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Assessment Report of Ecological, Social, and Economic Conditions, Trends, and Sustainability

Carson National Forest
New Mexico

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Assessment Report

Carson National Forest

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Abstract: The Assessment Report presents and evaluates existing information about relevant ecological, economic, and social conditions, trends, and risks to sustainability and their relationship to the 1986 Carson National Forest Land Management Plan (forest plan), within the context of the broader landscape.

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List of Commonly Used Acronyms

ALP	Alpine and Tundra (ecological response unit)
AML	appropriate management level
AOI	annual operation instructions
BAND1	Bandelier National Monument (air quality monitoring)
BASI	best available scientific information
BBER	Bureau of Business and Economic Research
BISON	Biota Information System of New Mexico
BLM	Bureau of Land Management
BMP	best management practice
BP	Bristlecone Pine (ecological response unit)
CAA	Clean Air Act
Cb	Cruces Basin (local zone)
CCC	Civilian Conservation Corps
CCF	hundred cubic feet
CCVA	Climate Change Vulnerability Assessment
CDNST	Continental Divide National Scenic Trail
CERCLA	Comprehensive Environmental Response Compensation and Liability Act
CFF	cubic Feet
CFR	Code of Federal Regulations
CFRP	Collaborative Forest Restoration Program
CO	carbon monoxide
CPCC	Comprehensive Plan for Colfax County
CPM	coarse particulate matter
Cr	Camino Real (local zone)
CSP	concentrating solar power
CWCS	Comprehensive Wildlife Conservation Strategy
CWD	coarse woody debris
CWPP	County Wildfire Protection Plan
DI	distribution index
DOD	Department of Defense
DOE	Department of Energy
DOI	Department of Interior
EA	environmental assessment
EPA	Environmental Protection Agency
ERU	ecological response unit
FAR	Functioning at Risk
FCI	facility condition index
FEIS	final environmental impact statement

FIA	Forest Inventory and Analysis
FIDO	Forest Inventory Data Online
FP	Functioning Properly
FPM	fine particulate matter
FRCC	fire regime condition class
FRI	fire rotation interval
FSH	Forest Service Handbook
FVS	Forest Vegetation Simulator
FWS	Fish Wildlife Service
FY	fiscal year
GCM	Global Circulation Model
GCVTC	Grand Canyon Visibility Transport Commission
GMU	game management unit
HBI	Hilsenhoff Biotic Index
HERB	Herbaceous Riparian (riparian ecological response unit)
HM	head month
HUC	Hydrologic Unit Code
IBA	Important Bird Area
IF	Impaired Function
ILAP	Integrated Lands Assessment Project
IMPROVE	Interagency Monitoring of Protected Visual Environments
Ji	Jicarilla (local zone)
KCEC	Kit Carson Electric Cooperative
Kg/ha	kilograms per hectare
LAR	Land Area of the National Forest System Report
LSRS	Land Status Records System
MCD	Mixed Conifer, with Frequent Fire (ecological response unit)
MCW	Mixed Conifer, with Aspen (ecological response unit)
MDN	Mercury Deposition Network
ML	maintenance level
MMCF	million cubic feet
MOU	memorandum of understanding
MSG	Montane Subalpine Grassland (ecological response unit)
MTBS	monitoring trends in burn severity records
MVUM	motor vehicle use map
NAAQS	national ambient air quality standards
NADP	National Atmospheric Deposition Program
NSHR	Narrowleaf Cottonwood Shrub (riparian ecological response unit)
NSPR	Narrowleaf Cottonwood-Spruce (riparian ecological response unit)
NEI	National Emission Inventory

NEPA	National Environmental Policy Act
NF	National Forest
NFMA	National Forest Management Act
NFS	National Forest System
NHD	National Hydrography Dataset
NHPA	National Historic Preservation Act
NM	New Mexico
NMAAQS	New Mexico ambient air quality standards
NMBCC	New Mexico Biodiversity Collection Consortium
NMCHAT	New Mexico Crucial Habitat Assessment Tool
NMDGF	New Mexico Department of Game and Fish
NMED	New Mexico Environment Department
NMED-AQB	New Mexico Environment Department, Air Quality Bureau
NMOCD	New Mexico Oil Conservation Division
NMOSE	New Mexico Office of the State Engineer
NMRPTC	New Mexico Rare Plants Technical Council
NO	nitrogen dioxide
NPS	National Park Service
NRHP	National Register of Historic Places
NRV	natural range of variation
NTN	National Trends Network
NWI	National Wetland Inventory
O	ozone
OHV	off-highway vehicle
ONRW	outstanding natural resource water
Pb	lead
PFC	proper functioning condition
PHA	priority heritage asset
PILT	payment in lieu of taxes
PJO	Piñon-Juniper Woodland (ecological response unit)
PJS	Piñon-Juniper Sagebrush (ecological response unit)
PM	particulate matter
PNC	potential natural community
PPF	Ponderosa Pine Forest (ecological response unit)
PSD	Prevention of Significant Deterioration
PV	photovoltaic
RACCP	Rio Arriba County Comprehensive Plan
RAD	Risk Assessment Database
RASES	Riparian Area Survey and Evaluation System
Rc	Rio Chama (local zone)

RD	Ranger District
Rg	Rio Grande (local zone)
RGCS	Rio Grande Cottonwood-Shrub (riparian ecological response unit)
RGCT	Rio Grande cutthroat trout
RHR	Regional Haze Rule
RMP	Resource Management Plan (Bureau of Land Management document)
RNA	research natural area
ROD	record of decision
ROS	Recreation Opportunity Spectrum
Rr	Red River (local zone)
SAGE	Sagebrush (ecological response unit)
SAPE1	San Pedro Parks (air quality monitoring)
SCC	species of conservation concern
SEINet	Southwest Environmental Information Network
SFF	Spruce-Fir Forest (ecological response unit)
SIP	state implementation plan
SMS	Scenic Management System
SO_2	sulfur dioxide
SYFMA	Sustained Yield Forest Management Act
TCCP	Taos County Comprehensive Plan
TCP	traditional cultural properties
TES	Terrestrial Ecosystem Survey
TEU	terrestrial ecosystem unit
USDA	United States Department of Agriculture
UMCW	Upper Montane Conifer-Willow (riparian ecological response unit)
USGS	US Geological Survey
Vc	Vallecitos (local zone)
VDDT	Vegetation Dynamics Development Tool
VFSYU	Vallecitos Federal Sustained Yield Unit
VOC	volatile organic compounds
Vv	Valle Vidal (local zone)
WHPE	Wheeler Peak (air quality monitoring)
WPA	Works Program Administration
WQCC	Water Quality Control Commission
WRAP	Western Regional Air Partnership
WRAPTSS	Western Regional Air Partnership Technical Support System
WTLA	Willow-Thinleaf Alder (riparian ecological response unit)
WUI	wildland-urban interface
YCC	Youth Conservation Corps

I. Introduction

Purpose

The 2012 Planning Rule (36 CFR 219) provides the process and structure to create local land management plans for national forests across the nation. The rule establishes an ongoing, three phase process: 1) assessment; 2) plan development or revision; and 3) monitoring.

The 2012 Planning Rule is intended to create plans that guide integrated resource management on the Carson National Forest within the context of the broader landscape. It takes an integrated and holistic approach that recognizes the interdependence of ecological processes with social and economic systems. The approach uses best available science to inform decisions along the way. Collaboration with stakeholders and transparency of process are key ways the 2012 Planning Rule guides creation of forest plans for the future. The revised Carson National Forest Land Management Plan will consider a full range of multiple uses on National Forest System (NFS) lands.

This document represents the assessment phase of the process and is designed to rapidly evaluate readily available existing information about relevant ecological, economic, and social conditions, trends, and sustainability and their relationship to the current land management plan (forest plan), within the context of the broader landscape. The assessment uses information that is currently available in a form useful for the planning process, without further data collection, modification, or validation.

During the assessment, conditions and trends of 15 assessment topics listed in 36 CFR 219.6(b) and the sustainability of social, economic, and ecological systems (36 CFR 219.5(a)(1)) are identified and evaluated. The assessment report is not a decision making document, but provides current information on planning topics (36 CFR 219.19).

Structure of the Assessment Report

Throughout this document, the Carson National Forest is referred to as “Carson NF”, the “forest”, or the “plan area” and the Carson National Forest Land Management Plan is referred to as the “Carson forest plan” or “forest plan”.

This chapter of the Carson NF Assessment Report includes the Setting, Distinctive Features, and Background of the Plan Area to describe the physical and climate characteristics and setting of the forest assessment area, and its place with the broader landscape. The Ecosystem Services Framework section describes how chapters II and III are interrelated and dependent on one another to provide sustainable ecosystem services and multiple uses. An explanation of Best Available Scientific Information follows. Public Participation describes the variety of ways the Carson NF has interacted with the public and tribes during the early stages of the forest plan revision process.

Chapter II. Ecological Integrity and Sustainability examines the conditions, trends, and risks to integrity and sustainability for the five ecologically–based resource areas laid out in the 2012 Planning Rule (36 CFR 219.6 (b)). In the chapter, an ecological assessment of each resource area, vegetation, soils, water, air, carbon, and federally recognized species and other species of conservation concern, is conducted to understand current conditions and trends and identify key characteristics at risk for a loss of ecological integrity. The ecological assessment culminates in assessing the risk to ecological integrity and determining ecological need-for-change. There is an ecological need for change for characteristics that show a potential or likelihood for risk, due to ongoing conditions and trends.

Chapter III. Social and Economic Sustainability and Multiple Uses, assesses conditions, trends, and risks to sustainability for the ten social and economic based topic areas listed in the 2012 Planning Rule (36 CFR 219.6 (b)). Chapter III assesses the plan area contributions (goods and services), which provide social, economic, and cultural benefits to people and communities. The social, cultural, and economic assessment considers the current condition of the goods and/or services, stressors affecting demand or availability, the current condition and trend of the ecosystem providing the goods and/or service, and its relationship to outside social, cultural, and economic conditions. This portion of the assessment culminates issues of concern or risks preventing the sustainability of the goods and/or service.

Chapters II and III describe the nature, extent, and role of existing conditions and possible future trends within the plan area and in the broader landscape. The two chapters represent a rapid assessment of existing information about relevant ecological, economic, and social conditions, trends, and sustainability. Ecological integrity and sustainability and the ability to contribute to social and economic conditions are intricately connected and interdependent. This concept is discussed below in the section on Ecosystem Services Framework. There is considerable cross-referencing between chapters II and III, and within each chapter, in order to accomplish an interdisciplinary consideration of condition, trend, and risks to sustainability.

Finally, References and Glossary conclude the report.

Setting, Distinctive Features, and Background of the Carson National Forest

High elevation lakes and meadows, diverse ecosystems extending from high desert to alpine tundra, deeply carved canyons where rivers and streams originate as headwaters of the upper Rio Grande, and rust red hills near Abiquiu describe the Carson NF. The Carson NF represents the scenic beauty and intrigue that attracted Native Americans, early Spanish explorers and settlers, and travelers from other parts of the North America to find and experience the American Southwest.

The Carson NF administers 1,486,372[1] acres stretching across northern New Mexico, within the San Juan, Rio Grande, and Canadian River drainages. The Carson NF overlaps four counties: 23 percent of Rio Arriba County, 37 percent of Taos County, 3 percent of Colfax County, and 1.4 percent of Mora County. The forest abuts the Santa Fe NF to the south and the Rio Grande NF to the north of Tres Piedras RD in Colorado (Figure 1). The forest is divided into six ranger districts - Camino Real, Canjilon, El Rito, Jicarilla, Tres Piedras, and Questa. East of the Rio Grande Gorge, the Questa and Camino Real ranger districts span the Sangre de Cristo Mountains (referred to as the “east side”). West of the Rio Grande, the Tres Piedras, El Rito, and Canjilon ranger districts cover the slopes of the Tusas Mountains (referred to as the “west side”). To the far west, Jicarilla RD sits on the eastern edge of the San Juan Basin, with rugged buttes, steep canyons, and prominent mesas. About 7.5 percent (110,662 acres) of the Carson NF is designated wilderness.

[1] This calculation is based on NFS land area using North American Datum 1983, Universal Transverse Mercator zone 13. The administrative boundary (includes private and other inholdings) for the Carson NF is 1,587,079 acres.

Figure 1. Vicinity map of the Carson National Forest

The Carson NF's topography consists of two distinct mountain ranges, high plateaus or mesas, canyons, valleys, and normally dry arroyos. The Carson NF's landscape is generally mountainous, with numerous perennial streams mostly draining into the Rio Grande, small lakes, alpine valleys, meadows, aspen groves, and virgin spruce-fir forests highlight the area. The Carson NF comprises some of the most productive and important watersheds and provides an important component for biological diversity in the landscape of the southwestern United States. Over 400 species of plants and animals occur on the Carson NF and it contributes over 40 percent of the waters that flow into the Rio Grande from northern New Mexico and southern Colorado.

Elevations range from 6,000 feet in low elevation grassland to over 13,000 feet in alpine tundra, creating a vast diversity of life zones and wildlife habitats. Wheeler Peak, the highest point in New Mexico at 13,161 feet above sea level, provides a dramatic backdrop to those who live in or visit the Taos area.

Northern New Mexico has a mild, arid or semiarid, continental climate characterized by light precipitation totals, abundant sunshine, low relative humidity, and a relatively large annual and diurnal temperature range. Elevation is the dominant localized influence on climate. At the lower elevations, summers are warm and winters are cold. As elevation increases, so does the harshness of winters. The lower elevations receive less than 10 inches of precipitation per year, with temperature extremes above 90 degrees Fahrenheit in the summer and well below freezing in the winter. The higher elevations receive in excess of 24 inches of precipitation each year, with summer temperatures in the 80s and winter temperature at zero Fahrenheit or below.

Warmest days quite often occur in June, with an average maximum temperature of 84 degrees Fahrenheit, while the coldest month of the year is January, with a mean minimum temperature of 11 degrees Fahrenheit. Temperature variations between night and day tend to be relatively big during summer, with a difference that can reach 32 degrees Fahrenheit, and moderate during winter, with an average difference of 28 degrees Fahrenheit.

The annual average precipitation at Taos is 12.30 inches, with most falling as snow above 8,000 feet. The Carson NF receives up to half of its annual rainfall during the summer "monsoon" season, when warm, moist air masses move up from Mexico. In July and August, afternoon convective storms tend to decrease solar insolation, lowering temperatures before they reach their potential daily high. The monsoon season suppresses much of the hot summer temperatures, replenishes water resources, and nourishes the vegetation. In recent years, northern New Mexico has experienced temperatures well above normal, with the highest period, particularly from the early 1990s to present. From 2002 through 2004 and 2011 to the now, the region has experienced lower than normal precipitation levels. Since 2002, much of northern New Mexico has experienced extreme drought conditions (SCCSC 2013).

The Sangre de Cristo Mountains are generally considered the southernmost range of the Rocky Mountains. They rise about 8,000 feet above the Great Plains to the east and the Española Valley to the west, with a nearly uninterrupted ridge line that runs from the Colorado state line to near Santa Fe. This topographical barrier had important impacts on the settling of the Southwest by "Anglos" arriving from the eastern United States, as it forced pioneers southward and thus into contact -- and sometimes conflict -- with both American Indian communities along the Rio Grande and Spanish colonial settlements at Santa Fe, Albuquerque, and other places. The mixing, and sometimes clash, of the three cultures continues to exert an influence on the region long after the settlers passed.

Timberline in these mountains is unusually high, approaching 12,000 feet in some places, but there are no permanent snowfields. Consequently, recreational opportunities in the Sangre de Cristos are highly diverse and seasonal, so that many areas used for hiking and backpacking in the summer turn into downhill ski resorts in the winter. Towns on the eastern slopes of the Sangre de Cristos tend to have cultural ties to the Great Plains, while the ones on the west side are more closely tied to the Hispanic and Native American settlements along the Rio Grande. The west side towns, such as Red River, Taos Ski Valley, Taos, and Santa Fe usually have somewhat more well-developed resources for tourism than the ones on the east. However, a unifying feature of the high mountain towns is that, apart from those intentionally developed for tourism, they tend to be relatively poor, whether on the east or the west sides. These economic conditions can be attributed to the difficulty in extracting a living from the mountains. Their height and resulting short growing season preclude most agriculture, and most of the range has little mining.

The Tusas Mountains run from the Colorado-New Mexico border south to the Rio Chama Valley. They are comprised of a vast, high, green region of gentle mountains and high mesas, interspersed with forests, meadows, and "valles", along the eastern side of Rio Arriba County. The Tusas Mountains are an extension of Colorado's well known San Juan Mountains and one of New Mexico's largest mountain groups. The western slopes of the mountains are part of the Tierra Amarilla Land Grant, while the eastern slopes are within the Carson NF. The highest point is Grouse Mesa at 11,403 feet, within the Tierra Amarilla Land Grant. A famous rock formation here is the Brazos Cliffs, most often viewed when looking east from US 64 between Chama and Tierra Amarilla. The Tusas Mountains are well known to native New Mexicans, who either live in several communities scattered across the Tusas Mountains or come to camp, fish, hunt, collect firewood, and enjoy the outdoors.

The San Juan Basin is a geologic structural basin in the Four Corners region of the Southwestern United States, encompassing much of northwestern New Mexico, southwest Colorado, and parts of Arizona and Utah. The Jicarilla Ranger District (RD) of the Carson NF lies on the eastern edge of the basin. The region is arid with rugged topography of plains and valleys interspersed by buttes, canyons, and mesas. The San Juan Basin also has uplands that exceed elevations of 9,800 feet. As a geologic region, the San Juan Basin is noted for its large deposits of coal, uranium, and natural gas. Since the 1980s, the Fruitland Formation in the basin has been one of the major U.S. sources of coalbed methane. In 2012, the Jicarilla RD's 800 natural gas wells produced over $27 million in revenues, 90 percent of royalties and other revenues generated in the Southwestern Region of the Forest Service.

The most predominant vegetation types on the Carson NF are spruce-fir, mixed conifer, and ponderosa pine forests, each about 20 percent of the forest. The remainder is comprised primarily of piñon-juniper woodland and sagebrush, totaling around 28 percent. The main vegetation system drivers on the forest are fire disturbances, regional climate change, insects, and natural vegetation succession. More details on vegetation and drivers and stressors are provided in Chapter II of this report.

Ecosystem Services Framework

Ecosystem services are a product of functioning ecosystems that affect social, cultural, and economic conditions within the plan area and the broader landscape. Ecosystem services are the ecosystem products and processes that people enjoy or from which they benefit, including but not limited to scenic views, fish and wildlife, recreation opportunities, food, fiber, fuel, energy, clean water, timber, cultural amenities, carbon storage, flood control, and disease regulation. The Millennium Ecosystem Assessment (MEA 2005) has served as the initial impetus for applying the ecosystem services concept to national forest management. The ecosystem services, benefits people obtain from ecosystems, are grouped into four broad categories:

- **Supporting** ecosystem services are those that are necessary for the production of other ecosystem services, such as pollination, seed dispersal, soil formation, and nutrient cycling.
- **Regulating** ecosystem services are the benefits people obtain from the regulation of ecosystem processes, including such as long term storage of carbon; climate regulation; water filtration, purification, and storage; soil stabilization; flood and drought control; and disease regulation.
- **Provisioning** ecosystem services are the products people obtain from ecosystems, such as clean air and fresh water, energy, food, fuel, forage, wood products or fiber, and minerals.
- **Cultural** ecosystem services are the nonmaterial benefits people obtain from ecosystems such as educational, aesthetic, spiritual, and cultural heritage values, recreational experiences, and tourism opportunities (36 CFR 219.19).

The ecosystem services framework can be adapted to explain the benefits people obtain from the Carson NF under each assessment topic (Figure 2).

Use of the ecosystem concept and the analysis of ecosystem services are integrated throughout the sections of Chapter II. Ecological Integrity and Sustainability and Chapter III. Social and Economic Sustainability and Multiple Uses. The sections of Chapter II describe the current condition of the ecosystems that produce ecosystem services, which may include, clean air, water, and carbon cycling. Chapter III addresses ecosystem services that come from ecological materials, such as grazing, wood products, recreation, and spiritual and cultural values.

In using the adapted ecosystem services framework, the ecological integrity of the ecosystems providing ecosystem services are evaluated and determined. An ecosystem with low ecological integrity will not be able to sustain or provide the appropriate ecosystem functions, such as energy flow, nutrient cycling and retention, predation and herbivory, and natural disturbances. We evaluate second level ecosystem services to determine their ability to be sustained in order to meet the needs and desires of the people who use and benefit from them.

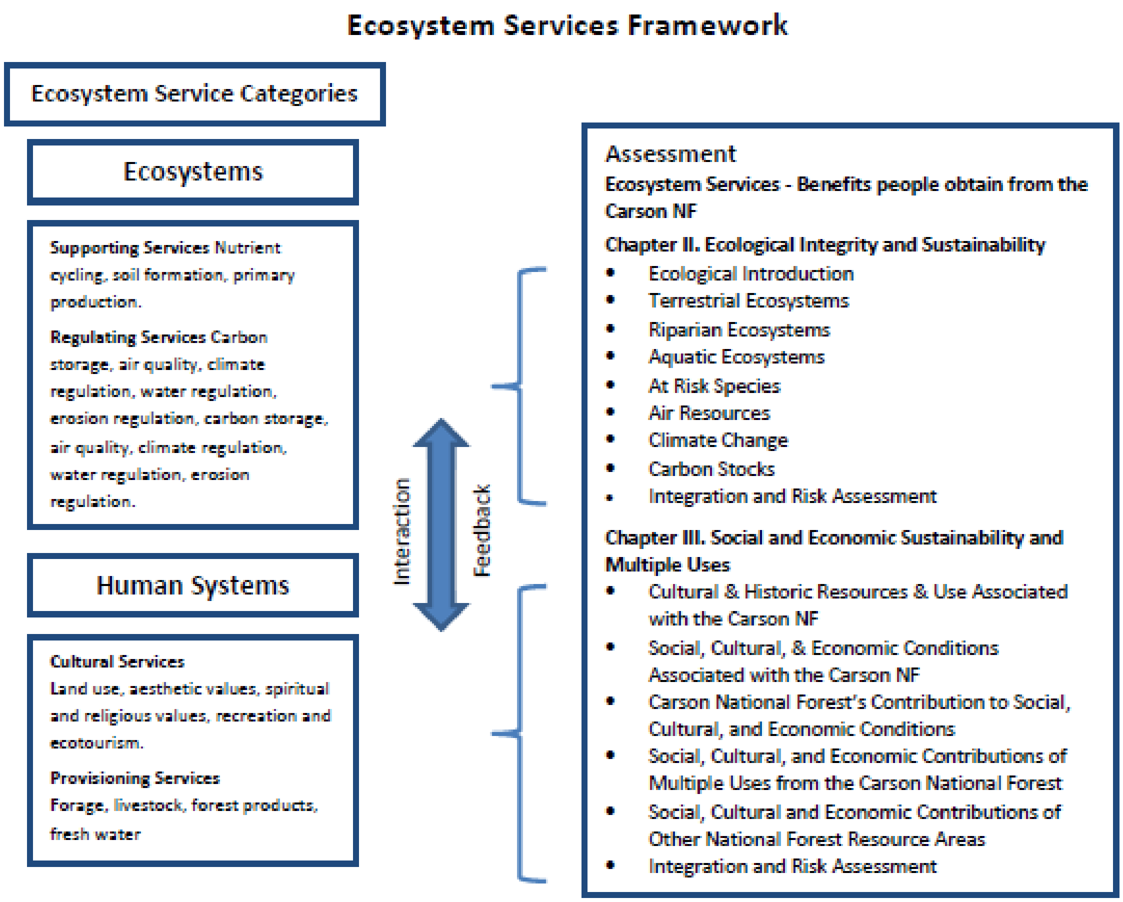

Figure 2. Ecosystem services framework used in this assessment report

The interaction and feedback between the two levels is discussed and evaluated throughout this report. Many of the second level ecosystem services are identified as stressors for the different ecosystems (i.e., ungulate grazing, recreation, infrastructure, and water consumption). These second level ecosystem services can affect the proper functioning of an ecosystem, and impair its ability to provide both first level and second level ecosystem services. Conversely, ecosystems with low ecological integrity can be impaired to provide second level ecosystem services. Through the body of the assessment report, these relationships are discussed and analyzed to provide a complete picture of the Carson NF's ability or inability to provide ecosystem services.

In evaluating ecosystem services through the adapted framework, this report identifies the ecosystem services provided by the forest that are important in the broader landscape outside of the plan area and are likely to be influenced by the Carson forest plan. Also identified are those ecosystem services that may be at risk of being unsustainable and may require changes in management identified in the current forest plan.

The intent is to focus planning on these ecosystem services, rather than all possible ecosystem services that may be provided by the Carson NF. Ecosystem services provided by the forest are identified and evaluated throughout the various sections of this report and are expected to be the initial set of ecosystem services tracked. The assessment helps to identify ecosystem services that may be at risk of being unsustainable and may require changes in our management identified in our current forest plan.

Best Available Scientific Information

The assessment is based on the best available scientific information (BASI) that has been determined to be accurate, reliable, and relevant to the issues being considered (FSH 1909.12, Chap. 0, Sec. 07). Throughout the assessment process, relevant ecological, social, and economic scientific information was identified, documented, and evaluated to form a basis for the development of plan components and other plan information. The Carson NF has provided opportunities for public and governmental participation, inviting submission of information, including scientific information that may be relevant to the planning process. Through public meetings and other collaboration with governmental organizations and interested parties, the Carson NF has developed a shared determination and understanding of the BASI and clarified how the BASI was identified for the assessment process.

The scientific information determined to be the BASI is identified throughout this assessment. How the BASI was used to inform the assessment is discussed as each issue is being considered, and contradictory BASI is briefly described when it exists. A list of References (p. 505) is found at the end of this document. Among the scientific information that may be considered the BASI are:

- Peer reviewed articles
- Scientific assessments
- Other scientific information, including, expert opinion, panel consensus, inventories, and observational data
- Data prepared and managed by the Forest Service or other federal agencies. This information may include monitoring results, information in spatially referenced

databases, data about the lands and resources of the plan area, and various types of statistical or observational data.

- Scientific information prepared by universities, national networks, and other reputable scientific organizations
- Data or information from public and governmental participation (FSH 1909.12, Chap. 0, Sec. 07.13)

Not all scientific information is the BASI (FSH 1909.12, Chap. 0, Sec. 07.12). The BASI was determined according to the following three criteria:

1. **Accurate.** To be accurate, the scientific information must estimate, identify, or describe the true condition of its subject matter. This description of the true conditions may be a measurement of specific conditions, a description of operating behaviors (physical, biological, social, or economic), or an estimation of trends. Statistically accurate information is near to the true value of its subject, quantitatively unbiased, and free of error in its methods. The extent to which scientific information is accurate depends on the relationship of the scientific findings to supportable evidence that identifies the relative accuracy or uncertainty of those findings. The accuracy of scientific information can be more easily evaluated if reliable statistical or other scientific methods have been used to establish the accuracy or uncertainty of any findings relevant to the planning process.

2. **Reliable.** Reliability reflects how appropriately the scientific methods have been applied and how consistent the resulting information is with established scientific principles. The scientific information is more reliable if it results from an appropriate study design and well-developed scientific methods that are clearly described. The assumptions, analytical techniques, and conclusions are well referenced with citations to relevant, credible literature, and other pertinent existing information. Conclusions are based on reasonable assumptions that are supported by other studies and are consistent with the general theory underlying those assumptions or are logically and reasonably derived from the data presented. Any gaps in information and inconsistencies with other pertinent scientific information are adequately explained.

   Scientific information that describes statistical or other scientific methods used to determine both its accuracy and uncertainty can be considered more reliable. The use of quantitative analysis that has known (and quantifiable) rates of errors and results improves this reliability. An accuracy assessment of the data supports the reliability of the quantitative analysis.

   The application of quality control to the scientific information also improves the reliability of the information. One form of quality control is peer review when scientific information has been critically reviewed by qualified scientific experts in that discipline and the criticism provided by the experts has been addressed by the proponents of the information. Publication in a refereed scientific journal usually indicates that the information has been appropriately peer reviewed.

3. **Relevant.** The information must pertain to the issues under consideration at spatial and temporal scales appropriate to the plan area and to a land management plan. Relevance in the assessment phase is scientific information that is relevant to providing information, including conditions and trends, about the 15 topics in 36 CFR 219(b) or to the sustainability of social, economic, or ecological systems (36 CFR 36 219.5(a)(1)). Relevance in the planning phase is

scientific information pertinent to the plan area or issues being considered for the development of plan components or other plan content. (FSH 1909.12, Chap. 0, Sec. 07.12)

The BASI is not always a single source of scientific information that is “best” for a specific subject. When scientific consensus does not exist, the BASI may be from multiple sources and may recognize conflicting scientific information (FSH 1909.12, Chap. 0, Sec. 07.12).

Public Participation

Public participation for the assessment has included a series of public meetings to gather local knowledge to understand how the public valued the forest. In addition, the Carson NF has interacted with others through presentations and meetings with county planners, land grant communities, tribes, stakeholders, and other government entities. Public engagement, both formal and informal will continue through the assessment and into the plan development phase of the forest plan revision process. Shared knowledge and understanding between the Forest Service and the public needs to be a continual and dynamic part of the planning effort.

In June 2014, the Carson NF held 14 meetings in communities around the forest. The communities were identified to acquire the broadest representation of individuals and communities who use the forest. The meetings were held from June 2 to 28 in Peñasco, Truchas, Española, El Rito, Canjilon, Tres Piedras, La Jara CO., Taos, Questa, Red River, Taos Ski Valley, Bloomfield, Angel Fire, and Cimarron (USDA FS Carson NF 2014a). The attendees were asked three questions:

1. How is the Carson National Forest important to you and why?
2. What changes have you seen on the Carson National Forest?
3. How do you hope the forest will serve future generations?

These questions were also posted on the forest’s website to engage a wider audience. The responses were compiled and published in a report available on the Carson NF’s Website. These responses were used in the development of parts of the social, cultural, and economic section of the assessment. The responses to the questions articulated a very diverse representation of how forest users valued and used the forest. Carson NF employees heard many of the same responses in each engagement around the forest. At almost every location the public emphasized traditional and cultural uses, such as the ability graze, collect firewood, hunt on the forest, and gather herbs and plants. These uses are a very important part of the social and cultural identity of the communities. Other information gathered on what the public and forest users valued was access, concern about climate change and forest health, clean and available water, concern for fire, a love of nature, family, and relationship building.

From the land grant communities the Forest Service gained a powerful understanding of the local people’s connection to the land and the land to the people. They stressed the importance of maintaining traditional uses provided by the forest. From the local counties, towns, and communities Carson NF employees heard their concern about the economy of the constituents, water for community use and growth, and fire.

In June 2015, the Carson NF held 14 public meetings in communities around the forest to present the key findings from the draft assessment report and to hear solutions from the public on how to address the findings. The meetings were well received and the public appreciated the opportunity to be heard. When the forest's planning team evaluated the comments, it considered: (1) incorporating suggestions in this final assessment report; (2) using people's ideas in developing the proposed forest plan; and (3) directly addressing more specific concerns using current management, prior to revising the forest plan. The forest will continue to engage with key stakeholders to encourage dialogue with the Forest Service on working together around specific projects, now and around plan development.

Tribal Engagement

Involvement with federally recognized Tribes has been ongoing. Meetings have been held with tribal governments to inform them of the forest planning process, while other less formal meetings have been with tribal planners to specifically discuss how the Carson NF can integrate aspects of tribal plans into its revised plan and what is of tribal importance concerning the forest. In July 2014, the Carson NF's tribal liaison contacted local tribal governments asking if they have any wildlife, fish, and plant species of which they are concerned. The tribes responded affirmatively, but did not disclose any species. The Carson NF presented the importance of participating and contributing to the forest's plan development at the All Pueblo Council in March 2015.

Many of the tribes who consider the Carson NF an important place, both spiritually and culturally, have a strong interest in the management of the natural resources on the forest. The Carson NF has also engaged with the individual tribes, particularly the Taos Pueblo, Picuris Pueblo, and Jicarilla Apache Nation, to better understand how the Carson NF impacts the tribes, and gain input on how the forest can work to address these and other concerns when developing the new forest plan. The Carson NF will continue to engage and involve the tribes throughout the planning process, to learn, consider, and respect their ecological, social, and cultural needs and concerns.

II. Ecological Integrity and Sustainability

An ecosystem is a spatially explicit, relatively homogeneous unit of the Earth that includes all interacting organisms and elements of the abiotic environment within its boundaries (36 CFR 219.19). Ecosystem or ecological integrity is the quality or condition of an ecosystem, when its dominant ecological characteristics (e.g., composition, structure, function, connectivity, and species composition and diversity) act to maintain that quality or condition and maximize its ability to withstand or recover from perturbations imposed by natural environmental dynamics or human influence. Ecosystem sustainability is the capability of an ecosystem to meet the needs of the present generation, without compromising the ability to meet their needs of future generations. Ecosystem sustainability refers to the capability of ecosystems to maintain ecological integrity (36 CFR 219.19).

Structure of this Chapter

The ecological assessment is broken into seven sections to address the ecological integrity and sustainability of the Carson NF. Each section's resource area is assessed to understand current conditions and trends and identify key characteristics at risk for a loss of ecological integrity. These sections include:

Section 1: **Terrestrial Ecosystems** are assessed for ecosystem integrity to determine whether terrestrial ecosystems (upland vegetation and soils) are functioning normally and are uncompromised.

Section 2: **Riparian Ecosystems** are assessed for ecosystem integrity to determine whether riparian ecosystems (plant, animal, and aquatic communities directly or indirectly attributed to water induced or related factors) are functioning normally and are uncompromised.

Section 3: **Aquatic Ecosystems** are assessed for ecosystem integrity to determine the status of watersheds and water resources (surface and groundwater) and their role in sustaining the structure and function of terrestrial, riparian, and aquatic ecosystems on the Carson NF.

Section 4: **At-Risk Species** are identified and assessed to understand the ecological conditions necessary to sustain them.

Section 5: **Air Resources** is described and assessed through existing conditions and trends of airshed conditions and air quality.

Section 6: **Climate Change** predictions are summarized and assessed in relation to the range of climatic conditions that have supported ecosystems in the past.

Section 7: **Carbon Stocks** are assessed to determine the amount or quantity of carbon contained in a carbon pool. For purposes of carbon stock assessment for National Forest System land management planning, carbon pools do not include carbon in fossil fuel resources, lakes or rivers, emissions from agency operations, or public use of NFS lands (such as emissions from vehicles and facilities).

Section 8. **Ecological Integration and Risk Assessment** integrates risk to ecological integrity and determines ecological need-for-change. There is an ecological need for changing the Carson NF's current forest plan for characteristics that show a potential or likelihood for risk.

The ecological assessment includes characterizations of current condition and trend for specific ecosystem characteristics. For each characteristic, where available, the following information is evaluated:

- Reference condition
- Deviation of current condition from reference condition (departure)
- Predicted future departure (trend)

Departure from reference condition is equivalent to a loss of ecological integrity. To determine a loss of integrity, current departure and departure trend are considered.

Some systems have characteristics that do not lend themselves to the historic reference condition and system integrity approach, such as air quality and water quality and quantity. For these systems and characteristics, an alternative approach will be used and discussed in each resource area's respective section.

Key Ecosystem Characteristics

Ecological integrity is simple in concept to define, but more difficult in practice to assess. Ecosystem characteristics are specific components of ecological conditions that sustain ecological integrity (FSH 1909.12 Chap.14). A key ecosystem characteristic describes the composition, structure, connectivity, and/or function of an ecosystem that is most dominant. Key ecosystem characteristics are identified and evaluated for each ecosystem, but not all possible characteristics of ecosystems are identified. Only those characteristics needed to provide ecological conditions necessary to maintain or restore the ecological integrity of terrestrial, aquatic, and riparian ecosystems in the plan area are considered in the assessment (36 CFR 219.8).

A limited suite of ecosystem characteristics are selected to assess ecological integrity based on:

- information was readily available
- characteristic is relevant to key issues and sensitive to drivers and stressors
- characteristics represent elements needed to assess other resource areas (e.g., at-risk species and habitat)

The process for identifying and selecting key ecosystem characteristics was iterative throughout the assessment, and was influenced by information provided by public and governmental participation.

System Drivers and Stressors

System drivers are processes that act on ecosystem characteristics, such as natural vegetation succession, predominant climatic regimes, and broad-scale disturbance regimes (wildfire, flooding, and insect and disease). Disturbance regimes that are not characteristic of a system may also act as stressors.

Stressors are factors that may directly or indirectly degrade or impair ecosystem composition, structure, or ecological process and thereby impair its ecological integrity, such as an invasive species, loss of connectivity, or the disruption of a natural disturbance regime (36 CFR 219.19). A stressor can be a driver that is new to the system (e.g., invasive species, climate change) or a driver that is uncharacteristic, non-functional, or has a disproportionately undesirable outcome (e.g., current fire regimes in many ponderosa pine systems, or uncharacteristic insect and disease infestations).

Specific system drivers and stressors are identified and evaluated for each primary resource area in this assessment.

Carson NF management actions may act as system drivers when they are of sufficient duration, intensity, and magnitude, to affect ecosystem characteristics. Management actions include any alterations to ecosystems or activities that the Forest Service conducts, authorizes, or restricts on NFS lands. These may include mechanical thinning, prescribed burning, permitted grazing, permitted fuelwood gathering, vehicular access, stream restoration treatments, seeding, trail construction, fencing, among others.

Management Actions

When they are of sufficient duration, intensity, and magnitude Carson NF management actions may exert influence system drivers and thereby affect ecosystem characteristics. Management actions include any alterations to ecosystems or activities that the Forest Service conducts, authorizes, or restricts on NFS lands. These may include mechanical thinning, prescribed burning, permitted grazing, permitted fuelwood gathering, vehicular access, stream restoration treatments, seeding, trail construction, water developments, fencing, and special uses, among others. The National Environmental Policy Act (NEPA) requires that federal government management actions "use all practicable means and measures … to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans." (NEPA 1969) Four principle management actions on the Carson NF are of sufficient duration, intensity, and magnitude to influence system drivers at the plan scale (there are other management actions that have more localized or short-term impacts).

Spatial Scales of Analysis

The area of analysis for the assessment should be large enough to capture: 1) broad-scale trends and 2) the natural range of variation in disturbance intensity, frequency, and areal extent. For most characteristics, it is valuable to consider multiple scales for the assessment. The assessment evaluates ecological integrity at three spatial scales:

- **Context scale** is needed to put the forest condition in context with the greater area, including lands beyond the forest boundary. The context scale informs the spatial niche of the forest in the greater landscape.
- **Plan scale** displays current condition and trends as an average of conditions across the Carson National Forest (NF).
- **Local scale** subdivides the plan scale. It is valuable for describing departure patterns for a given characteristic and identifying where particular issues may need attention and drive forest plan components. This scale is not as likely to drive ecological need for change, but may drive development of plan components.

Each key ecosystem characteristic is reported at each of these three scales. Table 1 is a summary of examples for scales of assessment of primary resource areas.

Table 1. Summary of scales for primary resource

Scale	Vegetation	Soils	Water	Air
Context	Portions of intersecting and adjacent sections[1]	Portions of intersecting and adjacent sections	Sub-basin (HUC[2] 8)	Airsheds[3]
Plan Unit (Carson NF)	Plan unit	Plan unit Aggregation of TEUs[4] by ERU[5]	Plan unit watersheds (HUC 10)	Plan unit
Local	District or sub-district geographic zones	District or sub-district geographic zones	Sub-watersheds (HUC 12)	Places with parallel air quality monitors

Evaluating ecological integrity at scales broader than the plan area places the management of resources within the plan area into context. An understanding of the environmental context extending beyond the plan area is necessary for determining the opportunities or limitations of NFS lands to contribute to the sustainability of broader ecological systems, as well as the impacts of the broader landscape on the sustainability of resources within the plan area. In some instances, a unique role of NFS lands may become apparent at this scale.

Reference Conditions

Reference conditions are the environmental conditions that infer ecological sustainability. When available, reference conditions are represented by the characteristic natural range of variation (NRV) (not the total range of variation), prior to European settlement and under the current climatic period. For many ecosystems, NRV also reflects human-caused disturbance and effects prior to settlement. It may also be necessary to refine reference conditions according to contemporary factors (e.g., invasive species) or projected conditions (e.g., climate change). Reference conditions are most useful as an inference of sustainability when they have been quantified by amount, condition, spatial distribution, and temporal variation.

For many ecosystems, the NRV provides insight into the temporal dynamics and key characteristics of ecological systems and therefore helps to evaluate ecological integrity. The NRV is a tool for assessing ecological integrity of terrestrial, riparian, and aquatic ecosystems, and does not necessarily constitute a management target or desired condition. The NRV can help identify key structural, functional, compositional, and connectivity characteristics, for which plan components may be important for either maintenance or restoration of such ecological conditions.

In some situations, there is not enough information about selected key ecosystem characteristics to understand the reference conditions under historical disturbance regimes. In these cases,

[1] Ecological sections (Cleland et al. 2007)

[2] A hydrologic unit code (HUC) identifies hierarchical system of surface drainage areas. The smaller the HUC number, the larger the drainage area. See Spatial Scales for Aquatic Ecosystems.

[3] Geographic areas that, because of topography, meteorology, or climate, are frequently affected by the same air mass.

[4] TEU – terrestrial ecosystem unit identifies a unique soil type.

[5] ERU – ecological response unit identifies a unique vegetation community. See Ecological Response Units and Terrestrial Ecosystem Units.

ecological integrity is evaluated based on the current understanding of conditions that would sustain these key ecosystem characteristics (FSH 1909.12, Chap. 10, Sec. 12.15b).

Departure measures the degree to which the current condition of a key ecosystem characteristic is unlike the reference condition. When departure can be quantified, it is rated in this assessment on a scale from 0 to100 percent, where 0 to 33 percent is considered "low", and within NRV. The "moderate" (34 to 66%) and "high" (67 to 100%) classes are outside of NRV and are uncharacteristic for the system.

Assessing Risk to Ecological Integrity

Risk results from threats to ecological integrity from ecosystem departure, either current or predicted. The risk of losing integrity of each key ecosystem characteristic is integrated geographically to quantify overall risk to the system. Risk is assessed on NFS lands, as it relates to systems and processes that are under agency control and/or authority. However, to understand risk to those lands, systems, and processes, they are assessed in the context of the larger landscape to the extent possible. An understanding of the environmental context extending beyond the plan area frames the opportunities or limitations for NFS lands to contribute to the sustainability of the broader ecological systems, and characterizes the impacts of the broader landscape on the sustainability of resources within the plan area. In some instances, a unique role of the NFS lands may become apparent at this scale (FSH 1909.12, Chap. 10, Sec. 12.13b).

The risk to ecological integrity was assessed for each ecosystem characteristic by weighing the current departure from reference condition against the trend for that resource, as conceptualized in a decision matrix (Figure 3). A risk can be mitigated if the characteristic is within agency authority and control, and the trend and condition can be improved (reversible).

Departure from Reference Condition	Trend: Toward Reference Condition	Trend: Stable	Trend: Away from Reference Condition
Significant Departure	**Risk Addressed** Continue current management and identify restoration opportunities	**Legacy of Past Mgmt** **OR** **Deviation due to Current Mgmt (ongoing activities)** Evaluate system reversibility and threats	**Potential for High Risk** Evaluate system reversibility and threats
No Significant Departure		**No Risk** Continue current management	**Potential Risk** Evaluate magnitude of future deviations, threats, and reversibility

Figure 3. Matrix to assess risk to ecological integrity

Terrestrial Ecosystems

Terrestrial ecosystems are assessed using key ecosystem characteristics related to vegetation and soils. To evaluate ecological integrity, vegetation and soils on the forest are subdivided into smaller ecosystem types based on ecosystem potential and typical disturbances. This section assesses current and expected future departure (the degree to which the integrity of a system has been compromised) by comparing the results of current Carson NF management to a defined reference condition for each ecosystem type. Departed current condition, or a trend toward higher departure suggests that ecological integrity and associated ecosystem services are at risk.

Departed current condition or a trend toward higher departure suggests that ecological integrity and associated ecosystem services are at risk. Current and reference conditions rely on regional summaries of BASI; other scientific information that is more specific and appropriate for the plan area; Carson NF developed and maintained databases; Carson NF specialist knowledge; and additional information provided through public participation. In addition to those sources specifically cited below, the following community wildfire protection plans (CWPP) were considered:

- Rio Arriba County CWPP (2007)
- Taos County CWPP Update (2009)[1]

Terrestrial Ecosystem Services

The Carson NF is more mountainous with higher average elevations than the surrounding landscape. The high elevations support rare ecosystems, like alpine tundra, and rare species, such as bristlecone pine. There are broad uninterrupted expanses of native forests, woodlands, shrublands, and grasslands that provide habitat for wildlife, solitude for hikers, and fuel for woodstoves. Plentiful snow in the winter and rain during the summer monsoons fall on the high peaks and feed the major rivers that flow to nearby towns, through New Mexico, into Texas, and beyond. From the top of Wheeler Peak to the edge of the Rio Chama canyon, visitors, local residents, and the many people who live downstream, downhill, and downwind all obtain benefits from the intact and functional ecosystems on the Carson NF (ecosystem services). Ecosystem services that vegetation and soils provide benefit people by supporting other ecosystem services, including:

- **Supporting** terrestrial ecosystem services create photosynthesis that produces oxygen and accumulates solar energy, nutrient cycling that maintain appropriate levels of many nutrients essential for life, genetic diversity that supports plant adaptation, and soil fertility which sustains many of the products that people value.

- **Regulating** terrestrial ecosystem services regulate processes for vegetation and soils by contributing and extracting chemicals from the atmosphere; effecting local temperature and precipitation patterns; sequestering or emitting greenhouse gasses and carbon; effecting timing and quantity of runoff and groundwater recharge to both regulate flooding and maintain water storage; purifying water by filtering out and decomposing organic wastes; and stabilizing soils to reduce erosion and prevent landslides.

[1] CWPPs are available on the New Mexico State Forestry Website: http://www.emnrd.state.nm.us/SFD/FireMgt/cwpps.html

- **Provisioning** terrestrial ecosystem services include food derived from plants or animals that directly or indirectly depend on plants; construction materials such as vigas and latillas; fuelwood for home heating; plants used for landscaping or ornaments; natural medicines; fresh water; and clean air.
- **Cultural** terrestrial ecosystem services are nonmaterial benefits such as scenic beauty and aesthetic value, spiritual or religious uses, formal and informal educational and research opportunities, cultural heritage in the form of cultural landscapes or culturally significant species, specific types of recreational experiences, tourist attractions, a sense of place, and a source of inspiration for art, folklore, symbolism, and advertising.[1]

Ecological Response Units and Terrestrial Ecosystem Units

The assessment of terrestrial ecosystem condition is stratified using the ecological response unit (ERU) system, which is a classification of sites that are each similar in plant species composition, succession patterns, and disturbance regimes. The ERUs are constructed in concept and resolution, such that they are applicable to management decisions. The Forest Service has previously employed the ERU concept in successful landscape analysis and strategic planning in the Southwestern Region.

The ERU framework describes all major ecosystem types found in the region based on a coarse stratification of biophysical themes. The ERUs are map unit constructs, technical groupings of finer vegetation classes, with similar site potential and disturbance history. In other words, it is the range of plant associations (USDA FS 1997), along with structure and process characteristics that would occur when natural disturbance regimes and biological processes prevail (Schussman and Smith 2006). Similar to LANDFIRE biophysical settings (NIFTT 2010), ERUs combine themes of site potential and historic fire regime:

Ecological Response Unit = Site Potential + Historic Disturbance Regime

Each ERU characterizes sites with similar composition, structure, function, and connectivity, and defines their spatial distribution on the landscape.

Stratifying terrestrial ecosystems based on vegetation characteristics and function is appropriate for two reasons. First, vegetation is the primary terrestrial and biological ecosystem component that is manipulated through management and affected by natural processes. Second, it represents habitat for wildlife and provides the required link to species diversity. The section on At-Risk Species is based on these ERUs, ecosystem characteristics, and ecological integrity.

Upland ERUs on the Carson NF are derived from the Terrestrial Ecosystems Survey (TES)[2] of the Carson NF, an inventory of soil types or terrestrial ecosystem units (TEUs). The TEUs relate to combinations of soils, land types, and vegetation communities (USDA Forest Service 1987b). They are summarized by ERU for some key ecosystem characteristics, particularly those that are

[1] Many of these ecosystem services are identified by the Millennium Ecosystem Assessment (MEA 2005), others were discussed during public engagement meetings.

[2] The Terrestrial Ecosystem Survey (USDA FS Carson NF 1987) contains information used in land planning and management programs on the Carson National Forest. It contains predictions and limitations of soil and vegetation behavior for selected land uses. This survey also highlights hazards or capabilities inherent in the soil and the impact of selected uses on the environment. At the context scale, upland ERUs are derived from the Santa Fe NF Terrestrial Ecosystem Survey on Santa Fe NF lands (USDA FS Santa Fe NF 1993).

soil related. Boundaries are coincident between upland ERUs and TEUs, such that any TEU belongs to only one upland TEU. The ERUs for other non-NFS lands in Arizona and New Mexico are mapped by the Integrated Lands Assessment Project (ILAP). In Colorado, ERUs have not been defined, but LANDFIRE Biophysical Setting is cross-walked to ERUs, in order to calculate departure. No other data provides analogous TEU soil information for lands outside the Carson and Santa Fe NFs.

Ten riparian ERUs on the Carson NF cover more than 10 percent of the forest. They are:

- ALP – Alpine and Tundra
- MSG – Montane Subalpine Grassland
- BP – Bristlecone Pine
- SFF – Spruce-Fir Forest
- MCW – Mixed Conifer, with Aspen
- MCD – Mixed Conifer, with Frequent Fire
- PPF – Ponderosa Pine Forest
- PJO – Piñon-Juniper Woodland
- PJS – Piñon-Juniper Sagebrush
- SAGE - Sagebrush

Key Ecosystem Characteristics for Terrestrial Vegetation

The key ecosystem characteristics for terrestrial vegetation (ERUs) are:

- Seral state proportion
- Ecological status
- Vegetative groundcover
- Coarse woody debris
- Snag density
- Patch size
- Fire regime
- Fire regime condition class
- Insect and disease

Seral state proportion is the percent of ERU in each seral state at context, plan, and local scales. Each ERU can manifest in a range of potential overstory vegetative conditions, each representing a unique phase in the overall ecology of the system (Weisz et al. 2009). By grouping these phases into seral state classes with unique vegetation characteristics (overstory composition and structure), models can be developed that define transitions among phases. These "state-and-transition" models can be built and adapted so that the dynamics of the system reflect NRV, and the resulting distribution among state classes represents the ERU reference condition (Weisz et al. 2009).[1] Reference conditions are based on a review of the relevant BASI by the Forest Service Southwestern Regional Office (USDA FS 2014c), with input from Carson NF specialists. ERU summary tables are footnoted with specific reference condition sources, where applicable.

Departure from the reference distribution is quantified by comparing it to the actual current distribution and to future predicted distributions. The closer composition, structure, and process are to their historic conditions, the more the system is maintaining ecological integrity, and the more resilient it will be to stress. For each state class, the similarity to reference is equal to the proportion in common that exists either on the current landscape or on the projected future landscape. The similarity value is equal to the lesser value between the current or projected proportion and the reference proportion. The sum of similarity values for an ERU is 100 percent or less, and 100 percent minus the similarity value equals the departure of the ERU (Figure 4). Departure is broken into thirds for descriptive purposes (0 to 33% = low departure, 34 to 66% = moderate departure, 67 to 100% = high departure), but is best addressed as varying continuously from low to high.

[1] Also see example in Ryan et al. (2006) and Smith (2006b).

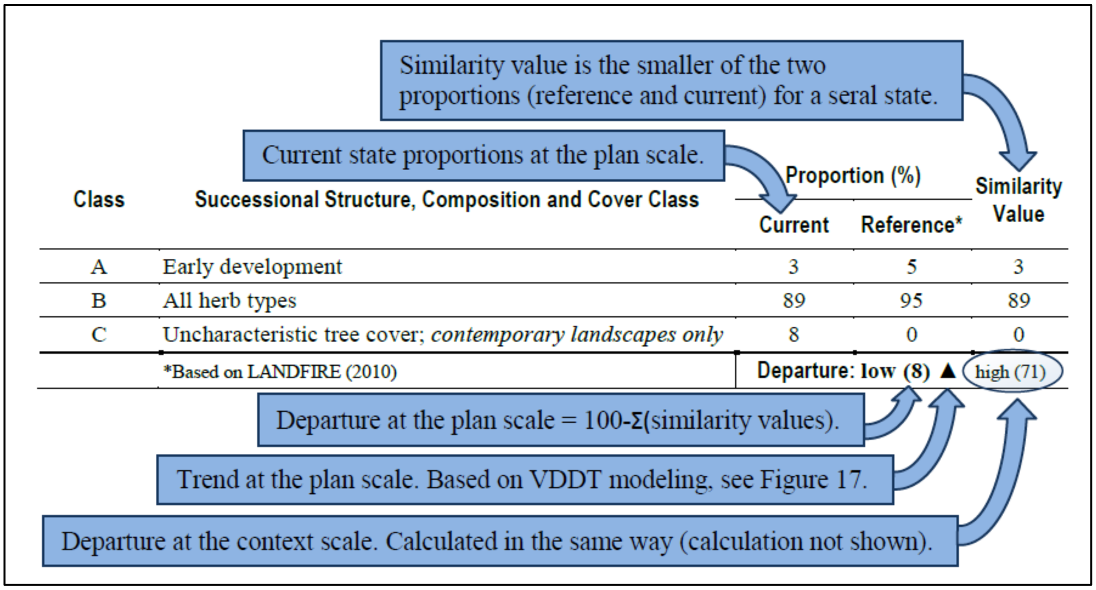

Figure 4. Sample seral state proportion departure calculation

The assignment of current state class proportions uses regional satellite imagery based classifications of vegetation size class, canopy cover, dominance type, and storiedness[1] at a 1:100,000 scale, with extensive photo interpretation and field data collection (Midscale Vegetation Mapping Project (Mellin et al. 2008). Existing vegetation is assigned to an ERU and then to the appropriate state class within that ERU according to state class descriptions that were developed by the Southwestern Regional Office (USDA FS 2011a, 2014b).

Projections of future state class proportions are produced using the Vegetation Dynamics Development Tool (VDDT) (ESSA 2006) and models developed by LANDFIRE, The Nature Conservancy, and the Integrated Landscape Assessment Project and refined by the Southwestern Regional Office, with input from forest specialists. These VDDT state and transition models both define seral states for each ERU and allow comparison among management scenarios. Model results are not precise predictions, but indicate relative trends and are sensitive to changes in management or disturbance. For this analysis, future trend assumes the continuation of current levels of management indefinitely. Most state transition destinations and probabilities are derived from Forest Vegetation Simulator (FVS) modeling (Dixon 2002). Burn severity information is compiled from Monitoring Trends in burn severity records (Wildland Fire Leadership Council 2014). Other inputs came directly from forest management actions, insect and disease surveys, and wildfire data from the past 15 to 30 years (USDA FS Carson NF 2014d). The alpine, bristlecone pine, and riparian ERUs have either too little acreage on the Carson NF or stand structure has not been adequately mapped; therefore, they are not appropriate for VDDT modeling and trend is not calculated. Instead, they are addressed qualitatively.

By comparing regional Midscale and LANDFIRE current vegetation information to reference seral state proportions, departure is calculated for the context, plan, and local scales. The Carson

[1] Size classes are based on tree diameter at breast height (seedling/sapling: 0-5”; small: 5-10”; medium: 10-20”; large: 20-30”; very large: 30”+). Canopy cover is non-tree (<10% tree cover); open (10-29.9% tree canopy cover); or closed (30%+ tree canopy cover). Dominance type refers to the lifeform, tree, shrub, or grass. Storiedness refers to the number of tree canopy levels having greater than 10% canopy cover: 1 level=single storied; 2 or more levels=multi-storied.

NF only affects management at the plan scale and only collects management information on the forest; so VDDT models can only be reliably parameterized at the plan scale. Therefore, future trend is modeled only at the plan scale, though trends at the context or local scale may be discussed where information suggests they differ. The trend analysis relies mostly on VDDT modeling results, while trend for other characteristics is addressed only when a probable trajectory can be inferred. Seral state proportion trend is presented in the summary table for each ERU (Figure 4). Actual future modeled departure values are shown in Figure 20 (p. 77).

Ecological status measures vegetation composition (structure being represented by other characteristics). The departure analysis results in an index value that considers all plant species collectively (as opposed to evaluating every species or every plant life form). It is a measure of the degree of dissimilarity between the existing plant community and the potential natural community (PNC) as described in the Carson NF Terrestrial Ecosystem Survey (USDA FS Carson NF 1987). The PNC is not necessarily a management goal in itself for an ecosystem or landscape, since it defines the climax of succession. The PNC, along with the earliest successional stage, determines the range of conditions that should prevail in a healthy ecosystem (USDA FS 1987). Daubenmire transects were collected for most TES map units, and were used to develop PNC. The actual transect data was summarized by TEU and compared to PNC. The departure for the most common TEUs in each ERU was area weighted and averaged.

Vegetative groundcover is percent combined cover of basal vegetation and litter at the plan and local scales. Groundcover provides soil stability, increases water capture, and improves moisture retention. Reduction of groundcover can lead to decreased productivity, changes in runoff timing and quantity, increased erosion, and increased sedimentation. Estimates of current and "natural" vegetative groundcover are available at the plan scale as part of the Carson NF's Terrestrial Ecosystem Survey (USDA FS Carson NF 1987). Similar data is not available for non-National Forest System (NFS) lands in the context landscape, and no departure estimate is made at the context scale, since stressors and drivers are very likely different in some ERUs, due to additional anthropogenic impacts in populated areas. Total percent vegetative cover includes basal area for all plant species, as well as percent cover of litter. The TES current estimate reflects decreases resulting from road construction or other development, concentrated recreation, management related ground disturbance, or legacy impacts from logging, excessive unmanaged grazing, etc. The change in percent vegetative groundcover is calculated for each TEU, and then area-weighted to determine the average departure within each ERU. The same calculation is done for each local zone using only the area of each TEU in that zone.

Coarse woody debris (CWD) is defined as tons per acre of dead material ≥ 3 inches in diameter at the plan scale. Coarse woody debris (downed woody material) serves as an important ecological function. It provides wildlife habitat and contributes to the formation of soil organic matter. Coarse woody debris also helps to reduce soil erosion by shielding the soil surface from raindrop impact and interrupting rill and sheet erosion. Current conditions are based on stand exam survey information collected by the Carson NF at the plan scale only. No analogous information is available at the context scale, and plan scale data are not necessarily numerous or well distributed enough to allow local scale analysis.

Snag density is defined as the number of stems per acre by diameter classes (i.e., ≥ 8", ≥ 18") at the plan scale. Like CWD, snags (standing dead trees) serve an important ecological function. Large standing snags provide key habitat for many species, such as woodpeckers that feed on insects dwelling in decomposing wood. Current conditions are based on stand exam survey information collected by the Carson NF at the plan scale only. No analogous information is available at the context scale, and plan scale data are not necessarily numerous or well distributed enough to allow local scale analysis.

Patch size is the average patch size in acres for seral state classes by ERU at the plan scale. A "patch" is a contiguous area of the same system type in the same structural state. Patch size plays a significant role in wildfire behavior. Historic timber harvest and fire suppression are largely responsible for decreased fire frequency, increased fire severity, and an increase in closed canopies across Rocky Mountain forests (Schoennagel et al. 2004). These changes, where combined with uncharacteristically large patches of contiguous tree canopies, set the stage for uncharacteristically large, severe wildfires. Patch size is also an important element of wildlife habitat. Each wildlife species has its own patch size preference, and these preferences vary by species. For these reasons, and also for reasons of wildfire behavior, current landscape distribution of patches should resemble the distribution under reference conditions—the conditions to which wildlife species adapted—so as to best accommodate the varying preferences of all wildlife species and simultaneously mimic historic fire behavior. Patch size is calculated based on the average of all patches of an ERU that intersect the plan area. For some ERUs, this means the analysis area may extend significantly into the context landscape. The same analysis at the context scale would similarly extend outside the context scale (where information was not collected as part of this assessment). Departure was calculated by comparing current patch size to the reference range of patch sizes as described in Table 2.

Table 2. Definition of patch size departure based on current patch size in relation to a reference range of patch sizes

Current Patch Size	Smaller than Reference Patch Size	Within Reference Patch Size Range	Larger than Reference Patch Size
Departure	$= 1 - \left(\frac{current\ patch\ size}{low\ end\ of\ ref.range}\right)$	0	$= 1 - \left(\frac{high\ end\ of\ ref.range}{current\ patch\ size}\right)$

Fire regime combines fire frequency[1] and the percent of burns that are non-lethal, mixed severity, and stand replacement (fire severity). Fire frequency is assessed at the context, plan, and local scales. Fire severity is only assessed at the context scale and plan scales, since burn severity data is limited or unavailable in some local zones on the Carson NF. Fire is an integral component in the function and biodiversity of many natural habitats and organisms, and these communities have adapted to withstand and even to exploit natural wildfire. More generally, fire is regarded as a "natural disturbance", similar to flooding, wind-storms, and landslides, that has driven the evolution of species and controls the characteristics of ecosystems. Each ERU has a characteristic fire regime that is integral to its ecological integrity. If fires are too frequent, plants may be killed before they have matured, or before they have set sufficient seed to ensure population recovery. If fires are too infrequent, plants may mature, senesce, and die, without ever releasing their seeds or

[1] Reference fire frequency is measured in mean fire return interval (MFRI), or the average number of years between two successive fire events in a given area. Current fire frequency is measured slightly differently, using fire rotation (FR). Fire rotation is the number of years it would take for an area equal to the entire ERU to burn. Both a shorter MFRI or FR indicate more frequent fire in the system; however, they are calculated from different measurements and are not equivalent, but can still be compared to infer trends.

species composition may shift to favor uncharacteristic combinations, or live and dead biomass may simply accumulate to uncharacteristic levels.

Fire severity information was obtained from Monitoring Trends in Burn Severity (MTBS) data (all available records collected for CO and NM going back to 1984), supplemented by Burned Area Emergency Response (BAER) data, where MTBS was missing or incomplete. Burn severity was summarized by ERU, at the plan and context scales.

Fire frequency at the plan scale is based on Carson NF wildfire history data from the 30 year period between 1984 and 2013. Point data was buffered by acreage and replaced by polygons of known perimeters where available.[1] Fire rotation (FR-average area burned per year) was calculated for each ERU and the total ERU acreage was divided by that average. Fire rotation at the context scale is based on nationally compiled federal agency wildfire occurrences point information,[2] which was buffered by acreage and replaced by actual fire perimeters, when available. Fire perimeters were obtained from Carson NF data at the plan scale and a combination of Santa Fe NF, Rio Grande NF, and MTBS perimeters elsewhere. MTBS only maps fires over 1,000 acres as far back as 1984. For large parts of the context scale the only source of fire perimeter information is MTBS data, so the analysis was bounded using its earliest available information (1984-2013). Any discrepancies at the plan scale were resolved in favor of Carson NF data.

Departure was calculated by comparing FR to the reference mean fire return interval (MFRI) as shown in Table 3.

Table 3. Definitions of fire frequency departure based on current fire return (FR) in relation to a range of reference mean fire return intervals (MFRI)

Current Fire Rotation	Less Frequent than Reference MFRI	Within the Reference MFRI range	More Frequent than Reference MFRI
Departure	$= 1 - \left(\frac{current\ FR}{low\ end\ of\ ref.MFRI}\right)$	= 0	$= 1 - \left(\frac{high\ end\ of\ ref.MFRI}{current\ FR}\right)$

Fire regime condition class (FRCC) is the combination of seral state departure and fire regime departure into a single metric. FRCC is an important tool for measuring the effectiveness of efforts to maintain sustainable landscapes (NIFTT 2010). FRCC ratings describe a level of departure from native ecosystems as they existed prior to Euro-American settlement:

- FRCC I – Fire regimes are within the natural or NRV and risk of losing key ecosystem components is low. Vegetation attributes (composition and structure) are intact and functioning (departure < 33 percent).
- FRCC II – Fire regimes have been moderately altered. Risk of losing key ecosystem components is moderate. Fire frequencies may have departed by one or more return intervals

[1] The Carson NF collects actual perimeters (polygon data) for all fires over 10 acres, smaller fires are recorded only as a point and acreage.

[2] Maintained by USGS, available for download from wildfire.cr.usgs.gov/firehistory. Accessed 2/22/2013.

(either increased or decreased), potentially resulting in moderate changes in fire and vegetation attributes (33-66 percent departed).

- FRCC III – Fire regimes have been substantially altered. Risk of losing key ecosystem components is high. Fire frequencies may have departed by multiple return intervals, potentially resulting in dramatic changes in fire size, fire intensity, and fire severity as well as landscape patterns. Vegetation attributes have been substantially altered (>66 percent departed) (Wildland Fire Management RD&A 2012).

FRCC was calculated at the local scale by averaging seral state proportion departure and fire regime departure. Characteristic fire regime was defined as the average of HRV reported for each ERU below. Local scale ratings were area weighted for each ERU to determine a percentage by class at the plan scale. ERUs with higher proportions in FRCC II or III are at higher risk of loss of ecosystem integrity because of uncharacteristic disturbance (Figure 5).

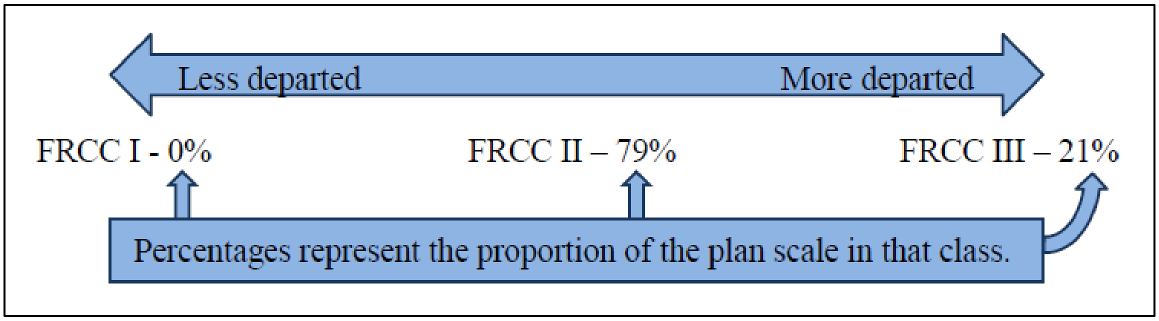

Figure 5. Plan scale departure as represented by FRCC classes I through III

Insect and disease is the severity and frequency of outbreaks of damage agents at the plan and local scales. Insects and diseases are important components of forest ecosystems and greatly influence forest structure and species composition over time. They are characteristic to some degree and at some frequency in all ERUs, not only as disturbance agents, but also as significant contributors to ecosystem function. While insect and disease impacts often conflict with human objectives and forest management goals, their effects on the forest may be detrimental or beneficial from an ecological perspective (USDA FS 2014e).

The USFS Southwestern Region has evaluated the most common forest insects and diseases on the Carson NF using information from historical reports, published documents, aerial survey information, and Forest Service specialist knowledge (USDA FS 2014e). Annual aerial surveys are summarized for the Carson NF by ERU for the period 1998-2013. Similar survey data is not available for non-NFS lands, therefore insect and disease outbreaks are discussed qualitatively at the context scale, when information is available. Otherwise, insects and diseases are only assessed at the plan and local scales.

System Drivers and Stressors for Terrestrial Vegetation

System drivers and stressors for terrestrial vegetation are:

- Natural vegetation succession
- Fire
- Insects and diseases
- Ungulate grazing
- Human ground disturbance
- Invasive species
- Climate

Natural vegetation succession is the progressive change in species composition and structure over time. Early successional stages ("seres" or "states") are often dominated by small, short-lived, poorly competitive, non-woody species (annual forbs and grasses), which take advantage of the available "biological space" and plentiful soil nutrients and sunlight present after a disturbance. As succession proceeds, soil nutrients are converted into plant biomass, and plant community dominance generally shifts toward larger, longer-lived, woody species that are better competitors for limited soil nutrients and sunlight—shrubs, shade-intolerant tree species, and eventually, shade-tolerant tree species. Disturbances like wildfire, drought, and grazing can interrupt or reverse succession.

The shade tolerance and competitive ability of the "highest seral" ("latest seral" or "climax") species present on a site naturally tend to decrease with decreasing elevation (warmer, drier). For example, the latest-successional plant communities on the highest-elevation (coldest, wettest) sites on the Carson NF tend to be dominated by Engelmann spruce and corkbark fir—highly shade-tolerant tree species that are good competitors for limited soil nutrients. Descending in elevation (progressively warmer, drier), the highest seral species found on a site are mixed-conifer (Douglas fir, white fir), followed by ponderosa pine, then piñon-juniper woodland, then shrublands, and finally, desert scrub or grasslands at the lowest elevations. A relatively high seral species on one site is likely to be present as a relatively mid-seral species on a site that is higher in elevation (colder, wetter). For example, Douglas fir may be a climax species in a mixed-conifer forest, but may be present as a mid-seral species in a spruce-fir forest 1,000 feet uphill.

Mature individuals of high-seral species may rarely be (if ever) present on a site where a natural disturbance regime maintains the site in a lower seral state. For example, in the absence of fire, a site could support Douglas fir, but a naturally brief fire return interval periodically interrupts succession by killing Douglas fir seedlings and maintaining dominance by ponderosa pine—a lower seral, fire-resistant species.

Fire is an integral part of many ecosystems on the Carson NF and across the western US. Wildfire frequency and effects vary from short return intervals and low severity to long return intervals of fires that consume all vegetation (stand-replacing). The fire regime of an ERU is defined by the mean fire return interval (MFRI), the number of years between fires at any one location, and the severity of these fires, from low to stand-replacing. In fuel types where fires historically burned frequently (like ponderosa pine), the interaction between pattern and process was integral in maintaining characteristic species composition, structure, and spatial pattern. That is, frequent fires removed surface fuels, but maintained forest structure that encouraged continued low-severity fires (Reynolds et al. 2013). In other systems, like spruce-fir or piñon-juniper woodlands, fire was less frequent and had less influence on stand structure but may have significantly influenced landscape scale patterns.

Fire generally reverses succession, by establishing an earlier seral state. Each ERU has evolved under a specific fire regime to adapt to the frequency and severity of fire characteristic in that ERU, such that ecological integrity is maintained over time. Multiple interacting influences may alter an ERU's fire regime; some are legacies of past human impacts, while others are still evolving. A history of fire suppression and unmanaged grazing (leading to a lack of fine fuels) has resulted in fewer fires since the late-1800s. The subsequent accumulation of live and dead fuels in some ERUs has created the potential for larger and more severe fires. Tree mortality from drought or insect and disease outbreaks contributes to fuel accumulation. Into the future, changing climate is expected to continue to lengthen the fire season and favor larger, more destructive fires (Westerling et al. 2006). Thus, fire may be either a driver or a stressor, depending on whether its effects are characteristic of the system or not. Prescribed fire acts as a driver. Large, destructive wildfires are in many cases stressors, because their effects degrade the integrity of the system, and may convert the system to a condition that may never recover (Roccaforte et al. 2012; Savage and Mast 2005).

Insects and diseases are important components of forest ecosystems and greatly influence forest structure and species composition over time. While insects and diseases have ecological roles, their impacts often conflict with human objectives and forest management goals. However, whether these effects are detrimental or beneficial to the forest depends on an ecological perspective (USDA FS 2014e). Insects and diseases may function as a driver or as a stressor. Forested systems have evolved under endemic pathogen levels that were sustainable historically and may help maintain ecosystem function. An outbreak may have uncharacteristic effects to which the system is not entirely resilient, either because the outbreak is more severe (outside the historical range of variability), or because of confounding factors that amplify damaging effects.

Ungulate grazing - The introduction of widespread, heavy domestic livestock grazing in the late 1800s is one of the events that demarks the end of the reference period. Though native ungulates, such as deer, were present prior to United States settlement, grazing by native species during the reference period differed in degree, foraging pattern, diet, preference for less slope and riparian areas, time spent in a single area, and soil trampling (Currie 1977; Osmond et al. 2007).

There is a long history of grazing in the Southwest, to which range plants have adapted (Holechek et al. 2010; Pieper 1994), and grazing animals play a key role in nutrient cycling (Pieper 1994). In most ecosystems on the Carson NF, grazing is a characteristic disturbance. Properly managed grazing, with respect to utilization levels, season of use, and type of animal, minimizes impacts to ecosystem function and is sustainable over the long term (Davies et al. 2011; Holechek et al. 2006; Pieper 1994). Light grazing increases productivity of some species (Caldwell et al. 1981; Paulsen and Ares 1962) and can increase grass species diversity (Laycock 1994). Rest from grazing has been shown to reduce ecosystem degradation, especially in riparian areas (Dalldorf et al. 2013, Schulz and Leininger 1990), but alone, even total cessation of all grazing will not return grass systems to a historic reference state (Pieper 1994). By adaptively varying grazing timing, intensity, and duration, effects to vegetation productivity and species composition can be managed (Holecheck et al 2010). Grazing during drought years can increase soil erosion and reduce perennial grass cover over the long term (Ford et al. 2012; Thurow and Taylor 1999).

Grazing decreases biomass and can reduce the ability of frequent fire ecosystems to carry low intensity fire (Belsky and Blumenthal 1997; Holechek et al. 2010). The removal of vegetative cover and soil compaction that result from heavy grazing reduce water infiltration, increase runoff, and accelerate erosion (Holechek et al. 2010; Belsky and Blumenthal). The BASI related to effects from light to moderate grazing are less conclusive, and are more system, species, and measurement specific, with conclusions ranging from degradation, to no effect, to improvement of range condition because of grazing (Holecheck et al. 2010; Belsky and Blumenthal 1997; Pieper 1994; Holechek et al. 2006).

Human ground disturbance - Localized ground disturbance from flooding, landslides, and avalanches would have historically been a minor factor in some ecosystems, but human ground disturbance, mainly road construction, is a stressor. Roads mainly influence water flow and soil erosion, but also provide a vector for invasive species spread.

Invasive species are defined here as species that were not native to the plan area during the NRV period, and are characterized by a tendency to encroach upon and increase in native ecosystems, often with undesirable consequences, such as displacing native species or ecological processes.

Climate influences all aspects of vegetation potential and expression. Temperature and precipitation patterns define dominant species and productivity of vegetation, nutrient availability, and cycling in soils. The natural range of variation in cyclical drought and temperature fluctuation define a characteristic extent and severity of disturbance from drought, insects, and fire. While climate has varied continually in the past, current vegetation has evolved under a defined average climate with a defined level of variability. Climate becomes a stressor, when the mean, variability, or rate of change shifts outside its historic range.

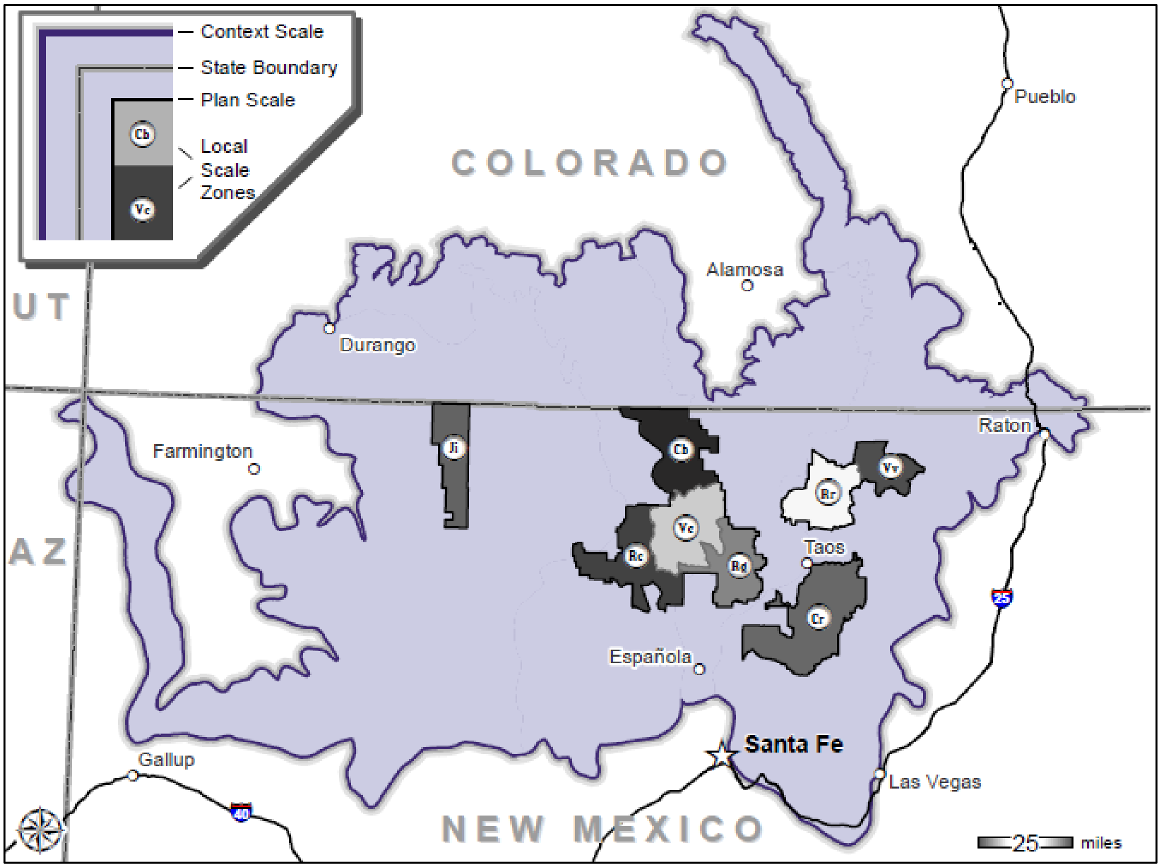

Figure 6. Context, plan, and local scales for terrestrial ecosystems

Spatial Scales for Terrestrial Ecosystems

The plan scale of analysis for terrestrial ecosystem characteristics is defined by the administrative forest boundary of the Carson NF, and includes privately owned inholdings not managed by the Carson NF. The context scale of analysis is the cluster of ecoregional subsections (Cleland et al. 2007) that surround the forest (Figure 6). This area includes all subsections that contain any portion of the plan scale. Additional full and partial subsections are included to provide adequate representation of each ERU off-forest (to the degree feasible)[1]. The local scale of analysis breaks the plan scale into eight local zones differentiated by level or type of management, level of public visitation, and types of use. In some cases, local zones are defined by ranger district boundaries and in other cases, districts are split along HUC 12 watershed boundaries. The minimum zone size/maximum number of zones was based on recommendations provided by the Forest Service's

[1] Nine subsections intersect the Carson NF. Those nine are part of 4 ecoregional sections. To assure that the interrelationships between conditions in the plan area and the broader landscape could be adequately assessed within each section, the Carson NF must be balanced by sufficient area outside its boundaries. Additional area was added, first as whole subsections then as intersecting HUC8 watersheds, such that the Carson NF made up less than 20 percent by area of the context scale in any one ecoregional section. Three additional subsections were added based on the similarity of their ERU distribution to the distribution at the plan scale, similar elevation, and continuity with the rest of the context scale. Additional area was included from two HUC8 watersheds based on the same criteria. The majority of those watersheds was already part of the context landscape, the remaining portions were added, which cross two additional subsections. A description of how the context scale was determined for this assessment is included in the planning record.

Southwestern Regional Office[1] (USDA FS 2014f). The eight local zones are Jicarilla (Ji), Cruces Basin (Cb), Rio Chama (Rc), Vallecitos (Vc), Rio Grande (Rg), Red River (Rr), Valle Vidal (Vv), and Camino Real (Cr) (Figure 6).

The forest's contribution to the context for each ERU is shown in Table 4. The Carson NF makes up 21 percent of the context landscape by area. When an ERU is more common at the plan scale than would be expected based on area (greater than 21% of the total ERU in the context landscape), the plan area has a disproportionate influence on sustainability of the system or greater proportional representation. ERUs that are rare at the context scale will be influenced more by conditions at the plan scale than ERUs that are more abundant, for which plan scale conditions may be overwhelmed by off-forest conditions.

Table 4. Proportional representation of ERUs within the context scale

	Alpine & Tundra	Montane Subalpine Grassland	Bristlecone Pine	Spruce-Fir Forest	Mixed Conifer with Aspen	Mixed Conifer Frequent Fire	Ponderosa Pine	Piñon-Juniper Woodland	Piñon-Juniper Sagebrush	Sagebrush
	ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE
Total acres in context landscape	67,961	248,090	23,688	1,426,671	1,304,634	1,312,651	2,352,463	897,337	613,853	2,188,690
% of context landscape	0.9	3.3	0.3	18.9	17.3	17.4	31.2	11.9	8.1	29.0
Acres on Carson NF	9,996	125,351	4,585	289,929	130,959	182,847	312,900	178,196	217,326	59,144
% of Carson NF	0.6	7.9	0.3	18.3	8.3	11.5	19.7	11.2	13.7	3.7
Carson NF's contribution as a % of the context landscape (21% for all ERUs)	14.7	50.5	19.4	20.3	10.0	13.9	13.3	19.9	35.4	2.7
Proportional representa-tion[2]	-0.18 much less common	0.41 much more common	-0.04 nearly equal	-0.02 nearly equal	-0.35 much less common	-0.20 much less common	-0.23 much less common	-0.03 nearly equal	0.25 much more common	-0.77 much less common

[1] Each ERU should be represented by a minimal area within each local zone. As a general guide, the minimal area for an ERU should be ten times the characteristic patch size for that ERU.

[2] Proportional representation is calculated using the formula:

$Proportional\ Representation = \frac{(\%\ of\ Carson\ NF - \%\ of\ context\ landscape)}{(\%\ of\ Carson\ NF + \%\ of\ context\ landscape)}$. A value of 1 means the percent of the forest covered by an ERU is the same as the percent of the context landscape covered by that ERU. Positive values indicate the proportion of the forest is greater than the proportion of the context (the ERU is more common on forest). Negative values indicate the opposite (the ERU is less common on forest).

When information is available, key ecosystem characteristics are assessed at the local scale. Local zones were delineated such that they might best capture variations that exist within the Carson NF. Systems may be at risk in some local zones, but not others. For example, stressors may be a concern only on certain parts of the forest. The eight local zones are designed to distinguish those differences. Similar to the filter applied at the plan scale, there must be enough of an ERU in a local zone to serve an ecological role in that zone, and there must be enough that its condition can be accurately assessed.

Table 5 shows the number of acres of each ERU by local zone. Grey shaded cells indicate either the ERU is not present in the zone or the amount is too small for the condition of the ERU in that zone to be assessed. Values followed by an asterisk (*) are marginally sufficient for analysis (at least 40% the recommended representation).[1] This same sufficiency criterion is carried throughout the terrestrial ecosystem assessment. That is, values for each key ecosystem characteristic are reported only for those ERU/zone combinations that are represented sufficiently or marginally. Information in cells with marginally represented ERUs should be considered accordingly, it might reflect a small sample size rather than actual conditions.

Table 5. ERU distribution (acres) at the local scale[2]

ERU/Zone	Zone Code	ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE
Jicarilla	Ji							63,469	72,009	3,912	17,668
Cruces Basin	Cb		77,990		59,183	3,581	40,459	16,207	913*		
Rio Chama	Rc		8,044		7,092*	15,916	1,109	57,047	55,622	57,118	1,011*
Vallecitos	Vc		16,010		11,689	6,371	54,395	97,965	10,754	16,198	44
Rio Grande	Rg		9				1	7,958	18,400	96,649	39,346
Red River	Rr	4,631	5,735	146	74,701	35,896	6,094	8,834	11,695	11,835	134
Valle Vidal	Vv	432	12,439	2,754*	27,801	13,934	11,725	25,090			
Camino Real	Cr	4,933	5,123	1,685	109,464	55,251	69,056	36,325	8,723	31,531	927*

[1] The necessary number of acres is equal to 10 times the historic patch size for each ERU. Therefore, the minimum recommended acres varies by ERU, so 1,685 acres of BP in Camino Real is insufficient, but 432 acres of ALP in Valle Vidal is sufficient (USDA FS 2014i).

[2] Light gray cells indicate that an ERU is not present or not sufficiently represented to analyze. An asterisk (*) indicates the number of acres is at least 40 percent the recommended representation for analysis. The white cells have values sufficient for analysis, while the cells with an asterisk may be sufficient for analysis.

Terrestrial Ecosystem Spatial Niche

The spatial niche analysis relates the Carson NF to its surroundings. Spatial niche is dependent on the relative spatial distribution of an ERU, as well as the relative spatial distribution of departure within that ERU. The contribution of the Carson NF to the ecological integrity of an ERU in the context of the surrounding landscape is dependent first on the percent of the forest occupied by the ERU. There must be enough of the ERU on the forest that it may serve an ecological role, and enough that its condition can be accurately assessed. For terrestrial ecosystems, all ERUs that make up more than one percent of the forest have been included. The Carson NF's contribution to integrity also depends on the percent of the context landscape occupied by the ERU and the relative representation of the ERU on-forest to off-forest (proportional representation, Table 4, p. 29). Finally, high departure or the loss of ecological integrity suggests risk in a system, and the distribution of that departure defines the Carson NF's role in addressing risk. Departure values are presented below. Their derivation and interpretation will be discussed in the ERU specific sections that follow.

Abundance on the landscape and proportional representation at the plan scale can be combined into a single variable that defines the opportunity for the plan scale to influence context scale conditions. Opportunity for influence is represented in Figure 7 along the diagonal axis, increasing toward the upper right corner, where ERUs are more common in the plan area than in the context landscape, but are rare overall. Higher opportunity for influence means that the sustainability of the system at the context scale is more sensitive to conditions at the plan scale, and the Carson NF has a unique role in restoring or maintaining integrity when possible.

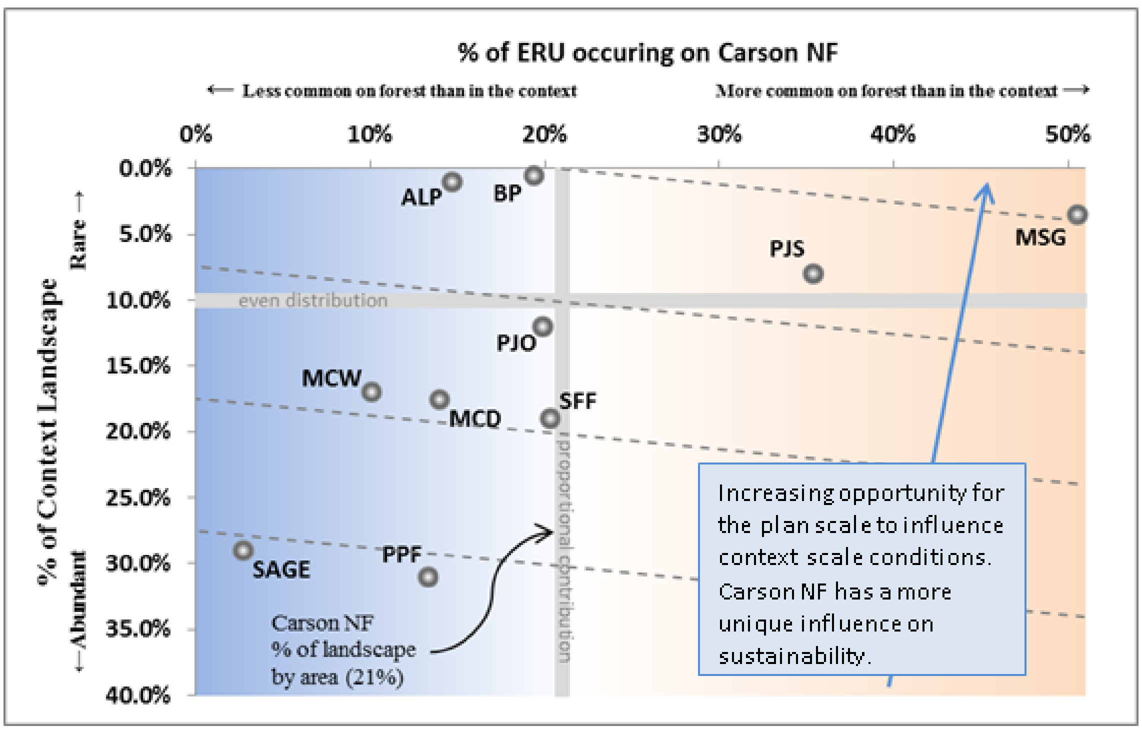

Figure 7. Opportunity for influence - For ERUs toward the upper right corner sustainability of the system at the context scale is more sensitive to conditions at the plan scale

For example, the Carson NF has a unique role in the sustainability of the montane subalpine grassland (MSG) and bristlecone pine (BP) ERUs. MSG is more common at the context scale than BP, but a majority of the ERU occurs on the Carson NF. BP is more proportionally distributed on- and off-forest, but is very rare overall. Thus, the small amount that occurs on the Carson NF may significantly influence the context scale. The role of the plan area on the sustainability of ERUs like sagebrush (SAGE) and ponderosa pine forest (PPF) is not unique, since these ERUs are common outside the plan area. While the Carson NF may influence conditions of these ERUs, the opportunity for influence is not unique, but can be many places in the context landscape. The Carson NF may have less opportunity to influence context scale conditions in these ERUs.

Spatial niche relates opportunity for influence of an ERU to that ERU's departure. It describes the Carson NF's impact on the ecological sustainability of the landscape and the role it might play in restoring or maintaining integrity. There is potential for restoration in systems that are highly departed, but the role of the Carson NF is dependent on its opportunity for influence and how departure is distributed within the ERU. Figure 8 graphically depicts how terrestrial ecosystems on the Carson NF fit into a spatial niche. ERUs in the lower left corner have high ecological integrity. Those in the upper right corner have low ecological integrity. ERUs in the upper left are less departed at the plan scale (possible refuges). Marker size corresponds to the opportunity for the Carson NF to influence ERU condition at the context scale. Three spatial niche scenarios are important to consider:

1. The Carson NF can have a greater influence on ERUs that are uniquely represented on the forest, either because they are generally rare or because they are proportionally more common at the plan scale. This opportunity for influence variable was displayed in Figure 5, along the diagonal axis. Greater opportunity for influence in an ERU on that graph corresponds to larger bubbles in Figure 8.

2. More highly departed ERUs are of greater concern because existing ecological integrity is already low (upper right corner of Figure 8).

3. If an ERU is less departed at the plan scale than at the context scale, it may be an important refuge, and important to maintain as a functioning system (upper left corner of Figure 8).

Using these scenarios, the ERUs on the Carson NF can be loosely grouped. The MCD and PPF ERUs are highly departed, and the Carson NF should have a role in their restoration. However, both are abundant, and many areas on the landscape outside the plan area have a similar influence on the sustainability of those systems.

The ALP, MSG, and SAGE may act as refuges. The ALP and MSG distribution on the Carson NF is unique in the context landscape, and the plan area may play a large role by maintaining intact reservoirs. On the other hand, SAGE is common on the landscape and rare at the plan scale, so the role of the forest may be less. The PJS, MCW, and SFF are moderately departed, and there is a moderate opportunity for the Carson NF to influence their condition. The forest should have some role in their restoration and maintenance. The opportunity for the Carson NF to influence BP is high and BP may be highly departed, but there is some uncertainty due to a small sample size. There is a moderate opportunity for the Carson NF to influence PJO condition, but PJO has high ecological integrity.

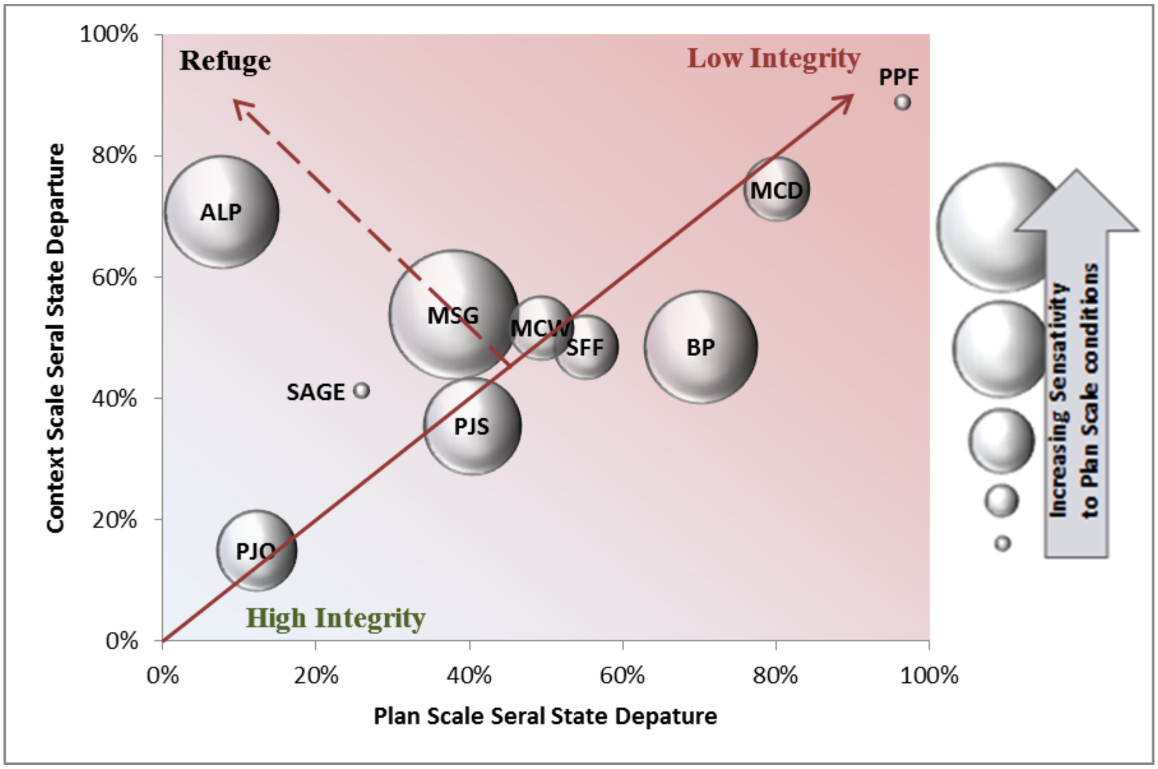

Figure 8. Carson NF terrestrial ecosystem spatial niche

Terrestrial Vegetation

Alpine and Tundra (ALP)

Extent: 9,996 acres   Proportion of Carson NF: 0.6%   Elevation: 10,600+ feet

Vegetation Structure – Reference and Current Conditions

Class	Successional Structure, Composition, & Cover Class	% Proportion		Similarity Value
		Current	Reference[1]	
A	Early development	3	5	3
B	All herb types	89	95	89
C	Uncharacteristic tree cover; *contemporary landscapes only*	8	0	0

[1]Based on LANDFIRE (2010)   **Departure:** Context Scale = High (71)   **Plan Scale = Low (8)**

Ecological Status – Current Departure from Reference Conditions

Moderate (44), decrease in overall cover, Ross's avens▼, tufted hairgrass ▲

Vegetative Groundcover – Reference and Current Conditions

Reference avg: 60%   Current avg: 40%   TEU weighted departure: Low (33% reduction)

Coarse Woody Debris and Snag Density - Reference and Current Conditions

Departure: Low; reference conditions for coarse woody debris and snags have not been defined, but both would have been rare. These would not have been defining characteristics of ALP, since trees would have been uncommon, found only as krummholz at the lower elevation ecotone.

Mean Patch Size – Reference and Current Conditions

Undefined, but presumably reduced by anthropogenic disturbances that increase erosion.

Fire Regime (Frequency and Severity) – Reference and Current Conditions

Historically, mixed severity fire every 200-400 yrs. 0 acres have burned on the Carson NF in the last 30 years, though this is not necessarily departed from reference. No severity data is available.

Fire Regime Condition Class – Reference and Current Conditions

FRCC I – 100%   FRCC II – 0%   FRCC III – 0%

Insect and Disease – Reference and Current Conditions

Very small incidence of western spruce budworm and spruce beetle, but tree insects and diseases are not a significant characteristic of this system.

Spatial Niche

The ALP ERU is the 2nd rarest on the landscape (among assessed ERUs). It is less common at the plan scale, where it is also 2nd rarest. Since the Carson NF has a unique influence on the sustainability of the system and plan scale departure is low, it may act as an important refuge.

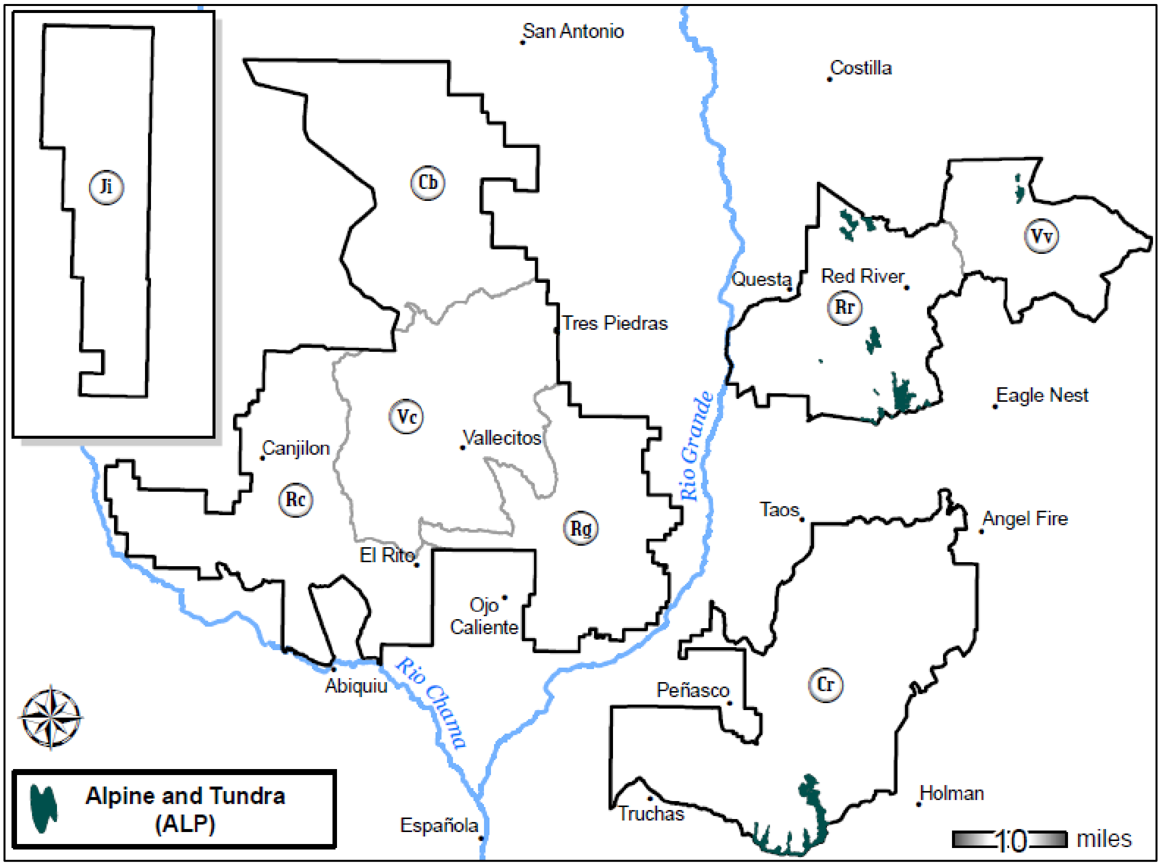

Figure 9. Distribution of Alpine and Tundra ERU across the Carson National Forest (plan and local scale)

The Alpine and Tundra (ALP) ERU is present on only 9,996 acres of the Carson NF, and in significant amounts only in the Red River (Rr) and Camino Real (Cr) local zones, mostly in wilderness areas (Figure 9). It occurs on sites above 10,600 feet and supports sparse, low-growing vegetation, due to unstable substrates, exposure to high winds, and a short growing season. On gradual to moderate slopes, flat ridges, valleys, and basins, where soils are fairly stable, the system may support tundra systems characterized by perennial, rhizomatous, sod-forming sedges, and prostrate and mat-forming forbs with thick rootstocks or taproots. The Sangre de Cristo and San Juan mountains have highly diverse alpine flora, with 143 recorded taxa of vascular plants (Pase 1994). Typically, tree cover is less than 10 percent (LANDFIRE 2010). Tundra species include Ross's avens (*Geum rossii*), Bellardi bog sedge (*Kobresia myosuroides*), sedges (*Carex* spp.), fescue grasses (*Festuca* spp.), and alpine clover (*Trifolium dasyphyllum*). Elsewhere, arctic alpine forget-me-not (*Eritrichium nanum*) and twinflower sandwort (*Minuartia obtusiloba*) are common (USDA FS Carson NF 1987; Wahlberg et al. 2014). ALP ecosystems are important habitat for ptarmigan and Rocky Mountain bighorn sheep (Dick-Peddie 1993).

Reference Condition

Historically, barren rocky areas or scree slopes and other recently disturbed areas made up a small percentage of ALP. Most of this ERU was finely patterned mixes of rock and herbaceous cover, with 60 percent total vegetative groundcover. At the lower elevation ecotone, some krummholz would have been present (Engelmann spruce and subalpine fir trees growing in dwarf, wind sheared forms) (Dick-Peddie 1993). Plant growth habit and species composition generally are dominated by climatic factors including a short growing season (<90 days), extreme evapotranspiration, and wind influenced soil moisture patterns (Dick-Peddie 1993).

Current Condition

ALP has been altered and damaged by past grazing in some areas and by recreation activities in more limited areas. Until recently, most alpine areas were grazed during the summer. This likely has altered species composition (Romme, Floyd et al. 2009) and has subjected some areas to wind erosion, leaving only the rocky substrate (Fletcher and Robbie 2004). Vegetative groundcover is 33 percent less than reference and ecological status is moderately departed, mainly reflecting a decrease in overall cover. Romme and others, “speculate that general [historic] vegetation structure and distribution resembled what we see today …” (Romme, Floyd et al. 2009: p. 204). Hikers and horseback riders mainly affect vegetation and soils in localized areas, but recovery from any damage is slow and not guaranteed (Pase 1994). Mining and prospecting occurred in what are now the Wheeler Peak Wilderness and Columbine-Hondo Wilderness Study Area, but the lasting impact is less than exists in some areas of Colorado at the northern end of the context landscape (Romme, Floyd et al.2009).

Fire has been characteristically rare in ALP, both at the context and plan scales. In Colorado, LANDFIRE mapping places over 90 percent of Rocky Mountain Alpine Turf - Biophysical Setting in an “uncharacteristic native vegetative cover” state (presumably disturbed and eroded); therefore, the seral state departure appears much higher in the context landscape than at the plan level. This is most likely an overestimation of actual departure. If only characteristic LANDFIRE states are considered, departure is 5 percent, much lower and similar to the 7.6 percent calculated at the plan scale.

Future Trend

Given its current limited extent and elevation constraints, ALP is very susceptible to climate change on the Carson NF and is likely to decline in western mountain systems generally (USDA FS 2010b). Shifts in treeline location are likely under a warmer climate, but the direction of the shift (lowering v. rising) will depend on the moisture regime. More precipitation will cause an increase in tree extent, while less precipitation will cause a contraction of tree extent (Peterson et al. 2011). Recreation impacts will continue or increase, further stressing ALP integrity in some places. However, 86 percent of ALP on the Carson NF already receives the highest level of protection, having been designated as wilderness. Since ALP is rare, sustainability at the context scale is sensitive to conditions at the plan scale. The Carson NF has a significant role in maintaining ALP, and to the degree that it is less departed on the Carson NF than off the forest is an important refuge for dependent organisms.

Montane Subalpine Grassland (MSG)

Extent: 125,351 acres Proportion of Carson NF: 7.9% Elevation: 8,000-11,000 feet

Vegetation Structure – Reference and Current Conditions

Class	Successional Structure, Composition, & Cover Class	% Proportion Current	% Proportion Reference[1]	Similarity Value
A	Recently burned; sparsely vegetated; early development grassland	0	20	0
B, C	All grass and forb types; mid to late development. Perennial-mixed grasses, <10% shrub/tree cover, >10% grass cover	62	80	62
D	Tree or shrub invaded; *contemporary landscapes only*	38	0	0

[1]Based on LANDFIRE (2010) **Departure:** Context Scale = Mod (54) **Plan Scale = Mod (38) ▼**

Ecological Status – Current Departure for Reference Conditions

High (71), fescue spp. ▼, brome spp. ▼, Kentucky bluegrass ▲, blue grama ▲

Vegetative Groundcover – Reference and Current Conditions

Reference average: 91% Current average: 54% TEU weighted departure: Mod (41% reduction)

Coarse Woody Debris and Snag Density - Reference and Current Conditions

Departure: Not present historically. Currently some snags result from mortality of invading trees, representing a departure from reference.

Mean Patch Size – Reference and Current Conditions

Reference: 186 ac. Current: 127 ac. Smaller. Departure: Low (32)

Fire Regime (Frequency and Severity) – Reference and Current Conditions

Historically, stand replacing, low to moderate severity wildfire every 15-20 yrs, but somewhat dependent on fire regime of adjacent vegetation. On average 43 ac burn per yr on the Carson NF currently. Frequency is much less than reference and departure is high (99). 80% of fire is low to moderate severity, probably similar to reference (Departure: Low).

Fire Regime Condition Class – Reference and Current Conditions

FRCC I - 0% FRCC II – 79% FRCC III – 21%

Insect and Disease – Reference and Current Conditions

Western spruce budworm is common. Spruce beetle, fir engraver, and western tent caterpillar are also present. All would have been uncommon under uninvaded, historic conditions.

Spatial Niche

The MSG ERU is the 3rd rarest on the landscape (among assessed ERUs). It is much more common at the plan scale, where it is 4th rarest. The Carson NF has a unique influence on the sustainability of the system. Departure is moderate, but lower than at the context scale, and the Carson NF may act as an important refuge, particularly Valle Vidal (Vv) and Cruces Basin (Cb) local zones.

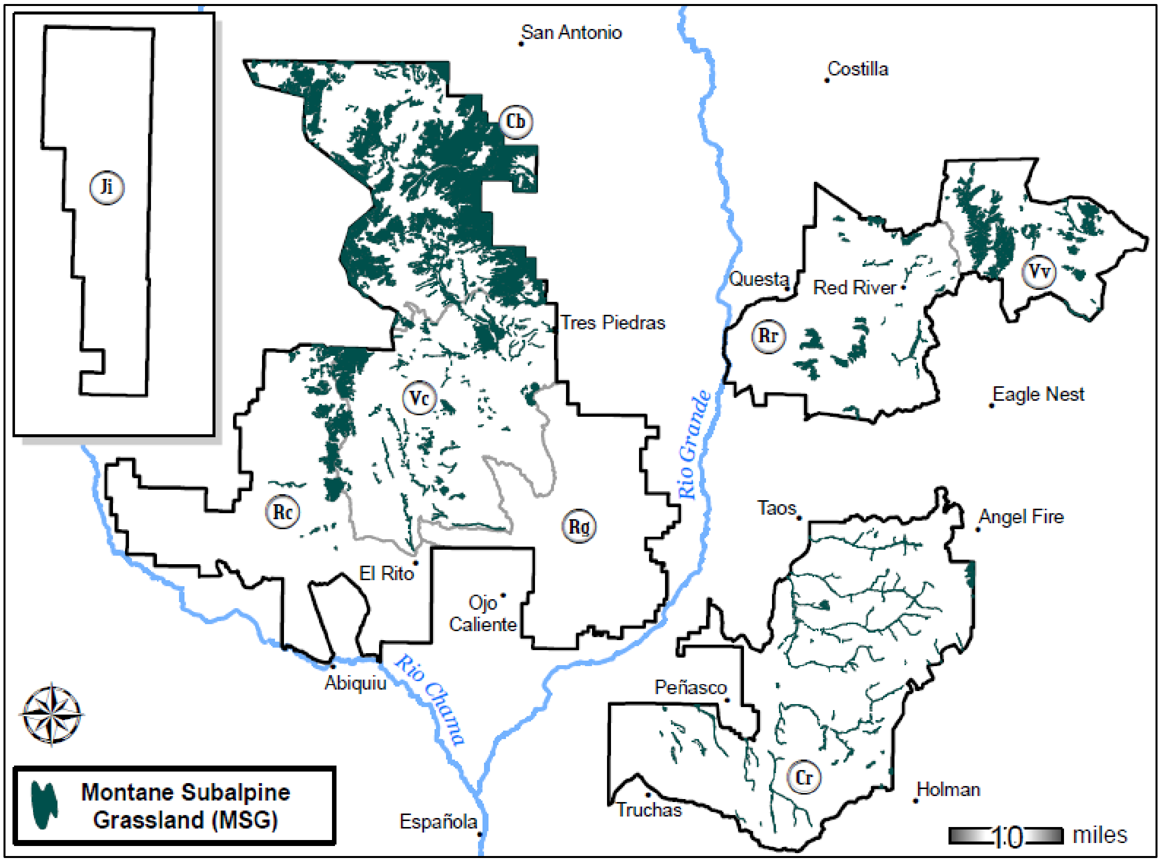

Figure 10. Distribution of Montane Subalpine Grassland ERU across the Carson National Forest (plan and local scale)

The Montane Subalpine Grassland (MSG) ERU occurs on 125,351 acres (7.9%) of the Carson NF and is present in six of the local zones (Figure 10). It is naturally fragmented, occurring as meadows and openings surrounded by spruce fir, mixed conifer, and ponderosa pine (Vankat 2013). It is often interspersed with the Herbaceous Riparian ERU. MSG is a mix of a diverse variety of grass communities ranging from 8,000 to 11,000 feet, with dominant species that may include Arizona fescue (*Festuca arizonica*), mountain muhly (*Muhlenbergia montana*), various sedges (*Carex* spp.), Parry's oatgrass (*Danthonia parryi*), pine dropseed (*Blepharoneuron tricholepis*), Thurber's fescue (*Festuca thurberi*), and blue grama (*Bouteloua gracilis*) (USDA FS Carson NF 1987; Wahlberg et al. 2014). Kentucky bluegrass (*Poa pratensis*), and dandelion (*Taraxacum officinale*) are not native, but are common (Romme, Floyd et al. 2009).

Grassland openings are created and maintained by a combination of tree-limiting site conditions and disturbance, mainly fire (Robbie 2004; Vankat 2013: p.13). Trees may occur along the periphery of meadows and some shrubs may be present, though canopy cover was historically no more than 10 percent for either. Hydrology is closely tied to snowmelt, and these meadows are seasonally wet but typically do not experience flooding events (Wahlberg et al. 2014).

Reference Condition

Describing reference condition for MSG is more difficult than for forested ERUs. Few sites have been unaltered by heavy unmanaged livestock grazing during the late 1800s. Even in areas where there has never been grazing, reconstruction of historic composition or structure is not straightforward, since past conditions and disturbance are not recorded by grass the way they are by long-lived trees. Additionally, grassland systems are naturally dynamic, and species and patterning are very responsive to recent rainfall and disturbance (Fletcher and Robbie 2004; Romme, Floyd et al. 2009). Still, some assumptions and generalizations regarding historic condition can be made.

Fire is thought to be important in maintaining grassland composition, structure, and function (Romme, Floyd et al. 2009). The historic fire regime was correlated with that of the adjacent forest types, though likely somewhat more frequent. Fire timing may differ in some drier stands from the primary fire season, with more fires occurring in late summer-early fall or before spring green-up. Fires would have occurred as frequently as every 15 to 22 years (Vankat 2013), limiting the establishment and encroachment of tree species. Patch size in this assessment relates only to that grassland/tree encroachment dynamic. The reference condition assumes no encroachment, resulting in a patch size of 186 acres, equal to the mean MSG ERU polygon size.

Historic composition, structure, and function of montane subalpine grasslands evolved in response to grazing by wild herbivores, which presumably was low intensity, and spatially and temporally variable. Species composition is assumed to have been dominated by native bunchgrasses, with dense cover from diverse forbs, sod-forming grasses, and sedges in the interspaces. Surface litter would have been high (Romme, Floyd et al. 2009), and only about 9 percent of the surface would have had no vegetative groundcover (USDA FS Carson NF 1987).

Current Condition

Without a complete understanding of the NRV or historic disturbance regimes for MSG, it is more difficult to place current conditions in context. Not all key ecosystem characteristics applied to other ERUs are applicable or informative in grassland systems. For example, coarse woody debris and snag density are not relevant, and seral state proportion does not address changes in grass species composition or structure. On the other hand, species composition (ecological status) is more indicative of overall condition for MSG than it is in other ERUs. It is clear that species composition in MSG has been altered by a legacy of heavy unmanaged grazing, continued managed grazing, fire exclusion, seeding with non-native grasses, and drought.

Two additional analyses were done to address grassland composition, structure, and function. First, species percent cover measurements were compiled from 75 recent range monitoring transects in the MSG ERU from across the forest. The data were stratified by TEU (between 1 and 8 transects per TEU, 21 TEUs total) and TEU averages were compared to TEU survey plant community composition percentages developed from observations made in the early 1980s (USDA FS Carson NF 1987). Unlike, ecological status, which assesses departure of the system overall (average of all species), the range data was analyzed by species for each TEU (those with available information). Range transect data show a general reduction in fescue bunchgrass species, indicative of drought and a grazing preference by herbivores (Fletcher and Robbie 2004). This shift in species composition from bunchgrass dominance to sod-forming grasses and forbs and the resulting reduction in overall litter and groundcover are consistent with long-term trends documented in southern Colorado (Zier and Baker 2006) and at the context scale (Romme, Floyd et al. 2009). Blue grama is more drought tolerant and its cover has increased. The same is true of introduced species, such as Kentucky bluegrass and crested wheatgrass (*Agropyron cristatum*).

The ecological status analysis shows similar decreases in fescues and increases in blue grama and Kentucky bluegrass.[1]

In the second additional analysis for those grazing pastures where either there are over 1,000 acres of MSG or over 20 percent of the pasture is in this ERU, recent range specialist reports were collected, when available. The range specialist report rates vegetation condition and trend as it relates to available forage for livestock and wildlife, and helps to assess grazing capacity (Jones 2004). While the rating is not necessarily a measure of ecological integrity, it does combine species composition, percent bare ground, and overall groundcover information. Fair to good ratings are therefore indicative of maintained grassland function related to soil stability, water capture, and moisture retention. Condition and trend differs from vegetative groundcover departure in that it focuses on key areas (meadows), and may not address other anthropogenic influences, such as roads or other clearing.

Of the 42 pastures with significant representation of MSG, 5 were rated as having “excellent” vegetation condition, 11 were rated “good”, 24 rated “fair” or “fair to good”, and 2 rated “poor”. Ten pastures were trending upward, 1 trended downward, 29 were stable, and the 2 that were rated “poor” had a mix of upward and downward trending areas. Overall, current vegetative groundcover is 54 percent, or moderately departed (41%) from natural conditions (USDA FS Carson NF 1987). This is mainly the result of human disturbance, road construction, and areas of concentrated recreation and grazing.

Fires in MSG are much less frequent on the Carson NF than in the past, and less frequent than they are in the context landscape. Around 91 percent of MSG acres burned at the plan scale have been the result of human caused fires, suggesting a drastic reduction in natural fire. Fire in grasslands is usually stand-replacing, though recovery usually occurs quickly and severity is low or moderate.

At the context and local scales, the seral state departure analysis resolved MSG into only three states: early development grassland; late development grassland; and tree or shrub invaded. MSG on the Carson NF is moderately departed according to this model (37.9%) due to overrepresentation in the uncharacteristic tree/shrub state, as a result of reduced fire, climate change, and decreased competitive ability from overutilization by large herbivores (Fletcher and Robbie 2004; Vankat 2013; Zier and Baker 2006). MSG in the context landscape is more tree/shrub encroached (54% versus 38% on forest). Tree and shrub encroachment has resulted in a reduction in average patch size, from the reference of 186 to 127 acres. This trend has been documented off the forest also. Montane subalpine grassland is more fragmented with less connectivity and total acreage is less than it would have been historically (Fletcher and Robbie 2004).

At the plan scale, VDDT modeling can incorporate two additional MSG states, a mid-development grass state and an uncharacteristic ruderal (disturbance) state. The ruderal state is dominated by Kentucky bluegrass or other (mainly introduced) species that permanently prevent the system from returning to another state.[2] Currently, 37 percent of MSG on the Carson NF is

[1] Agropyron showed increases in both ecological status and range data. Bromes decreased in both. Carex increased overall in both, due to large increases in some areas, but it also had smaller declines in other areas.

[2] A ruderal species is a plant species that is first to colonize disturbed (e.g., avalanche, fire, heavy grazing) lands. Ruderal proportion was based on the percentage of species in range transects (the 75 discussed above) that are classified as increasers or invaders by the Range Vegetation Scorecard Handbook (USDA FS 1987).

dominated by these ruderal species, and departure is much higher when both woody species encroachment and ruderal species dominance are accounted for (75% currently). At the context and local scales, data is not available or not sufficient to quantify the ruderal proportion, but those proportions are likely similarly high and departure is likely similarly high.

Invasive plants can be spread by vehicles, grazing animals, visitors, or streams, and as a result are most common along roads, trails, and riparian areas (USDA FS 2007). In MSG, 18.0 acres of bull thistle (*Cirsium vulgare*) have been mapped, as well as 2.2 acres of Canada thistle (*Cirsium arvense*), and 33.7 acres of nodding plumeless thistle (*Carduus nutans*). Invasive plants have been most frequently mapped in Valle Vidal (Vv) and Camino Real (Cr) local zones. Bullthistle in Valle Vidal is known to have hybridized with native thistle, making detection and eradication essentially impossible without also removing native thistles, which fill an essential ecological role for pollinators (USDA FS 2007). Even without hybridization, native thistles are indistinguishable from bullthistle during their first year of development before they flower and produce seeds. Therefore, the window for effectively treating bullthistle without negatively affecting native populations is very narrow (USDA FS 2007).

Future Trend

At the context scale, current seral state departure values in MSG are based only on the degree to which grass dominated meadows have been invaded by uncharacteristic woody species. VDDT modeling predicts tree and shrub invasion will continue into the future and MSG departure will increase as a result. Departure in MSG is also related to ruderal species dominance, which has only been measured at the plan scale. Modeling predicts this uncharacteristic state will continue to increase into the future. The combined departure is already high (75 percent, when both invasive and ruderal species are considered) and is predicted to remain high, reaching 92 percent by year 100.[1] This certainly overestimates future departure; however, introduced species, including Kentucky bluegrass, will continue to establish dominance by outcompeting and displacing native bunchgrasses in highly disturbed riparian areas or on other sites where native vegetation has been reduced or removed (Girard et al. 1997; Uchytil 1993). Woody species encroachment and infill is likely to continue. There is evidence that much of the 20th century tree expansion was driven by unusually wet periods, but even in a drier future climate, increased atmospheric CO_2 concentrations may favor woody species in grasslands (Ford et al. 2012).

The MSG ERU has low vulnerability to climate change on the Carson NF (with moderate uncertainty). Camino Real (Cr) and Vallecitos (Vc) are essentially the only local zones where any portion of MSG is moderately vulnerable. Drought probability and severity are likely to increase in the future (USDA FS 2010b), leading to reduced grassland productivity, lower overall groundcover, shifts in species composition, and soil instability. Stressed grasslands will be more susceptible to invasive species invasion and invasive species management will need to continue in order to limit their establishment and spread.

[1] Departure reported elsewhere in this report reflects woody species invasion only (Figure 20, p. 77-seral state proportion, spatial niche). Ruderal species information is only available from Carson NF range transects at the plan scale, and is too limited and poorly distributed for local scale evaluation.

Bristlecone Pine (BP)

Extent: 4,585 acres   Proportion of Carson NF: 0.3%   Elevation: 10,500-11,500 feet

Vegetation Structure – Reference and Current Conditions

Class	Successional Structure, Composition and Cover Class	% Proportion		Similarity Value
		Current	Reference[1]	
A	Recently burned; grass, forb, shrub, and seedling/sapling size trees	9	20	9
B	Small trees, closed canopy; *contemporary landscapes only*	9	0	0
C	Small trees, open canopy	27	20	20
D	Medium and large trees, open canopy	1	60	1
E	Medium and large trees, closed canopy; *contemporary landscapes only*	53	0	0

[1]Based on LANDFIRE (2010)   **Departure:** Context Scale = Mod (49)   **Plan Scale = High (70)**

Ecological Status – Current Departure from Reference Conditions

Moderate (41), bristlecone pine ▼, aspen ▲

Vegetative Groundcover – Reference and Current Conditions

Reference avg: 90%   Current avg: 61%   TEU weighted departure: Low (32% reduction)

Coarse Woody Debris and Snag Density - Reference and Current Conditions

Reference: 43 tons/ac   28 snags > 8”/ac   11 snags > 18”/ac

Departure: No data available, but likely not highly departed.

Mean Patch Size – Reference and Current Conditions

Reference has not been defined, but patch size is likely not highly departed.

Fire Regime (Frequency and Severity) – Reference and Current Conditions

Historically, low to mixed severity fire every 35-200+ yrs. < 1 ac burned on Carson NF over last 30 yrs, though this is not necessarily a departure from reference. No severity data is available.

Fire Regime Condition Class – Reference and Current Conditions

FRCC I – 0%   FRCC II – 100%   FRCC III – 0%

Insect and Disease – Reference and Current Conditions

Some western spruce budworm has been recorded, but is likely characteristic of BP.

Spatial Niche

Among assessed ERUs, BP is the rarest on the landscape and at the plan scale, and is about as common at the context scale as at the plan scale. The Carson NF has a unique influence on the sustainability of the system. Departure may be higher on forest than off, and BP may be an important ERU to restore at the plan scale. There is some uncertainty in the level of departure due to small sample size.

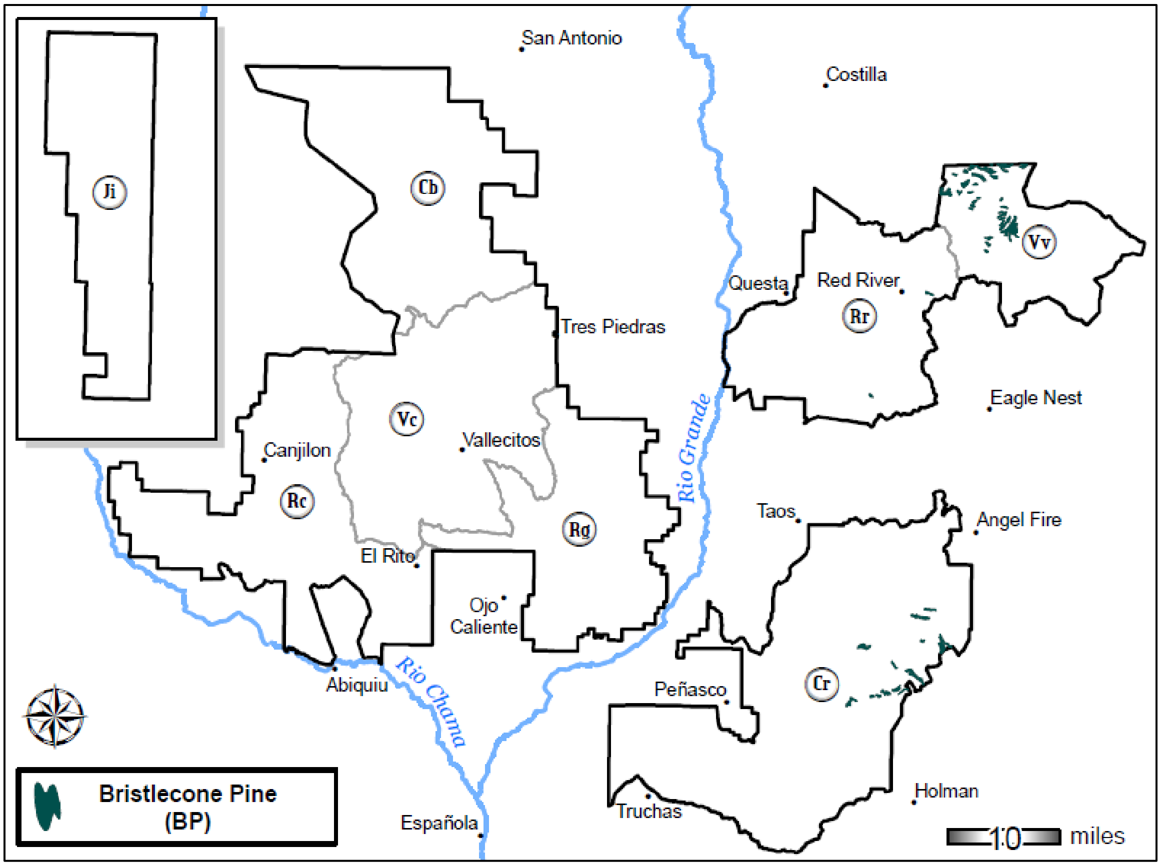

Figure 11. Distribution of Bristlecone Pine ERU across the Carson National Forest (plan and local scale)

Bristlecone pine (*Pinus aristata*) is rare in the Southwestern Region. The Carson NF is one of only three forests where the Bristlecone Pine (BP) ERU is found, and only in limited amounts. Approximately 4,585 acres of this ERU are scattered across three local scale zones (Camino Real – Cr, Red River – Rr, and Valle Vidal – Vv) on the Camino Real and Questa ranger districts (0.3% of the forest) (Figure 11).[1] BP occurs above 10,500 feet, often between ALP and Spruce-Fir ERUs. In the northern portion of Valle Vidal, it is mainly surrounded by mixed conifer forests. Bristlecone pine is the primary overstory species in BP and favors south facing, dry, rocky ridges and slopes, supporting a patchy open-canopy. Other occasional tree species in BP are Douglas-fir (*Pseudotsuga menziesii*), Engelmann spruce (*Picea englemannii*), and ponderosa pine (*Pinus ponderosa* var. *scopulorum*) (USDA FS Carson NF 1987; Wahlberg et al. 2014). The understory is typically sparse, but may include Arizona fescue (*Festuca arizonica*), mountain muhly (*Muhlenbergia montana*), alpine false goldenaster (*Chrysopsis villosa*), western yarrow (*Achillea millefolium*), ragweed sagebrush (*Artemisia franserioides*), fleabane (*Erigeron* spp.), Thurber's fescue (*Festuca thurberi*), and prairie Junegrass (*Koeleria macrantha*) (USDA FS Carson NF 1987).

[1] Bristlecone Pine ERU does not occur in sufficient amounts for analysis in any local zone, it is marginally represented in Valle Vidal. Numbers will be reported for that zone, but should be considered less reliable. See regional guidance, Scales of Forest Plan Assessment (2014i) .

Reference Condition

Historically BP was comprised of mostly large, late development trees, widely spaced with a "parklike appearance" (DeVelice et al. 1986, p. 7). The remainder of BP is split between open and early seral states (LANDFIRE 2010). Vegetative groundcover may be as high as 90 percent (USDA FS Carson NF 1987), but would have been lower at lower elevations, where Arizona fescue dominated the understory (DeVelice et al. 1986).

Due to isolation and sparse fuels, fire was rare in BP and generally thought to be mixed to low severity and surface, as opposed to stand replacing (LANDFIRE 2010). High severity fire may have occurred very infrequently (LANDFIRE 2010), but rather than maintaining stand structure, fire may be more important in initial bristlecone establishment. Tomback and others suggest bristlecone pine forests in Colorado "are not simply mature, static, persisting entities, although many stands are over 500 years old, [rather] *P. aristata* appears to be a long-lived pioneer species that regenerates well primarily after fires…"(2011: p. 25). Several bristlecone pine stands in the Sangre de Cristo Mountains just north of the New Mexico border originated following large fires in or around 1900 (Tomback et al. 2011).

Current Condition

At both the plan and context scales, BP is not highly departed, though its current condition is difficult to quantify due to its limited extent. Seral state departure is high in the plan area because of an overrepresentation of uncharacteristic closed canopy, but the sample size is too small to draw definitive conclusions. In BP, fire may help to maintain an open stand structure and grazing and fire exclusion may have contributed to reduced fire frequency and increased tree density (Brown and Schoettle 2008). On the Carson NF, there has been essentially no recent fire in BP,[1] but at the context scale departure is moderate. There is evidence from central Colorado that bristlecone pine has experienced some uncharacteristic stand replacing fire during the late 20th century (Brown and Schoettle 2008).

A decrease of 32 percent in vegetative groundcover may reflect the increase in canopy cover and resulting decrease in understory grass or may reflect impacts from grazing and other human disturbances. However, it may simply be the result of a small sample. Ecological status departure is moderate, suggesting a decrease in bristlecone pine and many grass species and an increase in aspen. Again, the sample size is small and may be misleading. Some bristlecone pine trees were cut for mine timbers, but overall, the species "does not appear to face any imminent threats" (Romme, Floyd et al. 2009: p. 210) and it is unlikely that just over a century of indirect human impacts have had a significant effect on a tree that can live for more than 2,400 years. The limited extent of BP on the Carson NF does not lend itself to quantifying coarse woody debris, snags, or patch size.

Future Trend

While bristlecone pine may not face "imminent threats", it is affected by insect and disease pathogens in other parts of its range (Romme, Floyd et al. 2009: p. 210). Mountain pine beetle (*Dendroctonus ponderosae*) is a native insect that favors lodgepole and ponderosa pine, but may attack other species (Tomback et al. 2011). White pine blister rust (*Cronartium ribicola*) is a fungal infection, introduced to the Pacific Northwest around 1910. It has since spread through white pine and alternate species, including bristlecone pine, causing mortality across the western

[1] Less than one acre of fire was recorded in Bristlecone Pine ERU on the Carson NF over the last 30 years.

U.S. and Canada. It is not currently a factor on the Carson NF, but will likely spread across the entire range of bristlecone pine in the Southwest (Tomback et al. 2011).

Climate change vulnerability for BP was not assessed because of its small spatial extent. However, most BP on the Carson NF occurs on the low elevation end of its current climate envelope,[1] in areas that are predicted to become marginal in the future (USDA FS 2015a).

[1] The climate envelope for an ERU refers to the current range for climate variables that encompasses the existing ecosystem distribution, which can be used to define ecosystem tolerance.

Spruce-Fir Forest (SFF)

Extent: 289,929 acres   Proportion of Carson NF: 18.3%   Elevation: 9000-11,500 feet

Vegetation Structure – Reference and Current Conditions

Class	Successional Structure, Composition and Cover Class	% Proportion Current	% Proportion Reference[1]	Similarity Value
A, K	Non-tree: Recently burned; grass, forb, and shrub types	6	9	6
B	All aspen, deciduous tree mix, and evergreen-deciduous mix tree types	17	11	11
C, G, P, L	Seedling/sapling and small trees, all cover classes	12	21	12
D, M, H, Q	Medium trees, all cover classes	62	14	14
E, N, F, O	Large trees, closed canopy	3	45	3
I, R, J, S	Large trees, open canopy; *contemporary landscapes only*	1	0	0

[1] Based on LANDFIRE (2010), with Weibull age-class distribution model

Departure: Context Scale = Mod (48) **Plan Scale = Mod (55) ▲**

Ecological Status – Current Departure from Reference Conditions

Moderate (34), aspen ▲, fir species ▼, grouse whortleberry▼, Oregon boxleaf ▲

Vegetative Groundcover – Reference and Current Conditions

Reference avg: 99%   Current avg: 81%   TEU weighted departure: Low (17% reduction)

Coarse Woody Debris and Snag Density - Reference and Current Conditions

Reference: 46 tons/ac   28 snags > 8”/ac   11 snags > 18”/ac
Current: 17.4 tons/ac   9.0 snags > 8”/ac   2.6 snags > 18”/ac
Departure: High; coarse woody debris and snags are significantly decreased due to harvest.

Mean Patch Size – Reference and Current Conditions

Reference: 100s to 1,000s ac.   Current: 398 ac.   Similar. Departure: Low (0)

Fire Regime (Frequency and Severity) – Reference and Current Conditions

Historically, stand replacing wildfire every 200-400 yrs, mixed severity every 35-100 yrs (low elevation sites). Currently, 48 ac burn/yr on Carson NF. Frequency may be less than reference, but is not highly departed. Almost 50% of fire is high severity, probably similar to reference.

Fire Regime Condition Class – Reference and Current Conditions

FRCC I – 0%   FRCC II - 100%   FRCC III – 0%

Insect and Disease – Reference and Current Conditions

Reference: Chronic insect and fungal outbreaks kill individual trees or small groups. Spruce beetle can cause widespread mortality. Western spruce budworm very common and causes extensive mortality. Current: Though levels are higher on the Carson NF than in some other parts of the context, they are not necessarily uncharacteristic.

Spatial Niche

The SFF ERU is the 3rd most abundant on the landscape. It is about as common at the plan scale, where it is 2nd most abundant. The influence of the Carson NF on the sustainability of the system is similar to other areas on the landscape. SFF is highly departed in Vallecitos (Vc) and Rio Chama (Rc) local zones and moderately departed elsewhere.

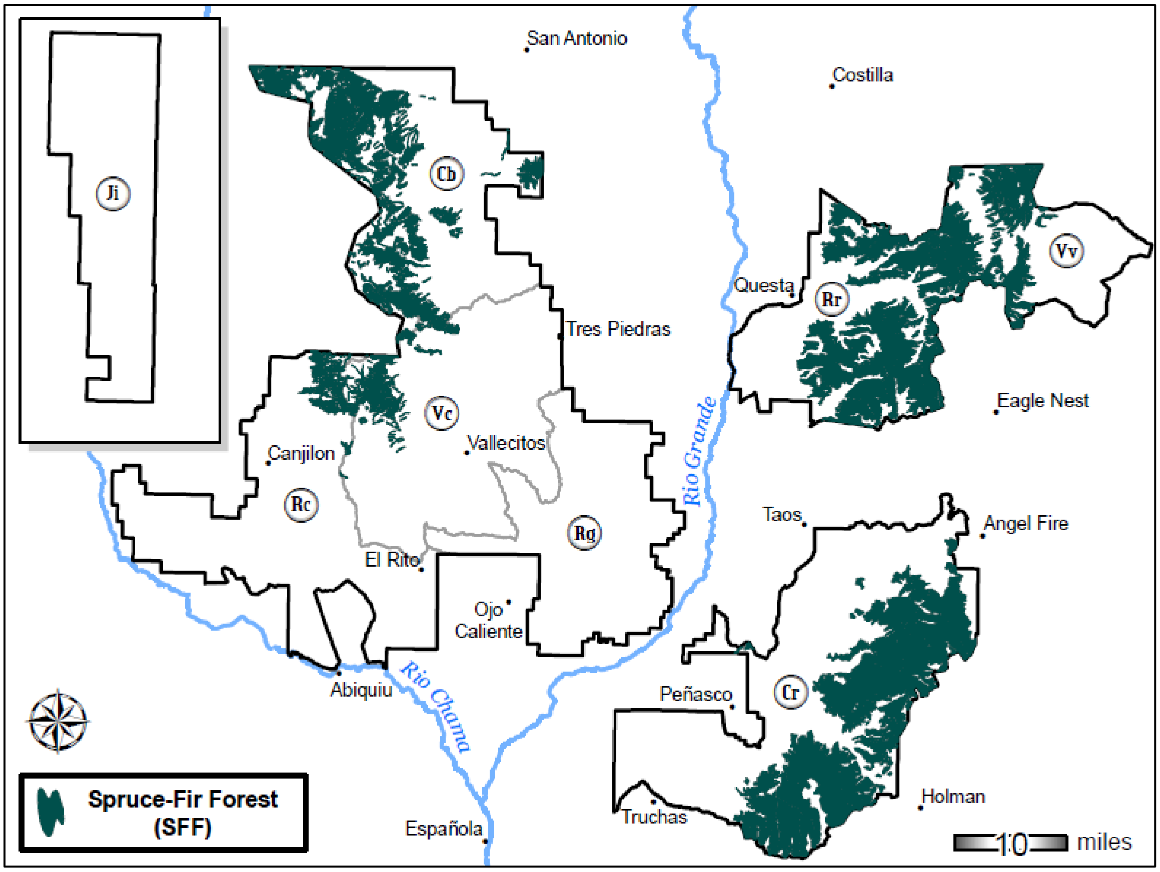

Figure 12. Distribution of Spruce-Fir Forest ERU across the Carson National Forest (plan and local scale

The Spruce-Fir Forest (SFF) ERU occupies the coldest and wettest forested slopes, ridges, and valleys on the Carson NF, bounded at upper elevations by alpine tundra and transitioning to mixed conifer at lower elevations. It is found on 289,929 acres (18.3%) of the Carson NF (Figure 12) at elevations between 9,000 and 11,500 feet (Wahlberg et al. 2014). It is present in significant amounts in five of the local zones.[1]

Engelmann spruce (*Picea englmannii*), subalpine fir (*Abies lasiocarpa* var. *lasiocarpa*), and corkbark fir (*Abies lasiocarpa* var. *arizonica*) are the dominant species. Near timberline, firs are less abundant (Romme, Foyd et al. 2009), while at lower elevations, mixed conifer species can be present, especially Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*). Below 10,500 feet, quaking aspen (*Populus tremuloides*) occurs following disturbance, and may be codominant or dominant (Smith 2006a). On the Carson NF, common understory species include whortleberry (*Vaccinium myrtillus*), huckleberry (*Vaccinium scoparium*), common juniper (*Juniperus communis*), Oregon boxleaf (*Paxistima myrsinites*), spruce-fir fleabane (*Erigeron eximius*), Jacob's-ladder (*Polemonium pulcherrimum*), Parry's goldenrod (*Oreochrysum parryi*), and strawberry (*Fragaria* spp.) (Romme, Floyd et al. 2009).

[1] There are 7,092 acres of SFF in the Rio Chama (Rc) local zone, which may not represent sufficient area for meaningful analysis. Values are reported, but should be considered marginally reliable. See regional guidance, Scales of Forest Plan Assessment (2014i) .

Reference Condition

Historically, SFF occurred as a mosaic of structural and seral stages, with the majority of stands exhibiting closed canopy and dominated by large trees. Aspen was present, occasionally in large patches, but became less common with increasing elevation. Fire was typically stand replacing and linked to infrequent, severe drought (Schoennagel et al. 2004). Fire return intervals were longer at higher elevations (>200 years) (Reynolds et al. 2013; Schoennagel et al. 2004); therefore, individual trees may have never been affected over their life span (Romme, Floyd et al. 2009). At lower elevations, especially near the transition to mixed conifer forests, fire return intervals would have been shorter (35 to 100+ years) and a some proportion may have burned with mixed severity (Reynolds et al. 2013). Romme and others (2009) calculated an average fire return interval in spruce-fir forest on the San Juan NF in southern Colorado of about 300 years, though they observed that many stands had not burned for many centuries (Romme, Floyd et al. 2009). Very large patch sizes reflected succession following these large infrequent fires; however, the more dominant disturbances in most stands were “chronic, fine scale processes involving insects, fungi, and wind, that killed individual trees, or small groups of trees” (Romme, Floyd et al. 2009: p. 96). Bark beetles were more active in disturbed areas (particularly following windthrow), denser, older stands, and stands with a higher proportion of the host tree (USDA FS 2014e). The understory was diverse in terms of species composition and dense with vegetative cover approaching 100 percent.

Current Condition

SFF is moderately departed at both the plan and context scales, mostly from a legacy of timber harvest that removed old trees and built roads. The current disturbance regime is not significantly altered from reference condition (Schoennagel et al. 2004; Vankat 2013). Characteristic insect, disease, and wind-throw events have occurred throughout the 20^{th} century. While there have been few recent large fires in SFF, particularly on the Carson NF, long fire-free intervals are not necessarily far outside the NRV, and the ecological effects of fires that occurred have been typical (Romme, Floyd et al. 2009). Livestock grazing and fire suppression may have reduced fire frequency at the lower elevations of the SFF range, both directly, and indirectly by reducing the number of fires spreading from lower elevation frequent fire types (Vankat 2013). Some spruce-fir stands in the Southwest may have reduced representation of aspen relative to reference condition (Vankat 2013); however, on the Carson NF, aspen presence is greater than reference and distribution is probably not significantly altered (Romme, Floyd et al. 2009). Seral state proportion and ecological status both suggest aspen is about 170 percent of reference. All other tree species have a reduced presence, especially white fir and corkbark fir.

Vegetative groundcover has decreased only slightly in SFF across the forest. Understory cover decreases as overstory cover increases with succession and increased forest density. Less disturbance results in less understory cover and a shift in species composition from herbs and shrubs to non-vascular plants (Vankat 2013). These processes may contribute to the reduction in groundcover in the plan area, but the majority of the impact is likely a direct result of human disturbance, road construction, and concentrated recreation.

The effects of logging between 1950 and the late-1970s are still evident in the shift of size classes from large to medium trees. Logging also removed organic matter from the system, an effect not caused by other types of disturbance (such as insects), which leave large standing and dead trees in place (Romme, Floyd et al. 2009). Snags and down woody debris have decreased by over half from reference levels.

Logging roads, many of which predate Forest Service acquisition, are prevalent, especially in Valle Vidal (Vv) and Camino Real (Cr) zones. Roads may affect SFF more substantially than any other human induced change through wildlife habitat loss, habitat dissection, increased edge, and decreased interior habitat (Romme, Floyd et al. 2009). Roads also have indirect or secondary effects, such as corridor avoidance by wildlife, road kill, impacts from increased human access, and spread vectors for invasive species (Romme, Floyd et al. 2009; Watson 2005).

Recent bark beetle activity seems to be similar to patterns observed since the 1800s (USDA FS 2014e). However, SFF on the Carson NF has been subject to severe defoliation by the western spruce budworm (*Choristoneura freemani*, formerly *C. occidentalis*), a native defoliating moth that often causes the greatest defoliation to its preferred hosts, Douglas-fir and white fir (USDA FS 2014e). Multiple consecutive years of heavy feeding by western spruce budworm can result in reduced tree growth, top-kill, and predisposition to bark beetle attack. Direct tree mortality can result from repeated defoliation and often occurs in the understory, where the trees are heavily fed upon by budworm larvae descending from the upper canopy. Aerial detection surveys have mapped a consistent and extensive area affected by western spruce budworm defoliation in northern New Mexico (Figure 13). Data from 1985 to the present show peaks of activity in 1994, 2001, and 2009 (USDA FS 2014e).

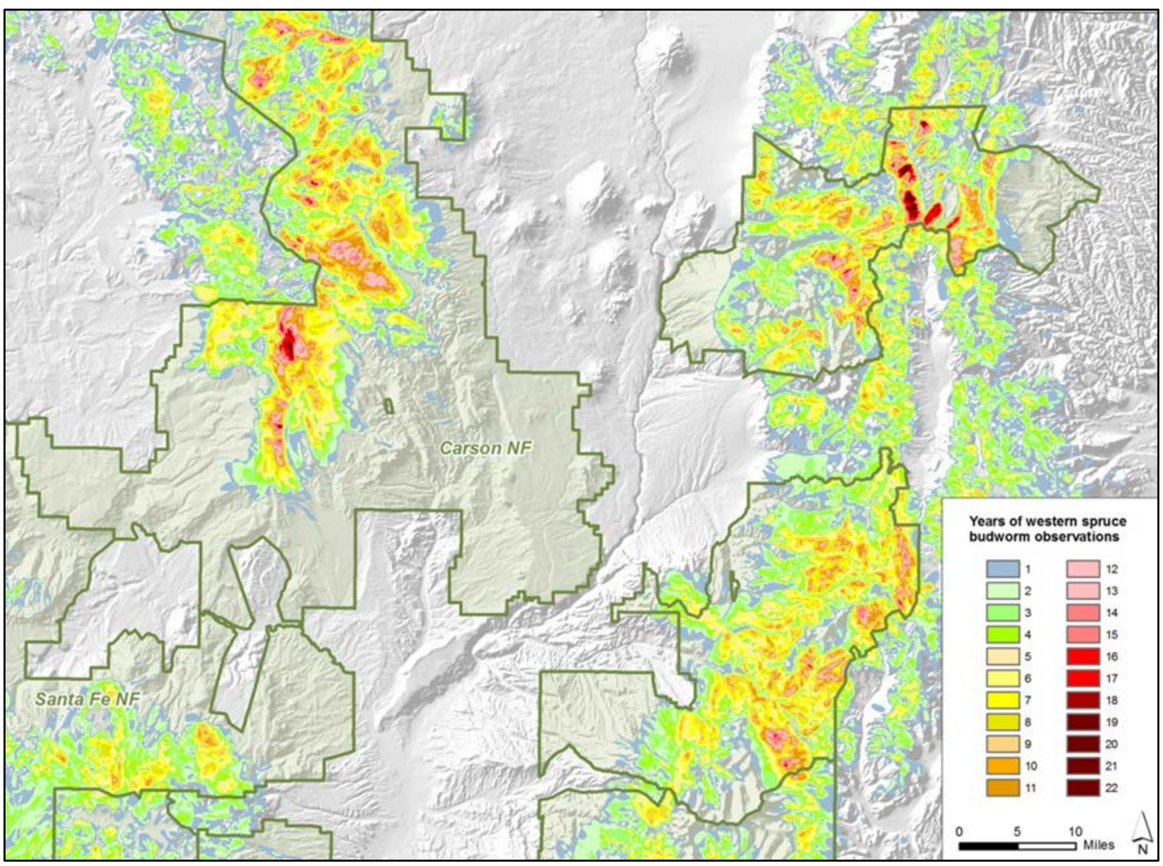

Figure 13. Western spruce budworm infestations on the Carson NF

Future Trend

Modeling of SFF predicts a transition from medium to large tree size classes as stands continue to mature away from cut-over, logged states. Large closed states, which are currently very underrepresented, quickly become more widespread and their proportion continues to grow toward reference levels through year 1000. Overall departure declines steadily, reaching the low category (< 33%) in about 100 years.

SFF, however, likely faces significant threats that were not modeled by VDDT. The SFF ERU is one of the most vulnerable ERUs to climate change, with over a quarter of its extent on the Carson NF highly or very highly vulnerable. It is particularly vulnerable in the more southern local zones, Camino Real (Cr) and Vallecitos (Vc)(USDA FS 2014a). Increased temperatures would likely lead to increases in fire frequency and extent, but if precipitation also increases, the current fire regime may change little (Romme, Floyd et al. 2009).

Recent drought and increased temperature have already exacerbated insect outbreaks (Vankat 2013: p. 92). An extensive spruce beetle outbreak has been occurring just across the New Mexico – Colorado border on the Rio Grande and San Juan NFs. This outbreak started in the early 2000s (still active in 2013) and affected approximately 387,000 acres on these two national forests in 2012 (Harris et al. 2013). As of 2013, however, no extensive spruce beetle outbreaks are occurring in New Mexico (USDA FS 2014e). The northern end of the Tres Piedras RD adjoining the Rio Grande NF would be the area mostly likely to experience spruce beetle activity in the near future. The Colorado forests have relatively pure stands of large diameter spruce, while the stands on the Carson NF tend to be a greater mix of spruce and corkbark fir, potentially reducing the risk of the same scale event occurring on the Carson NF.

If widely accepted climatic projections for the Southwest are correct, warmer temperatures, more variable precipitation, and greater moisture deficit (NM 2005) would generally create greater stresses on Southwest forests. Root diseases, such as *Armillaria* root rot, are already established and adapted to the Interior West and would be expected to proliferate in stressed forest environments (Klopfenstein et al. 2009).

The long-term tree-ring based reconstructions in northern New Mexico show a trend toward more synchronous and widespread outbreaks (Swetnam and Lynch 1993). These trends suggest fire suppression and past logging practices have led to more contiguous denser stands composed primarily of white fir and Douglas-fir, contributing to more widespread and intense budworm outbreaks. Based on past activity, budworm will continue to be a persistent defoliator in the mixed conifer ERUs and SFF of the Carson NF. Since outbreaks have been associated with periods of increased moisture (Ryerson et al. 2003; Swetnam and Betancourt 1998; Swetnam and Lynch 1993), the warmer and more drought prone conditions projected in future climate change scenarios could reduce budworm activity and temper severity of future budworm outbreaks.

Mixed Conifer, with Aspen (MCW)

Extent: 130,959 acres Proportion of Carson NF: 8.3% Elevation: 7,000-10,000 feet

Vegetation Structure – Reference and Current Conditions

Class	Successional Structure, Composition and Cover Class	% Proportion Current	% Proportion Reference[1]	Similarity Value
A, F	Non-tree: Recently burned; grass, forb, and shrub types	3	1	1
B	All aspen, deciduous tree mix, and evergreen-deciduous mix tree types	17	21	17
C, G, P, L, D, M, H, Q	Seedling/sapling, small trees and medium trees, all cover classes	76	29	29
E, N, F, O	Large trees, closed canopy	4	49	4
I, R, J, S	Large trees, open canopy; *contemporary landscapes only*	0	0	0

[1] Based on LANDFIRE (2010) with Weibull age-class distribution model

Departure: Context Scale = Mod (53) **Plan Scale = Mod (49) ▲**

Ecological Status – Current Departure from Reference Conditions

Low (33), slightly less aspen, Gambel oak ▼, Kentucky bluegrass ▲

Vegetative Groundcover – Reference and Current Conditions

Reference avg: 95% Current avg: 75% TEU weighted departure: Low (22% reduction)

Coarse Woody Debris and Snag Density - Reference and Current Conditions

Reference: 34 tons/ac 14 snags > 8”/ac 4 snags > 18”/ac
Current: 10.4 tons/ac 13.1 snags > 8”/ac 2.3 snags > 18”/ac
Departure: Mod to high; decreased coarse woody debris. Snags slightly lower due to harvest.

Mean Patch Size – Reference and Current Conditions

Reference: 100-300 ac Current: 649 ac Larger. Departure: Moderate (54)

Fire Regime (Frequency and Severity) – Reference and Current Conditions

Historically, mixed severity wildfire every 50-100 yrs. Stand replacing fire was less frequent, every 300 yrs or longer. On avg 93 ac/yr currently burn on Carson NF. Frequency is significantly less than reference and departure is high (93). Fire effects are probably similar to reference, though on the forest most fires burn with high severity and very few burn with moderate severity (Departure: Low to moderate).

Fire Regime Condition Class – Reference and Current Conditions

FRCC I – 0% FRCC II – 100% FRCC III – 0%

Insect and Disease – Reference and Current Conditions

Reference: Periodic outbreaks of western spruce budworm and aspen defoliation are characteristic. Current: Western spruce budworm is common and results in mortality on the Carson NF. Widespread aspen mortality related to drought and chronic defoliation has resulted in decreased abundance at the context and plan area scales. Recent levels of mortality are significant, but do not necessarily represent a departure from reference.

Spatial Niche

The MCW ERU is the 5th most abundant on the landscape. It is less common at the plan scale, where it is 6th most abundant. The influence of the Carson NF on the sustainability of the system is similar to other areas on the landscape. Departure is moderate at all scales.

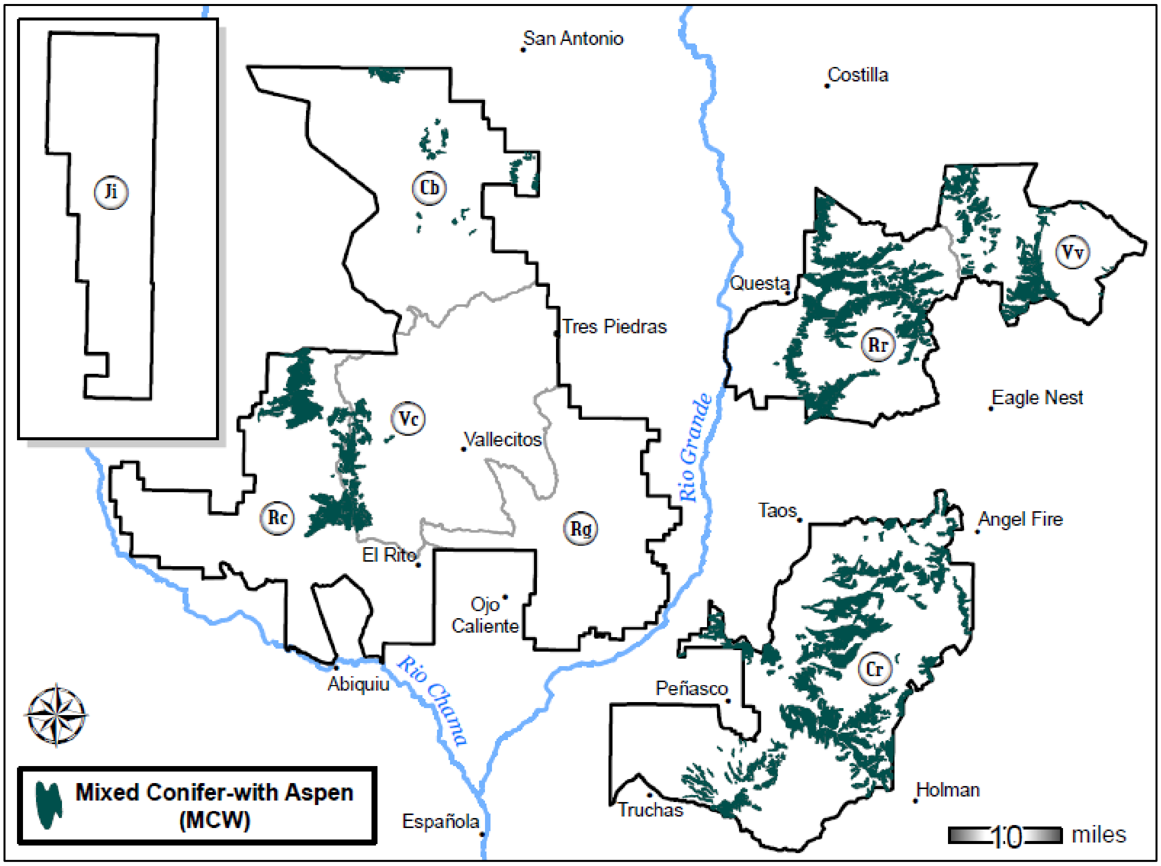

Figure 14. Distribution of Mixed Conifer, with Aspen ERU across the Carson National Forest (plan and local scale)

Mixed conifer forests occupy a transitional zone between the spruce-fir forests at higher elevations and ponderosa pine forests at lower elevations. Mixed conifer forests can have characteristics of both adjacent types in proportions that are influenced by soil, climate, tree species composition, and disturbance regime (Romme, Floyd et al. 2009). The cooler and wetter sites in the mixed conifer life zone generally fall into The Mixed Conifer, with Aspen (MCW) ERU. The distinguishing feature of MCW is a more infrequent fire regime than other mixed conifer, characterized by mixed to high severity, as well as the presence of quaking aspen (*Populus tremuloides*) in a post disturbance seral state. MCW is found on 130,959 acres (8.3%) of the Carson NF (Figure 14), in six of the local zones, at elevations between 7,000 and 10,000 feet (Wahlberg et al. 2014). It makes up a larger proportion of the landscape (17.3%) at the context scale.

Dominant and codominant vegetation in MCW varies by elevation and moisture availability. Ponderosa pine (*Pinus ponderosa*) occurs incidentally or is absent, while Douglas-fir (*Pseudotsuga menziesii*), southwestern white pine (*Pinus strobiformis*), white fir (*Abies concolor*), and Colorado blue spruce (*Picea pungens*) occur as dominant and/or codominant conifer species. Limber pine (*Pinus flexilis*) may be present in subdominant proportions. Oregon boxleaf (*Paxistima myrsinites*) is characteristic in the understory, but a wide variety of other shrubs, graminoids, and forbs may be present, depending on soil type, aspect, elevation, disturbance history, and other factors (USDA FS Carson NF 1987; Wahlberg et al. 2014).

Distribution of aspen within MCW is limited by several factors, including adequate soil moisture to meet its high evapotranspiration demand; the length of the growing season or low temperatures; and major disturbances that clear overstory vegetation and groundcover, as well as stimulate root sprouting and colonization. In the aspen component, conifer species may or may not be present in significant proportions, depending on successional status. Aspen may persist as a seral state for decades to centuries, when a conifer seed source is unavailable (Romme, Floyd et al. 2009). The aspen understory herbaceous layer may be dense or sparse, dominated by graminoids or forbs (Wahlberg et al. 2014). Some of the species typically found associated with aspen include western yarrow (*Achillea millefolium*), violet (*Viola canadensis*), and several grasses and sedges (*Poa* spp. and *Carex* spp.). The understory may also contain shrubs, including creeping barberry (*Mahonia repens*), Oregon boxleaf (*Paxistima myrsinites*), and mountain snowberry (*Symphoricarpos oreophilus*) (USDA FS Carson NF 1987; Wahlberg et al. 2014).

Reference Condition

Historically, MCW would have occurred in a range of states differentiated by the time since the previous disturbance. Across the landscape, trees 20+ inches in diameter, with closed canopies, were more common (40%) than all smaller size classes combined (32%). Mixed severity fire occurred at intervals of 50 to 100 years. High severity events were less frequent, occurring as infrequently as every 300 years or longer (Romme, Floyd et al. 2009). Stand replacing fire played an important role in aspen regeneration (Jones and DeByle 1985), and resulted in large average patch sizes, about 100 to 300 acres. Aspen occurred as an early seral state following disturbance and made up of about 21 percent of the landscape. In stands dominated by aspen, stand replacing fire was less frequent, for example Romme and others (2009) estimated a 140 year fire return interval in aspen on the San Juan NF.

The reference condition for coarse woody debris is lower than in SFF, but still high (34 tons/acre). Standing snags were common (14/ac above 8” and 4/ac above 18”). Reference vegetative groundcover was high at 95 percent.

Western spruce budworm may have had as large an impact on forest structure as fire (Romme, Floyd et al. 2009). Effects in MCW are similar to those described under SFF reference condition, but spruce budworm favors Douglas-fir and white fir, which are more common in mixed conifer (USDA FS 2014e). Periodic outbreaks have occurred every 20 to 33 years in northern New Mexico and southern Colorado and preferentially attack smaller trees (Romme, Floyd, et al. 2009). Aspen defoliation by a variety of agents has been common throughout the 20th and 21st centuries, particularly in the western local zones. Typically these defoliators are not considered detrimental to aspen stands, because the trees refoliate during the same season. However, repeated defoliation over successive years can reduce the growth and vigor of trees and potentially predispose them to other agents (USDA FS 2014e).

Current Condition

Both on the Carson NF and at the context scale, MCW is moderately departed from reference conditions, with overrepresentation of medium size classes, fewer large trees, and less aspen regeneration. Selective harvesting in the 1960s and 70s altered stand structures by removing high-value, large, overstory Douglas-fir trees, and shifting composition toward dense, moderate size true firs (Fruits 2014; Romme, Floyd, et al. 2009). By contrast, natural disturbance kills many small trees, as well as some overstory trees of all fire intolerant species (Romme, Floyd et al. 2009). Some killed trees remain in the system as coarse woody debris, as opposed to the complete removal that results from harvest. On the Carson NF, timber harvesting has reduced coarse woody debris by greater than two-thirds and there are slightly fewer snags per acre than there would have been historically. As in SFF, legacy logging roads are common in most local zones.

The conifer dominated states in MCW have missed one or more mixed severity fire cycles and the fire regime has been altered. However, at the context scale human impacts during the last century have reduced stand replacing fire occurrence only slightly. Less fire has occurred on the Carson NF, but infrequent stand replacing fire over several decades is not necessarily unusual. In fact, human presence may have increased the amount of fire on the forest over the past 30 years, since the majority of acres burned in MCW have been from human causes (Figure 23, p. 88). Fires at high wetter elevations coincide with drought more so than fine fuel accumulation (Margolis et al. 2007); therefore, heavy unmanaged grazing during the 19th century likely had less impact in MCW than in lower elevation ERUs (Romme, Floyd et al. 2009). At the context scale, there were few fires in MCW during the 20th century. This is likely due to fire suppression, in adjacent, drier forest types that were a major historic ignition source, but it may also reflect wetter average weather patterns over that period (Romme, Floyd et al. 2009). More recently, large fires like Hondo (1996), Las Conchas (2011), and Thomson Ridge (2013), have burned into MCW from lower elevation forests, and fire frequency during the last 30 years is near the historic range at the context scale. At the plan scale, mixed severity fire has been rare and more fires have burned with high severity on the forest than in the context landscape.

The presence and distribution of aspen as a seral state in MCW is dependent on fire. Most aspen stands establish following a crown fire and aspen regeneration is stimulated by fire (Jones and DeByle 1985; Margolis et al. 2007). While the extent of aspen occurrence is largely dependent on long interval, stand replacing fire, and therefore may be similar to reference conditions (it is slightly underrepresented at the plan scale), the structure of aspen stands is altered. Conifers as an understory component are increasing (as they are in the rest of the ERU), and the majority of aspen trees are mature to over-mature. “Young stands are not common” (Jones and DeByle 1985: p. 78), though “fairly large patches” of aspen have regenerated inside the 1996 Hondo Fire burned area (Margolis et al. 2007). Fire in aspen would have been more common prior to heavy grazing by sheep during the late 19th and early 20th centuries. There is evidence that aspen historically supported a more dense grass understory, which carried mixed severity fires at shorter intervals, repressing conifer establishment and stimulating aspen sprouting (Jones and DeByle 1985). Maintained by this type of fire, aspen stands may have persisted as a seral state more so in the past than they do today (Romme, Floyd et al. 2009). Direct browsing of aspen seedlings by wild ungulates and domestic livestock has been shown to reduce aspen regeneration, but to what degree, or any anthropogenic influence on that impact is not known (Romme, Floyd et al. 2009). Particularly in the Rio Chama (Rc), Cruces Basin (Cb), and Vallecitos (Vc) zones, recent aspen mortality has been widespread, thought to be related to drought and chronic defoliation by western tent caterpillar (*Malacosoma californicum*) and large aspen tortrix (*Choristoneura conflictana*) over the last decade. This is a trend across the Carson NF and New Mexico, and while extensive aspen mortality may not be unprecedented, the species has decreased in abundance at the context scale (USDA FS 2014e).

Future Trend

Similar to SFF, modeling predicts a shift from the over represented medium closed D state to the very large, closed, multi-storied F state. This represents recovery of previously logged areas and results in a reduced departure, nearing the low departure class by year 100 (36%). However, departure plateaus and is still moderate (36%) in year 1000. Aspen as a state is already underrepresented and will continue to decline for the next 200 years. Future drought and insect pressure will likely continue to stress the aspen component of MCW.

The vulnerability of MCW to climate change at the plan scale is moderate to low (moderate uncertainty), and is particularly low in the Cruces Basin (Cb) local zone (USDA FS 2014a). However, fire frequency is regulated by late melting snowpacks and frequent summer rains (Romme, Floyd et al. 2009), both of which may be altered by climate change, increasing the risk of more frequent stand replacing fires. Spruce budworm will continue to be a persistent defoliator, but the warmer and drier conditions projected in future climate change scenarios could reduce budworm activity and temper severity of future budworm outbreaks (USDA FS 2014e). Root diseases often proliferate on stressed trees, so their significance increases following drought, which will become more likely with climate change. Infected trees, especially true firs and Douglas-fir, then become more susceptible to bark beetle attack (USDA FS 2014e).

Mixed Conifer, with Frequent Fire (MCD)

Extent: 182,847 acres Proportion of Carson NF: 11.5% Elevation: 6,000-10,000 feet

Vegetation Structure – Reference and Current Conditions

Class	Successional Structure, Composition and Cover Class	% Proportion Current	% Proportion Reference[1]	Similarity Value
A, N, B, F	Recently burned; grass, forb, and shrub types; seedling/sapling size trees	2	20	2
C	Small trees, open canopy	5	10	5
G	Small trees, closed canopy	6	5	5
J, K	Multi-storied with open canopy, largest trees are medium to large	3	60	3
H, L, I, M	Medium to large trees, closed canopy	83	5	5
D, E	Single-storied with open canopy, largest trees are medium to large; *contemporary landscapes only*	1	0	0

[1] Based on LANDFIRE (2010) **Departure:** Context Scale = High (75) **Plan Scale = High (80) ▲**

Ecological Status – Current Departure from Reference Conditions

Moderate (35), aspen ▼, Gambel oak ▼, creeping barberry ▼, ragweed sage absent

Vegetative Groundcover – Reference and Current Conditions

Reference avg: 97% Current avg: 84% TEU weighted departure: Low (14% reduction)

Coarse Woody Debris and Snag Density - Reference and Current Conditions

Reference: 15 tons/ac 9 snags > 8”/ac 4 snags > 18”/ac
Current: 8.2 tons/ac 12.4 snags > 8”/ac 2.0 snags > 18”/ac
Departure: Moderate; coarse woody debris has decreased; more small snags, fewer large snags.

Mean Patch Size – Reference and Current Conditions

Reference: 0.6 ac Current: 676 ac Much larger. Departure: High (100)

Fire Regime (Frequency and Severity) – Reference and Current Conditions

Historically, low severity fire every 14-24 yrs, mixed severity fire every 77 yrs (cooler, wetter sites). On avg, 260 ac/yr currently burn on Carson NF. Frequency is significantly less than reference and departure is high (97). Fire effects are departed, more skewed toward high severity than reference, and more severe at the plan scale than the context (Departure: High).

Fire Regime Condition Class – Reference and Current Conditions

FRCC I – 0% FRCC II – 0% FRCC III – 100%

Insect and Disease – Reference and Current Conditions

Reference: Western spruce budworm is common, but not necessarily uncharacteristic. Current: Mistletoe may be more prevalent than reference; crowded stands have increased the potential for bark beetle outbreaks.

Spatial Niche

The MCD ERU is the 4th most abundant on the landscape. It is less common at the plan scale, where it is also 4th most abundant. The influence of the Carson NF on the sustainability of the system is similar to other areas on the landscape. MCD is highly departed at all scales, and likely at risk.

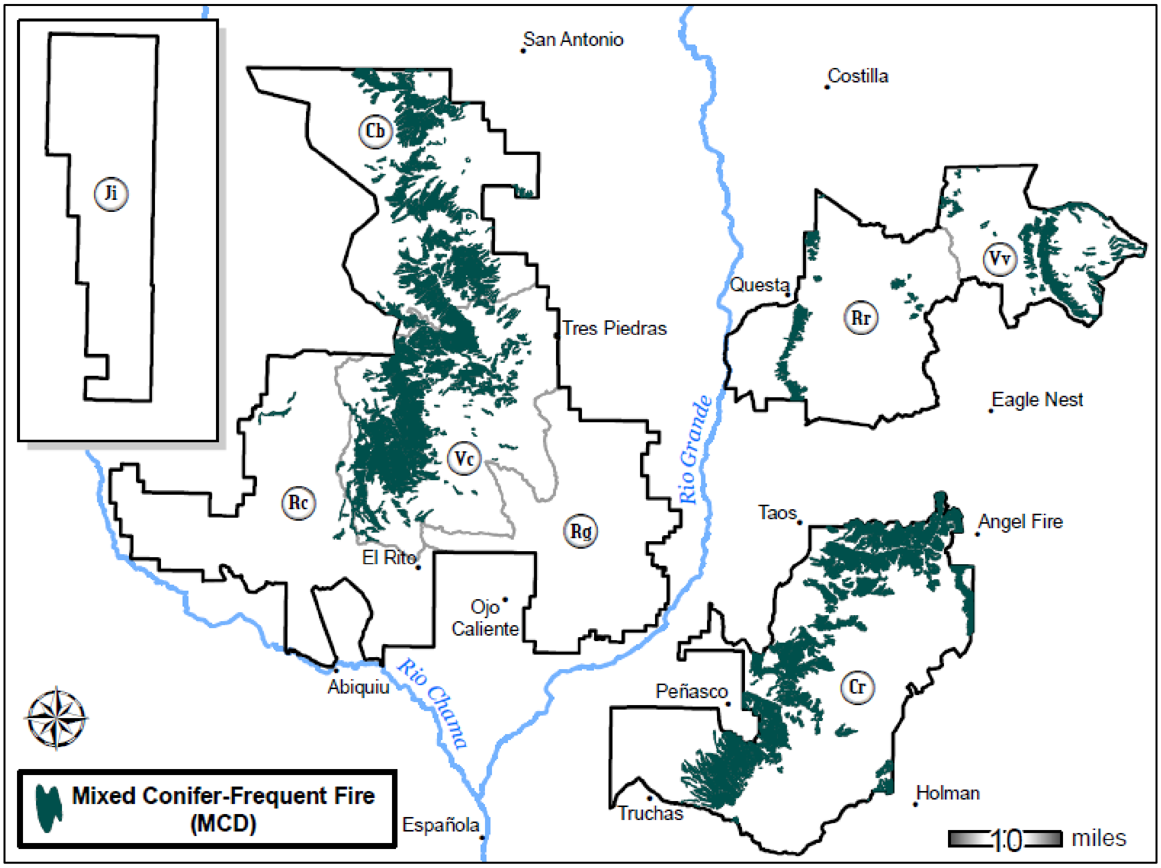

Figure 15. Distribution of Mixed Conifer, with Frequent Fire ERU across the Carson National Forest (plan and local scale)

Occupying warmer, drier sites in the mixed conifer life zone, the Mixed Conifer, with Frequent Fire (MCD) ERU spans a variety of environments between 6,000 and 10,000 feet. MCD is found on 182,847 acres (11.5%) of the Carson NF and is present in six local zones (Figure 15). The ERU is distinguished from MCW by a more frequent, lower severity fire regime and aspen is a minor component found within dissimilar inclusions rather than as a seral stage (Wahlberg et al. 2014). Typically MCD is dominated by ponderosa pine (*Pinus ponderosa* var. *scopulorum*), with some Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*). An open forest structure (<30% tree cover) with fire tolerant ponderosa pine and Douglas-fir in the overstory is maintained by episodic low to mixed severity fire which kills both mature and juvenile white fir (Romme, Floyd et al. 2009). Gambel oak (*Quercus gambelii*), creeping barberry (*Mahonia repens*), and mountain snowberry (*Symphoricarpos oreophilus*) are common in the understory (USDA FS Carson NF 1987).

Reference Condition

With more frequent fire than MCW, the open post-fire state would have been more common in MCD. Most areas were multi-aged, with the largest trees over 10 inches in diameter. Unlike MCW, over two-thirds of stands had open canopies, and only 5 percent were late development with a closed canopy. Small meadows were common (Reynolds et al. 2013). Low severity fires occurred on average every 14-24 years (Evans et al. 2011; LANDFIRE 2010), and maintained open stand structure that favored large, fire resistant ponderosa pine and Douglas-fir, by limiting competition from smaller or more fire sensitive understory trees. In turn, open stands of large fire resistant trees encouraged low severity frequent fire (Reynolds et al. 2013). Trees were multi-aged and canopies were multi-storied. Trees per acre ranged from 38 to 89 on limestone soils and canopy closure was as low as 15 percent or less (Reynolds et al. 2013). On cooler, wetter sites, mixed severity fire occurred less frequently, every 77 years on average (LANDFIRE 2010). Patches ranged from 0.1 to 1 acre (Moore et al. 2004). As in MCW, vegetative groundcover approached 100 percent (USDA FS Carson NF 1987), but more frequent fire left less coarse woody debris and fewer small snags (Weisz et al. 2011).

Southwestern dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cryptopodum*) and Douglas-fir mistletoe (*A. douglasii*), are parasitic plants, and are considered the most damaging pathogens in frequent fire forests on the Carson NF (USDA FS 2014e). Dwarf mistletoes are a persistent, chronic infection that causes direct mortality following years of infection and exacerbates bark beetle outbreaks, especially during dry periods (USDA FS 2014e). Historical distribution of dwarf mistletoe was likely similar to the current distribution, but spatial continuity and levels of infection may have been lower in the past (Reynolds et al. 2013). Fire would have checked infections by killing or scorch pruning infected trees and maintaining heterogeneous, less vulnerable stand structures (Evans 2011). Large witches' brooms that develop on older infected host trees and are beneficial for wildlife may have been more common historically, when average stand ages were older overall (USDA FS 2014e). Bark beetle outbreaks occurred cyclically in Douglas-fir and white fir, mainly in areas predisposed to attack by other, non-lethal agents or poor site conditions (USDA FS 2014e).

Current Condition

Throughout the southwestern U.S., 20^{th} century fire exclusion, selective logging, and intensive unmanaged grazing have significantly altered species composition and stand structure in mixed conifer forests, with frequent fire. Many mature, large ponderosa pine and Douglas-fir trees have been replaced by dense stands of young trees (Reynolds et al. 2013). Without fire, shade-tolerant, less fire-resistant species are able to establish and mature more easily. White fir and Douglas-fir have in-filled and become more common as dominant species, increasing stand density and species homogeneity (Reynolds et al. 2013). Aspen is much less common (about one-sixth of reference). Patch size increased drastically as large overstory trees were harvested, and mixed-severity fires no longer maintained heterogeneity (Reynolds et al. 2013). Overall, seral state departure is high, and similar at the context, plan, and across all local scales.

While fire frequency has been below historic levels in the context landscape, it has been even lower at the plan scale, with the exception of Valle Vidal (Vv) and Red River (Rr) zones, which both have had one large fire in the past 30 years. With the resultant accumulation of smaller, more densely packed trees, fuels are more continuous, and more able to carry fire across the landscape and into the crowns of large trees. Thus, for those fires that have occurred, burn severities have been uncharacteristically high. In fact, the majority of fire at the plan scale has been high severity (60%), similar to the proportion in MCW and greater than the proportion in SFF. As in MCW, a greater proportion of fires have burned with high severity on the Carson NF than in the context landscape.

An outbreak of Douglas-fir beetle (*Dendroctonus psedotsugae*) in Douglas-fir and fir-engraver (*Scolytus ventralis*) in white fir occurred in the mid-2000s, most likely related to drought. While the recent frequency and duration of outbreaks are characteristic, it is assumed that dense, crowded stands have increased the potential for bark beetle activity, above what would have been expected in pre-settlement conditions and have contributed to greater tree mortality when outbreaks do develop (USDA FS 2014e). Current stand structure also encourages the expansion of dwarf mistletoe, resulting in direct mortality and slower growth of trees that do survive, along with other changes that together make forests more susceptible to damaging fire (Evans et al. 2011).

Vegetative groundcover is only slightly below reference in all local zones. Gambel oak and creeping barberry are less common than reference. Ragweed sagebrush (*Artemisia franserioides*), which was not common but was historically present, is now almost completely absent. Small snags are more common than reference because they are not thinned by fire. Large snags are less common, possibly reflecting a legacy of selective harvest of large trees. More trees (live and dead) are left standing because there is less fire, and dead and downed wood is gathered for fuelwood, resulting in coarse woody debris that is well below the historic average.

Future Trend

VDDT modeling predicts a shift from the medium, closed, single-storied H state to underrepresented early development states, mainly the closed seedling/sapling F state. Departure declines through year 100, reaching a moderate 63 percent. However with little fire, the medium to large open multi-storied states, which would have made up 60 percent of the reference landscape, never surpass 7 percent. All open states together never make up more than 16 percent, and trees stay younger than reference on average. Continued lack of fire allows horizontal and vertical infill by understory trees, especially fire sensitive, shade-tolerant species that were historically suppressed. That arrangement is unlikely to persist as modeled since it raises the risk of widespread mortality from fire or pathogens. More contiguous, dense stands are more susceptible to spruce budworm outbreaks, Douglas-fir dwarf mistletoe (*A. douglasii*) infestation, and rot (*Armillaria* root rot, annosum root rot (*H. occidentale*), and Schweinitzii root and butt rot are common) (USDA FS 2014e). White fir is shade tolerant and especially vulnerable to fire. It has proliferated in response to the interruption of natural fire cycles. The fir engraver bark beetle (*Scolytus ventralis*) attacks white fir and with more abundant, continuous host, it will spread more easily and outbreaks are likely to cause greater mortality when they occur (USDA FS 2014b). Given current and predicted stand structures MCD is vulnerable to large and sever wildfire. Fire has been rare at the plan scale, and somewhat more common (closer to reference levels) at the context scale, but it will be more likely in the future. Uncharacteristically high burn severity is already being observed in MCD and that trend is expected to continue (Dillon et al. 2011).

The vulnerability of MCD (Figure 21, p. 83) to climate change at the plan scale is generally low (USDA FS 2014a). It is especially low in the Cruces Basin (Cb) local zone, and slightly higher in the Camino Real (Cr) zone. MCD is an ecosystem that spans a wide climatic range from hot, dry ponderosa forests to cool, moist spruce fir forests incorporating characteristics of both. It may persist in the face of large climate fluctuations were it in a stable, resilient condition. However, secondary impacts of climate change (more common fire and drought, and more impact from insects and diseases) may severely stress the already overgrown MCD forests at the plan and context scales. Water stressed mixed conifer forests will be more susceptible to bark beetle activity and large scale disturbances, such as fire, may help initiate some outbreaks, especially those of Douglas-fir beetle.

Ponderosa Pine Forest (PPF)

Extent: 312,900 acres Proportion of Carson NF: 19.7% Elevation: 6,000-7,500 feet

Vegetation Structure – Reference and Current Conditions

Class	Successional Structure, Composition and Cover Class	% Proportion		Similarity Value
		Current	Reference[1]	
A, N	Recently burned; grass, forb, and shrub types;	5	0	0
B, F	Seedling/sapling and small trees, closed canopy	3	0	0
C	Single-storied with open canopy, largest trees are medium to large	8	0	0
D, J, E, K	Multi-storied with open canopy, largest trees are medium to large	4	100	4
G	Small trees, closed canopy; *contemporary landscapes only*	12	0	0
H, L, I, M	Medium to large trees, closed canopy; *contemporary landscapes only*	68	0	0

[1] Based on LANDFIRE (2010) **Departure:** Context Scale = High (89) **Plan Scale = High (96) ▲**

Ecological Status – Current Departure from Reference Conditions

Moderate (41), sagebrush ▼, kinnikinnick ▼, grama spp. ▼, Arizona fescue ▼, muttongrass ▼, carex spp. ▲, Kentucky bluegrass common in some areas

Vegetative Groundcover – Reference and Current Conditions

Reference avg: 85% Current avg: 65% TEU weighted departure: Low (23% reduction)

Coarse Woody Debris and Snag Density - Reference and Current Conditions

Reference: 5-13 tons/ac 0.2-1.1 snags > 8”/ac 0.2-1.1 snags > 18”/ac

Current: 4.0 tons/ac 6.6 snags > 8”/ac 1.8 snags > 18”/ac

Departure: Moderate; more snags resulting from high overall stand density.

Mean Patch Size – Reference and Current Conditions

Reference: 0.3 ac Current: 375 ac Much larger. Departure: High (100)

Fire Regime (Frequency and Severity – Reference and Current Conditions

Historically, low severity wildfire every 4-18 yrs. On average, 50 ac burn per year on Carson NF currently. Frequency is significantly less than reference, and departure is high (95). Fire effects are departed, more skewed toward high and moderate severity than reference, and slightly more severe at the plan scale than the context (Departure: High).

Fire Regime Condition Class – Reference and Current Conditions

FRCC I – 0% FRCC II – 0% FRCC III – 100%

Insect and Disease – Reference and Current Conditions

Due to lack of fire and denser stand structure dwarf mistletoe has become more persistent and chronic, and bark beetle infestations result in higher levels of tree mortality.

Spatial Niche

The PPF ERU is the most abundant on the landscape. It is less common at the plan scale, though it is still the most abundant ERU. Many areas on the landscape outside the Carson NF have a similar influence on the sustainability of the system. PPF is highly departed at all scales, and likely at risk.

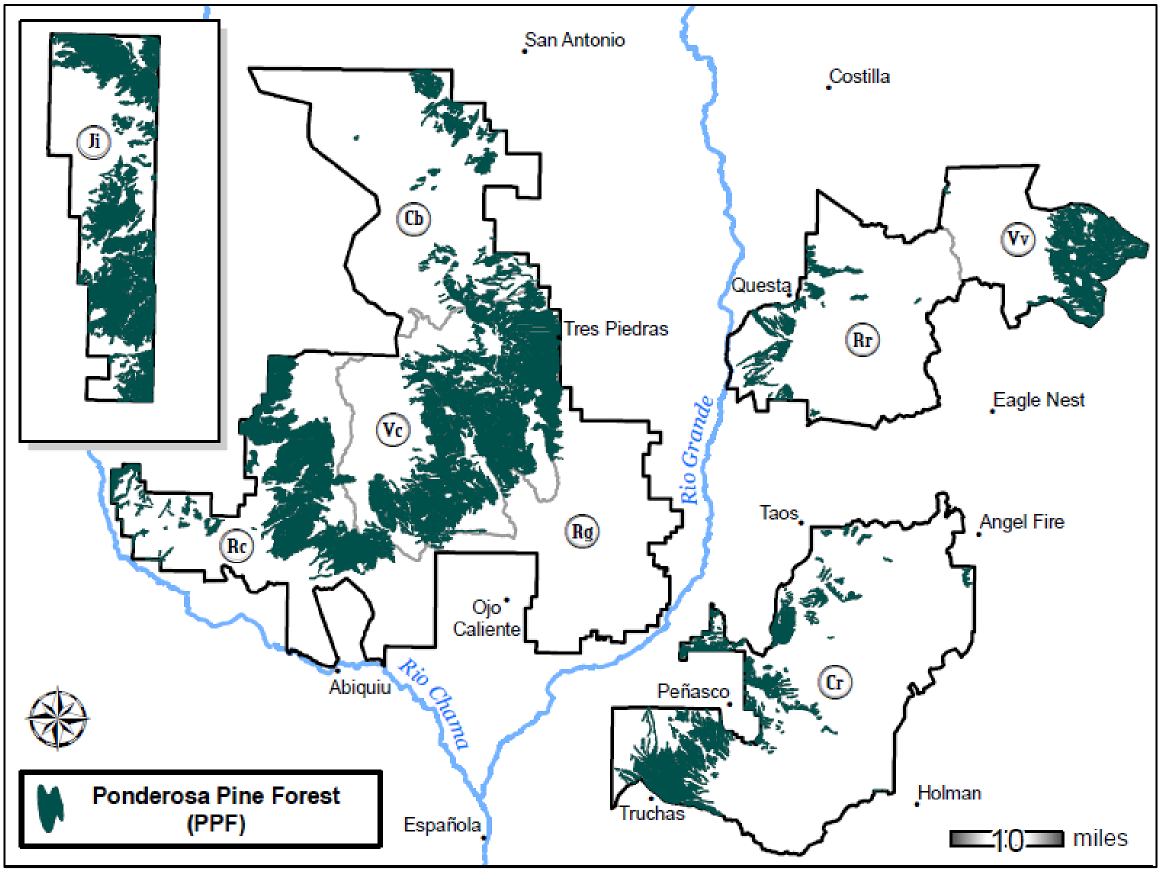

Figure 16. Distribution of Ponderosa Pine ERU across the Carson National Forest (plan and local scale)

The Ponderosa Pine Forest (PPF) ERU is the most extensive ERU on the Carson NF. PPF comprises 312,900 acres (19.7%) of the Carson NF, and is present in every local scale zone, spanning moisture gradients from 6,000 to 7,500 feet (Figure 16).Ponderosa pine (*Pinus ponderosa* var. *scopulorum*) is the dominant species in this ERU, but other trees, such as Gambel oak (*Quercus gambelii*), piñon pine (*Pinus edulis*), and juniper (*Juniperus* spp.) may be present. There is typically a productive grass-forb-shrub understory, Gambel oak, sagebrush (*Artemisia tridentata*), and kinnikinnick (*Arctostaphylos uva-ursi*) are common (USDA FS Carson NF 1987). Other areas are more typical savannah, with grasses and forbs dominating the understory and extensive interspaces between widely spaced clumps or individual trees (Smith 2006b). Common grass species are blue grama (*Bouteloua gracilis*), mountain muhley (*Muhlenbergia montanum*), muttongrass (*Poa fendleriana*), and Arizona fescue (*Festuca arizonica*) (USDA FS Carson NF 1987). During the growing season, ponderosa pine adapts to drought, and has evolved mechanisms to tolerate frequent, low intensity surface fires (Smith 2006b).

Reference Condition

Historic stand structure in PPF has been well documented. Stands were open, and multi-aged, with individual trees or small groups of two to dozens of trees distributed heterogeneously across the landscape (Reynolds et al. 2013). Average patch size was small (0.1-0.5 acres (Moore et al. 2004), so that the resolution of the midscale mapping used to assign state classes 100 percent of PPF falls into multi-aged, open classes. At a finer scale, groups were highly variable, both in terms of the level of aggregation and tree age distribution (Reynolds et al. 2013). Trees per acre in the Southwest ranged from 12 to over 100 (Reynolds et al. 2013), with an average of 38 recorded in 1911 on the Carson NF (Woolsey 1911).

As ponderosa pine trees mature they develop adaptations that protect them from fire, including fire resistant bark, self-pruning lower branches, cones held high above the ground, open branches and needles that do not readily carry fire, deep roots, and thick bud scales (Vankat 2013). Open stand structure was maintained by frequent surface fire, which killed most small and shade tolerant trees, but left mature, fire resistant ponderosa pine. Mean fire return interval in the Southwest ranged from 2-24 years (Reynolds et al. 2013). Romme and others (2009) cite an interval of 4-17 years in the Jemez Mountains and 6-18 years on the San Juan NF. Grasses forbs and shrubs recovered quickly in open interspaces and plant cover and species richness were greatest in canopy openings (Reynolds et al. 2013). Vegetative groundcover averaged 85 percent (USDA FS Carson NF 1987). Fire removed many snags and most coarse woody debris, but actual levels varied by site and disturbance history (Reynolds et al. 2013).

As in MCD, fire is an important natural control of southwestern dwarf mistletoe in PPF, both as a result of direct mortality and pruning, and by maintaining forest structure that limits the tree-to-tree spread of the plant (USDA FS 2014e). Mistletoe was present in PPF in the past, but to what extent or intensity is difficult to quantify. Presumably under reference conditions of more frequent fire in open stands, it would not have been as successful as it is currently, though a 1950s survey did find incidence similar to current levels (USDA FS 2014e).

Several bark beetles attack ponderosa pine including, western pine beetle (*Dendroctonus brevicomis*), the mountain pine beetle (*Dendroctonus ponderosae*), numerous species of *Ips* engravers (*Ips* spp.) (USDA FS 2014e). Major outbreaks may last 2-14 years, and return cyclically every 50-100 years primarily triggered and sustained by extended drought (Romme, Floyd, et al. 2009; USDA FS 2014e). Additionally, dense, crowded stand conditions can contribute to greater levels of tree mortality during outbreaks, because of competition for moisture (USDA FS 2014e). Cyclic outbreaks have been recorded on the Carson NF, since the earliest available conditions reports dating back to 1918 (USDA FS 2014e). Beetle outbreaks in PPF, without subsequent fire, may result in replacement by another tree species or Gambel oak. Ponderosa pine seedlings do not establish easily in the deep organic litter or shade that may result from beetles and lack of fire (Romme, Floyd et al. 2009). This could explain the large expanses of oak in the Rio Chama (Rc) local zone, which based on soils and climate have the potential for ponderosa pine, but few trees are actually present.

Current Condition

PPF is the most departed ERU at both the plan and context scales. Seral state distribution is severely departed in all local zones. Fire suppression, historic unmanaged grazing, and logging have resulted in a lack of open canopy, lack of large tree dominated stands, and fewer snags. Beginning around the turn of the 19th century and continuing into the 1950s, high-grade logging on what is now Carson NF removed most of the merchantable timber from accessible PPF in the plan area and context landscape (Romme, Floyd et al. 2009). What remains are even-aged, relatively young stands that did not exist in the reference condition. The combination of unmanaged livestock grazing and fire suppression has drastically reduced the ability of fire to thin dense regrowth (Romme, Floyd et al. 2009: p. 80). Moore and others (2004) recorded an average increased tree density in the Jemez Mountains of 62 to 171 trees per acre (+276%). Romme and others (2009) found a seven-fold increase in tree density in southwestern Colorado. Patch size has increased dramatically, as stands with multiple canopy layers and fine scale structural diversity have been replaced by predominantly similar aged forests with dense canopies.

As in MCD, fuel continuity has increased in PPF, as open spaces fill in horizontally and vertically, resulting in extraordinarily high burn severities from wildfire. Slightly more (41%) PPF has burned with high severity on the Carson NF than in the context landscape (34%). Both represent a departure from the historic fire regime, under which high severity fire was very rare. Forests often follow uncharacteristic trajectories after stand replacing fire, transitioning to dense ponderosa pine that is vulnerable to another fire or to non-forested grass/shrub vegetation states (Savage and Mast 2005). The number of fires over the last 30 years is far below historic levels at the context scale, and even more departed at the plan scale. The Rio Chama (Rc) and Valle Vidal (Vv) zones have had the most fire, while the Rio Grande and Cruces Basin have had the least.

Vegetative groundcover is lower than reference levels in all local zones, especially the Cruces Basin zone where it is significantly lower. This is caused partially by human disturbance (e.g., road construction and concentrated recreation), but also by forest infill, which reduces the size of openings where percent cover, abundance, and diversity of grass-forb-shrub communities tend to be greatest (Reynolds et al. 2013). With additional tree cover and the effects of historic unmanaged grazing, the presence of herbaceous plants has been reduced in general, and some species may have become rare or extirpated entirely (Romme, Floyd, et al. 2009). Decreased grass cover may also affect a reduction in mycorrhizal fungi, which support plant nutrition, nutrient cycling, and soil structure (Reynolds et al. 2013).

Southwestern dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cryptopodum*) is the most damaging pathogen in PPF on the Carson NF. The parasitic plant is persistent and chronic, with infection rates ranging from 21 to 66 percent (USDA FS 2014e). At the forest or context scales, the overall incidence (acres affected) changes only slightly from year to year. As of 1987, the incidence of pine dwarf mistletoe on the Carson NF remained essentially unchanged since the 1950s (Beatty et al. 1987). However, there is general agreement that incidence throughout the Southwest has increased over the past century, due to harvesting practices that allowed densely stocked young trees to become established under infected overstory seed trees, which resulted in an increase in the number of infected trees (USDA FS 2014e). Dense, crowded ponderosa pine stands have also increased the potential for bark beetle activity (relative to reference conditions) and contribute to higher mortality levels when drought-related outbreaks develop (USDA FS 2014e). This is the case at the context scale too, where outbreaks are, “larger and more frequent than previously recorded” (Reynolds et al. 2013: p. 14).

PPF has slightly more snags than reference, because there are more trees in general, and snags are not being removed by fire. As in MCD, more trees are left standing and many downed trees are collected for fuelwood, resulting in coarse woody debris that is on the low end of the historic range.

Future Trend

VDDT modeling predicts a rapid decrease in medium, closed, single-storied stands as understory development moves them into multi-storied classes. There is a large increase in medium to large, closed, multi-storied stands over the next 50 to 100 years. There is a slight increase in the (reference condition) open J and K states over the next 100 years, but with continued current levels of disturbance, departure remains high (down to 86% by year 10, but still 81% in years 100 and 1000). Dense stands will continue to suppress grass cover.

The vulnerability of PPF to climate change varies by local zone, but at the plan scale it is generally moderate. It is most vulnerable (with low uncertainty) in the Jicarilla (Ji) zone. It is least vulnerable in the Cruces Basin (Cb) zone (with low uncertainty) and Valle Vidal (Vv) (with more moderate uncertainty) (USDA FS 2014a). Climate change is expected to increase stress and make forested environments more susceptible to pathogens(USDA FS 2014e). Root diseases that are already established and adapted to the interior west, such as *Armillaria* root rot, would be expected to proliferate in PPF under stressed conditions (Klopfenstein et al. 2009). Bark beetle activity is likely to increase, with lower elevation ponderosa pine sites being most affected. Dense ponderosa pine forests experiencing increased levels of water stress have a greater potential for widespread bark beetle activity. Shorter drought periods, which previously may not have triggered more extensive bark beetle outbreaks, could under warmer conditions, be sufficient to cause greater mortality (Adams et al. 2009; USDA FS 2014e).

The greatest threat to PPF may be from uncharacteristic wildfire, which can significantly alter stand structure or result in type conversion to grass or shrub systems (Savage et al. 2013). Human impacts have increased stand densities and fuel continuity, allowing fire to reach tree crowns, producing mortality that would not have occurred in the past (Allen et al. 2002). Larger and more frequent fires since 1986 have also been closely linked to earlier spring snowmelt (Westerling et al. 2006). A trend toward more years with earlier runoff has already been documented and is predicted to intensify under a warming climate (Barnett et al. 2008; USDA FS 2010b). Thus, climate change alone would be expected to increase the amount of fire in PPF, but with the added effects of anthropogenically altered stand structures, severe and frequent fires in the future seem inevitable.

Piñon-Juniper Woodland (PJO)

Extent: 178,196 acres Proportion of Carson NF: 11.2% Elevation: 6,200-7,500 feet

Vegetation Structure – Reference and Current Conditions

Class	Successional Structure, Composition and Cover Class	% Proportion		Similarity Value
		Current	Reference[1]	
A	Non-tree: Recently burned; grass, forb, & shrub types	20	10	10
B, E, C	Seedling/sapling and open canopy small trees	20	5	5
D	Medium to large trees, open canopy	12	10	10
F	Small trees, closed canopy	9	15	9
G	Medium to large trees, closed canopy	39	60	39

[1] Based on LANDFIRE (2010) **Departure:** Context Scale = Low (21) **Plan Scale = Low (27) ▲**

Ecological Status – Current Departure from Reference Conditions

Moderate (41), sagebrush ▼, grama spp.▼, large increase in Gambel oak in some areas

Vegetative Groundcover – Reference and Current Conditions

Reference avg: 69% Current avg: 37% TEU weighted departure: Moderate (47% reduction)

Coarse Woody Debris and Snag Density - Reference and Current Conditions

Reference: 4 tons/ac 2 snags > 8"/ac 1 snag > 18"/ac

Current: 0.4 tons/ac 8.0 snags > 8"/ac 0 snags > 18"/ac

Departure: High; more snags resulting from beetle infestation, coarse woody debris is probably closer to reference than what was measured, since many snags have fallen in recent years.

Mean Patch Size – Reference and Current Conditions

Reference: 10s to 100s of ac Current: 74 ac Similar. Departure: Low (0)

Fire Regime (Frequency and Severity) – Reference and Current Conditions

Historically, stand replacing fire every 300-400+ yrs. On average 122 ac burn per yr on Carson NF currently. Frequency is still less than reference and departure is high (73). Reference severity is not well quantified. Fire has less influence on structure than other types of disturbance.

Fire Regime Condition Class – Reference and Current Conditions

FRCC I – 53% FRCC II – 47% FRCC III – 0%

Insect and Disease – Reference and Current Conditions

Cyclical, significant beetle outbreaks have been documented for centuries. During the 2002-2004 outbreak, portions of the Carson NF had the highest levels of piñon pine mortality recorded in the state. Climate change induced water stress may be increasing susceptibility to infestation.

Spatial Niche

The PJO ERU is the 6th most abundant on the landscape. It is about as common at the plan scale, where it is 5th most abundant. The Carson NF has a unique influence on the sustainability of the system; however, departure is low at all scales and there is a low potential for risk.

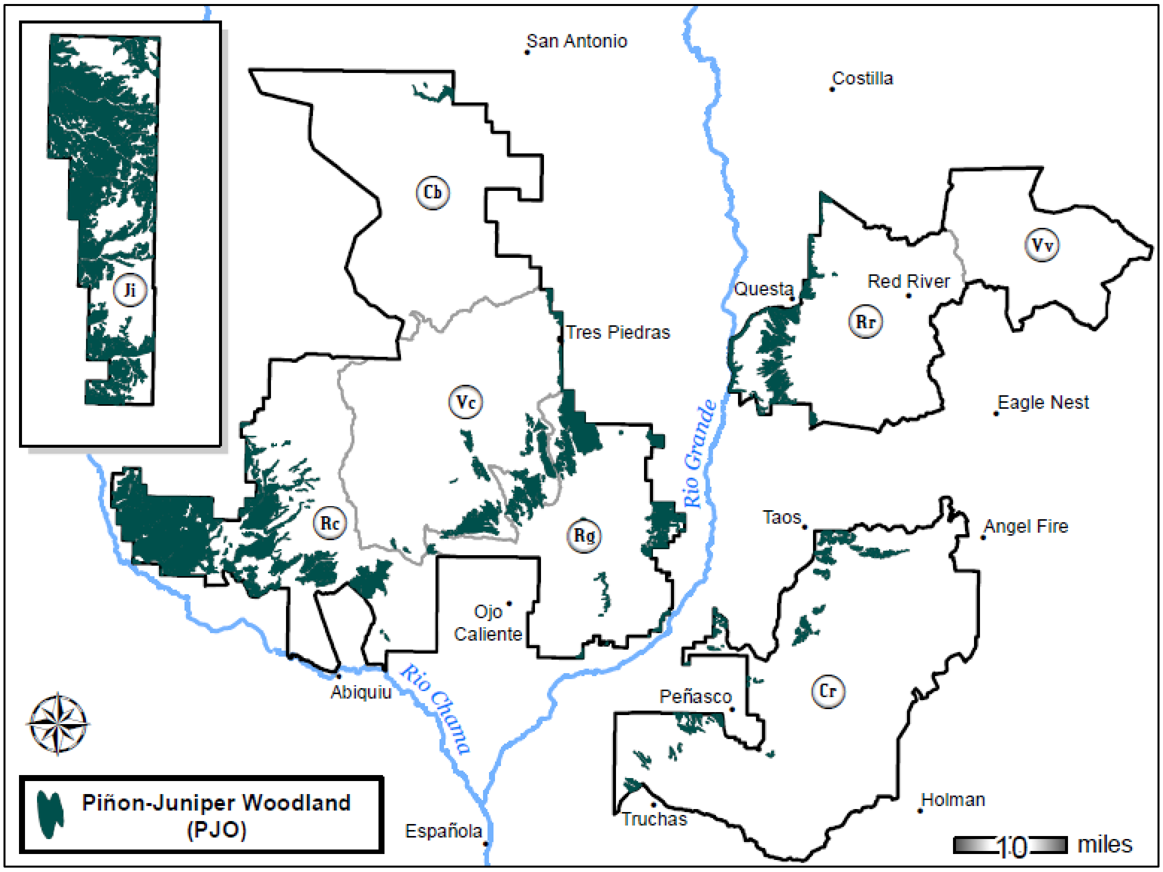

Figure 17. Distribution of Piñon-Juniper Woodland ERU across the Carson National Forest (plan and local scale)

The Piñon-Juniper Woodland (PJO) ERU occurs on 178,196 acres (11.2%) of the Carson NF (Figure 17). It is found in seven local zones,1 occupying drier sites from 6,200 to above 7,500 feet, where it begins to be outcompeted by ponderosa pine and Douglas-fir. The moderate to high density overstory is dominated by two-needle piñon pine (*Pinus edulis*), Rocky Mountain juniper (*Juniperus scopulorum*), and one-seed juniper (*J. monosperma*) (USDA FS Carson NF 1987). Soils are generally shallow, coarse, and often rocky, and support sparse shrubs and grasses, mainly blue grama (*Bouteloua gracilis*) and sideoats grama (*Bouteloua curtipendula*) (Romme, Allen, et al. 2009; USDA FS Carson NF 1987). Typical disturbances (e.g., fire, insects, and disease) are high severity and occur infrequently, creating and maintaining the even-aged nature of this ERU. Woodland development occurs in distinctive phases, ranging from open grass-forbs, to mid-aged open canopy, to mature closed canopy forest (Wahlberg et al. 2014).

Reference Condition

Historically, PJO was characterized by even-aged patches of up to hundreds of acres. Old growth was concentrated in stands or larger areas, and very old trees (over 300 years) were present. Overall, 60 percent of trees were medium to large (>10” dbh). At the landscape scale, the mosaic

[1] There are 913 acres of PJO in the Cruces Basin (Cb) local zone, which may not represent sufficient area for meaningful analysis. Values are reported, but should be considered marginally reliable. See regional guidance, Scales of Forest Plan Assessment (June 2014).

of disturbance history and physical site potential resulted in a variety of ages and stand structures (Huffman et al. 2006). Over 75 percent of stands were dense, with closely spaced trees and a closed canopy (Dick-Peddie 1993; LANDFIRE 2010). Huffman and others (2006) reconstructed 1890 tree density and found an average of 177 trees per acre on the Canjilon RD. Widespread fire was rare, in most cases fire return intervals were on the order of centuries, up to 400 years or more (Huffman et al. 2006). The historic extent and pattern of stand replacing fires have not been well quantified. Most fires likely burned single trees or small patches, but had little effect on woodland structure overall (Romme, Allen et al. 2009).

Stand structure and extent of PJO were more likely driven by climate fluctuation and insect and disease outbreaks than by fire. The resultant tree expansion and contraction along grassland and shrubland borders has likely occurred cyclically for thousands of years (Romme, Allen et al. 2009). Drought and piñon pine *Ips* beetle outbreaks occurred in 2002-2004 and in the 1950s, but have also been well documented during a severe drought in the 1500s (USDA FS 2014e). There is a high probability that individual piñon pine trees will experience “killing” drought during their lifespan (Romme, Allen et al. 2009). Altogether, piñon pine populations are often affected by disturbance and rarely reach equilibrium (USDA FS 2014e).

Current Condition

Drought conditions beginning in the late 1990s initiated a bark beetle outbreak from 2002-2004 that killed a significant portion of the piñon pine component in some woodlands of central and northern New Mexico (USDA FS 2014e). Mapping of seral state distribution conducted prior to this outbreak rated PJO as slightly departed in the context landscape and at the plan scale. There was a slight shift toward early seral states likely due to ground disturbances, such as chaining during the 1950s and 60s (Romme, Allen et al. 2009), roads, and energy development on the Jicarilla RD. Closed states were already slightly underrepresented, but have since declined further, due to bark beetle induced mortality. As a result, current departure is higher than reported here (27%), though the magnitude has not been quantified.

Beetle killed piñon pine trees are mostly recorded as snags in the stand exam data, and there are four times the reference number of snags per acre under 8 inches. Many of these have fallen and would now be classified as coarse woody debris. The areas surrounding Ojo Caliente and La Madera in the Rio Grande (Rg) local zone were some of the most severely impacted by bark beetle infestation in the state. The Rio Chama (Rc) local zone had the largest portion of the 284,500 acres of piñon pine mortality on the Carson NF between 2002 and 2005. Low elevation sites were most affected, and in some cases may have been supporting piñon pine trees that encroached upon drier juniper grassland sites during wetter periods following drought in the 1950s. However, even in areas of high mortality, observations and measurements showed varying degrees of piñon pine survival from seedlings to some mature trees. Drought may also trigger outbreaks of woodboring beetles in juniper, though mortality is less common. The resultant shift in tree species over the last decade has been a historically common occurrence, particularly along the edges of ecotones, such as those between woodlands and grasslands (USDA FS 2014e). Mistletoes (*Arceuthobium divaricatum*, *Phoradendron juniperinum*) cause gradual tree decline and increased susceptibility to beetle infestation and drought. Little direct quantitative information is available on current or historic distribution and abundance, but they are widespread and the intensity of infestations may be greater than it was in the 1800s (USDA FS 2014e).

Prior to beetle induced changes, closed PJO stands supported more trees per acre than under reference conditions, for both piñon pine and Rocky Mountain juniper (Huffman et al. 2006). This is clearly related to a warmer, wetter climate since the late 1800s and increasing atmospheric CO_2. It is difficult to disassociate those effects from any human impacts that began at about the same time, but increasing tree density may have also been influenced by fire exclusion and widespread livestock grazing (which removes competition from grasses, reduces fine fuels to carry fire, and often increases shrub cover that serves as "nurse plants" for seedlings). However, the evidence for these effects is not as strong as it is for atmospheric influences (Romme, Allen et al. 2009; Pieper 1994). Denser stands lead to lower soil moisture and a corresponding decrease in understory cover (Jacobs 2008). This has contributed to the significant reduction in vegetative groundcover observed in all local zones. Groundcover is also reduced by high road (both open and closed) densities in all local zones, except for Valle Vidal (Vv). Cover from blue grama and sideoats grama are both well below reference.

Fire exclusion probably has had little effect on PJO, since fire return intervals are naturally very long in this ERU (Romme, Allen et al. 2009). There has been little fire in PJO over the past 30 years,[1] but this is not necessarily uncharacteristic. What fire there has been was predominantly human caused (83% of acres burned), and presumably ignited under less extreme weather conditions than would support natural fire, since less than a third burned with characteristic high severity. Lack of fine grass fuels would also limit the ability of fires to carry, and may thereby reduce the amount of high severity fire.

Future Trend

Modeling predicts continued infilling and tree expansion in PJO, with a trend toward closed, late development stands that are currently underrepresented on the Carson NF. For the first 50 years, this results in progressively lower departure. As growth and infilling continues, closed canopy, medium to large trees dominate and overshoot the 60 percent reference proportion, but departure remains low, leveling off at 21 percent around year 250. The likelihood of piñon *Ips* activity in the next few decades has been reduced by the recent outbreak as a result of (1) less competition among the now more widely spaced remaining trees; (2) previous mortality of the most at-risk trees, including those on very poor sites or those at the edge of the natural range of piñon; and (3) less available host type (USDA FS 2014e). However, the predicted effects of climate change are expected to substantially change forest insect and disease dynamics (USDA FS 2014e) .Even in the presence of normal precipitation levels in the Southwest, warmer temperatures alone could lead to tree mortality from moisture deficits caused by an increase in evapotranspiration (Adams et al. 2009). Periods of drought or even average precipitation levels exacerbated by higher temperatures and high stand densities could contribute to future widespread bark beetle outbreaks and tree mortality in PJO (USDA FS 2014e). Continued increases in atmospheric CO_2 will favor woody species growth. A warmer, drier climate may increase fire frequency, but will be counteracted by reduced fine fuel development.

Climate change vulnerability for PJO is moderate in the Rio Grande (Rg), Vallecitos (Vc), and Jicarilla (Ji) local zones, and low elsewhere.

[1] The Hondo Fire burned 1,409 acres of PJO in the Red River zone in 1996, representing 40% of all acres burned in PJO over the last 25 years.

Piñon-Juniper Sagebrush (PJS)

Extent: 217,326 acres Proportion of Carson NF: 13.7% Elevation: 5,900-7,500 feet

Vegetation Structure – Reference and Current Conditions

Class	Successional Structure, Composition and Cover Class	% Proportion		Similarity Value
		Current	Reference[1]	
A	Non-tree: Recently burned, grass, forb, & shrub types	30	10	10
B, E, C	Seedling/sapling and open canopy small trees	38	25	25
D	Medium to large trees, open canopy	6	35	6
F	Small trees, closed canopy	9	20	9
G	Medium to large trees, open canopy	28	10	10

[1] Based on LANDFIRE (2010) & Huffman et al. (2006)

Departure: Context Scale = Mod (36) **Plan Scale = Mod (40)**

Ecological Status – Current Departure from Reference Conditions

Moderate (64), juniper ▼, grama spp.▼, muttongrass ▲, broom snakeweed ▲

Vegetative Groundcover – Reference and Current Conditions

Reference avg: 64% Current avg: 26% TEU weighted departure: Mod (59% reduction)

Coarse Woody Debris and Snag Density - Reference and Current Conditions

Reference: 4 tons/ac 6 snags > 8"/ac 1 snags > 18"/ac

Current: 0.4 tons/ac 13 snags > 8"/ac 1.5 snags > 18"/ac

Departure: High; more snags resulting from beetle infestation, coarse woody debris is probably closer to reference than what was measured since many snags have fallen in recent years.

Mean Patch Size – Reference and Current Conditions

Reference: 50-200 ac Current: 71 ac Similar. Departure: Low (0)

Fire Regime (Frequency and Severity) – Reference and Current Conditions

Historically, mixed severity every 80-100+ yrs, stand replacing fire less frequently. On average, 29 ac burn per yr on Carson NF currently. Frequency is much less than reference and departure is high (99). Fire severity may be uncharacteristically low (Departure: Likely Moderate).

Fire Regime Condition Class – Reference and Current Conditions

FRCC I – 0% FRCC II – 100% FRCC III – 0%

Insect and Disease – Reference and Current Conditions

Cyclical, significant beetle outbreaks have been documented for centuries. During the 2002-2004 outbreak portions of the Carson NF had the highest levels of piñon pine mortality recorded in the state. Climate change induced water stress may be increasing susceptibility to infestation.

Spatial Niche

The PJS ERU is the 7th most abundant on the landscape. It is more common at the plan scale, where it is the 3rd most abundant. The influence of the Carson NF on the sustainability of the system is similar to other areas on the landscape. Departure is moderate at all scales, though slightly higher in the Jicarilla (Ji) and Vallecitos (Vc) local zones.

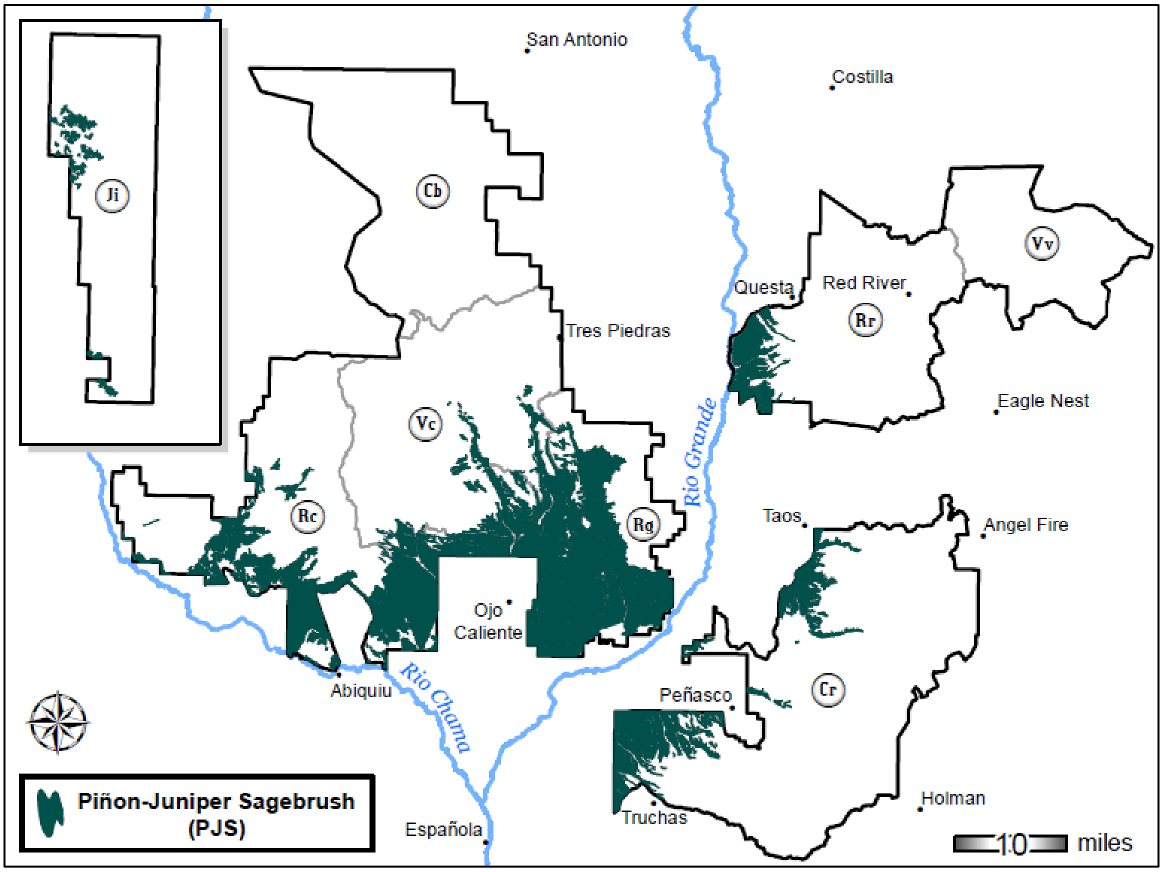

Figure 18. Distribution of Piñon-Juniper Sagebrush ERU across the Carson National Forest (plan and local scale)

Piñon-Juniper Sagebrush (PJS) is a transitional ERU, between wetter, higher elevation PJO and the lower elevation Sagebrush ERU. PJS occurs on 217,326 acres (13.7%) of the Carson NF, between 5,900 to 7,500 feet (Figure 18). This ERU is much more common on the forest, than at the context scale, and is found in six of the eight local zones. The two-needle piñon pine (*Pinus edulis*) and Rocky Mountain juniper (*Juniperus scopulorum*) overstory is open, with trees occurring as individuals or in small, often even-aged clumps. Some Utah juniper (*Juniperus osteosperma*) occurs in the Rio Grande (Rg) local zone. Cover in the understory is 6 to 25 percent big sagebrush (*Artemisia tridentata*). A limited herbaceous layer is concentrated in canopy openings, with common grass species of blue grama (*Bouteloua gracilis*) and sideoats grama (*Bouteloua curtipendula*) (USDA FS Carson NF 1987).

Reference Condition

PJS was historically made up of nearly even proportions, medium to large closed canopy trees, medium to large open canopy trees, and early seral grass/shrub/young tree states (Huffman et al. 2006; LANDFIRE 2010). Compared to PJO, this additional diversity resulted in smaller patches (1 to 10s of acres). The sagebrush understory provides more continuous fuel to carry fire than is available in PJO; therefore, fire was likely more common and exerted a greater influence on stand structure. Low intensity fires were still very unusual. Most fires removed the shrub layer and killed some to all trees (Romme, Allen et al. 2009). Fire return intervals were long (>100 years) (LANDFIRE 2010), but more frequent than in PJO (Romme, Allen et al. 2009). Climate and insects and diseases likely had similar effects as they did in the woodlands; that is, pulses of drought or insect and disease outbreaks would result in episodic tree mortality (Romme, Allen et al. 2009). Snag densities are estimated to have been around 6 total snags per acre.

Current Condition

The 2002-2004 bark beetle outbreak described for PJO had similar effects on PJS. Mortality was greatest at lower elevations and drier sites, the same areas that favor PJS over PJO (USDA FS 2014e). This is evident in the current number of snags per acre, which is over twice the reference condition (13:6). Seral state distribution mapping conducted prior to 2002 rated PJS as moderately departed (40%), due to overrepresentation of early-seral shrub and late-seral, closed tree states, and underrepresentation of mid-seral and late-seral, open tree states. That is, there is an increase in open, non-treed states and dense tree stands. On the Carson NF, the early seral, open state has increased three fold. Shrubs or bare ground have replaced trees in areas that were chained, plowed, and crushed. As many as 20,000 acres of these treatments may have been applied to PJS during the 1950s and 60s (9.3% of the ERU). The remaining 10 to 11 percent that has moved from a treed to open state may be the result of historic overgrazing, drought, tree harvest, or a combination of factors.[1] In the ERU overall, sagebrush and grama species have declined, in favor of broom snakeweed (*Gutierrezia sarothrae*), muttongrass (*Poa fendleriana*), and Indian ricegrass (*Oryzopsis hymenoides*).

In areas where trees remain, the observed infill is consistent with a documented trend across the western U.S. (Romme, Allen et al. 2009). The causal drivers of infill in piñon-juniper systems are not fully understood, and human impacts are difficult to quantify (see PJO discussion, p. 65). However, since fire plays a bigger role in maintaining seral state proportions in PJS as compared to PJO, it is likely that fire exclusion and grazing have had a more substantial impact on departure in PJS. Recent fire history is similar to that of PJO, with most of the infrequent fire resulting from human causes (73% of acres burned) and burning with uncharacteristically low severity (indicating a lack of fuel to carry fire). The combined effects of grazing and increased tree canopy have resulted in decreased grass cover. PJS is the most departed ERU in terms of vegetative groundcover, and it is over 60 percent departed in 5 of the 6 local zones where it occurs. Road densities are lower than in PJO, except in the Red River (Rr) local zone, where both open and closed road densities are very high, mainly due to the many roads in the Cebolla Mesa area. Invasive species are not an immediate threat, but a few acres of hardheads (*Acroptilon repens*) and whitetop (*Cardaria draba)* have been mapped in lower elevations of the Camino Real (Cr), Rio Grande (Rg) and Rio Chama (Rc) local zones.

Future Trend

As in PJO, modeling predicts continued infilling and tree expansion in PJS, with a shift from the early seral A and C states to medium and large trees (D and G states). While the overrepresented A state trends toward, and then past reference, the already overrepresented, late development, closed G state trends consistently away from reference. Therefore, overall departure fluctuates only slightly (first decreasing then increasing), but is generally stable near 40 percent. The recent piñon *Ips* activity has had the same effect in PJS as in PJO, reducing likelihood of a subsequent outbreak (USDA FS 2014e). Climate change may affect fire regimes in piñon-juniper systems,

[1] Some of the overrepresentation in the shrub state may not indicate actual departure. The reference condition is based on LANDFIRE models for the region. However, the shrub component may have been more abundant in northern NM than in other parts of the region (Vankat 2013).

with a sage component more than piñon juniper systems, where the tree overstory carries fire (Romme, Allen et al.2009).

Overall, PJS at the plan scale is highly vulnerable to climate change. It is most vulnerable in the Jicarilla (Ji) local zone (where 98% is either highly or very highly vulnerable and uncertainty is moderate to low) and the Rio Grande (Rg) local zone (80% high or very high, low uncertainty).

Sagebrush (SAGE)

Extent: 59,144 acres Proportion of Carson NF: 3.7% Elevation: 6,100-7,500 feet

Vegetation Structure – Reference and Current Conditions

Class	Successional Structure, Composition and Cover Class	% Proportion		Similarity Value
		Current	Reference[1]	
A	Recently burned, all herb types	8	15	8
B	Shrub, closed canopy	33	30	30
C	Shrub, open canopy	36	55	36
D	All tree types; *contemporary landscapes only*	23	0	0

[1] Based on LANDFIRE (2010) **Departure:** Context Scale = Mod (41) **Plan Scale: Low (26) ▼**

Ecological Status – Current Departure from Reference Conditions

Moderate (64), sagebrush ▼, grama spp. ▼, fourwing saltbush ▲, broom snakeweed ▲

Vegetative Groundcover – Reference and Current Conditions

Reference avg: 57% Current avg: 26% TEU weighted departure: Moderate (52% reduction)

Coarse Woody Debris and Snag Density - Reference and Current Conditions

Not a significant characteristic, reference condition is not defined, no current surveys.

Mean Patch Size – Reference and Current Conditions

Reference: 113 ac Current: 565 ac Much larger. Departure: High (80)

(113 ac is the maximum possible size, see reference condition discussion below)

Fire Regime (Frequency and Severity) – Reference and Current Conditions

Historically, mixed severity fire every 35-200 yrs. On average 4 ac burn per year on the Carson NF currently. Frequency is much lower than reference and departure is high (99). Fire effects are probably similar to reference (Departure: Low).

Fire Regime Condition Class – Reference and Current Conditions

FRCC I – 0% FRCC II – 98% FRCC III – 2%

Insect and Disease – Reference and Current Conditions

Cyclical insect and disease outbreaks limit tree encroachment. Some piñon pine beetle kill occurred during the 2002-2004 outbreak.

Spatial Niche

The SAGE ERU is the 2nd most abundant on the landscape. It is much less common at the plan scale, where it is the 3rd least abundant. SAGE is less departed at the plan scale than at the context scale, and could act as a refuge. However, many areas on the landscape outside the Carson NF have similar influence on the sustainability of the system.

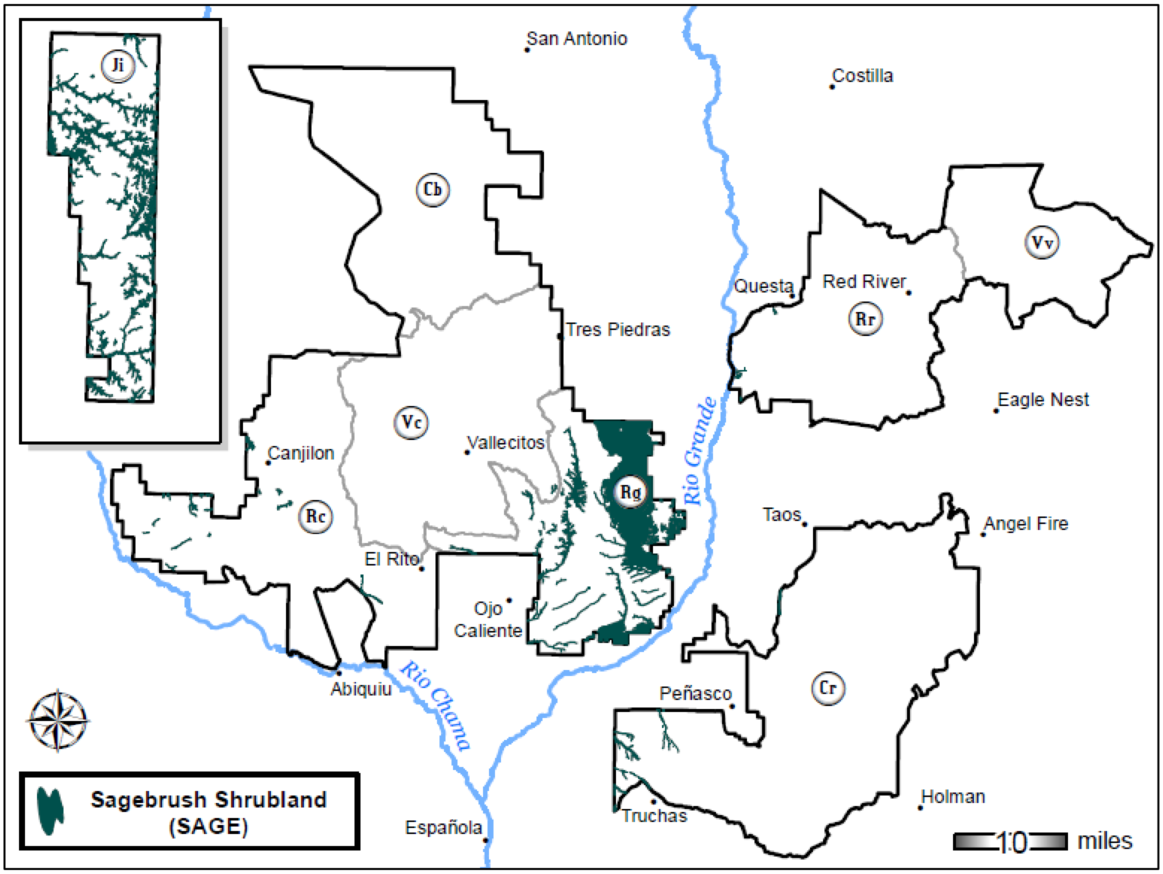

Figure 19. Distribution of Sagebrush ERU across the Carson National Forest (plan and local scale)

The Sagebrush (SAGE) ERU occurs on the Carson NF at the southern edge of its range, at elevations below 7,500 feet. There are only 59,144 acres (3.7%) of this ERU is on the Carson NF (Figure 19). It is much more common on lower elevation land off the forest, and therefore makes up a much larger percentage of the context landscape (29%). SAGE is found in 4 local zones.1 It is dominated by big sagebrush (*Artemisia tridentata*), with less than 10 percent tree cover and few other shrub species present. Grama grass species occur sparsely (*Bouteloua gracilis*, *B. eriopoda*, *B. curtipendula*) (USDA FS Carson NF 1987). Historically, fires burned as frequently as every 35 years and maintained both treeless shrub states and large grass dominated interspaces (LANDFIRE 2010). While the Carson NF's ability to influence the ecological sustainability of the sagebrush community overall is limited, SAGE is slightly less departed on the forest compared with the context; therefore, SAGE may be important to maintain as a functioning system at the plan scale for dependent organisms.

[1] Camino Real (Cr) and Rio Chama (Rc) zones have 927 and 1,011 acres of SAGE, respectively. The area of SAGE in each zone is nearly sufficient for meaningful analysis. Values are reported and should be considered likely reliable. See regional guidance, Scales of Forest Plan Assessment (June 2014) and SAGE patch size discussion.

Reference Condition

While sagebrush shrubland, with sparse grass understory, is the natural community on some sites in New Mexico, a majority of current sagebrush cover is the result of heavy unmanaged livestock grazing during the late 1800s (Dick-Peddie 1993). The vegetative composition and structure for all of the SAGE ERU on the Carson NF has been influenced by grazing (USDA FS Carson NF 1987), but to an unknown degree. Under reference condition, 15 percent of SAGE would be early seral (sparse or grass dominated) and 85 percent would be shrub dominated, with the majority in an open shrub state (LANDFIRE 2010). At 57 percent, vegetative groundcover was historically sparser than in any other ERU (USDA FS Carson NF 1987). Mixed severity fires occurred every 35-200 years (Wahlberg et al. 2014). In areas that were cool and moist enough to support piñon-juniper, a fire return interval of less than 50 years would have been required to maintain shrub dominance (Miller et al. 2014), though drought and tree insect and disease dynamics also helped to limit tree encroachment.

Since historic patch size is difficult to reconstruct and has not been well documented for SAGE, a maximum reference patch size was calculated. Based on ERU boundaries and state proportions, the maximum patch size would occur if all shrub states in SAGE were contiguous with any shrub states in adjacent grass ERUs; however, this is an unlikely configuration. Therefore, actual historic patch size would have been smaller than the calculated maximum of 113 acres.

Current Condition

On the Carson NF and at the context scale, the late development shrub state of SAGE is underrepresented, having been replaced by an uncharacteristic treed state.[1] Tree encroachment is less extensive in the Rio Grande (Rg) local zone then in the Jicarilla (Ji) and Rio Chama (Rc) zones. The 927 acres that occur on the Camino Real (Cr) zone have almost completely converted to tree cover. The open “A” state is underrepresented in all local zones, despite up to 4.4 percent of the ERU having been treated by chaining in the past. This is consistent with trends throughout the West of tree expansion into grassland/shrubland, as well as shrub expansion into grasslands (Dick-Peddie 1993; Romme, Floyd et al. 2009). Sagebrush expansion into semi-desert grassland (outside the SAGE ERU) has been significant off the forest on New Mexico State and BLM lands in the Rio Grande plateau, resulting in more contiguous shrublands and much larger average patch size. SAGE is less departed on the forest (26%) than at the context scale (41%), and though sagebrush as a cover type has declined on the forest, it has increased dramatically in the context landscape (mainly through grassland invasion). The actual percent canopy cover of sagebrush in the ERU is below reference, having been replaced by other shrub species, like broom snakeweed (*Gutierrezia sarothrae*) and fourwing saltbush (*Atriplex canescens*). All grama species have declined significantly. Sideoats grama (*Bouteloua curtipendula*) and black grama (*B. eriopoda*) are nearly absent. At the plan scale the decrease in vegetative groundcover is substantial (-52%) and close to what is observed in PJS. Road densities are also similarly high, but surprisingly, the percent of fires that are human caused is low, though fire occurrence has been very rare over the last 30 years.

[1] The 2002-2004 beetle outbreak in piñon reduced the level of tree encroachment, but the magnitude of that reduction has not been quantified. Piñon trees that established in lower, drier sagebrush communities were probably most susceptible to beetle attack and experienced significant mortality.

Future Trend

Modeling predicts juniper encroachment will continue into the future, and departure will worsen. Predictions from VDDT have the juniper state increasing from 23 to 35 percent over the next 100 years. This expansion would be tempered by increased fire, insect, and disease related mortality on marginal tree sites. Juniper encroachment is likely to continue to some degree, given that current fire frequency is well below the historic range. However, future drought may counterbalance a lack of fire and limit tree expansion. Grama grass cover and overall vegetative groundcover are likely to remain low, the result of degraded soils, probable drought, and continued grazing.

With good certainty, SAGE is the ERU least vulnerable to climate change on the Carson NF. The Jicarilla (Ji) is essentially the only local zone where any SAGE is moderately vulnerable (CCVA). The Rio Grande (Rg) is the only local zone that is currently less departed (23%) than the context (41%); however, it contains 66.5 percent of the SAGE on the forest. Therefore, it may be appropriate to protect as a refuge, if sagebrush communities continue to degrade into the future.

Summary of Ecosystem Characteristics for Terrestrial Vegetation

Seral State Proportion

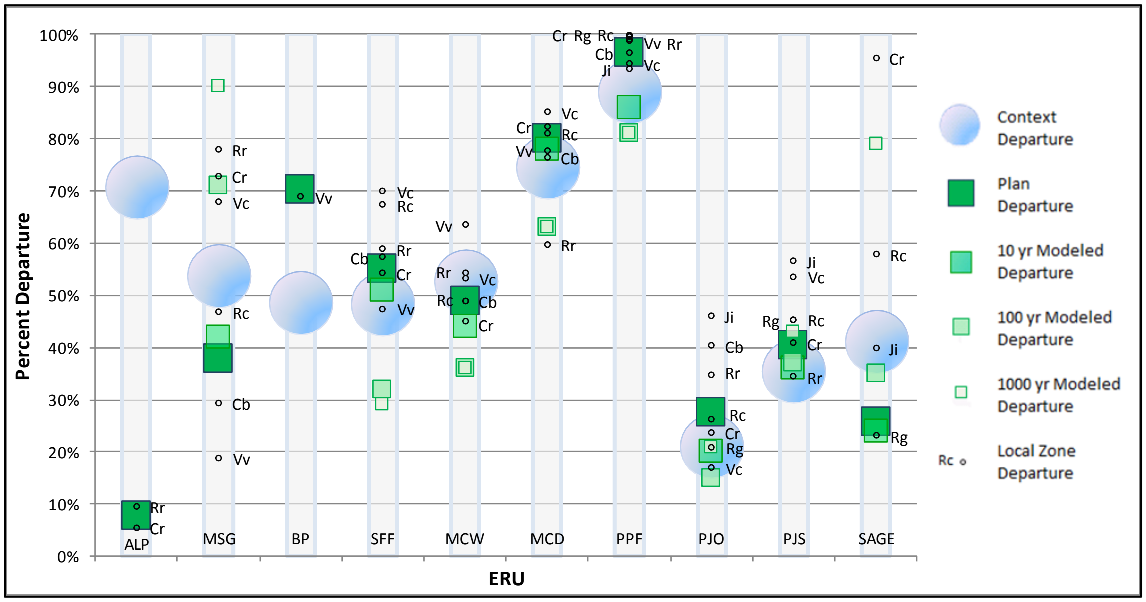

Figure 20. Seral state departure for each ERU at each scale[1]

Departure at the context, plan, and local scale was calculated for all ERUs by comparing current seral state proportion to the reference. Plan scale departure was modeled 1,000 years into the future using VDDT for the eight ERUs that make up more than 1 percent of the Carson NF. Modeled departure at 10,100, and 1,000 years is represented in Figure 20 by increasingly smaller squares.[2] Future departure at the context and local scales was not modeled. As seral state departure increases, terrestrial ecosystems look less like their reference condition, which is the best estimate of a sustainable system. Therefore, high departure indicates that an ecosystem is less sustainable.

For most ERUs, plan scale departure is similar to context scale departure (Figure 20). Sagebrush Shrubland (SAGE) and Montane Subalpine Grassland (MSG) are less departed at the plan scale, but seral state departure in those ERUs only measures tree encroachment, which is projected to continue to increase into the future. Alpine and Tundra (ALP) and Bristlecone Pine (BP) departures at the local and context scales are significantly different, but sample sizes are small and ALP departure may be overestimated in LANDFIRE data (see ALP, Current Condition, p. 36). The frequent fire systems, Ponderosa Pine Forest (PPF) and Mixed Conifer, Frequent Fire (MCD) are slightly more departed at the plan scale, but are very highly departed everywhere, and projected to remain highly departed. The higher elevation Spruce-Fir Forest (SFF) and Mixed Conifer, with Aspen (MCW) ERUs are moderately departed, and predicted to become slightly

[1] Smaller green boxes represent modeled plan scale departure. Local zone abbriviations are: Ji – Jicarilla; Cb – Cruces Basin; Rc – Rio Chama; Vc – Vallecitos; Rg – Rio Grande; Vv – Valle Vidal; Rr – Red River; Cr – Camino Real.

[2] In some ERUs where disturbance return intervals are long (i.e., SFF), 1,000 years of projection is necessary to capture the full range of variability. In other ERUs where disturbance is more frequent (i.e., MSG, SAGE), the 1,000 year model prediction is less reliable. In all cases, the trend in departure is more important than the exact magnitude in any given year.

less departed in the future as medium size classes grow into larger size classes. Piñon-Juniper Sagebrush (PJS) is moderately departed, Piñon-Juniper Woodland (PJO) has low departure, and both have a stable modeled trend.

Ecological Status

Table 6 shows ecological status at the plan scale for each ERU. Ecological status is a classification of species composition departure that may result from non-native species invasion, altered disturbance regimes, degraded or changing environmental conditions, or other influences. Altered species composition indicates lowered ecological integrity and has a negative influence on sustainability. Ecological status is moderately departed for most ERUs, due to a combination of fire suppression, historic and current grazing, introduced grass species, timber harvest, and drought. Generally, high elevation ERUs are less departed than lower elevation ERUs. Higher elevations are cooler and wetter, and have less inherent water stress; therefore, they are more resilient to grazing pressure and drought. The lower elevation ERUs were heavily grazed in the past, and have been more impacted by human activity. Though it spans a wide elevational range, MSG is particularly dissimilar, having been altered by drought, heavy unmanaged grazing, tree encroachment, and the introduction of non-native grasses. MCW is the only ERU with low departure, though SFF and MCD are also very nearly in the low class.

Table 6. Ecological status for each ERU at the plan scale

ERU	ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE
Ecological status	44	71	41	34	33	35	41	41	60	60
Departure class	Mod	High	Mod	Mod	Low	Mod	Mod	Mod	Mod	Mod

Vegetative Groundcover

Table 7 displays vegetative cover departure by ERU at the plan and local scales. Reference condition (reported as a percent cover in the first row) was historically higher for upper elevation, wetter ERUs and lower as elevation declines toward water-limited SAGE. All other cells in Table 7 represent percent departure from the reference condition in that ERU. All ERUs in all parts of the Carson NF have reduced vegetative groundcover, as a result of road construction or other development, concentrated recreation, management related ground disturbance, or legacy impacts from logging or excessive grazing. Additional departure may be present (due to changes in overstory vegetation condition), but is not captured here. Departure resulting from structural changes in an ERU (i.e., increased tree density in PPF or PJO) may not be included in the departure reported in the Carson NF TES. Vegetative ground cover is important for soil stability, water capture, and moisture retention. Reduced ground cover can reduce productivity, change runoff timing and quantity, increase erosion potential, and increase sedimentation.

Table 7. Vegetative groundcover departure from reference (percent) for each ERU at the plan and local scales[1]

ERU/Scale	ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE
Reference (% cover)	60	91	90	99	95	97	85	69	64	57
Forest-wide	-33	-41	-32	-17	-22	-14	-23	-47	-59	-52
Jicarilla							-12	-43	-73	-70
Cruces Basin		-48		-14	-18	-10	-40	-57*		
Rio Chama		-21		-13*	-11	-19	-21	-50	-63	-51*
Vallecitos		-33		-8	-11	-12	-28	-47	-66	
Rio Grande							-27	-44	-53	-45
Red River	-33	-50		-23	-33	-17	-26	-54	-68	
Valle Vidal		-34	-38*	-17	-24	-20	-23			
Camino Real	-33	-14		-17	-19	-16	-28	-53	-63	-49*

[1] An asterisk (*) indicates the number of acres in that ERU/local zone is between 40 and 100 percent the recommended representation for analysis. Values are reported for these cells, but the sample size is not necessarily sufficient for analysis. Blank cells indicate either that the ERU does not occur in that local zone or it occurs at less than 40 percent the recommended representation for analysis.

Coarse Woody Debris and Snag Density

Coarse woody debris and snags provide important habitat, and can slow surface runoff. Deficient coarse woody debris and snags can indicate a lack of appropriate habitat and inadequate nutrient cycling. An overabundance may indicate underlying stress on an ecosystem (such as drought or insect outbreaks, and potentially increases wildfire severity. Coarse woody debris is lower than reference in all ERUs, where data is available (Table 8). Reduced disturbance frequency in many ERUs means that fewer trees are dying and becoming available as debris. Also, timber and fuelwood harvesting remove mature and dead trees that could act as a source. Table 8 also shows reference and current snags per acre in two diameter classes. The > 8-inch class is inclusive of the >18-inch class. In ERUs that are departed due to an uncharacteristic abundance of trees (i.e., MSG, MCD, PPF, PJO, PJS), there are more snags per acre. This is especially true of smaller diameter snags, because many larger trees have been harvested in the past or the species does not frequently achieve diameters over 18 inches (as in PJO and PJS). Snags in SFF and MCW are slightly to very below reference, reflecting a legacy of mature tree harvesting and residual stands that are younger than reference.

Table 8. Coarse woody debris (tons/acre) and snag (snags/acre) density for each ERU at the plan scale

	ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE
Reference - Coarse woody debris	UD[1]	UD	43	46	34	15	5-13	4	4	UD
Current - Coarse woody debris	No data	No data	No data	17.4	10.4	8.2	4.0	0.4	0.4	No data
Reference - Snags > 8”	UD	UD	28	28	14	9	0.2-1.1	2	6	UD
Current - Snags > 8”	No data	12.9	No data	9.0	13.1	12.4	6.6	8.0	13.0	No data
Reference - Snags >18”	UD	UD	11	11	4	4	0.2-1.1	1	1	UD
Current - Snags >18”	No data	0.7	No data	2.6	2.3	2.0	1.8	0	1.5	No data

[1] UD - Undefined

Patch Size

Patch size (and associated heterogeneity) influences wildfire behavior, insect and disease spread and persistence, and wildlife habitat. Larger patches mean there is less diversity in a system than there was historically. This may mean disturbances can spread more continuously, species composition is uniform, and there is less edge habitat. In general, the reduction in variety as patch size increases lowers the adaptive capacity of an ecosystem. Most ERUs on the Carson NF have become uniform, and patch size has increased as a result (Table 9). Homogeneity is driven by lack of fire disturbance, post-harvest single-age regeneration, and sagebrush expansion. Exceptions are SFF and PJO where patch size is within the NRV, and MSG where patch size has decreased due to tree encroachment. MSG provides important habitat for multiple species, and smaller patches mean there is less habitat available. Tree encroachment also decreases available water, degrades soil condition, and alters the fire regime.

Table 9. Average patch size (acres) at the plan scale

ERU	ALP[1]	MSG	BP[1]	SFF	MCW	MCD	PPF	PJO	PJS	SAGE
Reference patch size	NA	186	NA	100s to 1000s	100 to 300	0.6	0.3	10s to 100s	50 to 200	113[2]
Current patch size	NA	127	NA	398	649	676	375	74	71	565
Change in patch size	NA	Smaller	NA	Similar	Larger	Much larger	Much larger	Similar	Similar	Much larger
Departure	NA	Low (32)	NA	Low (0)	Moderate (54)	High (100)	High (100)	Low (0)	Low (0)	High (80)

Fire Frequency

Each ERU has evolved under the influence of wildfire. The frequency of wildfire experienced by an ERU varies among ERUs, but each is adapted to withstand and even exploit a characteristic level of fire. If fires are uncharacteristically infrequent, plants may mature, senesce, and die without ever releasing their seed; species composition may shift to favor uncharacteristic combinations; or live and dead biomass may accumulate to uncharacteristic levels. Current fire frequency is measured in fire rotation, the number of years it would take for an area equal to the entire ERU to burn. A shorter rotation indicates more frequent fire in the system. Reference fire frequency is measured using the mean fire return interval, the average number of years between two successive fires in a given area. Table 10 displays fire frequency for each ERU at context, plan, and local scales. Cells are colored according to departure classes, with Low = 0-33%; Moderate = 34-66%; and High = 67- 90% or 91-100%.

All ERUs have had less frequent fire than reference at the plan scale leading to dense forests and woodlands and encroachment into grasslands across much of the Carson NF. BP and SFF are not departed at the context scale. Frequent fire MCD and PPF, warm-dry PJS and SAGE, MSG, and ALP are all extremely departed at the plan and context scales. PJO and MCW are both more

[1] Patch size is not calculated for ALP and BP since reference conditions have not been defined and very little of either ERU occurs in the plan area.

[2] Calculated patch size for SAGE is the maximum possible historic condition. Actual reference patch size is likely somewhat smaller.

departed at the plan than at the context scale. Red River and Valle Vidal local zones have had slightly more frequent fire on average; however, both frequencies are the result of just one large fire in each zone. The two largest recorded fires on the Carson NF are the Hondo Fire, which burned in the Red River zone, and the Ponil Fire, which burned in the Valle Vidal zone. The number of fire starts is actually lower in the Valle Vidal than in any other zone (0.0078 fires/mi^2/year). Number of starts is highest in the Vallecitos (0.0845 fires/mi^2/year) and Jicarilla zones (0.0711 fires/mi^2/year); however, those fires are either suppressed or stay small, so that acres burned are far below reference.

Table 10. Fire frequency (fire rotation in years) for each ERU at context, plan, and local scales[1]

ERU/Scale	ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE
Reference	200-400	15-20	35-200	200-400	50-100	14-24	4-18	300-400	80-100	35-200
Context	4,721	499	232	337	221	175	279	1,145	1,870	3,243
Forest-wide	million+	2,904	6,495	6,041	1,409	704	329	1,465	7,444	13,792
Jicarilla							1,222	3,067	7,227	4,561
Cruces Basin		33,327		202,088	million+	12,942	2,602	27,475*		
Rio Chama		1,303		427,451*	2,888	42,136	256	1,142	5,645	million+*
Vallecitos		19,327		6,261	74,841	3,017	3,494	7,802	9,352	
Rio Grande							15,098	28,238	31,764	103,890
Red River	million+	1,671		2,230	534	93	137	248	1,167	
Valle Vidal		414	million+*	million+	2,022	77	46			
Camino Real	million+	18,664		8,887	4,198	3,502	1,279	62,478	8,751	27,430*

[1] An asterisk (*) indicates the number of acres in that ERU/local zone is between 40 and 100 percent the recommended representation for analysis. Values are reported for these cells, but the sample size is not necessarily sufficient for analysis. Blank cells indicate either that the ERU does not occur in that local zone or it occurs at less than 40 percent the recommended representation for analysis.

Fire Severity

The historic distribution of fire severity among low, moderate, and high severity types is ecosystem specific. The current distribution is more departed in some ERUs than in others, and the direction of departure is ERU specific (Figure 21). Fire severities in MSG, SAGE, MCW and SFF are probably similar to NRV. In PJS and PJO, fires over the past 25 years have burned with uncharacteristically low severity. There is less grass in the understory to carry a surface fire, and fires do not spread easily on the surface. A large proportion of these fires have been human caused and presumably were ignited under less extreme weather conditions than would support natural fire. In frequent fire MCD and PPF fires have been much more severe than reference, a result of the well documented continuous fuel build up that is created in overgrown, young stands.

Generally the patterns of fire severity are similar at the plan and context scale. The exceptions are the mixed conifer ERUs, where fires are more likely to be severe at the plan scale. This is not driven by seral state conditions, which are similar on and off forest for both ERUs. It may simply be the product of a small plan scale sample size (few acres burned), or it may reflect a subtle difference in the fire regime at the plan scale relative to the context. If fires burn less frequently at the plan scale more fuel builds up and promotes more severe fires when they do occur.

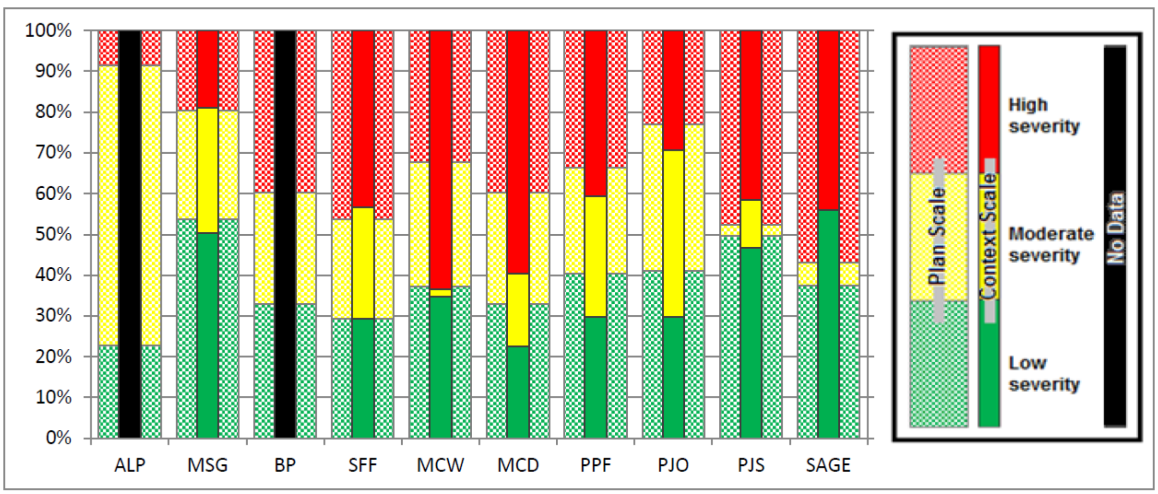

Figure 21. Fire severity (% severity class) for each ERU at the plan and context scale

Fire Regime Condition Class

Fire Regime Condition Class (FRCC) is a summary measure of ecological departure from reference conditions under a natural fire regime. It is calculated by averaging seral state departure and fire regime departure (0-100 scale) and then classified into low (I), moderate (II), high (III) departure classes (see FRCC definition, pp. 19-20). FRCC for each ERU is generally consistent across local scales on the Carson NF. MSG and PJO vary between zones because of differing levels of tree encroachment. Differences are mainly from influences on tree encroachment other than fire (see MSG, Current Condition, p. 39 and PJO, Current Condition, p.67). They may be partially due to the particular fire history of a local zone (less fire resulting in more tree encroachment), however fire regime departure was calculated forest-wide and does not vary across local zones. The MCD and PPF ERUs are the most altered, and are most at risk of uncharacteristic fire and losing key ecosystem components (Table 11).

Table 11. Fire regime condition class for each ERU by local zone[1]

ERU	ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE
Jicarilla							III	I	II	II
Cruces Basin		II		II	II	III	III	II*		
Rio Chama		II		II*	II	III	III	II	II	II*
Vallecitos		III		II	II	III	III	I	II	
Rio Grande							III	II	II	II
Red River	I	III		II	II	III	III	I	II	
Valle Vidal		II	II*	II	II	III	III			
Camino Real	I	III		II	II	III	III	II	II	III*

[1] An asterisk (*) indicates the number of acres in that ERU/local zone is between 40 and 100 percent the recommended representation for analysis. Values are reported for these cells, but the sample size is not necessarily sufficient for analysis. Blank cells indicate either that the ERU does not occur in that local zone or it occurs at less than 40 percent the recommended representation for analysis.

Insect and Disease

Forest health insect and disease surveys have been annually conducted on the Carson NF since 1998. This information can be found on the Southwestern Region's Website (USDA FS Southwest Region 2013). Insect and disease outbreaks from multiple agents affect all ERUs on the Carson NF (Table 12). The 2002-2004 piñon *Ips* outbreak caused significant mortality in all ERUs where piñon pine occurs (in particular PJO and PJS). Western spruce budworm is the most common pathogen on the Carson NF, with persistent defoliation leading to mortality in many instances. It is most active in Valle Vidal (Vv) and Vallecitos (Vc) local zones, but it is common in MCD, MCW, and SFF across the forest (Figure 6, p. 28). Currently no insect or disease agent occurs at levels that threaten the integrity of an ecosystem. There have been large outbreaks in some ERUs, but none have been outside the natural range of variation (USDA FS 2014e).

Table 12. Insects and diseases by agent (acres/year) for each ERU at plan scale[1]

ERU/Agent	ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE
Western spruce budworm	29	6,965	992	66,861	23,151	20,424	2,421	87	36	
Fir engraver		334	71	5,553	3,008	2,307	341	47	27	
Spruce beetle	15	118	8	2,635	139	96	22			
Western balsam bark beetle		30		2,252	44	12				
Aspen defoliation		752	8	3,046	1,430	731	225			
Western tent caterpillar		501	39	2,026	1,120	511	140			
Douglas-fir beetle		94		312	695	1,186	617	53	31	
Douglas-fir dwarf mistletoe		35		315	168	34				
Mountain pine beetle		7		9	62	195	98	6	9	
Western pine beetle		12		6	16	96	193	9	7	
Ips engraver beetles		18			12	18	211	30		
Piñon *Ips*		63			13	46	2,717	3,604	13,064	1,167

[1] 15 year average (1998-2013), USDA FS 2014e). Blank cells indicate that the insect or disease agent has not been observed in that ERU.

However, some areas of the Carson NF are at risk of extraordinarily high mortality over the next 15 years. Krist and others (2014) modeled the potential risk of tree mortality from insects and diseases over a 15-year time period, based on current forest conditions irrespective of climate change (Figure 22). Red areas are at risk of losing ≥ 25 percent of basal area, representing "uncommon or extraordinarily high mortality" (Krist et al. 2014; USDA FS 2014e). Fire suppression has favored the proliferation of more susceptible species, and has resulted in forest landscapes that are more homogeneous, continuous, and dense, and are therefore more vulnerable to insect and disease outbreaks (Parker et al. 2006). Future climate could further increase risk to the Carson NF from piñon pine *Ips* and *Ips* engraver in ponderosa pine, fir engraver, and aspen decline (USDA FS 2014e).

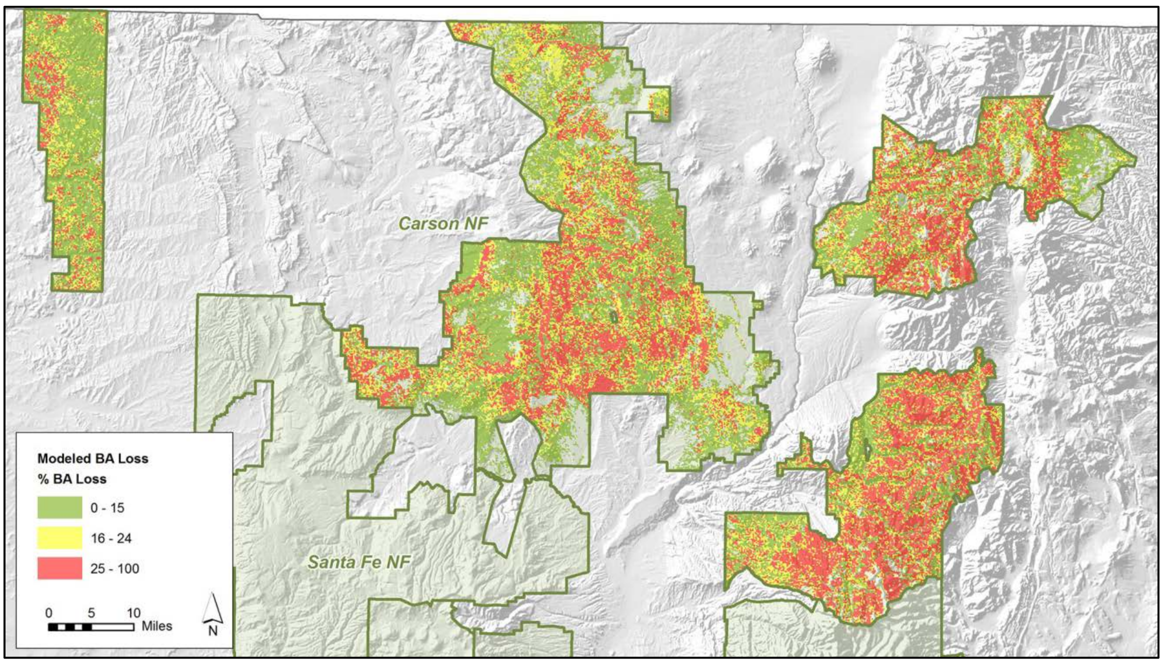

Figure 22. Modeled percent basal area at risk from insect and disease activity on the Carson NF over the next 15 years (USDA FS 2014e)

Terrestrial Ecosystem Stressors

Stressors are influences that may directly or indirectly degrade or impair ecosystem composition, structure, or ecological process in a manner that may impair ecological integrity, such as invasive species, disruption of a natural disturbance regime, or climate change (36 CFR 219.9(c)). Many drivers may become stressors when they occur at uncharacteristic levels. These have been addressed throughout the ERU condition descriptions and in the driver section above, when appropriate. Data related to those stressors that can be quantified at the plan scale is presented below. Climate change will be more fully addressed in the climate change section. The stressors that have not been previously addressed and that can be quantified are:

- Uncharacteristic wildfire
- Human ground disturbance
- Invasive plant species
- Climate change

Uncharacteristic Wildfire

Large, destructive wildfires are in many cases stressors, because their effects degrade the integrity of the system and may convert the system to a condition that may never recover (Savage and Mast 2005). The total number of acres burned severely in recent years has increased throughout the Southwest. In the Southern Rockies ecoregion (including the Sangre de Cristo, Tusas, and Jemez mountains), fires are becoming more likely to burn severely (Dillon et al. 2011). Particularly in frequent fire systems that historically supported mostly low severity fire, high severities may alter ecological function and shift vegetation types, due to regenerative failure, mainly when followed by drought (Hurteau et al. 2014).

Over the past 20 years, there have been more fires and more acres burned per year, both nationally and on the Carson NF (Figure 23). The 2011 Las Conchas Fire burned near Los Alamos, and, at the time, was the largest fire in New Mexico history. It was surpassed the following year by the Whitewater-Baldy Complex, which burned 297,845 acres on the Gila NF. The 468,638-acre Rodeo-Chediski Fire was the largest fire in Arizona from 2002 until 2011, when the Wallow Fire burned 538,049 acres. Colorado’s largest fire, the Hayman Fire, burned 137,760 acres in 2002. In 2013, the West Fork Complex burned 109,615 acres on the San Juan and Rio Grande NFs (InciWeb 2015). The largest fire on the Carson NF was the 92,188 acre Ponil fire in 2002 in Valle Vidal. The Carson NF has not had large fires since, though record setting fires have burned just to the north and just to the south, and it is probable that uncharacteristic wildfire will be a stressor on the forest in the future.

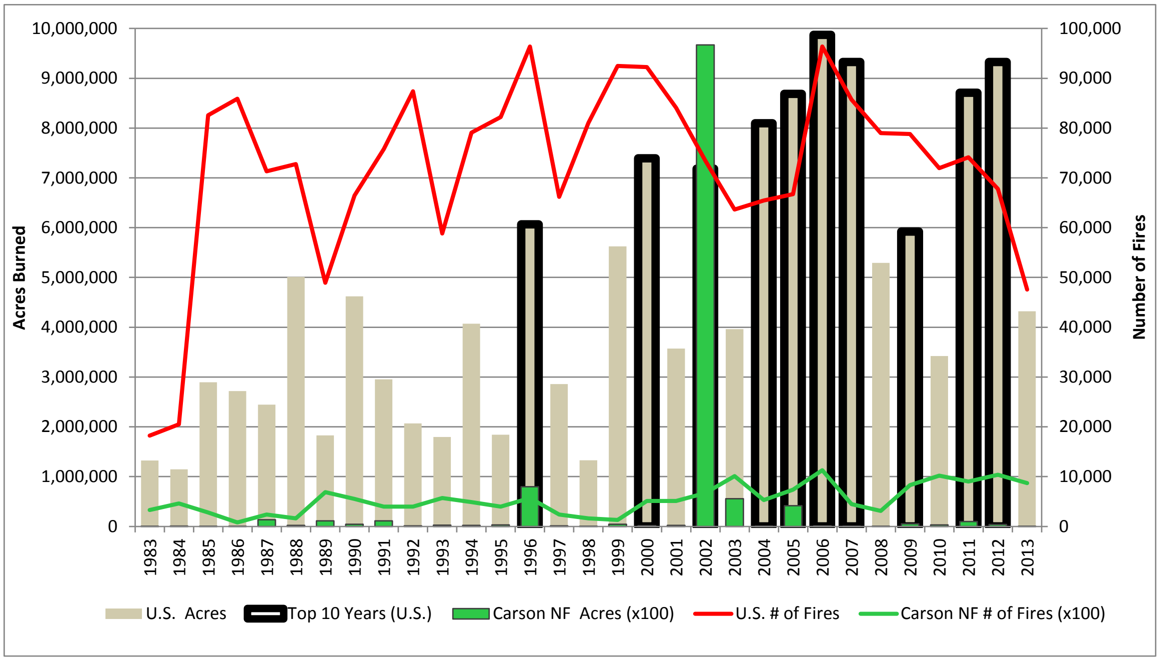

Figure 23. Fire history for the US and Carson NF over last 20 years

For the most part, human caused fire is uncharacteristic. Prior to 1600, Native Americans likely ignited fires with a variety of objectives, but those fires had little effect on overall fire regimes, which closely track environmental controls in the dendrochronological record (Allen 2002a). Human caused wildfire not only increases the number of total ignitions, but also can occur at times of year when natural lightning starts are rare. There is a distinct increase from west to east at the plan scale in (1) the number of human caused fires, (2) the proportion of all fires that are human caused, and (3) the proportion of acres burned by human caused fires (Figure 24). There are more people in the eastern local zones recreating and gathering forest products. Valle Vidal, Red River, and Camino Real zones are also higher elevation with fewer acres of frequent fire systems.

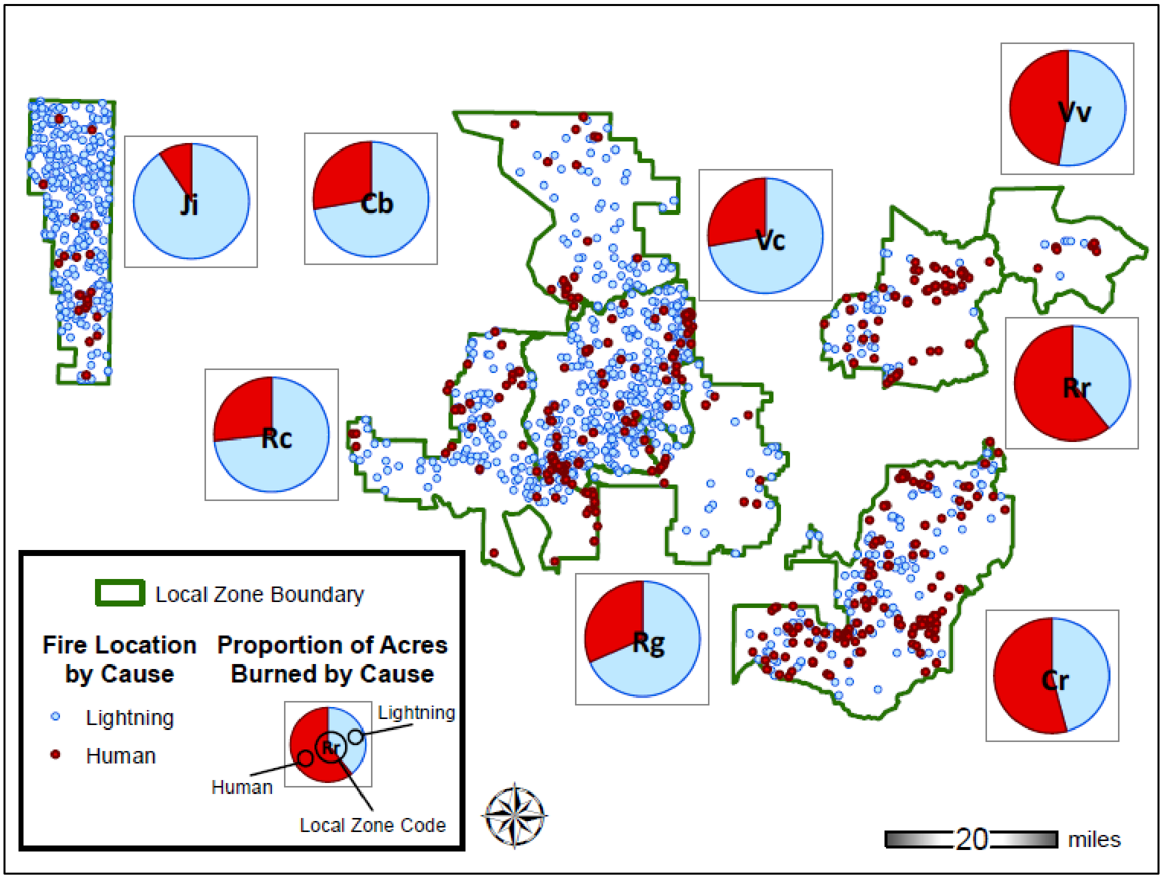

Figure 24. Human and lightning caused fires by local zone (1988-2013)

Human Ground Disturbance

Human ground disturbance may result from infrastructure development, concentrated recreation, or other management activities, but road construction is the most influential at the plan scale, in terms of amount of area affected and impact. Open roads are designated as such by the Motor Vehicle Use Map (MVUM) and are assigned an objective maintenance level. All roads include open roads, closed system roads, and undetermined (legacy non-system or user-created roads). Closed and undetermined roads are not maintained and may have significant effects on hydrology and sedimentation, though many are vegetated and at least partially stabilized. Open and closed roads that are being used illegally provide a vector for invasive species spread and dissect habitat, reducing interior habitat and increasing edge.

Open road density reflects public demand and level of use. Table 13 displays the road densities across ERUs and local zones on the Carson NF. The lowest road density on the Carson NF is in the Cruces Basin local zone. Open road density in the Jicarilla and Valle Vidal zones is low, and those roads are well maintained. Higher elevations in the Red River zone are mainly in wilderness areas and open and closed road densities are low, though open and closed roads are common elsewhere. The Camino Real and Vallecitos zones have the highest road densities, both open and closed, especially in the MSG ERU. These are areas with long histories of heavy human impacts, including unmanaged grazing and fire suppression, which are evidenced by extensive tree encroachment in the MSG ERU (see Figure 20, p. 77, for high seral state departure).

Table 13. Road densities across ERUs and local zones on the Carson NF (miles/mi²)[1]

		ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE
Forest-wide	Open	0.0	1.12	1.19	0.40	0.59	0.77	1.05	1.23	1.10	1.94
	All	0.0	2.30	2.20	2.59	2.36	2.75	2.64	2.53	2.06	3.37
Jicarilla	Open							0.72	0.53	0.58	2.08
	All							1.72	1.26	2.13	4.42
Cruces Basin	Open		0.70		0.41	0.18	0.65	0.52	0.69		
	All		1.50		1.15	0.81	2.18	1.48	1.24		
Rio Chama	Open		1.32		0.20	1.17	0.30	1.38	1.88	0.94	3.64
	All		2.89		0.78	3.02	0.96	3.03	3.22	1.46	6.67
Vallecitos	Open		2.34		0.45	1.55	1.18	1.35	2.05	0.57	
	All		4.14		1.78	3.78	2.83	2.94	4.41	1.33	
Rio Grande	Open							1.49	1.88	1.26	1.83
	All							2.97	4.08	2.10	2.68
Red River	Open	0.0	0.53		0.29	0.37	0.35	0.99	1.16	2.95	
	All	0.0	1.03		0.57	0.86	1.24	2.65	3.00	5.58	
Valle Vidal	Open		0.45	0.63	0.11	0.31	0.42	0.27			
	All		2.56	1.31	4.98	3.19	1.06	0.87			
Camino Real	Open	0.0	5.76		0.54	0.55	0.61	1.05	0.66	0.54	2.33
	All	0.0	8.57		4.36	2.87	3.48	4.45	2.42	2.04	9.09

[1] Gray cells have over 2.5 miles of road per mi². Blank cells indicate either that the ERU does not occur in that local zone or it occurs at less than 40 percent the recommended representation for analysis.

Invasive Plant Species

Where weeds occur and continue to spread over native grasslands, riparian areas, rare plant areas, and other sites on the Carson NF, they cause reduced abundance and variety of native plants. In turn, this affects the abundance and diversity of wildlife species that depend on those native habitats. In addition, the root systems of some weed species do not hold soil in place as well as native plants, resulting in increased soil erosion and stream bank instability (ISAC of the NISC 2006; Lacey et al. 1989; USDA FS 2014d).

While the number of known weed infestation sites on the Carson NF is relatively small (Table 14), there are additional sites that have not yet been discovered. Most of the weed populations on the Carson NF are along roads, in developed or dispersed (undeveloped) recreation sites, in valley bottoms, and along streams. Weed infestations occur on the roads and at trailheads leading into wilderness areas and a few invasive plant species have already spread into those wilderness areas (USDA FS 2005a). Weeds typically spread at a rate of between 5 and 30 percent per year, depending on the plant species and site-specific conditions (DiTomaso 2000; Frid et al. 2013; Tu et al. 2001; USDA FS 2014d).

Table 14. Inventoried invasive plants on the Carson National Forest (USDA FS 2005a)

Common Name	Scientific Name	Acres
Russian knapweed	*Acroptilon repens*	41
Whitetop	*Cardaria draba*	49
Musk thistle	*Carduus nutans*	585
Diffuse knapweed	*Centaurea diffusa*	394
Yellow star-thistle	*Centaurea solstitialis*	1
Canada thistle	*Cirsium arvense*	310
Bull thistle	*Cirsium vulgare*	1,647
Russian olive	*Elaeagnus angustifolia*	331
Leafy spurge	*Euphorbia esula*	9
Black henbane	*Hyoscyamus niger*	44
Perennial pepperweed	*Lepidium latifolium*	43
Yellow toadflax	*Linaria vulgaris*	47
Scotch thistle	*Onopordum acanthium*	130
Tamarisk (saltcedar)	*Tamarix ramosissima*	548

Bull thistle is the most abundant invasive plant species on the Carson NF, ranging in population size from a few hundred square feet up to a 130-acre patch on the Questa RD (Table 14). Along roads, bull thistle and Canada thistle are most common and most likely to spread, but small populations of leafy spurge found along US 285 and US 64 near Tres Piedras also pose a threat of spread. In valley bottoms or in riparian areas, the saltcedar/Siberian elm/Russian olive/bull thistle complexes predominate, along with populations of Canada thistle and musk thistle. Even though their numbers are small, knapweed, leafy spurge, and yellow toadflax pose a special threat, because of their ability to take over plant communities (USDA FS 2005a).

The largest concentration of known bull thistle lies in the Ponil Fire burn area in Valle Vidal (1,250 acres). On the Jicarilla RD, infestations of Scotch thistle and musk thistle are found at natural gas wellheads and along roads leading to these facilities. Although the amount of Scotch thistle is relatively small, the potential for spread is high because of the intermingled nature of land ownership and use in this area. Cooperation among all the land management agencies is particularly important in order to control this threat. Along the Rio Tusas drainage, the amount of leafy spurge is relatively small, but when viewed in the context of infestations on adjacent private land, the threat increases (USDA FS 2005a).

The NM Department of Agriculture has inventoried 14 additional species with special management considerations in counties that the Carson NF intersects[1]. While these species have not yet been mapped on the Carson NF, some are known to occur including cheatgrass (*Bromus tectorum),* Siberian elm (*Ulmus pumila*), jointed goatgrass (*Aegilops cylindrical*), spotted knapweed (*Centaurea biebersteinii*), oxeye daisy (*Leucanthemum vulgare*), tree of heaven (*Ailanthus altissima*), and chicory (*Cichorium intybus*).

Regional Climate Change

The American Southwest is experiencing a warming and drying trend that is predicted to continue well into the latter part of 21st century and create significant stress on ecosystems (USDA FS 2010b). Vulnerability to climate change has been summarized for the Carson NF by ERU and local zone (CCVA). See the Climate Change section for a complete discussion.

[1] These are species that have either been targeted as noxious weeds for control or eradication pursuant to the Noxious Weed Management Act of 1998 or have the potential to become problematic. The complete (2010) state-wide list is available online: http://www.nmda.nmsu.edu/apr/noxious-weed-information/

Soil Resources

The diverse and productive soils of the Carson NF are described, characterized, and classified in Terrestrial Ecosystem Survey of the Carson National Forest (USDA FS Carson NF 1987). Soil types on the Carson NF are intricately linked to the climate, vegetation, and geology of the forest. Ecosystems span 7,000 feet in elevation, from high, cold alpine and tundra to warm, dry piñon-juniper and sagebrush communities. Climate and vegetation interact with the diverse geology of the Carson NF, which occurs predominately along two mountain ranges and exhibits a variety of bedrock types and mountain forming processes.

The **Sangre de Cristo Mountains** of northern New Mexico and southern Colorado are a north-trending chain of mountains located between the Rio Grande depression on the west and the Raton basin on the east. The Sangre de Cristo Mountains are the southernmost subrange of the Rocky Mountains. The Taos Mountains occupy the area near Costilla Creek in the north to the Tres Ritos area in the south. The Santa Fe Mountains lie south of Tres Ritos and extend to the southerly end of the Carson NF in the Pecos Wilderness. The Sangre de Cristo Mountains are one of the longest fault-block mountain ranges in the world (Clark 1966).

The **Tusas Mountain** range is a northwest-trending portion of the Brazos uplift of north-central New Mexico. It is underlain predominantly by Precambrian crystalline and supracrustal rocks that are flanked and locally mantled by Tertiary and Quaternary volcanic and elastic sedimentary strata. Geology is composed of uplifted Precambrian rocks flanked by basement-derived gravel and Tertiary volcanic and volcaniclastic strata related to the Rio Grande Rift. Quaternary alluvium occupies the floors and valleys, and glacial deposits can be found in the highlands of the northern Tusas Mountains (Finch 2011).

The **Rio Grande Rift** is a north-trending rift zone extending from central Colorado to the state of Chihuahua, Mexico. The Rio Grande flows the course of the rift from its headwaters in southern Colorado to El Paso, Texas. Three major basins within the rift include the San Luis, Espanola, and Albuquerque basins. Numerous smaller basins reside within the rift area, interspersed between the three major basins. Sedimentary fill of the basins consist largely of alluvial fan and mafic volcanic flows. These sedimentary deposits (sandstones, conglomerates, and volcanics) are commonly known as the Santa Fe Group (Wikipedia 2015).

The **San Juan Basin** is a geologic structural basin in the Four Corners region of the Southwest United States. The basin is arid with rugged topography of plains and valleys interspersed with buttes, canyons and mesas. Geology of the San Juan Basin is mainly sedimentary rocks of Mesozoic age. The Fruitland Formation in the basin has been one of the major U.S. sources of coalbed methane (Wikipedia 2014).

Climate is highly variable as a consequence of the uneven topography and a wide range in elevation and precipitation. Elevation on the forest ranges from approximately 6,000 to 13,161 feet at Mount Wheeler, the highest peak in New Mexico. Precipitation ranges from around 10 inches to over 35 inches per year. Plant communities follow an elevation-climatic gradient, from low-elevation (6,000 feet) sagebrush shrub and grassland upward to piñon-juniper woodlands, mid-elevation ponderosa pine and mixed conifer (8,000-9,000 feet), and eventually up to high-elevation (over 10,000 feet) spruce-fir forest and montane and subalpine grasslands. All vegetation types are in the cold-winter climatic zone, characterized by deciduous oaks in the piñon-juniper woodland and ponderosa pine forest.

Across the Carson NF, soils vary from an ustic (dry) moisture regime and mesic (moderate) temperature regime at lower elevations to an udic (humid–subhumid) moisture regime and cryic (very cold winter, cold summer) temperature regime at the highest elevations. Soils tend to be shallow and skeletal (>35% rock fragments) on steeper slopes. Less well-developed soils are most common on the more unstable, steep slopes. Moderately steep to flat slopes tend to have deeper, more well-developed soils, with variable amount of rock fragment. Soil texture varies by parent material kind and origin. Soils developed in parent materials, such as andesite and basalt, tend to have more clay content, as these parent materials are high in clay-forming minerals. Soils formed from parent materials, such as rhyolite and tuff, are lower in clay content, because these parent materials have a lower percentage of clay-forming minerals.

Ecosystem Services from Soil Resources

Soil provides a foundational basis on which other organisms (including humans) depend. Soil provides numerous ecosystem services, such as:

- **Supporting** ecosystem services from soils deliver a substrate, nutrient, and water source for plant growth, and are a source of nutrients and nutrient cycling for plant growth and maintaining its own fertility.
- **Regulating** ecosystem services from soils provide an environment to control where water goes, how quickly it runs off, and how much is infiltrated and stored. Soils act as a purification system for water, both surface flows and groundwater, and contribute to climate thermoregulation (i.e., daytime heat absorption, nighttime heat release).
- **Provisioning** ecosystem services from soils include wildlife habitat (burrows, dens), plant-growth media (nurseries), fill for construction, building materials (i.e., adobe and brick), and sources for construction sites.
- **Cultural** ecosystem services from soils offer materials such as pottery clay, play sand, and minerals for aesthetic, spiritual, and cultural heritage values that are important to society.

Key Ecosystem Characteristics for Terrestrial Soil Resources

The key ecosystem characteristics evaluated for terrestrial soil resources are:

- Soil condition
- Soil erosion hazard

Soil condition and soil erosion hazard are directly linked to the ability of the soil to withstand disturbances from management actions and natural events, while maintaining site productivity and sustainability of the soil resource. These characteristics are used to analyze the reference and current conditions and future trends of the soil resource. Soil condition rates soils as they exist currently and reflects the effects of management and disturbance history. Reference soil condition on the Carson NF was generally assumed to be satisfactory. The soil erosion hazard rating reflects inherent site and soil characteristics. Reference and current soil condition and soil erosion hazard are rated in the Terrestrial Ecosystem Survey of the Carson National Forest (USDA FS Carson NF 1987).

Soil Condition

Soil condition is an evaluation of soil quality, based on an interpretation of factors that affect vital soil functions. Soil quality is the capacity of the soil to function within ecosystem boundaries to sustain biological productivity, maintain environmental quality, and promote plant and animal health (Doran and Parkin 1994). The interrelated functions of soil hydrology, soil stability, and nutrient cycling are evaluated to assess soil condition. Unlike soil erosion hazard, soil condition is influenced by management activities. Soil condition is evaluated through the following functions:

Soil hydrology is assessed by evaluating or observing changes in surface structure, surface pore space, consistence, bulk density, infiltration, or penetration resistance using appropriate methods. Increases in bulk density or decreases in porosity result in reduced water infiltration, permeability, and plant-available moisture.

Soil stability is assessed by evaluating erosion potential. Erosion is the detachment, transport, and deposition of soil particles by water, wind, or gravity. Vascular plants, soil biotic crusts, and litter cover are the greatest deterrents to surface soil erosion. Visual evidence of surface erosion may include rills, gullies, pedestalling, soil deposition, erosion pavement, or loss of the "A" (surface) horizon. Erosion models are also used to predict on-site soil loss.

Nutrient cycling is assessed by evaluating plant community composition, litter, coarse woody material, root distribution, and soil biotic crusts. These indicators are directly related to soil organic matter, which is essential in sustaining long-term soil productivity. Soil organic matter provides a carbon and energy source for soil microbes and nutrients needed for plant growth. Soil organic matter also provides nutrient storage and capacity for cation and anion exchange.

Ecological response units (ERUs) are assigned a soil condition category that is an indication of the status of soil function. Soil condition categories reflect soil disturbances, resulting from both planned and unplanned events. Current management activities offer opportunities to maintain or improve soil functions, which are critical in sustaining soil productivity. The following is a brief description of each soil condition category:

- **Satisfactory.** Indicators signify that soil function is being sustained and soil is functioning properly and normally. The ability of the soil to maintain resource values and sustain outputs is high.
- **Unsuited (Inherently Unstable[1]).** These soils have natural erosion exceeding tolerable limits. Based on the Universal Soil Loss Equation[2] (USLE) these soils are eroding faster than they are renewing themselves, but are functioning properly and normally.
- **Unsatisfactory.** Indicators signify a loss of soil function has occurred. Degradation of vital soil functions result in the inability of the soil to maintain resource values, sustain outputs or recover from impacts. Soils with an "unsatisfactory" rating are candidates for improved management practices or restoration designed to recover soil functions.

[1] This class is not described in FSH 2509.18. This is a category where long-term soil productivity and management are not primary objectives, and management activities are avoided due to expected risk of irreprable loss of soil productivity.

[2] Universal Soil Loss Equation - an empirical mathematical model used to describe soil erosion processes. USLE has been modified from its original form to predict soil loss in forestlands and rangelands (Renard et al. 1997)

Existing management actions need to be evaluated to determine if current management is contributing to the loss of soil function. In some cases, current management actions may not have caused the loss of soil function, but may be preventing recovery. Management actions that slow or prevent recovery of soil function should be avoided. Departures in soil condition are identified as low, moderate, or high, and are based on acre differences between current and reference soil condition by ERU.

Soil Erosion Hazard

Soil erosion hazard is the probability of soil loss resulting from complete removal of vegetation and litter, an inherent soil property not influenced by management. Slope, soil texture, and vegetation type greatly influence soil erosion hazard rating. It is an interpretation based on the relationship between the maximum soil loss and the tolerable (threshold) soil loss of a site. Soils are given a slight, moderate, or severe erosion hazard rating:

- **Slight** rating indicates the maximum soil loss does not exceed the threshold; therefore, the loss of the soil production potential is of low probability.
- **Moderate** rating indicates the loss in soil production potential from erosion is probable and significant if unchecked.
- **Severe** rating indicates the loss of soil production potential from erosion is inevitable and irreversible if unchecked.

These ratings provide land managers with an index for identifying three classes of land stability and are useful in determining areas with the greatest potential for response to seeding after a wildfire or areas where exposure of mineral soil should be minimized. Soil erosion hazard was calculated using the Hillslope Erosion Model (Lane et al. 1995) for all major soils within each ERU.

Reference and Current Condition

Satisfactory soil condition (soil quality) is important in maintaining long-term soil productivity—key to sustaining ecological diversity. Unsatisfactory and unsuited (inherently unstable) soil conditions have resulted in the reduced ability of the soil to grow plants and sustain productive, diverse vegetation. Very little quantitative data exist to measure historical soil condition. However, some qualitative and quantitative inferences can be made, providing insight into historical soil condition by using knowledge about present disturbances and their effect on soil hydrology, soil stability, and nutrient cycling. Reference conditions generally estimate Pre-European settlement conditions.

Historically (without anthropogenic disturbance), soil hydrology (compaction), soil stability (soil loss), and nutrient cycling would probably have been within functional limits to sustain function and maintain productivity for most soils that are not inherently unstable—the exception being during cyclic periods of drought and possibly local areas impacted through non-domestic herbivory. Natural flood disturbance would have had a limited effect on the extent of soil loss, only causing accelerated erosion adjacent to stream channels or floodplains. Drought may have reduced the amount of protective vegetative groundcover, resulting in accelerated erosion during prolonged rainstorms.

On the Carson NF, the most productive soils (satisfactory soil condition), historically and currently, are within the Spruce-Fir Forest (SFF, p. 46), Mixed Conifer, with Aspen (MCW, p.51), and Mixed Conifer, Frequent Fire (MCD, p.56) ERUs (Table 15). These ERUs produce high amounts of organic matter that ensure stability of the soil and support nutrient cycling.

Historically, Montane and Subalpine Grassland (MSG, p. 37), Ponderosa Pine Forest (PPF, p. 60), Piñon-Juniper Woodland (PJO, p. 65), Piñon-Juniper Sagebrush (PJS, p.69), and Sagebrush (SAGE, p. 73) were very productive ERUs and are assumed to have had satisfactory soil condition on the Carson NF, but now exhibit reduction in soil function. The lack of effective vegetative groundcover, a shift in vegetative composition from desirable perennial plants towards annual plants, shallow rooted grasses, and tap-rooted woody perennials, as well as a reduction of organic matter levels, have resulted in alteration of soil stability and reduced nutrient cycling in these ERUs. The PFF and PJO ERUs are approximately 40 percent unsatisfactory, while MSG, PJS, and SAGE range from 60 to 70 percent unsatisfactory (Table 15).

Some soils, typically associated with steep, rocky slopes are considered inherently unstable. Inherently unstable soils are those in which their geologic formation and geomorphic properties are naturally active, and soil erosion has existed historically and will continue. Inherently unstable soils are common in the ALP and BP ERUs, but are dispersed across the landscape. Soil erosion hazard influences soil condition—an inherently unstable soil is more vulnerable to soil condition impairment than an inherently stable soil. Table 15 displays the amount of each soil condition and erosion hazard category, as well as future trend.

Table 15. Soil condition and erosion hazard percentages and trend by ERU

	ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE
Soil Condition										
Satisfactory	0	27	42	88	76	100	54	51	22	40
Unsuited	64	0	0	0	0	0	0	0	0	0
Unsatisfactory	36	73	58	12	24	0	46	49	78	60
Erosion Hazard										
Slight	0	6	0	4	15	15	29	8	37	69
Moderate	0	61	0	21	5	27	30	80	18	0
Severe	100	32	100	75	80	58	42	12	45	31
Trend	Stable	Down	Stable	Stable	Stable	Stable	Stable/ Down	Down	Down	Down

In addition, moderate to high departure of current vegetation conditions from site potential in most ERUs may indicate a reduction in vital soil functions (Table 6, p.78). Soil hydrology has decreased, due to the alteration of soil structure and surface pore space, which affect the ability of the soil to allow infiltration of precipitation. A loss of soil stability, due to high amounts of bare soil and lack of protective surface soil litter cover, has resulted from soil erosion losses at levels beyond its threshold. Nutrient cycling has also declined, due to a change in soil organic matter inputs and surface soil litter cover. Reductions in these soil functions may also occur as soils trend toward conditions of declining site productivity.

Future Trend

Current estimates of soil condition trend are not available; however, stressors such as altered fire regimes, nonnative species, and drought—coupled with historical unmanaged grazing and fuelwood gathering—have produced unnaturally dense overstory conditions in PJO, PJS, and SAGE. The MSG ERU has seen a shift in herbaceous vegetative composition, from native grasses and forbs, to a community of non-native, shallow-rooted grasses, with sparse vegetative groundcover that is expected to persist.

Summary of Terrestrial Ecological Integrity

Key Findings of Terrestrial Ecosystems

The ERUs with the highest risk to ecological integrity are at low elevations, with a history of overgrazing (PJS and SAGE), and mid-elevation fire dependent systems (PPF and MCD). Major shifts in species composition, grass cover, and soil condition drive departure in MSG, and to a lesser degree, in PJO. High elevation ALP, BP, SFF, and MCW are currently not highly departed, and some areas are recovering from past timber harvesting practices to regain appropriate large trees. Across the Carson NF, multiple factors are favoring expansion and infill of woody shrub and tree species. Primary threats to the ecological integrity of terrestrial ecosystems on the Carson NF include:

- In those systems that historically burned frequently, the Forest Service's policy of fire suppression during the 20th century has created more even-aged stands, with higher tree densities, and less grass cover. The current structure and composition that resulted are at high risk from intense wildfire that may lead to type conversion or serious erosion.
- Current levels of insects and diseases on the Carson NF are within the NRV for most ERUs, with the possible exceptions of spruce budworm and piñon pine *Ips*, which may be more pervasive and destructive than they have been historically. Insects and diseases spread more easily through stressed, dense stands and outbreaks that have occurred in other areas of the western U.S. may affect the plan area in the future.
- Around the turn of the 19th century, sheep and later cattle were allowed to graze heavily and unsustainably in northern New Mexico. The legacy of that overgrazing has contributed to fire exclusion, tree and shrub encroachment, shifts in species composition, and degraded soil conditions.
- Continued ungulate grazing (a combination of domestic livestock and wildlife) has combined with recent drought to significantly reduce graminoid cover and degrade soil conditions in some localized areas.
- Grazing and fire suppression have favored woody species over grasses and forbs. Tree and shrub expansion and infill have also been driven by 20th century warm, wet periods and increasing atmospheric CO_2. The effect has been a reduction in vegetative groundcover and degraded soil conditions in the piñon-juniper-sage complex, as well as in the adjacent grasslands. Sagebrush has very successfully invaded grasslands and SAGE patch size has increased many times over.
- Through the 1970s timber harvesting practices included clearcutting and selective harvesting techniques, which left behind forests that were younger, more dense, even-aged, and more susceptible to insect and disease infestation.
- Kentucky bluegrass and crested wheatgrass are introduced species that are seeded, because of their rapid growth and palatability to livestock. While these seeded areas are used less now than in the past, they are already well established across the Carson NF. They increase in the face of disturbance and have displaced other native grasses in many areas.

- Soils at lower elevations (PPF ERU and lower) have substantially reduced soil function, due to the combination of lack of effective vegetative groundcover and a shift from perennial to annual plants and shallow rooted grasses or tap-rooted woody species. Soils at higher elevations are more productive, more stable, and support more nutrient cycling.
- Aspen is overrepresented in the SFF ERU, but declining elsewhere, due to competition and a lack of regeneration producing fire.
- Roads, both administratively closed and open to motor vehicle use but under maintained, contribute to soil erosion, reductions in vegetative groundcover, and stream sedimentation and collect and concentrate surface runoff. All roads contribute to habitat dissection and act as vectors for invasive species and human caused fires.

Risk discussed here is based on current condition and trend under current influences. The effects of climate change or other potential stressors are not addressed and are not included in Table 16 (p. 101). Risk to many ERUs will be magnified by future stressors, and will be discussed in Integration and Risk Assessment (p. 298).

Table 16. Summary of risk to terrestrial ecological integrity

	ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE
Seral state	Low	Mod[1]	Mod	Low	Low	High	High	Low	Mod	Mod
Ecological status	Mod	High	Mod	Mod	Low	Mod	Mod	Mod	Mod	Mod
Groundcover	Mod	Mod	Mod	Low	Low	Low	Mod	Mod	High	High
Coarse woody debris	N/A[2]	N/A	N/A	Low	Low	Mod	Low	Mod	Mod	N/A
Snag density	N/A	N/A	N/A	Low	Low	Mod	High	Low	Low	N/A
Mean patch size	N/A	Mod	N/A	Low	Mod	High	High	Low	Low	High
Fire frequency	N/A	Mod	Low	Mod	Mod	High	High	Mod	High	Mod
Fire severity	N/A	Low	N/A	Mod	Mod	High	High	Mod	High	Mod
FRCC	Low	Mod	Mod	Mod	Mod	High	High	Mod	High	High
Insect & disease	N/A	Low	Low	Mod	Mod	High	High	Mod	High	Low
Soil condition	Mod	High	Mod	Low	Low	Mod	Mod	Mod	High	High
Soil erosion hazard	High	Mod	High	High	High	High	Mod	Mod	Mod	Low

[1] MSG's Moderate seral state departure is based on woody species encroachment alone (38%). When departure due to ruderal species is also considered departure is high (75%).

[2] N/A = Not Applicable or Not Assessed

Riparian Ecosystems

Riparian ecosystems are defined as the plant, animal, and aquatic communities that are directly or indirectly related to the presence of water or water induced site characteristics (Kauffman and Krueger 1984). Riparian ecosystems support a greater diversity of plants and animals than do upland habitats and a significant percentage of all wildlife in the Southwest uses riparian habitat (Thompson et al. 2002; Hosten and Whitridge 2007). In addition, aquatic habitat function and fish productivity are directly related to properly functioning riparian systems (Knutson and Virginia 1997).

Riparian systems are dynamic, defined by change, and responsive to disturbance. Because water availability is so variable in the Southwest, shifts in the balance between erosion, runoff, sedimentation, and vegetation resistance are discrete and episodic. Properly functioning riparian systems reach a "dynamic equilibrium" where, on the whole, sediment movement is sustainable and hydrologic forces of change are balanced by deposition and vegetation recovery (DeBano et al. 1995: p. 130). Specific reference conditions have not been developed for riparian ERUs, but maintaining or restoring riparian function that support equilibrium will, in turn, promote ecological integrity.

Riparian Ecosystem Services

Riparian ecosystems provide a disproportionate quantity of ecosystem services relative to their extent on the landscape. On the Carson NF, riparian ecosystems occupy approximately 4 percent of the landscape, yet they provide habitat, water, and other resources to greater than half the wildlife species on the forest and harbor the highest plant, bird, insect, reptile-amphibian and mammal biodiversity of any terrestrial ecosystem. Riparian ecosystem services include:

- **Supporting** riparian ecosystem services from streams flowing through healthy riparian zones are superior habitat for fish, because (1) riparian trees provide shade and buffer temperatures; (2) inputs of woody debris creates fish habitat; (3) inputs of organic matter via leaf fall provides food sources for invertebrates and fish; and (4) invertebrates that fall into the stream from the surrounding riparian vegetation provides food for other organisms.

- **Regulating** riparian ecosystem services (1) subsidize aquatic ecosystems; (2) provide linkages across and within landscapes for the passage of organisms; (3) conserve soil; (4) stabilize stream banks; (5) perform important biochemical cycling and water quality functions; (6) store groundwater; (7) slow runoff and dissipate flood flows; (8) recharge aquifers; and (9) are associated with a range of other services valued by humans and important ecologically.

- **Provisioning** riparian ecosystem services help to supply water for home and agricultural uses off the Carson NF, by storing groundwater and recharging aquifers. These areas provide grazing opportunities and access to water for livestock and wildlife.

- **Cultural** riparian ecosystem services provide people with access to rivers and lakes that are an important recreational resource for fishing, rafting, camping, swimming, or simply relaxing.

All of these ecosystem services provided by riparian areas are becoming more valuable in the context of the larger landscape, where many watersheds outside the plan area are facing increased development pressure and degrading influences. However, the quantity of these same ecosystem services on the Carson NF may be declining in the face of drier and hotter climatic conditions and increased demand of water resources that these riparian ecosystems maintain.

Riparian Ecological Response Units

At the plan scale, riparian ERUs were defined based on Regional Riparian Mapping Project (RMAP) riparian area delineations (Triepke et al. 2014). RMAP boundaries are not coincident with TEUs. Therefore, a TEU may occur in multiple riparian ERUs, and a single riparian ERU contains portions of many TEUs (and may include TEUs with both upland and riparian characteristics). Riparian ERUs for other lands in the context landscape were mapped by LANDFIRE (LANDFIRE 2010). LANDFIRE Biophysical Setting was cross-walked to riparian ERUs on the Carson NF, in order to calculate the plan area's riparian niche.[1] There are 6 riparian ERUs that cover more than 500 acres each at the plan scale (Figure 26 through Figure 31, pp. 136-126):

- HERB – Herbaceous Riparian
- WTLA – Willow-Thinleaf Alder
- UMCW – Upper Montane Conifer Willow
- NSPR – Narrowleaf Cottonwood-Spruce
- NSHR – Narrowleaf Cottonwood-Shrub
- RGCS – Rio Grande Cottonwood-Shrub

Surveys of Riparian Condition

Riparian information from four surveys is available at the plan scale (Figure 25). No one survey is sufficient on its own to assess current condition or trend, and even combined they are not representative of all riparian areas on the Carson NF. However, collectively these data represent the BASI and can be used to infer patterns of departure. A brief description of the four surveys follows:

Riparian Area Survey and Evaluation System (RASES) systematically conducted over 400 riparian surveys across the Carson NF between 1987 and 1991. Each survey involved 5 transects distributed 400 feet along streams. The data were intended to describe "capability and suitability for riparian resources and uses" by "using a distinct combination of four characteristics (vegetation series, valley form, water regime, and water permanence)." Riparian management areas were delineated in the 1986 Carson forest plan, and RASES documents the major management concerns that were present in those areas at the time. The RASES survey collected information about many stream and riparian variables. Those considered in this analysis are channel organic debris, percent shade over water, beaver activity, perennial bunch grass presence, and sod forming grass presence. Overstory ecological status compares RASES species composition information to reference composition for the overlapping TEU from the Carson TES.

Proper functioning condition surveys (PFC) are rapid assessments of stream, seep, or spring condition based on 17 criteria of proper function related to hydrology, vegetation, and

[1] There is no consistent data that provides analogous TEU soil information or current condition and trend for riparian systems outside the Carson and Santa Fe NFs.

erosion/deposition (USDI BLM et al. 1998). They are conducted by Carson NF personnel on a project by project basis or as needed, and therefore do not cover the entire forest, though they are all more recent than RASES surveys. Stream condition is summarized into a single rating, either Proper Functioning Condition (PFC) or Functioning at Risk (FAR). For those stream segments that are FAR, trend is also assessed, when applicable (FARU – upward trend; FARS – stable trend; FARD – downward trend). FARU indicates less risk to system integrity than does FARD.

Stream habitat surveys were conducted by Carson NF fisheries biologists between 2001 and 2005. Information gathered was relevant to aquatic species habitat following a Southwestern Region 3 survey protocol adapted from the Hankin and Reaves Survey methodology. The only measurement from these surveys considered in this analysis is coarse woody debris.

Terrestrial Ecosystem Survey (TES) is an inventory of soil types or terrestrial ecosystem units (TEUs). A TEU relates to a combination of soils, land types, and vegetation communities and estimates current and "natural" vegetative groundcover (USDA FS Carson NF 1987). The current estimate reflects decreases resulting from road construction or other development, concentrated recreation, management related ground disturbance, or legacy impacts from logging, excessive grazing, etc. The change in percent vegetative groundcover is calculated for each TEU intersecting an RMAP riparian ERU, and then area-weighted to determine the average departure within each riparian ERU. Ecological status is an index derived from TES surveys of species composition. It is a measure of the departure of the existing plant community from the potential natural community, as described in the Carson NF TES (USDA FS Carson NF 1987). Ecological status is calculated for a single representative TEU for each riparian ERU, except for HERB.[1]

[1] No TEU is similar to HERB. The HERB ERU occurs as a minor inclusion in many TEUs, but its species composition cannot be separated from the majority of the TEU. Each of the other ERUs could be matched to its central TEU: WTLA = 76; UMCW = 94; NSPR = 90; RGCS = 33; NSHR = 84 (TEU 84 is edaphic-zootic, meaning the reference state cannot be separated from effects of human impacts. There is not an alternative edaphic TEU for NSHR).

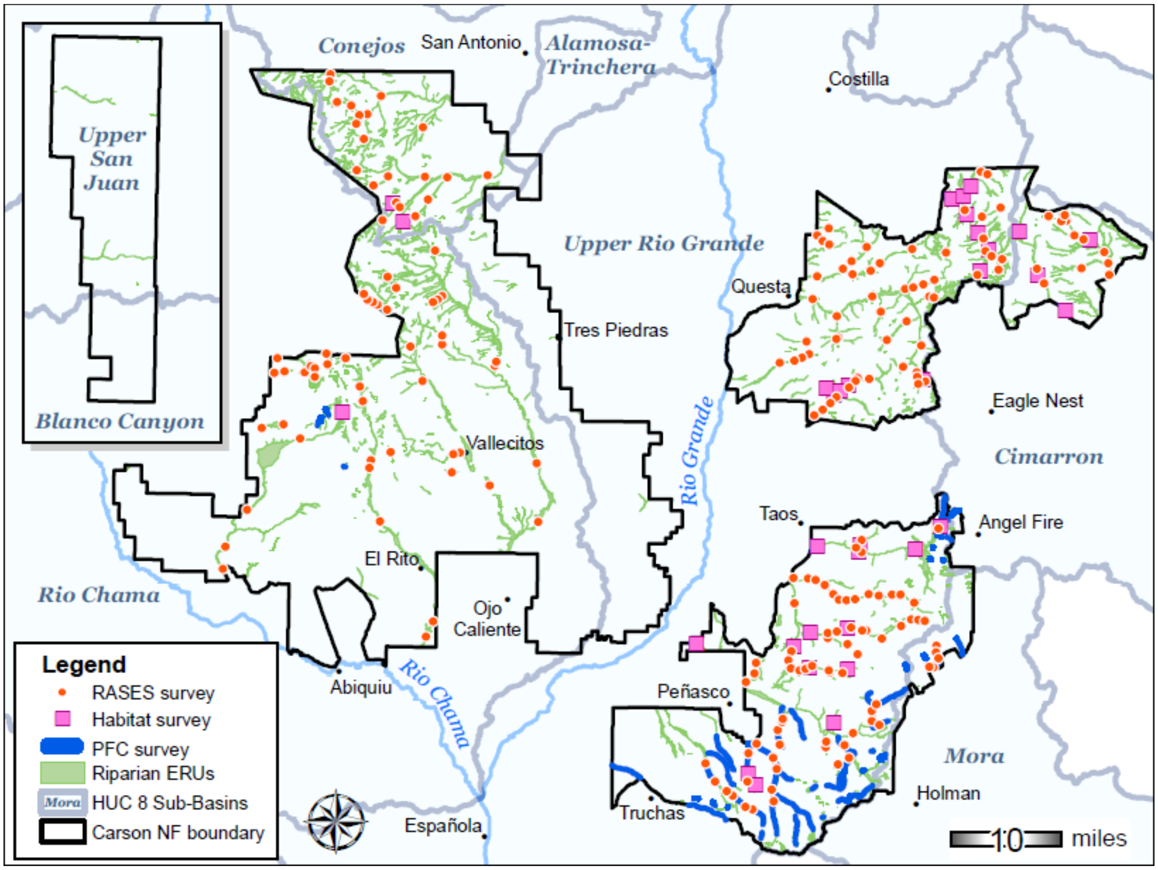

Figure 25. Distribution of riparian vegetation and surveys at plan scale

Key Ecosystem Characteristics for Riparian Vegetation

Key ecosystem characteristics for riparian systems in most cases cannot be assessed directly by a single metric. The BASI supports conclusions about riparian condition and trend, and inferences can be made from some survey data that relates symptomatically or in part to these characteristics. The key ecosystem characteristics for riparian vegetation ERUs are:

- Flood regime
- Beaver activity
- Upland condition
- Age-class distribution
- Species composition
- Riparian vegetative cover
- Coarse woody debris
- Ecological status

Flood regime – Frequent floodflows that spread out on a low-lying area adjacent to a stream provide energy dissipation, sediment deposition, and periodic flooding of vegetation. Stream systems that are not highly confined generally support a floodplain landform that is flat and adjacent to the stream. If a channel is downcut, flood flows can no longer access the floodplain and can no longer provide important hydrologic functions (USDI BLM et al. 1998). Flood regime measures alterations to natural flow amount and timing caused by water use and impoundment, as well as the degree to which floodflows are able to spread out on a low-lying area adjacent to a stream or are confined within a channel. A functional floodplain should be inundated at peak runoff in most years, and larger floods should inundate a larger area of the floodplain. Altered flood regimes may result in much smaller, more infrequent flood events, or floods that are confined in incised or oversized channels (USDI BLM et al. 1998). Flood regime is a factor in proper functioning condition (PFC) ratings, but for this assessment, the rating is based mainly on agency specialist knowledge of water use, impoundments, and channel condition.

Beaver activity - Beavers are key agents of riparian succession, because the dams they build act as hydrologic modifiers. For some riparian areas, beavers have been largely responsible for the establishment of the floodplain (Gebhardt et al. 1989). Beaver dams are blockages that change an area's site progression. A flowing stream can be changed overnight to an aquatic pond. If the dams are not maintained or captured by vegetation, over time, they breach and unleash tremendous energies that usually result in degradation (USDI BLM et al. 1998). Beaver activity is measured by presence or absence of dams, and whether those dams have current beaver activity or have been abandoned. Beaver activity was recorded during RASES surveys; however, more recent anecdotal evidence suggests that beaver populations have recovered and dam effects have increased in some areas.

Upland condition - The condition of the surrounding uplands can substantially affect the condition of a riparian area. Changes in upland condition can change the discharge, timing, or duration of streamflow events, and the amount of sediment supplied to a riparian area. Uplands that are able to store less water or that are more erodible or more prone to uncharacteristic fire will have a negative effect on adjacent riparian systems; however, degradation of the uplands does not necessarily result in degraded riparian condition. While the influence of upland condition has not been directly measured by any riparian survey, upland ERUs are assessed in the Terrestrial Ecosystems section (p. 16) and some effects on adjacent riparian can be inferred.

Age-class distribution - For a riparian area to recover or maintain itself, it has to have more than one age-class of riparian plants. A variety of age classes results in structural diversity, which provides a variety of habitats and includes old vegetation for woody component recruitment. Most riparian areas will recover or maintain themselves with two age classes, as long as one of the age classes is young (recruitment) and the other is middle-aged (replacement). Older age classes (mature) usually take care of themselves, as they are well-attached to existing water tables. Older age classes can persist even with degraded conditions (USDI BLM et al. 1998). Number of canopy levels was recorded during RASES surveys. Canopy levels are not a measure of the age-class distribution for any one species, but may indicate departure in some systems.

Species composition – Maintenance and recovery of riparian systems requires a diverse composition of vegetation. For most riparian areas, this means having two or more riparian species present, depending on site potential and/or capability. The presence of only one species makes a site very vulnerable to disease or extreme changes in climate, which may result in degradation (USDI BLM et al. 1998). Plants that occur where the water table is high are called hydrophytes. Since hydrophytes must be in contact with the water table, they can be used as indicators that riparian soil moisture characteristics are being maintained. Increasing dominance by normally upland plants may indicate a declining water table (USDI BLM et al. 1998). Riparian species, such as willow, alder, aspen, birch, and cottonwood prefer wetter conditions and have root masses capable of withstanding high-flow events (USDI BLM et al. 1998). Native aquatic species like sedges and rushes colonize scoured areas soon after floods, capture sediment, and keep stream substrates from eroding. Native riparian graminoids have extensive root masses that are strong and fibrous and stabilize streambanks, and resist undercutting during high flow events (Neary and Medina 1995). Seeding often introduces sod forming annual grasses, which have shallower and more delicate root systems that are less resistant to erosion (Medina 1995). Erosion leads to bank undercutting and collapse, and changes the active channel’s width/depth ratio, gradient, and sinuosity, which reduces a riparian area’s ability to dissipate energy.

Ratings from PFC surveys incorporate species composition insofar as it relates to function of the system. In the RASES surveys, lower percent shade over water may indicate a departure in species composition toward less productive, uncharacteristic species. RASES surveys also note the presence of perennial bunch grasses to sod forming grasses. Native bunch grasses are indicative of reference composition, while dominance by sod forming grasses is a departed condition and is more susceptible to erosion and channel degradation. The number of surveys that recorded each grass type is summarized by ERU. A larger bunch grass to sod forming grass ratio indicates less departure from reference species composition.

Species composition was measured more directly in the Terrestrial Ecosystem Survey (USDA FS Carson NF 1987). Actual observed composition can be compared to reference (“natural” composition) from the TES to arrive at departure for any TEU (see full discussion in Ecological Status section, p. 21). Since riparian ERUs do not correspond directly to TEUs, a central TEU was identified for each riparian ERU except Herbaceous Riparian (HERB) (see footnote, p. 104). The central TEU is the most common in the ERU and in all cases has similar species composition (Triepke et al. 2014; USDA FS Carson NF 1987).

Riparian vegetative cover - Vegetation filters sediment, protects streambanks, and aids floodplain development that dissipates stream energies associated with high-flow events (USDI BLM et al. 1998). The greater the above ground biomass, the more protection it provides, and native graminoids usually produce more biomass than non-natives (Medina 1995). Vegetative cover departure was calculated from TEU reference and current values, area weighted for all TEUs intersecting an ERU. The PFC rating and the RASES the bunch grass/sod forming grass ratio may also relate to the amount of vegetative groundcover.

Coarse woody debris - Large organic and woody debris in the stream channel capture sediment, aid floodplain development, dissipate stream energy, and provides habitat. More coarse woody debris creates more pools and drops, reducing the average stream gradient, slowing the movement of sediment, and increasing channel stability (DeBano et al. 1995). Many rangeland and meadow riparian areas do not require woody material to maintain channel stability (USDI BLM et al. 1998). Coarse woody debris was measured by the stream habitat surveys. For all streams, more than 30 pieces per mile, greater than 12 inches in diameter, and longer than 35 feet were considered properly functioning for habitat purposes. A range of 20-30 pieces per mile was considered at risk, and less than 20 pieces per mile was considered not properly functioning. The RASES surveys classified “Channel Organic Debris” in a stream on a scale ranging from infrequent small floatable organic debris to extensive large debris dams either continuous or influencing more than 50 percent of the channel.

Ecological status is the same as the metric applied to Key Ecosystem Characteristics for Terrestrial Vegetation (p. 21). It evaluates vegetation composition relative to the potential natural community (PNC), as described in the Carson NF Terrestrial Ecosystem Survey (USDA FS Carson NF 1987). For all riparian ERUs, except HERB, ecological status was calculated using only one central TEU (see footnote, p. 104).

System Drivers and Stressors for Riparian Vegetation

Riparian system drivers and stressors are based on the attributes and processes that define properly functioning riparian condition (USDI BLM et al. 1998), and for which information is available on the Carson NF. System drivers and stressors for riparian vegetation are:

- Water flow regime
- Landscape position
- Flooding
- Natural vegetation succession
- Sedimentation
- Upland condition
- Herbivory and ungulate compaction
- Adequate large woody debris
- Roads
- Invasive species
- Climate
- Fire

Water flow regime refers to both the amount and timing of streamflow. It effects the availability of water for riparian species (aquatic and terrestrial), and also the physical balance of sediment transport (erosion and deposition). Flow regime is impacted by stream diversions and impoundments, as well as upland watershed condition and stream function. It is a function of water table depth, which is affected by stream channel downcutting and withdrawals.

Landscape position is the topographic position and stream morphological characteristics that define a stream's range of sustainable gradient, sinuosity, channel shape and size, and riparian zone characteristics.

Flooding is an important natural driver, providing sediment deposition, scour, and periodic wetting of floodplain vegetation, but may also become a stressor in nonfunctional systems or when flood events exceed the system's capacity.

Natural vegetation succession – Stream systems are inherently variable and the vegetation community must be able to adapt and maintain a functional riparian zone. In many systems, natural deposition leaves unvegetated point bars that provide riffle habitats important for aquatic invertebrates and some fish species. However, natural deposition must be rapidly colonized by riparian plants with adequate root masses, in order to prevent accelerated erosion during subsequent high flows. Herbaceous riparian vegetation must provide bank protection, dissipate energy, and capture sediment, allowing succession by larger woody species with deep, anchored roots. Multiple vegetation age classes are necessary to provide a source of recruitment and adequate shading over water. Natural succession is disrupted by reduction of soil moisture from drought, other dewatering, or channel downcutting, which all lower the water table and favor drier upland species. Uncharacteristic flooding or other disturbance (like fire or heavy grazing) may also disrupt the natural succession of riparian vegetation. Introduced species, notably shallow-rooted, sod-forming grasses like Kentucky bluegrass, outcompete native bunchgrasses, but are easily damaged by high flows and so do not provide the same resistance to erosion.

Sedimentation – Sediment load is a function of the natural erodibility of the parent material and the topography of the stream and watershed, but is also dependent on upland and riparian vegetation and soil conditions, as well as channel shape and function. Appropriate riparian vegetation and channel shape creates a positive feedback by capturing sediment that builds the floodplain and increases water retention, and in turn provides riparian habitat. Sediment load may become a stressor when it exceeds stream capacity for transport or capture, and scours and inundates the stream channel, degrading aquatic habitat for many types of macroinvertebrates and fish.

Upland condition effects discharge timing and sediment delivery to the riparian zone. Departed upland condition does not necessarily result in degradation of the riparian systems, but any changes to upland vegetation and soils that affect sediment supply or water infiltration will have impacts.

Herbivory and ungulate compaction - Riparian areas in the Southwest have evolved under the influence of and are adapted to herbivory and other ungulate use (Holechek et al. 2010). Grazing by native species during the reference period differed from current practices in degree, foraging pattern, diet, preference for less slope and riparian areas, time spent in a single area, and soil trampling (Currie 1977; Osmond et al. 2007). Excessive herbivory and ungulate compaction can lead to inadequate bank protection, cutbanks, increased erosion and sedimentation, stream widening, and a loss of thermal cover (Holechek et al. 2010, Gunderson 1968; Platts and Rinne 1985; Kaufman and Krueger 1984; Hosten and Whitridge 2007).

Adequate large woody debris – Enough large woody debris must be available to provide adequate damming by either beavers or other mechanisms. The plant community must provide a source of woody debris sufficient to modify stream hydrology, by slowing flow, establishing the floodplain, encouraging local scour pool formation, and promoting wetland vegetation. Damming limits erosion, slows runoff, and provides pools for aquatic species.

Roads can cause stream channel confinement, diversion, and increased sedimentation, particularly at stream crossings

Invasive species are characterized by a tendency to encroach upon and increase in native ecosystems, often with undesirable consequences, such as degraded native species composition or ecological processes.

Climate – Climate dictates water quantity and timing, soil moisture, and vegetation communities. Changes in climate may affect riparian, as much as any system. Climate change’s direct effects will favor drought and significantly alter stream flow regimes. Climate change indirectly influences large wildfires.

Fire – The combination of reduced available water, altered flooding regime that does not remove accumulated fuels, encroachment by upland species, and uncharacteristic wildfire severity can lead to wildfire burning through riparian areas that would otherwise have acted as fire breaks, providing a buffer for streams. The effects of severe fires in upland systems can have indirect effects in downstream riparian areas from increased runoff and sedimentation.

Spatial Scales for Riparian Ecosystems

The plan scale of analysis for riparian ecosystem characteristics is defined by the administrative forest boundary of the Carson NF, and includes any privately owned inholdings. The context scale of analysis is the cluster of seven HUC 8 watersheds that intersect the Carson NF (Figure 32, p.136). The local scale is defined by HUC 12 sub-watersheds within the plan area, though there is not enough information to assess riparian condition at any scale smaller than the plan area. Riparian ecosystems were assessed at the plan scale using information from several forest-wide sources. The same information is not available at the context scale, and on the forest, survey information is not sufficient or distributed adequately to assess conditions at a local scale.

Assessment at the context and local scales is limited to the spatial distribution of riparian areas on and off the forest to describe the Carson NF's riparian niche in the context landscape (Table 17). Acreages were calculated for each HUC 8 watershed that intersects the Carson NF, both within and outside of the forest boundary (Table 17). Because RMAP does not map riparian ERUs in Colorado[1], riparian niche was assessed using LANDFIRE Biophysical Setting. Five LANDFIRE biophysical settings in the context landscape have riparian characteristics (11590-Rocky Mountain Montane Riparian: 644,470 ac; 11600-Rocky Mountain Subalpine/Upper Montane Riparian: 46,888 ac; 11620-Western Great Plains Floodplain: 17,974 ac; 14950-Western Great Plains Depressional Wetland: 9 ac; 11550-North American Warm Desert Riparian: 7,633 ac). Classification of riparian by LANDFIRE does not match the plan scale ERU delineation, either spatially or thematically; therefore, all LANDFIRE riparian BpSs were merged into one riparian cover type for analysis at the context scale.

The Carson NF's riparian contribution to the context landscape is shown in Table 17. Proportional representation compares the portion of the watershed that is in the plan area to the proportion of total riparian that is in the plan area. When more riparian occurs in the plan area than would be predicted, based on the forest's total percent of a watershed, the plan area has greater proportional representation and a disproportionate influence on riparian sustainability in that watershed. In watersheds where riparian occurs disproportionately on the Carson NF, sustainability will be influenced more by conditions at the plan scale than in watersheds with a lower percentage of riparian on the forest, where plan scale conditions may be overwhelmed by off-forest conditions.

[1] Riparian ERUs are mapped by RMAP on Southwestern Region national forests and by ILAP in AZ and NM only.

Table 17. Proportional representation of LANDFIRE Riparian Biophysical Settings within the context scale (HUC 8 watershed)

	Upper San Juan	Conejos	Rio Chama	Upper Rio Grande	Canadian Head-waters	Cimarron	Mora
Watershed ac	2,196,540	490,714	2,020,430	2,081,260	1,103,310	671,148	931,844
Total riparian acres	124,647	54,841	105,392	84,522	25,856	28,168	35,202
% of watershed	5.7	11.2	5.2	4.1	2.3	4.2	3.8
Acres on Carson NF	124,499	125,838	561,112	652,635	2,426	60,922	23,918
Riparian acres on Carson NF	8,300	4,451	27,552	25,071	29	2,520	373
% of Carson NF portion of watershed	6.7	3.5	4.9	3.8	1.2	4.1	1.6
Carson NF's contribution as a % of the watershed riparian (% by total area-all cover)	6.7% (5.7%)	8.1% (25.6%)	26.1% (27.8%)	29.7% (31.4%)	0.1% (0.2%)	9.0% (9.0%)	1.1% (2.6%)
Proportional representation[1]	0.08 more	-0.52 much less	-0.03 nearly equal	-0.03 nearly equal	-0.32 much less	-0.01 nearly equal	-0.42 much less
Number of surveys (RASES/PFC/ Habitat)	0	38 (36/0/2)	133 (126/6/1)	274 (211/37/26)	0	21 (16/1/4)	11 (7/4/0)

[1] Proportional representation is calculated using the formula:

$$Proportional\ Representation\ = \frac{(\%\ of\ Carson\ NF - \%\ of\ context\ landscape)}{(\%\ of\ Carson\ NF + \%\ of\ context\ landscape)}$$

. A value of 1 means the percent of the forest covered by an ERU is the same as the percent of the context landscape covered by that ERU. Positive values indicate the proportion of the forest is greater than the proportion of the context (the ERU is overrepresented on forest). Negative values indicate the opposite (the ERU is underrepresented on forest).

Riparian ERUs vary in terms of redundancy, that is, their extent and uniformity of distribution. A more common riparian ERU has more adaptive capacity than a less common ERU. A more widespread riparian ERU has more adaptive capacity than an ERU that occurs in only one area. When a riparian ERU occurs only a few times within a very limited geographic area, it is vulnerable to events (or actions) that could lead to a loss of integrity over a high proportion of the known occurrences. Redundant systems have a lower risk to system integrity. No riparian ERU on the Carson NF is completely redundant, since none occur in every watershed on the forest; however, that does not necessarily mean there is not sufficient redundancy to offset risk. To describe the distribution of each riparian ERU at the plan scale, a distribution index was calculated. The distribution index is equal to the number of HUC 10 watersheds that contain at least two-thirds of an ERU's total acres, divided by the total number of HUC 10 watersheds where the ERU occurs. Higher values correspond to more uniform distribution. For example, two-thirds of HERB occurs in 27 percent of watersheds, while two-thirds of WTLA occurs in only 13 percent of watersheds. In addition, all watersheds that make up two-thirds of WTLA occur in the Upper Rio Grande HUC 8 sub-basin. While the Distribution Index for RGCS is 0.38, all two-thirds are in the Rio Chama HUC 8 sub-basin.

Table 18. Distribution of riparian ERUs, with over 10 total acres of riparian vegetation, within the context (HUC 8) and plan (HUC 10) scales

HUC 8 (Sub-basin) HUC 10 (Watershed)	HERB	WTLA	UMCW	NSPR	NSHR	RGCS	Total
Canadian Headwaters		42					42
Headwaters Vermejo River		42					42
Cimarron	3,106	291					3,397
Eagle Nest Lake-Cimarron	38	17					55
Ponil Creek	3,068[1]	274					3,342
Mora	363	21	7				390
Coyote Creek	219						219
Upper Mora River	143	21	7				171
Conejos	7320	276	121		12		7,730
Rio de Los Pinos	3,835	230	111		12		4,188
Rio San Antonio	3,485	46	10				3,541
Upper Rio Grande	7,536	7,776	961	4,083	1,708	1	22,065
Costillo Creek	1,538	1,258					2,796
Latir Creek-Rio Grande	15	76		152			242
Red River	159	3,646		2,196	18		6,020
Red River-Rio Grande		57		170			227
Rio Pueblo de Taos-Rio	62	821		598	233		1,713
Rio Pueblo de Taos	1,924	217	46	96	135		2,419
Rio Grande del Rancho	614	100	399		824		1,937
Arroyo Aguaje de la Petaca	225	10			24		259
Embudo Creek	2,721	1,461	457	872	460	1	5,972
Rio Chama-Rio Grande	278	130	59		13		480
Rio Chama	17,796	801	493	65	97	2,918	22,169
Chavez Creek	1,426						1,426
Chavez Creek-Rio Chama	13						13
Rio Tusas	4,910	133	233		35	983	6,295
Rio Cebolla	276	4					280
Rio Nutrias-Rio Chama	732	68					800
Arroyo Seco	3,893	355	71			493	4,813
El Rito	2617	14				608	3,239
El Rito-Rio Chama	4	153				137	293
Rio Vallecitos	3,925	74	188	65	61	381	4,693
Rio Ojo Caliente						317	317
Upper San Juan	259	149				112	520
San Juan River-Navajo						112	112
Canon Bancos	11	149					160
La Jara Creek	248						248

[1] Shaded HUC 10 watersheds represent at least 2/3 of the total ERU area.

HUC 8 (Sub-basin) HUC 10 (Watershed)	HERB	WTLA	UMCW	NSPR	NSHR	RGCS	Total
Forest-wide Total Acres[1]	36,380	9,356	1,581	4,148	1,818	3,031	56,314
Forest-wide Total Perennial Stream Miles[2]	321	175	63	79	48	25	712
Percent of Carson NF[3]	2.29	0.59	0.10	0.26	0.11	0.19	3.55
Percent on NFS lands[4]	64	75	98	75	47	40	66
Distribution Index[5]	0.27	0.13	0.30	0.29	0.20	0.38	

[1] Sum of all ERU acres on the Carson NF.

[2] Number of perennial stream miles that fall within the ERU on the Carson NF.

[3] Forest-wide total ERU acres/total forest acres (1,586,931).

[4] Percent of forest-wide total ERU acres that are on NFS lands (the remainder occur on private inholdings within the forest boundary).

[5] Distribution index (DI) - Number of HUCs making up the top 2/3 of the ERU by area (highlighted)/total #HUCs with the ERU represented (a larger value indicates the ERU is more evenly distributed).

Riparian Vegetation

Reference conditions have not been defined for riparian ERUs on the Carson NF, since no record of reference condition is available. Historically on the Carson NF, as in most of the Southwest, riparian areas have been subjected to water withdrawal (from private water rights), domestic livestock grazing, roads and motor vehicle activity, recreation pressure, and wild ungulate grazing that can all profoundly impair riparian ecosystem function.

Herbaceous Riparian (HERB)

The Herbaceous Riparian (HERB) ERU is extensive and inclusive, occurring at nearly all elevations on the Carson NF (Figure 26). This ERU occurs in 26 of 30 HUC 10 watersheds, making up 2.3 percent (36,366 acres) of the Carson NF overall (Table 18, p. 114). It supports a wide diversity of riparian and wetland herbaceous species that vary greatly with elevation and climate, but sedges (*Carex* spp.) and rushes (*Juncus* spp.) are particularly important to system function (Neary and Medina 1995). It is most common in wide, low gradient meadows, where the water table is seasonally high with saturated soils and trees or shrubs are mostly absent (Culver and Lemly 2013).

Current Condition

HERB is highly redundant and somewhat evenly distributed across the forest (Distribution Index (DI) = 0.27, a larger value indicates the ERU is more evenly distributed). It occurs on the forest in six of the seven HUC 8 watersheds. Overall HERB is moderately departed. Only 13 percent of surveyed HERB areas received the worst PFC rating (FAR, with a downward trend), but less than half are properly functioning. Flood regime has been moderately altered. Although 64 percent of HERB inside the forest boundary is managed by the Carson NF, most areas that are privately owned have been significantly altered by crop cultivation, water diversion, and water impoundment, particularly at lower elevations.

On NFS lands, instream flows are reduced and their timing is altered by human water uses (Romme, Floyd et al. 2009). Decreased flooding, channelization, downcutting, and lowered water tables all contribute to a reduction in available soil moisture and an increase in upland species. Species composition is highly departed, riparian vegetative cover is moderately departed, and ecological status is moderately departed. In areas that have been surveyed, 42 percent have some shrub cover and 52 percent have some tree cover. Though overall vegetative groundcover is similar to reference (16 percent departed), in some areas of the Carson NF, vigor is significantly reduced and species composition is altered, due to historic and current management. Loss of hiding, breeding, and forage cover degrades species habitat and is a major impact in some areas. Reduced cover and dominance by sod forming grasses negatively affects stream temperature, bank stability, and sedimentation.

HERB may be the riparian ERU most impacted by invasive species. Invasive thistles (*Cirsium vulgare, Cirsium arvense, Carduus nutans*, and 70 acres total) have been mapped in Valle Vidal, Camino Real, and Cruces Basin local zones. They were originally spread mainly along roadways, but are becoming increasingly established in riparian areas, distributed by stream flows (USDA FS 2005a). Upland conditions are moderately departed. Beaver activity and coarse woody debris are not characteristic of this ERU. There is not enough information to assess the level of departure for age-class distribution.

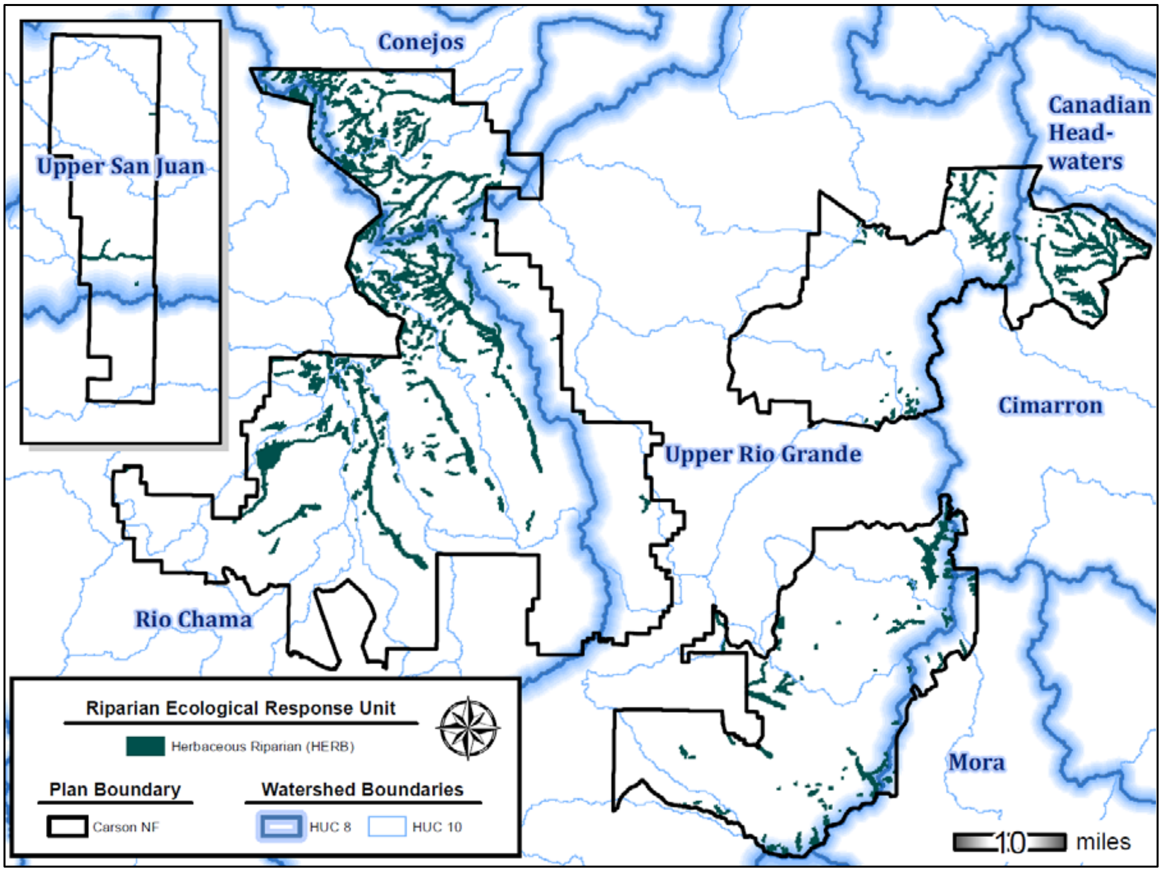

Figure 26. Distribution of Herbaceous riparian ERU across the Carson National Forest

Willow-Thinleaf Alder (WTLA)

The Willow-Thinleaf Alder (WTLA) riparian ERU frequently occurs in wet drainages associated with ponderosa pine and mixed conifer forests. It is generally found in higher elevation stream reaches up to about 11,900 feet; however on the Carson NF, it can also be found in areas like Ojo Sarco (Camino Real RD) and the lower Red River (Questa RD) at around 7,600 feet (Table 18, p. 114 and Figure 27). A total of 9,314 acres (0.59%) occur on the Carson NF. Both thinleaf alder (*Alnus incana*) and willows (*Salix* spp.) are indicative of this ERU, some locations may contain only one species or the other. Common willow species include, dewystem willow (*Salix irrorata*), Drummond's willow (*S. drummondiana*), park willow (*S. monticola*), and grayleaf willow (*S. glauca*) (Triepke et al. 2014).

Current Condition

WTLA is redundant, but not evenly distributed (DI=.13) across the forest, occurring in 24 of 30 HUC 10 watersheds and in every HUC 8 on the forest. Most of WTLA is found in the Upper Rio Grande Watershed. Overall WTLA is highly departed. Almost two-thirds of surveyed streams were properly functioning, and only one had a downward trend. However, coarse woody debris is moderately departed. Only about half of streams surveyed had adequate coarse woody debris, and channel organic debris was rare or absent. No beaver activity was observed, though that may not be the case currently, since beaver have returned to some areas (moderately departed). Species compostition is highly departed, riparian vegetative cover is moderately departed, ecological status is highly departed, and upland condition is highly departed. Conifer species have increased dramatically, due to upland dynamics and decreased competition from riparian species. Vegetative groundcover has decreased by 20 percent overall, mostly from high road density and a shift from riparian groundcover to drier upland species. Sedges and rushes are far below reference, and sod forming, shallow rooted grasses are much more common than perennial bunch grasses - a legacy of past intense, unmanaged grazing and subsequent seeding with annual grasses, resulting in reduced riparian adaptive capacity. Flood regime is moderately departed. There is not enough information to assess the level of departure for age-class distribution.

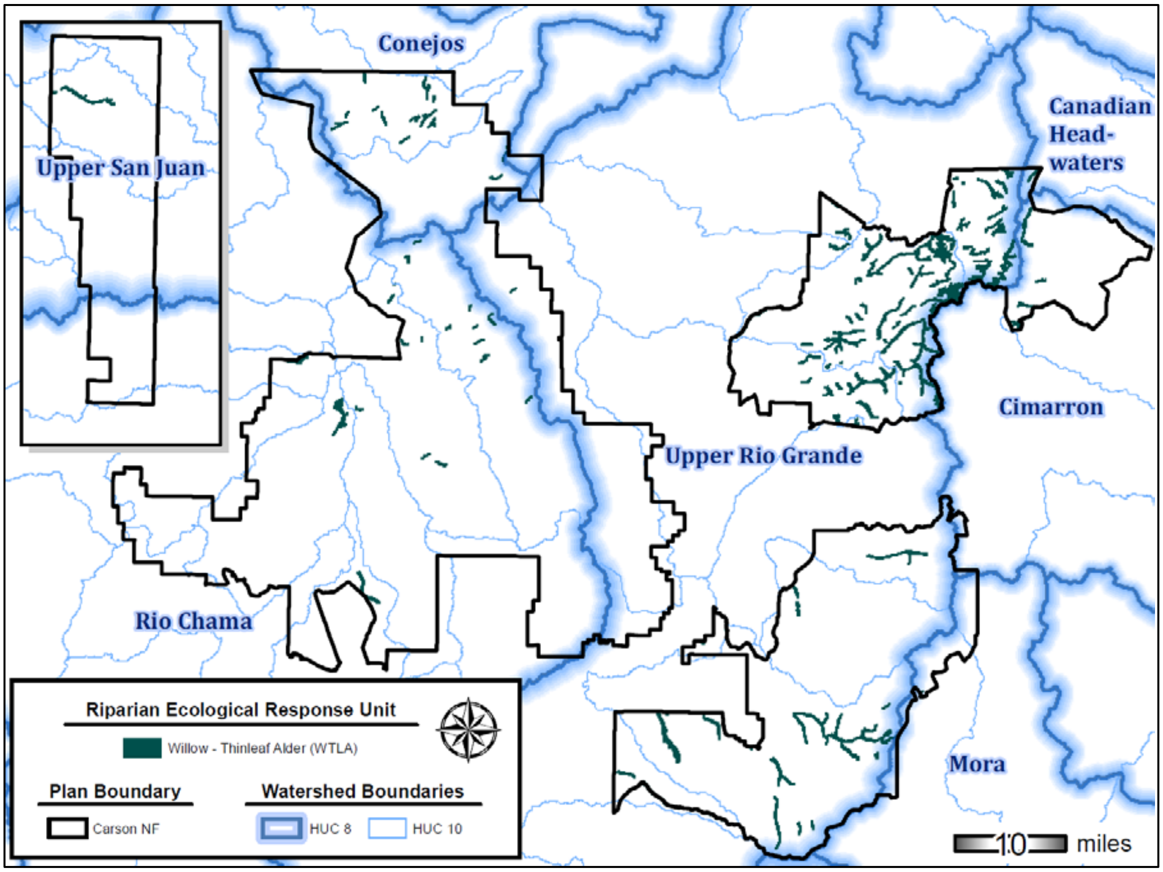

Figure 27. Distribution of Willow-Thinleaf Alder riparian ERU across the Carson National Forest

Upper Montane Conifer-Willow (UMCW)

The Upper Montane Conifer-Willow (UMCW) riparian ERU occurs at elevations up to 11,400 feet. Only 1,581 acres (0.1%) of this ERU is found on the Carson NF (Table 18, p. 114 and Figure 28). It is interspersed among WTLA, but is distinguished by the presence of spruce trees. Other conifer species may include subalpine fir, white fir, and Douglas-fir. Quaking aspen (*Populus tremuloides*) can be present to codominate. Willow (*Salix* spp.) dominates the riparian species, but thinleaf alder and box elder are also common.

Current Condition

While UMCW is rare, it is moderately redundant (occurring in four HUC 8 watersheds) and somewhat evenly distributed (DI = .30). Overall, UMCW has low departure. Just over 50 percent of surveyed streams are FAR, but none had a downward trend. Three of five surveys found an adequate amount of coarse woody debris (low departure) and there was some evidence of beaver activity (moderate departure). All streams surveyed had some level of organic debris in the channel, reflecting high availability from upland and riparian sources. Species composition is moderately departed, riparian vegetative cover has low departure, and ecological status is moderately departed. Conifer and alder species have increased, but sedges have declined considerably. No rushes were recorded. The bunchgrass/sod grass ratio is close to 1, and better than in lower elevation riparian ERUs. Road density is very high, leading to channelization and an overall decrease in vegetative groundcover (-19%). Flood regime and upland condition both have low departure. There is not enough information to assess the level of departure for age-class distribution.

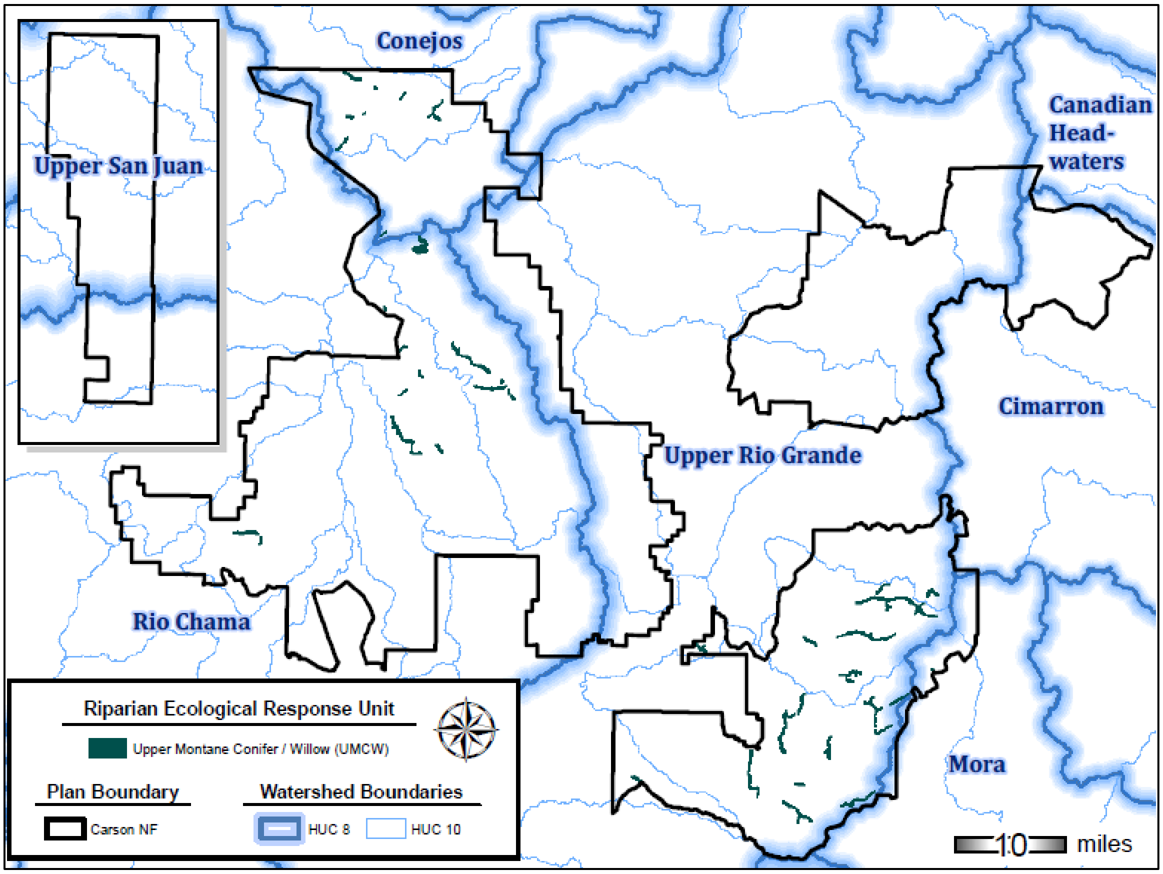

Figure 28. Distribution of Upper Montane Conifer-Willow riparian ERU across the Carson National Forest

Narrowleaf Cottonwood–Spruce (NSPR)

The Narrowleaf Cottonwood-Spruce (NSPR) riparian ERU may be found at elevations up to 10,800 feet, but on the Carson NF it is most common downstream from WTLA and UMCW (Table 18, p. 114 and Figure 29). The Carson NF has 4,148 acres of NSPR, only 0.26% of the forest. Evergreen tree species dominate, particularly Engelmann spruce, but the main riparian species is narrowleaf cottonwood (*Populus angustifolia*). Box elder (*Acer negundo*), willows (*Salix* spp.) are also common.

Current Condition

NSPR is not redundant on the Carson NF, occurring in only seven HUC 10 watersheds, six of which are in the Upper Rio Grande Watershed (HUC 8). Where it occurs, it is somewhat evenly distributed (DI=0.29). Overall, NSPR is moderately departed. The majority of areas surveyed were FAR, and 2 of 4 did not have adequate coarse woody debris, though all had at least some organic channel debris (moderately departed). Beaver activity was observed on 23 percent of streams (moderately departed). Species composition is moderately departed, riparian vegetative cover has low departure, and ecological status is moderately departed. Lower elevation riparian ERUs have experienced a dramatic increase in willow species. Willow may have a competitive advantage under less frequent flooding, due to reduced cottonwood establishment and competition. The increase in willow relative to reference may be partially a result of differences in the way riparian zones were delineated by RASES and TEU surveys.[1] High willow cover provides shade over a large proportion (67%) of stream area, by far the most of any riparian ERU on the forest. Groundcover is only slightly less than reference condition (least departure on the forest). Sod forming grasses are 9 times more common than bunch grasses. Closed roads are very common, but open road density is more moderate. Flood regime and upland condition are moderately departed. There is not enough information to assess the level of departure for age-class distribution.

[1] RASES may have preferentially sampled existing riparian vegetation, as opposed to TEU (USDA 1987), which tried to capture potential riparian extent and would have included a greater proportion of upland (not currently riparian) areas where willow would not be as abundant. A better understanding of the influences from and interaction among drivers is needed to determine the mechanisms that might drive an increase in willow in these systems.

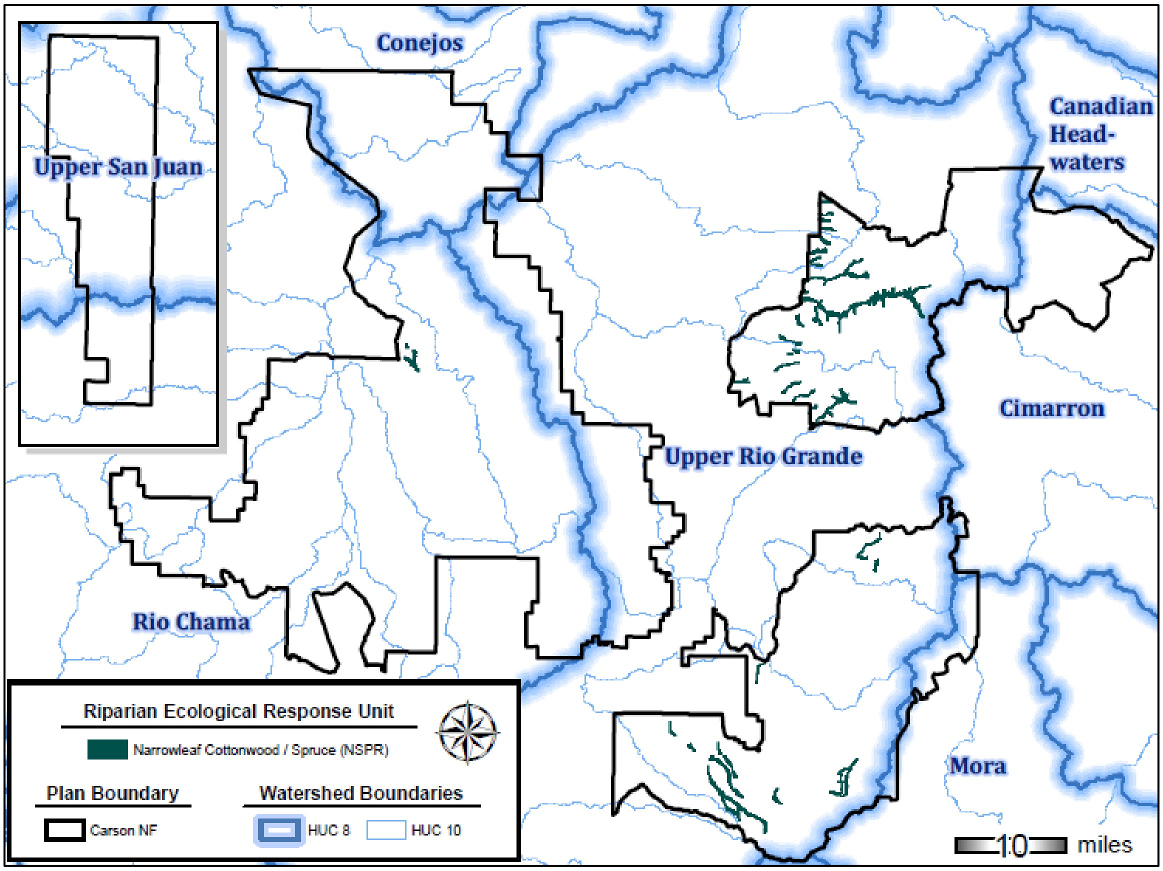

Figure 29. Distribution of Narrowleaf Cottonwood–Spruce riparian ERU across the Carson National Forest

Narrowleaf Cottonwood-Shrub (NSHR)

Only 1,818 acres (0.11%) of Narrowleaf Cottonwood-Shrub (NSHR) riparian ERU is found on the Carson NF (Table 18, p. 114 and Figure 30). It is generally found at lower elevations, downstream from NSPR. NSHR is similar to NSPR, but lacks the spruce dominated overstory.

Current Condition

NSHR's ecosystem characteristics are similar to NSPR. NSHR is not redundant and not evenly distributed, concentrated mainly in the Upper Rio Grande Watershed (HUC 8). Overall NSHR is moderately departed. Coarse woody debris and channel organic debris are slightly more common in this ERU (low departure). Beaver was less common (moderately departed). Flood regime is highly departed, species composition is highly departed, riparian vegetative cover has low departure, and ecological status is moderately departed. Less frequent flooding has driven a shift in species composition, with a significant reduction in cottonwood cover, which is highly departed from a habitat perspective. Percent shade over water is high (59%) and vegetative groundcover is slightly departed (-15%). Sod forming grasses are nearly four times more common than bunch grasses. The mechanisms driving a large increase in willow are similar to those in NSPR. Road density is lower than in NSPR. Over half of NSHR inside the forest boundary is located on private lands and are neither managed nor accessed by the Carson NF. Upland condition is moderately departed. There is not enough information to assess the level of departure for age-class distribution.

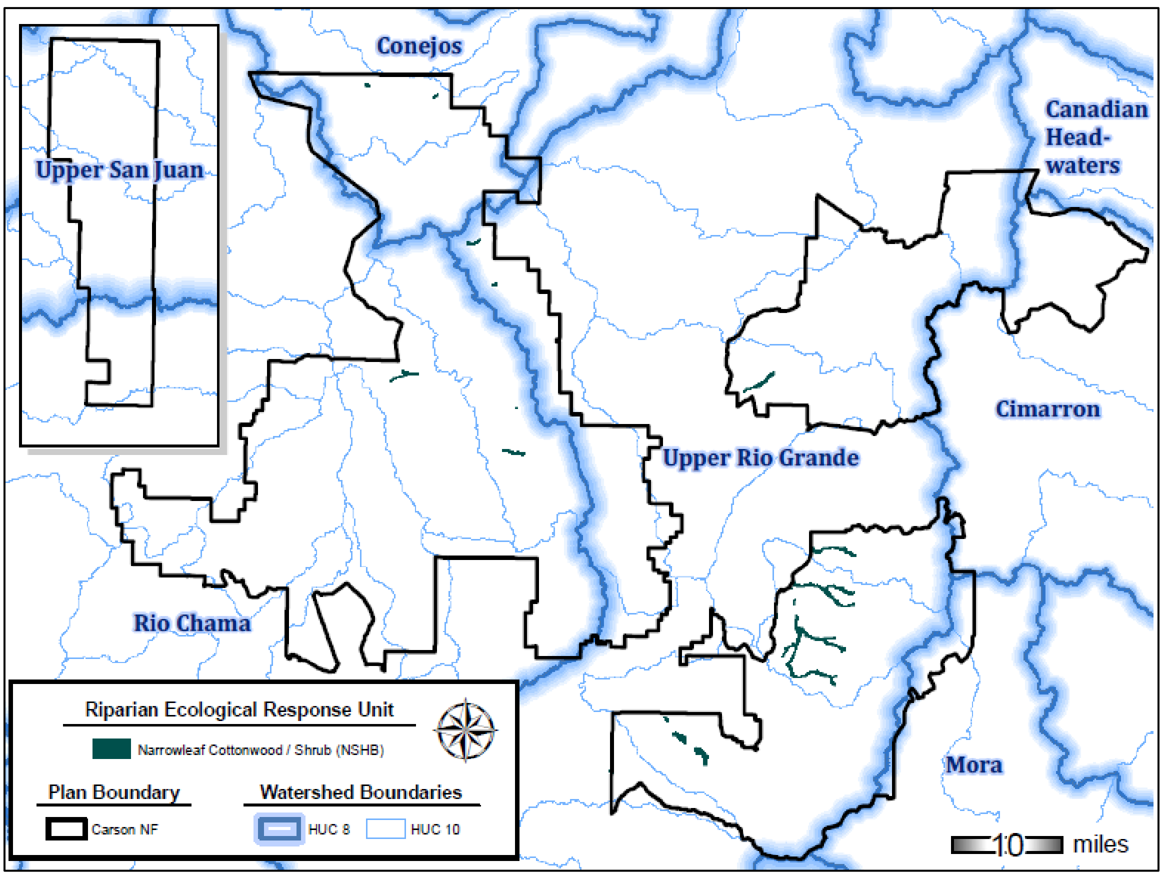

Figure 30. Distribution of Narrowleaf Cottonwood–Shrub riparian ERU across the Carson National Forest

Rio Grande Cottonwood-Shrub (RGCS)

The Rio Grande Cottonwood-Shrub (RGCS) riparian ERU can occur at elevations up to 8,500 feet. Around 3,031 acres (0.19%) of this ERU is present on the Carson NF at the low end of tributaries to the Rio Chama (Table 18, p. 114 and Figure 31). It is occurs along low gradient streams with wider floodplains that provide flood terraces with infrequent flood regimes (Durkin et al. 1995). The overstory is Rio Grande cottonwood (*Populus deltoides*) and willow species may be present.

Current Condition

The majority of RGCS on the Carson NF occurs in the Rio Chama Watershed (HUC 8). It is not redundant, though it is evenly distributed across the 7 HUC 10 watersheds that contain the majority of RGCS. It makes up a small percentage of the forest, and only 40 percent occurs on NFS lands, yet conditions in areas that have been surveyed are highly departed overall and consistent with conditions recorded elsewhere in the context landscape. Species composition, riparian vegetative cover, and ecological status are highly departed. Vegetative groundcover is almost 70 percent lower than reference and sod forming grasses dominate. Rio Grande cottonwood-shrub systems in the region generally have been heavily grazed and flood regimes have been significantly altered (Romme, Floyd et al. 2009). Together, these impacts reduce cottonwood and willow reproduction and allow the invasion of alien species, such as Russian olive (*Elaeagnus angustifolia*) and salt cedar (*Tamarix* spp.) (Dick-Peddie 1993). On the Carson NF, cottonwood and willow cover have decreased and percent shade over water is only 3 percent. Most cottonwood trees that remain are mature, with little reproduction. The average number of canopy levels is only 1.5 in areas surveyed (highly departed). A much higher average would be expected with higher rates of tree establishment under reference conditions. Cottonwood gallery forests would require active management to restore, as they will not likely reestablish on their own (Dick-Peddie 1993). Beaver activity is highly departed, upland condition is moderately departed, and coarse woody debris is moderately departed.

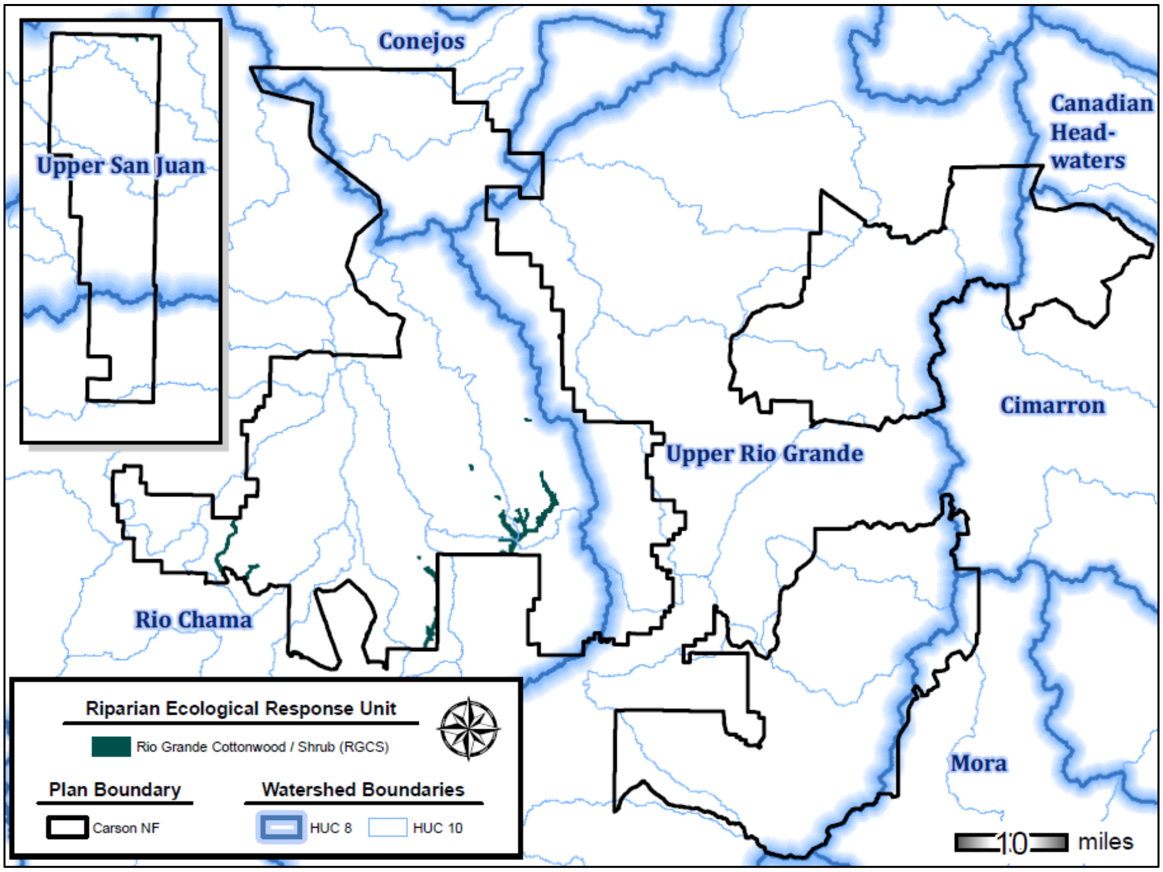

Figure 31. Distribution of Rio Grande Cottonwood-Shrub riparian ERU across the Carson National Forest

Riparian Ecosystem Trend

In most cases, there is insufficient informational resolution to draw conclusions regarding trend for individual riparian ERUs; however, some trends, based on water availability, water use, and upland watershed conditions are clear. One-third of all riparian vegetation on the Carson NF is contained within private inholdings, where the forest does not impact management. The impacts to riparian systems in these areas are expected to continue or intensify. This includes impacts from water extraction and impoundment for agriculture or other uses; impacts (runoff and sedimentation) from agriculture; grazing; or other private land development; impacts (reduction of groundcover and bank destabilization) from livestock grazing; and impacts from the conversion of wetlands to other uses. On NFS lands, current levels of human disturbance and the associated impacts are expected to continue. These include the combined impacts from roads, concentrated recreation, grazing, and other development that increase siltation and removal of vegetative cover and reduce infiltration, compared to historic levels. Introduced grass species, like Kentucky bluegrass, are expected to persist and expand. Beaver populations may continue to recover, but will be maintained below historic levels, due to competing demands, such as wildlife and livestock foraging, which limit woody species establishment, maintaining consistent stream flow for acequias and agriculture, and preventing flooding of infrastructure or fields used for agriculture or grazing.

Riparian systems will be influenced by trends in the adjacent upland ERUs (see Terrestrial Ecosystems section, p. 16). Lack of functional vegetative cover in lower elevation upland ERUs on the Carson NF will continue to alter runoff, such that headcutting and stream incision are likely. Increased biomass in frequent fire systems may reduce instream flows through increased evapotranspiration, but may also make organic matter more available, particularly as mortality increases. Increased risk of large, severe wildfire and insect and disease outbreaks may have direct impacts on riparian vegetation in the form of uncharacteristic mortality, and may also impact stream function through increased runoff and sediment loads originating in burned areas.

Predicted impacts to aquatic ecosystems, include altered seasonal discharge events, increases in drought severity during summer flows, and increasing temperatures in small streams and tributaries that further limit habitat. There are already observed shifts in the timing of snowmelt in the American West, which, along with increases in summer air temperatures, have serious implications for the survival of fish species, and may affect the success of some efforts to reintroduce species into their historic range. For cool and coldwater species, a nearly 50 percent reduction in thermal habitat is projected, given a 4.4^{o} C average temperature increase (Eaton and Scheller 1996) and thermal habitat fragmentation is expected to increase (Meyer et al. 1999). Warmer stream temperatures also affect nutrient cycling and uptake, and may degrade downstream water quality (Meyer et al. 1999). Earlier spring warming may have cascading effects of development and generation timing for aquatic insects that are highly sensitive to temperature (Meyer et al. 1999). Many of the region's plant, animal, and insect species depend on precise phonological events based on climatic conditions for migration, flowering, and timing for foraging and reproductive activities. Climate thus influences their distribution and abundance through changes in resource availability, fecundity, and survivorship (USDA FS 2010b).

Projected future drought conditions will exacerbate water quality problems by concentrating pollutants. Projected lower flows will also reduce instream habitat, soil moisture, and groundwater levels, resulting in changes in species composition and productivity. Projected drier overall conditions will favor upland adapted species over existing riparian species (NM 2005).

Projected more frequent extreme flood events will degrade stream channel morphology and function. Bank erosion, sediment transport, runoff contamination, and scouring of debris from stream channels are all projected to intensify (Meyer et al. 1999). While mean runoff may decline, and peak timing may shift, riparian condition will be impacted most significantly by projected extremes of drought and flooding (Meyer et al. 1999). Cottonwood establishment, for example, is more dependent on timing of spring floods and inundation duration, than on total average streamflow (Auble et al. 1994; Poff et al. 2002). More variable flow will likely drive the need for more storage, particularly in combination with demand from a growing human population (NM 2005). If the solution is to construct additional impoundments, habitat may be further fragmented (Meyer et al. 1999).

Summary of Ecosystem Characteristics for Riparian Vegetation

Flood Regime

Flood regime has not been directly measured, but has been altered by water withdrawals, diversion, and storage as discussed in the Surface Water section (p. 141), as well as changes to channel shape and function, as measured by PFC ratings. Channel confinement results in faster runoff, because water is not being stored or delayed. Channel confinement may result from incision, which is a factor in PFC and Rosgen ratings, or from roads built in the floodplain that restrict flood flows. The degree to which roads are restricting flood flows have not been measured, but it is assumed to be more likely where road densities are higher. Flood regime impacts are cumulative, that is, upstream alterations also affect downstream flows. Therefore, flood regime is least impacted in UMCW, which occurs at mostly high elevations (Table 19, p. 133). NSHR and RGCS occur downstream at lower elevations and have been and are still more altered by human development and activities. At the context scale flood regime is even more departed due to additional water use and channel alteration (see Aquatic Ecosystems section, p. 141).

Beaver Activity

There are many fewer beaver dams on the Carson NF now than in the past, due to historic beaver trapping. Across all ERUs, very few RASES surveys recorded effects on streams from beaver dams, such as water impoundment or flood plain alteration. There is anecdotal evidence that beaver populations have recovered on some parts of the Carson NF, since the RASES surveys were conducted in the late 1980s. Therefore, though the available data indicates that departure across the plan area is high,[1] the trend is improving or stable and risk is moderate (Table 19, p. 133). The RGCS ERU is the exception. Beaver have not recovered in this ERU on the forest. The history of beaver extirpation is similar at the context scale. While some areas have seen recovery comparable to that the plan scale, human uses and desires that are incompatible with beaver dams are more common and as a result their reestablishment and success at the context scale has likely been more limited.

Upland Condition

Upland conditions are fully described by terrestrial ERU in the Terrestrial Ecosystem section and summarized (Table 15, p. 97). Risk due to upland condition is summarized for riparian ERUs for those upland ERUs that are adjacent (Table 19, p. 133). WTLA intersects with mostly frequent fire upland ERUs, which are highly departed. These ERUs are at high risk from uncharacteristic wildfire and subsequent erosion, and are more susceptible to insect and disease damage. Tree stands are crowded and more water is lost to transpiration, leaving less to support riparian function. UMCW is surrounded mostly by SFF and MCW, both of which have low departure and for the most part regulate hydrologic function and sediment delivery. Other riparian ERUs are adjacent to upland ERUs that are moderately departed or a mix of departed and less departed ERUs. The pattern of departure is probably similar at the context scale, though this cannot be conclusively stated, since riparian ERUs have not been spatially defined on the context landscape outside of the Carson and Santa Fe NFs.

[1] HERB does not characteristically contain trees and therefore does not naturally provide habitat for beaver.

Age-Class Distribution

Age classes of riparian species have not been specifically measured. Average number of canopy levels of all species was measured during RASES surveys. For most riparian ERUs, multiple canopy levels were recorded. This may indicate distribution among age classes of riparian species, but it could also reflect understory invasion by upland species or even conversion to mainly upland species. Multiple canopy levels do not necessarily indicate there is adequate riparian species recruitment or replacement; therefore, departure and trend for age class distribution are unknown (Table 19, p. 133). The RGCS riparian ERU is an exception. There are fewer than 2 canopy levels, indicating that recruitment of all species is lacking and that Rio Grande cottonwood in particular is not reproducing. This trend has been observed anecdotally on the Carson NF and has been documented throughout the context landscape (Dick-Peddie 1993). It reflects the significant alteration in flow regime, and a history of heavy, unmanaged grazing (Dick-Peddie 1993).

Species Composition

Species composition is a component of PFC ratings, and can influence the Habitat Survey coarse woody debris rating and the RASES organic debris and percent shade over water ratings. It is more directly measured by the RASES overstory ecological status (comparison of RASES overstory species to TES “natural” species percentages), by TES ecological status, and by the RASES perennial bunch grass to sod forming grass ratio. In HERB, species composition has been altered by changes resulting from historic overgrazing and continued grazing, fire exclusion, concentrated recreation, and dewatering from surface and groundwater withdrawal, upland species encroachment, or channel incision. Changes that have been measured include, woody species encroachment, conversion of native bunch grass cover to (mostly introduced) sod forming grass cover, and the spread of invasive species, all of which are expected to persist or worsen into the future (high risk, Table 19, p. 133). Departure, trend, and stressors are similar in WTLA. Fire exclusion has had a substantial impact as fire adapted upland systems have expanded into riparian zones and reduced available water. Riparian *Carex* and *Juncus* have declined. Species composition in RGCS on the Carson NF and in the context landscape has been impacted by heavy, unmanaged grazing, agricultural conversion, and substantial stream flow regulation. There is much less understory cover, which is evident in the nearly 70 percent decrease in vegetative groundcover and mere 3 percent shade over water in RGCS. RGCS cover is 32 percent below reference, and not reproducing as indicated by the low number of canopy levels. Both narrowleaf cottonwood ERUs have a much greater proportion of sod forming grasses than native bunch grasses, as a result of seeding combined with past and current grazing. NSHR generally occurs at a lower elevation than NSPR, where flow alteration is compounded, resulting in a more substantial decline in cottonwood regeneration and cover. UMCW is at moderate risk, with moderate ecological status departure (55%), but a large increase in the number of conifer species. UMCW is higher elevation than other riparian ERUs, and has been impacted less by human activity, but it has been effected by drought, which shrinks the riparian zone, and by fire exclusion, which encourages conifer expansion. Many riparian areas outside the forest have been converted to agriculture, and native species have been removed.

Riparian Vegetative Cover

Vegetative groundcover departure is low in all riparian ERUs except RGCS where it is high (69%). In HERB and WTLA the summary of risk due to a loss of vegetative groundcover is moderate because of decreased above ground biomass (Table 19, p. 133). To some extent this is a result of conversion from bunch grasses to sod forming grasses, but mainly it is due to wildlife and livestock grazing and concentrated recreation that trample or remove large amounts of above ground vegetation. Where these ERUs occur outside the plan area recreation and grazing have had similar impacts.

Coarse Woody Debris

Coarse woody debris is similar to reference in UMCW, NSPR, and NSHR and moderately reduced in WTLA and RGCS (Table 19, p. 133). Less large wood is available in the WTLA system naturally.[1] Neither willow nor alder produce large enough trees to maintain function on their own, and an altered flood regime has reduced recruitment from upstream sources. Streams are kept free of debris for irrigation efficiency, particularly at lower elevations where WTLA is most common. The same is true in the highly regulated RGCS ERU, where large wood is not being deposited by flooding, and is removed where it does exist. The contribution of debris from cottonwoods has been reduced too, as regeneration has slowed. Under reference conditions coarse woody debris is not a significant characteristic in the HERB ERU.

Ecological Status

Ecological status takes into account both riparian and upland species composition and percent cover. It is summarizes the difference between current and potential natural vegetation communities. Ecological status departure for each riparian ERU is summarized:

- **HERB** is high (73%). Fescue species (native bunch grasses) have declined and have been replaced by Kentucky bluegrass (*Poa pratensis*). Sedges (*Carex* spp.) have declined slightly and dandelion (*Taraxacum officinale*) has increased.
- **WTLA** is high (81%). Decrease in willow species (*Salix spp*). Increases in rushes (*Juncus drummondii*) and some sedges (*Carex aquatilis, C. bella*).
- **UMCW** is moderate (45%). Decrease in willow species, Engelmann spruce (*Picea engelmannii*), and sedges. Increase in dandelion (*Taraxacum officinale*) and Kentucky bluegrass.
- **NSPR** is moderate (41%). Alder species have declined (*Alnus incana*, *A. oblongifolia*), aspen and sedges have increased. Blue spruce (*Picea pungens*) has increased and Douglas fir (*Pseudotsuga menziesii*) has decreased.
- **NSHR** is moderate (54%). Upland conifer species (*Abies concolor*, *Picea pungens, Pseudotsuga menziesii*) have increased, thinleaf alder (*Alnus incana*) has decreased, and Kentucky bluegrass has increased.

[1] Stream habitat surveys did not distinguish among ERUs. In all stream segments 30 pieces of wood at least 12 inches in diameter and longer than 35 feet were required for properly functioning habitat.

- **RGCS** is high (68%). Rio Grande cottonwood (*Populus deltoides*) did not show a decline, but willow species declined dramatically. Annual forbs increased (*Ambrosia psilostachya*, *Melilotus officinalis*).

Soil Condition and Erosion Hazard

HERB is at moderate risk for soil condition and soil erosion hazard due to the extensive use by grazing animals (domestic and wild ungulates) and resulting loss of function from decreased groundcover, loss of bank stabilizing vegetation through an increase in non-native grasses (e.g., Kentucky bluegrass), and mechanical damage to soils by grazing animals and human use (Table 19, p. 133). WTLA and RGCS are also at moderate risk, due to their past and current uses. These ERUs typically occur in lower elevations and more open and accessible locations than UMCW, NSPR, and NSHR; therefore, subject to many uses (grazing, recreation, water development, etc.) that upper elevation ERUs are not. Less stream flow and a lower water table lead to drier, less productive, and more erodible soils. Alteration of the flood regime may also be a factor.

Summary of Riparian Ecological Integrity

Key Findings of Riparian Ecosystems

In general, riparian ecosystems on the Carson NF are currently at risk, and future impacts from fire, drought, and climate change will stress them further (Table 19). There are functional systems on the Carson NF representative of each riparian ERU, with the possible exception of RGCS. For the most part, upper elevation systems (especially UMCW) are functioning properly. Lower elevation ERUs are more departed, due to greater human activity, including water withdrawal, diversion and storage, agriculture, livestock grazing, recreation, and seeding with non-native species. Degradation at lower, drier elevations is compounded by upland systems with inherently less groundcover, and less capacity to recover. Legacy impacts from intensive, unmanaged grazing, fire suppression, and beaver trapping are still evident in many riparian systems. The shift from bunchgrasses and native riparian species to sod forming grasses, like Kentucky bluegrass, is pervasive. Stressors, including invasive species and climate change and its associated effects, will significantly increase risk in riparian systems. These stressors are not addressed in this discussion or in the ratings in Table 19 (stressors are incorporated in the integrated risk section). More complete and more recent monitoring of riparian condition is needed.

Table 19. Summary of risk to riparian ecological integrity

	HERB	WTLA	UMCW	NSPR	NSHR	RGCS
Flood regime	Mod	Mod	Low	Mod	High	High
Beaver activity	N/A[1]	Mod	Mod	Mod	Mod	High
Upland condition	Mod	High	Low	Mod	Mod	Mod
Age-class distribution	N/A	N/A	N/A	N/A	N/A	High
Species composition	High	High	Mod	Mod	High	High
Riparian vegetative cover	Mod	Mod	Low	Low	Low	High
Coarse woody debris	N/A	Mod	Low	Low	Low	Mod
Ecological status	Mod	High	Mod	Mod	Mod	High
Soil condition & erosion hazard	Mod	Mod	Low	Low	Low	Mod

[1] N/A = Not Applicable or Not Assessed

Aquatic Ecosystems

This assessment of aquatic ecosystems uses the BASI to characterize and evaluate the status of watersheds and water resources (surface and groundwater) and their role in sustaining the structure and function of terrestrial, riparian, and aquatic ecosystems on the Carson NF and at the larger context scale, assuming management consistent with current plan direction. The status of watersheds and water resources across the larger landscape influences conditions on the forest, and in turn the forest contributes to the overall sustainability of areas far from Forest Service ownership.

In addition to sources specifically cited below, the following State of New Mexico regional water plans[1] were considered:

- Colfax Regional Water Plan (2003)
- Rio Chama Regional Water Plan (2006)
- San Juan Regional Water Plan (2003)
- Taos Regional Water Plan (2008)

Aquatic Ecosystem Services

Aquatic resources on the Carson NF offer many ecosystem services from which society derives enjoyment or benefit, including:

- **Supporting** ecosystem services of water in streams, springs, and seeps support society by contributing to nutrient cycling and primary production, and water is a catalyst in soil formation. Streams, springs, seeps, and groundwater resources provide fresh water for people and all other life forms, satisfying thirst for all.

- **Regulating** ecosystem services of water contribute to storage and diversions for current and future use of domestic and agriculture needs, erosion control, flood regulation, drought control, recharging aquifers, and water purification.

- **Provisioning** ecosystem services of water is critical in the production of forage for livestock, fruits and nuts, and game animals taken for meat and other animal products. Mining and other industries related to fuel and energy extraction also depend on water as a provisioning service for their operations.

- **Cultural** ecosystem services of water provides for society in a multitude of ways, such as research opportunities, educational study areas, and public entertainment opportunities. Providing recreation (e.g., fishing, wildlife viewing, boating, and swimming) or places of quiet solitude and personal enrichment next to a stream or spring are other forms of cultural services. All of these opportunities depend on clean and available stream flow.

All of these ecosystem services related to watersheds and water are becoming more valuable in the context of the larger landscape, where many watersheds off the plan area are facing increased development pressure and degrading influences. However, the quantity of these same ecosystem services on the Carson NF may be declining in the face of drier and hotter climatic conditions and increased demand of water resources.

[1] Regional water plans are available from the NM Office of the State Engineer/Interstate Stream Comission Website.

Spatial Scales for Aquatic Ecosystems

Surface drainage basins are used to define areas that are hydrologically connected to the Carson NF at three scales. The US Geological Survey (USGS) has divided and subdivided the United States into hierarchical hydrologic units based on the area of land that drains to a single stream mouth or outlet. A unique hydrologic unit code (HUC) identifies each unit at each level, and nested levels are identified by successively longer codes. A HUC 8 sub-basin is 700 square miles or larger and is divided into multiple HUC 10 watersheds that range from 62 to 390 square miles. HUC 12 sub-watersheds are 15 to 62 square miles and nest inside HUC 10 watersheds (Table 20).

The Carson NF only has authority to manage those resources that occur on NFS lands within its boundaries. The plan and local scales are therefore defined by the Carson NF boundary, though for some analyses it is more appropriate to consider complete watersheds, rather than splitting them by ownership. In these cases, plan and local scale include watersheds and sub-watersheds that intersect the plan area, in their entirety. The local scale is made up of the 131 sub-watersheds (HUC 12) that intersect the Carson NF. The plan scale defined by the 38 intersecting watersheds (HUC 10). The context scale is the group of nine sub-basins (HUC 8) that intersect the Carson NF (Figure 32, p. 136). Over 76 percent of the Carson NF drains into two sub-basins, the Rio Chama and the Upper Rio Grande. Most of the Jicarilla RD drains into the Upper San Juan sub-basin, though that area is much drier overall and contains little of the total water on the Carson NF.

Table 20. Sub-basins and their extent that intersect the Carson National Forest

	Upper San Juan	Blanco Canyon	Alamosa-Trinchera	Conejos	Rio Chama	Upper Rio Grande	Canadian Headwaters	Cimarron	Mora
Sub-basin acres (12,216,578 total)	2,196,544	1,097,244	1,624,085	490,714	2,020,427	2,081,262	1,103,310	671,148	931,844
Sub-basin percent of context landscape	10.39	5.19	7.68	2.32	9.56	9.85	5.22	3.17	4.41
Sub-basin acres on Carson NF	124,499	33,362	2,362	125,271	561,112	652,635	2,426	60,922	23,918
% of Carson NF in each sub-basin	7.85	2.10	0.15	7.90	35.37	41.14	0.15	3.84	1.51
Carson NF's contribu-tion as % of sub-basin[1]	0.06 (under repre-sented)	0.03 (under repre-sented)	0.00 (under repre-sented)	0.26 (over repre-sented)	0.28 (over repre-sented)	0.31 (over repre-sented)	0.00 (under repre-sented)	0.09 (similar)	0.03 (under repre-sented)

[1] Contribution = $\frac{Acres\ on\ Carson\ NF}{Acres\ in\ subbasin}$. Proportion is compared to the proportion of the context scale that is on the Carson

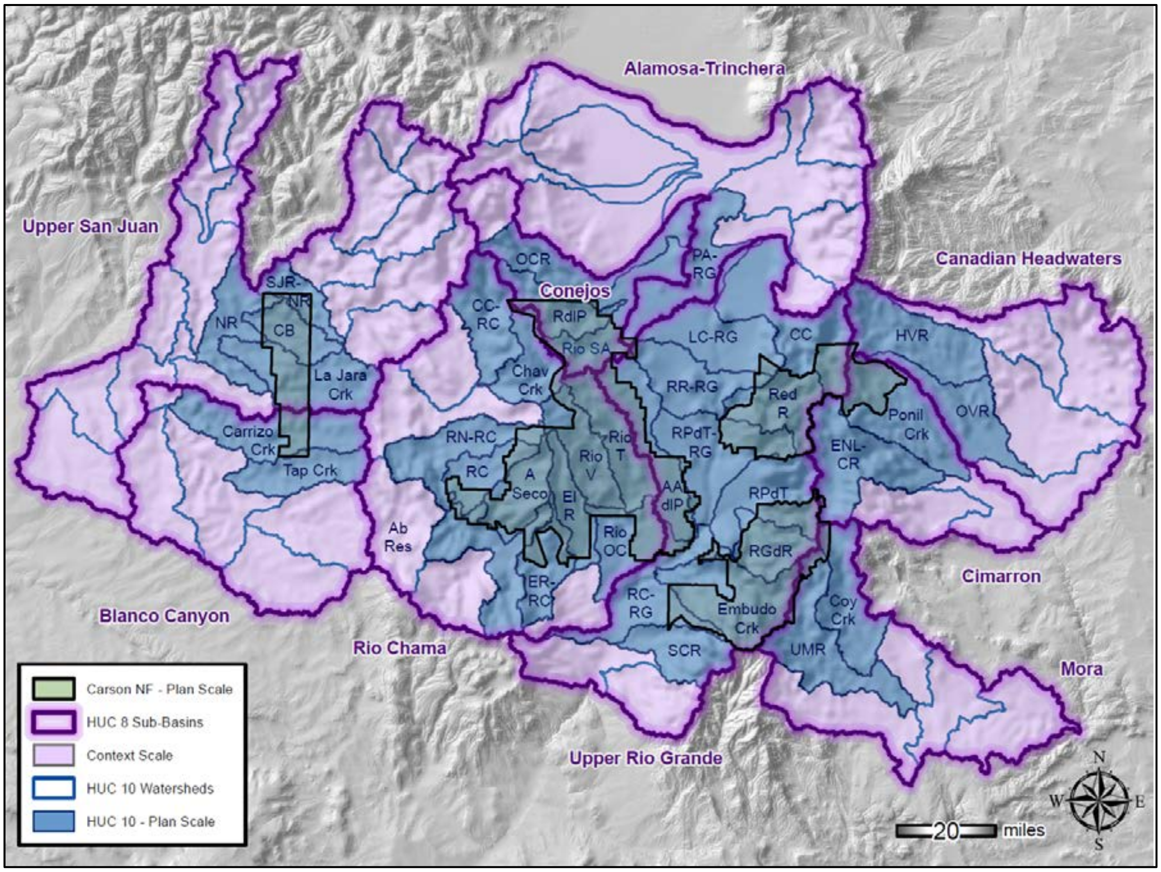

Figure 32. Context and plan scales for aquatic ecosystems on the Carson National Forest[1]

NF (13%) to determine representativeness.

[1] The local scale is made up of those 131 HUC 12 sub-watersheds that intersect the Carson NF and are not shown on this map.

Key Ecosystem Characteristics for Aquatic Ecosystems

Table 21. Water features and key ecosystem characteristics

Water Resource Feature	Key Ecosystem Characteristic (How Measured)
Perennial streams	▪ Representativeness and redundancy at the plan scale ▪ Water quality – miles of impaired perennial stream (attainment status NMED §303(d) list) - All 3 scales ▪ Water quantity – change in amount & timing - Plan and local scales
Waterbodies (lakes, ponds, wallows, fens, stock tanks, etc.)	▪ Representativeness and redundancy at the plan scale
Seeps and springs	▪ Representativeness and redundancy at the plan scale ▪ Percent developed or degraded at the plan scale
Wetlands	▪ Representativeness and redundancy at the plan scale
Groundwater	▪ Recharge and discharge zones ▪ Wells per acre within Carson NF boundary - plan scale
Aquatic biota	▪ Native species (presence or absence) Plan & local scales ▪ Invasive species (presence or absence) Plan & local scales ▪ Macroinvertebrates (species & distribution) Plan & local scales

Representativeness and redundancy is based on occurrence of a feature in the plan area, compared to the wider landscape (see complete discussion below). The locations of perennial streams are based on the National Hydrography Dataset (NHD),[1] with modification based on Carson NF agency specialist knowledge. Locations of other surface water features, such as springs, seeps, and waterbodies, are from NHD (USGS 2015a). Waterbodies were limited to 3 NHD feature types: 390 (lake/pond), 361 (playa), and 466 (swamp/marsh). The locations of wetlands are from the National Wetland Inventory (NWI).

Stream water quality is measured by the State of New Mexico. Streams that do not meet their designated uses are listed in the §303(d)/§305(b) Integrated List and Report (NMED 2014). The water quality in each HUC 10 watershed at the plan scale was rated according to the percent of streams on the Carson NF that are impaired on the state list. Watersheds with 0-10 percent stream impairment are classified as moderately at risk, those with over 10 percent impairment are classified as high risk.

Water quantity information was compiled from available USGS stream gauge data for drainages at the context, plan, and local scales.

Seeps and springs - The Carson NF maintains GIS locations of seep and spring developments. Some springs on the Carson NF have been assessed for proper functioning condition. The

[1] Available for download from: http://nhd.usgs.gov/.

percentage of springs at the plan scale that either coincide with an inventoried development or have been rated as not properly functioning was calculated for each HUC 10 watershed.

Groundwater well locations are maintained by the NM Office of the State Engineer (NMOSE). The number of wells within the Carson NF, including private inholdings, was summarized by HUC 10 watershed.

System Drivers and Stressors for Aquatic Ecosystems

The system drivers and stressors that affect the key ecosystem characteristics for aquatic ecosystems are:

- Surface water diversions and use
- Groundwater extraction
- NFS and non-NFS roads, trails, and stream crossings
- Ungulate foraging and grazing
- Climate
- Upland vegetation condition

Surface water diversions and use - Water originating from the forest is used both on and off forest for many uses. Groundwater and surface water uses include, but limited to:

  - drinking water
  - waste disposal
  - livestock
  - agricultural
  - industry
  - recreation
  - wildlife

Some of these uses directly benefit the Carson NF. Other uses directly or indirectly degrade terrestrial and aquatic resources, both on and off the Carson NF. There are many groundwater and surface water rights that serve private, industrial, public, tribal, federal, state, county, or community uses. Acequia water use originating from the Carson NF is a critical cultural use and is partially incorporated in the analysis portion of New Mexico Office of the State Engineer derived data of existing known groundwater wells and surface take-outs (diversions) that exist within the State of New Mexico, which are analyzed at the HUC 12 sub-watershed local scale.

Diversion and use remove water from streams, which affect the quantity and quality of physical habitat and reduce groundwater recharge. Lower streamflow leads to higher stream temperatures and concentration of pollutants.

Groundwater extraction - Groundwater pumping can lead to a lowered water table, increased pumping cost, less available water for discharge to streams and lakes, and land subsidence.

NFS and non-NFS roads, trails, and stream crossings are known to create sediment detachment and transport. Best management practices (BMPs) that are planned, implemented, and/or maintained greatly decrease detachment and transport of sediment. High road densities, and especially roads located in riparian areas, can create conditions that degrade floodplain and/or channel function. User-created (unmanaged) routes and poorly stabilized old logging skid trails exist in various densities throughout the Carson NF. Motorized and non-motorized trails may have similar effects on sedimentation and overland flow concentration.

Ungulate foraging and grazing currently occurs from native and non-native wildlife and livestock. Reference condition prior to European settlement likely included effective populations of ungulate predators. Anthropogenic manipulation of ungulate and predator populations is a significant stressor on watershed, riparian, and stream channel function. Ungulates without effective predators are known to excessively graze riparian vegetation, resulting in the removal or degradation of riparian vegetation necessary to provide bank stabilization and a food source for beavers. Willows (*Salix* spp.), alders (*Alnus* spp.), quaking aspen (*Populus tremuloides*) are often browsed to an extent that recruitment levels fail to sustain a resilient system. Deciduous components are preferentially consumed allowing for conifer encroachment (Roger and Mittanck 2014). This results in a cascading effect that reduces soil organic carbon, which has less available water holding capacity (Shepperd et al. 2006; Woldeselassiea et al. 2012) and promotes warm season bunchgrasses over cool season bunchgrasses. Eventually overgrazing removes bank stabilizing vegetation, creating channel downcutting and a dysfunctional floodplain (Beschta and Ripple 2006).

Climate dictates timing, amount, and type of precipitation and controls the evapotranspiration rate through temperature and vegetation assemblages. Aquatic ecosystems have evolved to be resilient in the face of a certain level of variability in climatic regime. Climate becomes a stressor when it exceeds the NRV in terms of averages, extremes, or variability (see Climate Change section, p. 275).

Upland vegetation condition – Vegetation and soil condition influence water quality, runoff timing, and groundwater recharge through the combination of precipitation interception, evapotranspiration rate, soil and stream bank stability, and shading. For example, frequent fire ponderosa pine and mixed conifer forests are more dense and even-aged as a result of fire suppression. They are more susceptible to uncharacteristic, severe wildfire that removes cover and degrades soil stability, raising the potential for flooding, erosion, and sedimentation (see Mixed Conifer, with Frequent Fire p. 56; Ponderosa Pine Forest p. 60; Fire Frequency p. 81; and Fire Severity p. 83 sections).

Assessing Risk to Ecological Integrity

Risk summarizes threats to ecological integrity from unsustainable levels of stressors, either current or predicted. The risk of losing integrity for each key ecosystem characteristic is summarized by HUC, in order to quantify overall risk to the system. Risk is assessed on NFS lands as it relates to systems and processes that are under agency control and/or authority. However, to fully understand risk to these lands, systems, and processes, they are assessed in the context of the larger landscape, to the extent possible. An understanding of the environmental context extending beyond the plan area is useful in determining opportunities or limitations for NFS lands to contribute to the sustainability of broader ecological systems, as well as the impacts of the broader landscape on the sustainability of resources within the plan area. In some instances, a unique role of the NFS lands may become apparent at this larger scale (FSH 1909.12, Chap. 10, Sec. 12.13b).

In most cases, natural range of variation (NRV) for aquatic resources is not measurable or quantifiable, and given current climatic and cultural conditions it may not be possible or desirable to restore aquatic systems to their natural variability. In some cases regulatory condition may supersede NRV, then departure and trend relative to the regulated reference condition defines risk. For example, water quality standards are set by the State of New Mexico and are used as reference condition for this assessment.

When NRV is not known and no regulatory standard applies, risk can be assessed by rating the representativeness and redundancy of a feature. Representativeness indicates that a given area contains a proportional amount of a system. Features that are not adequately represented on the Carson NF may require more attention to ensure adequate system function, likewise, features that are over-represented may impose a greater responsibility to maintain system integrity. Redundancy is the degree to which a feature occurs repeatedly and in a distributed pattern across the landscape. A system lacks redundancy when it its features occur only a few times, and in a limited geographic area. A system that is not redundant is vulnerable to events of limited scope or frequency that could nonetheless impact the integrity of a high proportion of the features. A system with high redundancy is less vulnerable to such events, since they would only affect a small portion of features at any one time. Thus, less redundancy equals greater risk to system integrity.

Representativeness and redundancy can be combined into a risk matrix similar to the departure and trend matrix used for terrestrial ecosystem risk (Figure 33). Moderate or high risk does not mean that system integrity is definitively compromised. Moderate or high risk suggests that the system requires closer examination to determine if system integrity is satisfactory or not. Representativeness and redundancy is calculated for all watersheds, but summarizes only the subset of sub-watersheds (131) that make up the local scale.

	Representative	Not Representative
Redundant	Low Risk	Moderate Risk
Not Redundant	Moderate Risk	High Risk

Figure 33. Representativeness and redundancy risk matrix for aquatic ecosystems

Surface Water

Surface water includes all streams, seeps and springs, wetlands, and other waterbodies that are replenished by precipitation and recruitment from groundwater. Precipitation maybe intercepted by vegetation and cycled back into the atmosphere by evapotranspiration and lost through evaporation; seep into the ground where it becomes groundwater; be used by plants for transpiration; be extracted by humans for agriculture, drinking, industry, and other uses; or discharge to the sea. Surface water systems support aquatic and riparian habitat, absorb excess runoff to moderate flooding, transport nutrients and sediment, and provide a continuous flow of fresh water.

Some human uses of water are non-consumptive, such as hydroelectric dams that return the original flow without diversion or diminishment. Most uses however are consumptive, meaning they diminish quantity, quality, rate of flow, or availability. Many water uses and associated water rights (acequias, private wells, etc.) within the plan area predate the establishment of the Carson NF and are held by private parties or public water suppliers. These water uses are not within the jurisdiction of the Forest Service, but the associated infrastructure, such as acequia headgates and pipelines are subject to management through special use authorizations.

Streams

There are approximately 7,577 miles of perennial streams at the context scale, about 1,044 (14.0%) of those miles are on the Carson NF, which means that perennial streams are slightly overrepresented at the plan scale. There is no perennial water in three of the sub-basins that intersect the Carson NF (Table 28, p. 166). Figure 35 (p. 143) shows the location of perennial streams at the plan scale. Streams on the Carson NF are a major contributor to the flow in the Rio Grande. The Rio Chama and Upper Rio Grande sub-basins contain 75 percent of the Carson NF by area. In those two sub-basins the Carson NF covers just 27.8 and 31.4 percent of the total area, respectively, yet streams on the Carson NF contribute 40.3 percent of the total runoff in the two sub-basins.[1]

Current Condition and Trend

Inadequate information exists for perennial stream characteristics to understand reference conditions; therefore, perennial stream risk is evaluated based on distribution (representativeness and redundancy), conditions that are mandated by regulation, and recent trends in water quantity. Water quality (attainment of New Mexico water quality standards) and water quantity (flow amount and timing) are used in place of historic reference conditions.

[1] Streamflow is based on modeling developed by Horizon Systems. Available for download at the NHDPlus Website. A map displaying the Carson NF's stream flow contribution to the Rio Grande can be found in the planning record.

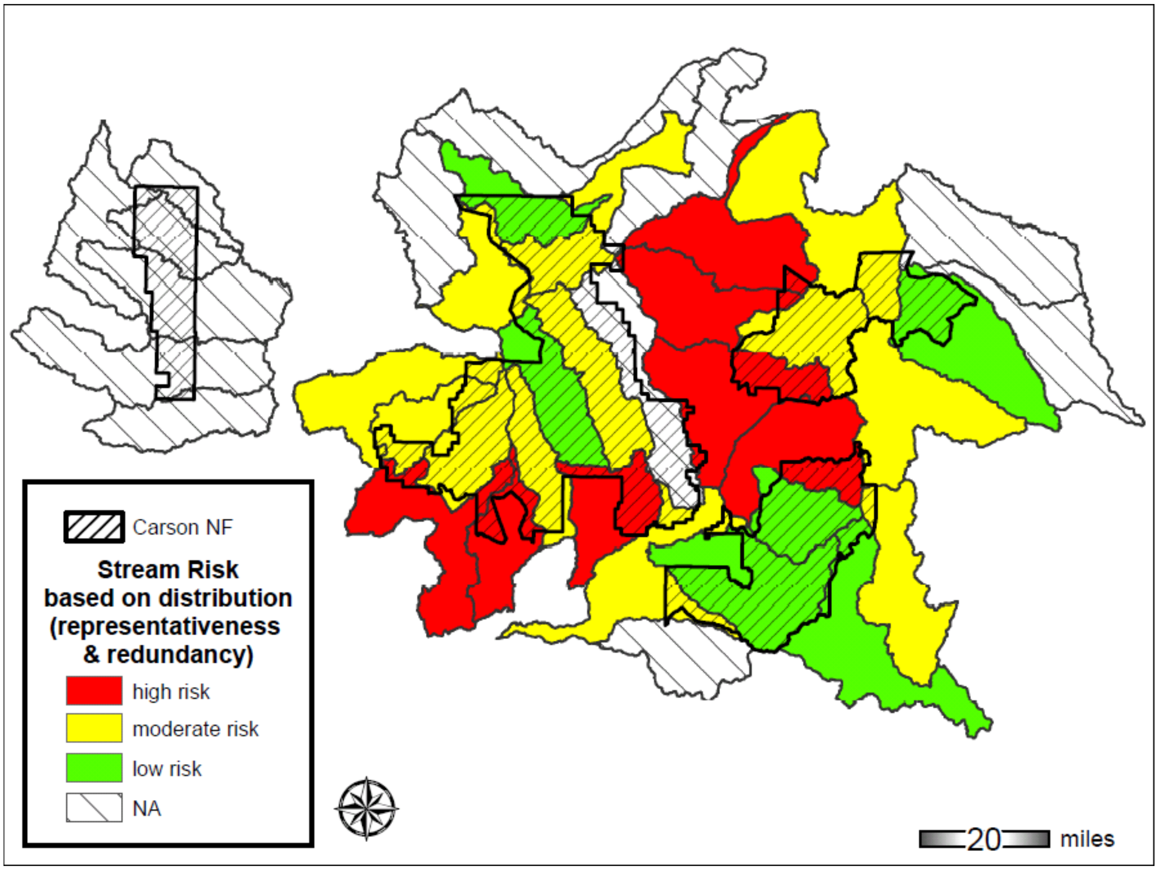

Figure 34. Risk based on distribution of streams at the HUC 10 watershed scale

Representativeness and Redundancy

Based on perennial stream distribution alone, there are seven HUC 10 watersheds at high risk. The four in the Upper Rio Grande sub-basin all have overrepresentation of streams at the plan scale. In other words, there are proportionally more streams on the Carson NF, compared to off the forest. These watersheds drain the western slope of the Sangre de Cristo Mountains and discharge to the Rio Grande in the area of the Rio Grande Gorge. Lands on the Carson NF include the higher elevation portions of these watersheds, where water and streams are more abundant. As streams flow toward the deep Rio Grande Gorge, they converge and become confined to narrow canyons. The Carson NF contains the majority of stream miles in these watersheds, and many of them are not in full attainment of water quality standards (Rio Pueblo de Taos, Rio Pueblo de Taos – Rio Grande watersheds are at high risk based on water quality, see below).

In the Rio Chama sub-basin, the three HUC 10 watersheds at high risk are all underrepresented at the plan scale. That is, there are proportionally more perennial streams that occur off the forest. These are all low elevation, dry areas, with very few stream miles on the Carson NF (e.g., the Abiquiu Reservoir watershed has 0 perennial streams on the Carson NF). Most streams in these watersheds flow into the Rio Chama from the south outside of the forest, not from the Carson NF to the north. Still, the El Rito – Rio Chama watershed and the Rio Ojo Caliente watershed both have a high percentage stream miles not in full attainment of water quality standards (see below), and the risk to integrity is high. Many watersheds cannot be rated, either because they have small representation at the plan scale or they have no perennial streams (the gray hatched watersheds in Figure 34).

Water Quality

Of the 131 perennial streams assessed, portions of 56 perennial streams (42.7%) on the Carson NF are not in full attainment of water quality standards (Figure 35 and Table 28, p. 166). Seven (5%) of those streams are wholly within the Carson NF.

Table 28 (p. 166) displays the percent of stream miles on the Carson NF that are not in full attainment of water quality standards at the HUC 12 sub-watershed level. Water temperature is the most common source of water quality impairment at the plan scale, affecting 218 miles of streams. The daily fluctuation of stream temperatures is moderated mainly by primary and secondary shade structure (vegetation) and stream bedload, since direct sunlight (solar input) has the greatest influence on daily stream temperature (much more than air temperature) (Thompson 2004). Bedrock (gravel-poor) streambeds result in wider daily fluctuations of stream temperature than streambeds with more gravel load and floodplain connectivity (Thompson 2004). In many places on the Carson NF, loss of riparian habitat and associated stream shading are causing warming stream temperatures. It is also the result of reduced stream flow from drought or water diversion.

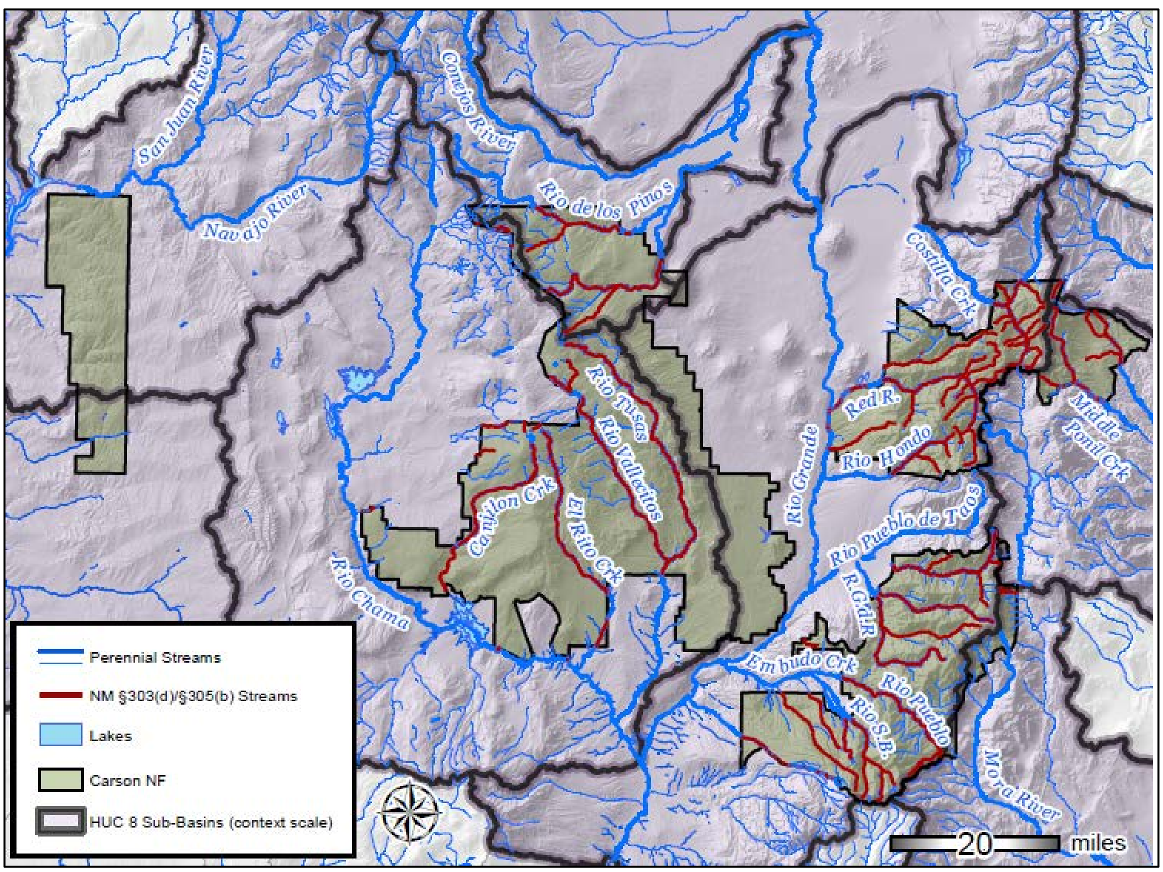

Figure 35. Distribution of perennial streams on the Carson National Forest, including those streams that do not meet water quality standards

Turbidity, sedimentation, and specific conductance account for the second largest cause of water quality impairment at the plan scale, affecting 156 miles of streams. Turbidity and sedimentation often result from degraded upland vegetative conditions or roads and trails in poor condition. Insufficient upland vegetative groundcover allows for easy detachment of soil and transport to the stream channel. Roads and trails that do not drain effectively or are in close proximity to streams will transport detached soil to stream channels.

Water Quantity

Water quantity is a function of both climate and watershed condition. Streamflow data for some gauging stations on or near the Carson NF is available with periods of record dating back as far as 1915. While human activity undoubtedly influenced streamflow prior to that time, the 100-year record provides a good baseline for comparison to current conditions. Figure 36 shows the location of streamflow gauging stations on streams originating on the Carson NF. The Rio Grande, Rio Chama, and San Juan River gauges measure drainage from HUC 8 sub-basins. The remaining gauges measure HUC 10 watershed and HUC 12 sub-watersheds. The gauge locations and contributing watersheds and sub-watersheds were selected based on coincidence with the plan area and the length of record for each gauging station.

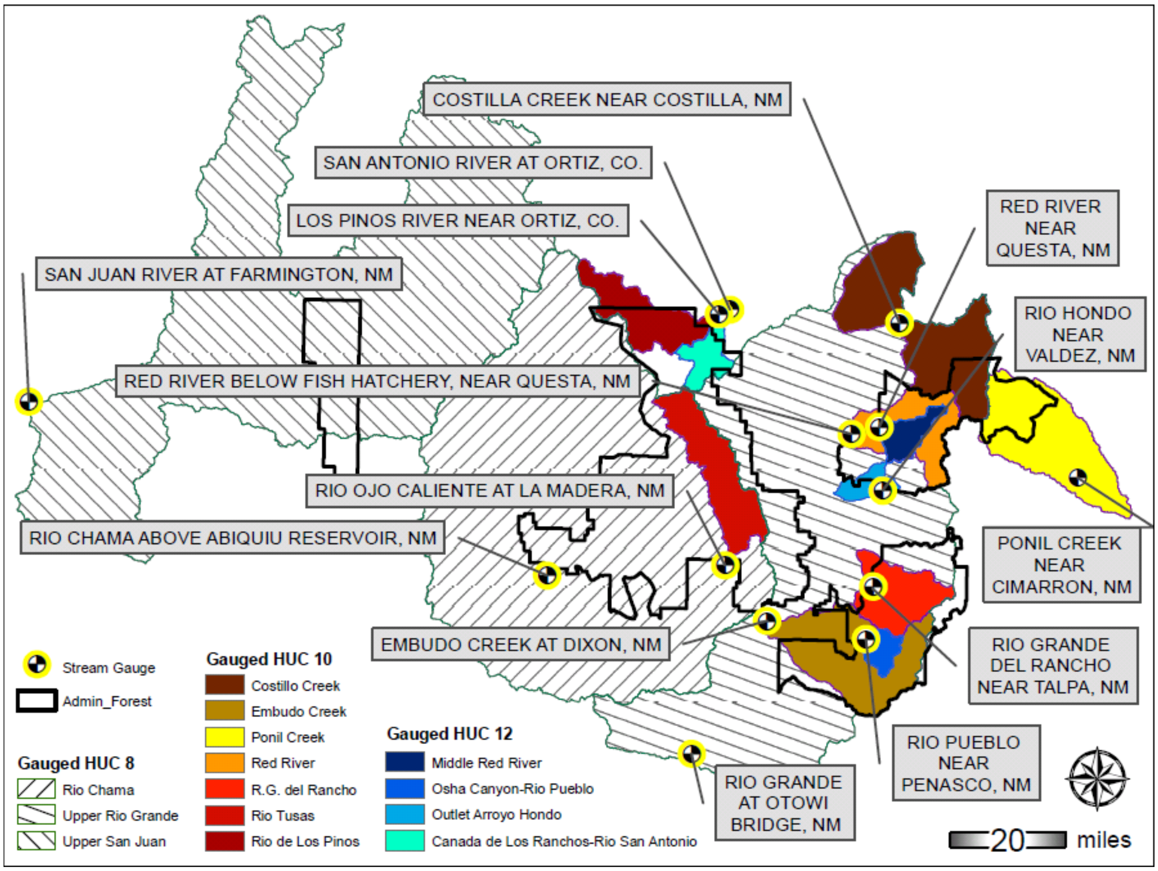

Figure 36. Distribution of selected gauged watersheds and sub-watersheds and location of stream gauges

The most conspicuous signal in the record is one of recent drought, which is well documented by various sources. The current drought in northern New Mexico began in the spring of 1996

(NOAA 1996), following several years of above average temperature and was exacerbated by subsequent below average precipitation and continued heat (Figure 37). Stream gauge data from across the forest reflects this same drop in available water. Table 22 (p. 146) shows the reduction in annual streamflow for gauged drainage areas since 1996. All areas have significantly reduced flow. On average streamflow has declined by 20.0 percent from pre-1996 levels (USGS 2014b).

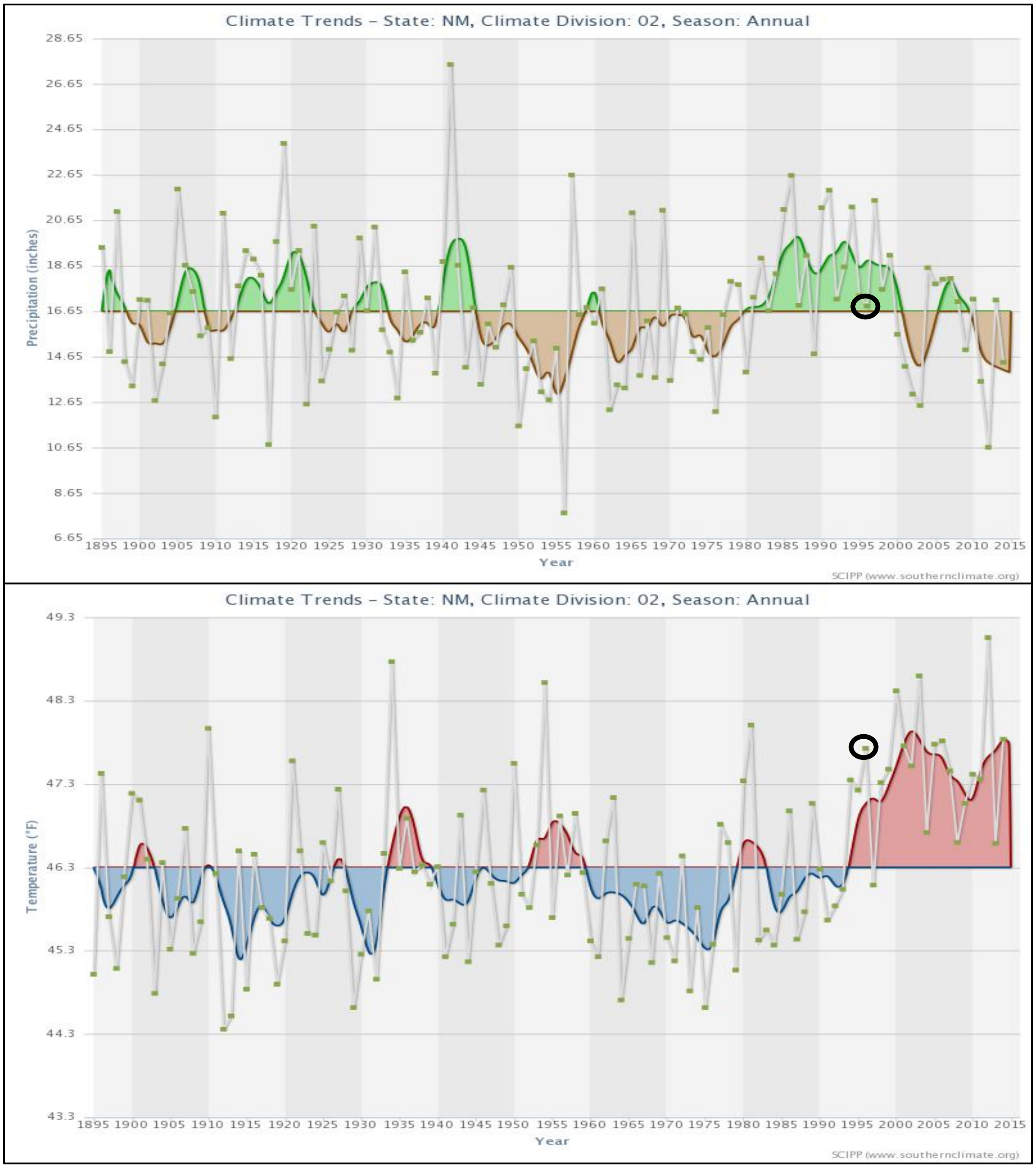

Figure 37. Annual precipitation (top graph) and temperature (bottom graph) history for the northern NM mountains (climate division 02) from 1895-2014[1]

[1] The horizontal line represents long-term average. Five year moving averages are depicted as green/brown curves for

Table 22. USGS data of selected gauges draining the Carson NF (USGS 2104b)

USGS Gauge #	Name/Location	Data Record Period	Pre 1996 Annual Mean Flow (cfs)	Post 1996 Annual Mean Flow (cfs)	Annual Mean Flow Reduction (%)
9365000	San Juan River at Farmington, NM[1]	1931-2013	2,097	1,526	**-27.2**
8248000	Rio Los Pinos near Ortiz, CO	1915-2013	117	92.5	**-20.9**
8247500	Rio San Antonio at Ortiz, CO	1940-2012	24.6	17.9	**-27.2**
8286500	Rio Chama above Abiquiu Reservoir	1971-2013	522	425	**-18.6**
8289000	Rio Ojo Caliente at La Madera, NM	1932-2013	67.5	50.3	**-25.5**
8313000	Rio Grande at Otowi, NM[2]	1971-2013	1,580	1,177	**-25.5**
8265000	Red River near Questa NM	1966-2012	41.7	36.8	**-11.8**
8266820	Red River below State Fish Hatchery near Questa, NM	1978-2012	76.7	63.1	**-17.7**
8267500	Rio Hondo near Valdez, NM	1953-2012	34.5	27.8	**-19.4**
7207500	Ponil Creek near Cimarron, NM	1916-2012	11.7	11.07	**-5.4**
8255500	Costillo Creek near Costilla, NM	1942-2012	45.2	39.5	**-12.6**
8275500	Rio Grande del Rancho near Talpa, NM	1953-2012	19.1	13	**-31.9**
8277470	Rio Pueblo near Peñasco, NM	1992-2012	44	33.4	**-24.1**
8279000	Embudo Creek at Dixon, NM	1924-2013	81	62.1	**-23.3**

Spring runoff in the southwestern U.S. in recent years has trended toward an earlier peak and shorter overall duration. Historic data from the Navajo River in Colorado clearly shows that since 1996, the 50th percentile of snowmelt flows has on average occurred consistently earlier in the year and late season runoff has dropped (Falk, Anderholm, and Hafich 2013). The Navajo River has also experienced slightly earlier onset to the spring pulse of snowmelt runoff. To measure runoff duration and timing at the plan scale an ordinal number technique was applied to daily streamflow data for gauges that measure runoff from three HUC 12 sub-watersheds that fall

precipitation and red/blue curves for temperature and indicate above/below average periods. The 1996 data point is circled on each graph. (data from Southern Climate Impacts Planning Program).

[1] Since June 1962 flow is partly controlled by operation of Navajo Reservoir.

[2] Abiquiu Reservoir came on-line regulating Rio Grande Otowi gauge flows in 1963, prior to 1963 9-peak flows over 15,000 cfs. Since 1963, no peak flows have exceeded 13,000 cfs.

mostly on the Carson NF. The results indicate shorter total runoff duration, but not necessarily a later pulse of snowmelt runoff (Table 23). Since 1996, spring snowmelt runoff has lasted 12.3 fewer days on average, but the peak runoff date has been similar to previous years, and there is no evidence of an earlier start to snowmelt runoff. Overall, there has been less water available in recent years, both in terms of the annual total and the springtime snowmelt pulse (USGS 2014b).

There are few withdrawals within the forest boundary, most occur on private inholdings or adjacent private lands and are not regulated by the Carson NF. In some areas, mainly at lower elevations, these withdrawals significantly reduce instream flows. The Carson NF has constructed, maintained, or permitted an extensive network of small reservoirs for watering wildlife and livestock. That water storage slows runoff and increases infiltration, though to what extent has not been quantified. In the Upper Rio Grande watershed, the Carson NF permits snowmaking at three ski areas, which removes winter streamflow, stores it in snowpack, and releases it as spring runoff.

Drought has multiple and interrelated effects on ecological and socioeconomic resources and the ecosystem services they provide. They include increased fire risk, decreased forage, loss of aquatic habitat and habitat quality, and loss of riparian function. Some of the social and economic impacts of these effects are reduced recreational opportunities (fishing, camping), less water supply for domestic use and agriculture, negative impacts to traditional uses (acequias), and decreased livestock grazing opportunities.

Table 23. Daily stream flow for streams with longest period of record and most extent on the Carson NF (USGS 2014b)

Name/Location (Reference Runoff Start Date)	Data Record Period	Avg Delay From Runoff Start Date Until Peak Runoff (days)	Avg Runoff Duration Beyond Peak Runoff (days)	Avg Peak Runoff Duration (days)	Average Peak Flow (cfs)	Reduction in Runoff Peak Flow (% cfs change)
Embudo Creek at Dixon, NM	1924-1995	45	47	36	594	--
(March 14th)	1996-2014	44	35	21	389	-34.5
Los Pinos near Ortiz, CO	1915-1995	21	49	31	1,068	--
(April 8th)	1996-2013	23	40	20	792	-25.8
Rio Ojo Caliente at La Madera, NM	1932-1995	38	61	32	803	--
(March 6th)	1996-2013	41	53	21	536	-33.3

Outstanding National Resource Waters

The U.S. Environmental Protection Agency (EPA) oversees regulations (40 CFR 131), which establish the requirements for states and tribes to review, revise, and adopt water quality standards. Water quality standards include an antidegradation policy. Antidegradation implementation procedures identify the steps and questions that must be addressed when regulated activities are proposed that may affect water quality. The specific steps to be followed depend upon which tier or tiers of antidegradation apply.

Tier 3 of the antidegradation policy maintains and protects water quality in outstanding national resource waters (ONRWs). Except for certain temporary changes, water quality cannot be lowered in such waters. ONRWs generally include the highest quality waters of the United States. However, the ONRW classification also offers special protection for waters of exceptional ecological significance (i.e., those that are important, unique, or sensitive ecologically). Decisions regarding which water bodies qualify to be ONRWs are made by states and authorized Indian Tribes.

The New Mexico Water Quality Control Commission (WQCC) has approved the statewide designation of ONRWs throughout the State of New Mexico. Designations include the west, middle and east forks of the Rio Santa Barbara on the Camino Real RD (designated in 2005); all surface waters within the Valle Vidal on the Questa RD (designated in 2006); and all perennial streams, lakes, and wetlands within the Carson NF's wilderness areas (designated in 2010) (NMED 2015).

New Mexico's water quality standards establish designated uses for water bodies, set criteria to protect those uses, and establish provisions to preserve water quality. ONRWs are subject to the same water quality criteria as other waters with the same designated uses; however, ONRWs receive additional protection aimed at preserving water quality. Degradation of water quality is not allowed in ONRWs except under very limited circumstances. Where water quality meets or exceeds standards, that higher water quality must be protected.

Land-use activities in existence at the time an ONRW is designated will not be affected, so long as they are allowed by state or federal law, controlled by best management practices, and do not result in new or increased discharges of contaminants to the ONRW. Examples of such activities that occur near currently designated ONRWs include recreation and grazing. In addition, acequia operation, maintenance and repair are not subject to new requirements because of ONRW designation. New land uses or activities can proceed so long as they do not impact water quality in the ONRW. If a proposed project on the Carson NF has the potential to cause degradation in an ONRW from nonpoint sources, it would be reviewed by the oversight agency to make sure it can be proceed in a manner consistent with ONRW protection.

Temporary degradation from certain activities can be allowed, but only for public health and safety and for water quality restoration or maintenance. Temporary degradation resulting from projects or activities to restore or maintain the physical, chemical or biological integrity of the ONRW may be approved by the Surface Water Quality Bureau or an oversight agency. Such activities are encouraged and should not be delayed or prohibited as result of ONRW designation. Degradation must be minimized and limited to the shortest possible time. Water quality monitoring may be required, especially if the degradation will last longer than six months.

For more information see Chapter III. Designated Areas, Outstanding National Resource Waters (p. 459).

Waterbodies

There are 1,565 waterbodies on the Carson NF totaling over 1,308 acres. The Upper Rio Grande and Rio Chama sub-basins contain the greatest number of waterbodies in the plan area. Most of the largest lakes are in the Conejos sub-basin (Ursulo Lake, Laguna Larga, others). Lucero and Cabresto Lakes are the next largest, they both are in the Upper Rio Grande sub-basin, though on opposite sides of the Rio Grande and in different ranger districts. Many smaller waterbodies are constructed or modified, which impounds water that would otherwise supply perennial or intermittent streams. Reservoirs or stock tanks improve water availability for livestock and wildlife.

Current Condition

There are seven HUC 10 watersheds with waterbodies at high risk based on distribution alone. Five of the seven do not substantially overlap the Carson NF, and waterbodies are under-represented on the Carson NF, because areas off the forest are wetter. The two exceptions are the Rio Nutrias–Rio Chama and El Rito–Rio Chama, where waterbodies are over-represented at the plan scale. The Carson NF has a significant role in maintaining the integrity of waterbodies in the Rio Nutrias–Rio Chama in particular, where the overlapping land contains almost 40 percent of the waterbodies in the watershed, but less than 10 percent of the land area. The larger lakes in this area are developed for recreation. Trout Lakes Campground is heavily used at some times of the year, and the Trout Lakes drain into the Rio Nutrias, which is impaired based on high turbidity (Figure 38 and Table 24). Many small waterbodies on the Carson NF are constructed reservoirs for livestock and wildlife watering. These constructed tanks increase the total number and distribution of waterbodies, but also alter hydrology and concentrate grazing pressure.

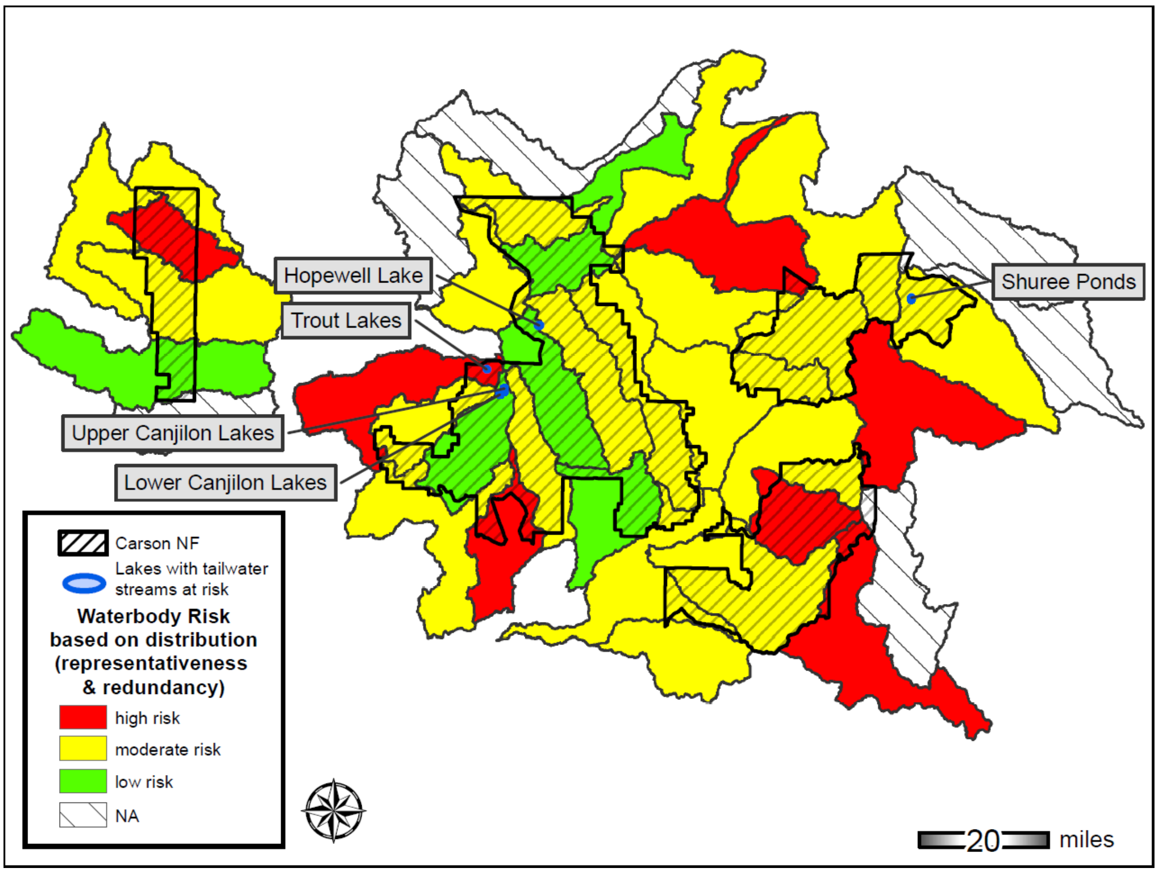

Figure 38. Risk based on distribution of waterbodies at the HUC 10 watershed scale. Lakes with tailwater streams not meeting water quality standards are also shown.

Table 24. Waterbodies on the Carson National Forest not meeting water quality standards

Reservoirs, Lakes	Tailwater Stream[1] with §303(d) Impairment or Not Meeting Designated Use	Impairment
Hopewell Lake	Placer Creek and Rio Vallecitos	Placer Ck-temperature; Rio Vallecitos-temperature, turbidity
Shuree Ponds	Middle Ponil Creek	Benthic-macroinvertebrate bioassessments; temperature
Trout Lakes	Rio Nutrias	Turbidity
Lower Canjilon Lakes	Canjilon Creek	Nutrient/Eutrophication Biological Indicators, specific conductance, temperature, turbidity
Canjilon Lakes	Canjilon Creek	
Upper Canjilon Lakes	Canjilon Creek	

Seeps and Springs

Seeps and springs provide key habitat for many species and many have been developed for human benefit, such as to supply community water systems or to maintain livestock. Seeps and springs occur where groundwater emerges on sloping terrain, toe-slope breaks, and geologic formation transition zones. They may either contribute to stream flow or infiltrate through the immediate geology and return to the groundwater. Seeps and springs discharging into a channel are considered part of the riverine (lotic) system (Cowardin et al. 1979).

Current Condition

Before European colonization, seeps and springs were not overly developed or degraded and the water from springs supported intact ecosystems. As population increased, all of the easily accessible seeps and springs were developed for human consumption, irrigation, and livestock use. Development diverts or completely removes water from its natural movement resulting in a loss or reduction in function of adjacent or connected wetland systems. Some seeps and springs accessed by humans and ungulates can be degraded beyond a functional tipping-point through a combination of timber clear-cutting, livestock grazing, water withdrawal for human use, and degraded watershed conditions. In addition, seeps and springs may become less productive as a result of cyclical drought or longer term climate change. Many historic seeps and springs are dewatered at the plan and context scales.

There are 659 documented seeps or springs on the Carson NF, 597 are developed or degraded (90.6 percent) (Figure 39 and Table 28, p. 166). A spring or seep was rated as developed or degraded if:

- It is a developed water source for wildlife or grazing and identified within the Carson NF corporate GIS database (USDA FS 2014h).
- It has dysfunctional channel condition or invasive plant component as documented by a Forest Service hydrologist during field examination.

[1] A tailwater stream is the water immediately downstream from a dam or impoundment that creates a waterbody.

Springs are most common in the Rio Chama sub-basin, both at the plan and context scales. They are also well distributed in the Rio Chama sub-basin, and risk is mostly low or moderate, though almost all seeps and springs here have been developed. In the Upper Rio Grande, Cimarron, and Mora sub-basins, the sub-basins that are at high risk based on seep and spring distribution are either drier off the forest, or do not have significant overlap with the plan area. These three sub-basins (particularly the east side of the Upper Rio Grande) have lower levels of seep and spring development, since much of this part of the Carson NF is in one of five designated wilderness areas.

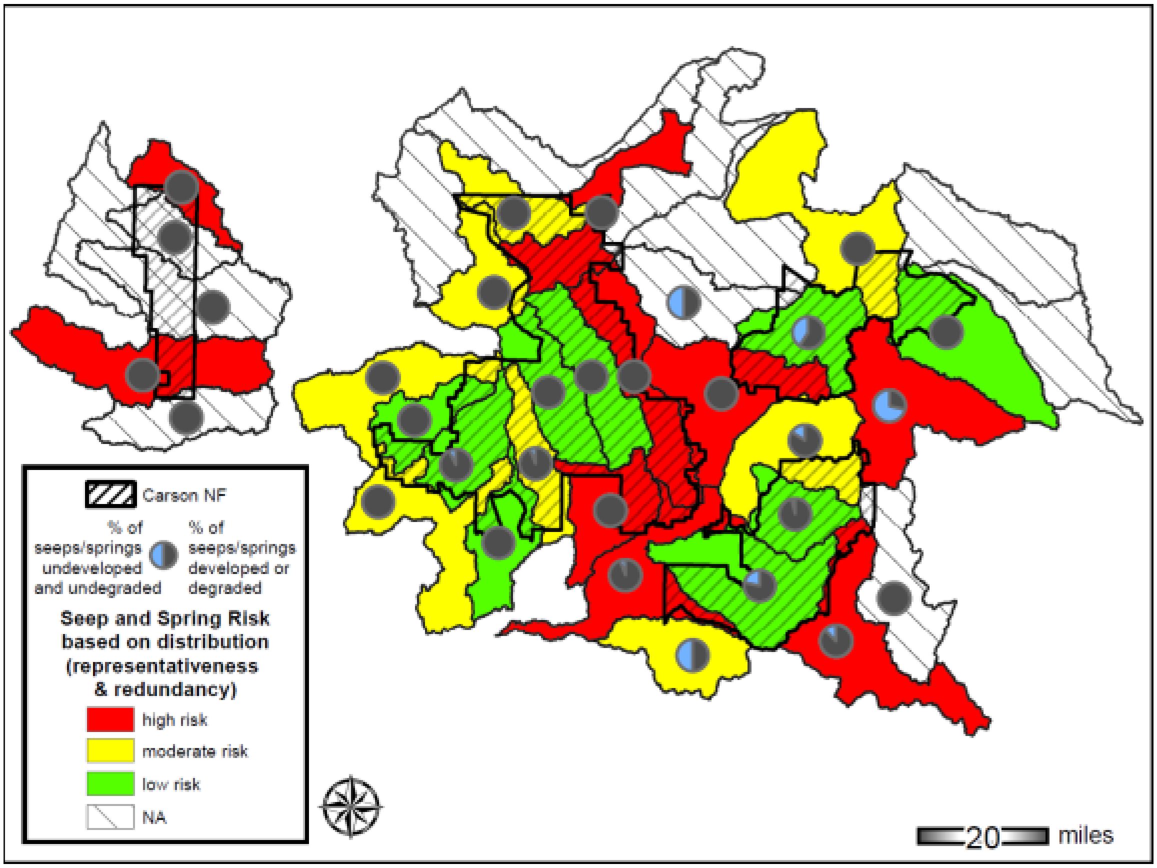

Figure 39. Risk based on distribution of seeps and springs at the HUC 10 watershed scale[1]

[1] Pie charts represent the percentage of seeps and springs on the Carson NF that have been developed.

Wetlands

Wetlands are either perennially or seasonally saturated or flooded, such that soils and vegetation are distinct from the adjacent uplands. They are complex ecosystems affected by slope, aspect, geology, elevation, latitude, flora, fauna, climate, weather, micro climate/weather, surface and groundwater, land-use, and management actions. Wetlands provide vital ecosystem services locally and regionally, with benefits to people including freshwater, flow regulation, unique habitat, and aesthetic value. As the transition between terrestrial and aquatic systems, wetlands provide increased biodiversity where they occur. They improve water quality and quantity by slowing both channel and overland peak flows allowing for greater absorption, by processing and storing peak flows, by supporting surface flows with released groundwater, and by retaining and transforming excess nutrients and sediments, including many heavy metals. They are relatively productive sites and many sequester carbon (MES 2005; Kusler 2004).

The National Wetlands Inventory (NWI) was completed for the conterminous United States by the U.S. Fish and Wildlife Service in 2014 (Tiner 2014). The NWI collected information regarding wetland location and type to facilitate inventory and mapping. While certain impacts are assessed (i.e., partly drained, excavated, impounded, farmed) other abiotic properties that are important for evaluating function are not included (Tiner 2014). NWI does not assess wetland condition (dewatering, species composition, etc.) (Tiner 2014).

Wetlands may be associated with streams (riverine) or water bodies (lacustrine), or isolated from other surface water (palustrine). They may be supplied by either surface or groundwater, or frequently a combination of both. Thus, drivers and stressors that influence surface water will have similar influence on the condition of many wetlands, but in other cases wetlands are also dependent on groundwater and sensitive also to drivers and stressors that will be discussed in the Groundwater section (p. 162). Wetland condition cannot be considered in isolation. Ecosystem conditions such as watershed hydrology, upland condition, connectivity of the wetland to other wetlands or water, rarity in the landscape, extent and function of buffers, and other "landscape-level natural resource relationships" are all critical to the onsite functioning of wetlands (Kusler 2004, p. 3). A spring-fed wetland, for example, is dependent on groundwater levels, which in turn are dependent on groundwater recharge from streams, waterbodies, upland sites, as well as other wetlands.

On the Carson NF riverine wetland mapping in NWI is inconsistent, with some areas mapped in great detail and others clearly lacking. Many riverine wetlands occur in areas that were mapped as riparian, and were analyzed in the Riparian Ecosystems section (p. 102). For these reasons, riverine wetlands are excluded in the calculations that follow. Wetlands may occur in any of the terrestrial or riparian ERUs, but for Montane Subalpine Grassland (MSG, p. 37) and Herbaceous Riparian (HERB, p.116) in particular, a significant portion of the ERU might also be classified as wetland. The discussions of departure, trend, and risk for those ERUs are also indicative of condition for a large portion of wetland systems at the plan and context scales.

There are 271,939 acres of lacustrine and palustrine wetlands in the context landscape, of which 12,214 acres are on the Carson NF (4.5%), meaning wetlands are less common at the plan scale. Wetlands are more common on private, tribal, and other USFS owned lands in the context landscape.

Current Condition

NWI is currently being updated with hydrogeomorphic descriptors of wetlands to allow assessment of wetland function across the landscape. These additional attributes have been added for wetlands on the east side of the Carson NF, as well as some watersheds on the southern Tres Piedras RD (Figure 40)[1] . This "NWI+" dataset describes wetlands by their landscape position, landform, water flow path, and waterbody type (for open water) and provides a better accounting of a wetland's function based on its location in a watershed, its water sources, and hydrodynamics. NWI+ is not an assessment of condition, though there are some non-required modifiers that can be used to indicate specific human alterations (e.g., logged, severely human-induced, channelized flow, etc.) (Tiner 2014). Since no quantitative reference condition exists for wetland function on the Carson NF, functional departure cannot be calculated. NWI+ information is presented below as an inventory of what currently exists, then departure and trend are discussed qualitatively, and risk is assessed using representativeness and redundancy.

Wetlands are at risk, due to their distribution alone, in all but one HUC 10 watershed that significantly overlaps the Carson NF. Only three (Ponil Creek, Costillo Creek, Rio Nutrias-Rio Chama) are over-represented at the plan scale. Of those, Ponil Creek has the largest overlap with the plan area and the Carson NF has a substantial influence on wetland integrity in this area (Table 28, p. 166).

Wetland condition at the plan and context scales is departed (Figure 40). Declines in wetland systems has greater significance in the arid western United States, where less than 2 percent of the landscape is with a wetland system, yet 80 percent of the wildlife species are dependent on the ecological services wetlands provide. Wetland systems research has shown from the 1780s to the 1980s a decline of 33 percent wetland extents in New Mexico (Dahl 2011). Current condition of wetland systems is dependent on both climate variability and land use. Climate greatly affects wetland systems that are dependent on daily temperatures and changes in the precipitation regime. Grazing, spring development, and water withdrawals have all impacted water availability and wetland function.

[1] Descriptor mapping was conducted by Saint Marys University of Minnesota for the New Mexico Environment Department (NMED) Surface Water Quality Bureau (SWQB) Wetlands Program. "The functional assessment schema was developed through a 'best professional judgment' exercise and was based on the consensus of local, regional and national biologists plus local stakeholders who were familiar with wetland habitats in the project area. The first step in this process was to develop consensus amongst the group on the wetland functions that were important to assess for the project area. Then, the group was asked to document the wetland characteristics that were representative of specific functions and to correlate them to both NWI and LLWW codes. Finally, wetlands were categorized as either high or moderate for the performance of specific functions." (Mapping and Classification of Wetlands for Protection: Northeastern New Mexico Highlands and Plains. 2013. Digital map.)

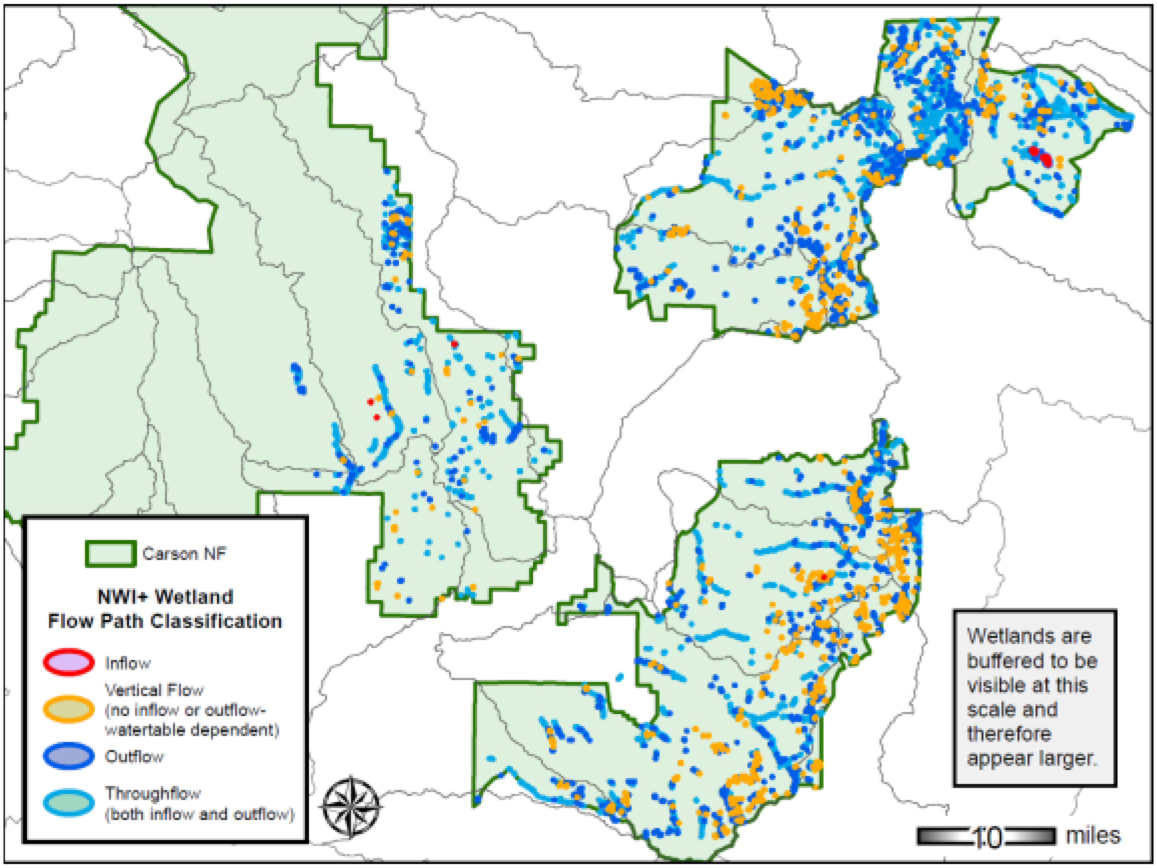

Figure 40. Wetland flow paths (areas on the Carson NF that have been mapped by NWI+)

Wetland landscape position as defined by NWI+ on the Carson NF includes terrene (surrounded by upland), lentic (along a lake or reservoir), and lotic (associated with a river). Landforms may be basins, flats, or slopes. Basin wetlands exist in a distinct depression. Flat wetlands exist on relatively flat areas. Slope wetlands exist on noticeable slopes (greater than 2%). Water flow path describes wetland connections to surface and groundwater resources. There are four descriptors for wetlands on the Carson: outflow, inflow, through flow, and vertical flow (Figure 40). The first three have surface water connections, most are also connected to groundwater. Vertical flow wetlands are topographically isolated, with connections to groundwater only. There are concentrations of outflow and vertical flow wetlands along the Sangre de Cristo Mountains divide and high peaks, as well as surrounding the community of Tres Piedras. Through flow wetlands become more prevalent at lower elevations, with a few scattered inflow wetlands.

Landscape position affects the function of a wetland. For example, outflow wetlands are less likely to have a high influence on groundwater recharge (Figure 41). Through flow wetlands are likely to have a high contribution to sediment retention (Figure 42, p. 156). Both outflow and through flow wetlands may help maintain streamflows (Figure 43, p. 157). Table 42 (p. 229) displays wetland functions mapped for the Carson NF by the percent of wetlands classified in the moderate and high categories.

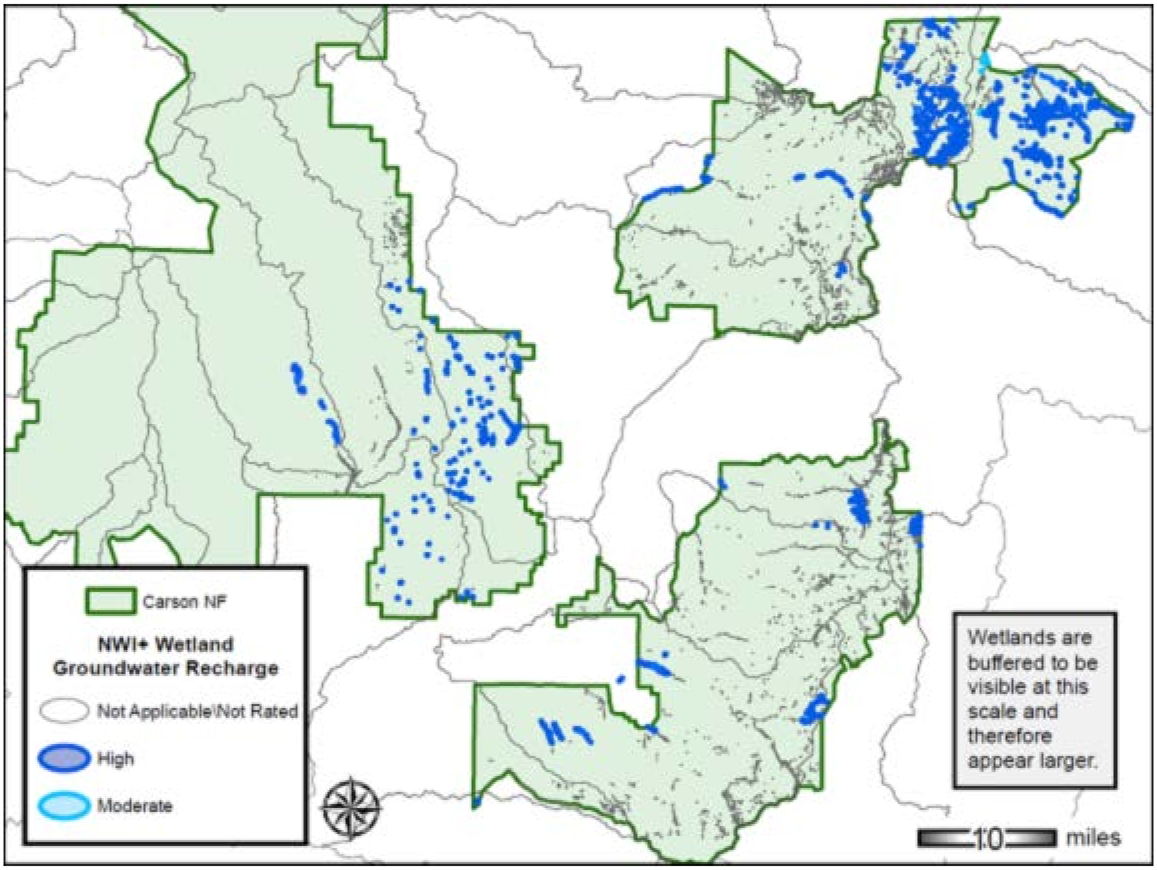

Figure 41. Wetland contribution to groundwater recharge (areas on the Carson National Forest that have been mapped by NWI+)

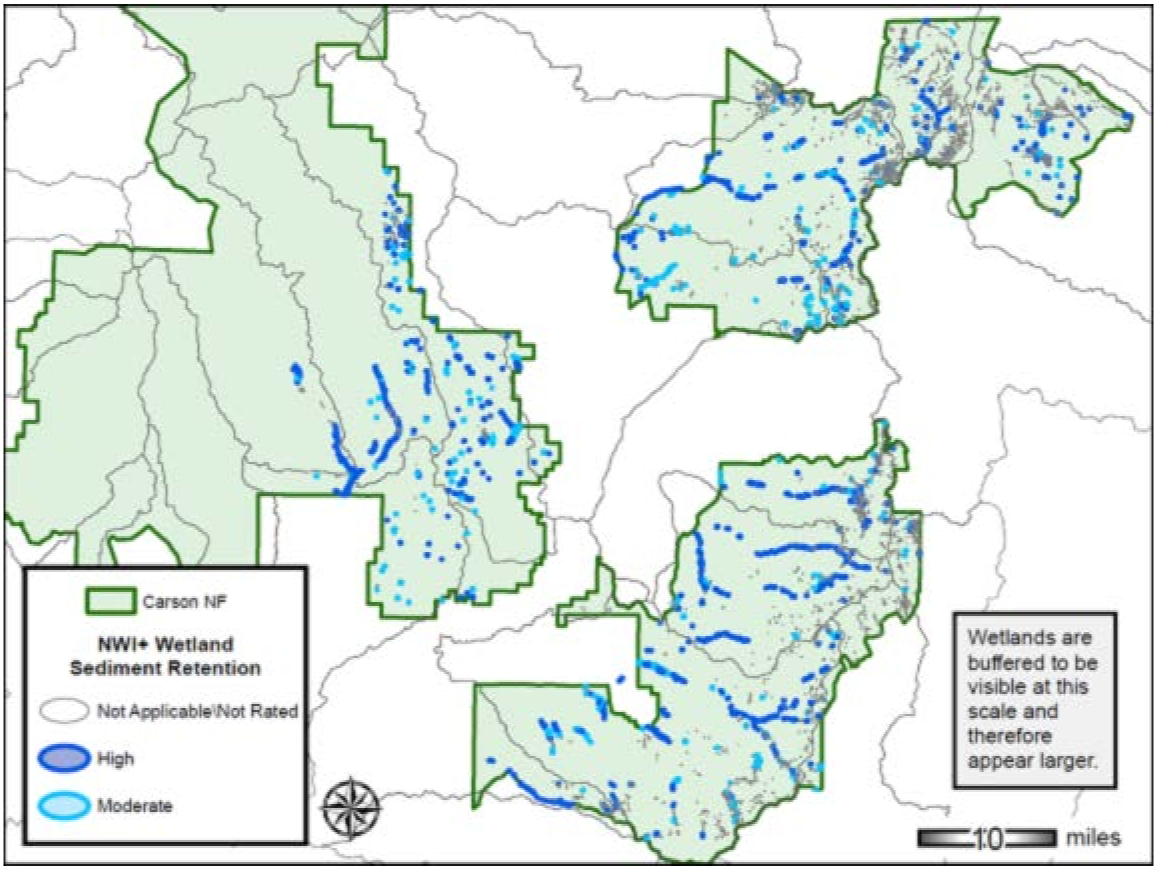

Figure 42. Wetland contribution to sediment retention (areas on the Carson National Forest that have been mapped by NWI+)

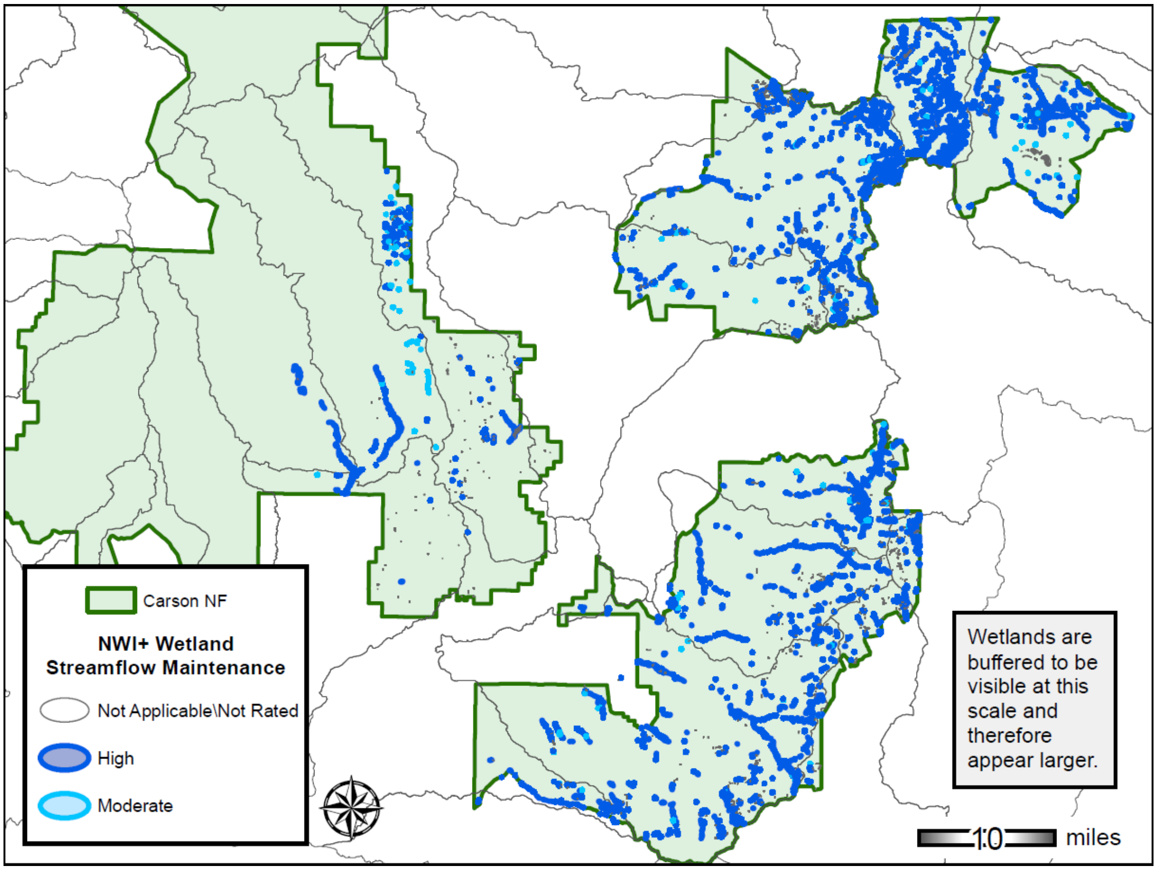

Figure 43. Wetland contribution to streamflow maintenance (areas on the Carson National Forest that have been mapped by NWI+)

Table 25. Summary of wetland function on the Carson National Forest (areas that have been mapped by NWI+)[1]

Wetland Function	Not Rated (%)	Moderate (%)	High (%)
Aquatic invertebrate habitat	83.1	9.3	7.6
Bank stabilization	57.0	29.8	13.2
Carbon sequestration	1.3	9.9	88.8
Fish habitat	85.0	7.4	7.6
Groundwater recharge	79.4	0.3	20.3
Nutrient transformation	9.2	68.9	21.9
Other wildlife habitat	0.3	77.1	22.6
Streamflow maintenance	29.7	5.0	65.3
Sediment retention	69.2	10.2	20.6
Surface water detention	68.7	11.2	20.1
Water birds	85.5	1.5	13.0

While wetland function is important to an understanding of the system as a whole, alone it cannot define risk. It is clear that wetland condition at the plan and context scales is departed and declines in wetland systems have greater significance in the arid western United States, where less than 2 percent of the landscape is made up of wetland systems, yet 80 percent of wildlife species are dependent on the ecological services wetlands provide. Between the 1780s to the 1980s, wetland extent has declined by an estimated 33 percent in New Mexico (Dahl 2011). Current condition of wetland systems is dependent on both climate variability and land use. Climate greatly affects wetland systems that are dependent on daily temperatures and changes in the precipitation regime. Grazing, spring development, and water withdrawals have all impacted water availability and wetland condition.

Human wetland modification is mapped by NWI. The function of these wetlands has been altered. Most watersheds on the Carson NF with low levels of wetland modification are east of the Rio Grande. These watersheds are high elevation and have the highest wetland densities on the forest. Rio de los Pinos is the exception, overlapping the Tres Piedras RD on the west side, but much of its area on the forest is within the Cruces Basin Wilderness Area. The six watersheds with the most wetland modification are all on the west side of the Rio Grande, mostly in the Tres Piedras and El Rito RDs (Figure 44). They are generally drier with more gradual topography; meaning wetlands are more accessible for farming or livestock developments.

[1] Ratings indicate the percentage of mapped wetlands providing either a moderate or high contribution to each function.

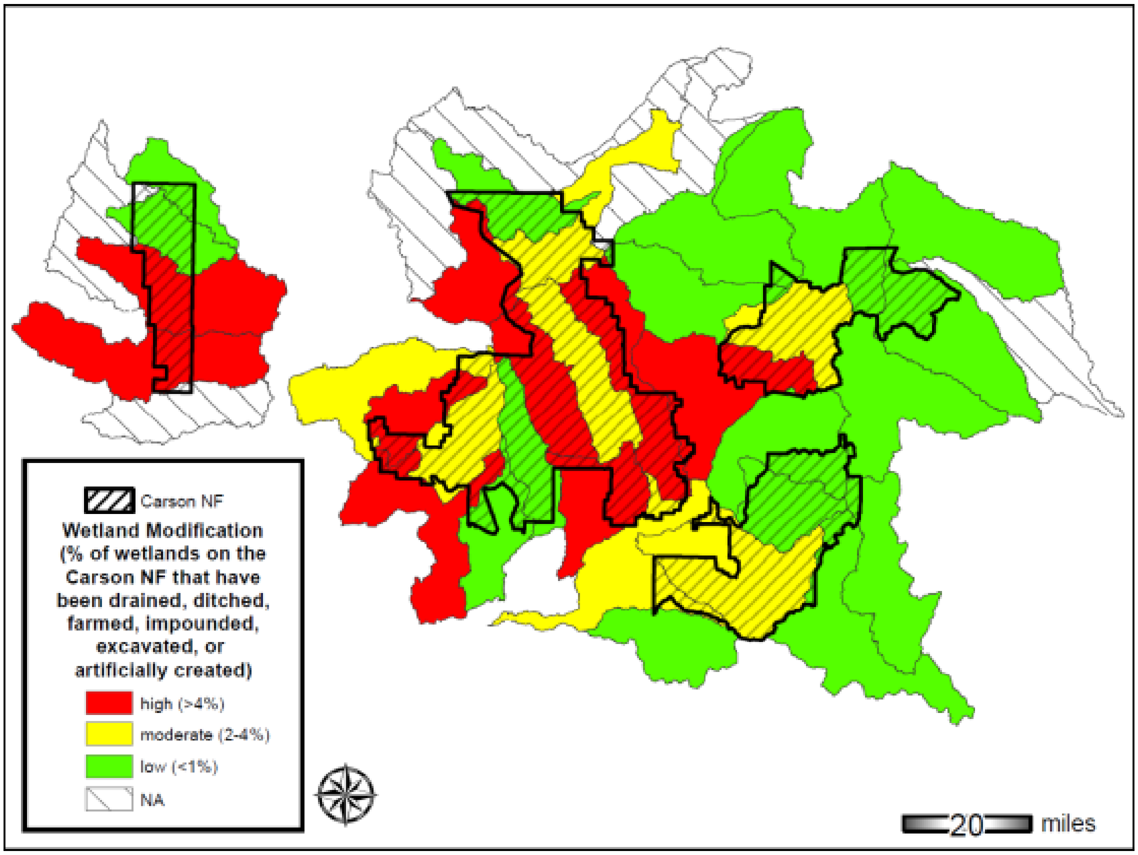

Figure 44. Percent of wetlands anthropogenically modified by HUC 10 watershed on the Carson National Forest

Due to their distribution alone, wetlands are at risk in all but one HUC 10 watershed that significantly overlaps the Carson NF. In only three (Ponil Creek, Costillo Creek, Rio Nutrias-Rio Chama) HUC 10 watersheds are wetlands over-represented at the plan scale. Of those, Ponil Creek has the largest overlap with the plan area and the Carson NF has a substantial influence on wetland integrity in this area (Figure 45).

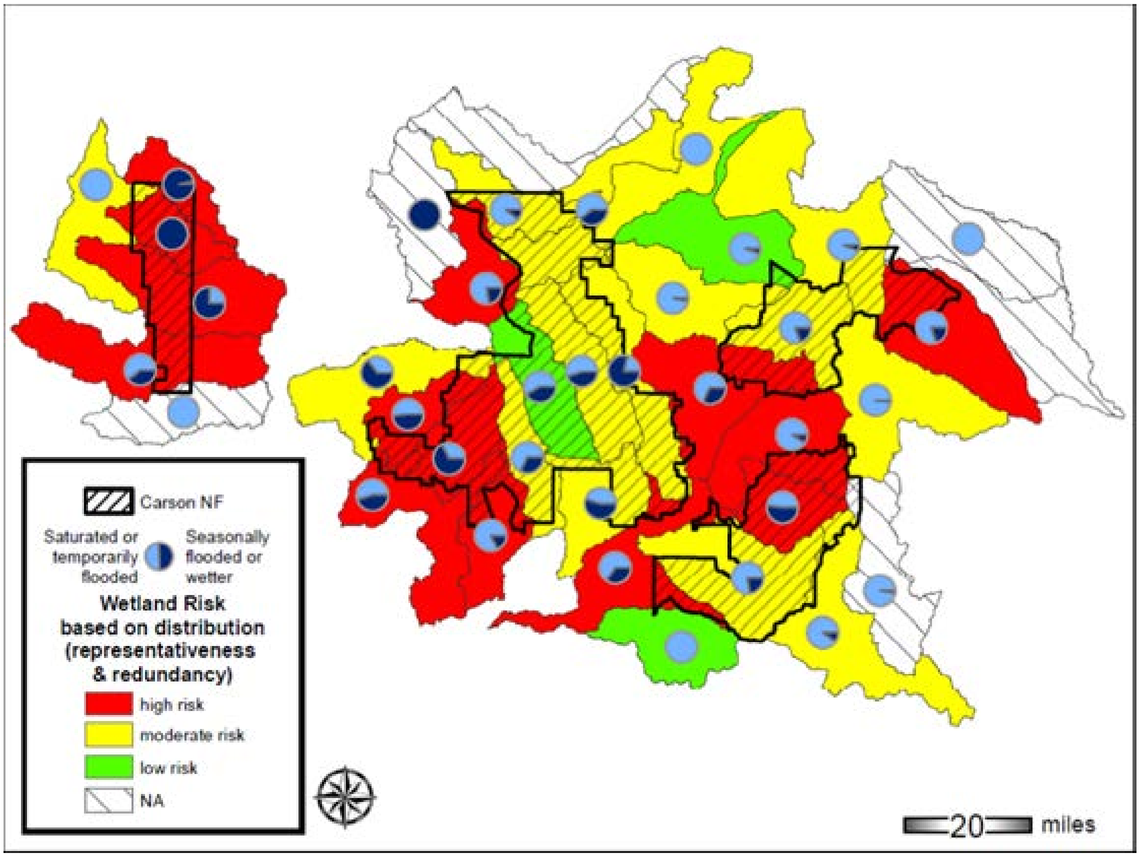

Figure 45. Risk based on distribution of wetlands at the HUC 10 watershed scale[1]

[1] Pie charts represent the percentage of wetlands on the Carson NF that are temporarily flooded or saturated (light blue) and seasonally flooded or wetter (dark blue).

Surface Water Trend

Warming temperatures, shifts toward earlier snowmelt, and less snowpack have all been already observed in the American West (USDA FS 2010b). Current drought conditions may very well become the new climatology of the Southwest, within a time frame of years to decades. Though some climate models predict increased precipitation, they also predict warmer temperatures, resulting in an overall decrease in available moisture (USDA FS 2010b). Less surface water will impact aquatic, riparian, and wetland systems, and will have serious implications for the survival of fish and other aquatic species. Changing flow and temperature regimes may challenge efforts to reintroduce (or maintain) species in their historic range. The Intergovernmental Panel on Climate Change (2007b) predicts temperature increases associated with climate change will reduce fish habitat by 15 to 40 percent in the Rocky Mountain Region. Stand replacing wildfire further degrades fish habitat by removing the shade provided by riparian vegetation and increasing sedimentation. One study found a 45 to 63 percent reduction in habitat following the Hayman Fire in Colorado (Rahel 2002). Increasing temperatures, water shortages, and changes to available moisture will affect biodiversity and put pressure on wildlife populations, by influencing distribution, viability, and migration patterns, because decreased surface water will concentrate pollutants (USDA FS 2010b).

Recent improvements in water use efficiency have reduced per capita withdrawals for industrial, domestic, and agricultural uses. Even with a projected 51 percent increase in population over the next 50 years, desired withdrawals in the United States are projected to stay within 3 percent of their 2005 level, if climate does not change (Brown et al. 2013). However, additional demand is likely as a result of predicted warming. By 2060, water withdrawals in most of the Carson NF context scale are predicted to increase by 25 to 50 percent, the result of, “increases in agricultural and landscape irrigation in response to rising potential evapotranspiration, and to a much lesser extent to water use in electricity production in response to increased space cooling needs as temperatures rise” (Brown et. al 2013, p. 1259).

Wetlands are among the ecosystems at highest risk from climate change and human development (Dahl 2011). The rate of freshwater wetland loss in the U.S. has slowed since 1974, as a result of regulation and wetland reestablishment or creation on agricultural and undeveloped lands. Most wetland losses between 2004 and 2009 occurred in the upper Midwest and Southeast, not the Southwest. Still, under the influence of future stressors, many wetland systems with marginal functionality will be at increased risk on the Carson NF. Climate warming and precipitation changes will directly impact the ecological benefits that wetlands provide, and will make restoration efforts more challenging. Indirect effects from uncharacteristic wildfire, increased water withdrawal, or changes in human development patterns may further stress wetland systems.

Seeps and springs may lose some or all function as precipitation patterns change, average temperatures increase, and groundwater recharge slows. The loss of these habitats and functions will significantly affect plant and animal communities that depend on spring and seep ecosystems (Dahl 2011).

Groundwater

Groundwater is an important component of water resources on the Carson NF. Much of the surface water on the forest comes from groundwater resources and precipitation that falls on the mountains of the Carson NF recharges the aquifers in the region. Groundwater is used on NFS and surrounding lands for many different purposes. Groundwater wells provide water for drinking, waste disposal, domestic use, and Forest Service facilities. They also water livestock and wildlife.

All groundwater in northern New Mexico originates as infiltrating precipitation (USGS 1995). The States of New Mexico and Colorado have designated groundwater basins, defined by surface flow (HUCs) and political boundaries (OSE 2013; CODNR 2015) (Figure 46). The plan area is located within three New Mexico declared groundwater basins– the Canadian River, Rio Grande, and San Juan. Surface water from each basin supplies both shallow (alluvial) and deep geologic (over and underburden) aquifers (Table 26). Two deep aquifer systems are hydrologically connected with the Carson NF, the Rio Grande aquifer and the Colorado Plateaus aquifer (USGS 1995) (Figure 46).[1]

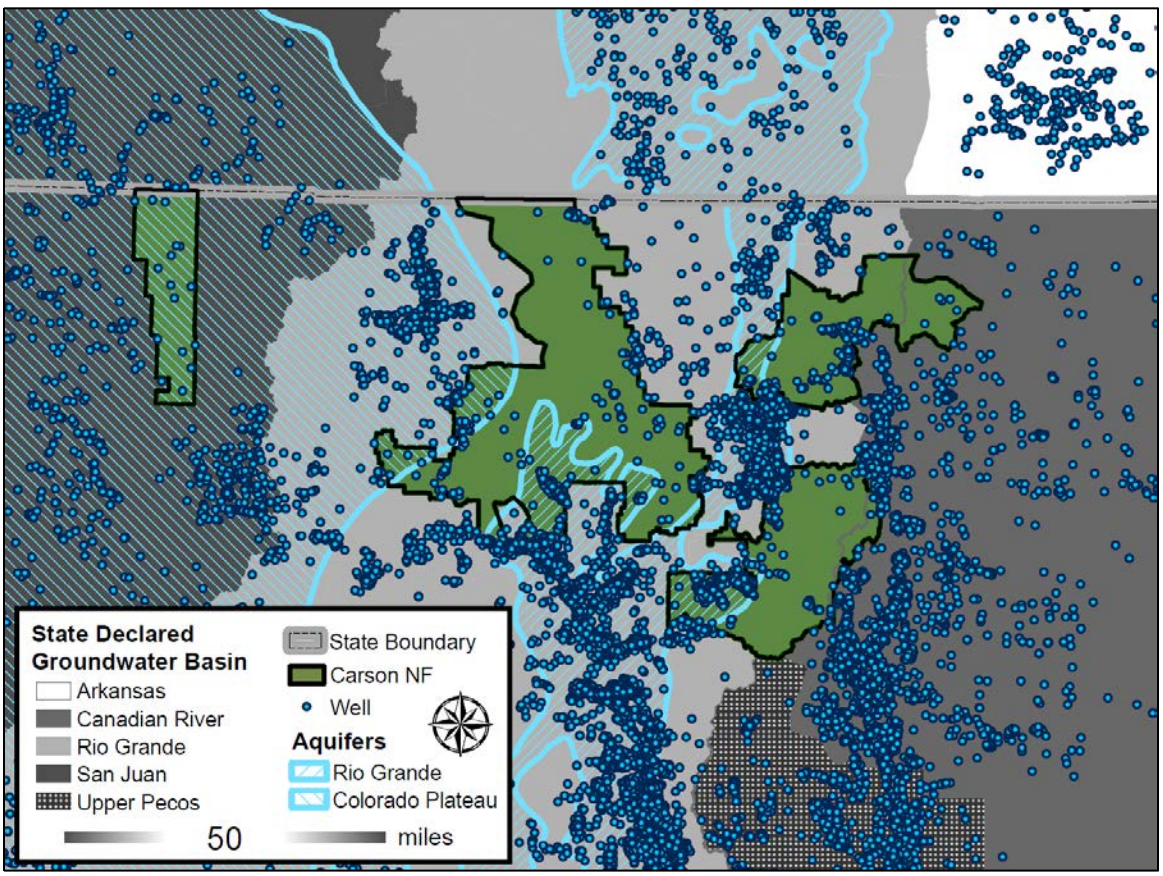

Figure 46. Carson National Forest relative to groundwater basins and wells

[1] The High Plains aquifer system near the Texas border receives some water from the Carson NF in the form of stream infiltration through downstream alluvium, but the plan and context scales have little impact on overall aquifer condition.

Table 26. Size and extent of declared groundwater basins on the Carson National Forest

Basin Name	Rio Grande	San Juan	Canadian River
Acres on Carson NF	1,341,896	157,861	87,208
Percent of Carson NF	85	10	5

Current Condition

The Rio Grande aquifer is comprised of a shallow alluvium that is directly connected to the deeper basin-fill aquifer system. The Rio Grande Rift is a northward trending downfault between uplifted blocks to the east and west that has filled with alluvium and volcanic rock. The depth of this basin fill is estimated to be between 20,000 and 30,000 feet in northern NM and is bounded below by minimally permeable bedrock. The Rio Grande is the principal river in the area and is entrenched in the Rio Grande Gorge near the Carson NF. Along most of the Rio Grande, groundwater discharges to the river and its tributaries. Groundwater levels are generally lower near the river than at the margins of the basin by 600 to 800 feet, and water flows from recharge areas at the margins toward the river. Recharge for the entire aquifer originates mostly in wetter, northern mountainous areas, many of which are on the Carson NF. Precipitation infiltrates through permeable streambeds or directly into bedrock fractures that discharge right into the subsurface basin fill.

Water quality in the aquifer system is affected primarily by the soluble minerals in the mountains that drain into the aquifer. In northern New Mexico, the dissolved-solids concentration is low (about 230 milligrams per liter) and contains mainly calcium, bicarbonate, and sulfate ions. As groundwater flows through the basin fill, it acquires minerals such as calcite and dolomite (calcium and magnesium carbonates), gypsum (calcium sulfate), and halite (rock salt). Where the water table is high and subject to evapotranspiration or there is significant withdrawal of water for mineral (e.g., oil and gas) extraction, a concentration of minerals develops and alkali deposits or salt flats are formed. If these accumulations are then flushed by precipitation or irrigation back to the aquifer they can degrade groundwater quality in the top layer of the aquifer (USGS 1995).

The Colorado Plateaus aquifer system is a complex, multi-layered formation that underlays the San Juan Basin in northwestern New Mexico. The Jicarilla RD is in the San Juan Basin and is hydrologically connected with three distinct aquifers that are part of the Colorado Plateaus system; the Uinta-Animas, and the deeper Mesaverde and Dakota-Glen Canyon aquifers. These principle aquifers are formed by permeable, moderately-to well-consolidated sedimentary rocks of increasing age, separated by relatively impermeable confining units that act as barriers to groundwater movement. The depth of the Uinta-Animas aquifer increases toward the northeastern part of the basin to a maximum thickness of about 3,500 feet. Recharge occurs in the higher altitudes ringing the basin and groundwater flows, mainly north and west toward the San Juan River and its tributaries. Depth to the water table ranges from 100 feet above to 500 feet below land surface. Dissolved-solids concentrations range from 1,000 milligrams per liter at higher elevations to about 4,000 milligrams per liter where groundwater discharges to the San Juan River as a sodium bicarbonate or sulfate type. The top of the Mesaverde aquifer, which underlies the Uinta-Animas, is about 2,500 to 5,000 feet above sea level. It is composed of sandstone, coal, siltstone, and shale. Recharge of the Mesaverde aquifer occurs mostly outside the forest boundary, to the south and west of the Uinta-Animas aquifer. Discharge is mainly to the San Juan River and Chaco River, though there is some upward movement into the overlaying aquifer.

Dissolved-solids concentrations are similar to those in the Uinta-Animas. The Dakota-Glen Canyon aquifer in the area below the San Juan Basin is formed by Dakota Sandstone and is completely separated hydrologically from overlaying aquifers by thick confining units. The depth to the top of the Dakota-Glen Canyon aquifer in the San Juan Basin is about 12,000 feet and recharge zones and groundwater movement are not well defined. Water quality has not been quantified, but dissolved-solids concentrations are very high in other deep portions of the aquifer they can exceed 35,000 milligrams per liter. The combination of poor water quality and great depth make the aquifer unsuitable for development (USGS 1995).

Gas wells on the Jicarilla RD produce primarily from the Pictured Cliffs, Mesaverde Group, Fruitland Coal, and Dakota formations, which lie below the Uinta-Animas aquifer. Recently, there has been interest in development of the deeper Mancos Shale within the San Juan Basin, with the current development taking place in the oil plays south of the Jicarilla RD. Mancos Shale gas development is likely to occur on the Jicarilla RD, but due to the current natural gas economic situation, major development is not expected in the next few years (J.J. Miller, personal communication 2015).

The Carson NF, particularly along its eastern edge, overlays or is adjacent to several surficial aquifers that are part of the Mountain Alluvial system. These aquifers are shallow and small, created where alluvium of stream valleys overlays relatively impermeable bedrock. Some are locally important. All are locally recharged and discharge to dominant streams (USGS 1995).

Groundwater is recharged by surface water, and aquifer levels are affected by reductions in available surface water, either due to reduced precipitation, increased evapotransporation, increased runoff rate, or extraction. Groundwater availability is affected by precipitation, and stream and vegetation condition. Many of the risks already addressed that relate to vegetation, soils, riparian, and surface water condition will also affect infiltration and recharge. Vegetation that is more similar to reference conditions will have structure and function that provides greater interception and storage of precipitation. Vegetation types with sufficient large woody debris have greater surface flow grade control, which slows overland runoff. Stands with a greater aspen (*Populus tremuloides*) component intercept and store more water than stands with little or no aspen (Shepperd et al. 2006). Infiltration occurs over a larger area during the winter, when snowmelt percolates through the soil. In the summer, most precipitation collects in channels and then infiltrates through the stream bed (Titus et al. 1995). Reduced snowpack results in less infiltration. Stream channels with functional floodplain connection and appropriate vegetative structure will have sufficient grade control to slow peak flows and allow for greater infiltration through the alluvium into the deeper groundwater stores. At the plan scale recharge processes are largely intact.

If withdrawal exceeds recharge, the water table may be lowered, river flows may decline, lake levels may fall, and groundwater discharge to wetlands and springs may be reduced or eliminated. Well withdrawals are not a major stressor on NFS lands on the Carson NF, where terrain is more rugged and communities are sparse. Most groundwater wells recorded by the New Mexico Office of the State Engineer are in communities just outside the plan area or in private inholdings (Figure 46, p. 162). Most are shallow, normally located in the valley alluvial fill. At the context scale wells are a potential stressor, particularly near the Carson NF boundary where human development is concentrated. To the extent that extraction there draws down groundwater on the Carson NF it is a risk to forest conditions. The degree to which this is occurring is not known, but potential exists for impacts in the future. In the San Luis Valley just over the Colorado border, the

Rio Grande aquifer has been depleted by nearly 4 cubic kilometers since 1900, and in the middle Rio Grande Valley to the south just under 3 cubic kilometers have been removed, mostly in the area around Albuquerque (Konikow 2013).

The Rio Grande groundwater basin has by far the most groundwater wells (0.98 wells/square mile). The San Juan and Canadian River groundwater basins have 0.40 and 0.36 wells/square mile respectively (Figure 46, p. 162). At the HUC 10 watershed scale, watersheds with the highest well densities surround the towns of Taos, Española, Abiquiu, and Mora (Table 27 and Table 28, p. 166).

Table 27. HUC 10 watersheds with the greatest well density (wells/square mile)

HUC 10 Watershed	Well Density
Rio Pueblo de Taos	4.63
Rio Chama-Rio Grande	4.00
Rio Grande del Rancho	3.89
Santa Cruz River	3.34
El Rito-Rio Chama	2.54
Upper Mora River	2.26

Groundwater Trend

Currently groundwater extraction at the plan scale is not clearly drawing down aquifers, but it will need to be carefully monitored into the future to maintain system integrity. More significant impacts to groundwater and groundwater-dependent ecosystems will likely come from reduced snowpack and spring runoff, as more precipitation falls as rain and average spring time temperatures warm. The duration of spring runoff and peak flow has already declined, and the trend is expected to continue or intensify as climate change makes recent drought conditions more likely to reoccur in the future. The function of some groundwater-dependent systems is likely to be impaired and others may be completely dewatered.

Table 28. Summary of water resources at the context (sub-basin), plan (watershed), and local (sub-watershed) scales

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)	HUC Extent (acres)	Percent Overlapping Carson NF (%)	Percent of the Carson NF (%)	Perennial Streams in HUC (mi)	Perennial Streams on Carson NF (%)	Impaired Streams[1] on Carson NF (mi)	Impaired Streams on Carson NF (%)	Waterbodies[2] (#)	Waterbodies on Carson NF (%)	Seeps/Springs (#)	Seeps/Springs on Carson NF (#)	Wetlands (acres)	Wetlands on Carson NF (acres)	Well Density within Carson NF (#/acre)
Canadian Headwaters (HWs)	1,103,310	0.22	0.15	667.4	0.6	2.7		1,819	0.00	128	0			0.09
HWs Vermejo River	204,433	1.16	0.15	125	3.3	2.7		238	0.00	20	0	3093	2	0.12
Leonardo Ck	15,143	15.72	0.15	16.3	24.9	2.7	45.12	9	0.00	0	0	466	2	0.13
Outlet Vermejo River	150,409	0.03	0.00	100.7	0	0		216	0.00	5	0	4447	0	0.09
HWs Van Bremmer Ck	30,561	0.15	0.00	22.7	0	0	NA	66	0.00	1	0	792	0	0.02
Cimarron (Cim)	671,148	9.08	3.84	582.9	5.2	28.5		999	6.61	94	7			0.56
Eagle Nest Lk-Cim River	213,811	0.91	0.12	224.3	0	0		325	0.62	25	0	9268	25	1.45
HWs Moreno Ck	28,216	0.29	0.01	32.9	0	0	NA	43	4.65	0	0	1376	4	0.48
Outlet Moreno Ck	22,684	0.11	0.00	35.1	0	0	NA	14	0.00	0	0	1358	0	1.55
HWs Cieneguilla Ck	35,159	5.21	0.12	32.6	0	0	NA	77	0.00	2	0	1904	21	3.70
Eagle Nest Lake	18,517	0.03	0.00	15.0	0	0	NA	29	0.00	0	0	3000	0	3.32
Ponil Creek	208,057	28.35	3.72	145.0	20.9	27.7		238	26.89	26	7	3374	1362	0.09
Greenwood Cyn	10,273	57.71	0.37	7.3	46.0	1.7	96.78	1	0.00	0	0	27	2	0.00
Middle Ponil Ck	36,873	57.70	1.34	27.3	60.1	13.0	79.23	32	84.38	1	1	616	539	0.07
Headwaters North Ponil Ck	20,428	84.49	1.09	12.2	66.9	8.1	100.00	33	63.64	4	4	831	665	0.09
Outlet North Ponil Ck	34,569	34.04	0.74	18.8	12.7	2.4	100.00	25	60.00	2	1	87	40	0.11

[1] State of New Mexico CWA §303(d)/§305(b) Integrated List and Report (2014-2016)

[2] National Hydrography Dataset (NHD)

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)	HUC Extent (acres)	Percent Overlapping Carson NF (%)	Percent of the Carson NF (%)	Perennial Streams in HUC (mi)	Perennial Streams on Carson NF (%)	Impaired Streams[1] on Carson NF (mi)	Impaired Streams on Carson NF (%)	Waterbodies[2] (#)	Waterbodies on Carson NF (%)	Seeps/Springs (#)	Seeps/Springs on Carson NF (#)	Wetlands (acres)	Wetlands on Carson NF (acres)	Well Density within Carson NF (#/acre)
HWs Cerrososo Ck	23,560	11.66	0.17	23.5	0	0	NA	14	7.14	1	1	587	114	0.03
Mora	931,844	2.57	1.51	589.3	4.7	2.6		1,597	0.94	21	0			1.20
Coyote Creek	158,846	5.07	0.51	111.2	9.8	2.6		340	2.35	7	0	7199	248	1.78
Upper Coyote Ck	37,262	21.60	0.51	24.8	25.4	2.6	23.68	76	10.53	5	0	3215	248	1.98
Upper Mora River	205,458	7.72	1.00	188.3	8.8	0		399	1.75	3	0	6068	121	2.26
Luna Ck	12,336	61.11	0.48	14.8	67.8	0	NA	4	0.00	0	0	299	41	0.31
Quemado Cyn-Mora River	21,801	22.84	0.31	21.1	23.3	0	NA	6	33.33	0	0	765	53	0.94
Vigil Ck-Mora River	28,126	11.52	0.20	20.8	7.9	0	NA	31	16.13	1	0	481	26	1.59
Rio La Casa	15,105	0.01	0.00	23.5	0	0	NA	21	0.00	0	0	491	0	0.72
Rio La Casa-Mora River	15,081	0.72	0.01	19.7	0	0	NA	17	0.00	1	0	218	0	3.73
Alamosa-Trinchera	1,624,085	0.15	0.15	1131.8	0	0		2,621	0.00	124	0			0.01
Punche Arroyo-Rio Grande	161,509	1.46	0.15	29.1	0	0		105	0.00	1	0	3217	0	0.00
Cove Lake Reservoir	26,012	7.60	0.12	0	0	0	NA	14	0.00	0	0	349	0	0.00
Punche Arroyo	40,082	0.96	0.02	0	0	0	NA	11	0.00	0	0	157	0	0.02
Conejos	490,714	25.53	7.90	488.2	22.1	49.0		1,392	12.14	110	32			0.04
Rio de Los Pinos (RDLP)	98,967	60.48	3.77	117.2	46.6	17.7		181	30.39	26	20	2216	600	0.17
Beaver Creek	16,531	100	1.04	28.4	100	6.6	23.28	18	100.00	4	4	372	372	0.00
Toltec Creek-RDLP	32,770	44.89	0.93	50.1	34.7	4.9	28.47	43	6.98	12	7	479	64	0.00
City of Ortiz-RDLP	33,311	85.89	1.80	16.6	54.0	6.2	98.28	35	97.14	9	9	361	163	0.50

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)	HUC Extent (acres)	Percent Overlapping Carson NF (%)	Percent of the Carson NF (%)	Perennial Streams in HUC (mi)	Perennial Streams on Carson NF (%)	Impaired Streams[1] on Carson NF (mi)	Impaired Streams on Carson NF (%)	Waterbodies[2] (#)	Waterbodies on Carson NF (%)	Seeps/Springs (#)	Seeps/Springs on Carson NF (#)	Wetlands (acres)	Wetlands on Carson NF (acres)	Well Density within Carson NF (#/acre)
Rio San Antonio (RSA)	140,335	46.62	4.12	96.7	54.5	31.3		199	57.29	12	12	9717	770	0.03
Cañada Tio Grande-RSA	33,697	94.04	2.00	45.8	97.6	21.9	48.43	74	97.30	11	11	455	450	0.02
Cañada dL Ranchos-RSA	40,381	80.63	2.05	17.2	55.3	9.4	98.35	45	88.89	1	1	329	320	0.08
San Antonio Cemty-RSA	24,865	4.71	0.07	0.2	0	0	NA	15	13.33	0	0	291	0	0.00
Outlet Conejos River	166,123	0.34	0.04	163.2	0.2	0		634	0.00	64	0	15502	0	0.00
Bighorn Creek	11,283	5.03	0.04	9.0	3.1	0	NA	5	0.00	17	0	43	0	0.00
Upper Rio Grande	2,081,262	31.36	41.14	1375.7	43.2	314.5		1,561	31.33	88	42			2.33
Costillo Creek	248,592	16.02	2.51	168.8	33.8	49.1		124	11.29	10	4	4575	1304	0.23
Comanche Ck	27,241	99.95	1.72	42.5	100	36.0	84.78	12	100.00	2	2	1076	1076	0.02
Comanche Ck-Costillo Creek	16,633	60.33	0.63	19.1	67.2	11.5	90.00	13	15.38	2	2	680	192	0.04
Latir Ck-Costillo Ck	34,795	7.51	0.16	29.0	6.0	1.6	153.42	15	0.00	0	0	299	36	0.18
Latir Creek-Rio Grande	182,066	3.72	0.43	41.7	13.7	0		99	1.01	0	0	1281	53	0.42
130201010202	14,034	2.79	0.02	0	0	0	NA	5	0.00	0	0	165	0	0.05
Urraca Canyon	43,520	0.25	0.01	0	0	0	NA	34	0.00	0	0	337	0	1.22
Latir Creek	22,119	28.39	0.40	24.3	23.4	0	28.24	24	4.17	0	0	300	53	0.61
Red River	121,274	90.45	6.91	125.2	97.0	83.0		103	68.93	3	3	2370	1692	0.91
Upper Red River	36,176	99.82	2.28	51.4	100	38.6	75.07	27	100.00	1	1	1239	1239	2.32
Cabresto Creek	25,136	98.51	1.56	26.5	93.2	15.9	NA	9	100.00	1	1	347	280	0.20
Middle Red River	37,323	99.70	2.35	39.6	98.7	25.6	65.30	14	92.86	1	1	152	142	0.43
Lower Red River	22,638	51.28	0.73	7.6	81.4	3.0	NA	53	41.51	0	0	632	31	0.23

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)	HUC Extent (acres)	Percent Overlapping Carson NF (%)	Percent of the Carson NF (%)	Perennial Streams in HUC (mi)	Perennial Streams on Carson NF (%)	Impaired Streams[1] on Carson NF (mi)	Impaired Streams on Carson NF (%)	Waterbodies[2] (#)	Waterbodies on Carson NF (%)	Seeps/Springs (#)	Seeps/Springs on Carson NF (#)	Wetlands (acres)	Wetlands on Carson NF (acres)	Well Density within Carson NF (#/acre)
Red River-Rio Grande	144,251	4.66	0.42	21.4	26.2	0		97	2.06	0	0	441	5	0.12
Arroyo Punche	35,777	4.24	0.10	0	0	0	NA	20	10.00	0	0	151	0	0.05
Red River-Rio Grande	32,267	16.12	0.33	21.4	26.2	0	NA	33	0.00	0	0	104	5	0.24
Rio Grande del Rancho (RGR)	94,208	88.75	5.27	90.2	89.0	48.6		22	59.09	10	10	1004	398	3.89
Rito de la Olla	21,253	100	1.34	27.5	100	13.7	49.84	1	100.00	5	5	111	111	0.12
Headwaters RGR	25,805	96.86	1.58	19.0	100	15.4	80.96	7	100.00	3	3	79	72	0.15
Rio Chiquito	25,029	98.45	1.55	26.8	93.7	15.8	NA	2	100.00	0	0	145	142	1.33
Outlet RGR	22,120	57.49	0.80	16.9	51.1	3.8	44.00	12	25.00	2	2	669	73	14.78
Rio Pueblo de Taos (RPT)	174,568	24.49	2.69	117.9	35.6	27.6		160	20.00	7	4	5067	798	4.63
HWs Rio Fernando del Taos	33,059	99.90	2.08	35.2	100	23.0	65.23	32	100.00	3	3	781	781	0.21
La Junta Creek-RPT	20,649	0.78	0.01	17.3	0	0	NA	8	0.00	1	0	152	0	0.06
Rita del Gato	20,896	0.56	0.01	27.3	0	0	NA	21	0.00	0	0	1320	0	0.74
Outlet Rio Fernando del Taos	12,868	66.33	0.54	11.3	59.1	4.6	69.00	8	0.00	2	1	366	15	9.10
Rio Fernando del Taos-RPT	32,385	0.09	0.00	18.1	0	0	NA	12	0.00	0	0	1374	0	1.98
Arroyo Seco-RPT	33,857	2.62	0.06	3.1	0	0	NA	71	0.00	0	0	1047	2	16.67
Arroyo del Alameda-RPT	20,854	0	0.00	5.6	0	0	NA	8	0.00	1	0	28	0	1.90
Rio Pueblo de Taos-Rio Grande	205,387	28.68	3.71	80.3	53.7	23.5		188	32.98	3	2	977	187	1.84
Headwaters Arroyo Hondo	20,525	99.98	1.29	22.4	100	11.9	56.86	13	100.00	0	0	82	82	0.90
Outlet Arroyo Hondo	25,225	43.78	0.70	26.5	47.0	3.3	26.26	39	2.56	0	0	190	0	8.65
Arroyo Hondo-Rio Grande	26,475	78.66	1.31	16.8	49.5	8.3	100.00	46	95.65	2	2	89	0	0.41

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Cerros de Taos Ranch	27,391	3.05	0.05	0	0	0	NA	21	0.00	0	0	381	1	0.42
Manby Hot Springs-Rio Grande	28,928	6.02	0.11	6.1	0	0	NA	21	4.76	1	0	0	4	3.19
Town of Carson	17,683	22.27	0.25	0	0	0	NA	11	27.27	0	0	10	1	0.65
Arroyo Aguaje de la Petaca (AAP)	158,475	68.85	6.88	0	0	0		259	72.59	4	4	698	432	0.26
Lamy Canyon-AAP	18,910	55.89	0.67	0	0	0	NA	34	67.65	1	1	81	70	0.03
Martinez Canyon-AAP	28,349	48.35	0.86	0	0	0	NA	39	66.67	1	1	32	18	0.20
Canon de Tio Gordito-AAP	37,476	53.99	1.28	0	0	0	NA	97	64.95	2	2	196	92	0.55
Indian Lake	10,821	100	0.68	0	0	0	NA	21	100.00	0	0	19	19	0.06
Carson Reservoir-AAP	38,571	85.71	2.08	0	0	0	NA	43	79.07	0	0	236	227	0.15
Scott Arroyo-AAP	24,347	85.11	1.31	0	0	0	NA	25	84.00	0	0	10	7	0.34
Embudo Creek (EC)	205,051	77.43	10.01	280.2	75.3	74.5		104	77.88	15	11	2181	1495	0.77
La Junta Creek	19,258	100	1.21	23.5	100	0	NA	4	100.00	1	1	305	305	0.03
La Junta Canyon-Rio Pueblo	21,255	99.97	1.34	32.1	100	12.5	38.89	32	100.00	3	3	557	557	0.54
Osha Canyon-Rio Pueblo	23,005	100	1.45	30.5	100	7.0	23.06	3	100.00	2	2	57	12	0.22
Headwaters Rio Santa Barbara	16,792	99.91	1.06	22.6	100	15.1	66.76	14	100.00	1	1	230	230	0.00
Outlet Rio Santa Barbara	25,032	68.73	1.08	44.1	59.9	11.0	41.54	18	22.22	0	0	619	98	2.17
Rio Santa Barbara-Rio Pueblo	28,800	59.21	1.07	22.8	63.6	4.3	41.26	16	62.50	1	1	232	116	0.31
Cañada del Oso Sarco	13,833	93.78	0.82	23.4	88.5	0	NA	1	100.00	1	0	21	21	1.62
Cañada del Oso Sarco-EC	38,236	77.29	1.86	47.5	77.2	24.7	67.26	16	81.25	3	3	130	110	1.39
Arroyo la Mina-EC	18,839	8.99	0.11	33.8	12.2	0	NA	0	0.00	3	0	30	0	0.14

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Santa Cruz River (SCR)	116,773	0.28	0.02	164.0	0	0		31	0.00	17	0	311	1	3.34
Rio Quemado	27,106	0	0.00	48.8	0	0	17.00	16	0.00	3	0	118	0	1.84
Santa Cruz Reservoir-SCR	30,668	1.06	0.02	24.7	0	0	NA	9	0.00	11	0	138	1	10.68
Rio Chama-Rio Grande (RG)	177,912	20.29	2.28	131.2	21.1	8.1		111	22.52	9	4	1315	124	4.00
Cañada Comanche	10,073	74.01	0.47	0	0	0	NA	9	77.78	0	0	6	5	0.13
Cañada Comanche-RG	38,402	23.28	0.56	20.4	0	2.2	NA	7	14.29	6	2	148	2	0.05
Rio Truchas	21,487	37.12	0.50	39.0	32.2	6.0	NA	32	15.63	2	1	211	105	1.01
Rio Truchas-RG	30,112	36.19	0.69	32.6	0	0	62.81	14	85.71	1	1	66	12	2.34
Arroyo del Palacio-RG	35,028	2.38	0.05	19.8	0	0	NA	22	0.00	0	0	127	115	9.52
Rio Chama	2,020,427	27.77	35.37	1352.8	20.6	149.4		2,838	27.55	338	120			0.76
Chavez Creek	107,979	12.71	0.87	126.0	9.9	2.5		96	11.46	56	12	2561	74	0.84
East Fork Brazos	12,550	48.46	0.38	20.5	39.8	2.3	28.42	8	12.50	9	7	70	29	0.00
West Fork Brazos	11,116	4.71	0.03	28.1	4.1	0.2	13.66	7	0.00	13	3	116	5	0.00
Gavilan Creek	10,407	32.50	0.21	10.6	9.2	0	NA	11	54.55	4	0	310	22	0.12
Gavilan Creek-Rio Brazos	28,132	13.28	0.24	18.9	11.1	0	NA	23	17.39	15	2	766	18	0.07
Chavez Creek-Rio Chama	145,309	0.46	0.04	124.5	0.7	0		456	0.44	15	0	3722	1	0.68
Wolf Creek	18,006	3.74	0.04	28.9	4.1	0	NA	30	6.67	5	0	191	1	0.04
Rio Cebolla	85,324	40.16	2.16	51.6	37.9	3.2		274	23.36	9	3	199	50	0.46
Cedar Grove Cmtry-Arroyo Blanco	19,809	27.52	0.34	0	0	0	NA	86	9.30	1	0	54	3	0.16
Headwaters Rio Cebolla	29,751	41.32	0.77	42.0	44.5	2.3	12.25	138	24.64	6	3	120	41	1.16

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Outlet Rio Cebolla	35,764	46.20	1.04	9.6	9.4	0.9	102.40	50	44.00	2	0	25	6	0.04
Rio Nutrias-Rio Chama	152,302	8.22	0.79	89.0	11.4	5.3		360	38.89	17	6	601	113	0.16
Upper Rio Nutrias	21,805	49.67	0.68	26.5	38.3	5.3	52.32	161	85.71	7	6	295	113	0.12
Huckbay Canyon-Rio Chama	27,178	6.22	0.11	15.3	0	0	NA	18	11.11	2	0	105	0	0.14
Arroyo Seco	103,523	87.83	5.73	28.5	98.5	28.1		270	91.85	31	30	968	462	0.30
Montoya Canyon-Canjilon Ck	22,987	100	1.45	21.4	100	16.7	78.30	180	100.00	11	11	320	320	0.61
Lopez Canyon-Canjilon Creek	17,166	99.78	1.08	1.9	100	1.8	94.11	19	100.00	11	11	10	10	0.11
Martinez Canyon	15,680	100	0.99	0	0	0	NA	22	100.00	3	3	157	0	0.04
Martinez Canyon-Canjilon Ck	16,127	57.42	0.58	5.2	91.9	4.8	92.76	29	37.93	0	0	45	17	0.20
Arroyo del Yeso-Arroyo Seco	31,564	81.95	1.63	0	0	6.2	48.01	20	80.00	6	5	605	87	0.34
Abiquiu Reservoir	168,403	15.53	1.65	146.7	0	0		88	37.50	29	1	2209	9	0.25
Ojito Canyon-Abiquiu Reservoir	22,640	47.89	0.68	12.6	0	0	NA	22	100.00	3	0	125	57	0.14
Rio Puerco-Abiquiu Reservoir	35,143	2.63	0.06	29.6	0	0	NA	25	16.00	8	0	561	1	0.09
Cañones Creek-Abiquiu Reservoir	36,013	39.95	0.91	3.9	0	0	NA	16	43.75	1	1	1301	2	0.55
El Rito	86,443	85.03	4.63	52.6	84.3	27.1		66	98.48	31	31	113	104	1.18
Arroyo Seco	10,550	100	0.66	8.1	100	0	NA	1	100.00	1	1	0	0	0.12
Headwaters El Rito	36,039	100	2.27	30.8	100	21.7	70.53	45	100.00	28	28	94	94	0.62
Outlet El Rito	39,854	67.53	1.70	13.7	44.1	5.3	99.46	20	95.00	2	2	18	9	1.96
El Rito-Rio Chama	103,940	27.72	1.82	53.3	1.8	1.0		39	35.90	14	3	567	13	2.54
Arroyo del Cobre	12,950	61.91	0.51	0	0	0	NA	0	0.00	2	0	0	0	0.35

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Arroyo del Cobre-Rio Chama	20,144	25.72	0.33	14.6	4.6	0.7	100.00	6	66.67	7	0	201	11	3.59
Madera Cañon	19,725	61	0.76	0	0	0	NA	15	60.00	4	3	2	2	0.58
El Rito-Rio Chama	21,672	16.52	0.23	7.8	3.8	0.3	99.64	3	33.33	0	0	349	1	7.83
Rio Tusas (RT)	126,520	100	7.97	70.8	100	42.7		117	100.00	15	15	828	828	0.10
Cañada Biscara-RT	32,453	100	2.05	28.5	100	11.7	41.16	35	100.00	7	7	240	240	0.00
Cañada del Aqua-RT	38,294	100	2.41	22.1	100	13.8	62.43	59	100.00	3	3	248	248	0.12
Cañada de los Comanches	14,132	100	0.89	0	0	0	NA	10	100.00	0	0	8	8	0.09
Cañada de los Comanches-RT	27,148	100	1.71	13.7	100	10.8	78.93	11	100.00	4	4	228	228	0.26
Rio Vallecitos-RT	14,492	100	0.91	6.5	100	6.4	NA	2	100.00	1	1	106	106	0.00
Rio Vallecitos (RV)	121,766	83.77	6.43	88.4	91.9	38.0		83	92.77	20	14	941	688	0.03
Jarosa Creek-RV	31,060	40	0.78	25.2	71.6	12.1	NA	21	80.95	12	6	402	150	0.00
Cañada Alamosa-RV	34,860	96.77	2.13	30.1	100	10.5	34.79	36	94.44	4	4	100	99	0.00
Cañada de Agua-RV	30,433	100	1.92	23.7	100	5.9	24.91	14	100.00	2	2	200	200	0.11
Rio Tusas-RV	25,412	100	1.60	9.5	100	9.5	66.88	12	100.00	2	2	239	239	0.03
Rio Ojo Caliente	119,698	43.45	3.28	66.5	14.9	1.6		23	47.83	7	5	418	142	1.07
Cañada de los Comanches	18,048	85.81	0.98	0	0	0	NA	3	100.00	0	0	9	9	0.11
Upper Rio Ojo Caliente	17,624	52.79	0.59	7.3	54.0	1.6	39.80	5	20.00	7	5	200	116	0.47
Cañada Las Lemitas	19,928	85.02	1.07	8.7	68.5	0	NA	7	85.71	0	0	14	12	0.16
Middle Rio Ojo Caliente	30,009	34.04	0.64	17.3	0	0	NA	3	33.33	0	0	166	4	1.07
Lower Rio Ojo Caliente	22,616	0.28	0.00	33.2	0	0	NA	5	0.00	0	0	28	0	3.59

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)	HUC Extent (acres)	Percent Overlapping Carson NF (%)	Percent of the Carson NF (%)	Perennial Streams in HUC (mi)	Perennial Streams on Carson NF (%)	Impaired Streams[1] on Carson NF (mi)	Impaired Streams on Carson NF (%)	Waterbodies[2] (#)	Waterbodies on Carson NF (%)	Seeps/Springs (#)	Seeps/Springs on Carson NF (#)	Wetlands (acres)	Wetlands on Carson NF (acres)	Well Density within Carson NF (#/acre)
Upper San Juan	2,196,544	5.67	7.85	1373.4	0	0		3,380	1.57	99	0			0.26
San Juan River-Navajo Reservoir	67,873	20.27	0.87	15.0	3.8	0		32	3.13	2	0	1177	8	0.00
Carracas Canyon	24,405	31.58	0.49	0	0	0	NA	15	6.67	2	0	12	1	0.00
San Juan River-Navajo Reservoir	32,474	18.64	0.38	15.0	3.8	0	NA	13	0.00	0	0	1162	7	0.00
Cañon Bancos	79,497	65.44	3.28	0	0	0		52	46.15	0	0	328	6	0.03
Headwaters Cañon Bancos	21,976	35.58	0.49	0	0	0	NA	16	25.00	0	0	6	0	0.00
Cabresto Canyon	34,475	77.32	1.68	0	0	0	NA	32	62.50	0	0	19	6	0.06
Outlet Cañon Bancos	23,045	76.15	1.11	0	0	0	NA	4	0.00	0	0	303	0	0.03
La Jara Creek	185,048	28.28	3.30	0.4	0	0		139	18.71	0	0	1015	88	0.03
Vaqueros Canyon	39,035	30.43	0.75	0	0	0	NA	27	29.63	0	0	80	15	0.03
Vaqueros Canyon-La Jara Ck	24,598	60.58	0.94	0	0	0	NA	16	62.50	0	0	107	66	0.00
La Fragua Canyon	29,945	61.39	1.16	0	0	0	NA	23	21.74	0	0	4	0	0.06
La Jara Canyon	35,355	20.27	0.45	0.4	0	0	NA	27	11.11	0	0	700	6	0.05
Navajo Reservoir	128,050	4.99	0.40	65.0	0	0		235	0.85	1	0	10710	0	0.16
Cañon Bancos-Navajo Reservoir	22,556	24.60	0.35	7.6	0	0	NA	40	2.50	0	0	4213	0	0.14
La Jara Canyon-Navajo Reservoir	29,658	2.82	0.05	7.3	0	0	NA	63	1.59	0	0	1737	0	0.09
Blanco Canyon	1,097,244	3.04	2.10	0	0	0		1,042	2.50	75	33			0.26
1408010303-Tapicito Creek	117,543	1.94	0.14	0	0	0		90	2.22	10	5	79	1	0.22
Wild Horse Cyn-Tapicito Ck	35,210	6.49	0.14	0	0	0	NA	27	7.41	6	5	20	1	0.04

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)	HUC Extent (acres)	Percent Overlapping Carson NF (%)	Percent of the Carson NF (%)	Perennial Streams in HUC (mi)	Perennial Streams on Carson NF (%)	Impaired Streams[1] on Carson NF (mi)	Impaired Streams on Carson NF (%)	Waterbodies[2] (#)	Waterbodies on Carson NF (%)	Seeps/Springs (#)	Seeps/Springs on Carson NF (#)	Wetlands (acres)	Wetlands on Carson NF (acres)	Well Density within Carson NF (#/acre)
1408010304-Carrizo Creek	203,192	15.29	1.96	0	0	0		184	13.04	38	28	205	12	0.08
Ciruelas Canyon-Arroyo	34,276	69.89	1.51	0	0	0	NA	33	63.64	22	19	24	10	0.09
Munoz Creek	20,073	21.48	0.27	0	0	0	NA	10	0.00	7	7	4	5	0.13
Martinez Canyon-Carrizo Cyn	36,005	7.81	0.18	0	0	0	NA	49	6.12	2	2	70	2	0.02

Aquatic Biota

The current condition of aquatic biota is assessed at two scales: plan and local. The plan scale includes perennial streams in HUC 10 watersheds that intersect the Carson NF. The local scale analyzes all perennial streams in HUC 12 sub-watersheds that are only within the Carson NF boundary (Figure 47). Since the Jicarilla RD does not have any perennial water, watersheds and sub-watersheds that are a part of that district are excluded from this analysis.

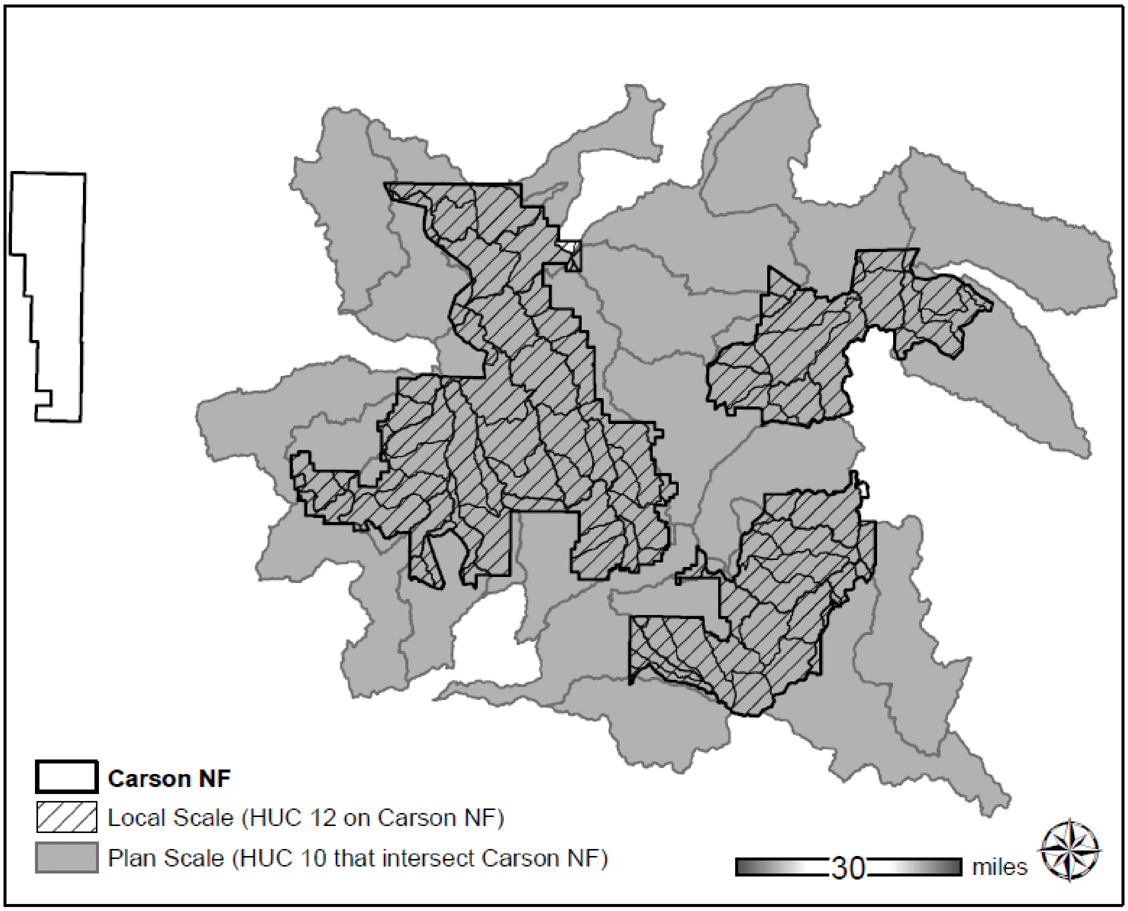


Figure 47. Plan (HUC 10 watershed) and local (HUC 12 sub-watershed) scales for aquatic biota assessment on the Carson NF

Current Condition

Fish Species

Prior to Euro-American settlement, only native aquatic species (such as fish and aquatic macroinvertebrates) were present in these watersheds, their populations were more widespread, interconnected, and the aquatic habitat had all necessary components needed to persist. This pre-Euro-American status of aquatic biota is used as the reference condition. Though, it is likely that aquatic habitat conditions have changed over time, it is assumed the total current perennial stream miles should only be inhabited by native aquatic species; therefore, the current quantity of stream miles is used as reference.

Historic land uses and introduction of nonnative species that occurred within the last hundred years or more have resulted in significant negative impacts to aquatic communities and their watersheds. As a result, native fish populations have been reduced from a large interconnected population to isolated populations within altered and degraded habitats (Alves et al. 2008). Because of the altered habitat and small, isolated populations, all native fish species have lost much of their population redundancy within and outside the Carson NF. These are indicators of watershed health.

Table 29 (p. 178) shows the current distribution of the native fish species found within the plan and local scales associated with the Carson NF. A native fish species that historically occurred within the watershed, but is now extirpated, is represented by the letter “R” for reference. A native fish species that occurred historically and is still occurring in the watershed is represented by “C” (Current). A blank cell indicates a native fish species was not historically present within the watershed.

Table 29. Reference (R) and Current (C) occurrences of native fish species at the plan (HUC 10 watershed) and local (HUC 12 sub-watershed) scales. Blank cells indicate native fish species were not historically present within watershed.

Watershed (HUC 10 gray shade) Sub-watershed (HUC 12 white)	American Eel	Bluntnose Shiner	Central Stonroller	Creek Chub	Fathead Minnow	Flathead Chub	Longnose Dace	Red Shiner	Rio Grande Chub	Rio Grande Cutthroat Trout	Rio Grande Sucker	River Carpsucker	Southern Redbelly Dace	White Sucker	Current/Historic Numbers	Number of Non-Native Fish	Percent Departure of Current From Historic	Risk Ranking[1]
HWs[2] Vermejo River			C	C	C	C	C			C				C	7/7	4	0	L
Leandro Creek			C		C		C			C				C	5/5	4	0	L
Ponil Creek			C	C		C	C	C		C				C	7/7	3	0	L
Greenwood Canyon				C		C	C			R				C	4/5	3	20	L
Middle Ponil Creek				C		C	C			C				C	5/5	2	0	L
HWs North Ponil Creek				R		C	C			C				C	4/5	2	20	L
Outlet North Ponil Creek				C		C	C			R				C	4/5	3	20	L
Coyote Creek			C	C	C	C	C			R			C	C	7/8	2	13	L
Upper Coyote Creek			C	C	C	C	C			R			C	C	7/8	2	13	L
Upper Mora River			C	C	C	C	C			C			C	C	8/8	6	0	L
Luna Creek							C			C				C	3/3	3	0	L
Quemado Cyn-Mora River				C	C	C	C			R			C	C	6/7	6	14	L
Vigil Creek-Mora River				C	C	C	C			R				C	5/6	5	17	L
Rio de Los Pinos					C	C	C		C	C					5/5	5	0	L
Beaver Creek							C		R	C					2/3	4	33	L
Toltec-Rio de Los Pinos							C		C	R					2/3	4	33	L
City of Ortiz-Rio de Los Pinos							C		C	R					2/3	4	33	L

[1] 0-33% departure = Low (L) risk ranking; 34-66% = Moderate (M) risk ranking; 67-100% = High (H) risk ranking

[2] HWs = Headwaters

Watershed (HUC 10 gray shade) Sub-watershed (HUC 12 white)	American Eel	Bluntnose Shiner	Central Stonroller	Creek Chub	Fathead Minnow	Flathead Chub	Longnose Dace	Red Shiner	Rio Grande Chub	Rio Grande Cutthroat Trout	Rio Grande Sucker	River Carpsucker	Southern Redbelly Dace	White Sucker	Current/Historic Numbers	Number of Non-Native Fish	Percent Departure of Current From Historic	Risk Ranking[1]
Rio San Antonio (RSA)					C	C	C		C	C	R				5/6	5	17	L
Cañada Tio Grande-RSA					C		C		C	C	R				4/5	4	20	L
Cañada de los Ranchos-RSA					C		C		C	R	R				3/5	4	40	M
Costillo Creek	R					C	C		R	C	R				3/6	6	50	M
Comanche Creek	R						C		R	C	R				2/5	6	60	M
Comanche Ck-Costillo Ck	R						C		R	C	R				2/5	6	60	M
Latir Creek-Costillo Creek	R						C		R	R					1/4	6	75	H
Latir Creek-Rio Grande	R					C	C		R	R	R				2/6	6	67	H
Latir Creek							C		R	R	R				1/4	5	75	H
Red River	R						C		R	C					2/4	7	50	M
Upper Red River							C		R	C					2/3	6	33	L
Cabresto Creek							C		R	C					2/3	5	33	L
Middle Red River	R						C		R	R					1/4	7	75	H
Lower Red River	R						C		R	R					1/4	7	75	H
Red River-Rio Grande	R				C	C	C		R	R	R				3/7	6	57	M
Red River-Rio Grande	R						C		R	R	R				1/5	6	80	H
Rio Grande (RG) del Rancho	R				C	C	C		C	C	R				5/7	6	29	L
Rito de la Olla	R						C		R	C	R				2/5	5	60	M
HWs RG del Rancho							C		C	C					3/3	5	0	L
Rio Chiquito	R						C		R	C	R				2/5	5	60	M
Outlet RG del Rancho	R						C		C	R	R				2/5	5	60	M

Watershed (HUC 10 gray shade) Sub-watershed (HUC 12 white)	American Eel	Bluntnose Shiner	Central Stonroller	Creek Chub	Fathead Minnow	Flathead Chub	Longnose Dace	Red Shiner	Rio Grande Chub	Rio Grande Cutthroat Trout	Rio Grande Sucker	River Carpsucker	Southern Redbelly Dace	White Sucker	Current/Historic Numbers	Number of Non-Native Fish	Percent Departure of Current From Historic	Risk Ranking[1]
Rio Pueblo de Taos	R				C	C	C		R	C	R	C			5/8	6	38	M
HWs Rio Fernando de Taos							C		R	R	R				1/3	5	67	H
Outlet Rio Fernando del Taos	R						C		R	R	R				1/5	6	80	H
Rio Pueblo de Taos-Rio Grande	R				C	C	C	C	R	C	R	C			6/9	6	33	L
Headwaters Arroyo Hondo							C		R	C	R				2/3	4	33	L
Outlet Arroyo Hondo	R						C		R	R	R				1/5	5	80	H
Arroyo Hondo-Rio Grande	R						C		R	R	R				1/5	6	80	H
Embudo Creek (EC)	R				C	C	C	C	R	C	R	C			6/9	6	33	L
La Junta Creek	R						C		R	C	R				2/5	5	60	M
La Junta Canyon-Rio Pueblo	R						C		R	C	R				2/5	5	60	M
Osha Canyon-Rio Pueblo	R						C		R	C	R				2/5	5	60	M
HWs Rio Santa Barbara							C		R	C	R				2/3	5	33	L
Outlet Rio Santa Barbara	R						C		R	R	R				1/5	6	80	H
Santa Barbara-Rio Pueblo	R						C		R	R	R				1/5	6	80	H
Cañada del Oso Sarco	R						C		R	R	R				1/5	6	80	H
Cañada del Oso Sarco-EC	R						C		R	C	R				2/5	6	60	M
Arroyo la Mina-EC	R						C		R	R	R				1/5	6	80	H
Santa Cruz	R				C	C	C	C	R	C	R	C			6/9	7	33	L
Rio Chama-Rio Grande	R				C	C	C	C	R	C	R	C			6/9	10	33	L
Rio Truchas	R						C		R	R	R				1/5	4	80	H
Rio Truchas-Rio Grande	R						C		R	R	R				1/5	4	80	H
Chavez Creek					C	C	C		R	R					3/5	6	40	M

Watershed (HUC 10 gray shade) Sub-watershed (HUC 12 white)	American Eel	Bluntnose Shiner	Central Stonroller	Creek Chub	Fathead Minnow	Flathead Chub	Longnose Dace	Red Shiner	Rio Grande Chub	Rio Grande Cutthroat Trout	Rio Grande Sucker	River Carpsucker	Southern Redbelly Dace	White Sucker	Current/Historic Numbers	Number of Non-Native Fish	Percent Departure of Current From Historic	Risk Ranking[1]
East Fork Brazos							C		R	R					1/3	4	67	H
West Fork Brazos							C		R	R					1/3	4	67	H
Gavilan Creek							C		R	R					1/3	4	67	H
Gavilan Creek-Rio Brazos							C		R	R					1/3	4	67	H
Chavez Creek-Rio Chama					C	C	C		R	C	R				4/6	6	33	L
Wolf Creek							C		R	R	R				1/4	5	75	H
Rio Cebolla					C	C	C		R	R	R				3/6	5	50	M
Headwaters Rio Cebolla							C		R	R	R				1/4	4	75	H
Outlet Rio Cebolla							C		R	R	R				1/4	4	75	H
Rio Nutrias-Rio Chama					C	C	C		C	R	R				4/6	4	33	L
Upper Rio Nutrias							C		C	R	R				2/4	4	50	M
Arroyo Seco					C	C	C		C	C	R	C			6/7	5	14	L
Montoya Canyon-Canjilon Ck						R	C		C	C	R				3/5	4	40	M
Lopez Canyon-Canjilon Ck						R	C		C	R	R				2/5	4	60	M
Martinez Canyon-Canjilon Ck						R	C		C	R	R				2/5	4	60	M
Abiquiu Reservoir					C	C	C		R	C	C	C			5/7	12	29	L
El Rito					C	C	C		C	C	R	C			5/6	5	14	L
Arroyo Seco							C		C	R	R				2/4	4	50	M
Headwaters El Rito					C		C		C	C	R				4/5	4	20	L
Outlet El Rito					C	C	C		C	R	R				4/6	5	33	L
El Rito-Rio Chama		R			C	C	C		R	R	R				4/8	6	57	M
Arroyo del Cobre					C	C	C		R	R	R				3/6	4	50	M

Watershed (HUC 10 gray shade) Sub-watershed (HUC 12 white)	American Eel	Bluntnose Shiner	Central Stonroller	Creek Chub	Fathead Minnow	Flathead Chub	Longnose Dace	Red Shiner	Rio Grande Chub	Rio Grande Cutthroat Trout	Rio Grande Sucker	River Carpsucker	Southern Redbelly Dace	White Sucker	Current/Historic Numbers	Number of Non-Native Fish	Percent Departure of Current From Historic	Risk Ranking[1]
El Rito-Rio Chama					C	C	C		R	R	R				3/6	5	57	M
Rio Tusas (RT)					C	C	C		C	R	C	C			6/7	6	14	L
Cañada Biscara-RT							C		C	R	C				3/4	5	25	L
Cañada del Aqua-RT							C		C	R	C				3/4	5	25	L
Cañada Comanches-RT							C		C	R	C				3/4	5	25	L
Rio Vallecitos-RT					C	C	C		C	R	C				5/6	5	17	L
Rio Vallecitos (RV)					C	C	C		C	C	C				6/6	2	0	L
Jarosa Creek-RV							C		C	C	C				4/4	2	0	L
Cañada Alamosa-RV							C		C	R	C				3/4	2	25	L
Cañada de Agua-RV							C		C	R	C				3/4	2	25	L
Rio Tusas-RV							C		C	R	C				3/4	2	25	L
Rio Ojo Caliente					C	C	C		R	R	R				3/6	2	50	M
Upper Rio Ojo Caliente					C	C	C		R	R	R				3/6	2	50	M
Cañada Las Lemitas							C		R	R	R				3/4	2	75	H
Current/historic #'s of HUC 10 watershed with fish occurrences	0/10	0/1	4/4	4/4	23/23	26/26	27/27	4/4	8/23	18/27	3/20	9/9	2/2	4/4				
Percent departure of current from reference	100	100	0	0	0	0	0	0	65	33	85	0	0	0				
Current/historic #'s of HUC 12 watershed with fish occurrences	0/22		2/2	6/7	12/12	12/14	68/68		20/59	21/68	8/43		2/2	9/9				
Percent departure of current from reference	100		0	14	0	14	0		66	69	81		0	0				

Historically, 14 native fish occurred within the plan scale (Sublette et al. 1990). Currently, 12 (86%) of these native species still occur, while two (14%) are now considered extirpated (Table 29, p. 178). Another three (21%) species still occurring at the plan scale have declined in their distributions. At the local scale, 11 native fish species historically occurred within the sub-watersheds of the Carson NF (Alves et al. 2008; Clamusso and Rinne 2009; NMDGF 2013d; Sublette et al. 1990) and 1 species (9%) is considered extirpated (Table 29, p. 178). Additionally, five (38%) native species still occurring at the local scale have declined in distribution, while the remaining five species (45%) are maintaining or showing slight increases in distribution (BISON-M 2014; NMDGF 2013d; Propst 1999; Sublette et al. 1990).

Habitat for native species is diminished or eliminated because of unfavorable changes in riparian and upland ERUs (see Terrestrial Vegetation and Riparian Vegetation) which have affected native fish diversity and distribution. Most riparian ERUs adjacent to waters currently exhibit altered structure, species composition, and canopy cover. In adjacent frequent fire ERUs, shifts in the fire regimes have increased the potential for catastrophic impacts associated with wildfire. Altered fire regimes have increased the susceptibility of uplands to large scale stand replacing fires or fire related catastrophic changes to the stability of the watershed, and have increased the potential for uncharacteristic fire effects in adjacent riparian ERUs. Uncharacteristic fire raises the possibility of increased sedimentation, higher water temperatures, and shifts in flood severity or frequency, essentially destabilizing the watershed.

The impacts from user-created roads, hiking trails, camping, and ungulate grazing have increased in the uplands and near streams. Increased forage removal associated with ungulate, camping, and hiking use removes protective vegetation cover from underlying soils and results in increased sedimentation, altered peak run-off flows, and greater habitat fragmentation. Existing user-created (motor vehicle) routes on the landscape, in combination with ungulate grazing, has degraded overall water quality and negatively impacted soil and vegetation conditions in floodplains and uplands. Although localized impacts can look dramatic and have lasting impacts in the immediate area, their overall impacts are small at a forest-wide scale.

Hybridization, depredation, and competition from non-native fish have likely contributed to diversity and distribution declines in native fish species, as well. There are 16 non-native species that currently inhabit the streams on the plan and local scales. Moreover, there are some fish that are native to certain watersheds, such as white sucker *(Catostomus commersonii)* and fathead minnow *(Pimephales promelas)*, that have been accidentally introduced into watersheds they historically did not occupy. Non-native fish species were introduced into these watersheds for sport fishing or by accident through bait bucket transport (see Chapter III. Angling). Red River State Fish Hatchery is the largest producing hatchery in New Mexico and provides most of the stocking of rainbow trout on the Carson NF. This hatchery has converted to raising triploid (sterile) trout to be stocked in waters where interbreeding with native fish is not desired (NMDGF 2009). The New Mexico Department of Game and Fish (NMDGF) coordinates fish stocking with the Carson NF to reduce effects to other species where conflicts are known.

Non-native fish currently inhabit approximately 2,591 miles (91%) of the 2,833 miles of perennial streams intersecting the Carson NF at plan scale (Table 30). Although native fish may still inhabit these streams, their population and condition are likely in a diminished state (Alves et al. 2008) (Table 29, p. 178 and Table 30). For example, 62 percent of Rio Grande cutthroat trout (Oncorhynchus clarki virginalis) populations are introgressed with rainbow trout (*Oncorhynchus mykiss*) (Alves et al. 2008). Currently, 243 (9%) perennial stream miles support only native fish in the plan area (HUC 10 watershed). These native only streams are generally found in headwaters, where genetically pure populations of Rio Grande cutthroat trout are isolated by a physical barrier (man-made and natural (Figure 48, p. 187) (RGCTWG 2013). Currently, sixty-one percent (61%) of the Rio Grande cutthroat trout range occurs on public lands (State, BLM, FS), of which more than half (63%) occurs on the Carson NF (RGCTWG 2013). The Carson NF has 1,044 perennial stream miles, of which only136 (13%) miles contain only native fish. The remaining 908 (87%) stream miles on the Carson NF have a combination of native and non-native fish present. Native fish populations will likely continue to diminish in the presence of nonnatives or maybe even cause extinctions of some native species. Barrier installations to protect and restore native fish streams will continually be required. Due to the popularity of nonnative sport fish, it is unlikely the Carson NF would ever have a fishery that is comprised of 100 percent native fishes.

Table 30. Current native fish only stream miles and non-native/native fish stream miles at the plan and local scales

Watershed (HUC 10 gray shade) Sub-watershed (HUC 12 white)	Perennial Stream Miles	Current Native Fish Only Stream Miles	Current Native/ Non-native Fish Stream Miles	% Departure of Current Native Only from Stream Miles	Risk Ranking[1]
Headwaters Vermejo River	125	0	125	100	High
Leandro Creek	4	0	4	100	High
Ponil Creek	145	17	128	88	High
Greenwood Canyon	3	0	3	100	High
Middle Ponil Creek	16	7	10	58	Moderate
HWs North Ponil Creek	8	7	1	16	Low
Outlet North Ponil Creek	2	0	2	100	High
Coyote Creek	111	0	111	100	High
Upper Coyote Creek	11	0	11	100	High
Upper Mora River	188	10	178	95	High
Luna Creek	10	0	10	100	High
Quemado Canyon-Mora River	5	0	5	100	High
Vigil Creek-Mora River	2	0	2	100	High
Rio de Los Pinos	117	10	107	91	High
Beaver Creek	28	0	28	100	High
Toltec Creek-Rio de Los Pinos	17	0	17	100	High
City of Ortiz-Rio de Los Pinos	9	0	9	100	High
Rio San Antonio (RSA)	97	0	97	100	High
Cañada Tio Grande-RSA	45	0	45	100	High
Cañada de Los Ranchos-RSA	10	0	10	100	High
Costillo Creek	169	81	88	52	Moderate
Comanche Creek	42	36	6	15	Low
Comanche Creek-Costillo Ck	13	8	5	38	Moderate
Latir Creek-Costillo Creek	2	0	2	100	High

[1] 0-33% departure = Low (L) risk ranking; 34-66% = Moderate (M) risk ranking; 67-100% = High (H) risk ranking

Watershed (HUC 10 gray shade) Sub-watershed (HUC 12 white)	Perennial Stream Miles	Current Native Fish Only Stream Miles	Current Native/ Non-native Fish Stream Miles	% Departure of Current Native Only from Stream Miles	Risk Ranking[1]
Latir Creek-Rio Grande	42	0	42	100	High
Latir Creek	6	0	6	100	High
Red River	125	9	116	92	High
Upper Red River	51	2	49	96	High
Cabresto Creek	25	0	25	100	High
Middle Red River	39	7	32	81	High
Lower Red River	6	0	6	100	High
Red River-Rio Grande	21	0	21	100	High
Red River-Rio Grande	6	0	6	100	High
Rio Grande del Rancho	90	0	90	100	High
Rito de la Olla	27	0	27	100	High
HWs Rio Grande de Rancho	19	0	19	100	High
Rio Chiquito	25	0	25	100	High
Outlet Rio Grande del Rancho	9	0	9	100	High
Rio Pueblo de Taos	117	0	117	100	High
HWs Rio Fernando del Taos	35	0	35	100	High
Outlet Rio Fernando del Taos	7	0	7	100	High
Rio Pueblo de Taos-Rio Grande	80	11	69	86	High
Headwaters Arroyo Hondo	22	6	16	73	High
Outlet Arroyo Hondo	12	0	12	100	High
Arroyo Hondo-Rio Grande	8	5	3	42	High
Embudo Creek (EC)	280	36	244	87	High
La Junta Creek	24	9	15	62	Moderate
La Junta Canyon-Rio Pueblo	32	10	22	68	High
Osha Canyon-Rio Pueblo	30	6	25	82	High
Headwaters Rio Santa Barbara	23	0	23	100	High
Outlet Rio Santa Barbara	26	3	24	89	High
Rio Santa Barbara-Rio Pueblo	14	0	14	100	High
Cañada del Oso Sarco	21	0	21	100	High
Cañada del Oso Sarco-EC	37	9	28	76	High
Arroyo la Mina-Embudo	4	0	4	100	High
Santa Cruz	164	9	155	95	High
Rio Chama-Rio Grande	28	10	18	64	Moderate
Rio Truchas	13	7	6	44	Moderate
Rio Truchas-Rio Grande	15	0	15	100	High
Chavez Creek	126	0	126	100	High
East Fork Brazos	8	0	8	100	High
West Fork Brazos	1	0	1	100	High

Watershed (HUC 10 gray shade) Sub-watershed (HUC 12 white)	Perennial Stream Miles	Current Native Fish Only Stream Miles	Current Native/ Non-native Fish Stream Miles	% Departure of Current Native Only from Stream Miles	Risk Ranking[1]
Gavilan Creek	1	0	1	100	High
Gavilan Creek-Rio Brazos	2	0	2	100	High
Chavez Creek-Rio Chama	159	8	151	95	High
Wolf Creek	1	0	1	100	High
Rio Cebolla	52	0	52	100	High
Headwaters Rio Cebolla	19	0	19	100	High
Outlet Rio Cebolla	1	0	1	100	High
Rio Nutrias-Rio Chama	89	0	89	100	High
Upper Rio Nutrias	10	0	10	100	High
Arroyo Seco	29	5	24	83	High
Montoya Canyon-Canjilon Ck	21	5	16	76	High
Lopez Canyon-Canjilon Creek	2	0	2	100	High
Martinez Canyon-Canjilon Ck	5	0	5	100	High
Abiquiu Reservoir	148	22	126	85	High
El Rito	53	9	44	83	High
Arroyo Seco	8	0	8	100	High
Headwaters El Rito	31	8	23	74	High
Outlet El Rito	6	0	6	100	High
El Rito-Rio Chama	53	0	53	100	High
Arroyo del Cobre	1	0	1	100	High
El Rito-Rio Chama	0	0	0	100	High
Rio Tusas (RT)	71	0	71	100	High
Cañada Biscara-RT	29	0	29	100	High
Cañada del Aqua-RT	22	0	22	100	High
Cañada de los Comanches-RT	14	0	14	100	High
Rio Vallecitos-RT	7	0	7	100	High
Rio Vallecitos (RV)	88	5	83	94	High
Jarosa Creek-RV)	18	2	16	91	High
Cañada Alamosa-RV	30	0	30	100	High
Cañada de Agua-RV	24	0	24	100	High
Rio Tusas-RV	10	0	10	100	High
Rio Ojo Caliente	67	0	67	100	High
Upper Rio Ojo Caliente	4	0	4	100	High
Cañada Las Lemitas	6	0	6	100	High
Watersheds intersecting Carson NF	2,833	243	2,591	91	High
Sub-watersheds on the Carson NF	1,044	136	908	87	High

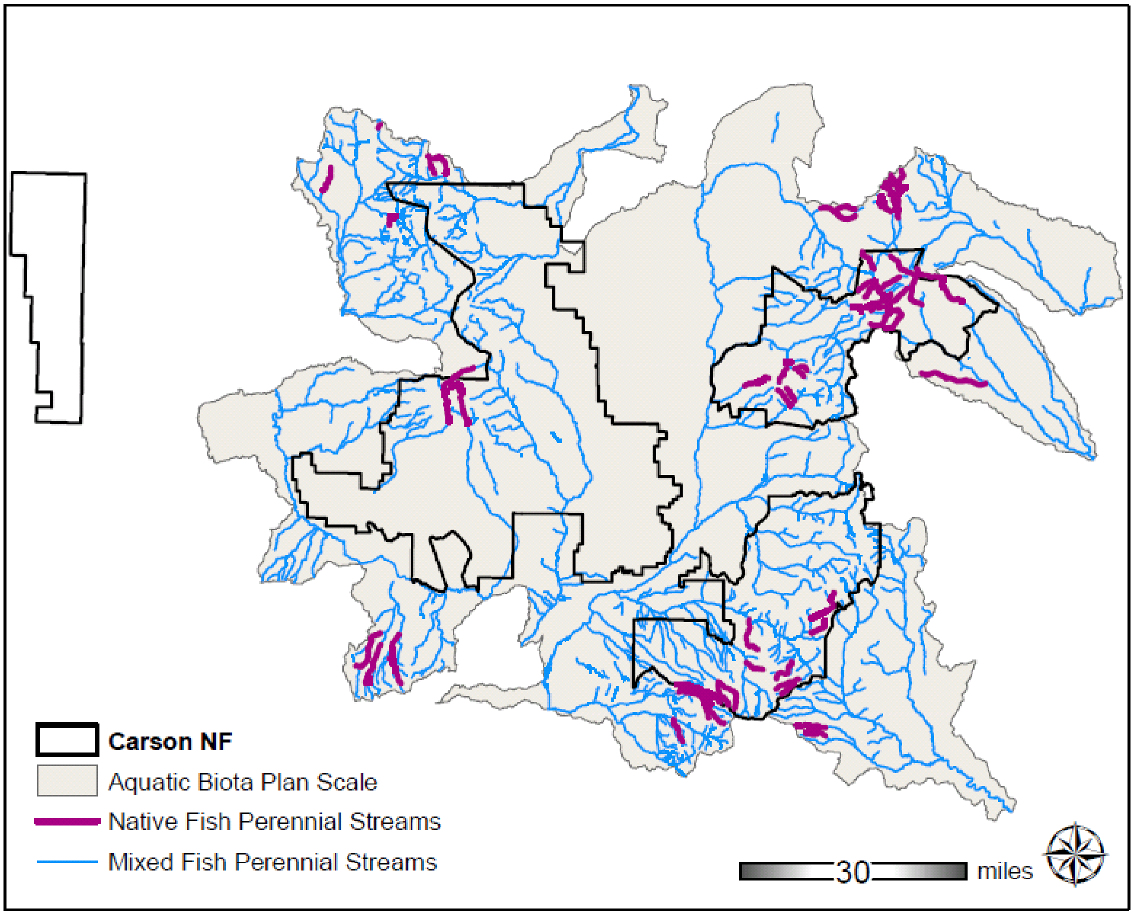


Figure 48. Native fish and mixed fish perennial streams and native fish perennial streams within plan scale

Macroinvertebrates

Aquatic macroinvertebrates are used as biological indicators of stream health, because they are found in all but the harshest or severely polluted streams. Within a stream, the composition of this diverse group of taxa is directly related to the water quality characteristics. For example, some families of invertebrates are found in high abundance in streams that are cold with cobble substrate that have high dissolved oxygen, while others do quite well in slow, muddy rivers. Furthermore, in cases of very poor water quality, only the most tolerant invertebrate species will persist. Generally, decreased water quality (e.g., increased fine sediment) reduces intolerant species diversity and abundance (Kaller and Hartman 2004; Reynoldson et al. 1997).

There are many popular invertebrate based indices for determining water quality conditions within streams and lakes. For example, the “EPT” test evaluates the abundance and diversity of taxa within the Ephemeroptera, Plecoptera, and Trichoptera families, because they are very sensitive to poor water quality. Furthermore, some indices group invertebrates into functional feeding groups (i.e., shredders, scrapers, collectors) and make inference to water quality conditions based on their abundance and diversity. While these indices work well when comparing samples from one location over time, they do not perform well when comparing non-similar areas. For example, a small headwater stream with very good water quality may have fewer EPT taxa than a larger stream. The EPT would indicate the larger being in better condition, when, in fact, it may not be. To account for this, this assessment uses a multi-metric approach, called the Hilsenhoff Biotic Index (HBI), which corrects for abundance bias in determining the current condition of water quality in streams on the Carson NF. The HBI categorizes species on their ability to tolerate organic pollution using a scale from 0 (most sensitive to pollution) to 10 (most tolerant to pollution). Though the HBI was designed specifically for organic pollution, it often works well with other environmental stressors (Griffith et al. 2005). Samples collected on the Carson NF (95 sample sites), as well as data from New Mexico Environment Department (NMED) (37 Sample sites), are used for this analysis. Samples were collected with a variety of techniques from targeted riffles at 132 sites, between 1980 and 2010. Stream water quality was determined from the assigned HBI values for each stream and placed into one of following water quality categories; excellent (HBI 0-3.5), very good (HBI 3.51-4.5), good (HBI 4.51-5.5), fair (5.51-7.0), and poor (HBI > 7.0) (Hilsenhoff 1987).

Current condition of macroinvertebrates is only analyzed at one scale (Carson NF), due to limited sample size. Currently, most stream sample sites on the Carson NF have either excellent or very good water quality (35% and 49%, respectively), while the rest are considered good with 2 sites considered fair (Figure 49). None of the sampled streams sites had a poor water quality rating. However, many streams on the Carson NF have impaired segments, due to temperature, sedimentation, toxins, etc. according to the NMED §303d water quality list (NM WQCC 2012), and many of the sampled macroinvertebrate sites were taken in these impaired stream segments. The discrepancies between the HBI and §303d list could be that the levels considered impaired by the NMED may not impact aquatic macroinvertebrates to the point of altering the community structure within the stream, which would leave the HBI value unchanged. These impairments are more thoroughly discussed in the Water Quality section of this document. Based on the HBI analysis and the NMED §303d water quality list, the current aquatic macroinvertebrate community is somewhat departed from reference condition, likely due to low stream flow, increase sedimentation, and the presence of toxins in some areas.

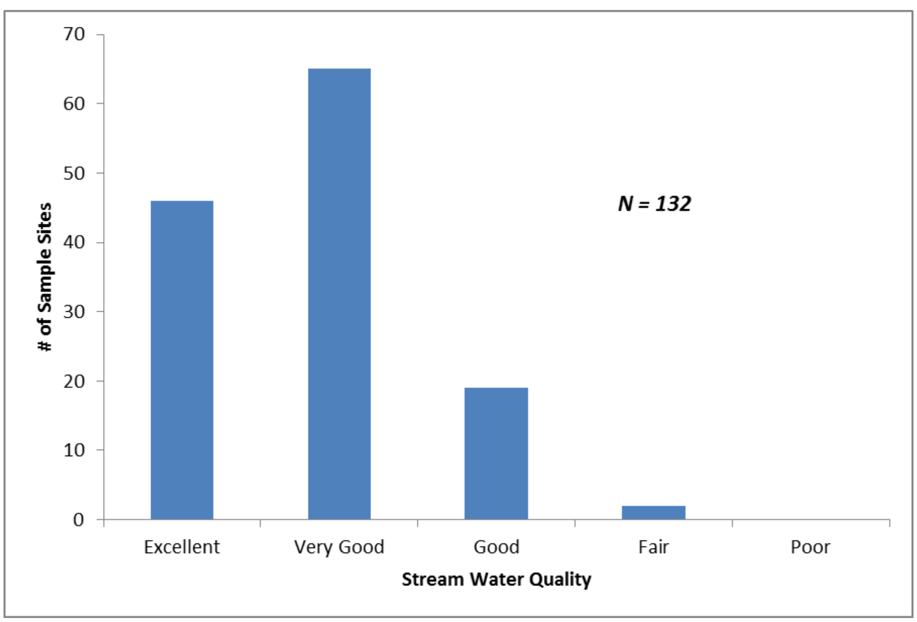


Figure 49. Water quality based on HBI ratings and enumerated macroinvertebrate sample sites for the Carson National Forest

The HBI analysis was further broken down into local zones (Figure 6, p. 28) within the Carson NF. The local scale analysis determined water quality groups based on HBI values for the following local zones: Cruces Basin, Rio Chama, Vallecitos, Rio Grande, Red River, Valle Vidal, and Camino Real. The majority of sample sites within zones are very good and excellent, with few being considered good or fair (Table 31). However, proportionally, Vallecitos have the most excellent water quality ratings within its zone (Table 31). Furthermore, the Valle Vidal local zone has the greatest proportion of streams considered very good, followed by Red River and Camino Real, respectively (Table 31). Habitat improvements may be needed within all local zones to increase the number of excellent water quality streams; however, the Carson NF generally has very good water quality as indicated by the aquatic macroinvertebrate community.

Table 31. Water quality categories for local zones within the Carson NF based on HBI ratings

		Water Quality Category[1]				
Local Zone	***N*[2]***	**Excellent (%)**	**Very Good (%)**	**Good (%)**	**Fair (%)**	**Poor (%)**
Cruces Basin	15	4 (26)	6 (40)	4 (26)	1 (8)	0 (0)
Rio Chama	2	0 (0)	1 (50)	1 (50)	0 (0)	0 (0)
Vallecitos	13	10 (77)	3 (23)	0 (0)	0 (0)	0 (0)
Rio Grande	3	0 (0)	0 (0)	2 (67)	1 (33)	0 (0)
Red River	37	14 (38)	19 (51)	4 (11)	0 (0)	0 (0)
Valle Vidal	27	4 (15)	20 (74)	3 (11)	0 (0)	0 (0)
Camino Real	34	13 (38)	16 (47)	5 (15)	0 (0)	0 (0)

[1] Numbers indicate sample site quantity within that category and parenthetical numbers indicate proportion of that category as a percent of total N.

[2] Local zone sample sites do not add up to the Carson NF total of 132, because one site did not have specific location information and the appropriate zone could not be determined.

Invasive Species and Disease

Four perennial streams within the local scale are known to have Didiymo (*Didymoshenia geminate*), an aquatic invasive species. Invasive species are defined as "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health" (Executive Order 13112, (USDA FS 2014g), p. 1). Didiymo (also known as rock snot) is an invasive alga that forms thick brown mats on stream bottoms. These mats alter stream conditions and can negatively affect macroinvertebrates on the stream bottom, which are a food source for larger aquatic species (NY DEC 2014). Whirling disease is the only known fish disease or parasite currently occurring in five streams at the local scale (NMDGF 2014b). Whirling disease is a parasite that infects salmonids and causes skeletal deformation and neurological damage, which, in turn, affects swimming, feeding, and makes the fish more vulnerable to predators (Montana Water Center 2002). Also found in some of streams of the Carson is a *Batrachochytrium dendrobatidis* fungus known as Chytrid. Chytrid fungus infects amphibian species with the chytridiomycosis disease, which is linked to devastating population declines or species extinctions (Kilpatrick et al. 2009). These invaders are primarily spread by anglers and others engaging in water-based recreation. These invaders cling to waders, boots, clothing, fishing equipment, and other equipment accidently being transported to other waterbodies. Currently, there are no other known "invasions" besides Didiymo, chytrid, and whirling disease, but invasive species and diseases are a continuing challenge. Invasive species and diseases are added threats to native fish, along with environmental conditions, such as high water temperatures and increased sedimentation, invasive species and diseases stress native fish, making it harder to co-exist with non-native fish species.

Trend

Aquatic species and habitat are projected to continue in a stable trend and native fish will continue to persist because:

- Non-native fish species are expected to persist, but not increase for their economic importance of sport fisheries.
- Invasive aquatic species distribution and aquatic diseases are expected to persist or increase.
- Watersheds will continue to be influenced by ERUs and soils that are departed from reference conditions.
- User-created roads and ungulate grazing will continue at current levels thereby influencing water quality and riparian vegetation condition.
- Many aquatic ecosystems have the ability to trend towards reference condition given the opportunity for restoration. Implementation of native fish restoration projects continue to increase on the Carson NF.

Watersheds

Watershed condition is the state of the physical and biological characteristics and processes within a watershed that affect the soil and hydrologic functions supporting aquatic ecosystems. Watershed condition reflects a range of variability from natural pristine (functioning properly) to degraded (severely altered state or impaired). Watersheds that are functioning properly have terrestrial, riparian, and aquatic ecosystems that capture, store, and release water, sediment, wood, and nutrients within their range of natural variability for these processes. When watersheds are functioning properly, they create and sustain functional terrestrial, riparian, aquatic, and wetland habitats that are capable of supporting diverse populations of native aquatic- and riparian-dependent species. In general, the greater the departure from the natural pristine state, the more impaired the watershed condition is likely to be. Watersheds that are functioning properly are commonly referred to as healthy watersheds (USDA FS 2011b).

The watershed condition classification approach was designed to classify the condition of all NFS watersheds, be quantitative to the extent feasible, rely on GIS technology, be cost-effective, implementable within existing budgets, and to include resource areas and activities that have a significant influence on watershed condition. Watershed condition classification is the process of describing watershed condition in terms of discrete categories (or classes) that reflect the level of watershed health or integrity.

Watersheds were rated by Carson NF personnel in 2011 using a combination of spatial GIS data and on the ground knowledge[1]. Except for those that were less than 5 percent NFS lands, all HUC 12 sub-watersheds on the Carson NF were classified utilizing the watershed condition classification approach (USDA FS 2011b) and were assigned a condition class related to the degree of level of watershed function or integrity:

- Class 1 = Functioning Properly (FP)
- Class 2 = Functioning at Risk (FAR)
- Class 3 = Impaired Function (IF)

[1] The complete watershed condition database is available online: http://gis.fs.fed.us/publications/watershed/

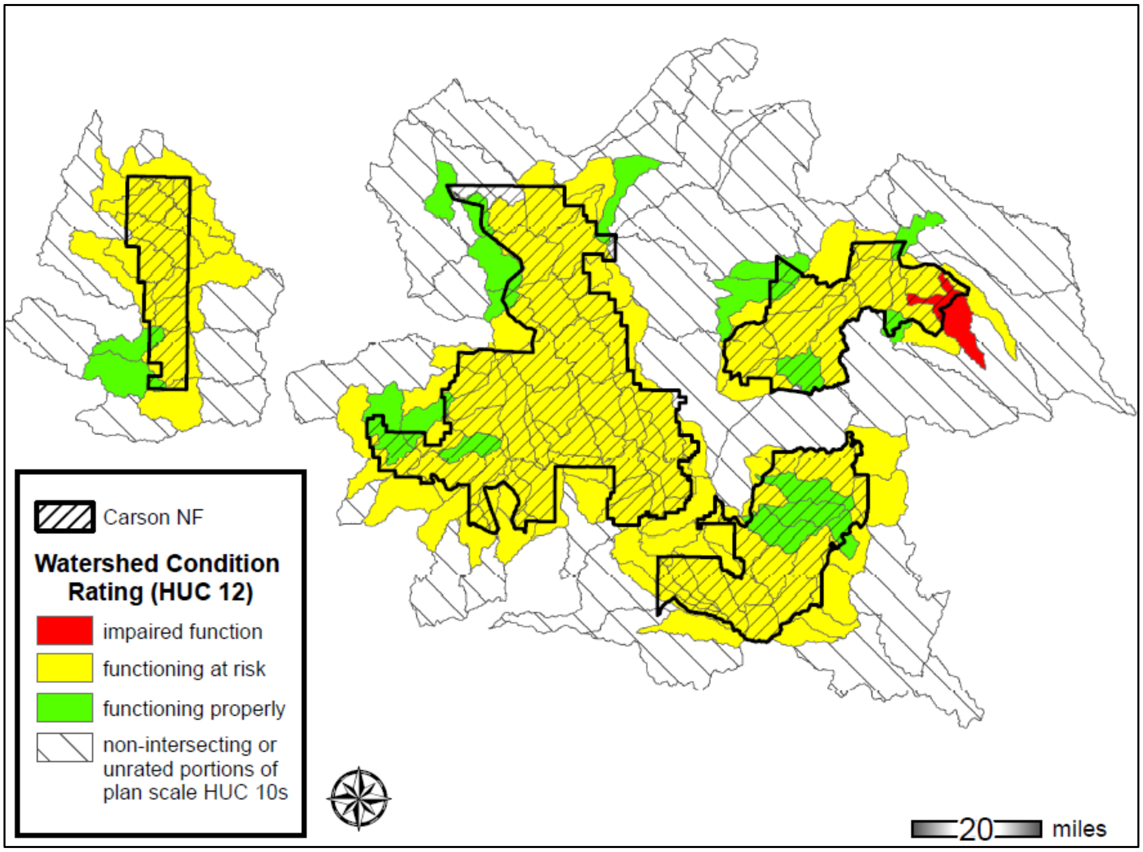


Figure 50. Watershed condition for the Carson National Forest

Current Condition and Trend

The assessment of watershed condition at the sub-watershed (HUC 12) level indicates the large majority of sub-watersheds assessed are in a Class 2 or "Functioning at Risk" condition (Figure 50). Only one watershed, Outlet North Ponil Creek, was rated a Class 3 or "Impaired Function". Approximately 20 percent of the sub-watersheds assessed were rated a Class 1 or "Functioning Properly" condition (Table 32, p. 195). The trend of watershed condition at the sub-watershed scale (HUC 12) is likely to continue to be in a "Functioning at Risk" category, due to the change of extent and timing of winter precipitation; risk of stand replacement fire events in forested watersheds; and increased risk from projected increase of daily average temperatures.

Summary of Aquatic Ecological Integrity

Key Findings of Aquatic Ecosystem and Watershed Integrity

The information provided in this assessment is summarized in Table 32 (p. 195). Overall, aquatic ecosystems are at risk on the Carson NF for the following reasons:

- Anthropogenic actions - The most significant human created actions acting as a stressor also have had a legacy effect of past management on aquatic ecosystems. These actions include unregulated livestock grazing around the turn of the 20th century, logging, and human activities, such as fire suppression, resource use, and infrastructure development (Reynolds et al. 2013). These actions and others have created hydrologic responses that have downcut stream channels and disconnected them from the floodplain. This leads to a loss of riparian area and function and creates drier mesic benches acting as levees along the stream courses. A worst case scenario of cumulative anthropogenic actions would create low adaptive capacity in riparian areas, allowing significant changes to floodplain function and lead to desertification (Neary 2009). These actions also increase forage removal, which in turn removes protective vegetation cover from underlying soils and results in increased sedimentation, altered peak run-off flows, higher water temperatures, shifts in flood severity or frequency, and greater habitat fragmentation for native aquatic species.

- Water quality is departed from regulatory reference in many parts of the plan scale. Where water quality has been measured, standards are not being met, primarily due to sediment and/or temperature. Contributing factors for sediment include legacy conditions, such as closed roads, stand structure altered by timber harvest, and rangelands altered by intense, unmanaged grazing. Current management and use also contribute, through open roads, stream crossings, trails, degraded riparian condition, and water withdrawals. Climate change is expected to increase risks to water quality in all locations.

- At the context scale, 259 miles of perennial streams are currently impaired for temperature. Stream temperature regimes are projected to continually increase. Coldwater fishes may find physical and biotic barriers that prevent migration. The increasing stream temperatures may exceed resident trout thermal tolerances. Furthermore, lower peak flows may exacerbate temperature effects on aquatic species.

- Streamflow (water quantity and timing) is at risk in all perennial streams on the Carson NF, because of water withdrawals/diversions and projected climate change effects. Climate change is expected to increase risks to streamflow in all locations.

- The projected effect of climate change would reduce the extent of waterbodies, due to reduced surface water and groundwater, increasing their risk. Many of the existing (both known and unknown) wetlands, seeps, springs, fens, playas, wallows will not receive snowmelt runoff in sufficient timing or quantity to allow a functional existence. With the expected effects from climate change, many wetland systems with marginal functionality currently will disappear from the Carson NF in the future.

- Most seeps and springs have been developed as water sources to the detriment of the associated aquatic ecosystem. Most that are accessible by humans are departed from reference condition. Development is mainly for livestock purposes, but drinking water supply and wildlife watering are other uses. Comparison of the current inventory of these water features to historic information indicates that seep and spring presence and discharge are decreasing on the Carson NF.

- Wetlands are a small but important ecosystem type on the Carson NF. They are less common at the plan scale than at the context scale. The extent of wetlands has decreased over the last two centuries, and the condition of remaining wetlands has been affected by land use and changes in climate, both of which are expected to continue. While wetlands have been modified across the Carson NF, they are less altered in watersheds that overlap high elevations, steep terrain, and protected wilderness, mostly east of the Rio Grande.

- At the plan and context scales, groundwater appears to meet standards for associated uses such as livestock watering, but groundwater recharge in the future is a concern, due to climate change and increasing demand. The trend for groundwater and groundwater-dependent ecosystems will likely be driven by the reduction of snowpack and higher average daily temperatures. As average temperatures climb, effects on snowmelt runoff timing and duration will become more pronounced and water inputs, transport, and recharge of groundwater basins will decrease. Function of some groundwater-dependent systems will be severely impaired and others will be completely dewatered.

- Only one watershed, Outlet North Ponil Creek, was rated in the “Impaired Function” class by the Watershed Condition Assessment. Thirteen watersheds are rated in a “Functioning Properly” condition, and the remaining watersheds were rated as “Functioning at Risk”. The trend of watershed condition for the HUC 12 sub-watersheds within the plan area is likely away from reference. Extended drought, increase risk of stand replacement wildfire, changes in runoff timing and duration, and projected increase of daily average temperatures pose risks to water quality and quantity, aquatic habitat, soil erosion and sedimentation, and overall watershed stability and function.

- Hybridization, depredation, and competition from non-native fish in all these watersheds have likely contributed to diversity and distribution declines in native fish species. There are 16 non-native species that currently inhabit these watersheds. Non-native fish species were introduced into these watersheds for sport fishing or by accident through bait bucket transport.

- Native fish only stream miles are more highly departed than native fish occurrence, because there are fewer watersheds that have streams with only native fish in them. These native fish only streams are generally found in headwaters, where genetically pure populations of Rio Grande cutthroat trout are isolated by a physical barrier (man-made and natural). This barrier keeps non-native fish from traveling into the stream section where native fish are isolated. Barriers prevent competition and introgression with the native fish, as long as non-natives are not accidently stocked above a barrier. Native only streams ensure the purity of native fish and their continued existence within watersheds.

- The Rio Pueblo de Taos-Rio Grande watershed has more highly departed ecosystem characteristics compared to other watersheds, as there is only one main perennial stream (Arroyo Hondo) in this watershed. Perennial waters, seeps, and springs are limited within this watershed compared to adjacent watersheds, so if perennial waters are departed then most of the watershed is departed.

Table 32. Summary of risk for aquatic key ecosystem characteristics and watershed condition at HUC 10

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)[1]	Proportion on Carson NF (%)	Perennial Stream R & R[2]	Perennial Stream Water Quality[3]	Perennial Water Amount & Timing[4]	Water-bodies R & R[5]	Seeps & springs R&R[6]	Seeps & springs development[7]	Groundwater[8]	Native Fish Occurrence[9]	Native Fish Only Stream Miles[10]	Macro Invertebrates[11]	Watershed Condition[12]
Canadian Headwaters	**0.22**											
Headwaters Vermejo River - Vv	1.16	NA	High		NA	NA	NA				Low	
Leonardo Creek - Vv	15.72		High	Mod			NA	Low	Low	High		FP
Cimarron	**9.08**											
Eagle Nest Lake-Cimarron River - Cr	0.91	Mod	Low		High	High	Mod				NA	

[1] HUC 10 watersheds & HUC 12 sub-watersheds are coded according to the Terrestrial Ecosystem local zone they overlap. Some HUC 10s overlap multiple local zones, most HUC 8 sub-basins overlap multiple zones. Local zone codes are: **Vv** = Valle Vidal; **Rr** = Red River; **Cr** = Camino Real; **Cb** = Cruces Basin; **Rg** = Rio Grande; **Rc** = Rio Chama; **Vc** = Vallecitos; **Ji** = Jicarilla (Figure 6, p. 27).

[2] R&R = Representativeness and redundancy. Risk is based on the distribution of stream miles on forest versus off-forest. NA = one HUC 12 is insufficient for analysis.

[3] Water quality risk classes follow the Watershed Condition Classification (WCC) Technical Guide criterea: HUCs with 0% of their streams impaired are "Low" risk (functioning properly); 0.1-10% impaired are "Moderate" risk (Functioning at Risk); greater than 10% are "High" risk (Impaired Function).

[4] Perennial stream water quantity (amount and timing) risk rating is taken from the 2012 WCC rating for "Flow Characteristics". Good = low risk, Fair = moderate risk, Poor = high risk. NR = not rated based on WCC criteria.

[5] R&R = Representativeness and redundancy. Risk is based on the distribution of NHD waterbodies on forest versus off-forest. NA = too few HUC 12s.

[6] R&R = Representativeness and redundancy. Risk is based on the distribution of NHD seeps and springs on forest versus off-forest. NA = too few HUC 12s.

[7] Seep and spring risk based on level of development. 0-25% developed = Low risk; 25-50% = Moderate risk; 50+% = High risk. NA = no seeps or springs on the Carson NF.

[8] Risk is based on wells per square mile on the Carson NF. Low = 0 - 0.40; Moderate = 0.4 – 4; High > 4.0.

[9] NA = lack of habitat.

[10] NA = lack of habitat.

[11] NA = lack of habitat.

[12] FP = Functioning Properly (low risk), FAR = Functioning at Risk (moderate risk), IP = Impaired Function (high risk). NR = not rated based on WCC criteria.

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)[1]	Proportion on Carson NF (%)	Perennial Stream R & R[2]	Perennial Stream Water Quality[3]	Perennial Water Amount & Timing[4]	Water-bodies R & R[5]	Seeps & springs R&R[6]	Seeps & springs development[7]	Groundwater[8]	Native Fish Occurrence[9]	Native Fish Only Stream Miles[10]	Macro Invertebrates[11]	Watershed Condition[12]
Headwaters Cieneguilla Creek - Cr	5.21		Low	High			Mod	Mod	NA	NA		FAR
Ponil Creek - Vv	28.35	Low	High		Mod	Low	High				Low	
Greenwood Canyon - Vv	57.71		High	Mod			NA	Low	Low	High		FAR
Middle Ponil Creek - Vv	57.70		High	High			High	Low	Low	Mod		FAR
Headwaters North Ponil Creek - Vv	84.49		High	High			High	Low	Low	Low		FAR
Outlet North Ponil Creek - Vv	34.04		High	High			High	Low	Low	High		IF
Headwaters Cerrososo Creek - Vv	11.66		Low	High			High	Low	NA	NA		FAR
Mora	**2.57**											
Coyote Creek - Cr	5.07	NA	High		NA	NA	High				Low	
Upper Coyote Creek - Cr	21.60		High	High			High	Mod	Low	High		FAR
Upper Mora River - Cr	7.72	Low	Low		High	High	High				Low	
Luna Creek - Cr	61.11		Low	Mod			High	Low	Low	High		FP
Quemado Canyon-Mora River - Cr	22.84		Low	Mod			High	Mod	Low	High		FAR
Vigil Creek-Mora River - Cr	11.52		Low	Mod			High	Mod	Low	High		FAR
Alamosa-Trinchera	**0.15**											
Punche Arroyo-Rio Grande - Cb	1.46	NA	Low		Mod	NA	NA				NA	
Cove Lake Reservoir - Cb	7.60		Low	Mod			NA	Low	NA	NA		FP
Conejos	**25.53**											
Rio de Los Pinos - Cb	60.48	Low	High		Mod	Mod	High				Low	

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)[1]	Proportion on Carson NF (%)	Perennial Stream R & R[2]	Perennial Stream Water Quality[3]	Perennial Water Amount & Timing[4]	Water-bodies R & R[5]	Seeps & springs R&R[6]	Seeps & springs development[7]	Groundwater[8]	Native Fish Occurrence[9]	Native Fish Only Stream Miles[10]	Macro Invertebrates[11]	Watershed Condition[12]
Beaver Creek - Cb	100		High	Mod			High	Low	Low	High		FAR
Toltec Creek-Rio de Los Pinos - Cb	44.89		High	Mod			High	Low	Low	High		FP
City of Ortiz-Rio de Los Pinos - Cb	85.89		High	Mod			High	Mod	Low	High		FAR
Rio San Antonio (RSA) - Cb	46.62	Mod	High		Low	High	High				NA	
Cañada Tio Grande-RSA - Cb	94.04		High	High			High	Low	Low	High		FAR
Cañada de Los Ranchos-RSA - Cb	80.63		High	High			High	Low	Mod	High		FAR
San Antonio Cemetery-RSA - Cb	4.71		Low	Mod			NA	Low	NA	NA		FAR
Outlet Conejos River - Cb	0.34	NA	Low		NA	NA	NA				NA	
Bighorn Creek - Cb	5.03		Low	Mod			NA	Low		NA		FAR
Upper Rio Grande	**31.36**											
Costillo Creek - Vv	16.02	Mod	High		Mod	Mod	High				Mod	
Comanche Creek - Vv	99.95		High	Mod			High	Low	Mod	Low		FAR
Comanche Creek-Costillo Creek - Vv	60.33		High	High			High	Low	Mod	Mod		FAR
Latir Creek-Costillo Creek - Vv	7.51		High	High			NA	Low	High	High		FAR
Latir Creek-Rio Grande - Rr	3.72	High	High		High	NA	NA				NA	
Latir Creek - Rr	28.39		High	Mod			NA	Mod	High	High		FP
Red River - Rr	90.45	Mod	High		Mod	Low	High				Mod	
Upper Red River - Rr	99.82		High	High			High	Mod	Low	High		FAR
Cabresto Creek - Rr	98.51		Low	High			High	Low	Low	High		FAR

Sub-basin (HUC 8) / Watershed (HUC 10) / Sub-watershed (HUC 12)[1]	Proportion on Carson NF (%)	Perennial Stream R & R[2]	Perennial Stream Water Quality[3]	Perennial Water Amount & Timing[4]	Water-bodies R & R[5]	Seeps & springs R&R[6]	Seeps & springs development[7]	Groundwater[8]	Native Fish Occurrence[9]	Native Fish Only Stream Miles[10]	Macro Invertebrates[11]	Watershed Condition[12]
Middle Red River - Rr	99.70		High	High			High	Mod	High	High		FAR
Lower Red River - Rr	51.28		Low	High			High	Low	High	High		FAR
Red River-Rio Grande – Cb, Rr	4.66	High	Low		Mod	NA	High				Mod	
Arroyo Punche - Cb	4.24		Low	NR			NA	Low	NA	NA		NR
Red River-Rio Grande - Rr	16.12		Low	Mod			High	Low	High	High		FP
Rio Grande del Rancho (RGR) - Cr	88.75	Low	High		High	Low	High				Low	
Rito de la Olla - Cr	100		High	Mod			High	Low	Mod	High		FP
Headwaters RGR - Cr	96.86		High	Mod			High	Low	Low	High		FP
Rio Chiquito - Cr	98.45		Low	Mod			High	Mod	Mod	High		FP
Outlet RGR - Cr	57.49		High	Mod			High	High	Mod	High		FAR
Rio Pueblo de Taos (RPT) - Cr	24.49	High	High		Mod	Mod	High				Mod	
HWs Rio Fernando del Taos - Cr	99.90		High	High			High	Low	High	High		FAR
Outlet Rio Fernando del Taos - Cr	66.33		High	Mod			High	High	High	High		FAR
Rio Pueblo de Taos-Rio Grande - Rr, Rg	28.68	High	High		Mod	High	High				Low	
Headwaters Arroyo Hondo - Rr	99.98		High	Mod			NA	Mod	Low	High		FP
Outlet Arroyo Hondo - Rr	43.78		High	High			NA	High	High	High		FAR
Arroyo Hondo-Rio Grande - Rr	78.66		High	High			High	Mod	High	Mod		FAR
Cerros de Taos Ranch - Rg	3.05		Low	NR			NA	Mod	NA	NA		NR
Manby Hot Springs-Rio Grande - Rg	6.02		Low	NR			NA	Mod	NA	NA		NR

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)[1]	Proportion on Carson NF (%)	Perennial Stream R & R[2]	Perennial Stream Water Quality[3]	Perennial Water Amount & Timing[4]	Water-bodies R & R[5]	Seeps & springs R&R[6]	Seeps & springs development[7]	Groundwater[8]	Native Fish Occurrence[9]	Native Fish Only Stream Miles[10]	Macro Invertebrates[11]	Watershed Condition[12]
Town of Carson - Rg	22.27		Low	Mod			NA	Mod	NA	NA		FAR
Arroyo Aguaje de la Petaca (AAP) – Cb,	68.85	NA	Low		Mod	High	High				NA	
Lamy Canyon-AAP – Cb	55.89		Low	High			High	Low	NA	NA		FAR
Martinez Canyon-AAP – Cb	48.35		Low	High			High	Low	NA	NA		FAR
Canon de Tio Gordito-AAP - Vc	53.99		Low	High			High	Mod	NA	NA		FAR
Indian Lake - Rg	100		Low	High			NA	Low	NA	NA		FAR
Carson Reservoir-AAP - Rg	85.71		Low	High			NA	Low	NA	NA		FAR
Scott Arroyo-AAP - Rg	85.11		Low	Mod			NA	Low	NA	NA		FAR
Embudo Creek (EC) - Cr	77.43	Low	High		Mod	Low	High				Low	
La Junta Creek - Cr	100		Low	High			High	Low	Mod	Mod		FAR
La Junta Canyon-Rio Pueblo - Cr	99.97		High	High			High	Mod	Mod	High		FAR
Osha Canyon-Rio Pueblo - Cr	100		High	High			High	Low	Mod	High		FAR
Headwaters Rio Santa Barbara - Cr	99.91		High	Mod			High	Low	Low	High		FAR
Outlet Rio Santa Barbara - Cr	68.73		High	Mod			High	Mod	High	High		FAR
Rio Santa Barbara-Rio Pueblo - Cr	59.21		High	High			High	Low	High	High		FAR
Cañada del Oso Sarco - Cr	93.78		Low	Mod			High	Mod	High	High		FAR
Cañada del Oso Sarco-EC - Cr	77.29		High	High			High	Mod	Mod	High		FAR
Arroyo la Mina-EC - Cr	8.99		Low	Mod			NA	Low	High	High		FAR
Rio Chama-Rio Grande (RG) - Rg, Cr	20.29	Mod	High		Mod	High	High				Low	

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)[1]	Proportion on Carson NF (%)	Perennial Stream R & R[2]	Perennial Stream Water Quality[3]	Perennial Water Amount & Timing[4]	Water-bodies R & R[5]	Seeps & springs R&R[6]	Seeps & springs development[7]	Groundwater[8]	Native Fish Occurrence[9]	Native Fish Only Stream Miles[10]	Macro Invertebrates[11]	Watershed Condition[12]
Cañada Comanche - Rg	74.01		Low	Mod			Low	Low	NA	NA		FAR
Cañada Comanche-RG - Rg	23.28		Low	Mod			High	Low	NA	NA		FAR
Rio Truchas - Cr	37.12		Low	High			High	Mod	High	Mod		FAR
Rio Truchas-RG - Cr	36.19		Low	Mod			High	Mod	High	High		FAR
Rio Chama	**27.77**											
Chavez Creek - Cb	12.71	Mod	High		Mod	Mod	High				Mod	
East Fork Brazos - Cb	48.46		High	Mod			High	Low	High	High		FP
West Fork Brazos - Cb	4.71		High	NR			NA	Low	High	High		NR
Gavilan Creek - Cb	32.50		Low	Mod			High	Low	High	High		FP
Gavilan Creek-Rio Brazos - Cb	13.28		Low	Mod			High	Low	High	High		FP
Chavez Creek-Rio Chama - Cb	0.46	NA	Low		NA	NA	NA				Low	
Wolf Creek - Cb	3.74		Low	Mod			NA	Low	High	High		FP
Rio Cebolla - Rc	40.16	Mod	High		Mod	Low	High				Mod	
Cedar Grove Cmtry-Arroyo Blanco - Rc	27.52		Low	Mod			High	Low	NA	NA		FP
Headwaters Rio Cebolla - Rc	41.32		High	Mod			High	Mod	High	High		FAR
Outlet Rio Cebolla - Rc	46.20		High	High			NA	Low	High	High		FP
Rio Nutrias-Rio Chama - Rc	8.22	Mod	High		High	Mod	High				Low	
Upper Rio Nutrias - Rc	49.67		High	Mod			High	Low	Mod	High		FAR
Huckbay Canyon-Rio Chama - Rc	6.22		Low	High			NA	Low	NA	NA		FAR

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)[1]	Proportion on Carson NF (%)	Perennial Stream R & R[2]	Perennial Stream Water Quality[3]	Perennial Water Amount & Timing[4]	Water-bodies R & R[5]	Seeps & springs R&R[6]	Seeps & springs development[7]	Groundwater[8]	Native Fish Occurence[9]	Native Fish Only Stream Miles[10]	Macro Invertebrates[11]	Watershed Condition[12]
Arroyo Seco - **Rc**	87.83	Mod	High		Low	Low	High				Low	
Montoya Canyon-Canjilon Creek - **Rc**	100		High	High			High	Mod	Mod	High		FAR
Lopez Canyon-Canjilon Creek - **Rc**	99.78		High	High			High	Low	Mod	High		FAR
Martinez Canyon - **Rc**	100		Low	Mod			High	Low	NA	NA		FP
Martinez Canyon-Canjilon Creek - **Rc**	57.42		High	High			NA	Low	Mod	High		FAR
Arroyo del Yeso-Arroyo Seco - **Rc**	81.95		High	Mod			High	Low	NA	NA		FAR
Abiquiu Reservoir - **Rc**	15.53	High	Low		Mod	Mod	High				Low	
Ojito Canyon-Abiquiu Reservoir - **Rc**	47.89		Low	High			NA	Low	NA	NA		FAR
Cañones Creek-Abiquiu Reservoir - **Rc**	39.95		Low	High			High	Mod	NA	NA		FAR
El Rito - **Vc**, **Rc**	85.03	Mod	High		Mod	Mod	High				Low	
Arroyo Seco - **Vc**	100		Low	High			High	Low	Mod	High		FAR
Headwaters El Rito - **Vc**	100		High	Mod			High	Mod	Low	High		FAR
Outlet El Rito - **Rc**	67.53		High	High			High	Mod	Low	High		FAR
El Rito-Rio Chama - **Rc**	27.72	High	High		High	Low	High				Mod	
Arroyo del Cobre - **Rc**	61.91		Low	Mod			High	Low	Mod	High		FAR
Arroyo del Cobre-Rio Chama - **Rc**	25.72		High	High			NA	Mod	NA	NA		FAR
Madera Cañon - **Rc**	61		Low	High			High	Mod	NA	NA		FAR
El Rito-Rio Chama - **Rc**	16.52		High	High			High	High	Mod	High		FAR
Rio Tusas (RT) – **Cb**, **Vc**, **Rg**	100	Mod	High		Mod	Low	High				NA	

Sub-basin (HUC 8) **Watershed (HUC 10)** **Sub-watershed (HUC 12)[1]**	**Proportion on Carson NF (%)**	**Perennial Stream R & R[2]**	**Perennial Stream Water Quality[3]**	**Perennial Water Amount & Timing[4]**	**Water-bodies R & R[5]**	**Seeps & springs R&R[6]**	**Seeps & springs development[7]**	**Groundwater[8]**	**Native Fish Occurrence[9]**	**Native Fish Only Stream Miles[10]**	**Macro Invertebrates[11]**	**Watershed Condition[12]**
Cañada Biscara-RT – Cb	100		High	High			High	Low	Low	High		FAR
Cañada del Aqua-RT - Vc	100		High	High			High	Low	Low	High		FAR
Cañada de los Comanches - Rg	100		Low	High			NA	Low	NA	NA		FAR
Cañada de los Comanches-RT - Vc	100		High	High			High	Low	Low	High		FAR
Rio Vallecitos-RT - Rg	100		Low	High			High	Low	Low	High		FAR
Rio Vallecitos (RV) – Cb, Vc	83.77	Low	High		Low	Low	High				Low	
Jarosa Creek-RV – Cb	40		Low	High			High	Low	Low	High		FAR
Cañada Alamosa-RV - Vc	96.77		High	Mod			High	Low	Low	High		FAR
Cañada de Agua-RV - Vc	100		High	High			High	Low	Low	High		FAR
Rio Tusas-RV - Vc	100		High	High			High	Low	Low	High		FAR
Rio Ojo Caliente - Rg	43.45	High	High		Low	High	High				Mod	
Cañada de los Comanches - Rg	85.81		Low	Mod			NA	Low	NA	NA		FAR
Upper Rio Ojo Caliente - Rg	52.79		High	Mod			High	Mod	Mod	High		FAR
Cañada Las Lemitas - Rg	85.02		Low	Mod			NA	Low	High	High		FAR
Middle Rio Ojo Caliente - Rg	34.04		Low	Mod			NA	Mod	NA	NA		FAR
Upper San Juan	**5.67**											
San Juan River-Navajo Reservoir - Ji	20.27	NA	Low		Mod	High	High				Low	
Carracas Canyon - Ji	31.58		Low	Mod			High	Low	NA	NA		FAR
San Juan River-Navajo Resvr - Ji	18.64		Low	Mod			High	Low	NA	NA		FAR

Sub-basin (HUC 8) Watershed (HUC 10) Sub-watershed (HUC 12)[1]	Proportion on Carson NF (%)	Perennial Stream R & R[2]	Perennial Stream Water Quality[3]	Perennial Water Amount & Timing[4]	Water-bodies R & R[5]	Seeps & springs R&R[6]	Seeps & springs development[7]	Groundwater[8]	Native Fish Occurrence[9]	Native Fish Only Stream Miles[10]	Macro Invertebrates[11]	Watershed Condition[12]
Cañon Bancos - **Ji**	65.44	NA	Low		High	NA	High				NA	
Headwaters Cañon Bancos - **Ji**	35.58		Low	Mod			High	Low	NA	NA		FAR
Cabresto Canyon - **Ji**	77.32		Low	Mod			High	Low	NA	NA		FAR
Outlet Cañon Bancos - **Ji**	76.15		Low	Mod			High	Low	NA	NA		FAR
La Jara Creek - **Ji**	28.28	NA	Low		Mod	NA	High				NA	
Vaqueros Canyon - **Ji**	30.43		Low	High			NA	Low	NA	NA		FAR
Vaqueros Canyon-La Jara Creek - **Ji**	60.58		Low	High			High	Low	NA	NA		FAR
La Fragua Canyon - **Ji**	61.39		Low	High			High	Low	NA	NA		FAR
La Jara Canyon - **Ji**	20.27		Low	High			High	Low	NA	NA		FAR
Navajo Reservoir - **Ji**	4.99	NA	Low		Mod	NA	NA				NA	
Canon Bancos-Navajo Reservoir - Ji	24.60		Low	Mod			NA	Low	NA	NA		FAR
Blanco Canyon	**3.04**											
Tapacito Creek - **Ji**	1.94	NA	Low		NA	NA	High				Low	
Wild Horse Canyon-Tapicito Creek - **Ji**	6.49		Low	Mod			High	Low	NA	NA		FAR
Carrizo Creek - **Ji**	15.29	NA	Low		Low	High	High				NA	
Ciruelas Canyon-Arroyo Companero - **Ji**	69.89		Low	High			High	Low	NA	NA		FAR
Munoz Creek - **Ji**	21.48		Low	Mod			High	Low	NA	NA		FP
Martinez Canyon-Carrizo Canyon - **Ji**	7.81		Low	High			High	Low	NA	NA		FP

At-Risk Species

This section of the assessment report focuses on identifying federally recognized threatened, endangered, proposed, and candidate species, as well as potential species of conservation concern (SCC). This section also documents information gaps relevant to at-risk species that may be filled through inventories, plan monitoring, or research. Other species of interest on the Carson NF, such as popular game species, are addressed in Chapter III. Contributions of Commonly Enjoyed Species to Social and Economic Sustainability (p. 309)

Under the National Forest Management Act, the Forest Service is directed to:

> *provide for diversity of plant and animal communities based on the suitability and capability of the specific land area in order to meet multiple-use objectives, and within the multiple-use objectives of a land management plan adopted pursuant to this section [of this Act], provide, where appropriate, to the degree practicable, for steps to be taken to preserve the diversity of tree species similar to that existing in the region controlled by the plan.* (NFMA, 16 U.S.C. 1604(g)(3)(B))

To meet this objective, the 2012 Planning Rule adopts a complementary ecosystem and species-specific approach to maintaining species diversity, known as coarse-filter/fine-filter (36 CFR § 219.9). The premise behind the coarse-filter approach is that native species evolved and adapted within the limits established by natural landforms, vegetation, and disturbance patterns prior to extensive human alteration. Therefore, maintaining or restoring ecological conditions and functions similar to those under which native species have evolved, offers the best assurance against losses of biological diversity and maintains habitats for the vast majority of species in an area. However, for some species, this approach may not be adequate, either because the reference condition is not achievable or because of non-habitat risks to species viability.

The fine-filter approach recognizes that for many species, ecological condition or additional specific habitat features (key ecosystem characteristics) are required, and these may not be met by the coarse-filter approach. To determine which animal and plant species may require this fine-filter approach, the Carson NF has identified federally listed threatened, endangered, proposed, and candidate species and developed a list of potential SCC that occur within the plan area. This list will be used at later stages of the plan revision process to develop specific plan components that ensure species diversity in the plan area. Maintaining species that are vulnerable to decline within the Carson NF will maintain the diversity of the forest and thus, comply with the National Forest Management Act diversity requirement.

Plant and animal species are highly dependent on the function of ecosystems with specific conditions, such as local soil, air, water, aspect, elevation, precipitation, etc., which create areas favorable or unfavorable for a particular species. The most important direct drivers of biodiversity loss and ecosystem service changes are habitat change (e.g., land use changes, physical modification of rivers, or water withdrawal from rivers), climate change, invasive species, overexploitation, and pollution (MEA 2005). Therefore, this section builds on the reference and current ecological conditions of other assessed terrestrial and aquatic ecological resources. It relies very heavily on the description of current ecological condition described within the terrestrial vegetation types, known as ecological response units (ERUs) (p. 17), on the Carson NF and the Integration and Risk Assessment (p. 298) of these ERUs. Additional information can be found in the Terrestrial Vegetation (p. 34) and Riparian Vegetation (p. 116) sections of this assessment report.

Species Ecosystem Services

The Carson NF is home to hundreds of animal, plant, and fungi species. For some of these species, changing land use patterns outside of the forest have reduced potential habitat availability and increased their reliance on Carson NF managed lands. These species provide many ecosystem services that, in turn, benefit society as a whole. This includes:

- **Supporting** ecosystem services from species provide nutrient cycling (by both plants and animals), soil formation and manipulation (e.g., burrowing insects and mammals), primary production (plants), and seed dispersal (e.g., animals).
- **Regulating** ecosystem services from species provide carbon sequestration (plants), pollination (both forest plants and adjacent croplands by both vertebrates and invertebrates), and erosion control (plants).
- **Provisioning** ecosystem services from species supply food (e.g., forage, game, and wild foods), fiber, medicine, and forest products.
- **Cultural** ecosystem services from species offer recreation (e.g. hunting and bird-watching), opportunities for scientific discovery and education, and cultural, intellectual, or spiritual inspiration.

Because this chapter focuses on at-risk species that occur in the plan area, it follows that the ecosystem services provided by these species are decreasing and/or at risk.

Federally Recognized Species

The Endangered Species Act (Act; 16 U.S.C. Sec. 1531-1544), administered by the U.S. Fish and Wildlife Service (FWS), recognizes imperiled species and provides for their protection and recovery. Table 33 identifies the five federally endangered and four threatened species listed for the four counties (Rio Arriba, Taos, Colfax, and Mora) of the Carson NF (USDI FWS 2015b). However, there are only three of the endangered species and three threatened species that are relevant to the plan area and to the planning process. There are no proposed or candidate species listed for the counties of the Carson NF.

The FWS lists the Jemez Mountain salamander, least tern, and piping plover for Rio Arriba or Colfax counties, but their range does not include the Carson NF (USDI FWS 2012a); thus these species will not be carried forward as federally listed species for the Carson NF. Mexican spotted owl, black-footed ferret, western yellow-billed cuckoo, and New Mexico meadow jumping mouse are not known to currently occupy any suitable habitat on the Carson NF, but they have been documented to occur on the forest in the past and are currently evaluated during project level analysis under the National Environmental Policy Act (NEPA). Canada lynx is not presently recognized to den or breed on the Carson NF, but it can sporadically use the forest for foraging. Southwestern willow flycatcher is a known resident on the Carson NF and has long-standing records documenting its presence on the forest. The six federally listed species for the Carson NF are denoted with an asterisk (*) in Table 33.

Section 4 of the Endangered Species Act requires the FWS to identify and protect all lands, water, and air necessary to recover an endangered species; this is known as critical habitat. Critical habitat are areas that have been determined to be needed for life processes for a species, including space for individual and population growth and for normal behavior; cover or shelter; food, water, air; light, minerals, or other nutritional or physiological requirements; sites for breeding and rearing offspring; and habitats that are protected from disturbances or are representative of the historical geographical and ecological distributions of a species. The Mexican spotted owl and southwestern willow flycatcher have designated critical habitat on the Carson NF and these are described in more detail in Chapter III. Designated Areas (p. 442).

Section 7 of the Endangered Species Act requires federal agencies to ensure actions they authorize, fund, or carry out are not likely to destroy or adversely modify designated critical habitat. Section 7 of the Act also requires that any federal agency that carries out, permits, licenses, funds, or otherwise authorizes activities that may affect a listed species must consult with the Fish and Wildlife Service to ensure that its actions are not likely to jeopardize the continued existence of any listed species.

Table 33. Federally listed threatened or endangered species listed for the counties (Rio Arriba, Taos, Colfax, and Mora) of the Carson National Forest (USDI FWS 2015b). An astrerisk (*) denotes species carried forward as federally listed species for the Carson NF.

Common Name	Scientific Name	Federal Status	Critical Habitat
Amphibians and Reptiles			
Jemez Mountain salamander	*Plethodon neomexicanus*	Endangered	No
Avians			
Least tern	*Sterna antillarum*	Endangered	No
Mexican spotted owl*	*Strix occidentalis lucida*	Threatened	Yes
Piping plover	*Charadrius melodus*	Threatened	No
Southwestern willow flycatcher*	*Empidonax traillii extimus*	Endangered	Yes
Western yellow-billed cuckoo*	*Coccyzus americanus occidentalis*	Threatened	No
Mammals			
Black-footed ferret*	*Mustela nigripes*	Endangered	No
Canada lynx*	*Lynx canadensis*	Threatened	No
New Mexican meadow jumping mouse*	*Zapus hudsonius luteus*	Endangered	No

Potential Species of Conservation Concern

A species of conservation concern (SCC) is defined in the 2012 Planning Rule as "a species, other than federally recognized threatened, endangered, proposed, or candidate species, that is known to occur in the plan area and for which the regional forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area." The guidance provided in the final directives for the 2012 planning regulations (Forest Service Handbook [FSH] 1909.12 – Land Management Planning, Chapter 10) is used to develop the SCC list for the Carson NF. The criteria for identifying species of conservation concern are also the criteria for identifying potential species of conservation concern, which are (FSH 1909.12, 12.52c):[1]

1. The species is native to, and known to occur in, the plan area.

   A species is known to occur in a plan area if, at the time of plan development, the best available scientific information indicates that a species is established or is becoming established in the plan area. A species with an individual occurrences in a plan area that are merely "accidental" or "transient," or are well outside the species' existing range at the time of plan development, is not established or becoming established in the plan area. If the range of a species is changing so that what is becoming its "normal" range includes the plan area, an individual occurrence should not be considered transient or accidental.

2. The best available scientific information about the species indicates substantial concern about the species' capability to persist over the long term in the plan area. See FSH 1909.12, zero code, section 07, for guidance on best available scientific information.

   If there is insufficient scientific information available to conclude there is a substantial concern about a species' capability to persist in the plan area over the long-term that species cannot be identified as a species of conservation concern.

   If the species is secure and its continued long-term persistence in the plan area is not at risk based on knowledge of its abundance, distribution, lack of threats to persistence, trends in habitat, or responses to management that species cannot be identified as a species of conservation concern.

Scales of Analysis

Three scales of analysis were used for the assessment of at-risk species: context, plan, and local. These roughly correspond with evaluating species within the state of New Mexico (context); species that occur somewhere on the Carson NF (plan); and finally associating species with individual local zones described in Spatial Scales for Terrestrial Ecosystems (p. 28) (local). The local scale of analysis breaks the plan scale into eight local zones, delineated along HUC12 watershed boundaries, and differentiated by level or type of management, and level of public visitation and types of use (Figure 6, p. 28). The minimum zone size/maximum number of zones was based on recommendations provided by the Regional Office (USDA FS 2014i).

[1] More detailed guidance for selecting SCC is presented in chapter 10 of the final directives (FSH 1909.12, 12.52).

Evaluating Relevant Information for At-Risk Species

A Microsoft Access database (Species Risk Assessment Database) was designed to evaluate potential SCC on the Carson NF through a four-step process:

1. Review and screen species that meet number 1 described above, and determine which species have been documented to occur on the Carson NF.
2. Determine which of the potential SCCs meet number 2 described above.
3. Associate the remaining potential SCC species with current ecological condition and key ecosystem characteristics described within ERUs on each of the Carson NF local zones.
4. Perform a risk assessment analysis on the remaining species, with their associated ERU.

Federally listed species (Table 33, p. 206) are also tracked throughout this process, but in a separate way to potential SCC. Both the Rule and final directives mandate the use of best available scientific information (BASI) for each of the resource parameters evaluated in this assessment. To form the list of potential SCC, BASI was used.

Step 1: Identify species that are native to, and known to occur in, the plan area.

The first step assessed a wide variety of sources to compile the BASI for species considered. According to NatureServe (Natureserve 2015), there are more than 7,000 unique animal, plant, and fungi species found in New Mexico. Species records were exported from NatureServe[1] for all species occurring in New Mexico that had status ranks of G or T 1, 2, or 3 and S 1 and 2. These are species that have been identified by state natural heritage programs, the U.S. Fish and Wildlife Service, the International Union for Conservation of Nature, the Canadian Wildlife Service, and others as facing possible risk of extinction. This list also includes:

- Species that are identified as recently delisted or have a positive 90-day finding in New Mexico by the USFWS (77 FR 69994);
- Species listed as threatened or endangered by New Mexico Department of Game and Fish (NMDGF) (BISON-M 2014) and State Forestry Division (NM EMNRD 2006);
- Species on the Southwestern Regional Forester's Sensitive Species List (USDA FS 2013a);
- Species listed as sensitive species on adjacent federal agency lands (SLV Public Land Center 2013; USDI BLM 2009);
- Species listed as threatened or endangered by adjacent Tribes (Navajo Nation 2008);
- Species identified as those of greatest conservation need by the New Mexico Comprehensive Wildlife Conservation Strategy (NMDGF 2006b);

[1] NatureServe conservation status ranks are based on a scale of one to five, ranging from critically imperiled (G1) to demonstrably secure (G5). Status is assessed and documented at three distinct geographic scales -global (G), national (Na), and state/province (S). Infraspecific taxa (subspecies or other designations below the level of species) are indicated by "T rank." The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by a letter reflecting the appropriate geographic scale of the assessment (G=Global, Na=National, and S =State), or infraspecific (T) where appropriate. The numbers have the following meaning: 1=Critically Imperiled, 2=Imperiled, 3=Vulnerable, 4=Appraently Secure, and 5=Secure.

- Rare plants as identified by the New Mexico Rare Plants Technical Council (NMRPTC 1999); and
- Migratory Birds List by the USFWS (USDI FWS 2015b)

This list of approximately 1,384 species formed the basis of the potential SCC list within the context area and was comprised of 694 vascular and non-vascular plants, 11 fungi, 341 invertebrates, and 338 vertebrates, which include 13 amphibians, 28 reptiles, 53 fish, 110 mammals, and 134 birds.

The next part of step 1 involved identifying which of these species occur on the Carson NF (FSH 1909.12, 12.52c (1)). Where possible, published location information was used to filter out species that were not reported in one of the four counties (Rio Arriba, Colfax, Taos, and Mora) encompassing the Carson NF or within the forest itself.

Internal databases (USDA FS 2014h) breeding bird species survey data (Beason et al. 2006, 2007) and museum databases, including Arctos Collection Management Information System (Arctos 2014), Biota Information System of New Mexico (BISON-M 2014), Natural Heritage New Mexico (NHNM 2014), New Mexico Biodiversity Collections Consortium (NM BCC 2009), Southwest Environmental Information Network (SEINet 2014) were queried for forest-specific observations.

In addition to the databases and lists cited above, Forest Service biologists at the Carson NF Supervisor's Office and ranger districts, as well as the Southwestern Regional Office were consulted in the development of the potential SCC list. Subject matter experts were interviewed via personal communications. Staff at Natural Heritage New Mexico (R. McCollough); New Mexico Department of Game and Fish (J. Stuart, N. Quintana, L Pierce, C. Hayes, S. Liley, R. Hansen, J. Caldwell, R. Winslow, E Goldstein, B. Lang, J. Davidson); New Mexico Museum of Natural History (J.T. Giermakowski); New Mexico State University (J. Frey); U.S. Fish and Wildlife Service (E. Hein); and others were able to review internal records and databases or rely on agency specialists to further filter the list.

The New Mexico Comprehensive Wildlife Conservation Strategy (CWCS) has older information and will be updated in 2015, to reflect recent knowledge and status of species. Some species in the New Mexico CWCS did not meet the ranking criteria for SCC, thus reducing the number of species to be considered. For highly visible and high-interest species (e.g., birds), reliable collection and observation data were readily available. In addition, the current Carson forest plan requires monitoring for management indicator species and federally listed species (USDA FS Carson NF 1986).

Another potentially valuable source of BASI is the recently released New Mexico Crucial Habitat Assessment Tool (NMCHAT). This web-based map tool provides spatial information on the conservation of animals, plants, and their habitats across New Mexico (NMCHAT 2013). This tool calculates a crucial habitat rank (a score between 1, most crucial, and 6, least crucial) for the entire state of New Mexico at a resolution of one square mile. This rank considers a number of factors when assigning rank scores, including presence species of concern (determined by a number of state and federal agencies, similar to but not duplicative of the SCC process described here), wildlife corridors (using models generated in a least-cost path analysis for cougars (Menke 2008)), terrestrial and aquatic species of economic and recreational importance (habitat models developed by NMDGF, wetland and riparian areas, large natural areas (areas greater than 1,000 hectares that are minimally fragmented by roads, power lines, railroads, pipelines, and other human impacts) and a number of other data sources. Much more information can be found at NMCHAT. Much of the Carson NF ranks “3” or lower in terms of overall crucial habitat, in most part because of presence of species of concern, presence of wetlands and riparian areas, and presence of large natural areas. While the wildlife corridor layer is promising, at this point in time the only information contained within it is the cougar model described above. It is expected NM CHAT will be an important resource in the upcoming phases of plan revision.

While compiling relevant species information, several sources of data that appeared to fill gaps in the BASI were encountered. Citizen science is a growing movement in conservation and allows volunteers to collect and submit data to online databases including eBird (eBird 2014), iNaturalist (iNaturalist 2014), and BugGuide.Net (BugGuide 2014). These resources were used where it was possible to verify observations.

For many other species, however, this information was simply not available. In many cases, it was not possible to determine if this was because surveys had been conducted, but the species were not found (negative surveys), or surveys had not been conducted at all. No fungi, lichen, or snail species were carried forward, because it is not known which of those identified as potentially at-risk occur on the Carson NF. This is a data gap that should be addressed through future inventories, plan monitoring, or research. Also, the Sangre de Cristo pea clam (*Pisidium sanguinichristi*), and swift fox (*Vulpes velox*) will not be considered as potential SCC, as the pea clam has not been determined as a valid species (Lang 2013) and the swift fox is considered “accidental” for the Carson NF (Apker and Navo 2013).

From the initial 1,384 potential SCC identified for the State of New Mexico, 202 potential SCC were identified for the counties of the Carson NF, but 136 of these species are not documented as occurring within the plan area. Table 34 lists the 66 species that are reliably documented on the Carson NF and assessed in Step 2.

Table 34. Species known to historically occur in the plan area and carried forward for consideration as species of conservation concern

Common Name	Scientific Name	Rationale for Consideration[1]	Presence in Plan Area Documented? (source)
Amphibians and Reptiles			
Northern leopard frog	*Lithobates pipiens*	CN, NN, NG5/Na5/S2, RF	Yes (Christman 2010)
Western boreal toad	*Anaxyrus boreas*	CN, NG4/T1/Na4, S, F	Yes (USDA FS Carson NF 2014)

[1] CN = Identified as a species of greatest conservation need in the New Mexico Comprehensive Wildlife Conservation Strategy Report; F = Federally delisted within last 5 years; PF= Federally petitioned for listing; N = NatureServe Global (G), Taxonomic (T), National (Na), or State (S) Ranking; NN = Navajo Nation Endangered; RF = Regional Forester’s Sensitive Species List and Adjacent federal agency’s Sensitive Species List; RP = Rare Plant; and S = State-listed as threatened or endangered.

Common Name	Scientific Name	Rationale for Consideration[1]	Presence in Plan Area Documented? (source)
Western diamondback rattlesnake	*Crotalus atrox*	CN, NG5/Na5/S5	Yes (USDA FS Carson NF 2014)
Avians			
American dipper	*Cinclus mexicanus*	NG5/Na5/S3, NN	Yes (USDA FS Carson NF 2014)
American goldfinch	*Spinus tristis*	NG5/Na5/S2	Yes (USDA FS Carson NF 2014)
American peregrine falcon	*Falco peregrinus anatum*	CN, NG4/T4/Na3/S2, NN, RF, S	Yes (USDA FS Carson NF 2014)
Bald eagle	*Haliaeetus leucocephalus*	CN, NG5/NA5/S2, NN, RF, S	Yes (USDA FS Carson NF 2014)
Band-tailed pigeon	*Patagioenas fasciata*	CN, NG4/Na4/S3, NN	Yes (USDA FS Carson NF 2014)
Bendire's thrasher	*Tomostoma bendirei*	CN, NG5/Na4, RF	Yes (eBird 2014)
Boreal owl	*Aegolius funereus*	CN, S, NG5/Na4/S2, RF	Yes (NMDGF 2010)
Brown-capped rosy finch	*Leucosticte australis*	NG4/Na4/S2	Yes (USDA FS Carson NF 2014)
Ferruginous hawk	*Buteo regalis*	CN, NG4/Na4/S2, RF, NN	Yes (USDA FS Carson NF 2014)
Golden eagle	*Aquila chrysaetos*	CN, NG5/Na5, NN	Yes (USDA FS Carson NF 2014)
Gray vireo	*Vireo vicinior*	CN, NG4/Na4, RF, S	Yes (Beason et al. 2006)
Juniper titmouse	*Baeolophus ridgwayi*	CN, NG5/Na5, RF	Yes (Beason et al. 2007)
Lincoln's sparrow	*Melospiza lincolnii*	NG5/Na5/S2	Yes (Beason et al. 2007)
Loggerhead shrike	*Lanius ludovicianus*	CN, NG4/Na4, RF	Yes (eBird 2014)
Northern goshawk	*Accipiter gentilis*	CN, NG5/Na4/S2, RF	Yes (USDA FS Carson NF 2014)
Northern harrier	*Circus cyaneus*	CN, NG5/Na5/S2	Yes (eBird 2014)
Pine grosbeak	*Pinicola enucleator*	NG5/Na5/S2	Yes (Beason et al. 2007)
Pinyon jay	*Gymnorhinus cyanocephalus*	CN, NG5/Na5	Yes (Beason et al. 2007)
Short-eared owl	*Asio flammeus*	NG5/Na5/S2	Yes (NMDGF 2010)

Common Name	Scientific Name	Rationale for Consideration[1]	Presence in Plan Area Documented? (source)
Western burrowing owl	*Athene cunicularia hypugaea*	CN, NG4/T4/Na4, RF, NN	Yes (USDA FS Carson NF 2014)
White-tailed ptarmigan	*Lagopus leucura*	CN, NG5/Na5/S1, S, RF	Yes (Wolfe et al. 2012)
Wilson's warbler	*Cardellina pusilla*	NG5/Na5/S2	Yes (Beason et al. 2006)
Fish			
Rio Grande chub	*Gila pandora*	CN, NG3/Na3, RF	Yes (USDA FS Carson NF 2014)
Rio Grande cutthroat trout	*Oncorhychus clarkii virginalis*	CN, NG4/T3/Na2/S2, RF	Yes (USDA FS Carson NF 2014)
Rio Grande sucker	*Catostomus plebeius*	CN, NG4/Na3/S2, RF	Yes (USDA FS Carson NF 2014)
Invertebrates			
Monarch	*Danaus plecippus*	PF, NG5/NA3	Yes, but not since 1990's (Lotts and Naberhaus 2014)
Nokomis fritillary butterfly	*Speyeria nokomis nokomis*	CN, NG3/T1/Na1/S1, RF	Yes (Selby 2007)
Spalding's blue butterfly	*Euphilotes spalding*	CN, NG4/Na4	Yes (Lotts and Naberhaus 2014)
Mammals			
American marten	*Martes americana*	CN, NG5/Na5/S2,RF, S	Yes (Long 2001)
American pika	*Ochotona princeps*	RF, NG5/S2	Yes (USDA FS Carson NF 2014)
Dwarf shrew	*Sorex nanus*	NG4/Na4/S2	Yes (Frey 2003)
Gunnison's prairie dog	*Cynomys gunnisoni*	CN,RF,NG5/Na5/S2	Yes (USDA FS Carson NF 2014)
Masked shrew	*Sorex cinereus*	RF, NG5/Na5/S2	Yes (Frey 2003)
Pale Townsend's big-eared bat	*Corynorhinus townsendii*	RF, NG4/T3/Na4	Yes (Gannon et al. 1998)
Rocky Mountain bighorn sheep	*Ovis canadensis canadensis*	CN, NG4/T4/Na4	Yes (USDA FS Carson NF 2014)
Snowshoe hare	*Lepus americanus*	CN, NG5/Na5/S2	Yes (USDA FS Carson NF 2014)

Common Name	Scientific Name	Rationale for Consideration[1]	Presence in Plan Area Documented? (source)
Spotted bat	*Euderma maculatum*	CN, NG4/Na4, RF, S	Yes (Geluso 2006)
Water shrew	*Sorex palustris*	RF, NG5/Na5/S2	Yes (Frey 2003)
White-tailed jackrabbit	*Lepus townsendii*	CN, NG5/Na5/S2	Yes (USDA FS Carson NF 2014)
Yellow-bellied marmot	*Marmota flaviventris*	NG5/Na5/S2	Yes (USDA FS Carson NF 2014)
Plants			
Alpine bluebells	*Mertensia alpina*	NG4/S2	Yes (SEINet 2014)
Alpine larkspur	*Delphinium alpestre*	NG2/Na2/S2, RF, RP	Yes (Larson 2008)
Altai chickweed	*Stellaria irrigua*	NG4/S2	Yes (SEINet 2014)
Arctic harebell	*Campanula uniflora*	NG4/S2	Yes (SEINet 2014)
Arizona willow	*Salix arizonica*	NG3/Na3/S2, RF, RP	Yes (USDA FS Carson NF 2014)
Chaco milkvetch	*Astragalus micromerius*	NG3/Na3/S2, RF, RP	Yes (Larson 2008)
Chama blazing star	*Mentzelia conspicua*	NG2/Na2/S2, RF, RP	Yes (SEINet 2014)
Eastwood's podistera	*Podistera eastwoodiae*	NG3/Na3/S2	Yes (Larson 2008)
Golden saxifrage	*Saxifraga chrysantha*	NG4/S2?	Yes (SEINet 2014)
Gunnison's mariposa lily	*Calochortus gunnisonii*	NG5/T4?/Na4?, RF, RP	Yes (USDA FS Carson NF 2014)
Moosewort	*Botrychium tunux*	NG3?/Na3?	Yes (SEINet 2014)
New Mexico stickweed	*Hackelia hirsuta*	NG4, RP	Yes (Larson 2008)
Nodding saxifrage	*Saxifraga cernua*	NG5/S2?	Yes (SEINet 2014)
Pagosa milkvetch	*Astragalus missouriensis var. humistratus*	NG5/T1/Na1, RF, RP	Yes (SEINet 2014)
Pecos fleabane	*Erigeron subglaber*	NG3/Na3/S3, RF,RP	Yes (SEINet 2014)
Ripley's milkvetch	*Astragalus ripleyii*	NG3/Na3, RF, RP	Yes (Larson 2008)
Robust larkspur	*Delphinium robustum*	NG2?/Na2?, RF, RP	Yes (SEINet 2014)
Rocky Mountain nailwort	*Paronychia pulvinata*	NG3?/Na3?	Yes (Larson 2008)

Common Name	Scientific Name	Rationale for Consideration[1]	Presence in Plan Area Documented? (source)
Rocky Mountain spike-moss	*Selaginella weatherbiana*	NG4/Na4/S2	Yes (Larson, 2008)
Showy alpine groundsel	*Senecio amplectens var. amplectens*	NG4/T3?	Yes (Larson, 2008)
Small-headed goldenweed	*Ericameria microcephala*	NG2/Na2/S2, RF	Yes (USDA FS Carson NF 2014)
Stiff beardtongue	*Penstemon strictifromis*	NG3?	Yes (Larson 2008)
Tufted sand verbena	*Abronia bigelovii*	NG3/Na3, RF, RP	Yes (Larson 2008)

Step 2: Identify species that are at risk of persisting over the long term in the plan area.

The second step of the SCC analysis process determined which species can be removed from the potential SCC list because it is secure and its continued long-term persistence in the plan area is not at risk. Step 2 criteria were: (1) species has been documented to use the plan area only during the winter or as “transients” (e.g., northern harrier or bald eagle); (2) species inhabit areas not known to be affected by threats; (3) there is insufficient information to evaluate whether or not the species is at risk for persistence within the plan area; (4) species has a stable to upward population or habitat trend on the Carson NF; or (5) is a “game” species according to NMDGF.

Based on knowledge of the species’ abundance, distribution, lack of threats to persistence, trends in habitat, or responses to management, 40 of the 66 species identified as potential SCC are secure and their continued long-term persistence in the plan area are not at risk. As such, these species are no longer considered for further analysis as potential SCCs. Table 35 lists the species removed and the rationale for removing them.

Table 35. Potential species of conservation concern removed from further analysis, and rationale for removal

Common Name	Rationale for Removal from Potential SCC List
Amphibians and Reptiles	
Western diamondback rattlesnake	There is insufficient information to evaluate whether or not the species is at risk for persistence within the plan area (Degenhardt et al. 1996).
Avians	
American dipper	Inhabits rocky, cliff riparian that has not changed from historical reference condition and that are not affected by any threats (Poole 2014).
American goldfinch	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (Poole 2014).

Common Name	Rationale for Removal from Potential SCC List
Bald eagle	Migrant (Cartron 2010).
Band-tailed pigeon	Game species (NMDGF 2014) .
Bendire's thrasher	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (Poole 2014).
Boreal owl	The SFF ERU is common and has a stable to upward habitat trend on the Carson NF and most is in wilderness areas.
Brown-capped rosy finch	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (Poole 2014).
Ferruginous hawk	Migrant (Cartron 2010).
Golden eagle	Population trends for NM are holding at stable, and this species was detected every year during survey on the Carson NF (Beason et al. 2006).
Gray vireo	Population trends for NM are holding at stable, and this species was detected every year during survey on the Carson NF (Beason et al. 2006).
Juniper titmouse	There is an overabundance of snags in PJO and PJS on the Carson NF. PJO not departed and has a stable to upward habitat trend.
Lincoln's sparrow	Population trends for NM are holding at stable, and this species was detected every year during survey on the Carson NF (Beason et al. 2006).
Loggerhead shrike	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (Poole 2014).
Northern harrier	Migrant (Cartron 2010).
Pine grosbeak	The SFF ERU is common and has a stable to upward habitat trend on the Carson NF and most is in wilderness areas.
Short-eared owl	Migrant (Cartron 2010).
Invertebrates	
Monarch	Migrant (Lotts and Naberhaus 2014).
Spalding's blue butterfly	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (Lotts and Naberhaus 2014).
Mammals	
American marten	The SFF ERU is common and has a stable to upward habitat trend on the Carson NF and most is in wilderness areas.
American pika	Inhabits rocky, talus slopes that has not changed fro historical reference condition and that are not affected by any threats (BISON-M 2014).

Common Name	Rationale for Removal from Potential SCC List
Dwarf shrew	Inhabits rocky, talus slopes that has not changed fro historical reference condition and that are not affected by any threats (BISON-M 2014).
Rocky Mountain bighorn sheep	Game species (NMDGF 2014).
Snowshoe hare	The SFF ERU is common and has a stable to upward habitat trend on the Carson NF and most is in wilderness areas.
White-tailed jackrabbit	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (Natureserve 2015).
Yellow-bellied marmot	Inhabits rocky, talus slopes that has not changed fro historical reference condition and that are not affected by any threats (BISON-M 2014).
Plants	
Alpine bluebells	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (NMRPTC 1999).
Altai chickweed	Inhabits rocky/talus areas that has not changed fro historical reference condition and that are not affected by any threats (SEINet 2014).
Arctic harebell	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (SEINet 2014).
Eastwood's podistera	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (SEINet 2014).
Golden saxifrage	Inhabits rocky/talus areas that has not changed fro historical reference condition and and that is not affected by any threats (SEINet 2014).
Gunnison's mariposa lily	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (NMRPTC 1999).
Moosewort	Inhabits rocky, talus slopes that has not changed fro historical reference condition and that is not affected by any threats (SEINet 2014).
New Mexico stickweed	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (NMRPTC 1999).
Nodding saxifrage	Inhabits rocky/talus areas that has not changed fro historical reference condition and that is not affected by any threats (SEINet 2014).
Pecos fleabane	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (NMRPTC 1999).
Rocky Mountain nailwort	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (SEINet 2014).
Rocky Mountain spike-moss	Inhabits rocky/talus areas that has not changed fro historical reference condition and that is not affected by any threats (SEINet

Common Name	Rationale for Removal from Potential SCC List
	2014).
Showy alpine groundsel	Inhabits rocky/talus areas that has not changed fro historical reference condition and that is not affected by any threats (SEINet 2014).
Stiff beardtongue	There is insufficient information to evaluate whether or the species is at risk for persistence within the plan area (SEINet 2014).

There are 26 potential SCC that meet the criteria of not being capable of persisting in the plan area over the long term. Western burrowing owl and Gunnison's prairie dog remained on the potential SCC list as these species have concerns for persistence in the plan area; however, the concerns for persistence are due to actions or activities outside of agency control, authority, or capability.

In summary, Table 36 lists the potential 26 SCC that are documented to occur on the Carson NF and that the best available scientific information indicates substantial concern about their capability to persist over the long term in the plan area.

Table 36. Potential species of conservation concern for the Carson National Forest

Common Name	Scientific Name	NatureServe Ranking[1]
Amphibians and Reptiles		
Northern leopard frog	*Lithobates pipiens*	G4/Na5/S2
Western boreal toad	*Anaxyrus boreas*	G4/T1/Na4
Avians		
American peregrine falcon	*Falco peregrinus anatum*	G4/T4/Na3/S2
Northern goshawk	*Accipiter gentilis*	G5/Na4/S2
Pinyon Jay	*Gymnorhinus cyanocephalus*	G5/Na5
Western burrowing owl	*Athene cunicularia hypugaea*	G4/T4/Na4
White-tailed ptarmigan	*Lagopus leucura*	G5/Na5/S1
Wilson's warbler	*Cardellina pusilla*	G5/Na5/S2
Fish		
Rio Grande chub	*Gila pandora*	G3/Na3

[1] NatureServe Ranking - Global (G), Taxonomic (T), National (Na), or State (S)

Common Name	Scientific Name	NatureServe Ranking[1]
Rio Grande cutthroat trout	*Oncorhychus clarkii virginalis*	G4/T3/Na2/S2
Rio Grande sucker	*Catostomus plebeius*	G4/Na3/S2
Invertebrates		
Nokomis fritillary butterfly	*Speyeria nokomis nokomis*	G3/T1/Na1/S1
Mammals		
Gunnison's prairie dog	*Cynomys gunnisoni*	G5/Na5/S2
Masked shrew	*Sorex cinereus*	G5/NA5/S2
Pale Townsend's big-eared bat	*Corynorhinus townsendii*	G4/T3/Na4
Spotted bat	*Euderma maculatum*	G4/Na4
Water shrew	*Sorex palustris*	G5/Na5/S2
Plants		
Alpine larkspur	*Delphinium alpestre*	G2/Na2/S2
Arizona willow	*Salix arizonica*	G3/Na3/S2
Chaco milkvetch	*Astragalus micromerius*	G3/Na3/S2
Chama blazing star	*Mentzelia conspicua*	G2/Na2/S2
Pagosa milkvetch	*Astragalus missouriensis var. humistratus*	G5/T1/Na1
Ripley's milkvetch	*Astragalus ripleyii*	G3/Na3
Robust larkspur	*Delphinium robustum*	G2?/Na2?
Small-headed goldenweed	*Ericameria microcephala*	G2/Na2/S2
Tufted sand verbena	*Abronia bigelovii*	G3/Na3

Step 3: Associate the federally listed (Table 33) and potential species of conservation concern (Table 36) with current ecological conditions and key ecosystem characteristics described within ERUs on each of the Carson NF local zones.

The third step associated the 26 remaining potential SCC and 6 federally listed species with ecological condition and key ecosystem characteristics described within ERUs on the Carson NF, at the local scale. Vegetation is one of the primary factors that influences species diversity and abundance and is one of the more obvious habitat components influenced by management, land use, and natural disturbance. To make the species risk assessment relevant to other ecological risk assessments presented in this document and because vegetation is such a significant habitat component for species, vegetation types and key ecosystem characteristics were categorized following ecological response units (ERUs), as applied in the Terrestrial Vegetation (p. 34) and Riparian Vegetation (p. 116) sections. These ERUs are a stratification of ecosystem settings that are each similar in indicator plant species, succession patterns, and disturbance regimes that, in concept and resolution, are most useful to management. In other words, ERUs are the range of plant associations (USDA FS 1997), along with structure and process characteristics that would occur when natural disturbance regimes and biological processes prevail (Schussman and Smith 2006).

A departed ERU may not contain the vegetation that would have existed under the natural range of variation (NRV) and historical disturbance regime. However, the assessment of vegetation characteristics within each ERU quantifies the current ecological conditions of each ERU. Species presence and absence on the forest is, in many cases, directly tied to availability, current ecological condition, and key ecosystem characteristics of ERUs. Associating particular ERUs with specific species is critical for assessing future management needs. The description of current ecological condition for each ERU is within Terrestrial Vegetation (p. 34) and Riparian Vegetation (p. 116) sections of assessment report and were used to discern the status of the ecological conditions on the forest that are necessary to recover federally listed species, conserve proposed and candidate species, and maintain viable populations of species of conservation concern.

Wildlife and plant species were associated with up to 9 dominant ERU types (Table 37, p. 220). These associations were informed by a number of different sources, including the Biota Information System of New Mexico (BISON-M 2014), the New Mexico Rare Plants Website (NMRPTC 1999), NatureServe Data Explorer (Natureserve 2015), and personal communications with species experts and agency biologists.

In many cases, species' habitat needs were not represented solely by the overall ecological conditions of ERUs, but by more specific ecosystem characteristics required by the species (e.g., avians requiring snags or rocky outcrops for perching or nesting). In these cases, specific ecosystem characteristics were recorded and assessed separately from the ERU model (Table 37, p. 220). Overall, an effort was made to associate species with ERUs (based on current ecological conditions described therein) whenever possible, because later stages of forest plan revision and development will center on the management of ERUs. This relationship between species and ERUs is the premise of the coarse-filter approach discussed above and appropriate management of ERUs is expected to benefit at-risk and common and abundant species. The relationship between species and key ecosystem characteristics will help to identify fine-filter approaches necessary for preserving species diversity on the Carson NF.

Table 37. Federally listed (*) and potential species of conservation concern currently known to occur in the plan area and associated ecological response unit types

Common Name	ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE	HERB	WTLA	UMCW	NSPR	NSHR	RGCS	Aquatics
Amphibians and Reptiles																	
Northern leopard frog		X									X						X
Western boreal toad																	X
Avians																	
American peregrine falcon	X	X			X	X	X	X	X	X	X						
Mexican spotted owl*					X	X	X							X	X	X	
Northern goshawk				X	X	X	X										
Southwestern willow flycatcher*												X			X	X	
Pinyon jay								X	X								
Western burrowing owl		X								X							
Western yellow-billed cuckoo*															X	X	
White-tailed ptarmigan	X																
Wilson's warbler												X	X	X			
Fish																	
Rio Grande chub																	X
Rio Grande cutthroat trout																	X
Rio Grande sucker																	X
Invertebrates																	
Nokomis fritillary butterfly											X				X	X	

Common Name	ALP	MSG	BP	SFF	MCW	MCD	PPF	PJO	PJS	SAGE	HERB	WTLA	UMCW	NSPR	NSHR	RGCS	Aquatics
Mammals																	
Black-footed ferret*		X								X							
Canada lynx*				X	X												
Gunnison’s prairie dog		X								X							
Masked shrew		X	X	X	X						X	X	X	X			
New Mexico meadow jumping mouse*											X	X			X	X	
Pale Townsend’s big-eared bat				X	X	X	X	X									
Spotted bat							X	X	X	X	X						
Water shrew											X	X	X	X			
Plants																	
Alpine larkspur	X	X															
Arizona willow		X										X	X				
Chaco milkvetch							X	X									
Chama blazing star								X	X								
Pagosa milkvetch							X	X									
Ripley's milkvetch							X	X	X	X							
Robust larkspur				X	X	X					X	X	X	X			
Small-headed goldenweed							X										
Tufted sand verbena								X	X	X							

Species can be grouped a number of different ways that are useful for identifying broad threats to their continued existence on the Carson NF. For efficiency during the risk assessment portion of this evaluation, species were grouped according to their associated ERUs, described above and presented in Table 37. This information is summarized by taxonomic group in Table 38. It is acknowledged that grouping species in this manner will not accurately capture all of their specific habitat needs, and so they have also been sorted by key ecosystem characteristics (Table 39).

Table 38. Federally listed species and potential species of conservation concern summarized by taxonomic group and their associated ERUs

ERU	Amphibs	Avians	Fish	Inverts	Mammals	Plants	Total
Alpine & Tundra (ALP)		2				1	3
Montane Subalpine Grassland (MSG)	1	2			3	2	8
Bristlecone Pine (BP)					1		1
Spruce-Fir Forest (SFF)		1			3	1	5
Mixed Conifer, with Aspen (MCW		3			3	1	7
Mixed Conifer, Frequent Fire (MCD)		3			1	1	5
Ponderosa Pine Forest (PPF)		3			2	3	8
Piñon-Juniper Woodland (PJO)		2			2	5	9
Piñon-Juniper Sagebrush (PJS)		2			1	4	7
Sagebrush (SAGE)		2			3	2	7
Herbaceous Riparian (HERB)	1	1		1	4	1	8
Willow-Thinleaf Alder (WTLA)		2			3	2	7
Upper Montane Conifer-Willow (UMCW)		1			2	2	5
Narrowleaf Cottonwood-Spruce (NSPR)		2			2	1	5
Narrowleaf Cottonwood Shrub (NSHR)		3		1	1		5
Rio Grande Cottonwood-Shrub (RGCS)		3		1	1		5
Aquatics	2		3				5

Table 39. Key ecosystem characteristics associated with federally listed species (*) and potential species of conservation concern known to currently occur in the plan area

Associated Key Ecosystem Characteristics	Associated Species
Tree features **(cavities, snags, leaves, bark, downed logs, leaf or forest litter)**	▪ Mexican spotted owl* ▪ Northern goshawk ▪ Piñon jay ▪ Canada lynx* ▪ Pale Townsend's big-eared bat ▪ Spotted bat
Rock features **(canyons, cliffs, crevices, outcrops, mine adits)**	▪ American peregrine falcon ▪ Mexican spotted owl* ▪ Pale Townsend's big-eared bat ▪ Spotted bat ▪ Alpine larkspur ▪ Chaco milkvetch ▪ Small-headed goldenweed ▪ Tufted sand verbena
Riparian and aquatic features **(riparian areas, springs, permanent water)**	▪ Northern leopard frog ▪ Mexican spotted owl* ▪ Southwestern willow flycatcher* ▪ Western yellow-billed cuckoo* ▪ Wilson's warbler ▪ Rio Grande chub ▪ Rio Grande cutthroat ▪ Rio Grande sucker ▪ Western boreal toad
Meadows and small openings	▪ Northern leopard frog ▪ American peregrine falcon ▪ Western burrowing owl ▪ Black-footed ferret* ▪ Gunnison's prairie dog ▪ Masked shrew ▪ Arizona willow
Alpine and tundra	▪ American peregrine falcon ▪ White-tailed ptarmigan ▪ Alpine larkspur
Soil features **(soil type, soil permeability, and soil condition)**	▪ Western burrowing owl ▪ Black-footed ferret ▪ Gunnison's prairie dog ▪ Masked shrew ▪ Alpine larkspur ▪ Arizona willow ▪ Chaco milkvetch ▪ Chama blazing star ▪ Pagosa milkvetch ▪ Ripley's milkvetch ▪ Robust larkspur ▪ Small-headed goldenweed ▪ Tufted sand verbena

During the data-gathering and risk assessment portions of this assessment, species were also grouped by individual zones within ranger districts (local scale) (Figure 6, p. 28). This grouping was appropriate for analysis of endemic or specialized species. It is expected that this may also benefit other planning purposes; however, caution should be exercised when making comparisons between local zones (Table 40).

Table 40. Federally listed, proposed, and potential species of conservation concern summarized by taxonomic group and associated local scale on the Carson National Forest[1]

Local Scale	Amphibs	Avians	Fish	Inverts	Mammals	Plants	Total
Jicarilla (Ji)	1	7	0	0	4	1	13
Cruces Basin (Cb)	2	6	3	1	8	3	23
Rio Chama (Rc)	2	7	2	1	8	4	24
Vallecitos (Vc)	1	7	3	1	7	6	25
Rio Grande (Rg)	1	6	2	1	4	1	15
Red River (Rr)	1	8	1	1	7	4	22
Valle Vidal (Vv)	1	6	1	1	8	3	20
Camino Real (Cr)	1	8	2	1	8	4	24

Step 4: Perform a risk assessment analysis on federally listed and potential species of conservation concern, with their associated ERUs.

The final step of the process involved a risk assessment analysis on the remaining 32 species, both federally listed and potential SCC (Table 37, p. 220). This was performed using the Risk Assessment Database (RAD), which is designed to assess habitat, population, and threat factors for each of the species in terms of historical, current, and future trends for each local zone. Numerical values (1 = high; 2 = moderate; or 3 = low) were assigned to habitat, population, and threat factors to analyze risk of persistence for each species. For example, a bird documented on all 8 local zones and known to use 3 different ERUs would undergo 24 separate risk assessments. Determining a numerical ranking of risk at the level of individual populations or habitat factors is not possible; however, the individual risk assessments provided in the RAD can contribute to our understanding of these factors.

The dual coarse-filter and fine-filter approach described earlier was used to assess risk to species on the Carson NF. The coarse-filter approach considered ERUs (habitat) associated with species and current condition and future trends of these ERUs were modeled using the Vegetation Dynamics Development Tool (VDDT) (ESSA 2006). This tool was used to simulate stand structure 15 years, 100 years, and 1,000 years into the future under current management. The data presented in the Terrestrial Vegetation (p. 34) and Riparian Vegetation (p. 116) sections of this assessment report is modeled at the plan or forest-wide scale of analysis. Additional VDDT

[1] Some species are associated with more than one local zone.

modeling for departure at current conditions was performed at the local scale for terrestrial ecosystems (p. 13) and this finer scale of resolution was used for the species risk assessment. Some of the results of that modeling are presented in Table 41 and the rest is available in the forest plan revision project record (ESSA 2006).

Table 41. Risk to ERUs (habitat) in local zones using Vegetation Dynamics Development Tool modeling[1]

ERU	Jicarilla	Cruces Basin	Rio Chama	Valle-citos	Rio Grande	Red River	Valle Vidal	Camino Real	Modeled Departure in 100 Years Forest-wide
Alpine & Tundra (ALP)						Low		Low	Mod
Montane Subalpine Grassland (MSG)		Mod	Mod	High		High	Mod	Mod	High
Bristlecone Pine (BP)							Mod		Mod
Spruce-Fir Forest (SFF)		Low	Low	Low		Low	Low	Low	Low
Mixed Conifer, with Aspen (MCW)		Low	Low	Low		Low	Low	Low	Mod
Mixed Conifer, Frequent Fire (MCD)		High	High	High		Mod	High	High	Mod
Ponderosa Pine Forest (PFF)	High	High	High	High	High	High	High	High	High
Piñon-Juniper Woodland (PJO)	Low	Low	Mod	Low	Low	Low		Low	Low
Piñon-Juniper Sagebrush (PJS)	Mod		Mod	Mod	Mod	Mod		Mod	Mod
Sagebrush (SAGE)	High		High		Mod			High	High
Herbaceous Riparian (HERB)	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod	Mod
Willow-Thinleaf Alder (WTLA)	High	High		High		High	High	High	High

[1] ERUs are divided by local zone and the departure from a reference condition are presented. The current local departure and future forest-wide departure are shown for each ERU. Gray indicates that ERU is not present on that local zone.

ERU	Jicarilla	Cruces Basin	Rio Chama	Valle-citos	Rio Grande	Red River	Valle Vidal	Camino Real	Modeled Departure in 100 Years Forest-wide
Upper Montane Conifer-Willow (UMCW)		Low	Low	Low				Low	Low
Narrowleaf Cottonwood-Spruce (NSPR)				Mod		Mod		Mod	Mod
Narrowleaf Cottonwood Shrub (NSHR)		Mod		Mod		Mod		Mod	Mod
Rio Grande Cottonwood-Shrub (RGCS)	High		High	High	High				High
Streams	High	High	High	High	High	High	High	High	High
Waterbodies	High	Low	Mod	Low	Low	Mod	High	Mod	High

Trend was not calculated for Alpine and Tundra (ALP, p. 34), Bristlecone Pine (BP, p. 42), and unspecified aquatic ERUs, where forest acreages were too small to adequately model in VDDT or where structure stand is not appropriate for VDDT modeling. Because these ecological conditions of these ERUs are important to species, they are rated qualitatively (low, medium, high) on professional judgment (Table 41).

Currently, most of the modeled ERUs are partially departed from reference and are predicted to be departed from reference 100 years from now. An extensive discussion of that analysis is presented in Terrestrial Vegetation (p. 34) and Riparian Vegetation (p. 116), and is only briefly summarized here. Fire regimes are disrupted in all but the highest elevation ERUs on the forest, due to historic overgrazing and over a century of fire suppression. The lack of fire has led to a shift toward smaller diameter trees and denser stands in frequent fire systems (MCD, p. 56) and PPF, p. 60) and expansion and infill by tree species in Montane Subalpine Grassland (MSG, p. 37), Piñon-Juniper Woodland (PJO, p. 65), Piñon-Juniper Sagebrush (PJS, p. 69) and Sagebrush (SAGE, p. 73). Many wildlife species are dependent on shrub and forb species that once grew in the understory of various ERUs, but are now crowded out by this overall shift in seral structure and density. Additionally, years of prolonged drought combined with overstocked stands increases the risk of higher-intensity, more severe fires that could further eliminate habitat in all ERUs.

Key ecosystem characteristics important to wildlife and plants, such as coarse woody debris, that provide shelter, food, and moisture retention and standing snags of sufficient size for roosting, nesting, or foraging, are also departed from reference conditions (see Summary of Ecosystem Characteristics for Terrestrial Vegetation, Coarse Woody Debris and Snag Density, p. 80). These key ecosystem characteristics are somewhat more transient on the landscape. For example, as snags fall and eventually decay, standing live trees die and become new snags. In some ERUs, where smaller diameter trees are favored, the recruitment rate of large trees may be less than required to provide adequate habitat for species such as Mexican spotted owl or northern goshawk.

For all modeled ERU types, the current departure from reference condition and modeled departure for 100 years into the future were entered into the RAD. Qualitative determinations for those ERU types not modeled were made using knowledge of current condition and expert opinion. The RAD calculates an overall risk rating for each ERU-local zone combination entered based on the parameters described below. The **bold** words describe how each parameter is identified in the RAD. Each qualitative ranking selected is assigned a numerical value between 1 and 3 and then an overall habitat risk ranking value is calculated. All parameters below are evenly weighted in this calculation. They are summarized as follows:

1. The **extent of habitat available** to a species does not change from reference to future conditions. As stated above, ERU map units reflect the potential of a site and the historical disturbance regime. These are not expected to change at the time scales used; therefore, the amount of habitat available in historical/reference conditions does not change when moving to current or future conditions. ERUs that make up less than 5 percent of the plan area provide low amounts of habitat. Moderate amounts of habitat are ERUs that range from 6 to 50 percent, and high amounts of habitat make up 51 to 100 percent of the plan area.

2. **Quality of habitat** represents the current ecological condition of ERU departure from reference. It is assumed that all habitats were sufficient to maintain viability during reference conditions. For current conditions, ERUs in low departure are considered high quality, ERUs in moderate departure are moderate quality, and ERUs in high departure are low quality. ERUs modeled 100 years into the future represent the future trend in habitat quality. While it is acknowledged that highly departed ERUs that are not necessarily low quality habitat for wildlife, for the purpose of this risk assessment, that is the assumption. The VDDT modeling for ERUs on the Carson NF represents the most comprehensive habitat data available. More detailed habitat information for the SCC is indicated, where available.

3. **Distribution** is a qualitative measure that indicates the representativeness and redundancy (p. 139) of ERU types across local zones. ERUs were determined to be even (habitat dispersed broadly), restricted (habitat restricted to certain areas), or highly fragmented (habitat isolated and separated by distance or barriers). The consistency of these ratings was also assessed across historical, current, and future trends.

4. **Processes** refer to ecological processes, such as herbivory, fire, and flooding, and were evaluated using ERU departure. Similar to quality of habitat, it is assumed these processes were functioning in historical conditions. ERUs that are 0 to 50 percent departed are classified as functioning in both current and future conditions. ERUs that are 51 to 100 percent departed are considered disrupted. The future trend in quality of habitat reflects ERUs modeled for 100 years from the present time.

After the risk to ERUs and key ecosystem characteristics (habitats) were analyzed and entered into the RAD, the historic, current, and future trend of potential SCC populations were evaluated. The RAD steps the user through a similar analysis of historical, current, and future population trends. Qualitative rankings are assigned a numerical value of 1 to 3. Overall risk to populations is then calculated where all parameters are weighted equally. As with the analysis of habitats, a number of assumptions were made regarding population trends. Data informing these trends were gathered from a variety of places including NatureServe (2015), BISON-M (2014), and North American Breeding Bird Survey Data (Sauer et al. 2014).

1. **Distribution** refers to the species occurrence on the Carson NF, with respect to the nation-wide range for that species. Detailed distribution maps for breeding birds were available from North American Breeding Bird Survey Data (Sauer et al. 2014) and NatureServe (2015), as well as distribution maps for many non-avian species. Distribution of the species on the Carson NF was determined by evaluating the availability and location of suitable habitat. Within a single species, populations across the forest were determined to be either in high isolation, moderate isolation, or high interaction with one another.

2. **Size** refers to the overall population size across the species' range. Detailed information about populations of each species on just the Carson NF was not available in most cases. Population sizes were categorized as small, moderate, or large.

3. **Stability** refers to a population's relative trend towards increasing, decreasing, or remaining the same. In nearly all cases, population trend information specific to the Carson NF was not available, which constitutes a data gap in the analysis. For these instances, trend was inferred from regional or state information where possible. Trends were assumed stable if it was unclear whether or not populations were increasing or decreasing, or if the trends were not significant. All species were ranked as either in decline, stable, or increasing.

4. **Diversity** refers to phenotypic, ecological, and genetic diversity. If there was no information available regarding diversity for a species, then moderate diversity was selected for that species.

Once population factors have been evaluated, the RAD enables other threats to be analyzed, including human related harassment, invasive species, diseases, parasitism, obstructions (e.g., collisions with wind turbines, cars), or predation (Table 42). The severity of each threat is determined to be low, moderate, or high and the likelihood of that threat is also determined to be low, moderate, or high. Unlike the habitat or population factors, which require assessment, these other threats do not require assessment if no data is available. Again, numerical values are assigned to both the severity and likelihood ratings. The RAD then calculates overall numerical risk (1to 3) to each species and assigns a qualitative rank (high, moderate, low).

Table 42. Additional threats to federally listed (*) and potential species of conservation concern on the Carson National Forest

Additional Threats	Affected Species
Harassment (e.g., human presence disrupting species during sensitive life stages, dogs, disturbance from mining, recreational, oil/gas development activities, target shooting)	▪ American peregrine falcon ▪ Mexican spotted owl* ▪ Northern goshawk ▪ Pinyon jay ▪ Southwestern willow flycatcher* ▪ Western burrowing owl ▪ Western yellow-billed cuckoo* ▪ White-tailed ptarmigan ▪ Wilson's warbler ▪ Canada lynx* ▪ Gunnison's prairie dog ▪ Pale Townsend's big-eared bat ▪ Spotted bat ▪ Alpine larkspur ▪ Arizona willow ▪ Chaco milkvetch ▪ Chama blazing star ▪ Pagosa milkvetch ▪ Small-headed goldenweed ▪ Tufted sand verbena
Invasive Species	▪ Northern leopard frog ▪ Western boreal toad ▪ Rio Grande chub ▪ Rio Grande cutthroat trout ▪ Rio Grande sucker ▪ New Mexico meadow jumping mouse ▪ Arizona willow ▪ Alpine larkspur ▪ Chama blazing star ▪ Chaco milkvetch ▪ Pagosa milkvetch ▪ Ripley's milkvetch ▪ Robust larkspur ▪ Small-headed goldenweed ▪ Tufted sand verbena
Diseases (e.g., White-nose syndrome, chytrid fungus, sylvatic plague)	▪ Northern leopard frog ▪ Western boreal toad ▪ Western burrowing owl ▪ Rio Grande cutthroat trout ▪ Gunnison's prairie dog ▪ Pale Townsend's big-eared bat ▪ Spotted bat
Parasitism (including nest parasitism from brown-headed cowbirds, whirling disease)	▪ Southwest willow flycatcher* ▪ Wilson's warbler ▪ Rio Grande cutthroat trout
Obstructions (e.g., dams, barriers, roads, collisions with wind turbines or vehicles)	▪ American peregrine falcon ▪ Western burrowing owl ▪ Western yellow-billed cuckoo*

Additional Threats	Affected Species
	▪ White-tailed ptarmigan ▪ Rio Grande chub ▪ Rio Grande cutthroat trout ▪ Rio Grande sucker ▪ Canada lynx* ▪ Pale Townsend's big-eared bat ▪ Spotted bat
Predation	▪ Northern leopard frog ▪ Western boreal toad ▪ Mexican spotted owl* ▪ Northern goshawk ▪ Western burrowing owl ▪ White-tailed ptarmigan ▪ Rio Grande chub ▪ Rio Grande cutthroat trout ▪ Rio Grande sucker ▪ Gunnison's prairie dog ▪ Masked shrew ▪ New Mexico meadow jumping mouse* ▪ Water shrew ▪ Ripley's milkvetch ▪ Robust larkspur ▪ Arizona willow ▪ Chama blazing star

Federally Listed Species and Species of Conservation Concern and Current Carson Management

All of the federally listed species and potential SCC can be affected by the management activities authorized under the current Carson forest plan. Risk was not assessed for ERUs or other habitat factors on non-NFS lands. Therefore, it is not possible to state with certainty the overall risk to the species at the context scale. However, for many of these species, habitat provided on the forest represents the majority of habitat available. Changing land use patterns, habitat degradation and loss, or simply the lack of suitable habitat off of the forest, places a particular emphasis on the Carson NF to maintain these species.

Federally Listed Species

New Mexico Meadow Jumping Mouse

New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) is federally listed as endangered. This species occurs in dense mid-elevation riparian areas (Herbaceous, Willow-Thinleaf Alder, Upper Montane Conifer-Willow, and Narrow Cottonwood-Shrub riparian ERUs) with dense and tall grass key ecosystem characteristics in the western U.S. It was historically documented on the Carson NF, but recent surveys on the forest were unable to detect this species. The number of historic locations of this species on public lands is far greater than on private land (Frey and Malaney 2009). The Carson NF currently has potential habitat for this species, but it is limited and highly fragmented. Major threats include the degradation of riparian habitat because of grazing, post-wildfire flooding events, and unmanaged recreation. Agricultural uses and development of land outside the forest boundary have permanently changed historic locations, which makes any potential habitat on the Carson NF vital.

Western Yellow-Billed Cuckoo

Western yellow-billed cuckoo (*Coccyzus americanus occidentalis*) is federally listed as threatened west of the Rio Grande (distinct population segment). The species occurs in dense cottonwood and willow riparian habitats (Narrow Cottonwood-Shrub, Rio Grande Cottonwood-Shrub riparian ERUs) in the western U.S. Although it has not been documented on the Carson NF, it is possible the species uses the Carson NF. The major threat to the species is the loss of riparian habitat, because of invasive species and changing water use and land use. Cuckoos are also susceptible to tower and turbine strikes. Current emphasis on prescribed burning in upland habitat has led to insufficient emphasis and funds for restoration in riparian areas with high potential for quality habitat. Protecting native saplings from grazing in restored areas is also a problem. The removal of non-native invasive woody species and the subsequent replanting of native cottonwood and willows require extensive multi-partner planning, involvement, and investment.

Southwestern Willow Flycatcher

Southwestern willow flycatcher (*Empidonax traillii extimus*) is federally listed as endangered and relies on dense riparian areas (Willow-Thinleaf Alder, Narrowleaf Cottonwood-Shrub, Rio Grande Cottonwood-Shrub riparian ERUs) typically dominated by the key ecosystem characteristic of dense willow species. There are 148 acres of designated critical habitat on the Camino Real RD of the Carson NF. This is described in more detail in Chapter III. Designated Areas (p. 442). Threats include loss of riparian habitat from altered hydrology, clearing and controlling non-native, increased fire risk, due to the establishment of non-native plants, unmanaged grazing, and nest parasitism by the brown-headed cowbird. These threats have consequently reduced population levels range-wide for this species.

Mexican Spotted Owl

Mexican spotted owl (*Strix occidentalis lucida*) is federally threatened species on the Carson NF. There are 22,954 acres of designated critical habitat on the Jicarilla RD of the Carson NF. This is described in more detail in Chapter III. Designated Areas (p. 442). Although numerous surveys have not documented this species on the Carson NF, a recent record described the movement of a Mexican spotted owl banded on the Gila NF and was found dead on private property adjacent to the Questa RD of Carson NF in 2012 (Ganey and Jenness 2013). The Mexican spotted owl requires a variety of mixed conifer habitats (Mixed Conifer, with Aspen, Mixed Conifer, Frequent Fire, and Ponderosa Pine Forest ERUs), with key ecosystem characteristics of proximity to riparian areas, standing large snags for roosting and nesting, or cavities in vertical canyon walls. Timber management activities negatively affected habitat before the Mexican spotted owl was listed as threatened in 1995. Timber harvest, prescribed burning, and other management activities are designed following the Mexican Spotted Owl Recovery Plan (2012b) along with consultation from FWS. These management activities can still have disturbance affects to the MSO, but they are minimalized.

Canada Lynx

Canada lynx (*Lynx canadensis*) is a federally threatened species and is not known to den or breed on the forest. Historically, the Carson NF did not support a naturally resident lynx population (USDI FWS 2014a), but occasionally an individual may roam out of Colorado onto the forest. In New Mexico, this species is a habitat specialist confined largely to mid- to high elevation boreal and subalpine spruce-fir forests at 9,800 to 12,000 feet in elevation (Spruce-Fir Forest ERU) (Koehler and Brittell 1990; Ruggiero et al. 1999). Snowshoe hare is the primary forage for this species. Lynx do not typically reside on the Carson NF because the forest lacks the aforementioned physical and biological features necessary to sustain a population (USDI FWS 2014a). Forest management activities are not expected to have any effect on this species as it only utilizes the forest occasionally.

Black-Footed Ferret

Black-footed ferret (*Mustela nigripes*) is a federally endangered species that is not known to occur on the Carson NF. This species is closely tied to the presence of prairie dog colonies of at least 80 to 100 acres in size depending upon the prairie dog species (USDI FWS 2013). Currently, there are no prairie dog colonies of this magnitude on the Carson NF. Forest management activities are not expected to have any effect on this species as suitable habitat features do not currently exist on the Carson NF.

Potential Species of Conservation Concern

Information on the species below indicates substantial concern about the species' capability to persist over the long term in the plan area, as evidenced by one or more of the following criteria:

1. Habitat is limited, rare, or has a downward trend within the plan area.
2. Current management activities that are of sufficient duration, intensity, and magnitude to be a threat to the species or species habitat within the plan area.

3. Available monitoring indicates a decline in population, range, or both within the plan area.

All species listed met one or more of the initial requirements for SCC (Table 36) and a number of sources were consulted to determine whether the above criteria were met (see Evaluating Relevant Information for At-Risk Species, p. 208). Additional threats for special habitat features used by potential SCC and federally listed are presented in Table 43.

Table 43. Primary threats to key ecosystem characteristics and their associated species[1]

Key Ecosystem Characteristic	Primary Threats	Associated Species
Tree features, cavities, snags, leaves, bark, downed logs, leaf or forest litter	▪ Fire not only creates but can also consume tree features directly resulting in the loss of nesting, breeding, and roosting habitat. Smoke from fire can displace species and cause direct mortality. ▪ Trampling can cause mortality to individuals occupying leaf litter. ▪ Timber harvest activities may result in direct damage/loss of trees and snags. ▪ Large-scale outbreaks of insects or disease could threaten large areas of habitat.	▪ Northern goshawk ▪ Mexican spotted owl* ▪ Pinyon jay ▪ Wilson's warbler ▪ Canada lynx* ▪ Masked shrew
Rock features, canyons, cliffs, crevices, outcrops	▪ Activities including recreational rock climbing, caving, mining, mine reclamation, construction and vandalism, can disturb or damage habitat. ▪ Removal of surface rock causes direct mortality and damages habitat. ▪ Alterations of the rock surfaces such as removing rock through excavation or rock climbing, can alter the habitat enough to prevent plant establishment. ▪ Trampling of plants in crevices causes direct mortality.	▪ American peregrine falcon ▪ Mexican spotted owl* ▪ Spotted bat ▪ Pale Townsend's big-eared bat ▪ Alpine larkspur ▪ Chaco milkvetch ▪ Chama blazing star ▪ Pagosa milkvetch ▪ Small-headed goldenweed ▪ Tufted sand verbena
Aquatic features, riparian areas, springs, permanent water	▪ Groundwater depletion and streamflow diversion, roads, trails, facilities, nonnative plant species and upland species encroachment, uncharacteristic fire in riparian and adjacent areas, mining, or unmanaged herbivory, leads to loss or damage of riparian characteristics. ▪ Disturbance to soil in these areas due to unmanaged herbivory, dispersed camping, or construction activities can decrease plant numbers. ▪ Spring development for livestock or wildlife use decreases water available for local ecosystems and trampling further degrades these areas. ▪ In some places, invasive species can out-compete native species found only in aquatic features.	▪ Northern leopard frog ▪ Western boreal toad ▪ Mexican spotted owl* ▪ Southwestern willow flycatcher* ▪ Western yellow-billed cuckoo* ▪ Wilson's warbler ▪ Rio Grande chub ▪ Rio Grande cutthroat trout ▪ Rio Grande sucker ▪ Nokomis fritillary butterfly ▪ Masked shrew ▪ New Mexico meadow jumping mouse* ▪ Water shrew ▪ Arizona willow

[1] An asterisk (*) denotes federally listed species. All others are potential species of concern.

Key Ecosystem Characteristic	Primary Threats	Associated Species
		▪ Robust larkspur
Alpine, tundra, meadows, small openings, other grassland features	▪ Unmanaged herbivory can change local conditions and invertebrate communities. ▪ Encroachment by woody vegetation eliminates grasses and forbs and decreases the size of these features.	▪ Northern leopard frog ▪ Western boreal toad ▪ Western burrowing owl ▪ White-tailed ptarmigan ▪ Gunnison's prairie dog ▪ Masked shrew ▪ Alpine larkspur ▪ Arizona willow ▪ Ripley's milkvetch ▪ Robust larkspur
Soil features, soil type, soil permeability, soil condition	▪ In some places, invasive species can out-compete native species found only in special soil types. ▪ Disturbance to soils from dispersed camping, off-highway vehicle use, unmanaged herbivory, or mining can negatively impact species.	▪ Western burrowing owl ▪ Gunnison's prairie dog ▪ Masked shrew ▪ Alpine larkspur ▪ Arizona willow ▪ Chaco milkvetch ▪ Chama blazing star ▪ Pagosa milk-vetch ▪ Ripley's milkvetch ▪ Robust larkspur ▪ Small-headed goldenweed ▪ Tufted sand verbena

Northern Leopard Frog

Northern leopard frog (*Lithobates pipiens*) is currently found in all local zones. There are also historic records documenting this species on each local zone. This aquatic species requires springs, slow streams, or other perennial water for overwintering (all riparian ERUs and aquatic ecosystems), which currently is found within less than 5 percent of the forest (crit. #1). These ERU habitats are currently highly departed and in a downward trend on the Carson NF (crit. #1). Current threats to these species and its habitat include habitat degradation caused by grazing (91% potential habitat affected), chytrid fungus, lack of beaver ponds, depredation by bull frogs, or siltation from poor road management (69% potential habitat affected) (crit. #2). These threats have contributed to the current ecological conditions of riparian areas on the Carson NF, which in turn has limited species distribution within these ERUs (crit. #3). This species has become extirpated from parts of its historic range on the Carson NF (crit. #3).

Western Boreal Toad

Western boreal toad (*Anaxyrus boreas*) was confirmed at Lagunitas, Canjilon, and Trout Lakes on the Carson NF (crit. # 1). This aquatic species requires springs, slow streams, or other perennial water associated with spruce-fir forest (Spruce-Fir Forest ERU and aquatic ecosystems). During warmer months, it may be found in wet meadows or other habitats near standing water, which are limited on the Carson NF (crit. #1). Presently, ecological conditions are highly departed and in a downward trend on the Carson NF (crit. #1). Current threats include degradation of these habitats caused by grazing (67% occupied habitat affected), chytrid fungus, lack of beaver ponds, and depredation by bull frogs, or siltation from poor road management (67% occupied habitat affected) (crit. #2). These threats have contributed to the current ecological condition for riparian areas on the Carson NF, which in turn has limited species distribution within these habitat types (crit. #3). According to NMDGF (2006a), western boreal toads are currently only found in Canjilon and Trout lakes (crit. #3).

American Peregrine Falcon

American peregrine falcon (*Falco peregrinus anatum*) is found on all local zones where it nests in cliffs and rock outcrops, a key ecosystem characteristic found within all terrestrial ERUs and are limited on the Carson NF (crit. #1). Threats include disturbance from recreational climbing (46% known sites affected) (crit. #2). Of the known eyries on the Carson NF, about a quarter of them were monitored each year under independent contracts through the US Fish and Wildlife Service or NMDGF. Long-term monitoring efforts documented declining productivity of American peregrine falcon from 2001-2013 in New Mexico (Johnson and Williams III 2014) (crit. #3).

Northern Goshawk

Northern goshawk (*Accipiter gentilis*) is a forest habitat generalist that uses a wide variety of forest ages, structural conditions and successional stages in Spruce-Fir Forest, Mixed Conifer, with Aspen, Mixed Conifer, with Frequent Fire, and Ponderosa Pine Forest ERUs. Ecological conditions of most of these ERUs are currently departed from reference on the Carson NF, because of historic fire suppression activities and wildfire (crit. #2). These ERUs are also in a downward habitat trend (crit. #1). This species can be found on all local zones. Threats to this species on the Carson NF include large-scale thinning (<5% of potential habitat impacted) and recreation (13% of potential habitat impacted, crit. #2). Following the northern goshawk guidelines, continually monitoring known nest sites, and surveying for new nests is sufficient to eliminate substantial concern about the species' capability to persist over the long term on the Carson NF.

Pinyon Jay

Pinyon Jay (*Gymnorhinus cyanocephalus*) is a pñon-juniper woodlands obligate species (Piñon-Juniper Woodland and Piñon-Juniper Sagebrush ERUs), and is found throughout the Carson NF. Changes in fire regimes, drought, and recent outbreaks of piñon engraver beetles have resulted in the loss of piñon pines on the forest (crit. #1) (Wiggins 2005). Threats to this species on the Carson NF include drought, widespread die-offs of piñon pines from beetles (approximately 50% of potential habitat impacted), large-scale thinning (<5% of potential habitat impacted), and fuelwood harvesting (14% of potential habitat impacted, crit. #2). Trends observed in New Mexico Breeding Bird Surveys data indicates declines of 4 percent per year, making it one of the fastest declining forest obligate bird species in the state (Sauer et al. 2014) (crit. #3).

Western Burrowing Owl

Western burrowing owl (*Athene cunicularia hypugaea*) is found on the Carson NF in Montane Subalpine Grassland and Sagebrush ERUs. They nest and roost in recently abandoned burrows dug by mammals, including ground squirrels, prairie dogs, and badgers. These burrows may soon become unsuitable for nesting (Green and Anthony 1989) (crit. #1). For this reason, viability of western burrowing owls is inextricably linked to that of burrowing mammals, including prairie dogs. Threats to this species on the Carson NF include burrowing mammals, such as Gunnison’s prairie dogs, recreational shooting, and sylvatic plague (Antolin et al. 2002; Finch 1992; USDA FS 2013a) (crit. #2). These threats are outside of Forest Service control.

White-Tailed Ptarmigan

White-tailed ptarmigan (*Lagopas leucura*) utilize the Alpine and Tundra ERU of the Carson NF (<1% of the forest), which is only found on the Red River, Valle Vidal, and Camino Real local zones (crit. #1). Threats include degradation of habitat by grazing (25% potential habitat affected), and recreation (15% potential habitat affected) (crit. #2). Monitoring indicates that ptarmigan are found in the alpine and tundra habitat of the Carson NF, but in very small numbers (Wolfe et al. 2012) (crit. #3).

Wilson's Warbler

Wilson's warbler (*Cardellina pusilla*) utilizes mesic shrub communities (all riparian ERUs). The optimal habitat for this species consists of key ecosystem characteristics found along the edges of beaver ponds, lakes, dense riparian zones, fens, bogs, and overgrown clear-cuts (crit. #1). Most of the riparian ERUs on the forest are departed from reference, because of changes in vegetative composition and hydrology (crit. #1). Wilson's warblers are only found on the Camino Real, Red River, and Jicarilla local zones (crit. #1). Habitat degradation and sedimentation from wildfire, grazing (64% potential habitat affect), recreation (28% potential habitat affected), motorized travel (11% potential habitat affected), and changes in hydrology can negatively impact this species (crit. #2). According to Breeding Bird Surveys (2014), this species showed a declining trend of 7 percent from 2003 to 2013 in New Mexico (crit. #3).

Rio Grande Cutthroat Trout, Rio Grande Chub, and Rio Grande Sucker

Rio Grande cutthroat trout (*Onchorychus clarkia virginalis*) (RGCT), Rio Grande chub (*Gila Pandora*) (RGC) and Rio Grande sucker (*Catostomus plebius*) (RGS) all need clear, cold water streams with gravel and cobble substrates to survive (aquatic ecosystems). These species are found in various streams throughout the Carson NF, but habitat is limited. This is because the ecological conditions of most streams are departed, due to grazing, wildfire, recreation activities, motorized travel, road management, or from negative interactions with non-native species (e.g., brown trout or rainbow trout) (crit. #1 and #2). Negative interactions with non-native fishes include competition for space and food and predation by non-natives. Furthermore, the hybridization that occurs between native RGCT and rainbow trout is of great concern for the continued persistence of RGCT (crit. #2). Hybridization and competition with non-native trout affects 61 percent of occupied RGCT, RGC, and RGS stream habitat. Sedimentation from various road sources (45% occupied habitat affected), recreational activities (40% occupied habitat affected), and grazing (71% occupied habitat affected) degrades water habitat quality and negatively impacts eggs and fry (crit. # 2). Clamusso and Rinne (2009) discovered RGC and RGS were found in less streams on the forest in 2009, compared to 1990; whereas, RGCT were found in more streams, because of reintroduction efforts (crit. #3).

Nokomis Fritillary Butterfly

Nokomis fritillary butterfly (*Speyeria nokomis nokomis*) is found in arid landscapes (Ponderosa Pine Forest, Piñon-Juniper Woodland, Piñon-Juniper Sagebrush, and Sagebrush ERUs), with the key ecosystem characteristics of streamside meadows and open seepage areas (Selby 2007). Low elevation arid landscapes with riparian habitat is limited (<1% of the entire forest), and the currently ecological condition of these ERUs are departed from reference, because of change in vegetative composition and hydrology (crit. #1). Presence of bog violet (*Viola nephrophylla*), the only confirmed larval food source, is an essential habitat component. During floral surveys in 2006 and 2007, only three species of bog violets were found on the Carson NF. The bog violets were documented in very limited numbers and in isolated occurrences (crit. #1 and #3). The main threat to Nokomis fritillary is loss of habitat from grazing (44% potential habitat affected), change in hydrological conditions, and recreation (5% potential habitat affected) (crit. #2).

Gunnison's Prairie Dog

Gunnison's prairie dog (*Cynomys gunnisoni*) is known to occur within the Montane Subalpine Grassland ERU of the Carson NF (crit. #3). Threats include recreational shooting (Finch 1992; USDA FS 2013a) (crit. #2) and sylvatic plague (Antolin et al. 2002). Most of these threats are outside of agency control, but sylvatic plague could be affected by management because the Carson NF could elect to "dust" prairie dog burrows with the insecticide Deltamethrin, which controls fleas infected with the plague bacterium (Antolin et al. 2002; Seery et al. 2003) (crit. #2).

Masked Shrew

Masked shrew (*Sorex cinereus*) hunts insects and small mammals along banks of cold streams, in springy meadows, or under logs in cold spruce forest (Spruce-Fir Forest ERU and Herbaceous, Willow-Thinleaf Alder, Upper Montane Conifer-Willow, and Narrowleaf Cottonwood-Spruce riparian ERUs). Most of these ERUs' current ecological conditions on the Carson NF are departed from reference, because of changes in vegetative composition and hydrology (crit. #1). The masked shrew is found on every local zone, except Jicarilla (Frey 2003). Negative impacts to the masked shrew include habitat degradation and sedimentation caused by grazing (79% potential habitat affected), fuelwood gathering (8% potential habitat affected), wildfire, recreation (2% potential habitat affected), motorized travel (8% potential habitat affected), and changes in hydrology (crit. #2).

Pale Townsend's Big-Eared Bat

Pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens*) has been recorded on Rio Chama, Jicarilla, and Red River local zones. This species has not been documented on the Carson NF since 1998. They require key ecosystem characteristics, such as caves (there are no caves on the Carson NF) and abandoned mine features (within all terrestrial ERUs), to hibernate and roost in, which are rare on the forest (crit. #1). Ongoing activities known to impact habitats used by the bats, include recreational mine exploring (25% potential habitat affected), vandalism (25% potential habitat affected), renewed mining (0.1 potential habitat affected), mine reclamation (50% potential habitat affected) (crit. #2), and potentially white nose syndrome, a lethal fungal infection found in some species of hibernating bats in the eastern- and Midwestern United States. Past activities, such as improper mine closures, have led to a reduction in the number of available hibernacula for this species (crit. #3).

Spotted Bat

Spotted bat (*Euderma maculata*) individuals have been recorded on the Rio Chama local zone of the Carson NF (Geluso 2006). They are believed to require key ecosystem characteristics of accessible rock crevices (within all terrestrial ERUs) to roost in , which are limited or unknown on the forest (crit. #1). Recreational climbing (26% potential habitat affected) is known to impact this species (crit. #2). The potential seems low for white-nose syndrome, a lethal fungal infection found in some species of hibernating bats in the eastern and Midwestern United States, as this bat is not known to hibernate in groups. This bat feeds on noctuid moths in and over the forest canopy. Large wildland fires can threaten this species and timely restoration of the Carson NF is needed to avoid impacts to the population, which is low to rare wherever it is found (crit. #3).

Water Shrew

Water shrew (*Sorex palustris*) hunts insects and small mammals exclusively near clear, cold high elevation streams (Herbaceous, Willow-Thinleaf Alder, Upper Montane Conifer-Willow, and Narrowleaf Cottonwood-Spruce riparian ERUs and aquatic ecosystems) throughout the Carson NF. High elevation riparian habitat is limited (3% of the entire forest) and is departed from reference, because of changes in vegetative composition and hydrology (crit. #1). Habitat degradation and sedimentation from grazing (70% potential habitat affected) recreation (11% potential habitat affected), motorized travel (29% potential habitat affected), and changes in hydrology can negatively impact this species (crit. #2).

Alpine Larkspur

Alpine larkspur (*Delphinium alpestre*) occurs in alpine/tundra and open meadows in subalpine coniferous forest (Alpine and Tundra and Montane Subalpine Grassland ERUs) from 11,500-13,000 feet in elevation (crit. #1). In New Mexico, it has only been found within Taos County (crit. #1). This species is occasionally targeted for weed control (0.1% of potential habitat affected), as some species of larkspur are poisonous to livestock (crit. #2). Additional, threats include degradation of habitat by grazing (25% potential habitat affected), recreation (15% potential habitat affected), and seed collecting (crit. #2).

Arizona Willow

Arizona willow (*Salix arizonica*) is only found in high elevation areas within open meadows and along streams (Montane Subalpine Grassland ERU and Willow-Thinleaf Alder, Upper Montane Conifer-Willow, and Narrowleaf Cottonwood-Spruce riparian ERUs) (crit. #1). It is a favored plant by grazers. The growth and vigor of this willow is impacted by livestock grazing (96% potential habitat affected) and recreational snowmobiling (71% potential habitat affected) (crit. #2). Protection by small enclosures on the Carson NF has resulted in expansion of this species in the past decade, but these enclosures have not been maintained. Measuring consumption by a percentage of use of available forage does not protect this species from preferred selection by livestock (crit. #2).

Chaco Milkvetch

Chaco milkvetch (*Astragalus micromerius*) is restricted to soils with the key ecosystem characteristic of gypsum soils and outcrops on the Rio Chama local zone (NMRPTC 1999) (crit. #1). Threats include habitat disturbance from recreation (0.1% potential habitat affected), motorized travel (5% potential habitat affected), and gypsum mining (not occurring at this time) (crit. #2). Populations of this plant are small and isolated on the Carson NF (crit. #3).

Chama Blazing Star

Chama blazing star (*Mentzelia conspicua*) is only found in small and isolated populations on the Rio Chama local zone (crit. #1 and #3). It is usually found on the key ecosystem characteristic of gray to red shales of Mancos and Chinle soil formations in the Piñon-Juniper Woodland ERU (NMRPTC 1999) (crit. #1). Threats include habitat disturbance from recreation (0.1% potential habitat affected) and road construction and maintenance (14% potential habitat affected) (crit. #2).

Pagosa Milkvetch

Pagosa milkvetch (*Astragalus missouriensis* var. *humistratus*) is only found in one small and isolated population on the Jicarilla local zone (crit. #1 and #3). This species is usually found in Ponderosa Pine Forest and Piñon-Juniper Woodland ERUs, within the key ecosystem characteristics of Mancos and Lewis soil formations (Decker 2006) (crit. #1). Threats include habitat disturbance from recreation (0.1% potential habitat affected), oil and gas development (0.3% potential habitat affected), and road construction and maintenance (7% potential habitat affected) (crit. #2).

Ripley's Milkvetch

Ripley's milkvetch (*Astragalus ripleyii*) is exclusively associated with key ecosystem characteristic of the volcanic substrates within the San Juan volcanic field and is only found on the Cruces Basin (Cr), Vallecitos (Vc), Rio Grande (Rg), and Red River (Rr), local zones (Ladyman 2003) (crit. #1 and #3). Currently, it has been identified at 44 locations in New Mexico, of which 10 are on the Carson NF (NHNM 2014). Determining occurrence size is difficult as the number of individuals appears to be correlated with the amount of moisture received in April and May. This species is vulnerable to herbivores, particularly sheep grazing, and invasion of non-native plants (crit. #2).

Robust Larkspur

Robust larkspur (*Delphinium robustum*) is a regional endemic species of south-central Colorado and north-central New Mexico (Beatty et al. 2004) (crit. #1). It occurs in valley bottoms, riparian woodlands, subalpine meadows, and aspen groves in lower and upper montane coniferous forests (Spruce-Fir Forest, Mixed Conifer, with Aspen, Mixed Conifer, with Frequent Fire, Ponderosa Pine Forest ERUs) from 7,000 to 11,200 feet. Six occurrences have been reported in New Mexico, three of which were found on the Carson NF (Seinet 2014) (crit. #1 and 3). This species is occasionally targeted for weed control (0.1% of potential habitat affected), as some species of larkspur are poisonous to livestock (crit. #2). This species is highly palatable to herbivores (88% potential habitat affected). Additional threats to this species include habitat disturbance from recreation (2% potential habitat affected) and road construction (13% potential habitat affected) (crit. #2).

Small-headed Goldenweed

Small-headed goldenweed (*Ericameria microcephala*) is restricted to the Cruces Basin local zone within the Ponderosa Pine Forest ERU, with the key ecosystem characteristic of granite rock crevices and outcrops (NMRPTC 1999) (crit. #1). Threats include habitat disturbance from recreation (0.1% potential habitat affected) and forest fires (crit. #2). Populations of this plant are small and isolated on the Carson NF (crit. #3).

Tufted Sand Verbena

Tufted sand verbena (*Abronia bigelovii*) is restricted to soils with the key ecosystem characteristic of gypsum soils and outcrops on the Rio Chama and Vallecitos local zones (NMRPTC 1999) (crit. #1). Threats include habitat disturbance from recreation (0.1% potential habitat affected), motorized travel (5% potential habitat affected), and gypsum mining (not occurring at this time) (crit. #2). Populations of this plant are small and isolated on the Carson NF (crit. #3).

Species Risk Analysis

The final products of the RAD are species ratings tables that give a numerical overall risk value to each species, for each ERU, in each local zone (1 to 1.66 = High Risk; 1.67 to 2.33 = Moderate Risk; 2.34 to 3.0 = Low Risk). These have been averaged to provide a single overall risk value and qualitative ranking for each species. Federally recognized species are presented in Table 44, while potential SCC are presented in Table 45. These potential SCC have been found to be declining in abundance and distribution by external entities, including the U.S. Fish and Wildlife Service, Southwestern Region of the U.S. Forest Service, the New Mexico Department of Game and Fish, the New Mexico Department of Forestry, the Navajo Nation, and Natural Heritage New Mexico, among others. It was determined that management actions implemented by the Carson NF further threatened these species' persistence on the forest. These species, in addition to federally listed species relevant to the plan area (Table 33, p. 206), will be considered as the Carson NF evaluates needs to change its current forest plan.

Table 44. Risk to federally recognized species relevant to the Carson National Forest[1]

Common Name	Scientific Name	Risk Assessment Value	Overall Risk
Birds			
Mexican spotted owl	*Strix occidentalis lucida*	2.03	Moderate
Southwestern willow flycatcher	*Empidonax traillii extimus*	1.91	Moderate
Western yellow-billed cuckoo	*Coccyzus americanus occidentalis*	1.97	Moderate
Mammals			
Black-footed ferret	*Mustela nigripes*	1.93	Moderate
Canada lynx	*Lynx canadensis*	2.22	Moderate
New Mexico meadow jumping mouse	*Zapus hudsonius luteus*	1.74	Moderate

[1] The Risk Assessment Database calculates a risk value between 1 and 3. Risk value determinations are: High = 1 to 1.5; Moderate = 1.51 to 2.49; and Low = 2.5 to 3.0.

Table 45. Risk to potential list of species of conservation concern for the Carson National Forest[1]

Common Name	Scientific Name	Risk Assessment Value	Overall Risk
Amphibians and Reptiles			
Northern leopard frog	*Lithobates pipiens*	1.91	Moderate
Western boreal toad	*Bufo boreas*	1.45	High
Avians			
American peregrine falcon	*Falco peregrinus anatum*	2.31	Moderate
Northern goshawk	*Accipiter gentilis*	2.24	Moderate
Pinyon jay	*Gymnorhinus cyanocephalus*	2.26	Moderate
Western burrowing owl	*Athene cunicularia*	1.86	Moderate
White-tailed ptarmigan	*Lagopus leucura*	2.27	Moderate
Wilson's warbler	*Cardellina pusilla*	2.22	Moderate
Fish			
Rio Grande chub	*Gila pandora*	1.78	Moderate
Rio Grande cutthroat trout	*Onchorhynchus clarkii virginalis*	1.94	Moderate
Rio Grande sucker	*Catostomus plebeius*	1.81	Moderate
Invertebrates			
Nokomis fritillary butterfly	*Speyeria nokomis nokomis*	2.30	Moderate
Mammals			
Gunnison's prairie dog	*Cynomys gunnisoni*	1.91	Moderate
Masked shrew	*Sorex cinereus*	2.31	Moderate
Pale Townsend's big-eared bat	*Corynorhinus townsendii pallescens*	2.21	Moderate
Spotted bat	*Euderma maculatum*	2.32	Moderate
Water shrew	*Sorex palustris*	2.13	Moderate

[1] Same risk values as previous footnote.

Common Name	Scientific Name	Risk Assessment Value	Overall Risk
Plants			
Alpine Larkspur	*Delphinium alpestre*	2.02	Moderate
Arizona willow	*Salix arizonica*	2.04	Moderate
Chaco milkvetch	*Astragalus micromerius*	2.14	Moderate
Chama blazing star	*Mentzelia conspicua*	2.10	Moderate
Pagosa milk-vetch	*Astragalus missourensis var. humistratus*	2.11	Moderate
Ripley's milkvetch	*Astragalus ripleyi*	2.15	Moderate
Robust larkspur	*Delphinium robustum*	1.98	Moderate
Small-headed goldenweed	*Ericameria microcephala*	1.94	Moderate
Tufted sand verbena	*Abronia bigelovii*	2.12	Moderate

These 26 potential SCC meet the requirements set forth in the proposed directives at FSH 1909.12.5 and have been linked to current Carson forest plan management direction that may be negatively affecting either habitat or populations on the Carson NF. Many of these species are also affected by activities outside of the plan area or beyond Forest Service control. It is important to recognize the limits of agency authority and the inherent capability of the plan area.

These potential SCC, along with the six federally recognized species, will be considered as the plan revision process moves forward and determines needs for change to the existing forest plan. The coarse-filter/fine-filter approach used to assess species will also be carried forward through the next steps. Plan components will be developed to maintain or restore ecological conditions for ecosystem integrity and ecosystem diversity in the plan area. By working toward the goals of ecosystem integrity and ecosystem diversity with connected habitats that can absorb disturbance, it is expected that over time, management would maintain and restore ecological conditions that provide for diversity of plant and animal communities and support the abundance, distribution, and long-term persistence of native species, both those considered common and secure, as well as those considered imperiled or vulnerable. In addition, species-specific plan components and the fine-filter approach will provide for additional specific habitat needs or other ecological conditions for those species that are not met through the coarse-filter approach. Species, for which the 2012 planning rule requires fine-filter plan components, when necessary, are federally listed threatened and endangered species, proposed, and candidate species, as well as SCC.

Summary of Conditions, Trends, and Risks

The Carson NF is home to hundreds of animal and plant species, some of which are found only on the Carson NF, and others for which changing land-use patterns have increased their reliance on Carson NF managed lands. These species provide many ecosystem services, including: (1) supporting services, such as nutrient cycling, soil formation and manipulation, primary production, and seed dispersal; (2) regulating services, including carbon sequestration, pollination, and erosion control; (3) provisioning services, such as food, fiber, medicine, and forest products; and (4) cultural services, including recreation, opportunities for scientific discovery and education, and cultural, intellectual, or spiritual inspiration. The most important drivers of change in ecosystem services are habitat change, climate change, invasive species, overexploitation, and pollution. This section focuses on at-risk species that occur on the Carson NF, which indicate the ecosystem services provided by these species are decreasing and at risk.

Federally recognized and potential SCC were identified and evaluated for the Carson NF. A total of six federally recognized species (three endangered) were determined to be relevant to the plan area. Of the six, three are mammals and three are birds. Potential SCC were determined following guidance in the proposed directives issued for the 2012 Planning Rule.

Wildlife and plant species identified as at-risk by a number of different entities were considered. The species that were ultimately considered to be at-risk met the following criteria: (1) met the initial requirements; (2) had been documented on the Carson NF; and (3) had the potential to be both positively and negatively affected by Forest Service management activities. An overall risk assessment for each species was calculated from data identifying the status of historic, current, and future population trends and associated ERUs and data identifying direct threats to the species or to key ecosystem characteristics. A total of 26 potential SCC were determined to be at risk by current Forest Service management activities, including: 2 amphibians; 6 birds; 3 fish; 1 invertebrate; 5 mammals; and 9 plants.

If management activities focus on ecosystem integrity and diversity goals by including disturbance-absorbing connected habitats, then ecological conditions would be effectively restored and maintained. These improved ecological conditions would increase the diversity of plant and animal communities and support the abundance, distribution, and long-term persistence of common and secure, imperiled, or vulnerable native species. Species-specific plan components within each ERU will be developed for those species with additional or key ecosystem characteristics or where ecological conditions are not otherwise met.

Air Resources

Air quality has long been recognized as an important resource on national forests to be protected. Not only does the public value the fresh air and sweeping views that national forests can provide, but the impacts from air pollution on forest health, water quality, and fisheries are also highly valued and are just a few that can be affected by poor air quality.

The 2012 Planning Rule requires national forests and grasslands to consider air quality when developing plan components. This section assesses air resources on and affecting the Carson NF. The purpose of the air resources assessment is to evaluate available information about air quality to disclose current conditions and trends in air quality resources, and to determine risk that might precipitate need-for-change in Forest Service management. This information will be used to anticipate future conditions and to determine if trends in air quality pose risks to system integrity at the forest level. Additionally, this assessment will identify information gaps regarding air quality and any uncertainty with the data.

Based on the above information, the assessment characterizes and evaluates the status of airsheds and air quality relevant to the plan area, assuming management is consistent with current plan direction.[1] The information contained in this assessment will be used to inform agency officials, whether current direction needs adjustment to protect air resources and the systems that rely on air quality on the forest.

This section presents current and historical data related to air quality in or near the Carson NF. This data and any relevant trends in the data provide an understanding of the air quality conditions and trends that could affect resources on the forest sensitive to air pollution. Included are a general description of baseline emissions inventories, ambient air quality measurements, visibility, and deposition measurements for sulfur, nitrogen, and mercury that define current air quality conditions of the plan area. Data are presented for the following parameters:

- Emissions
- Ambient air quality
- Visibility
- Atmospheric deposition (acid deposition, nitrogen, and mercury deposition)

In some cases, air quality resources on the forest are assessed differently from other resources in the ecological assessment, in that "reference conditions" are established by regulatory standards for ambient air quality that is deemed protective of human health, the environment, and visibility, which have been set by the U.S. Environmental Protection Agency (EPA) or the New Mexico Environment Department (NMED). However, for atmospheric deposition, particularly in the case of critical loads for acid deposition and nitrogen deposition, ecological thresholds have been established, where an exceedance of these values could result in negative impacts to forest health and/or aquatic resources.

[1] For this assessment, the best available science was used that is relevant, accurate, and reliable. Uncertainty in the assessment has been appropriately documented where relevant. Government data that has met strict protocols for data collection was used to assess the current conditions and trends with regards to ambient air quality, visibility, emissions inventories, and deposition. The critical load information was based on multi-agency government research, analysis, and following Forest Service protocols.

Air Ecosystem Services

Air provides many ecosystem services on which life depends, including:

- **Supporting** ecosystem services of air supply (1) oxygen for respiration by plants and animals; (2) carbon dioxide for photosynthesis; and (3) nitrogen for plant nutrition.
- **Regulating** ecosystem services of air are essential to global redistribution of biological and physical byproducts.
- **Provisioning** ecosystem services of air enables transportation (wind for sails, lift for airplanes) and providing energy (wind turbines).
- **Cultural** ecosystem services of air are especially important to humans and society by delivering aesthetically pleasing aromas.

Identification of Airsheds

Airsheds are similar to watersheds, in that they are defined geographic areas that because of topography, meteorology, or climate, they are frequently affected by the same air mass. The difference with airsheds is that air masses and air pollutants move between airsheds mostly based upon larger meteorological patterns, rather than primarily by topography, as with water flowing through a watershed. As with watersheds, airsheds can be defined at multiple scales. For this assessment, airsheds were defined according to the classification used by the New Mexico Environment Department as well as looking at a larger scale including northern New Mexico and southern Colorado (NMED 2003).

The Carson NF is spread out across four counties in New Mexico and numerous airsheds. Figure 51 identifies the airsheds as classified by the NMED. The Carson NF is mainly contained within Rio Arriba and Taos counties, with smaller ownership within Mora and Colfax counties. The Carson NF lies primarily within the Upper Rio Grande airshed, but portions are also included in the San Juan and Canadian airsheds.

For the purpose of this assessment, the air quality and emissions will be limited to those counties and airsheds identified in Figure 51, as well as emissions from southern Colorado that may affect air resources on the Carson NF.

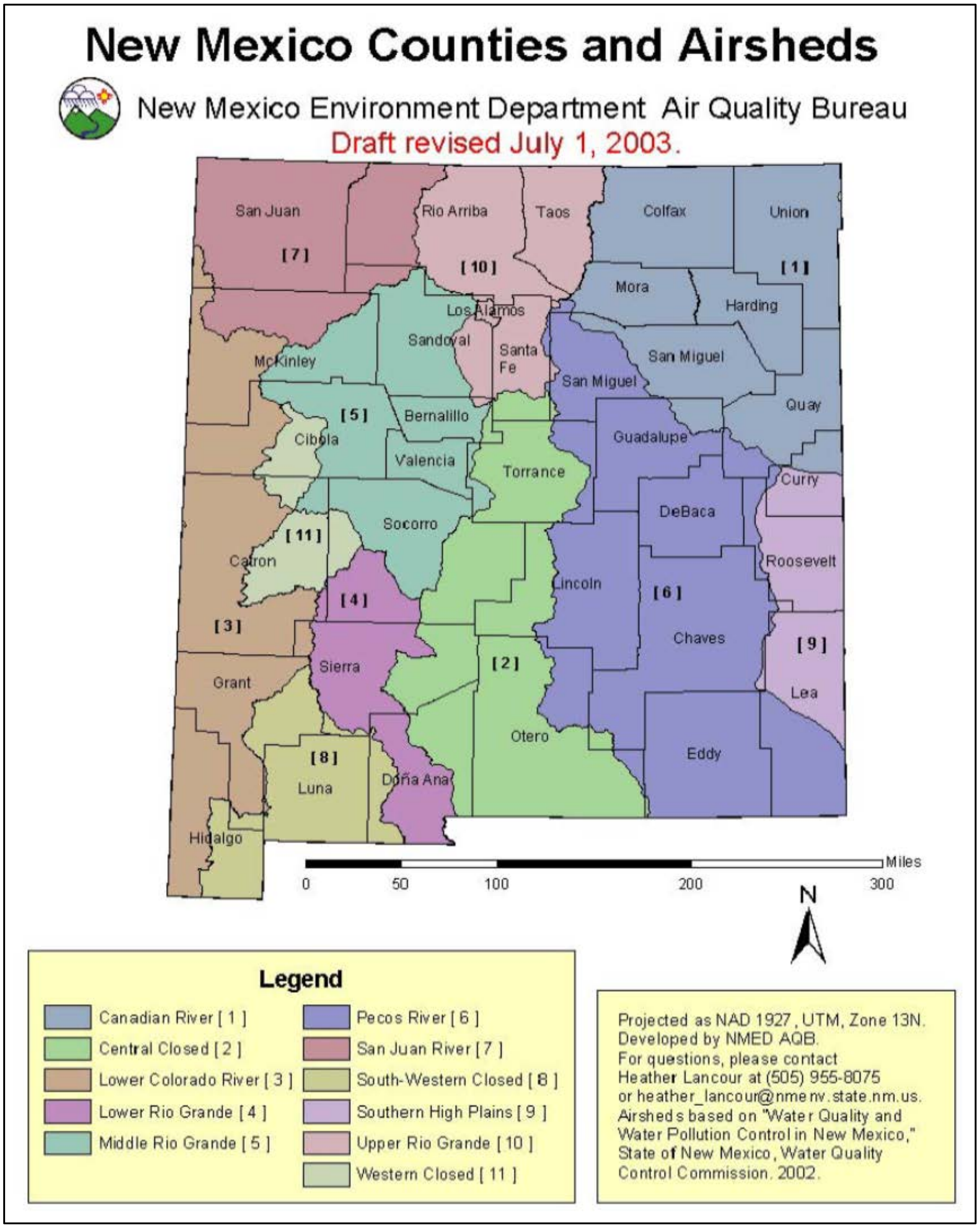


Figure 51. New Mexico counties and airsheds (NMED 2003)

Identification of Sensitive Air Quality Areas

The basic framework for controlling air pollutants in the United States is mandated by the Clean Air Act (CAA), originally adopted in 1963, and amended in 1970, 1977, and 1990. The CAA was designed to “protect and enhance” air quality. Section 160 of the CAA requires measures “to preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreation, scenic, or historic value.”

Congress classified 158 areas as Class I areas in existence on August 7, 1977, including national parks larger than 6,000 acres and national wilderness areas larger than 5,000 acres (CAA Section 162). Class I areas have been designated within the Clean Air Act as deserving the highest level of air-quality protection. These “mandatory” Class I areas may not be reclassified to a less protective classification. The Carson NF administers Wheeler Peak Wilderness and the northern portion of the Pecos Wilderness, which are both Class 1 areas. In addition, there are several nearby Class 1 areas that could be affected by projects and sources on or near the Carson NF (Figure 52). They include the San Pedro Parks Wilderness, Bandelier National Monument, and the southern portion of the Pecos Wilderness, which are all south of the forest.

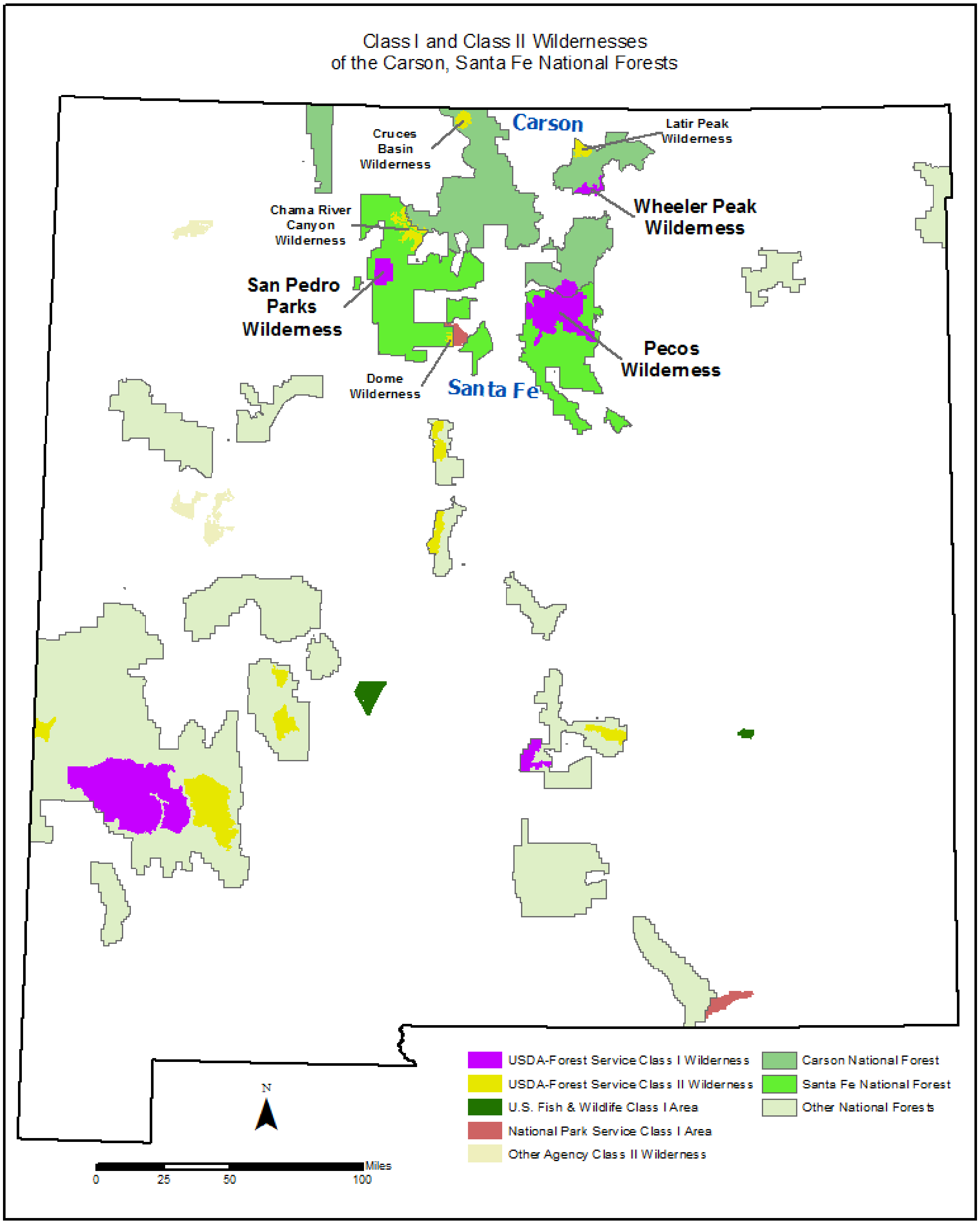


Figure 52. Class I and Sensitive Class II areas in New Mexico

Air Quality Standards

The purpose of the CAA is to protect and enhance air quality, while at the same time ensuring the protection of public health and welfare. The Act established NAAQS, which represent maximum air pollutant concentrations that would protect public health and welfare. The pollutants regulated by an NAAQS are called criteria air pollutants and include carbon monoxide (CO), nitrogen dioxide (NO_2), ozone (O_3), sulfur dioxide (SO_2), lead (Pb), and particulate matter (PM10 and PM2.5).

The US Environmental Protection Agency (EPA) established NAAQS for specific pollutants considered harmful to public health and the environment. The CAA identifies two types of NAAQS (US EPA 2015d):

1. The primary standards represent the maximum allowable atmospheric concentrations that may occur and still protect public health and welfare, and include a reasonable margin of safety to protect the more sensitive individuals in the population.

2. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

State agencies are given primary responsibility for air quality management as it relates to public health and welfare, and are further responsible for developing their State Implementation Plans (SIPs) to identify how NAAQS compliance will be achieved. If an area in a state has air quality worse than the NAAQS, that area becomes a non-attainment area. The state is then required to develop an SIP to improve air quality in that area. Once a non-attainment area meets the standards and that area can be designated as a maintenance area.

State standards, established by the New Mexico Environmental Improvement Board and enforced by the New Mexico Environment Department, Air Quality Bureau (NMED-AQB), are termed the NMAAQS. The NMAAQS must be at least as restrictive as the NAAQS. NMAAQS also includes standards for total suspended particulate matter, hydrogen sulfide, and total reduced sulfur for which there are not national standards. The NMED-AQB enforces air pollution regulations and sets guidelines to attain and maintain the national and state ambient air quality standards within the state of New Mexico, except for tribal lands and Bernalillo County, which maintain separate jurisdictions.

At the present time, the plan area attains all national and New Mexico ambient air quality standards.[1]

Federal, State, and Tribal State Implementation Plans

As stated previously, the federal CAA provides the basic framework for controlling air pollution, but the states are primarily responsible for implementing and enforcing CAA requirements. Within this framework, there are a couple tools particularly relevant to protecting air quality related to national forests. Typically, air pollution that occurs off national forests is the primary concern for causing impacts on national forests. Pollution can result from either new or existing sources.

[1] Dona Ana County (located in southern New Mexico and is outside any airshed being considered as it relates to the Carson NF) is the only area in New Mexico that is currently in non-attainment for PM_{10}

The primary tool for addressing air quality impacts from new sources is the Prevention of Significant Deterioration (PSD) program. The 1977 CAA amendments established the PSD program to preserve the clean air usually found in pristine areas, while allowing controlled economic growth. The PSD permitting program applies to new, major sources of air pollution or modifications to existing major sources, which have the potential to emit certain amounts of air pollution regulated by the EPA. The purpose of the PSD program is to prevent violations of NAAQS and to protect the environment including visibility and air quality is pristine areas such as Class 1 wilderness areas managed by the Forest Service. The PSD program can apply to non-criteria pollutants and can require analyses to assess the impacts of pollution on soils, vegetation, visibility and water resources managed by the Forest Service.

For existing sources of air pollution, the federal Regional Haze Rule (RHR) requires states to develop programs to assure reasonable progress toward meeting the national goal of preventing any future, and remedying any existing, impairment of visibility in mandatory Class I federal areas. The RHR addresses requirements for SIPs, plan revisions, and periodic progress reviews to address regional haze and achieve natural haze conditions in each of the Class I areas by the year 2064.

Regional Haze Rule

On July 1, 1999, the EPA issued regional haze rules to comply with requirements of the CAA. Under 40 CFR § 51.308, the rule requires the state of New Mexico to develop SIPs which include visibility progress goals for each of the nine Class I areas in New Mexico, as well as provisions requiring continuing consultation between the state and federal land managers to address and coordinate implementation of visibility protection programs. Under 40 CFR § 51.309, the rule also provides an optional approach to New Mexico and eight other western states to incorporate emission reduction strategies issued by the Grand Canyon Visibility Transport Commission designed primarily to improve visibility in 16 Class I areas on the Colorado Plateau, including the San Pedro Parks Wilderness Area in New Mexico (NMED 2011).

New Mexico Environmental Department-State Implementation Plan

On December 31, 2003, the state of New Mexico submitted a visibility SIP to meet the requirements of 40 CFR 51.309 (309 SIP). The 2003 309 SIP and subsequent revisions to the 309 SIP, address the first phase of requirements, with an emphasis on stationary source sulfur dioxide (SO2) emission reductions and a focus on improving visibility on the Colorado Plateau. In the 2003 submittal, New Mexico committed to addressing the next phase of visibility requirements and additional visibility improvement in New Mexico's remaining eight Class I areas by means of an SIP meeting the requirements in 309(g). The regional haze SIP describes the Class I areas where visibility protections are in place, monitors existing visibility conditions and trends, defines the cause in terms of source emissions of visibility impairment at each Class I area, projects future trends in visibility conditions based on implementation of various emission control measures, and provides a long-term strategy to meet the stated national visibility goal of reducing all man-made visibility impairment by 2064.

Since the 2003 submittal of the 309 SIP, the EPA has revised both 40 CFR 51.308 and 309 in response to numerous judicial challenges. The latest SIP petition was filed by the New Mexico Environmental Department on February 28, 2011, revised March 31, 2011 (NMED 2011). The February 2011 revision was made to satisfy New Mexico’s obligations under the “Good Neighbor” provision of the CAA at §110(a)(2)(D)(i). Included is a Best Available Retrofit

Technology determination and proposed reductions for the San Juan Generating Station to achieve visibility reductions relied upon by other states in setting their visibility goals (NMED 2013). This SIP was challenged by San Juan Generating Station and the U.S. EPA, which is currently still pending appeal. On February 15, 2013, a tentative settlement was announced between the state of New Mexico, the U.S. EPA, and San Juan Generating Station. (US EPA 2013). The agreement will shut down two of the plant's coal fired units and install selective non-catalytic reduction technology on the remaining two coal fired units. The two units being shut down will be replaced by less polluting natural gas-fueled units.

Grand Canyon Visibility Transport Commission – 1996 Findings and Recommendations

In 1990, amendments to the CAA under 40 CFR 51.309 established the Grand Canyon Visibility Transport Commission to advise the EPA on strategies for protecting visual air quality on the Colorado Plateau. The Grand Canyon Visibility Transport Commission released its final report in 1996 and initiated the WRAP, a partnership of state, tribal and federal land management agencies to help coordinate implementation of the Commission's recommendations (WRAP 1996). Issues addressed by the Grand Canyon Visibility Transport Commission and WRAP are summarized below:

- Air pollution prevention
- Clean air corridors
- Stationary sources
- Areas in and near parks and wilderness areas
- Mobile sources
- Road dust
- Emissions from Mexico
- Fire

Forest Service Policy and Actions

Regional Forest Service Air Resource Management staff act as the point of contact to receive and review permit applications filed with state and local regulatory agencies by new/modified emission sources and provide comments back to the state agency. Unless a specific issue arises, individual national forests are typically not responsible for conducting reviews of new/modified sources via the state-level air quality applications process. The Forest Service regional office provides air quality analysis to determine if proposed actions are likely to cause, or significantly contribute to, an adverse impact to visibility or other air quality related values within the national forest system (USDA FS 2012a).

Additionally, the Forest Service complies with the New Mexico State Smoke Management Program, which is described in Section 12.7.14 of the February 2011 New Mexico Section 309(g) Regional Haze SIP (NMED 2011). New Mexico's administrative code (20.2.65 NMAC-Smoke Management) stipulates that all burners must comply with requirements of the Clean Air Act and RHR, as well as all city and county ordinances relating to smoke management and vegetative burning practices. For prescribed fires and wildfires managed for resource benefit that exceed 10 acres, additional requirements include: registering the burn, notifying state and nearby population centers of burn date(s), visual tracking, and post-fire activity reports (NMAC 2013).

As indicated previously, the Forest Service typically lacks direct authority to control air emissions that impact a particular ranger district of the Carson NF. The primary role that Air Resource Management staff can provide the NMED staff as they prepare PSD permits or develop the RHR, is to provide information about potential impacts that could occur on national forest land, particularly in Class I areas.

The primary tool federal land managers use is the critical load concept described in the section on atmospheric deposition. Currently the Carson NF has critical loads based on a national assessment developing empirical critical loads for major ecoregions across the United States. However there are no forest specific critical loads developed for the Carson NF, and therefore they have not been included in the New Mexico SIP.

Emissions

For emissions, the information presented in this section represents statewide totals for New Mexico. County-level emissions inventories were analyzed and can be found on the Western Regional Air Partnership (WRAP) Website, using the Technical Support System tool (WRAP TSS 2012). Emissions inventories are useful tools for understanding regional sources of pollution that could affect the forest. Emissions inventories are created by quantifying the amount of pollution that comes from point sources (power plants, factories) and area sources (emissions from automobiles in a city or oil and gas development). Emissions can also originate from natural events like a wildfire.

The Western Regional Air Partnership is a voluntary partnership of states, tribes, federal land managers and the EPA. It tracks emissions data from states, tribes, and local air agencies, as well as emissions from wildland fire, in coordination with the EPA's National Emission Inventory (NEI). In addition, WRAP supports states by analyzing this data and models what future emissions maybe based on future trends, as part of the Regional Haze Rule. The Regional Haze Rule sets a 60-year timeline for states to improve visibility within mandatory federal Class I areas from baseline (2000-04) levels to natural conditions by 2064. States are required to show that reasonable progress is expected to be made toward this goal over the course of intermediary planning periods.

A summary of baseline emissions and projected emissions for 2018 for the states of New Mexico and Colorado and the counties within 200 km of the Carson NF were analyzed (WRAP TSS 2012). Carbon monoxide, nitrogen oxides, sulfur oxides, volatile organic compounds (VOCs), coarse particulate matter (surrogate for PM10), and fine particulate matter (surrogate for PM2.5) were pollutants included in the summary. Nitrogen oxides and VOCs were included, since they are precursors to the formation of O_3, which has both effects to human health and has also been shown to impact forested systems.

Emissions information is important, as adverse air quality impacts on the Carson NF can usually be traced to air emissions. Knowing the magnitude of emissions and recognizing trends in emissions over time is important, because emissions are usually correlated to the type and severity of air quality impacts. Often, adverse air quality impacts to air quality related values can be mitigated through programs that reduce associated air emissions. However, the Forest Service typically lacks direct authority to control air emissions that impact a particular ranger district or part of the national forest.

Current Condition and Trend

Air quality effects on national forests are generally traceable back to the original source of emissions; therefore, air emissions information provides an overview of the magnitude of air pollution and is important in understanding air quality on the forest. Also, trends in precursor emissions would be expected to track with trends on the forest (e.g., visibility and acid deposition). For example, improving visibility conditions in Class I areas would generally be associated with corresponding decreases in emissions for visibility precursor pollutants.

Emissions information is generally tracked for pollutants that have health-based air quality standards such as CO, NOx, SO_2, VOCs, and PM. Volatile organic compounds emissions do not have a health-based standard, but are involved in the atmospheric chemical reactions that lead to O_3, which does. Ozone pollution is of added concern, because it can stress sensitive ecological systems. Particulate matter emissions are generally broken into two categories based on the size of the PM emissions: Fine PM (FPM) represents the particulate matter emissions sized at or below 2.5 microns in diameter. Coarse particulate matter (CPM) represents the particulate matter emissions sized at or below 10 microns, but above 2.5 microns, in diameter. Smaller sized particles have greater health-related impacts because the smaller particles are more easily inhaled into the lungs.

Air emissions are assessed for the state of New Mexico and Colorado for the criteria air pollutants of interest: CO, NOx, SO_2, VOC, CPM, and FPM.[1] FPM is analogous to PM2.5 and CPM represents the PM10 emissions that are not PM2.5. The relative magnitude of emissions from various source categories, such as mobile sources (vehicle exhaust), point sources (industrial and commercial operations), fire, and biogenic sources were considered. Statewide emissions for the baseline period (2000-2004), along with projected emissions for the 2018 time frame, based on information at the end of 2005 are calculated. Since that time, additional regulations have been passed that should continue to reduce emissions. All of the emissions information in these figures has been taken from the WRAP Technical Support System (WRAP TSS 2012).

For CO, and NOx, the trend shows a projected decrease in statewide emissions through 2018, for New Mexico and Colorado. Most of the emissions reductions for CO and NOx emissions come from fewer mobile source emissions, and are associated with the introduction of lower emitting vehicles over time, cleaner transportation fuels, and improvements in vehicle gas mileage.

SO_2 emissions are expected to generally decrease in both states, except for area emissions in New Mexico, which are expected to increase significantly. The general improvement over time is largely from reductions in stationary source emissions, such as coal-fired power plants, which are expected, in the near term, to install emission controls defined as Best Available Retrofit Technology under the regional haze regulations. Some of the decrease in SO_2 emissions occurs from mobile sources and is associated with cleaner transportation fuels, such as the introduction of low sulfur diesel fuel.

The expected increase in oil and gas industry activity through 2018 increases emissions of NOx and SO_2, which offsets some of the emissions decreases described above, particularly in the Four Corners Area, including increases in emissions in both New Mexico and Colorado.

[1] Products obtained from WRAP TSS Emissions Review Tool data represent the 5-year baseline average period. PRP18b data represent WRAP's Preliminary Reasonable Progress Inventory. Blank entries represent instances where data categories are not applicable or data are not available.

The VOC emissions in New Mexico and Colorado are dominated by biogenic emission sources (i.e., trees, agricultural crops, and microbial activity in soils). Overall VOC emissions are projected to remain fairly stable through 2018, with some increases projected from oil and gas industrial activity.

Particulate emissions, both CPM and FPM, are expected to increase across New Mexico through 2018, consistent with the projected population growth in the state. Higher population translates to more vehicular traffic and the projected particulate emission increases generally occur in the “fugitive dust” and “road dust” categories. Relatively small increases in CPM are expected in Colorado, while relatively small decreases are expected in FPM in Colorado, both resulting in relative changes in wind blow dust.

Data analyzed using the WRAP TSS Emissions Review Tool shows similar emissions information for the pollutants of interest on a county-by-county basis (WRAP TSS 2012). The analysis consists of review of counties in northern New Mexico and southern Colorado. County-by-county distribution of emissions mostly follows the distribution of population across the counties of interest.

Particulate matter (PM) and VOCs are all expected to increase or stay stable at state and county levels through 2018 in New Mexico and Colorado. The primary source of PM, both coarse and fine, is from windblown dust across the land and from fugitive dust from anthropogenic sources. Higher temperatures and persistent drought could exacerbate this trend (Prospero and Lamb 2003). At the state level, VOCs are expected to increase primarily from oil and gas development in the Four Corners area. Biogenic sources of VOCs are a major source relative to the overall emissions in both New Mexico and Colorado and in the counties where the Carson NF is located.

San Juan County shows significant contributions to the NOx and SO2 emissions inventories from point source emissions. These data reflect the large coal-fired electric generating stations in that county (San Juan Generation Station and Four Corners Generating Station).

Rio Arriba and San Juan counties, in New Mexico, and Montezuma and La Plata counties, in Colorado, also show significant emissions from oil and gas development in that particular region of the state. The oil and gas industry emissions are important for SO_2, NOx and VOCs and to a lesser extent, CO emissions. In the absence of oil and gas industry sources, biogenic emissions make up most of the VOC inventory in each county. Fire was also shown as a significant contributor to the CO emissions inventory in Rio Arriba County and San Juan County.

Except where the industrial emissions noted above dominate, the county-by-county distribution of emissions mostly follows the distribution of population across the counties of interest. The county-by-county emissions trends through 2018 generally share the patterns described above for the statewide inventory trends. However, in those counties where oil and gas industry sources are significant, the downward trend of emissions noted in the state-wide data is offset somewhat by the increased level of local oil and gas development and associated emissions.

Ambient Air Quality

While emissions play an important role in determining overall air quality for a given area, air quality evaluations are also based, in part, on ambient concentrations of pollutants in the air. The EPA is primarily concerned with air pollutants that result in adverse health effects. The Forest Service also uses these ambient concentrations to determine how pollutants such as O_3, PM, NO_2 and SO_2 impact forest resources. Because ambient air quality measurements provide quantitative information, they can also be meaningfully incorporated into air quality models. Ambient air quality data are presented in this section for a number of state and federal monitoring stations, in and around the air quality monitoring plan area.

This section summarizes the ambient air quality measurements collected between the years 2000 and 2010 at New Mexico monitoring sites in and near the Carson NF. These monitoring data depict concentrations of air pollutants, which have the potential to cause adverse health effects in the general population and/or adverse ecological effects. Additional discussion about the health and ecological effects of individual pollutants is provided below.

Figure 53 shows the location of the air quality monitoring sites that are relevant to the plan area. There are a variety of air monitoring stations throughout New Mexico that are operated by the state, Bernalillo County, the Navajo Nation, and by federal land management agencies that can be used to gauge ambient air quality, visibility, and deposition of pollutants. A summary of the pollutants monitored and available period of record for each site is provided in Table 46. The visibility monitoring data are described in next section.

For the Carson NF, most of the nearby ambient air quality monitoring stations are located in the greater Albuquerque metropolitan area. Although air quality levels in an urban area are not likely to be totally representative of the Carson NF, these data do provide for a reasonable upper bound on air quality concentrations within the plan area. Lacking other data collected in more remote settings, the reported data are the best available information to characterize exiting air quality conditions for the wilderness areas of concern.

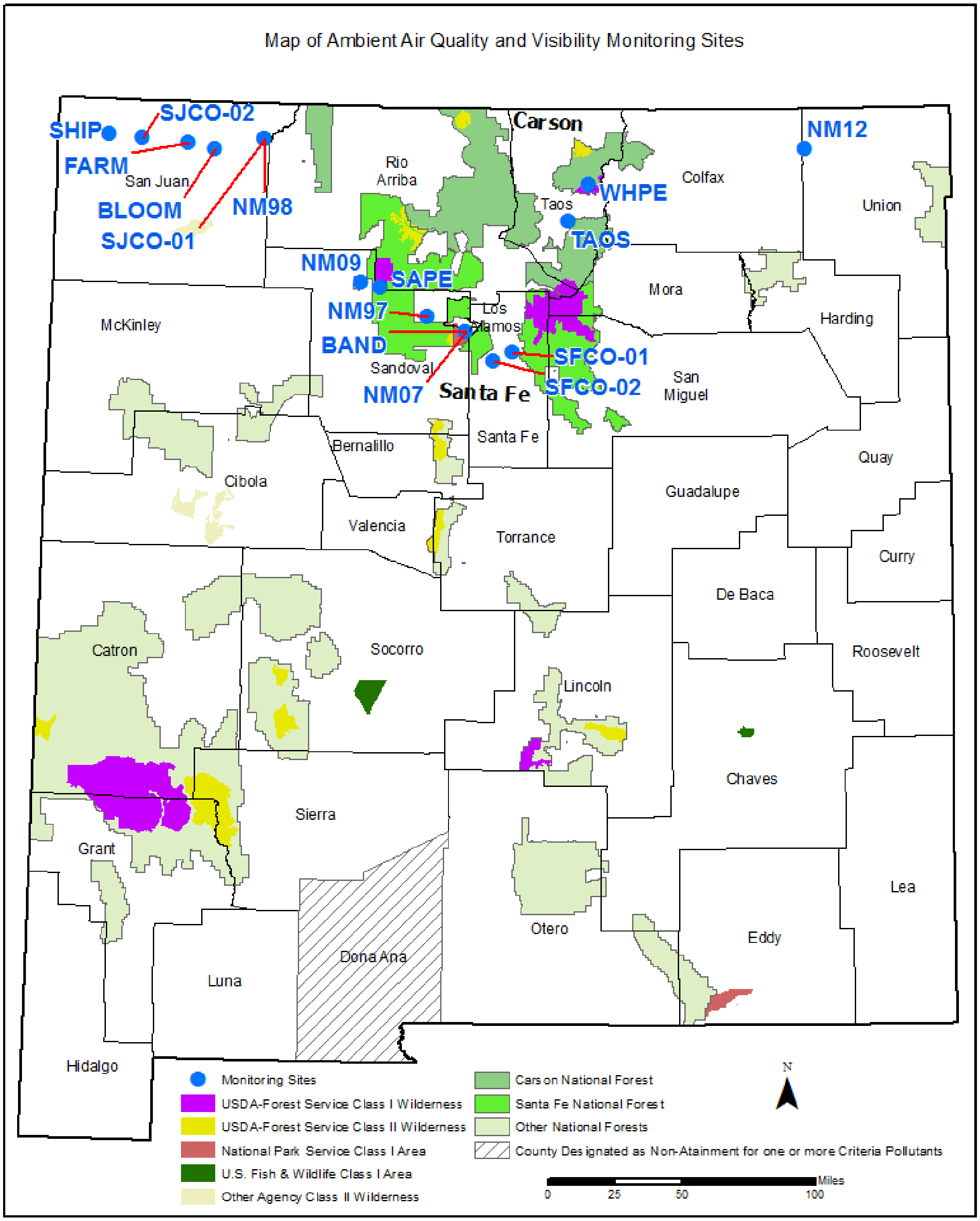


Figure 53. Map of air quality monitoring sites in the plan area

Table 46 lists the current primary NAAQS that represent ambient concentrations of air pollutants determined by the EPA to result in adverse health effects to the most sensitive population groups, such as: children, the elderly, and persons with breathing difficulties. The health effects of air pollution are discussed further in the subsequent sections that describe specifics of monitoring data for each pollutant.

Table 46. Air quality monitoring sites for the Carson National Forest

Monitoring Site	Site Label	Pollutants Monitored (review period)[1]
Bandelier	NM07	NADP/NTN (2000-2010)
Bandelier National Monument	BAND	IMPROVE Aerosol, dv (2000-2010)
Bloomfield – Highway Yard	BLOOM	O_3 (2000-2010), NO_2 (2000-2010), SO_2 (2000-2010)
Capulin Volcano	NM12	NADP/NTN (2000-2010)
Cuba	NM09	NADP/NTN (2000)
Farmington	FARM	$PM_{2.5}$ (2008-2010), PM_{10} (2008-2010)
Navajo Lake	NM98	MDN (2009-2010)
San Juan County #1	SJCO-01	O_3 (2006-2010), NO_2 (2005-2010)
San Juan County #2	SJCO-02	O_3 (2000-2010), NO_2 (2000-2010), SO_2 (2000-2010)
San Pedro Parks	SAPE	IMPROVE Aerosol, dv (2001-2010)
Santa Fe County #1	SFCO-01	$PM_{2.5}$ (2000-2010), PM_{10} (2000-2010)
Santa Fe County #2	SFCO-01	O_3 (2007-2010)
Shiprock	SHIP	O_3 (2010), NO_2 (2010), SO_2 (2010), PM_{10} (2007-2010)
Taos County	TAOS	PM_{10} (2000-2010)
Valles Caldera Natl Preserve	NM97	MDN (2009-2010)
Wheeler Peak	WHPE	IMPROVE Aerosol, dv (2001-2010)

Current Condition and Trend

Carbon monoxide (CO) concentrations - CO data has not been collected in the airsheds containing the Carson NF. Generally, CO emissions are caused by exhaust from fuel combustion in mobile sources (cars, trucks, etc.) and as such are generally monitored only in large urban settings, like Albuquerque. CO is not expected to be an issue in areas containing or near the Carson NF.

Ozone (O_3) concentrations - O_3 data have been collected at five sites near the Carson NF; however, some of the monitoring has only recently commenced. The Shiprock site has O_3 data only for 2010, the Santa Fe #2 site has O_3 data starting in 2007, and the San Juan #2 site has O_3 data starting in 2006 (US EPA 2015d). O_3 is one of the major constituents of photochemical smog. It is not emitted directly into the atmosphere, but instead is formed by the reaction between NOx emissions and VOCs emissions in the presence of sunlight. The highest concentrations of O_3 typically occur in the summer months.

Excessive O_3 concentrations can have a detrimental impact on human health and the environment. Elevated O_3 levels can cause breathing problems, trigger asthma, reduce lung function, and lead

[1] For the purposes of this assessment, only measurements collected between 2000 and forward were reviewed (dv=deciview).

to increased occurrence of lung disease. O_3 also has potentially harmful effects on vegetation, which is usually the principal threat to forested ecosystems. It can enter plants through leaf stomata and oxidize tissue, causing the plant to expend energy to detoxify and repair itself at the expense of added growth. Damage to plant tissue can be more pronounced where the detoxification and repair does not keep up with the O_3 exposure. The mesophyll cells under the upper epidermis of leaves are particularly sensitive to O_3. O_3 damage can generate a visible lesion on the upper side of a leaf, termed "oxidant stipple." Other symptoms of elevated O_3 exposure may include chlorosis, premature senescence, and reduced growth. These symptoms are not unique to ozone damage and may also occur from other stresses on plant communities such as disease and/or insect damage.

Data representing the 4th highest 8-hour average O_3 concentrations for calendar years 2000–2010 for the Bloomfield, San Juan #1, San Juan #2, Shiprock, and Santa Fe #2 monitoring stations were analyzed (WRAP TSS 2012). The applicable 8-hour NAAQS is based on the annual fourth-highest daily maximum O_3 concentration averaged over three years. At some New Mexico monitoring sites, the annual 4th highest concentration is at or near the NAAQS level (75 ppb). However, in the last three years, the 75 ppb level has not been exceeded, based on the 4th highest 8-hour average O_3 concentration. Note: Given the form of the O_3 NAAQS data analyzed does not allow for a strict comparison to the NAAQS as the data have not been averaged over 3 years as required for comparison to the NAAQS. However, it would appear that O_3 concentrations are below the applicable NAAQS, although the margin of compliance is small. It should also be noted that the EPA has proposed lowering the standard to between 65 and 70 ppb O_3, with an expected decision in early 2015.

Particulate Matter ($PM_{2.5}$/PM_{10}) - $PM_{2.5}$ data are currently available from two monitoring sites near the forest areas of interest (Farmington and Santa Fe #1). The Farmington site has $PM_{2.5}$ data going back to 2000 while Farmington has $PM_{2.5}$ data only for 2008-10. For PM_{10}, data are available for up to four sites over the reporting period (2000-2010). The Farmington site has $PM_{2.5}$ data going back to 2000, while Farmington has PM2.5 data only for 2008-10. For PM_{10}, data are available for up to four sites over the reporting period (2000-2010). However, only two PM_{10} monitoring sites were active for 2006 and earlier years. The Shiprock PM_{10} site was added in 2007 and the Farmington PM_{10} site was added in 2008 (US EPA 2015a).

As shown by the emissions inventory data discussed in the prior section, most PM emissions in New Mexico are associated with fugitive dust and other sources of dust (e.g., wind erosion and re-entrained dust from traffic on streets and roadways). Chronic exposure to elevated $PM_{2.5}$ and PM_{10} concentrations leads to an increased risk of developing cardiovascular and respiratory diseases (including lung cancer), where the PM emissions contain toxic constituents such as heavy metals (WHO 2014).

The annual average $PM_{2.5}$ concentration was in the range of 4-5 micrograms per cubic meter at both of the monitoring sites, compared to the NAAQS of 12 micrograms per cubic meter. On December 14, 2012, the EPA reduced the primary $PM_{2.5}$ NAAQS from 15 micrograms per cubic meter to 12 micrograms per cubic meter (annual mean, averaged over three years). The 15 micrograms per cubic meter standard was retained as the annual mean secondary $PM_{2.5}$ NAAQS.

The 98th percentile 24-hour average $PM_{2.5}$ concentrations measured 10 micrograms per cubic meter at the Santa Fe #1 site, with a peak measurement of 15 micrograms per cubic meter in 2002. At the Farmington site, the 98th percentile 24-hour average $PM_{2.5}$ concentration was around

18 micrograms per cubic meter in 2010. The 24-hour NAAQS for $PM_{2.5}$ is 35 micrograms per cubic meter, based on the 98th percentile concentration averaged over three years.

The PM_{10} data were charted for the annual mean and the maximum 24-hour average concentration. The PM_{10} NAAQS exists only for the 24-hour average (150 micrograms per cubic meter). Except for a few readings at the Shiprock monitor in 2007 and 2008, the highest measured 24-hour average PM_{10} concentration generally ranged between 50-75 micrograms per cubic meter. Shiprock measured PM_{10} levels near 150 micrograms per cubic meter in 2007 and near 125 micrograms per cubic meter in 2008.

Over the period of record, the annual mean PM_{10} at the various monitoring sites averaged 10-20 micrograms per cubic meter, with Shiprock showing somewhat highest PM_{10} concentrations (about 25 micrograms per cubic meter). There is no obvious trend in the annual PM_{10} measurements. An applicable annual mean NAAQS no longer exists for PM_{10} concentrations, although PM_{10} is still regulated by an NAAQS for the 24 hour average as noted above.

Available PM_{10} and $PM_{2.5}$ monitoring data show that concentrations within the plan area comply with the applicable NAAQS, although the PM_{10} levels approach the NAAQS at Shiprock.

Nitrogen dioxide (NO_2) and sulfur dioxide (SO_2) - NOx and SO_2 emissions occur as a result of fuel combustion, either in industrial or commercial emission sources such as power generation facilities or in mobile sources (e.g., cars, trucks, busses, aircraft etc.). SO_2 emissions are linked to the quantity of sulfur in fuels that are combusted. These emissions may also result from smelting and refining of copper ores, due to the liberation of sulfur compounds contained in the ore body. Nitrogen oxides and SO_2 emissions are also linked to the formation of nitrate and sulfate aerosols, which have potential adverse effects on visibility. Also, NOx and SO_2 emissions are linked to increases in acid precipitation and acid deposition.

Health effects from exposure to elevated concentrations of NO_2 include inflammation of the airways for acute exposures and increases in the occurrence of bronchitis for children and other sensitive individuals chronically exposed to elevated NO_2 levels (WHO 2014). Health effects from SO_2 exposures include changes in pulmonary function and increases in respiratory symptoms along with irritation of the eyes. Inflammation of the respiratory tract may result in coughing, mucus secretions, and aggravation of asthma and chronic bronchitis. Persons exposed to elevated SO_2 levels are also more prone to infections of the respiratory tract (WHO 2014).

NO_2 is the regulated form of NOx emissions. NO_2 monitoring data are currently available for four sites, although the Shiprock site only has data for 2010. NO_2 data at the San Juan #1 site are available since 2005 (US EPA 2015a). For sites with ambient NO_2 data, the 98th percentile 1-hour NO_2 concentration was generally around 40 ppb in most years and the annual mean NO_2 concentration was generally around 10-20 ppb. These levels are substantially below the applicable 1-hour and annual NAAQS (100 and 53 ppb respectively) and demonstrate that ambient NO_2 concentrations comply with the NAAQS in the area of interest. The Bloomfield monitoring site shows higher concentrations for NO_2 (annual average), while the differences between sites for the 98th percentile 1-hour average NO_2 concentrations are relatively minor.

SO_2 monitoring data are available for two sites in the area of interest from 2000-2010, with a third site (Shiprock) being added during 2010 (US EPA 2015a). In particular, the San Juan #2 site is located near the San Juan Generating Station and as such, these SO_2 measurements are probably not broadly representative of current ambient conditions in most areas on the Carson

NF. Away from the local impacts of the power plant emissions, ambient SO_2 concentrations are expected to be much less; however, there is a potential issue with regards to atmospheric deposition.

The measurements at San Juan #2 have shown a significant decline in ambient SO_2 levels since 2000 and 2010 levels are well below the NAAQS. Over this time period, emission reductions strategies have been implemented for SO_2 control at San Juan and the nearby Four Corners Generating Station. The 2010 Shiprock SO_2 data show elevated concentrations for the 99th percentile 1-hour average daily maximum concentration. However, NAAQS compliance for the Shiprock SO_2 monitoring station cannot be determined because the NAAQS is based on the concentrations averaged over a three year period.

Visibility

Visibility has been recognized as an important value going back to the 1977 CAA Amendments, which designated it as an important value for most wilderness areas that are designated as “Class I”. Visibility refers to the conditions that allow the appreciation of the inherent beauty of landscape features. This perspective takes into account the form, contrast, detail, and color of near and distant landscapes. Air pollutants (particles and gasses) may interfere with the observer’s ability to see and distinguish landscape features.

Visibility data are presented for stations operated as part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring program sponsored by the EPA and other government agencies. Visibility generally relates to the quality of visitors’ visual experience on the forest. Generally, the presence of air pollution degrades the visual quality of a particular scene. In the CAA, a national visibility goal was established to return visibility to “natural background” conditions no later than 2064. IMPROVE monitoring data tracks the quality of visibility conditions and trends in visibility data and are specific to the wilderness areas of interest.

The IMPROVE program has been monitoring visibility conditions in Class I wilderness areas in New Mexico and nationwide since the late 1980s. The following three IMPROVE monitoring sites (Figure 54) are relevant to the Carson NF:

- Bandelier National Monument (BAND1)
- San Pedro Parks (SAPE1)
- Wheeler Peak (WHPE)

IMPROVE monitors concentrations of atmospheric aerosols (sulfates, nitrates, etc.) and uses these data to assess light “extinction,” or the degree to which light is absorbed and/or scattered by air pollution. Visibility is normally expressed in terms of “extinction” or by using the “deciview” index, which is calculated from the measured extinction value. The “deciview” index represents a measure of change in visibility conditions that are typically perceptible to the human eye. A deciview change in the range of 0.5 to 1.0 dv is generally accepted as being the limit of human perceptibility. Figure 54 illustrates the relationships among extinction, deciviews, and visual range.

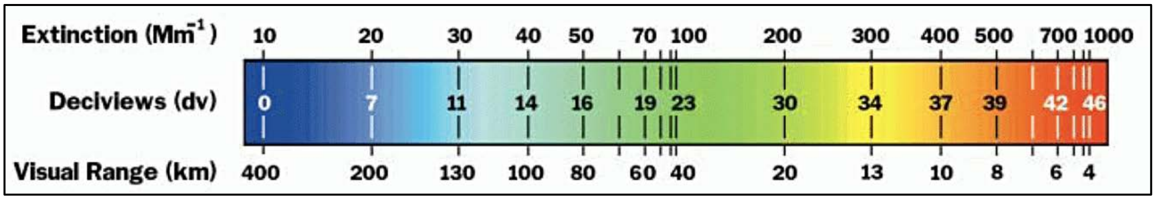


Figure 54. Relationship among extinction, deciview Index, and visual range

Current Condition and Trend

IMPROVE reconstructed extinction data for the Carson NF for 2000–2010 and is summarized in Table 47 (IMPROVE 2012). The IMPROVE measurements were sorted to provide the representative visibility conditions for the "worst 20%" visibility and the "average" visibility days, which are standard techniques for reviewing and assessing IMPROVE aerosol monitoring data. Table 47 also shows the visibility condition representing the 2064 goal for achieving "natural background". These data provide a measure of how much visibility improvement is required at each Class I area, in order to achieve the 2064 National Visibility Goal (NMED 2011).

The data in Table 47 are reported using the deciview metric described earlier. Higher values of deciview represent more degraded visibility conditions. Data are shown using the "baseline period" (2000–2004) along with the "progress period" (2005–2009) corresponding to the New Mexico regional haze SIP and the 2064 National Visibility Goal (natural background).

Table 47. Summary of IMPROVE visibility monitoring data, 20% worst-case days (dv)

Wilderness	IMPROVE Monitor	2000-04 Baseline Period	2000-04 Baseline Period	2005-09 Progress Period	2005-09 Progress Period	2064 Goal Natural Background
		Average	Range	Average	Range	
Bandelier	BAND1	12.2	10.5–14.6	11.8	11.0–12.8	6.26
San Pedro Parks	SAPE1	10.2	9.3–11.6	9.9	8.2–10.8	5.72
Wheeler Peak	WHPE	10.4	8.4-11.4	9.1	8.6-10.1	6.08

Table 47 shows that based on the 20 percent worst days during the 2005–2009 "progress period," Bandelier has the most degraded visibility and San Pedro Parks and Wheeler Peak have the least degraded visibility. Also, the general trend in visibility (based on the change in the worst 20 percent days between the baseline period and progress period) has been toward moderately improving visibility conditions. Table 47 also shows that the level of visibility improvement through the 2005–2009 "progress period," has been relatively modest, compared to the visibility improvements needed by 2064 to achieve the goal of natural background conditions.

IMPROVE measurements at each of the nearby Class I areas of interest can be found at the Federal Land Manager Environmental Database (IMPROVE 2012). Data from this site show the reconstructed extinction at each IMPROVE monitoring site for each year (2000–2010 where data are available for the entire period of record). This site also produces pie charts showing the percent contribution to the reconstructed extinction for the different aerosol species. The percent contribution charts represent the 2000–2004 "baseline" and the 2005–2009 "reasonable further progress" periods described above. For these particular charts, the visibility is reported using units of inverse megameters, which is a direct measure of atmospheric light extinction. Again, higher values of extinction represent more degraded visibility.

Bandelier National Monument (BAND1): The reconstructed extinction for the most impaired 20 percent days showed levels generally in the 30–40 Mm-1 range, except during 2000, when the extinction measured around 70 Mm-1. The conditions in 2000 at BAND1 appear somewhat anomalous, with very high extinction budgets for organics, strongly suggesting the presence of nearby wildfires. These conditions are not apparent in any other data year. Excluding the potential bias introduced by the year 2000 measurements, the extinction budgets at Bandelier are roughly 25 percent Rayleigh scattering, 25–30 percent sulfate and nitrate (indicative of industrial source emissions), 20–25 percent organics, and 10–15 percent coarse mass and soils. There has been a steady improvement in the visibility conditions represented by the 20 percent most impaired days since about 2007, which is mostly reflected by reductions in sulfate and may be a result of emissions control technology improvements at coal-fired electric generating stations.

San Pedro Parks (SAPE1) and Wheeler Peak (WHPE): As mentioned above, the SAPE1 and WHPE have similar trends in their data. They have the least degraded visibility, and this is also evident in the extinction data. For the 20 percent most impaired days, the reconstructed extinction ranges between 25–35 Mm-1. Because they have the least impaired visibility, the Rayleigh contribution in the extinction budget is 30 percent, slightly larger than other IMPROVE sites. The sulfate and nitrate contribution is about 25–30 percent, the organics contribution is about 25 percent, and the coarse mass and soil contribution is about 15 percent. Similar to some of the other sites, the extinction data show some improvements in visibility conditions since 2007, generally reflecting less impact from sulfate, which might be indicative of regional SO_2 emission reductions.

Atmospheric Deposition

Deposition data are presented from the National Atmospheric Deposition Program (NADP). Deposition generally arises from the transformation in the atmosphere of air pollution to acidic chemical compounds (e.g., sulfuric acid, nitric acid), a portion of which are deposited into forested ecosystems. Excessive deposition may lead to adverse effects on ecosystems and on other resources (e.g., cultural). Acid deposition can lead to changes in the pH of stream runoff and adverse effects on aquatic species. Also, acidic depositions can accumulate in the wintertime snowpack. Research has demonstrated that when portions of the snowpack with high acid concentrations melt during spring thaw, the acids are often released as an acute pulse. The sudden influx of acid can alter the pH of high altitude lakes and streams for short periods, with dramatic consequences for respective aquatic communities. Lastly, excessive nitrogen deposition can "over-fertilize" sensitive ecosystems, thereby promoting unnatural eruptions of native and nonnative plant species, invasions by noxious species, and altering long-term patterns of nutrient cycling. NADP monitoring data collected in the plan area were chosen to best characterize these conditions in the wilderness areas of interest.

Air emissions of NOx and SO_2 can lead to atmospheric transformation of these pollutants to acidic compounds (e.g., nitric acid and sulfuric acid) and the resultant deposition onto land and water surfaces in forested ecosystems. Documented effects of nitrogen and sulfur deposition include acidification of lakes, streams and soils, leaching of nutrients from soils, injury to high-elevation forests, changes in terrestrial and aquatic species composition and abundance, changes in nutrient cycling, unnatural fertilization of terrestrial ecosystems, and eutrophication of aquatic ecosystems.

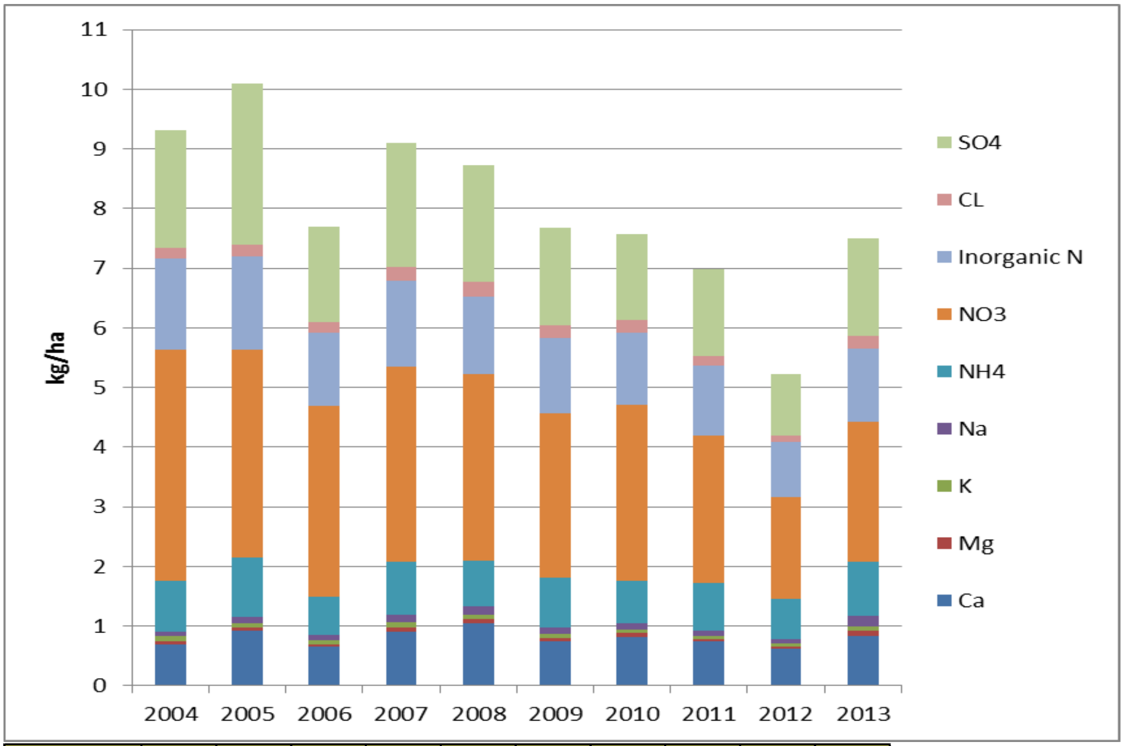
Where available, data on mercury deposition are also presented. Mercury is a neurotoxin that accumulates in plant and animal tissue, especially within the aquatic food chain. As birds, mammals, and humans consume fish and other aquatic organisms, the accumulated mercury is passed on to those species as well. Within human populations, mercury exposure is of particular concerns to pregnant women, as mercury can pass through the placenta to developing fetuses. Low-level mercury exposure is also linked to learning disabilities in children and interferes with the reproductive cycle in mammals that consume fish.

Mercury is a persistent bioaccumulative toxin that can stay in the environment for long periods of time, cycling between air, water and soil. Mercury deposits on the earth’s surface through wet or dry deposition, which can accumulate in the food chain and bodies of water. Toxic air contaminants like mercury, are emitted primarily by coal-fired utilities, and may be carried thousands of miles before entering lakes and streams as mercury deposition. Mercury can bioaccumulate and greatly biomagnify through the food chain in fish, humans, and other animals. Mercury is converted to methylmercury by sulfur reducing bacteria in aquatic sediments, and it is this form that is present in fish. Methylmercury is a potent neurotoxin, and has been shown to have detrimental health effects in human populations as well as behavioral and reproductive impacts to wildlife. Eating fish is the main way that people are exposed to methylmercury. However, each person’s exposure depends on the amount of methylmercury in the fish they eat, how much they eat, and how often. Typically, larger fish that are higher up the food chain (eat lots of little fish rather than algae) will have a greater amount of methylmercury in them.

Current Condition and Trend

Sulfur and nitrogen deposition - Deposition impacts are generally described in terms of the “critical load,” defined as “the quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment are not expected to occur based on present knowledge” (NADP 2009). In other words, the “critical load” determines the tipping point at which harmful effects attributable to deposition in a particular ecosystem start to occur. Critical loads have been established at some, but not all wilderness areas. For wilderness areas on the Carson NF, critical loads for nitrogen and acid deposition have been established based on a national assessment, although they lack some site-specific data for a more robust assessment (Pardo 2011). This general approach has been applied to determine critical loads for nitrogen and sulfur deposition, for some sensitive receptors on the forest.

Figure 55 shows the sulfur and nitrogen deposition measurements collected at the Bandelier National Monument station operated for the National Trends Network (NTN) over the period 2004–2014 (CASTNET 2015). Totals are shown for wet deposition and dry deposition for both sulfur and nitrogen, along with other chemical species. Units of measurement are kilograms per hectare (kg/ha). Deposition has remained relatively constant over the period of record, although some year-to-year variability is noted. Generally, the observed deposition at Bandelier ranges between 5.0-10.0 kg/ha-yr. Nitrogen deposition makes up the bulk of the deposition and typically constitutes about 3 kg/ha-yr, while sulfur deposition is typically closer to 2 kg/ha-yr. To put this in context for example, some ecological effects can be measured when nitrogen deposition exceeds 2.5 kg/ha-yr. In the case of the amount of sulfur deposition and acid deposition that can have impacts in general, can vary widely based on the specific area, where some areas are much more resistance than others due to geology, ecology, etc. Generally, the amount of atmospheric deposition occurring on the Carson is relatively low when compared to some forests in the east, for example; however there is reason for some concern as is highlighted in subsequent sections.



SO4	1.98	2.71	1.6	2.08	1.95	1.64	1.45	1.46	1.03	1.64
CL	0.17	0.19	0.19	0.23	0.25	0.2	0.21	0.15	0.11	0.2
Inorganic N	1.53	1.56	1.22	1.44	1.3	1.27	1.21	1.17	0.91	1.24
NO3	3.88	3.49	3.2	3.26	3.12	2.76	2.94	2.48	1.72	2.34
NH4	0.84	1	0.64	0.9	0.76	0.83	0.71	0.79	0.66	0.91
Na	0.086	0.101	0.092	0.13	0.156	0.104	0.108	0.095	0.071	0.182
K	0.075	0.073	0.062	0.081	0.067	0.064	0.06	0.049	0.053	0.068
Mg	0.053	0.059	0.048	0.067	0.078	0.057	0.067	0.046	0.045	0.08
Ca	0.7	0.92	0.65	0.91	1.04	0.75	0.82	0.74	0.62	0.84

Figure 55. Chemical deposition (Bandelier Station, 2004–2014)[1]

[1] Data obtained from http://nadp.sws.uiuc.edu/sites/siteinfo.asp?id=NM07&net=NTN

The Carson NF also supports the United States Geological Society (USGS) Snowpack Chemistry Monitoring Study that includes two locations on the forest (USGS 2014c). One site is located near Taos Ski Valley and the second is near Hopewell Lake. Generally, nitrate deposition at the two sites has decreased over the last 14 years, consistent with overall emissions and the expected trend in emissions. Sulfate emissions have been more variable, with levels increasing at the Taos Ski Valley site and decreasing at the Hopewell Lake site. While the trend is expected to decrease in sulfur emissions over time, many of the regulatory actions driving this trend have yet to take effect.

Mercury deposition - Almost every state (including New Mexico) has consumption advisories for certain lakes and streams warning of mercury-contaminated fish and shellfish. Many of the lakes on or near the Carson NF have fish consumption advisories for mercury for some species of fish (NMED 2011). The Mercury Deposition Network (MDN) collects and provides a long-term record of mercury concentrations and deposition in precipitation. As a result of coal-fired utilities in the Southwest, and the limited levels of mercury pollution controls at those sites, the total concentration of mercury in the air is fairly high relative to elsewhere in the United States (Figure 56) (MDN 2013). However, due to the relatively low precipitation rates (except at higher elevations), the mercury from wet deposition is comparatively low (Figure 57) (MDN 2013).

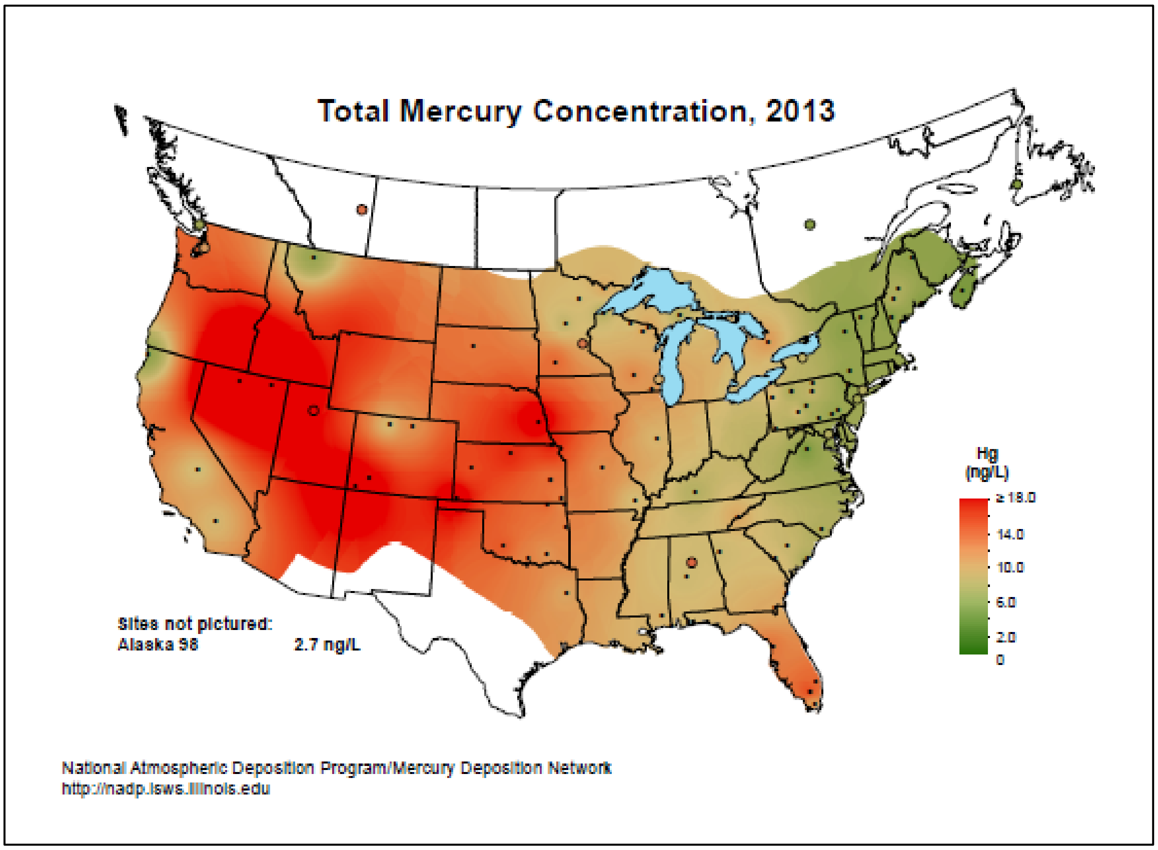


Figure 56. Total mercury concentration across the United States in 2013[1]

[1] Data obtained from: http://nadp.sws.uiuc.edu/maplib/pdf/mdn/hg_Conc_2013.pdf

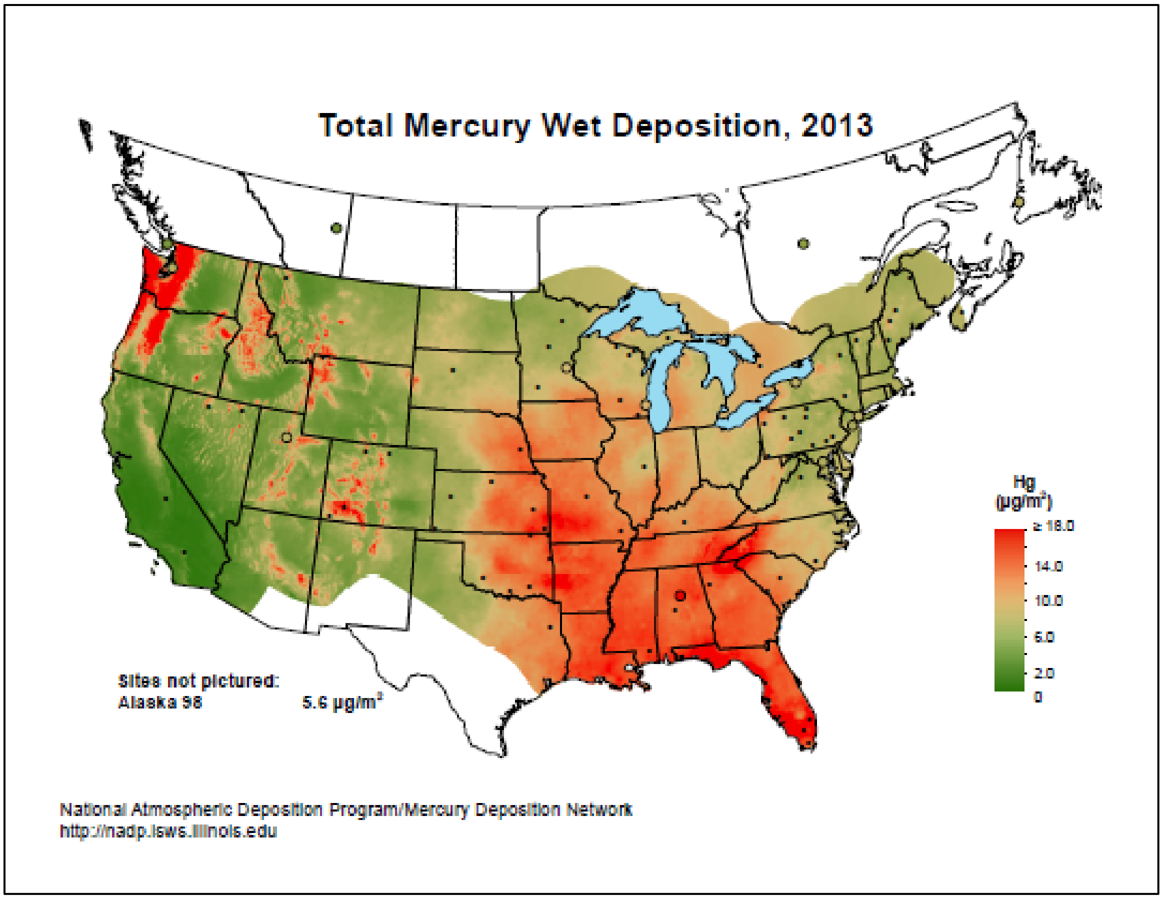


Figure 57. Total wet mercury deposition in 2013[1]

Some sites also are now collecting total deposition, both wet and dry. One site is located on the Valles Caldera National Preserve. Although it is not on the Carson NF, it can provide some indication of the conditions on the Carson NF. While it has only been operating for two years, initial results suggest that dry deposition adds significantly to the total deposition (Sather et al. 2013).

Mercury deposition measurements were collected at the MDN Valles Caldera National Preserve (Sandoval County) for 2009 and 2010, which show mercury deposition values in the range of 7,000 ng/m^2. Due to the toxicity of mercury no amount is good, but compared to the rest of the United States, these values are relatively low when compared to some sites in the east and northeast.

The USGS also monitors for mercury at the two snowpack chemistry monitoring sites near the Taos Ski area and near Hopewell Lake. Both sites have shown an increase in mercury deposition over the last 14 years that data has been collected.

While it is difficult to assess the current effects that mercury deposition is having on the Carson NF, trends in two areas suggest that overall mercury effects will decline. First, new regulatory controls at a couple regional coal fired power plants should reduce the total mercury emissions

[1] Data obtained from: http://nadp.sws.uiuc.edu/maplib/pdf/mdn/hg_dep_2013.pdf

over the next several years. In addition, sulfur emissions are also expected to decline, due to new sulfur fuel standards and pollution controls at the coal fired utilities. The link between sulfur-reducing bacteria and biotic mercury concentrations has led researchers to establish that reductions in sulfur dioxide emissions and a resulting reduction in sulfate deposition will abate mercury concentrations in wildlife. As a result, as sulfates are reduced in aquatic systems, sulfur reducing bacteria will reduce less sulfur, and this will lead to less inorganic mercury being methylated.

Critical Loads

Air pollution emitted from a variety of sources is deposited from the air into ecosystems. These pollutants may cause ecological changes, such as long-term acidification of soils or surface waters, soil nutrient imbalances affecting plant growth, and loss of biodiversity. The term critical load is used to describe the threshold of air pollution deposition below which harmful effects to sensitive resources in an ecosystem begin to occur. Critical loads are based on scientific information about expected ecosystem responses to a given level of atmospheric deposition. For ecosystems that have already been damaged by air pollution, critical loads help determine how much improvement in air quality would be needed for ecosystem recovery to occur. In areas where critical loads have not been exceeded, critical loads can identify levels of air quality needed to maintain and protect ecosystems into the future.

U.S. scientists, air regulators, and natural resource managers have developed critical loads for areas across the United States through collaboration with scientists developing critical loads in Europe and Canada. Critical loads can be used to assess ecosystem health, inform the public about natural resources at risk, evaluate the effectiveness of emission reduction strategies, and guide a wide range of management decisions.

The Forest Service is incorporating critical loads into the air quality assessments performed for forest plan revision. There are no published critical loads in the Southwest United States. For this assessment, national scale critical loads were used to determine if critical loads were exceeded for nutrient nitrogen (Pardo et al. 2011), acidity to forested ecosystems (McNulty et al. 2007), and for acidity to surface water (Lynch et al. 2012). In addition, mercury deposition was analyzed based on data from the mercury deposition network (MDN 2013), however no critical loads have been developed for mercury on the Forest Service. Ozone deposition was not assessed, due to lack of data availability and analysis in the Southwest United States. No critical loads have been developed for ozone on the Carson NF.

Nitrogen Saturation/Eutrophication

Nitrogen air pollution can have an acidifying effect on ecosystems as well as cause excess input of nitrogen in the ecosystem and nitrogen saturation. This excess nitrogen initially will accumulate in soil and subsequently be lost via leaching. While increased nitrogen may increase productivity in many terrestrial ecosystems (which are typically nitrogen limited) this is not necessarily desirable in protected ecosystems, where natural ecosystem function is desired. Excess nitrogen can lead to nutrient imbalances, changes in species composition (trees, understory species, nonvascular plants (lichens), or mycorrhizal fungi), and ultimately declines in forest health.

Based on research by Pardo and others (2011), national scale critical loads were developed for nitrogen deposition for lichen, herbaceous plants and shrubs, mycorrhizal fungi, forests, and nitrate leaching in soils for most major ecoregions. Summary results are in Table 48. Where results are not available, critical loads have not been developed for those ecoregions. Table 48 illustrates what percentage of the Carson NF exceeds the critical loads for various receptors, in addition to providing the range of the exceedance when an endpoint exceeds the critical load for nitrogen set for that receptor. Lastly, the 95 percent exceedance level is provided, to highlight data in the range that may be outliers or considered too high above the normal range of exceedances.

Table 48. Critical load exceedance summary for nitrogen deposition on the Carson National Forest

	% of total	Minimum Exceedance (kg-N/ha)	Maximum Exceedance (kg-N/ha)	95% Exceedance Level (kg-N/ha)
Lichens				
Exceedance	89	0.009751203	2.470469713	1.821734833
No Exceedance	2			
Critical Loads Not Available	9			
Herbaceous Plants and Shrubs				
Exceedance	28	0.00125561	2.186545077	0.944222983
No Exceedance	62			
Critical Loads Not Available	10			
Mycorrhizal Fungi				
Exceedance	3	0.004093927	1.186545077	0.153771288
No Exceedance	87			
Critical Loads Not Available	10			
Forests				
Exceedance	28	0.00125561	2.186545077	1.153771288
No Exceedance	62			
Critical Loads Not Available	10			
Nitrate Leaching				
Exceedance	28	0.00125561	2.186545077	1.153771288
No Exceedance	62			
Critical Loads Not Available	10			

Lichens

Lichens, which add significantly to biodiversity of ecosystems, are some of the most sensitive species to nitrogen deposition (Pardo et al. 2011). Unlike vascular plants, lichens have no specialized tissues to mediate the entry or loss of water or gases. They rapidly hydrate and absorb gases, water and nutrients during periods of high humidity and precipitation. They dehydrate and reach an inactive state quickly, making them slow growing and vulnerable to contaminate accumulation. As such, they are an important early indicator of impacts from air pollution.

Pardo and others (2011) used the major ecoregion types adapted from the Commission for Environmental Cooperation (CEC 1997), of which the Carson NF is within the Northwestern Forested Mountains ecoregions. The critical loads for lichens in these two ecoregions are based on research for Northwestern Forested Mountains, with minimum levels between 2.5-7.1 kg-N/ha-yr (Geiser et al. 2010; Pardo et al. 2011). Based on these values, 89 percent of the Carson NF exceeds critical loads to protect lichens, where 2 percent showed no exceedance and critical loads were not available for 9 percent or the area encompassing the Carson NF. The minimum amount that the Carson NF exceeded nitrogen deposition by was 0.0098 kg-N/ha and the maximum was by 2.47 kg-N/ha.

Forests, Herbaceous Plants and Shrubs, Mycorrhizal Fungi, and Nitrate Leaching

Adding nitrogen to forests whose growth is typically limited by its availability may appear desirable, possibly increasing forest growth and timber production, but it can also have adverse effects such as increased soil acidification, biodiversity impacts, predisposition to insect infestations, and effects on beneficial root fungi called mycorrhizae. As atmospheric nitrogen deposition onto forests and other ecosystems increases, the enhanced availability of nitrogen can lead to chemical and biological changes collectively called “nitrogen saturation". As nitrogen deposition from air pollution accumulates in an ecosystem, a progression of effects can occur as levels of biologically available nitrogen increase

Herbaceous plants and shrubs comprise the majority of the vascular plants in North America (USDA NRCS 2009). They are less sensitive to nitrogen deposition than lichens; however, they are more sensitive than trees due to rapid growth rates, shallow roots, and shorter life span (Pardo et al. 2011). Herbaceous plants are the dominant primary producers, contributing significantly to forest litter biomass and biodiversity (Gilliam 2010). The shorter lifespan of some species can result in a rapid response to nitrogen deposition and can result to rapid shifts (1–10 years) in community composition sometimes resulting in an increase in invasive species compared to native species (Pardo et al. 2011).

Based on the national scale empirical critical loads for nitrogen deposition for herbaceous plants and shrubs (Pardo et al. 2011), 28 percent of the Carson NF is potentially exceeding critical loads and 62 percent does not exceed, with 10 percent of the area where critical loads for these values were not available. The areas exceeding critical loads for nitrogen deposition range from a slight exceedance of 0.001 kg-N/ha to 2.19 kg-N/ha. 95 percent of the grid cells exceed the critical loads for herbaceous plants and shrubs with values less than 0.94 kg-N/ha. The critical loads were based empirical data developed for the Northwestern Forested Mountains ecoregion, which noted changes in species composition and individual species responses at 4 kg-N/ha-yr (Bowman et al. 2006).

Based on the national scale empirical critical loads for nitrogen deposition for forest and nitrate leaching (Pardo et al. 2011), 28 percent of the Carson NF is potentially exceeding critical loads and 62 percent does not exceed, with 10 percent of the area where critical loads for these values were not available. The areas exceeding critical loads for nitrogen deposition range from a slight exceedance of 0.001 kg-N/ha to 2.19 kg-N/ha. For forested systems and nitrate leaching, 95 percent of the grid cells exceed the critical loads with values less than 1.15 kg-N/ha. The critical loads were based empirical data developed for the Northwestern Forested Mountains ecoregion, which noted changes in changes in foliar chemistry, mineralization, and nitrogen leaching in soil at levels greater than 4 kg-N/ha-yr (Rueth and Baron 2002).

Acid Deposition

The potential for impacts from acid deposition on forests has been recognized for more than 30 years in the United States. Research has shown that deposition of nitrogen and sulfur has resulted in acidifying effects, which has had negative impacts on ecosystem health, including impacts to aquatic resources, forest sustainability, and biodiversity (McNulty et al. 2007). Acidifying effects can lead to mortality of tree species, reduced forest productivity, reduced biological diversity, and increased stream acidity (Driscoll et al. 2001).

The following section presents critical acid load for soils and surface water on the Carson NF. McNulty estimated critical loads and exceedances for forested soils across the United States (McNulty et al. 2007). The surface water critical acid loads were based on research from Lynch (Lynch et al. 2012).

Soils

Many factors contribute to an exceedance of critical acid loads in forested ecosystems. Key factors include the composition of the soil, including how weathered it is, the amount of organic matter present, and the amount of base cations (i.e., calcium, potassium, magnesium, and sodium), which all play a role in how well the soil is buffered against acid deposition (how well the soil can neutralize the acid). For example, sandy soils are typically low in base cations, which make them more vulnerable to acid deposition. Also important are the types of tree species present due to the various rates that they uptake nitrogen, and base cations, which can either counter act the effects of acid deposition or reduce soils buffering capacity. In conifer forests, as the needles break down, the soil is naturally acidified, which can also increase the system’s vulnerability to acidification. Also important is the rate at which sulfur and nitrogen compounds fall to the ground through either wet or dry deposition, which is related to what sort of emissions are occurring that are adding these compounds to the airshed. Elevation also plays a role, since more precipitation tends to occur at higher elevations increasing the rate of acid deposition.

Estimates that factor all the parameters described above show that there are no exceedances of acid critical loads on the Carson NF (Figure 58). This is primarily a result of low amount of acid gases in the airsheds in New Mexico and the western United States.

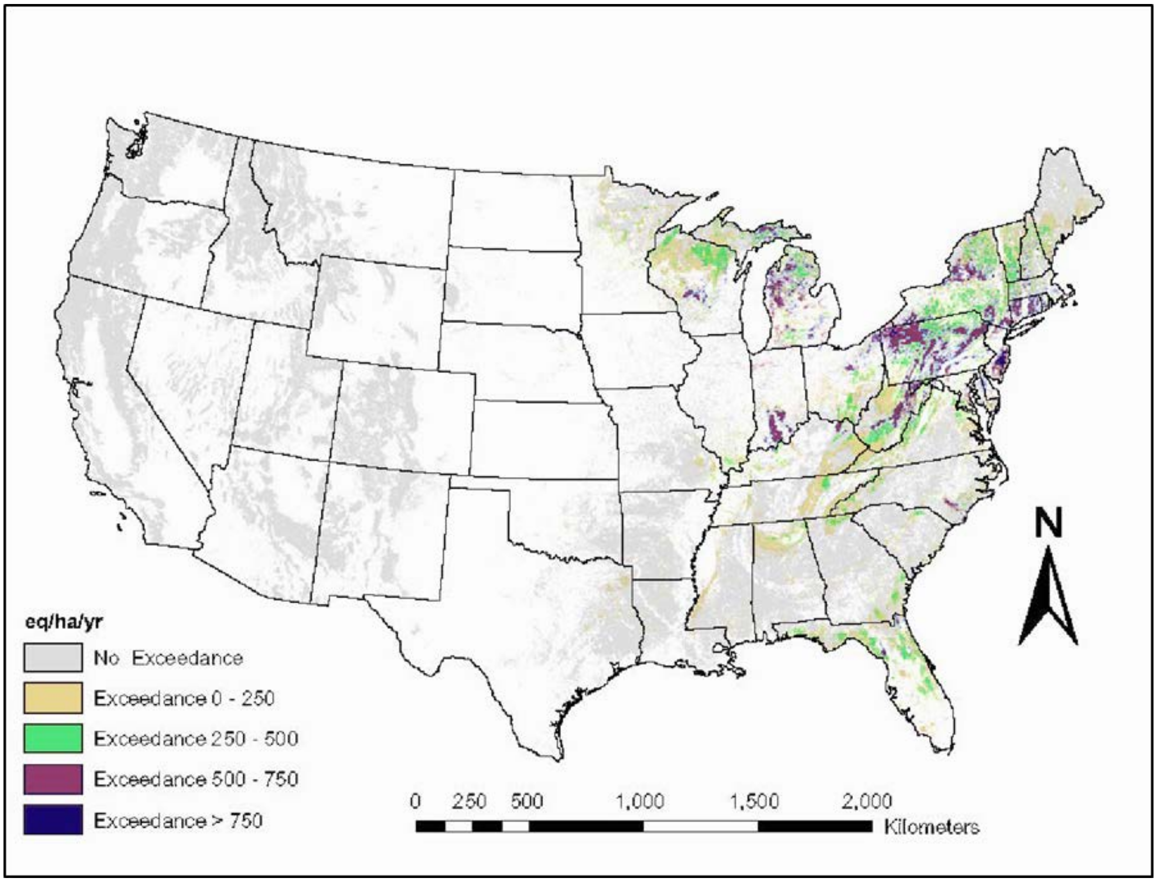


Figure 58. Average annual exceedance of the critical acid load for forest soils expressed in eq/ha-yr for the coterminous US for the years 1994–2000 at a 1-km2 spatial resolution (adapted from McNulty et al. 2007)

Surface Water

Stream and lake acidification can be a result of deposition of acid gases, which can reduce the pH of surface water resulting in reduced diversity and abundance of aquatic species. As described in the previous section, many of the same factors contribute to the susceptibility of aquatic ecosystems to the effects of acid deposition. Surface water acidification begins with acid deposition in adjacent terrestrial areas (Pidwirny 2006) and the system's ability to neutralize the acid before it leaches into the surface water.

There are only a few points in the national critical loads available for the Carson NF to assess acid deposition to surface water, however all of these points indicate that acidification of surface water on the forest does not appear to be an issue. A national analysis, by Lynch was conducted using the Steady-State Water Chemistry Model used a mass-balance approach to assess acid critical loads for surface water (Lynch 2012). This assessment included three surface water sites on the Carson NF, all of which were below levels of concern. In addition, every two years the New Mexico Environment Department is required by the Clean Water Act to submit an assessment of the surface waters in New Mexico to the EPA. Based on the current list of impaired water in New Mexico, there are no impaired waters as a result of pH on the Carson NF (NM WQCC 2012).

Ozone

Ground-level ozone interferes with the ability of plants to produce and store food, which makes them more susceptible to disease, insects, other pollutants, drought, and higher temperatures. Some plants have been identified as particularly sensitive to the effects of ozone and are reliable indicators of toxic levels of the pollutant on plant growth.

Ozone damages the appearance of leaves on trees and other plants. The most common visible symptom of ozone injury on broad-leaved bioindicator species is uniform interveinal leaf stippling. As a gaseous pollutant, ozone enters the stomata of plant leaves through the normal process of gas exchange, damaging the tissue. Elevated levels of ozone have not been directly measured on the Carson NF, nor has an assessment of the forest's vegetation been conducted in terms of looking for impacts from ozone. The effects of ozone on tree growth on the Carson NF are not well understood.

Uncertainty

There are many factors that contribute to the reliability and confidence of an assessment. Typically a sufficient amount of direct measurements taken over time, provide the greatest level of confidence regarding the current state and trends of forest health as it applies to air quality impacts. In the absence of direct measurements, modeled data can be used to assess relative risk of systems to the impacts for air pollution; however this creates a greater degree of uncertainty in the assessment. To understand the level of confidence in the modeled results, it is important to understand the assumptions in the models as well as how they perform in a given environment. In this case, how do they perform assessing the potential impacts that air pollution has on various indicators, such as lichens, on the Carson NF?

While there are direct measurements that have been taken over time, for ambient air quality and visibility, there are limited studies performed on the Carson NF to directly measure the impacts from air pollution on forest health, such as limited lichen surveys and snow chemistry surveys. The modeled results that are available indicate that lichens and to a lesser degree herbaceous plants and shrubs, forests, and nitrate leaching are at risk of being impacted by nitrogen deposition. There is a fair amount of uncertainty with these estimates, however. The critical loads were developed based on a few studies in Oregon, Washington, and the Sierra Nevada's in California (Pardo et al. 2011). In addition, atmospheric nitrogen deposition estimates and critical loads are influenced by several other factors, including the difficulty of quantifying dry deposition on complex mountainous terrain in arid climates with sparse data (Pardo et al. 2011), all of which are significant factors on the Carson NF. At this time, there is a fair amount of uncertainty with the critical load estimates to have a high level of confidence in the assessment.

Summary of Condition, Trend, and Risk

The ecosystem services provided by air are generally stable and not at risk. Air quality on the Carson NF is within regulatory levels for NAAQS, and the trend based on projected emission inventories appears to be stable or is improving for most pollutants (Table 49). This is also true regarding visibility conditions, from a regulatory perspective, in that the State is operating under an approved SIP to reduce visibility impacts and is on an acceptable trajectory to meet the 2064 goals. The main challenge could be with regards to both coarse and fine particulate matter, which can affect both the ambient air quality and visibility on the forest. Land-use both on and off the forest, as well as climate change and drought can contribute to windblown and fugitive dust. Wildfires can also be a significant source of particulate matter. Additionally, the Jicarilla RD may be at risk of ozone impacts as the trend in VOCs, an ozone precursor, are increasing from oil and gas development and there is a history of high ozone levels near the district. Further significant uncertainty exists as the ozone standards is expected to be lowered soon.

Table 49. Summary of conditions, trends, and reliability of assessment

Air Quality Measure	Current Conditions	Trend	Reliability
NAAQS[1]			
CO	Good	Improving	High
NO_2	Good	Improving	High
SO_2	Good	Stable	High
Pb	Good	Stable	High
O_3	Good	Stable	High
$PM_{2.5}$	Good	Stable to Declining	High
PM_{10}	Good	Stable to Declining	High
Visibility[2]			
Visibility	Departed	Stable to Improving	High
Critical Loads-Deposition			
Nitrogen Eutrophication			
Lichens	Potentially at risk	Improving	Moderate
Herbaceous Plants & Shrubs	Good[3]	Improving	Moderate
Mycorrhizal Fungi	Good	Improving	Low
Forests	Good[3]	Improving	Moderate
Nitrate Leaching	Good[3]	Improving	Moderate
Acid Deposition			
Soils	Good	Improving	Low
Surface Water	Good	Improving	Low

[1] Relative to NAAQS

[2] Relative to 2064 Regional Haze Goal

[3] Approximately 28% of the Carson NF may exceed critical loads for these parameters; however, the break point for low departure are when conditions affect less than 33% of the forest.

Air Quality Measure	Current Conditions	Trend	Reliability
Deposition (other)			
Mercury	Potentially at risk	Improving	Moderate
Ozone	Unknown	Unknown	N/A

There is some indication that current levels of nitrogen deposition have exceeded critical loads and are significant enough to have resulted in impacts to lichen diversity and community structure and to a lesser degree impacts to herbaceous plants and shrubs, forest and soil nitrate leaching. However, these results were based on modeled critical loads and have not been verified on the forest. The rate of deposition of nitrogen, which can lead to impacts affecting forest health, appear to be decreasing based on projected emissions at the state level.

Modeled results also indicate that the levels of acid gases are not at levels significant enough to result in impacts to either soils or surface water. There are no direct measurements on the forest that indicate otherwise.

There is some indication that mercury deposition at higher elevations on the forest may be significant, however, atmospheric mercury, based on regional emissions, is also expected to decrease.

Key Finding

Air quality and the values dependent on air quality on the Carson NF are generally in good condition or are improving as most pollutants are decreasing; however, visibility and ambient air quality conditions associated with particulate matter are expected to increase—likely a result of larger, more severe wildfires and increases in fugitive dust as the effects of climate change are realized. Uncertainty also exists as the ozone standard is lowered and the Jicarilla RD is included in a non-attainment area.

Climate Change

The USDA FS Southwestern Regional Office has compiled the best available science (BASI) for climate change relevant to forest planning in the Southwest (USDA FS 2010b). The review that follows is based on that report. Climate scientists agree that the earth is undergoing a warming trend and human-caused elevations in atmospheric concentrations of carbon dioxide (CO_2) and other greenhouse gases are chief among the potential causes of global temperature increases. The concentrations of these greenhouse gases are projected to increase into the future. Climate change may intensify the risk of ecosystem change for terrestrial and aquatic systems, affecting ecosystem structure, function, and productivity (USDA FS 2010b).

There is broad agreement among climate modelers that the Southwestern US is experiencing a warming and drying trend that will continue well into the latter part of 21st century (IPCC 2007a; Seager et al. 2007) While some models predict increased precipitation for the region, researchers expect the overall balance between precipitation and evaporation would still likely result in an overall decrease in available moisture (Seager et al. 2007). Temperatures are predicted to rise by 5 to 8 degrees Fahrenheit by the end of this century, with the greatest warming occurring during winter months. The number of extremely hot days is projected to rise during the first 100 years 21st century. By the end of the century, parts of the Southwest are projected to face summer heat waves lasting two weeks longer than those occurring in recent decades. Some climate model downscaling results also suggest a fivefold increase in unusually hot days by the end of the century, compared to 1961 to1985. In effect, the high temperatures that formerly occurred on only the hottest 5 percent of days could become the norm for a quarter of the year – 100 days or more – in much of the Southwest (IPCC 2007a; USDA FS 2010b).

Climate variability, with both wet periods and droughts, has been a part of southwestern climate for millennia and the droughts of the last 110 years pale in comparison to some of the decades-long “megadroughts” the region has experienced over the last 2,000 years (Seager et al. 2008). Indeed, severe regional floods or droughts have affected both indigenous and modern civilizations on time scales ranging from single growing seasons to multiple years, even decades (Sheppard et al. 2002). However, a warmer, drier, and faster changing climate will increase pressures on the region’s already limited water supplies, as well as increase energy demand; alter fire regimes and ecosystems; create risks for human health; and affect agriculture (Sprigg et al. 2000).

Water

Changes in water distribution, timing of precipitation, availability, storage, watershed management, and human water uses, may present some of the most important challenges from climate change to national forest management in the Southwest. Terrestrial and aquatic ecosystems and all human socioeconomic systems in the Southwest depend on water. The prospect of future droughts becoming more severe because of global warming is a significant concern, especially because the Southwest continues to lead the nation in population growth. Recent warming in some areas of the Southwest is occurring at a rate that is among the most rapid in the nation (Seager et al. 2007), significantly higher than the global average in some areas. This is already driving declines in spring snowpack and Colorado River flow. More water cycle changes are projected, which, when combined with increasing temperatures, signal a serious water supply challenge in the decades and centuries ahead. Water supplies are projected to become increasingly scarce, demanding trade-offs among competing uses, and potentially leading to conflict. Projections for this century point to an increasing probability of drought for the region, made more probable by warming temperatures. The most likely future for the Southwest is a substantially drier one. Combined with the historical record of severe droughts and the current uncertainty regarding the exact causes and drivers of these past events, the Southwest must be prepared for droughts that could potentially result from multiple causes.

The combined effects of natural climate variability and human induced climate change could result in a challenging combination of water shortages for the region (Karl et al. 2009). Additionally, the locations of most snow pack and upland reservoirs are on national forests in the Southwest (NM 2005; Smith et al. 2001). Some studies predict water shortages and lack of storage capabilities to meet seasonally changing river flow, as well as transfers of water from agriculture to urban uses, as critical climate-related impacts to water availability (Barnett et al. 2008). While agriculture remains the greatest user of water in the Southwest, there has been a decreased amount of water used by agriculture, as New Mexico's booming population demands more water for municipal and other uses, and irrigation technologies improve. This has been an ongoing trend and could affect future agricultural uses. Without upland reservoirs and watersheds (many managed by the Forest Service), alternative water sources, water delivery systems, and infrastructure support for agriculture would need to be developed (Lenart 2007). Flash flooding occurring after extended drought may increase the number and severity of floods and accelerate rates of soil erosion. The timing and extent of storm-related precipitation will play a key role in determining the degree to which people and the environment are affected (USDA FS 2010b).

The potential for flooding is very likely to increase, because of earlier and more rapid melting of the snowpack, with more intense precipitation. Even if total precipitation increases substantially, snowpack is likely to be reduced because of higher overall temperatures. However, it is possible that more precipitation would also create additional water supplies, reduce demand, and ease some of the competition among competing uses (Joyce et al. 2001; Smith et al. 2001). In contrast, a drier climate is very likely to decrease water supplies and increase demand for such uses as agriculture, recreation, aquatic habitat, and power; thus, increasing competition for decreasing supplies (Joyce et al. 2001).

Ecosystems

Long-term and short-term climate variability may cause shifts in the structure, composition, and functioning of ecosystems, particularly in the fragile boundaries of the semiarid regions. These areas already contain plants, insects, and animals highly specialized and adapted to the landscape. A changing climate of wetter, warmer winters, and overall temperature increases would alter species range, type, and number throughout the Southwest. Responding differently to shifts in climate, the somewhat tenuous balance among ecosystem components will also change. As phenology is altered, the overall effects among interacting species are difficult to predict, particularly given the rate of climate change and the ability of symbionts to adapt. Because the health of the ecosystem is a function of water availability, temperature, carbon dioxide, and many other factors, it is difficult to accurately determine the extent, type, and magnitude of ecosystem change under future climate scenarios. Yet, should vegetation cover and moisture exchanging properties of the land change, important local and regional climate characteristics such as albedo (amount of radiation reflected by a surface), humidity, wind, and temperature will also change, with potential compounding effects to vegetation (Sprigg et al. 2000).

Climate may influence the distribution and abundance of plant and animal species, through changes in resource availability, fecundity, and survivorship. The potential ecological implications of climate change trends in the Southwest indicate:

- More extreme disturbance events, including wildfires and intense rain, flash floods, and wind events (Swetnam et al. 1999).
- Greater vulnerability to invasive species, including insects, plants, fungi, and vertebrates (Joyce et al. 2007).
- Long-term shifts in vegetation patterns (Millar et al. 2007; Westerling et al. 2006).
- Cold-tolerant vegetation moving upslope, or disappearing in some areas. Migration of some tree species to the more northern portions of their existing range (Clark 1998).
- Potential decreases in overall forest productivity, due to reduced precipitation (USDA FS 2005b).
- Shifts in the timing of snowmelt (already observed) in the American West, which, along with increases in summer temperatures, have serious implications for the survival of fish species, and may challenge efforts to reintroduce species into their historic range (Joyce et al. 2007; Millar et al. 2007).
- Increasing temperatures, water shortages, and changing ecological conditions will effect biodiversity, by putting pressure on wildlife populations, distribution, viability, and migration patterns. Top predators and herbivores are disproportionally at risk in warming environments, which favor autotrophs (e.g., plants, algae) and bacteriovores (NM 2005).

Vegetation

A warmer climate in the Southwest is expected to alter the biotic and abiotic stresses that influence the vigor of ecosystems and increase the extent and severity of disturbances, as a result. Decreasing water availability will accelerate the stresses on forests, which typically involve some combination of multi-year drought, insects, and fire. As has occurred in the past, increases in fire disturbance superimposed on ecosystems, with increased stress from drought and insects, may have significant effects on growth, regeneration, long-term distribution, and abundance of forest species, and carbon sequestration. Many southwestern ecosystems contain water-limited vegetation today. Vegetation productivity in the Southwest may decrease further with warming temperatures, as increasingly negative water balances constrain photosynthesis, although this may be partially offset, if CO_2 fertilization significantly increases water-use efficiency in plants (USDA FS 2010b). Inter-decadal climate variability strongly affects interior dry ecosystems, causing considerable growth during wet periods. This growth increases the evaporative demand, setting the ecosystem up for dieback during the ensuing dry period (Swetnam and Betancourt 1998). Piñon-juniper woodlands, for example, are clearly water limited systems, and piñon-juniper ecotones are sensitive to feedbacks from environmental fluctuations. Existing canopy structure may provide trees a buffer against drought; however, severe multiyear droughts may overwhelm local buffering and periodically cause dieback of piñon pines. The dieback during the early 2000s was historically unprecedented in its combination of fire suppression influence, low precipitation, and high temperatures. Increased drought stress via warmer climate was the predisposing factor, and piñon pine mortality and fuel accumulations were inciting factors (USDA FS 2010b).

Temperature increases are a predisposing factor often causing lethal stresses on forest ecosystems of western North America, acting both directly, through increasingly negative water balances, and indirectly, through increased frequency, severity, and extent of disturbances—chiefly fire and insect outbreaks. Human development of the West has resulted in habitat fragmentation, barriers to migration such as dams, and the introduction of invasive species. The combination of development, presence of invasive species, complex topography, and climate change is likely to lead to a loss of biodiversity in the region. Some species may migrate to higher altitudes in mountainous areas; however, climate change is occurring more quickly than it has during past fluctuations. Some ecosystems, such as alpine tundra, may virtually disappear from the region (Joyce et al. 2008).

Natural disturbances having the greatest impact on forests include, insects, diseases, introduced species, fires, droughts, inland storms caused by hurricanes, flash flooding, landslides, windstorms, and ice storms. Climate variability and changes can alter the frequency, intensity, timing, and spatial extent of these disturbances. Many potential consequences of future climate change are expected to be buffered by the resilience of forests to natural climatic variation. However, an extensive body of literature suggests that new disturbance regimes under climate change are likely to result in significant perturbations to US forests, with lasting ecological and socioeconomic impacts (Joyce et al. 2001).

Wildfire

Historically, wildfires have been a recurring disturbance in conifer forests, piñon-juniper woodlands, shrublands, and grassland ecosystems of the Southwest. An analysis of trends in wildfire and climate in the western United States from 1974–2004 shows both the frequency of large wildfires and fire season length increased substantially after 1985 (Westerling et al. 2006). These changes were closely linked with advances in the timing of spring snowmelt and increases in spring and summer air temperatures. Earlier spring snowmelt probably contributed to greater wildfire frequency in at least two ways, by extending the period during which ignitions could potentially occur and by reducing water availability to ecosystems in mid-summer before the arrival of the summer monsoons; thus, enhancing drying of vegetation and surface fuels (Westerling et al. 2006).

This trend of increased fire size corresponds with an increased cost for fire suppression over the same period. In recent years, areas of western forests have been increasingly impacted by wildfires, with suppression costs of more than $1 billion per year from federal land management agencies. Since about the mid-1970s, the total acreage of areas burned and the severity of wildfires in pine and mixed-conifer forests have increased (USDA FS 2010b). The summer of 2012 saw both the largest and most costly wildfires in New Mexico state history, Whitewater-Baldy Complex and Little Bear Fire, respectively (InciWeb 2015; Ruidoso News 2012). If temperatures increase, precipitation decreases, and overall drought conditions become more common, fire frequency and severity may be exacerbated. In addition, continued population growth will likely cause greater human-caused fires, since humans start nearly half of the fires in the Southwest (USDA FS 2010b).

Insects and Diseases

Extensive reviews of the effects of climate change on insects and pathogens have reported many cases where climate change has affected and/or will affect forest insect species range and abundance, as witnessed in the Southwest (USDA FS 2010b, 2014e). Climate also affects insect populations indirectly through effects on hosts. Drought stress, resulting from decreased precipitation and/or warming, reduces the ability of a tree to mount a defense against insect attack, though this stress may also cause some host species to become more palatable to some types of insects (USDA FS 2010b, 2014e). Periods of drought or even average precipitation levels exacerbated by higher temperatures and high stand densities could contribute to future accelerated tree mortality from widespread bark beetle outbreaks and increased incidence of other disease agents, such as *Armillaria* root rot (USDA FS 2014e).

Invasive Species

The Southwest suffers from many types of invasive species outbreaks, including plants (e.g., leafy spurge, toadflax, hoary cress, Bull thistle, and cheatgrass) and animals (bullfrogs). Invasive plants can alter landscapes by overtaking native species, facilitating fire outbreaks, and altering the food supply for herbivorous animals and insects. For example, climate may favor the spread of invasive exotic grasses into arid lands, where the native vegetation is too sparse to carry a fire. When these areas burn, they typically convert to non-native monocultures and the native vegetation is lost (Ryan et al. 2008). Cheatgrass (*Bromus tectorum*) has not yet become established, except in limited pockets on the Carson NF. However the current climate could support the species and additional high severity fire may induce more widespread invasions.

Ecosystem Services

Changes in climate may have a major effect on ecosystem services, by reducing their capacity (Inkley et al. 2004). As the human population continues to grow in the 21st century so, too, will its demand for the goods and services that ecosystems provide. Ecosystem services brought by wildlife (e.g., pollination, natural pest control, seed dispersal, nutrient cycling) are derived from their roles within systems. If an ecosystem is vulnerable to changes in climate, so are the services it provides. Not only do animal and plant species contribute to ecosystem stability or to ecosystem health and productivity, but wildlife species provide a recreational value (e.g., sport hunting, wildlife viewing), which is large in market and non-market terms. In addition, a reduction in species, due to the loss or significant alteration of their habitat, could impact the cultural and religious practices of indigenous peoples around the world. Changes in the structure and function of affected ecosystems can result in a loss of species that can lead to loss of revenue and aesthetics (IPCC 2007b). Vegetation protects soil against erosion, and forest dieback or uncharacteristic wildfires can greatly increase watershed sediment yield (Allen and Breshears 1998; Miller et al. 2003), potentially reducing water storage capacity in reservoirs.

Climate Change Vulnerability Assessment (CCVA)

The Forest Service Southwestern Region and Rocky Mountain Research Station have developed an all-lands climate change vulnerability assessment for major upland ecosystems of the Southwest. Based on the anticipated effects of climate change on site potential, the vulnerability of individual plant communities is assessed and scored as low, moderate, high, and very high, according to the degree by which their climate envelopes1 are exceeded under future climate projections. Climate envelopes were developed for each major ERU on the Carson NF using contemporary climate data contemporary climate data for Arizona and New Mexico, according to the most discriminating climate variables. ERUs were segmented based on site potential and each segment was assigned a vulnerability score based on the projected departure in future climate from the current climate envelope of the given ERU2. Departure scores are then averaged together across the plan scale, by ERU within the plan scale, and by ERU at the local scale (Figure 59). The CCVA also provides a measure of uncertainty, which represents the degree of disagreement between different Global Circulation Models (GCMs), within a given emission scenario3 (USDA FS 2014a).

[1] 1The climate envelope for an ERU refers to the current range for climate variables that encompasses the existing ecosystem distribution, which can be used to define ecosystem tolerance.

[2] Downscaled climate data for both contemporary and future projections were obtained from the RMRS Moscow Lab (available online). Data obtained include downscaled data from multiple Global Circulation Models (GCMs) and emission scenarios that are fitted to thin plate splines to create contiguous climate surfaces for the Southwestern Region. The reader is referred to Rehfeldt 2006) and Rehfeldt et al. (2012) for detailed discussion of spline models and their application to contemporary and projected climate data. For this analysis, overall vulnerability was scored using data derived from the CGCM3 GCM for the 2090 projection using the A1B emission scenario. Four categories of vulnerability are reported, and category boundaries are defined by departure from climate envelope mean and envelope edge. Climate envelopes were developed independently for each discriminating variable, and are considered to be +/- 2 standard deviations of the sample mean.

[3] Three GCMs were used to assess uncertainty (CGCM3, HADCM3, and GFDLCM21). Uncertainty is reported using a simple agreement process and categories:

- If all three GCMs produce the same vulnerability category then uncertainty is “Low”
- Otherwise if two of the GCMs produce the same vulnerability category, then uncertainty is “Moderate”
- When all three GCMs differ on vulnerability then uncertainty is “High”

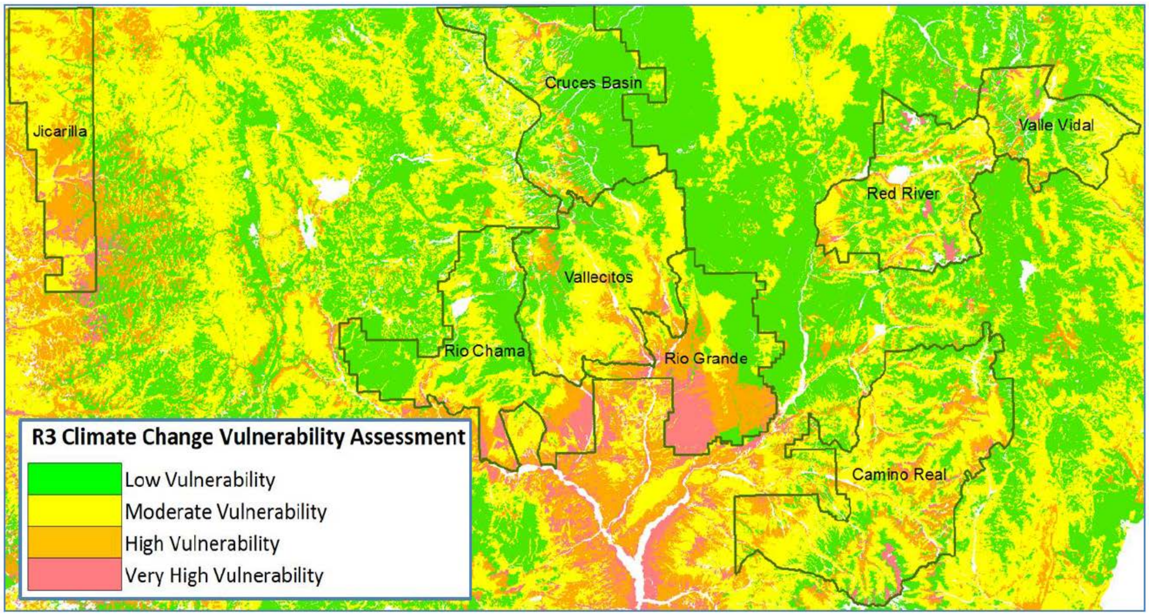


Figure 59. Modeled climate change vulnerability on the Carson NF and surrounding lands of north-central New Mexico according to the CCVA[1]

Vulnerability to climate change indicates higher potential for significant alteration of structure, composition, or function. The vulnerability of a point on the landscape is a function of (1) the breadth of the current climate envelope for the ERU; (2) the position of the location in climate envelope space; and (3) the projected magnitude of projected climate change at the location. Therefore, high vulnerability may indicate either that the area is on a marginal limit of current climate, or that climate in the area is predicted to shift far from the current envelope for the ERU, or a combination of both. Overall, about two-thirds of the plan area is at least somewhat vulnerable to climate change (Table 50). The Rio Grande and Jicarilla local zones are most vulnerable and the Cruces Basin and Valle Vidal are least vulnerable. PJS is the most vulnerable ERU, probably because it occurs on some of the most marginal, low elevation portions of the Carson NF (Table 51). The PJS ERU represents a transitional zone between SAGE and PJO, yet both have significantly lower predicted vulnerability. Among forested ERUs, PPF and SFF are most vulnerable.

[1] The Carson NF is delineated with dark green borders, subdivided by terrestrial ecosystem local zones

Table 50. Climate change vulnerability and uncertainty in percent (%) area of the Carson National Forest

Vulnerability/Uncertainty Category	Low	Mod	High	Total
Low Vulnerability	10	24	0	35
Moderate Vulnerability	1	29	14	44
High Vulnerability	6	10	0	16
Very High Vulnerability	5	0	0	5
Total	**22**	**63**	**14**	

Table 51. Climate change vulnerability and uncertainty in percent (%) of each ecological response unit (ERU)

ERU	Vulnerability/Uncertainty Category	Low	Mod	High	Total
MSG	Low Vulnerability	31	55	0	86
	Moderate Vulnerability	0	12	1	13
	High Vulnerability	1	0	0	0
	Very High Vulnerability	0	0	0	0
	MSG Total	**32**	**67**	**1**	
SFF	Low Vulnerability	0	12	0	12
	Moderate Vulnerability	0	45	15	60
	High Vulnerability	15	10	0	25
	Very High Vulnerability	2	0	0	2
	SFF Total	**18**	**67**	**15**	
MCW	Low Vulnerability	5	43	0	48
	Moderate Vulnerability	0	36	12	48
	High Vulnerability	1	3	0	4
	Very High Vulnerability	0	0	0	0
	MCW Total	**6**	**82**	**13**	
MCD	Low Vulnerability	17	43	0	61
	Moderate Vulnerability	0	29	8	37
	High Vulnerability	0	2	0	2
	Very High Vulnerability	0	0	0	0
	MCD Total	**17**	**75**	**8**	

ERU	Vulnerability/Uncertainty Category	Low	Mod	High	Total
PPF	Low Vulnerability	4	21	0	25
	Moderate Vulnerability	0	28	20	48
	High Vulnerability	3	19	0%	22
	Very High Vulnerability	4	0	0	4
	PPF Total	**12**	**67**	**21**	
PJO	Low Vulnerability	19	25	0	45
	Moderate Vulnerability	0	34	21	54
	High Vulnerability	0	1	0	1
	Very High Vulnerability	0	0	0	0
	PJO Total	**19**	**60**	**21**	
PJS	Low Vulnerability	0	1	0	2
	Moderate Vulnerability	0	23	16	39
	High Vulnerability	16	21	0	38
	Very High Vulnerability	22	0	0	22
	PJS Total	**39**	**45**	**16**	
SAGE	Low Vulnerability	51	35	0	86
	Moderate Vulnerability	13	0	0	14
	High Vulnerability	0	0	0	0
	Very High Vulnerability	0	0	0	0
	SAGE Total	**65**	**35**	**0**	

Carbon Stocks

Best available scientific information (BASI) indicates that the emission of greenhouse gases (GHGs) by human activities and natural processes contribute to the warming of the Earth's climate. Warming could have significant ecological, economic, and social impacts at regional and global scales (IPCC 2007). In 2005, U.S. forests were estimated to be sequestering nearly 220.5 million tons of carbon (Cameron et al. 2003), suggesting that forests and woodlands of the Southwest could have a significant role to play in the sequestration of carbon and climate change mitigation. Carbon sequestration provides the ecosystem service of climate regulation with all the associated constituents of human well-being including security, basic materials for a good life, and health (MEA 2005). Forest Service regulations (36 CFR 219.6(b)(4)) direct the Carson NF to include baseline assessment of carbon stocks as part of the forest plan assessment process.

The following assessment considers the major carbon components of Southwest ecosystems, including biomass, carbon emissions, and soil organic carbon. Estimates are provided for biomass and soil carbon on the Carson NF. The carbon emissions component is characterized using a case study synthesis from the Apache-Sitgreaves NFs. It is acknowledged that the description of other carbon components, such as forest products, would provide a fuller accounting of carbon stocks and flux; however, inclusion of the major components of biomass, emissions, and soil carbon will suffice for strategic purposes of forest planning.

Biomass (Vegetative Carbon)

Vegetative biomass serves as an integral component in forest carbon cycles. Forest vegetation, through the process of photosynthesis, converts atmospheric carbon dioxide to carbohydrates (referred to as carbon fixation). These carbohydrates (sugars) are used by plants to grow both above-ground biomass in the form of stems and leaves, and below-ground biomass in the form of roots and tubers. Conversely, through the process of decay, dead plant material slowly releases carbon into the atmosphere as it decomposes. Total carbon stored in vegetative biomass is referred to as the biomass carbon stock, and is a quantity that changes through time. The primary influences on biomass carbon stock are plant growth (primary productivity), which serves to increase biomass carbon stock, decay/decomposition that slowly decreases biomass carbon stock, and disturbance in the form of fire and harvest. Wildland fire provides a major source of carbon emissions in a forest setting, and is discussed in detail in the Carbon Emissions section (p. 290). Biomass harvest plays a varying role in carbon emissions, depending largely on the use of the wood products. For example, wood products utilized as sawtimber in construction tends to provide long-term carbon storage with slow release, while wood products used as fuelwood and burned for heat/energy provide increased carbon emissions into the atmosphere. As forest and grassland ecosystems are constantly changing through natural succession and disturbance, biomass carbon stock also changes through time. This section will focus on biomass carbon stocks over time in the plan area. For the purpose of this section, biomass carbon stock includes above-ground live biomass, standing dead biomass, downed woody debris, litter/duff, and below-ground live biomass (below-ground nonliving plant material is considered in soil organic carbon).[1]

[1] The methods for deriving biomass values for seral states within forest and woodland ecosystems are included in Appendix 1 of the Baseline Carbon Assessment found in the planning record.

Current Conditions of Biomass Carbon Quantities

Ecological response units (ERUs) are used to measure carbon stocks, as defined in Terrestrial Ecosystems (p. 16) of this chapter (Table 52). Each ERU contributes differently to carbon stocks and their flux based on its spatial extent, vegetative community composition and structure, and ecosystem dynamics. Generally speaking, relative contributions to carbon stocks are lowest in grassland ERUs, with increasing contributions by shrubland, woodland, and forest ERUs, respectively.

Table 52. Major ERUs on the Carson National Forest in acres and percent

ERU	ERU Code	System Type	Acres	Percent
Alpine and Tundra	ALP	Shrubland/Grassland	9,996	0.6
Montane Subalpine Grassland	MSG	Grassland	125,351	7.9
Bristlecone Pine	BP	Forest	4,585	0.3
Spruce-Fir Forest	SFF	Forest	289,929	18.3
Mixed Conifer, with Aspen	MCW	Forest	130,959	8.3
Mixed Conifer, with Freq Fire	MCD	Forest	182,847	11.5
Ponderosa Pine Forest	PPF	Forest	312,900	19.7
Piñon-Juniper Woodland	PJO	Woodland	178,196	11.2
Piñon-Juniper Sagebrush	PJS	Woodland	217,326	13.7
Sagebrush	SAGE	Shrubland	59,144	3.7
		Totals	1,586,931[1]	100.0

The figures and tables presented in this section represent carbon stock for current conditions, reference conditions, and for select ERUs, modeled future conditions under current management intensities. Carbon stock values are presented below both by ERU and collectively for the Carson NF. As one might expect on an acre-for-acre basis, ALP has the least biomass carbon concentration historically (about 1 ton/ac), while SFF has the greatest (about 94 tons/ac). The remaining ERUs ranged from 4 to 92 tons per acre, with forest ERUs having the greatest concentrations, followed by woodland, shrubland, and grassland ERUs, respectively. On a per acre basis, the 10 ERUs in Table 53 are currently in the same ranking as reference in terms of carbon storage, with the exception of MCD, which has taken on considerably more biomass than reference. When also considering the relative abundance of ERUs, the ranking changes somewhat among ERUs, though SFF still has the greatest overall carbon and ALP the least, for both current and reference.

As demonstrated below, the current forest overall carbon stock is about 102 percent of reference (historic) conditions. While this increase suggests little change over reference conditions, a more

[1] The forest-wide total acreage is 19,383 acres more than the sum of all major ERUs. 11,388 of those ac are from Juniper Grass ERU (JUG - 0.7% of forest) and 7,700 ac are Sparsely Vegetated ERU (SVG – 0.5% of forest). Neither were assessed under Terrestrial Ecosystems, and future conditions were not modeled; however, they do contribute substantially to soil organic carbon and are included in that section below.

complete picture can be drawn by looking at relative contributions from individual ERUs. As illustrated in Table 53 and Figure 60, carbon stock has decreased somewhat in woodland ERUs (PJO and PJS) and in two of the forest ERUs (MCW and SFF), while increasing in the other two forest systems (PPF and MCD). Carbon increases coincide with fire-adapted (frequent fire) ecosystems, while decreases are coincident with those systems of low to moderate fire frequency. Carbon increases in the fire-adapted types are presumably associated with land use patterns, including the decades-long policy of fire suppression, and limited harvest of trees in the most recent years and decades. The reduction in woodland biomass may be associated, at least in part, with type conversions (chaining), where much of the overstory was removed. The higher elevation forested ERUs are still recovering from early to mid-20th century timber harvest that removed large trees.

Table 53. Reference and current conditions of relative biomass carbon stock (tons) by ecosystem response unit on the Carson National Forest

ERU Code	Reference Condition (tons)	Current Condition (tons)
ALP	10,416	10,977
MSG	527,864	464,261
BP	301,469	300,950
SFF	26,707,886	24,373,327
MCW	12,025,677	11,134,887
MCD	10,723,927	13,581,735
PPF	10,156,758	12,253,053
PJO	3,908,518	3,090,154
PJS	2,630,871	2,359,935
SAGE	291,474	375,221
Totals	67,284,860	67,944,500

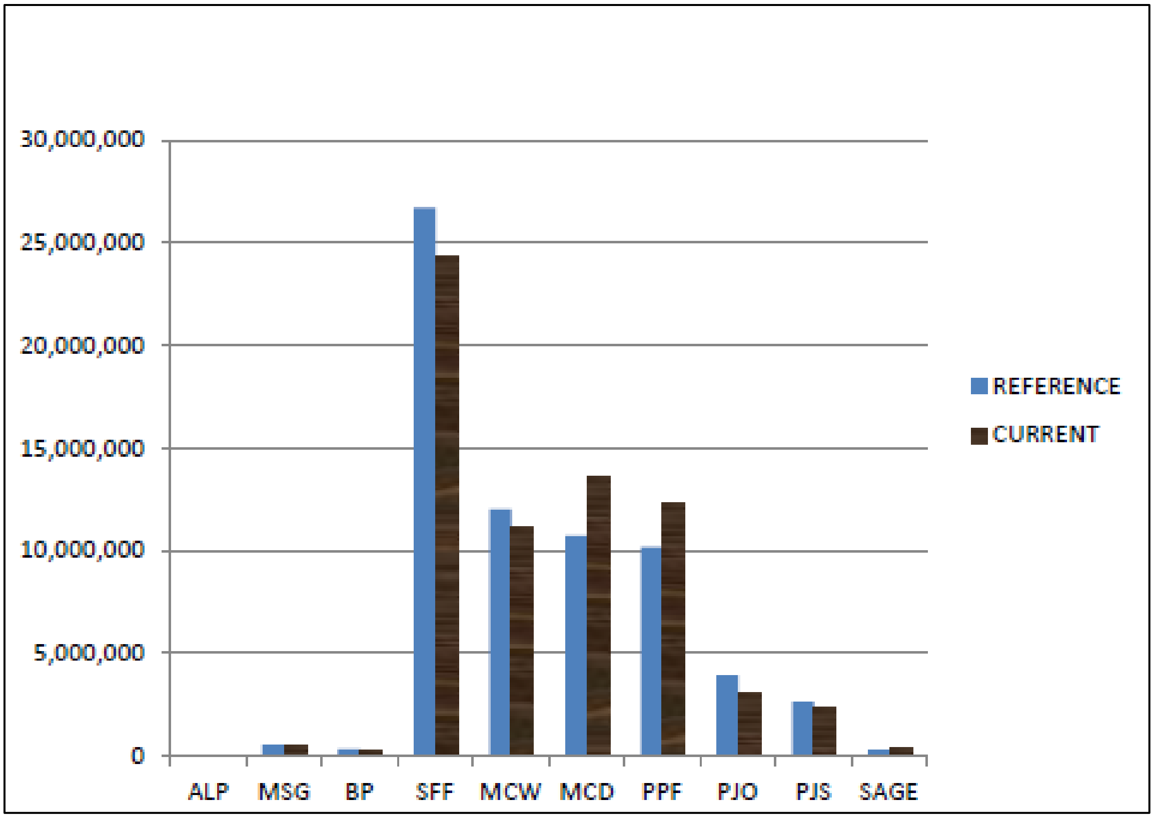


Figure 60. Reference and current conditions of relative biomass carbon stock (tons) by ecosystem response unit on the Carson National Forest

Also of note is the considerable shift in biomass regimes of the MSG and SAGE systems. In MSG, overall carbon has dropped significantly in part due to the decrease in amount of the most productive plant communities, increases in amount of low-productivity seral stages, and removal by grazing ungulates. The contemporary concentration of carbon in communities encroached by woody vegetation in the last century also represents a significant shift in biomass patterns within MSG. In the SAGE system, the amount of carbon has increased substantially, likely due to land use patterns of fire suppression and herbivory, which favor shrub development.

Future Trend

Many factors will influence future carbon stocks on the Carson NF, and this assessment is in no way a comprehensive accounting of all possible outcomes. Factors such as climate change, fire frequency and severity, and management budgets are all outside the span of control of Carson NF managers, and as such, only broad generalizations on these topics are provided. However, general ecosystem dynamics in southwestern systems are fairly well understood, and provide a good starting point for assessing trends in biomass carbon stocks. Forest and woodland conditions on the Carson NF have been modeled out into the future for most of the ERUs using State and Transition Modeling (STM), and assumptions based on current management and disturbance regimes. This allows the projecting of relative biomass carbon contributions through time for key ERUs.[1] Using past assumptions of stand development dynamics and management applications for future projections are inherently problematic in light of projected climate changes.

The general pattern of projected biomass carbon stock on the Carson NF (assuming continuation of current management patterns) is for an increase in total carbon storage in nearly all modeled ERUs above current conditions. Table 54 and Figure 61 depict 100-year projections for primary forest and woodland ERUs against current and reference conditions. These projections assume a continuation of current management, and are not reflective of changes in management that may emerge from the Carson NF's ongoing effort to revise its land management plan. However, these results do provide meaningful trend information with regards to biomass carbon storage in near future.

Table 54. Projected carbon stocks for major forest and woodland ecosystem response units on the Carson National Forest

ERU Code	Current Condition (tons)	Projected +100 Years (tons)	Projected +100yrs (% change from current)
MSG	464,261	631,257	36
SFF	24,373,327	27,397,317	12
MCW	11,134,887	11,319,335	2
MCD	13,581,735	13,236,878	-3
PPF	12,253,053	13,650,315	11
PJO	3,090,154	4,222,329	37
PJS	2,359,935	3,617,623	53
SAGE	375,221	366,993	-2.2

[1] A full description of process and methodology for projecting relative biomass carbon contributions through time are included in Appendix 1 of the Baseline Carbon Assessment found in the planning record.

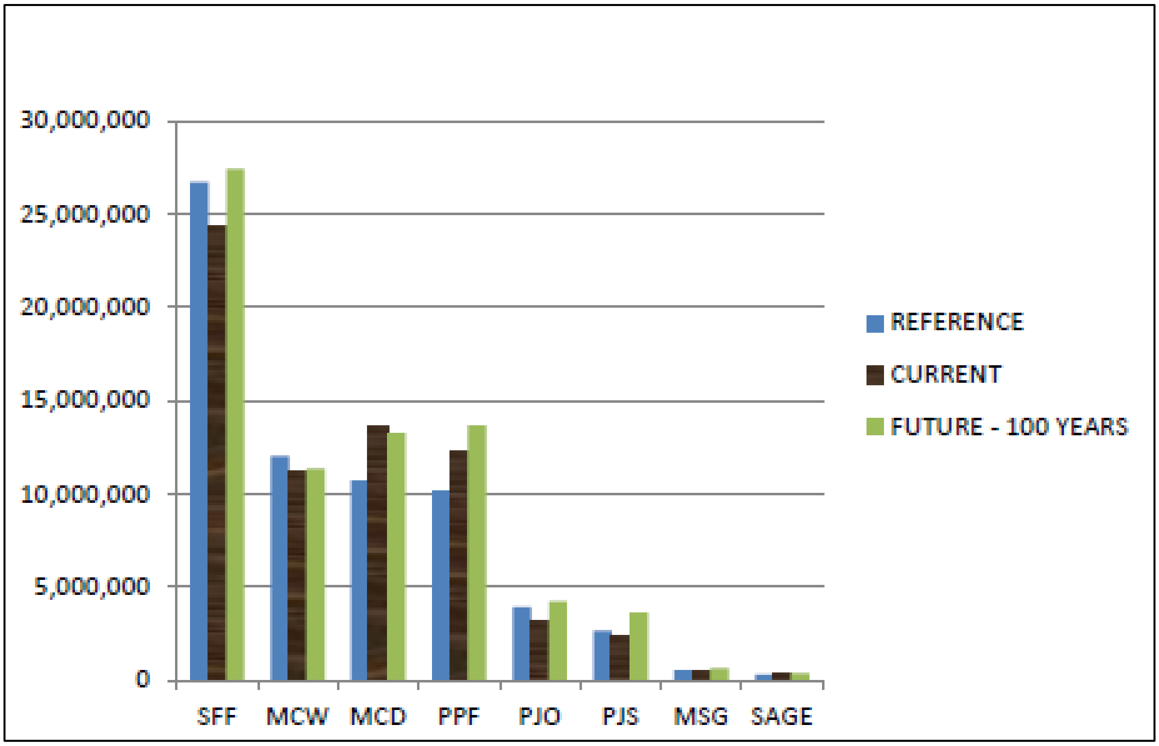


Figure 61. Trends in carbon stocks for major forest and woodland ecosystem response units on the Carson National Forest

In all cases except MCD, carbon stocks are projected to increase within the forest and woodland ERUs on the Carson NF. Results for MCD show a slight decrease. The most substantial increases are in the woodland systems, likely as a consequence of the trend toward lower fire frequency and minimal forest management such as harvest thinning. Here, PJS shows an increase of over 37 percent above reference condition, while PJO shows an increase of about 34 percent. While many factors work to drive these projected increases, two primary forces are noteworthy in this process, stand density and stand size.[1]

Current management does not appear to be at a level of intensification adequate to keep Carson NF systems at biomass levels commensurate with reference conditions, particularly in the cases of fire-adapted systems and SAGE. Current conditions and management trends favor closed canopy systems that in turn store more carbon than their open canopy counterparts. In ERUs showing increases, state-and-transition modeling suggests that current management intensities are not sufficient to overcome the current overrepresentation (in relation to reference conditions) of closed states, resulting in a continuation of excess carbon storage compared to reference conditions.

[1] Expressed in Forest Service-Southwestern Region modeling as stand cover class and stand size class, respectively.

Carbon Emissions

For the Carson NF assessment, carbon emissions have been characterized below by using a case study synthesis from the Apache-Sitgreaves NFs (Vegh et al. 2013), which is relevant to forested ecosystems of the Southwest generally, in terms of natural processes and common management activities. The study provides a surrogate solution for emissions assessment in lieu of emissions data and analysis specific to the Carson NF.

Background

To date there has been no binding commitment by the federal government or Forest Service for the regulation of carbon dioxide (CO_2), though there has been increasing activity at state and regional levels to control carbon emissions to the atmosphere, prompting regulation, voluntary carbon exchanges, and carbon inventory and monitoring programs (Wiedinmyer and Neff 2007). The Forest Service's Planning Rule directs forests to assessment baseline carbon stocks as part of the forest planning process (36 CFR 219.6(b)(4)), and though there are other carbon constituents released in wildfire and prescribed burning, CO_2 is the primary carbon compound and primary greenhouse gas associated with fire emissions (Table 55).

Table 55. Proportion of constituents of wildfire emissions for both greenhouse gases (GHG) and carbon compounds (NRC 2004)

Species	Proportion GHG	Proportion Carbon Constituents
Carbon dioxide	72.14	90.82
Water	21.18	
Carbon monoxide	5.57	7.02
Atmospheric particulate matter <2.5µ		0.60
Nitric oxide	0.39	
Methane	0.27	0.34
Volatile organic compounds	0.24	0.31
Organic Carbon		0.31
Non-methane hydrocarbon	0.20	0.25
Particulate matter > 10µ		0.22
Particulate matter <10µ and >2.5µ		0.11
Elemental carbon		0.03
	100.00	100.00

Though emissions by fire and other forest processes (e.g., methane from the decomposition of wood) have a relatively minor impact on carbon stocks and flux, atmosphere-based emissions are strongly impacted by biosphere-atmosphere carbon fluxes at regional scales, and represent the carbon component directly involved in the positive feedback of greenhouse gas forcing on climate change. In a given year in the Southwest, carbon emission from fire can exceed fossil fuel emissions at regional scales (Wiedinmyer and Neff 2007). In their study of fire emissions, Wiedinmyer and Neff found that on average carbon emissions were 4 to 6 percent of the total anthropogenic emissions for the United States. In a separate study, Woodbury et al. (2007) estimates that 10 percent of total anthropogenic emissions in the U.S. are captured by forest vegetation, suggesting forests can sequester more carbon than they emit and become an offsetting solution for anthropogenic emissions. The Intergovernmental Panel on Climate Change (IPCC) recognizes the potential for forest and woodland ecosystems, in particular, to perform climate change mitigation (IPCC 2007). In assessing carbon dynamics and emissions in the Southwest, Hurteau and others (e.g., Hurteau et al. 2008, North et al. 2009, Hurteau and North 2010) went further and proposed that large releases of carbon to the atmosphere could be minimized by reducing stand densities. Prior to the Apache-Sitgreaves study (presented below), it had been hypothesized, and shown through dynamical modeling and observation (Kobziar et al. 2009, Martinson and Omi 2013, Pollet and Omi 2002), that the reduction of stand densities precludes large pulses of wildfire emissions with a reduction in uncharacteristic fire, such as stand replacement fire in ponderosa pine forests. Preliminary research indicates that the sustainable management of forests, along with careful consideration of byproducts and management residues, would not only balance forest carbon stocks but could also partially mitigate global climate change through increased carbon storage.

Apache-Sitgreaves Study Overview

Recent research on carbon dynamics and emissions related to various conventional forest management activities, focused specifically on the Apache-Sitgreaves NFs in eastern Arizona and western New Mexico, provides surrogate information to guide National Forests of the Southwest in the assessment and management of carbon (Vegh et al. 2013). It is used here in lieu of a more specific analysis of carbon emissions for the Carson NF.

A key objective of the Apache-Sitgreaves study was to determine the long-term (100 years) difference in carbon stocks and carbon emissions between treated and untreated forest ecosystems. While the study was focused on the PPF ERU, the results can be abstracted to other forest and woodland ecosystem types for purposes of characterizing general trends among reference condition, no-action, and treatment scenarios, in terms of: (1) fire carbon emissions; (2) total (live and dead) above-ground biomass; and (3) live above-ground biomass. And while the Vegh and others study does not consider the effects of forest restoration per se (sensu R3 desired conditions), they do evaluate the effects of reduced tree densities on carbon stocks and flux.

Analysis

In their study, Vegh and others (2013) compare the effects of different management alternatives on overall carbon stocks and emissions. They apply three management alternatives – no action, light thinning, heavy thinning – to determine the overall management effects on carbon sequestration and emissions flux. The researchers used the Forest Vegetation Simulator (FVS) to model stand dynamics over a 100-year simulation and report outcomes for carbon stocks and emissions. For annual treatment in the analysis simulation, all suitable stands on the Apache-Sitgreaves NF were prioritized in order of the following conditions:

1. Wildland Urban Interface (WUI) areas in high departure plant communities
2. WUI areas in moderate departure plant communities
3. Non-WUI areas in high departure plant communities
4. Non-WUI areas in moderate departure plant communities
5. WUI areas in low departure plant communities
6. Non-WUI areas in low departure plant communities

In all cases, “departure” is a measure of similarity between the current and reference (historic) vegetation structure, with high departure reflecting vegetation heavily altered from past structural conditions, and low departure indicating a distribution of structural states that are highly similar to those we would have expected pre-European settlement. In the FVS simulations, individual stands were further prioritized for treatment according to basal area (BA) and quadratic mean diameter (QMD), so that stands with the greatest stocking (i.e., BA) and the smallest trees (i.e., QMD) would be given highest priority for treatment.

In their modeling, the investigators assumed conventional treatment scenarios and contemporary wildfire frequencies. Stands with a preponderance of trees over 16 inches in diameter were not included. Carbon emissions were estimated for wildfires, prescribed burning, and pile burning. In the simulations, all thinning harvests were followed by pile burning in the second year, and by broadcast burning in the tenth year. The researchers also assumed that trees would regenerate successfully after burning.

Findings and Discussion

In their results, Vegh and others (2013) report that carbon emissions and stocks are affected by both management alternatives and wildfire frequency. In the report, carbon stocks are divided into above-ground live biomass and total carbon occurring above- and below-ground, both live and dead. The following results were generated from the 100-year model simulation:

- The no-action alternative resulted in the lowest total carbon emissions, since no treatments would occur under this alternative. The alternatives with management treatments produced approximately five times the total carbon emissions of the no-action alternative.
- Carbon emissions by wildfire were lower in the treatment alternatives than in the no-action alternative, and wildfire emissions were lowest in the alternative with the greatest degree of thinning. Resulting wildfire emissions associated with the heavy thinning alternative were up to half the amount of emissions of the light thinning alternative, and about one third less than the no-action alternative.
- Total carbon stocks (above- and below-ground, live and dead) were lower in the treatment alternatives than in the no-action alternative, due to thinning and the removal of live tree biomass, assuming similar wildfire frequency and severity as the last three decades (1980-2009). The lowest carbon stocks were found in the heavy thinning alternative.

- Carbon stocks for live above-ground biomass alone were highest in the treatment alternatives, particularly in the second half of the simulation, due to the accumulation of carbon in large fire-resistant trees.

In conclusion at a landscape scale, total above-ground carbon stocks would remain somewhat higher in the treatment scenarios than in the reference condition, because of the number of untreated plant communities and because of a lower overall fire frequency compared to reference (due to fire suppression activities and loss of fine fuels in some ecological systems).

Implications of Biomass Conditions for Future Forest Management

Similar to implications of biomass conditions and resource management, the research synthesis on carbon emissions convey significant trade-offs among potential carbons strategies. Although the total carbon emissions were higher for the harvest alternatives in the study considered here (Vegh et al. 2013), thinning and fuels reduction did reveal lower wildfire emissions and reduced risk of uncharacteristic wildfire. The study also suggests that, in the long term, systematic thinning and burning ultimately lead to greater live above-ground sequestration. It is also important to keep in mind that the Apache-Sitgreaves NF is starting with uncharacteristically high levels of biomass on the heels of a century of fire suppression, and that strategies to maximize carbon sequestration and sustain carbon stores are not necessarily compatible (Hurteau and Wiedinmyer 2010). The indirect goal of contemporary management goals is to reduce, at least in part, current carbon stocks to pre-settlement levels.

In the future, the benefits to reduced emissions and increased carbon sequestration may be more pronounced. First, live trees continually sequester carbon and are a more stable carbon sink than dead biomass, particularly when generated by uncharacteristic fire, insect outbreaks, drought, and other stress. Therefore, proactive management and broad-scale fuel reduction may be preferable for the long-term mitigation of atmospheric carbon. Second, there is the related issue of trees regenerating poorly or not at all following uncharacteristic fire in some forest types (Savage and Mast 2005). Others investigators (Dore et al. 2008) also show that poor regeneration after stand replacement fire in ponderosa pine can render plant communities as carbon sinks for many years after the fire, casting further doubt on the sustainability of a strategy that intends to maximize sequestration, while indirectly promoting uncharacteristic fire and reduced ecosystem productivity (Hurteau and Wiedinmyer 2010).

The Apache-Sitgreaves study by no means represents a comprehensive analysis of the carbon emissions involved with forest management scenarios. A full accounting would include emissions involved in the harvest, transfer, and processing of any wood products, along with the sequestration and decomposition of those products and other forest residues, and the emissions involved with the associated energy consumption (Cameron et al. 2013). Cameron and others determined, on a 100-year model simulation, that even with an industrial forestry theme that the ratio of storage to emissions was 0.58. They also showed that if wood destined for paper and pulp was instead redirected to less lucrative biomass consumption that the storage ratio could increase substantially to 2.7.

Also for consideration are the effects by increased CO_2 levels on vegetation productivity and the potential for negative feedback by emissions on climate forcing. Such a feedback loop would involve carbon emitting processes, increased CO_2 levels and fertilization of the atmosphere, followed by an increase in vegetation production and increased carbon capture and sequestration (mitigation). Some research indicates that vegetation productivity does increase with elevated

CO_2 levels, but productivity rates soon level off as other factors appear to compete with the growth benefits (Archer 2011; Penuelas et al. 2011).

Finally, some have forwarded the notion of carbon carrying capacity as a potential foundation for carbon management plans (Keith et al. 2009, 2010; Hurteau et al. 2010). Carbon carrying capacity is the maximum amount of above-ground carbon that can be sustainably stored, according to climatic conditions and the disturbance regime of a system. Carbon carrying capacity may be a useful consideration for optimizing carbon stocks according to the inherent capabilities and processes of a given ecosystem.

Soil Organic Carbon

Soil organic carbon (SOC) is the energy source for soil organisms that, through their activity and interactions with mineral matter, impart the structure to soil that affects its stability and its capacity to provide water, air, and nutrients to plant roots. The amount and kind of soil organic carbon reflects and controls soil development and ultimately ecosystem productivity (Van Cleve and Powers 1995).

Globally, SOC contains more than three times as much carbon as either the atmosphere or terrestrial vegetation (Schmidt et al. 2011). Forest soils are a critical part of any forest carbon accounting effort. Forest soils are the largest active terrestrial carbon pool and account for 34 percent of the global soil carbon pool (Bucholtz et al. 2013). Accurate quantification of regional SOC stocks is a necessary component of atmospheric CO_2, soil productivity and global climate change models. Soils represent a significant portion of the active carbon cycle, with estimates of organic carbon on the order of 1500 to 2000 petegrams of carbon, or roughly two-thirds of the terrestrial organic carbon stocks (Rasmussen 2006).

Attempts to characterize regional SOC stocks include both ecosystem and soil taxa based approaches. The ecosystem approach involves averaging SOC data within a specific plant community or biome and multiplying the average SOC content by the estimated biome land area (Rasmussen 2006). This approach does not account for soil spatial heterogeneity, and results in large variability of SOC estimations within an ecosystem or biome.

The soil taxa approach has been extensively described in the soil science literature (Rasmussen 2006) and includes segregating landscapes by soil taxa (instead of biomes) and using average taxa SOC and estimated land area to calculate SOC stocks.

The process used for the Carson NF SOC stock assessment involves the aggregation of terrestrial ecological units (soil/vegetation/climate) into ERUs that represent the major terrestrial and riparian ecosystems on the Carson NF.

Methods

The Carson NF has a wide variety of soils that support many different ecosystems. These soils originated from igneous, sedimentary, and metamorphic geologic sources, and occur on a wide array of landforms of varying age. Soil weathering by various climates and supporting diverse plant communities leads to the development of SOC.

For this assessment, SOC was calculated from three sources. Soil pedons that were selected for physical and chemical characterization during the Carson NF and Santa Fe NF Terrestrial Ecosystem Surveys (USDA FS Carson NF 1987; USDA FS Santa Fe NF 1993) and the Valles

Caldera National Preserve Terrestrial Ecological Unit Inventory (USDA FS 2012) were used to establish average SOC reference values for ERUs that have similar life zones, vegetation and lithology. The soil pedons chosen for analysis are representative of the major kind of soil for that ERU. Other kinds of soil may also occur within ERUs; however, their proportion is minor relative to the representative pedon that was sampled and characterized.

Another source of SOC data came from the USDA-NRCS, National Soil Survey Office, Geospatial Research Unit at West Virginia University. The data was compiled from the Rapid Soil Carbon Assessment project initiated by the NRCS and gridded soil survey data (gSURGGO 2015). The minimum, maximum, average and median SOC values were calculated for each ERU.

Ecological response units were intersected with polygons from the gSURGGO data and site-specific pedon data and values for soil organic carbon were calculated for a depth of 0-100cm. These values were normalized and compared to established reference values of characterized pedons of similar soils and vegetation communities.

Bulk density was derived from both sampled pedon data and representative values from known soil textures.

Current Condition of Soil Organic Carbon

Soil organic carbon by ERU is provided in Table 56. The Herbaceous Riparian (HERB) and MSG ERUs have the greatest amount of SOC per acre. Grasslands and specifically montane grasslands are known to process organic matter into organic carbon rapidly due moist climate conditions. Soils with thick, dark surface and subsurface horizon yield Mollisols that are characteristically grassland soils. Where MSG is dominated by bunch grass fescues and muhly species, it is generally supported by very productive Haploborolls, Argiborolls and Cryoborolls.

Forested systems of the upper montane life zone, such as the MCW ERU, also produce high amounts of SOC. Largely due to the favorable climate and soils with high productivity, the biomass of mixed conifer and deciduous species in this life zone is perhaps the greatest of all forested ERUs.

With respect to total quantity, the total tons of SOC are greatest in the PPF ERU, primarily due to the vast acreages of this ecosystem on the Carson NF. The PPF, MSG, MCD, MCW, and SFF ERUs account for 81 percent (>62 million tons) of the total amount of SOC for the Carson NF.

The lowest amount of soil organic carbon is contained in the Rio Grande Cottonwood-Shrub (RGCS) riparian ERU. These riparian areas historically experienced significant amounts of disturbances (e.g., flooding), and the above ground biomass productivity is very dynamic. Soils are typically young Entisols or Inceptisols with little to no soil development. The process of accumulating and assimilating SOC in this ecosystem is very rapid. Due to the coarse soil textures and high gravel content, soil organic matter passes quickly through the soil profile resulting in low SOC accumulation.

Table 56. Total tons and tons per acre of soil organic carbon (SOC) by ecological response unit on the Carson National Forest

Ecosystem Response Unit (ERU)	ERU Code	Total Tons of SOC 0-100 cm	Tons/Acre of SOC 0-100 cm
Alpine and Tundra	ALP	127,492	13
Montane Subalpine Grassland	MSG	11,484,791	92
Bristlecone Pine	BP	77,063	17
Spruce-Fir Forest	SFF	10,401,487	36
Mixed Conifer, with Aspen	MCW	10,888,892	83
Mixed Conifer, with Frequent Fire	MCD	11,240,759	61
Ponderosa Pine Forest	PPF	18,454,273	59
Piñon- Juniper Woodland	PJO	4,501,648	25
Piñon-Juniper Sagebrush	PJS	5,097,525	23
Sagebrush	SAGE	641,021	11
Juniper Grass	JUG	267,113	23
Riparian Herbaceous	HERB	3,378,144	93
Willow-Thinleaf Alder	WTLA	133,293	14
Upper Montane Conifer-Willow	UMCW	24,925	16
Narrowleaf Cottonwood-Spruce	NSPR	59,089	14
Narrowleaf Cottonwood-Shrub	NSHR	31,405	17
Rio Grande Cottonwood-Shrub	RGCS	29,884	10
Sparsely Vegetated	SVG	99,811	13
Grand Total		76,941,693	631

Comparison of Results to Other Studies

The soil organic carbon for this analysis was compared to other studies in the southwestern United States. Rasmussen (2006) identified a range of SOC from piñon-juniper ecosystems in Arizona from 5.3-10.7 Kg/M^2. The values within the JUG, PJS, and PJO ERUs for the Carson NF soil organic carbon assessment range from 5-6 Kg/M^2 (Table 57).

Within PPF, the Carson NF values for SOC are approximately 13 Kg/m2, which are similar, although on the higher end, to previously reported values ranging from 3.4-13.5 Kg/M2 in Arizona (Rasmussen 2006).

Meurisse and others (1997) reported approximately 12 and 25 tons/acre of SOC for southwestern piñon-juniper and ponderosa pine ecosystems, respectively. These values are somewhat lower than those reported within this assessment. The difference is primarily due to the varying lithology supporting these ecosystems and differences in the sample load for the analysis.

Table 57. Soil organic carbon for the Carson National Forest by ecological response unit

ERU Code	SOC 0-100 cm (g/m^2)	SOC 0-100 cm (kg/m^2)	Acres	SOC 0-100 cm (tons)	SOC 0-100 cm (tons/acre)	SOC 0-100 cm (teragrams)
ALP	2,859	3	9,996	127,492	13	0.12
MSG	20,538	21	125,351	11,484791	92	10.42
BP	3,768	4	4,585	77,063	17	-.07
SFF	8,042	8	289,929	10,401,487	36	9.44
MCW	18,639	19	130,959	10,888,892	83	9.88
MCD	13,781	14	182,847	11,240,759	61	10.20
PPF	13,221	13	312,900	18,454,273	59	16.74
PJO	5,663	6	178,196	4,501,648	25	4.08
PJS	5,258	5	217,326	5,097,525	23	4.62
SAGE	2,430	2	59,144	641,021	11	0.58
JUG	5,258	5	11,388	267,113	23	0.24
HERB	20,815	21	36,381	3,378,144	93	3.06
WTLA	3,193	3	9,357	133,293	14	0.12
UMCW	3,534	4	1,581	24,925	16	0.02
NSPR	3,193	3	4,148	59,089	14	0.05
NSHR	3,872	4	1,818	31,405	17	0.03
RGCS	2,210	2	3,031	29,884	10	0.03
Sparsely Vegetated (SFM)	2,906	3	7,700	99,811	13	0.09

The total amount of soil organic carbon on the Carson NF is approximately 69 teragrams, which is lower than other tree dominated national forests in other northern regions (Farr 2014). The SOC for global temperate forests ranges from 84-152 Tg of SOC.

Integration and Risk Assessment

The integration of risk synthesizes risk to all resources at the plan and local scales and incorporates any additional deviation caused by stressors not already addressed by the trend analysis. The incorporation of stressors is not calculated explicitly, but is implied by relative vulnerability to climate change (Table 58). Very high and potentially moderate climate change vulnerability would act as a major stressor, resulting in potential to high risk for most systems in all local zones. A major stressor intensifies risk, as illustrated by the expanded risk matrix (Figure 62). Two new categories emerge under the influence of stressors, "potential risk" (orange) where risk is low but stressors may have an influence in the future, and "likely high risk" (dark red) where risk and stressors compound each other. Black cells represent the unachievable combination of no deviation with a trend toward less deviation.

Departure from Reference Condition	Major Stressor(s)	Trend: Toward Reference Condition	Trend: Stable	Trend: Away from Reference Condition
Significant Departure	NO	Risk Addressed	Legacy of Past Mgmt OR Deviation due to Current Mgmt	Potential for High Risk
Significant Departure	YES	Potential Risk	Potential for High Risk	Likely High Risk
No Significant Departure	NO		No Risk	Potential Risk
No Significant Departure	YES		Potential Risk	Potential for High Risk

Major system stressor is a stressor or combination of stressors that would likely lead to a significant departure from reference condition **NOT addressed in trend determination** (e.g., high ecosystem vulnerability to projected climate change).

Figure 62. Risk matrix including influence from major stressors

Table 58 summarizes the risk for all resource areas by local zone, with added effects of climate change as a stressor. Colors represent relative overall vulnerability (**green** = low, **yellow** = moderate, **red** = high). A percent in a cell represents the proportion of an ERU contained within that local zone. The ERU proportion is only shown for those local zones containing more than 25 percent of an ERU to highlight the contribution of that local zone to the overall risk in an ERU. Forest-wide risk for each ecological resource can be evaluated by looking horizontally at risk for each local zone, while considering the contribution to risk from each zone (the percent of the ERU in that zone).

Risk in riparian ERUs is not refined to the local scale, because there is insufficient data to do so. Therefore, risk ratings for riparian ERUs are forest-wide averages. No attempt was made to rate local zones individually. Aquatic ecosystem risk is summarized by aggregating HUC 12 sub-watershed ratings. Local zones were divided along sub-watershed boundaries so that each sub-watershed falls in only one local zone. In most cases, HUC 10 watersheds also fall into a single local zone. For key ecosystem characteristics that were only assessed at the HUC 10 watershed level (i.e., representativeness and redundancy), the summary by local zone accounts for only the proportion of the watershed that overlaps that zone (see Table 32, p. 195 for the crosswalk).

Climate change vulnerability is summarized both by terrestrial ERU ("Climate" column in) and by local zone (bottom row of Table 58).

Overall climate change vulnerability is rated as **low**, **moderate**, or **high** based on the distribution of vulnerability among low, moderate, high, and very high classes reported in the Regional Climate Change Vulnerability Assessment (USDA FS 2014a). Numbers in the climate cells correspond to the percent in each class. See Climate Change Vulnerability Assessment (CCVA) section (p. 280) of this report for a full description. Vulnerability to other stressors is not quantified, but they may include uncharacteristic wildfire, uncharacteristic insects and diseases, invasive species, and groundwater depletion, all of which would be exacerbated by climate change.

Table 58. Risk for all resource areas by local zone, with added effects of climate change as a stressor

	Ecological Resource	Ji	Cb	Rc	Vc	Rg	Rr	Vv	Cr	Climate
Vegetation (includes soils)	Alpine & tundra	N/A[1]	N/A	N/A	N/A	N/A	46%	N/A	49%	
	Montane subalpine grasslands	N/A	62%			N/A				86-13-0-0
	Bristlecone Pine	N/A	N/A	N/A	N/A	N/A	N/A	60%	N/A	
	Spruce-Fir Forest	N/A				N/A	26%		38%	12-60-25-2
	Mixed Conifer w/ Aspen	N/A				N/A	27%		42%	48-48-4-0
	Mixed Conifer w/ Frequent Fire	N/A			30%	N/A			38%	61-37-2-0
	Ponderosa Pine Forest				31%					25-48-22-4
	Pinon-Juniper Woodland	40%		31%				N/A		45-54-1-0

[1] N/A = Not Applicable or Not Assessed

	Ecological Resource	Ji	Cb	Rc	Vc	Rg	Rr	Vv	Cr	Climate
	Pinon-Juniper Sagebrush		N/A	26%		44%		N/A		2-39-38-22
	Sagebrush	30%	N/A		N/A	67%	N/A	N/A		86-14-0-0
Riparian (includes soils)	Herbaceous Riparian		36%							
	Upper-Montane Conifer Willow	N/A				N/A	N/A	N/A	61%	
	Willow-Thinleaf Alder					N/A	50%			
	Narrowleaf Cottonwood-Spruce	N/A	N/A	N/A		N/A		N/A	75%	
	Narrowleaf Cottonwood Shrub	N/A		N/A		N/A		N/A	79%	
	Rio Grande Cottonwood Shrub		N/A	41%		34%	N/A	N/A	N/A	
Aquatic Ecosystems	Aquatic biota	N/A								
	Stream distribution	N/A								
	Water quantity & quality									
	Waterbody distribution									
	Seep/spring distribution									
	Seep/spring development									
	Groundwater									
	Watersheds									
	Number of at-risk species	13	23	24	25	15	22	20	24	
	Air									

	Ecological Resource	Ji	Cb	Rc	Vc	Rg	Rr	Vv	Cr	Climate
	Climate change	6-56-31-8	67-26-6-1	45-36-11-8	35-52-12-1	28-23-31-18	37-47-12-4	38-50-9-3	24-54-18-4	

Forest-wide Risk

In general, risk is similar across local zones on the Carson NF. Greater variation occurs among systems (i.e., from ERU to ERU or between streams and groundwater), but most systems have similar risk throughout the plan area. Some risk is due to factors external to Forest Service management. For example, the influence of climate or water withdrawal on private land or state managed game populations. Some risk is a legacy of past management practices (either by the Forest Service, other landowners, or a combination), such as fire suppression, widespread timber harvesting, or overgrazing. Other risks are the result of or influenced by actions that are under the control of the Carson NF.

In the past, management was focused at a project area scale (less than several thousand acres). There is a recent regional trend toward emphasizing landscape level coordination of management (an order of magnitude larger, where multiple related projects treat a watershed or other naturally defined area as a whole). In many cases, Forest Service management alone is unable to effectively address risks at the landscape scale, due to a lack of workforce and financial capacity, land ownership, or management authority. An area or system at high risk does not automatically become a management priority, since the Forest Service may not have authority or control over the cause of that risk. Even when the Forest Service does have authority and control, risk will not dictate management priorities, since some areas with overall lower risk may provide important opportunities for successful restoration of those systems that are departed forest-wide.

Frequent Fire Ecosystems

Fire dependent ERUs are at high risk. PPF and MCD are the most departed ERUs, with stand structure and function that are no longer being maintained by frequent low intensity fire. Unmanaged grazing during 19^{th} and early 20^{th} century removed fuel to carry fire; 20^{th} century fire suppression limited fire spread; and timber harvesting removed many old, fire resistant trees. Patchy, multi-aged stands have been replaced by homogeneous, denser, younger ones that are prone to uncharacteristic, stand replacing wildfire. Current management does not adequately restore multi-aged, open stands that burn frequently. Treatments are limited by workforce capacity and current forest plan standards that are very prescriptive and set certain diameter limits in Mexican spotted owl and northern goshawk habitat. Acres burned are limited by smoke regulations, workforce capacity, and concerns over public safety and values at risk.

Risk at the context scale is similar to risk at the plan scale. Wildland urban interface is a greater concern off-forest and may further restrict management options at the context scale.

Encroachment and Infill

Encroachment and infill by woody species, lower grass cover, and reduced nutrient cycling, together increase risk in lower elevation ERUs. Much of this risk is driven by legacy or climatic influences, but is compounded by grazing. In the past, the Carson NF chained piñon pine and juniper trees followed by seeding to reestablish grass cover. Currently, prescribed fire and thinning treatments remove some encroaching or infilling trees, and sagebrush mowing restores some grasslands, but substantially more treatment would be required to restore historic conditions.

Piñon-juniper systems are slightly more departed at the plan scale than at the context scale, while the SAGE ERU is less departed (mainly due to less tree encroachment); however, sagebrush has invaded grasslands in large swaths of the context landscape. The sources of this variability are not clear, but most of the lower elevation areas of the forest are and have been inhabited by people, and have been impacted by wood gathering, roads, water diversion, and grazing. More remote areas in the context landscape are likely in better condition.

Grass Cover

The grass layer in many ERUs is less productive, partially due to legacy grazing, induced shifts in species composition, and the continuation of combined wild and domestic ungulate grazing. However, the main cause of loss of grass cover is competition from overabundant woody species. The focus of many management actions is to increase available grass cover for livestock forage and soil protection, but the limitations on reducing tree densities described above also mean that openings that could support grass are not being created. Larger prescribed burns and mechanical or chemical sagebrush treatments have restored some grass systems, particularly in the Rio Chama and Jicarilla zones. Adaptive range management has empowered the forest to work with permittees to adjust authorized livestock numbers and the season of use. Invasive and introduced plant species have the potential to out-compete native grasses, and in some areas they have become well established.

Risk to grass cover is probably similar at the context and plan scales, though current condition is influenced by the level of human use and may therefore be more departed on the Carson NF where small land dependent communities are common.

Aspen

Aspen as a cover type is well represented; however, regeneration is limited due to infrequent fire and some recent mortality from chronic defoliation by western tent caterpillar and large aspen tortrix. The lack of maintenance or regenerative fire has resulted in few newly established stands and increasing dominance by understory conifers in old stands. Without sufficient disturbance, the current levels of ungulate browsing are further inhibiting regenerative success. As a secondary objective, many forest management activities seek to improve aspen stand conditions for wildlife habitat, water retention, fire hazard reduction, and visual quality. While SFF and MCW are at low risk, treatments in these ERUs that could stimulate aspen regeneration and mimic historic patch size are limited by an emphasis on uneven-aged treatment management.

In the Colorado portion of the context scale there may be more aspen disease and decline than what has so far been observed at the plan scale. Aspen is common at the plan scale and mortality is not as high as it has been in some areas of the western United States, suggesting the Carson NF may play an important role in maintaining functional aspen systems at the context scale.

Water

Surface water is at risk across much of the Carson NF, due to temperature, turbidity, and abundant spring development. Water quantity is largely outside the Carson NF’s ability or authority to affect, as it is mainly influenced by climate and off-forest withdrawals. The Carson NF does affect water quality through road density, road condition, grazing, and overall watershed condition. The number and location of open roads is managed under travel management decisions made on the forest between 2010 and 2013 that prohibit driving any type of motor vehicle on closed roads and motorized cross-country travel. Enforcement capacity is limited and impacts from illegal vehicle use and unreclaimed closed or legacy roads are substantial in some locations. Grazing by livestock and wildlife degrades stream and riparian function in places, and contributes to water quality degradation. Wildlife populations are managed by the NMDGF, not by the Carson NF, but big game populations especially, can have an impact on riparian vegetation at the plan scale. Improvements have been made to domestic livestock grazing practices, and multiple effective stream protection and restoration projects have been implemented across the Carson NF. Still, many streams do not meet state water quality standards. Watershed condition affects sedimentation, runoff, infiltration, stream channel shape and function, and threats that can have secondary impacts on water quality like severe wildfire. To the extent that the Carson NF influences the vegetation conditions already discussed, it in turn affects water quality.

Risk to waterbodies is a function of their natural or anthropogenically altered distribution, and human development in some cases may lead to greater abundance, and overall lower risk. However, tanks constructed for livestock and wildlife use also alter hydrology by impounding and concentrating surface or subsurface flows and dewatering associated wetland areas in some cases. This alteration of waterbodies may also concentrate grazing pressure in these areas leading to water quality, soil, and vegetation impacts.

Water withdrawals from both surface water diversion and groundwater are not currently a widespread concern, but off-forest groundwater pumping may exceed recharge in the future. Surface water withdrawal is expected to remain steady as stream flows continue to decline. The Carson NF does not regulate withdrawal, but can manage watershed function to maintain and improve water retention and infiltration.

The Carson NF is a vital source of surface and groundwater at the context scale. The risks to water at the plan scale are similar or magnified at the context scale. Water use is concentrated off the forest, while snowpack and recharge occur mainly at higher elevations on the Carson NF. Because of the interconnectedness of the resource, risk at either scale effects condition at the other. Throughout the Southwest, the water resource is at high risk from climate change impacts and the increasing likelihood of drought.

Riparian and Aquatic Ecosystems

Despite departure in surface water quantity and timing, aquatic biota and riparian systems are able to maintain some of their function, though both are generally impaired. Riparian ERUs that occur in upper elevation watersheds are at less risk than those that occur downstream, where human impacts are greater. Impacts from livestock grazing are focused, historically and currently, at lower elevations closer to human settlements and where growing seasons are longer. Water is more abundant and less concentrated at higher elevations, and agriculture and other extractive uses occur mainly in lower, warmer valleys. Invasive and introduced species can impair riparian function and stream habitat. Restoration projects on the Carson NF include building exclosures and induced meanders, removing non-native fish species, and invasive species control.

Risks at the context scale are higher than risks at the plan scale, since they are compounded by additional human use near communities and on private land.

Soils

Soils at lower elevations (PPF ERU and lower) are at greater risk than those at higher elevations, since lower soils have substantially reduced soil function from the combination of less effective vegetative groundcover and a shift from perennial to annual plants and shallow rooted grasses or tap-rooted woody species. Where they have become established, invasive and introduced plants generally provide less total cover, soil stability, and soil protection.

Overall risk is probably similar at the context scale, though some areas in the context landscape have been more impacted by development than any place on the Carson NF.

Species Habitat

The threats discussed above to ecosystems also threaten species associated with those ecosystems due to alteration of habitat features. Specific habitat features that were identified as being threatened include: tree features (cavities, snags, leaves, bark, downed logs, leaf or forest litter); rock features (canyons, cliffs, crevices, and outcrops); aquatic features (riparian areas, springs, and, permanent water); grassland features (alpine, tundra, meadows, small openings, other grassland); and soil features (soil type, soil permeability, and soil condition). Additional species threats that are not linked to a particular ecosystem include harassment, invasive/ introduced species, disease, parasitism, obstruction, and predation.

The risk to species habitat is higher at the context scale overall than it is on the Carson NF. Ecosystems on the forest are managed to maintain habitat and to protect important habitat features, which is not necessarily the case in all parts of the context landscape.

Climate Change

Climate change is influenced by external factors, but will intensify the risk to ecosystem integrity in all systems. In response the Carson NF can implement adaptive management strategies; anticipate increased disturbance; maintain and restore resilient native ecosystems; increase water conservation and plan for reduced supply; and anticipate increased recreational use. Currently, monitoring for climate change resiliency is insufficient due to a lack of capacity and a focus on implementing projects.

The magnitude of climate change will be similar at the plan and context scales, though local impacts on ecosystem integrity will depend on the condition and adaptive capacity of the particular ecosystem.

Risk by Local Zone

Jicarilla (Ji)

The Jicarilla local zone is drier and less diverse than most of the forest. Soils and stream sedimentation are at risk, since most of the zone is low elevation and covered by ERUs that are less resilient. Water bodies are at high risk because they are uncommon, and not evenly distributed. There are the fewest number of at-risk species because there is the least habitat variety. Air is at higher risk than anywhere else on the forest, due to the combination of upwind coal fired power plants (mercury), oil and gas development (VOCs), and a history of high ozone levels. The larger area, which includes the Jicarilla zone, could fall into non-attainment for ozone concentration, if the standard is lowered.

Vulnerability to climate change is high, particularly in PPF, where 86 percent is highly or very highly vulnerable. Drought will further stress water resources, while fugitive dust and wildfire smoke may degrade air quality.

Cruces Basin (Cb)

The Cruces Basin local zone is one of the lower risk local zones on the Carson NF. It is predominantly high elevation, with 21 percent protected as wilderness. Much of the zone is north-facing, making it one of the wetter areas on the forest. It also sees less visitation pressure. However, on its southern end, there are large amounts of MCD that are at high risk of damaging wildfire. With an abundance of MSG and the most HERB of any zone, the majority of Cruces Basin is grazed by livestock and many seeps and springs have been developed. Vulnerability to climate change is lower than anywhere else on the Carson NF, though SFF vulnerability is moderate to high. Detrimental impacts from insects and diseases are likely to continue or intensify.

Rio Chama (Rc)

The Rio Chama local zone is dominated by PPF, PJO, and PJS, all of which are at moderate to high risk. It has one of the main concentrations of PJO on the forest, and PJO is at higher risk here than in any other zone. The piñon pine *Ips* outbreak was centered here, so recent insect and disease damage has been dramatic, but future risk may be lower as a result. Still, groundcover in PJO is highly departed, and soils are at risk. Aspen mortality from a combination of drought and chronic defoliation by western tent caterpillar has also been widespread, and aspen condition is seriously degraded and at risk. The Rio Chama zone also has the highest concentration of RGCS, which is at high risk.

Climate change vulnerability is moderate overall, and is actually lower than much of the forest in most ERUs. However, PJS vulnerability is extremely high, which may mean additional insect and disease mortality, loss of grass cover, and continued soil degradation.

Vallecitos (Vc)

The Vallecitos local zone contains large amounts of at-risk, frequent fire PPF and MCD. MSG is at high risk, due to more tree encroachment than in other parts of the forest, reduced groundcover, shifts in species composition, and degraded soils. The Vallecitos zone has the greatest number of species at-risk.

Climate change vulnerability is moderate, and for PPF, may be slightly lower than in the rest of the plan area.

Rio Grande (Rg)

The Rio Grande is another local zone with relatively low risk. It is low elevation, low relief, and dry, with a very deep water table at the level of the Rio Grande (the river), hundreds of feet below. Most springs are in steep, inaccessible canyons, and have not been developed. Most of the SAGE ERU occurs here, and it is at lower risk than SAGE elsewhere, because of less tree encroachment

Climate change vulnerability is the highest of any local zone, though vulnerability in SAGE is very low. Grass cover may continue to decrease and soil condition to degrade.

Red River (Rr)

Much of the Red River local zone is wilderness (47%), but it is also one of the most heavily used areas of the Carson NF. Aquatic biota is at high risk with high levels of invasive species, diseases, and stream impairments, due to concentrated recreation, roads, and mining impacts. High elevation ERUs are common and at low risk. MSG is at higher risk than on most parts of the Carson NF, because grass cover and species composition are significantly departed, and soils are degraded.

Climate change vulnerability is moderate, and patterns are similar to those that occur forest-wide. However, Red River contains nearly 50 percent of the ALP on the Carson NF. Vulnerability of ALP to climate change was not modeled, but is known to be very high, since its range is limited to only the highest elevations.

Valle Vidal (Vv)

The Valle Vidal local zone is unique on the Carson NF, in that it has very little development, either from communities or industry. There are few ground water withdrawals in the surrounding area, and watershed condition overall is good. Most water is free flowing, unlike in many parts of the Carson NF, and while wetlands and playas are common, standing water is not. Water bodies that do exist are at risk, because they are uncommon and not uniformly distributed. There are large expanses of MSG and riparian HERB and WTLA. The greatest concentration of BP on the Carson NF occurs here.

Climate change vulnerability is moderate, and patterns are similar to those that occur forest-wide.

Camino Real (Cr)

The Camino Real is the largest local zone, with the greatest habitat diversity. It ranges from ALP and BP ERUs in the Pecos Wilderness to SAGE in the southeastern valleys. The Camino Real is 7 percent in wilderness. It supports probably the most pristine watershed on the forest, in the Headwaters Rio Santa Barbara, as well as 32 unincorporated communities within the forest boundary and their associated stream diversions. Camino Real is one of the few areas of the forest with significant stream dewatering on the forest, though most withdrawals actually occur on private inholdings. It contains the majority of high elevation ERUs, and the most UMCW and narrowleaf cottonwood riparian. It is unremarkable in terms of risk, though smaller high risk areas are probably balanced by lower risk areas overall, because of its size.

As the most southerly local zone, the Camino Real has high vulnerability to climate change, especially in higher elevation ERUs (MSG, SFF, MCW, MCD, and PPF), which are all more vulnerable than on the Carson NF, as a whole. While ALP vulnerability was not modeled, it is at very high risk everywhere on the Carson NF, because it is limited by elevation. The Camino Real has the most ALP at the plan scale. Increasing fire, insects, and disease will exacerbate risk, and drought is likely to impact riparian systems, stream habitat, and downstream water uses.

III. Social and Economic Sustainability and Multiple Uses

The Carson National Forest (NF) not only provides ecological sustainability through the natural resources the forest manages, but it also contributes to social and economic sustainability as they relate to the human environment. This means that people are just as affected by forest management as are the forest resources that are managed by the Forest Service. For example, people benefit either directly or indirectly by the multiple uses, ecosystem services, and Forest Service management and presence the Carson NF provides. Local communities, surrounding areas, and visiting publics all gain some benefit or hold expectations as to what the forest can offer them, in terms of livelihoods, traditional uses, clean air and water, forest products, and recreation, just to name a few. As such, this chapter of the assessment report focuses on the human dimension side of forest management and offers a comprehensive approach to the assessment, alongside the ecological analysis in Chapter II.

The management of the Carson NF contributes to social and economic sustainability by maintaining a set of desired social, cultural, and economic conditions within the forest and by providing certain contributions to the broader landscape outside the forest. These contributions are primarily the provision of multiple uses and ecosystem services, infrastructure, and the direct management operations of the Carson NF. In turn, these contributions affect social, economic, and cultural conditions in a broader area of influence outside of the forest. Since land management planning only relates to making decisions about how to manage the national forest, understanding how management of the forest contributes to or affects social, economic, and cultural conditions in the broader area of influence is the focus for evaluating social and economic sustainability.

Chapter III of this assessment report evaluates the sustainability of the major social and economic contributions of the Carson NF. In this context, economic sustainability refers to the capability of producing goods and services, including contributions to jobs and market and nonmarket benefits. Social sustainability refers to the capability of the forest to support the network of relationships, traditions, culture, and activities that connect people to the land and to one another, and support vibrant communities. The assessment uses existing information to determine forest influences and contributions, the sustainability of these contributions, and any trends or risks related to influences or contributions.

Structure of this Chapter

To fully address the social and economic components of the Carson NF the social, cultural, and economic assessment is broken into five sections as follows:

Section 1: **Cultural and Historic Resources and Use Associated with the Carson NF** provides the historic and cultural context in which the Carson NF resides in northern New Mexico. Cultural and historic resources and uses on the Carson NF are critical to the social, economic, and ecological sustainability of the region.

Section 2: **Social, Cultural and Economic Conditions Associated with the Carson National Forest** describes the current social and cultural context of the Carson NF, depicts the demographic make-up of the assessment area, and shows the economic contributions of having a national forest in the assessment area.

Section 3: **Carson National Forest's Contribution to Social, Cultural, and Economic Conditions** examines the benefits provided by the Carson NF, looks at the demands placed on the forest, and discusses the influence of the Carson NF on key social, cultural, and economic aspects and conditions.

Section 4**: Social, Cultural, and Economic Contributions of Multiple Uses from the Carson National Forest** assesses the contributions and sustainability of the multiple uses across the forest. These include uses such as: Outdoor Recreation, Range, Renewable and Nonrenewable Energy, Mineral Resources and Geologic Hazards, Timber, Watershed, and Wildlife.

Section 5: **Social, Cultural and Economic Contributions of Other National Forest Resource Areas** analyzes the contributions and sustainability of other resource areas apart from the multiple uses the forest manages. These are: Areas of Tribal Importance, Cultural and Historic Resources, Designated Areas, Infrastructure, and Land Status and Ownership.

Section 6: **Social and Economic Integration and Risk Assessment** integrates risk to social and economic sustainability and determines social and economic need-for-change. Social and economic risks are inextricably tied to ecological risks found Chapter II.

The Assessment Area

For the purpose of this assessment, a four county "assessment area" was selected for analysis (Figure 63). Collectively, Mora, Rio Arriba, Colfax, and Taos counties best represent the relationship of current Forest Service management and the communities the Carson NF serves. While the Carson NF overlaps only these four counties, its economic influence reaches beyond its physical boundaries to San Juan and Costilla counties in New Mexico and Conejos County in Colorado. These counties benefit from having the Carson NF close by for activities such as recreation, wood product harvesting, oil and gas production, and livestock grazing.

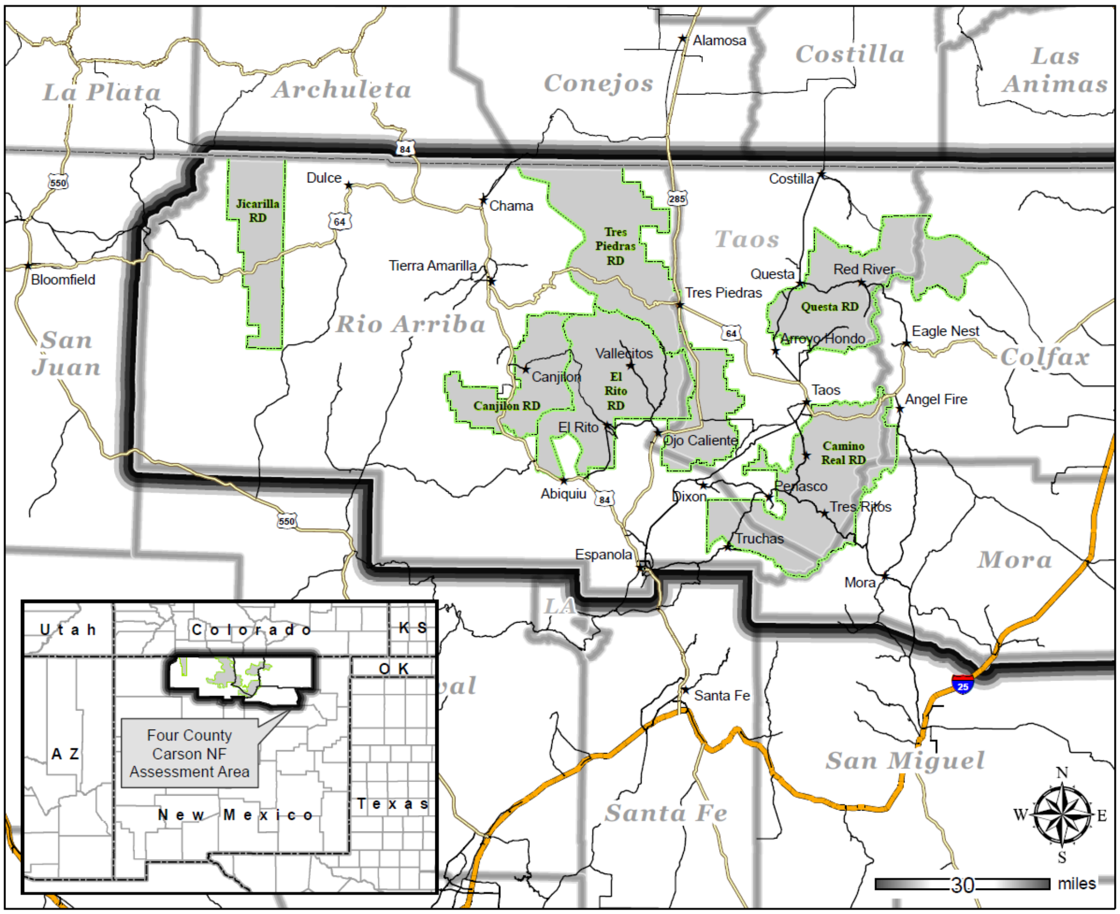


Figure 63. Counties within the Carson National Forest's influence (assessment area)

Cultural and Historic Resources and Use Associated with the Carson National Forest

Proclaimed in 1906 (originally as the Taos Forest Reserve), the Carson NF is a national forest with unique history, culture, and traditions. To this day, the Carson NF continues to be a key component in these long-standing cultural traditions and offers services for people who use the forest today. This section describes the historical social, cultural, and economic influences and conditions that shaped the landscape and the peoples that make up the present day assessment area of the Carson NF. It sets the stage for the present and helps the reader to understand the importance of the land, the culture, and the traditions of the current generation.

Cultural and historic resources and uses are critical to understanding the social, economic, and ecological sustainability. Cultural resources are a remarkable record of deliberate and intentional human actions, historic processes, and events important to the local communities, the State of New Mexico, local Tribes, the region, and the Nation. Currently, there are approximately 6,000 historic properties (including both prehistoric and historic cultural remains) identified which are located entirely or partially on forest service lands. Contemporary uses of floral, faunal, and mineral resources and recognition of distinct topographical and geological features and characteristics of the assessment area are integral to Native American, Hispanic, and Anglo-American traditional communities in sustaining their ethnic and cultural identity. Since the end of the 19th century, cultural tourism has become a significant component of the economy of the assessment area. Tourists are attracted by the spectacular and diverse visual beauty of the environment, the appeal of the living ancient traditional communities, and the extraordinary cultural resources the Carson NF and the surrounding areas have to offer.

Native American Occupation and Use Prior to A.D. 1540

For much of the span of human history, Native Americans were the only people to occupy and use the lands that encompass the Carson NF. Their utilization of the forest and the surrounding area was concurrent with the earliest human occupation of the Western Hemisphere and persists to the present day. Prior to A.D. 1600 in the American Southwest, and more specifically in the assessment area, archeologists divide Native American cultural history into three broad eras or periods: Paleoindian, Archaic, and Pueblo.

The Paleoindian era (> 12,000 years before present (YBP) to ~8,000 YBP) is associated with the initial colonization of the region, during the end of the Pleistocene. The last Ice Age was ending and dramatic environmental changes caused the retreat of the glaciers and an increase in temperatures and moisture. The first Paleoindian occupants were nomadic hunters and gatherers. In northern New Mexico, Paleoindian occupation and use focused on upland areas near significant lithic resources and along major stream tributaries that would have provided habitat for species of use to them. The diagnostic attributes of large projectile points, indicate Paleoindian big game hunters used lands currently occupied by the Carson NF.

The subsequent Archaic period (~8,000 to ~1,000 YBP) is a long span of time, when environmental conditions still fluctuated, but began to stabilize through time and became fairly similar to current conditions. The Archaic period saw increases in population, social and technological changes, along with the initial introduction of maize (corn) and other domesticated plants (beans and squash) from Mesoamerica, but with a continued focus on hunting and gathering. Around 5500 B.C., Archaic occupation and use of lands that would become the Carson

NF changed to a lifestyle less reliant on big game hunting and more on a diet supplemented by wild plant foods, including a variety of small game and plant species.

The Pueblo period (~2,000 YBP to present), which approximately overlaps the Archaic period by a 1,000 years, corresponds to the last two millennia of Native American occupation prior to A.D. 1540. It is characterized by the advent of a more sedentary way of life and a shift to a reliance on farming and significant population growth in the region. The origins of the modern ethnic identities of contemporary Pueblo peoples also lie within this time period. The Ute or Numic speakers may have descended directly from the Archaic hunter-gatherer cultures. Athabaskan peoples colonized portions the American Southwest near the end of the Pueblo period, initially as small mobile bands of hunters and gatherers, who also shifted somewhat to horticulture.

Occupation and Use After A.D. 1540

Europeans first visited the assessment area, specifically the Taos Valley and its fortified, multi-storied Pueblo, in 1540. A contingent of Francisco Vásquez de Coronado's expedition, led by Hernán de Alvarado, entered the valley during their quest for the fabled "Seven Cities of Gold." Spanish records note a possible brief visit to Taos and Picurís pueblos in 1581. In 1598, Juan de Oñate created his colonial capital by occupying the Tewa villages of Ohkay Owingeh (San Juan) and later Yunque (San Gabriel), becoming the first colony sanctioned by the Spanish Crown in New Mexico. Oñate appointed Fray Francisco Zamora missionary to Taos and Picurís pueblos the same year, thus establishing the first permanent Spanish presence in the valleys. By the early 1600s, a few hardy Spanish speaking *pobladores* (settlers) had moved into the Taos Valley, where they began to develop small isolated *ranchos* (fortified ranches or settlements consisting of one or more households), along the streams and rivers that lined the valley.

Concurrent with the arrival of, and colonizing by, the Europeans was a period of dramatic climatic change that affected most of North America. Known as "The Little Ice Age," this period of pronounced colder and drier weather spanned nearly 400 years, from A.D. 1450 to 1850. In the 1600s, as a result of this marked climatic change, New Mexico experienced a series of severe, devastating droughts and bitterly cold winters that caused widespread famine and hardships for both Native American and Hispanic settlers alike.

The increased cold, periodic droughts, and subsequent diminished food supply, combined with the catastrophic impact of European epidemic diseases, culminated in 1680 with the violent expulsion of the Spanish from New Mexico. The Pueblo Revolt was a province-wide rebellion organized and initiated by an Ohkay Owingeh (San Juan Pueblo) religious leader named Popé who had been in hiding from the Spanish at Taos Pueblo. For over twelve years, the Spanish were kept out of the northern Rio Grande Valley, but by 1693, Governor Diego de Vargas had reoccupied the capitol at Santa Fe.

Following the reconquest, Hispanic families began to reenter northern New Mexico and develop new homes and ranches. During this time period, the Spanish government created land grants to help foster an economic base for the settlers. Throughout the 1700s, life in northern New Mexico continued to be extremely difficult. The isolated farms and ranches of the assessment area were subject to frequent and intense raiding by plains and mountain tribes: Comanche, Ute, and various bands of Apache and Navajo. Of these tribes, however, the Comanche dominated the hostilities, politics, and commerce of the southern plains and New Mexico for much of the 18th century. With the defeat of the Comanche in 1786, life became easier in northern New Mexico for the Spanish settlers and Pueblos.

This period of relative peace and stability resulted in families from both southern New Mexico and Mexico moving into the area and a general increase in individual economic wellbeing. The Hispanic communities of northern New Mexico at this time began to prosper as the population increased. More land was put into cultivation, and trade with the other provinces of New Spain became safer. Many small new villages (i.e., Arroyo Hondo, Valdez, and Arroyo Seco) and new churches were created as farmers slowly moved into areas that formerly had been far too dangerous to occupy during the period of Comanche dominance. From the end of the 18th century and through much of the 19th century, very large numbers of domestic sheep were allowed to roam and graze in and around the Taos Valley and mountains of the assessment area, which radically changed the ecology of the valleys and foothills. Vast grasslands were overgrazed, leading to invasion by sagebrush and other woody plants by the middle of the 19th century.

With Mexican Independence in 1821, change accelerated in New Mexico. Spain had maintained an isolationist position with its northern provinces in New Spain, but independent Mexico opened its borders and sanctioned a trade route (Santa Fe Trail) with the United States. Previously unavailable trade goods began to flow into New Mexico and local merchants had an outlet other than Mexico for their surplus woolen goods, especially Rio Grande style blankets. Silver coins began to circulate from Mexico, and for the first time in its long history the area started to move away from a strictly barter economy, as many Hispanic New Mexicans became active and successful in the burgeoning international trade.

Not only was New Mexico open to trade with America, but the initiation of the Santa Fe Trail encouraged a large influx of Americans, Canadians, and other non-Hispanic traders and trappers to a new commercial enterprise in the region, the fur trade. The entrepreneurial American traders hauled goods over the Santa Fe Trail and made certain they carried the necessary supplies to outfit the growing number of trappers moving to New Mexico. The fur trade provided the impetus for an important period of American exploration, expansion, and cultural assertion. Trends in American and European fashions had created a high demand for beaver pelts and other quality furs. So much so that by the early 1900s, trapping had reduced beaver distribution to small remnant populations on the upper Rio Grande and San Juan drainages. Fur trapping was also important to protect valuable and limited domesticated livestock found in New Mexico at this time (predator control). Mexican wolves, Mexican grizzly bears, mainland grizzly bears, coyotes, and other predators were reduced to the point of extinction. With the opening of the trade routes with Mexico, Americans realized the entire reach of the southern Rocky Mountains and lands to the west were accessible for trapping. Taos very quickly became the unofficial headquarters for the American fur trade in the West.

Throughout the early part of the 19th century, western expansion of the United States increased the level of American influence over the Southwest. Following disputes over the United States' annexation of Texas, America invaded Mexico in 1845 and seized New Mexico by military force the next year. To resolve the conflict, in 1848 the Treaty of Guadalupe-Hidalgo was signed and established New Mexico as a territory of the United States. Unlike other portions of northern Mexico annexed by the United States (Texas, California, and Arizona), New Mexico did not see as large an influx of Anglo settlers into the territory, and the Hispanic population remained a majority. However, the adjudication of land ownership claims, especially the land grants from the time of Spanish and Mexican rule, were protracted and contentious, and many Hispanic communities and individuals lost lands to legal maneuvering, fraud, and court decisions of questionable legal merit (DeBuys 1985). Some of the areas in dispute included the land grants that intersect the assessment area. The current boundaries of the land grants are a result of the land adjudication that took place after 1848, but for several land grants, claims extended to include parts of the assessment area. New Mexico applied for statehood in 1850, soon after its annexation, but did not formally attain statehood until 1912.

Shortly after American takeover of New Mexico, numerous placer, prospects, adits, and mining claims were created on the Carson NF. There are stories of lost Spanish mines in the Taos Mountains, and the western slope of the Sangre de Cristos saw sporadic prospecting in the drainages, during the 1850s. Prospectors flooded the central mountains after the U.S. Civil War. In 1865, the Taos County Clerk recorded 105 claims for gold, silver, and copper in the lower Rio Hondo area, now the Questa Ranger District (RD), with many of the claims filed by U.S. Army soldiers stationed near Taos (Pearson 1986). But returns were low, and interest faded in Rio Hondo after placer gold was discovered in 1866 on Baldy Mountain on the Maxwell Land Grant, over the mountains to the east. The desire to develop gold interests in the Moreno Valley and inner mountains led to the removal of the Jicarilla Apache and Mouache Ute to the Cimarron Indian Agency in the 1860s, and to reservations by 1890 (Ackerly 1997; Keleher 1942). By the mid1890s, prospectors established lode claims in the mountains of the Red River, Cabresto Creek, Bitter Creek, Comanche Creek, and Rio Hondo watersheds. There are scattered patented mining claim inholdings of private land across the Questa, Camino Real, and Tres Piedras ranger districts (RDs) that have been worked periodically since the late 1800s. Gold mining and milling operations, along with their support towns named Amizette, Twining, Midnight, Anchor, Red River, LaBelle, and Hopewell grew and boomed from about 1893 through 1904. Due to nearby recreational opportunities, the historic towns of Red River and Twining grew into modern-day towns, with many turn-of-the-century buildings still in use in the Town of Red River. In 1903, Twining had a large hotel, several mills, a smelter, houses and buildings, but nearly every historic building was destroyed or removed by the 1930s, making room for development of Taos Ski Valley (Schilling 1960).

By 1880, railroads began to push into the assessment area from the north and east, and narrow and full gauge train logging became a powerful economic driver in northern New Mexico, for the next 40 years. Extensive harvest of ponderosa pine from the surrounding forests supported the rapidly expanding railroads, as well as many of the larger mining operations. Railroad ties cut from the Carson NF were utilized throughout the American West, and many were even exported to South Africa to meet the growing need to expand its railroads.

Extensive logging operations occurred on the Camino Real RD by the Santa Barbara Tie and Pole Company, which operated from 1907 until 1931. The slopes of the Rio Pueblo and Rio Santa Barbara watersheds were cleared of all the largest pine, fir, and spruce trees, with only the smallest left behind. In the first 17 years of operation the company supplied 400,000 ties annually (Graham 1998: p. 9). Temporary wooden dams (splash dams) were built to span the width of streams and rivers, such as the Rio Pueblo and Rio Santa Barbara, creating an upstream reservoir where water and logs were stored. When the dam was dynamited, logs and railroad ties would float in a rush of water downstream to the Rio Grande, where they were transported by rail to all parts of the country. Water releases from multiple splash dams on tributaries were also often combined to maximize the number of logs floated throughout a given watershed. By impounding the water and then releasing it on a schedule, these dams delivered many more logs to market than the natural flow of the creek would have allowed, albeit at the expense of radically altering and damaging the streambeds and ripping out riparian vegetation that grew along these waterways and stabilized the streambanks.

Railroad logging using narrow gauge trains was utilized throughout the Tres Piedras and El Rito RDs. Starting around 1888 with the development of a large mill in Tres Piedras, trains were laid into numerous canyons to extract all the timber possible. Once all the timber had been taken from an area, the tracks were pulled up and moved to the next available site. Logging was very successful on the west-side of the Carson NF, until 1892 when the mill burned down and the Denver and Rio Grande Railroad pulled out all of its rails and moved to another area. In 1914, the Hallack and Howard Lumber Co. established a mill in the tiny town of La Madera, situated on the El Rito RD and brokered a deal with the Denver and Rio Grande Railroad to build their logging railroad infrastructure. By 1925, however the lumber company had exhausted the marketable timber over an extensive area of the El Rito RD.

Synchronous with the arrival of the railroads in 1880, a new economic enterprise came into being throughout New Mexico, albeit with the greatest effect in the northern portion of the territory—tourism, with its remarkable infrastructure that would provide lodging, dining facilities, and tours to the burgeoning numbers of the rapidly expanding middle class visitors from across America and the world. The American Southwest became the readily accessible new “exotic”, with its stunning landscapes and terrains, breathtaking vistas, remarkable American Indian and Hispanic cultures and a truly original American Art—all of which became the focus and vision of a major national public relations campaign by the railroads specifically designed to attract tourists.

On November 7, 1906, the Taos Forest Reserve was created by President Theodore Roosevelt in a Presidential Proclamation. On March 4, 1907, the Carson NF came into being, by an act of Congress that combined the Jemez-North and Taos Forest Reserves. The Carson NF, at the time of consolidation in 1908, consisted of 966,000 acres and was headquartered in Santa Fe, but later that year was moved to Tres Piedras. In 1915, the Supervisor’s Office was moved to Taos, where it remains today.

The initial establishment of U.S. Forest Service jurisdiction over the assessment area had an impact on its traditional use by Spanish and Native American communities, with the greatest effect resulting from the confiscation of Taos Pueblo’s most sacred place, Blue Lake. Impacts to the Hispanic communities consisted primarily of the imposition of regulation on grazing and the inability for people to freely access what formerly had been forested upland portions of their land grants. Many small operations were granted free use by the agency, but this practice was phased out after World War II, with a strong negative impact on small operators (DeBuys 1985; Raish and McSweeney 2008). Those Native American, Hispanic, and Anglo peoples who had previously earned their living in logging and mining in the assessment area were arguably impacted the most by the new federally imposed constraints.

The Great Depression was a brutal financial disaster for the United States and marked a turning point in American political and economic history. Young people entering the work force were most affected by the crisis. Jobs were not available for unskilled laborers and there were limited opportunities for people to even gain experience. In 1933, President Franklin D. Roosevelt introduced the New Deal program, including the Civilian Conservation Corps (CCC) and Works Progress Administration (WPA). Workers in the New Deal programs operated under several federal agencies, including the Soil Conservation Service and the National Park Service, but more than fifty percent of all the public works projects administered by the New Deal were undertaken by the Forest Service (Otis et al. 1986). In the assessment area at least two CCC camps were established, one on the El Rito RD and one on the Taos RD (which later was subsumed by the Camino Real RD).

The CCC enrollees worked to save areas infested with pine bark beetle; built and maintained trails, roads, and picnic areas; fought wildfires and engaged in rescue efforts; planted trees; built fences and telephone lines; installed latrines, drinking fountains, and signs; and constructed extensive erosion control structures throughout the Carson NF (Melzer 2000). The WPA constructed the Pueblo Revival style Carson NF Supervisor's Office in the center of Taos. The structure was furnished with the traditional crafts of northern New Mexico workshops, also funded by the WPA. The structure remained the headquarters for the Carson NF, until its transfer to the Town of Taos in 1989.

Social, Cultural, and Economic Conditions Associated with the Carson National Forest

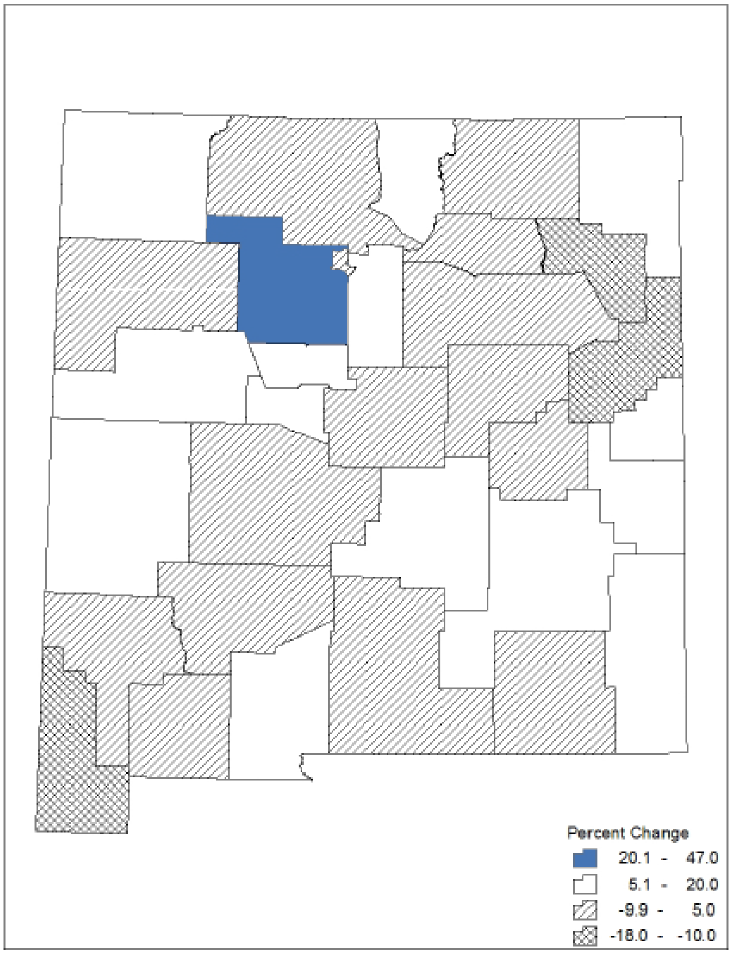
One of the most unique and defining characteristics of the assessment area is its diversity of people, culture, traditions, and values. This section describes the assessment area's demographics; illustrates the area's diversity; and highlights the social, cultural, and economic challenges facing communities and families today, in order to retain their way of life. Demographic and economic statistics for Mora, Rio Arriba, Colfax, and Taos counties are presented within the context of their multi-county associations. Statistics for the State of New Mexico are compared with those for the assessment area. Up to 10 standard demographic data sets for the State and the assessment area are reported, depending on relevancy and availability of data. There are some anomalies in the reporting as a result of data availability.

The data for the multi-county assessment area has been aggregated using a program economic tool kit from Headwaters Economics (2015). Many statistics were compiled by the University of New Mexico Bureau of Business and Economic Research (UNM-BBER). Not all of that data are reported in this assessment. To read more, please see the UNM-BBER Socioeconomic Assessment Supplement for the Carson NF 2013; and the UNM-BBER Socioeconomic Assessment for the Carson NF 2007, which are part of the planning record.

Population Statistics

In 2010, New Mexico was home to more than 2 million people (less than 1% of the U.S. population)(US CB 2010). Since 1980, the state's population growth has increased faster than the rest of the rest of the United States. New Mexico's population grew by 16, 20, and 13 percent between 1980 and 1990, 1990 and 2000, and 2000 and 2010, respectively. The U.S. population grew at 10, 13, and 10 percent, during these same periods. Migration played a relatively minor role in New Mexico's population growth. Net in-migration to New Mexico was approximately 150,000 people between 1990 and 2000, and approximately 100,000 people between 2000 and 2010 (a reduction of roughly one-third). UNM Geospatial and Population Studies has projected state population growth rates for the next two decades of 14 and 11 percent, which will result in a 2030 population of more than 2.6 million people (US CB 2010).

Figure 64 depicts the percentage change in each New Mexico's county populations between 2000 and 2010. Most New Mexico counties experienced population increases. Population declines that occurred across New Mexico during these years are in part a result of the Great Recession (October 2007 to June 2009) and the fact that New Mexico is largely a rural state without much to offer in the way of economic activity (UNM-BBER 2007, 2013). The Great Recession has required many people to move in order to find work.



Source: US Department of Commerce Census Bureau, 2000 and 2010 decennial censuses. Map created by UNM BBER.

Figure 64. Percentage change in each New Mexico's county populations between 2000 and 2010

Compared with other states, New Mexico has a relatively small population. In 2010, New Mexico's population rank was 36; only 14 states had smaller populations. In addition to having a relatively small population, New Mexico's land area is relatively large and average population density is low. In 2010, New Mexico had a population density of only 17 people per square mile. Only four states have a lower population density Alaska, Montana, North Dakota, and Wyoming.

The assessment area (Taos, Rio Arriba, Colfax, and Mora counties) contains approximately 4.4 percent of the population of the State of New Mexico. The assessment area has a population of 91,390, with Rio Arriba County being the most populous (40,218) and Mora County being the least (4,788). Figure 65 graphically depicts the population trend for the four counties, which has gradually increased from the 1970s to the early 2000s. From 1970 to 2013, population grew from 59,752 to 90,905 people, a 52 percent increase. Recent population trends for the assessment area show population at a plateau, with a slight decline beginning in the later 2000s.

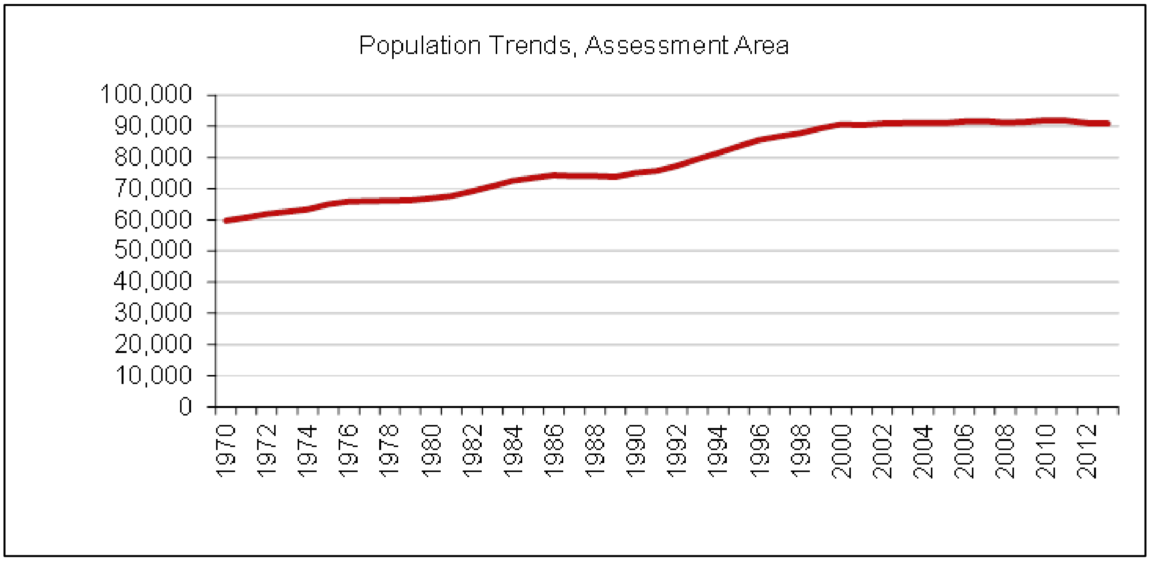


Figure 65. Cumulative population trend for the assessment area 1970-2012

Age and Gender Distribution

Changes in the age structure of New Mexico's population are similar to other areas of the country. The portion of the population in the 18 and under group steadily declined between 1990 and 2010 (from 25 to 21 percent), while the 65 and older age group steadily increased from 11 to 13 percent. These trends are expected to continue. The BBER report projects by 2030, those in the 0 to 14 age group will comprise 20 percent of New Mexico's population, and individuals age 65 and older will comprise 21 percent. Between 1990 and 2010, the portion of New Mexico's population of working age (ages 15 to 64) grew from 64 to 66 percent, but is expected to decline to 60 percent by 2030.

Population trends for the assessment area are similar to that of the State of New Mexico. In 2000, the age group of 18 and under made up 26 percent of the assessment area. Ages 45 to 64 made up the next biggest percentage at 25 percent. The 18 to 34 age group followed with 19 percent, and the 35 to 44 age group made up 15 percent. Those 65 and older made up the smallest percentage at 12 percent (Table 59). Over a 13 year period (2000-2013), those 18 and under and persons 35 to 44 have seen decreases in their numbers, while persons 65 and older have seen increases. The 45 to 64 age group have also experienced increases. The number of individuals ranging from 18 to 34 has remained fairly constant.

Table 59. Trend by age groups in the assessment area (2000-2013)[1]

Age Group	2000 (population)	2013 (population)	2000 (%)	2013 (%)
Total population	**90,538**	**91,390**	--	--
Under 18	24,060	19,898	26.6	21.8
18-34	17,947	16,821	19.8	18.4
35-44	13,968	10,950	15.4	12.0
45-64	23,172	27,750	25.6	30.4
65 and older	11,391	15,971	12.6	17.5

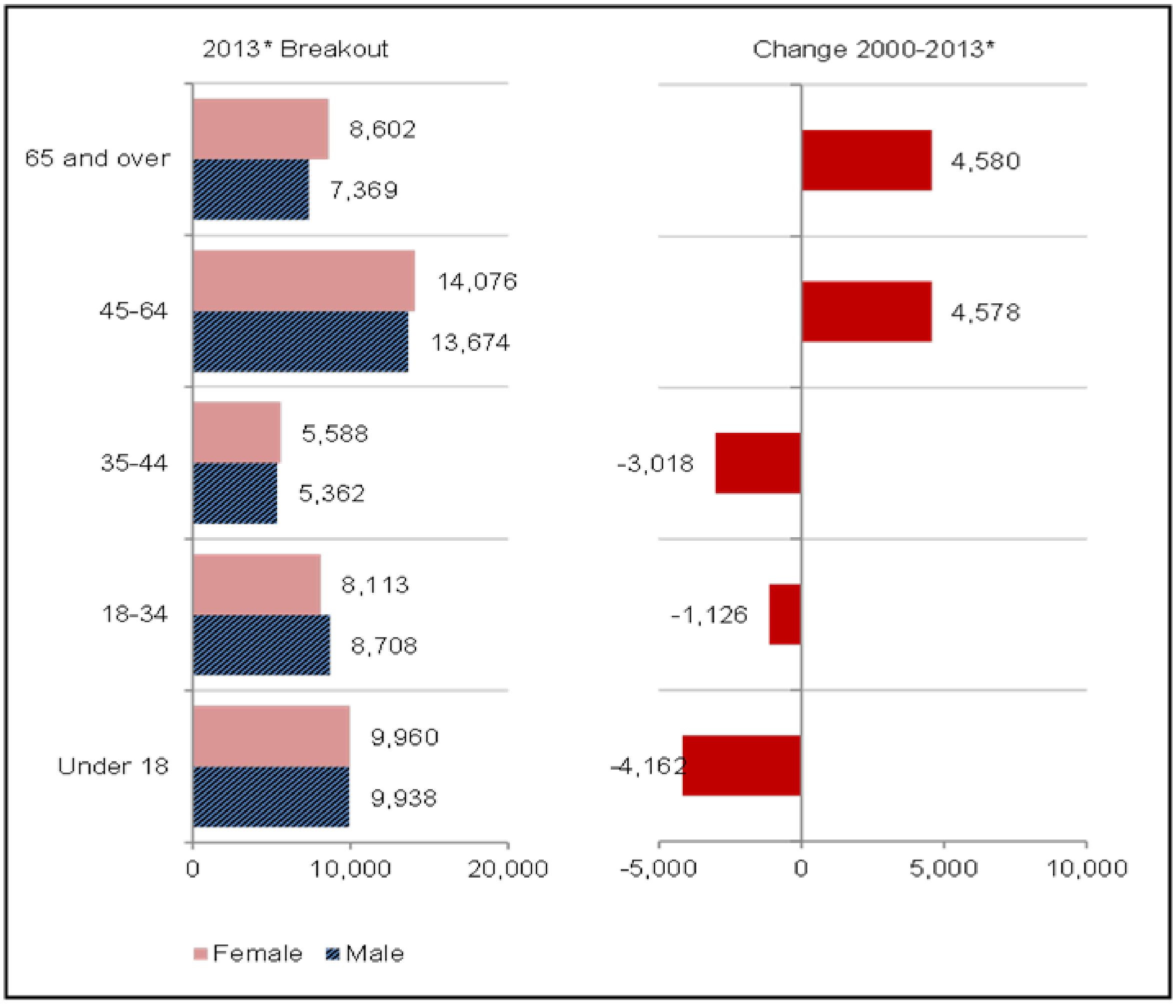


Figure 66. Change in population by age group between 2000 and 2013 within the assessment area

[1] The data in this table are calculated by American Community Survey (ACS) using annual surveys conducted during 2000-2013 and are representative of average characteristics during this period.

Figure 66 indicates the female and male ratio for each age group is relatively equal. It also shows the biggest gain occurred in the 45 to 64 and 65 and over age groups, and the largest decrease occurred in 18 and under age group. The age structure of the area's population has been slowly aging since at least 1990.

Between 2010 and 2030, the portion of the population ages 18 and under is expected to continue declining, while the 65 and over age group is expected to increase more rapidly. At the same time, the population that is of working age (between ages 15 and 64) is expected to fall. By 2030, Taos County is projected to have a population that is one-third (33.1 percent) in the 65 and older age group. The portions of the assessment area and state populations projected to be in this older age category by 2030 are smaller, 29.6 and 21 percent, respectively.

Racial Composition and Ethnicity

Cultural diversity is rich and evident in northern New Mexico; however, when it comes to race, diversity is not as prevalent within the assessment area. Those who identify as White dominate the racial make-up of the area at 68.7 percent (US CB 2014). Some other race alone makes up the second largest percentage at 18.6 percent (Table 60). Some other race alone includes those persons who did not classify themselves with any of the other racial categories. Less than one percent of racial variability can be found in races such as Black, African American, Pacific Islander, or Asian.

Table 60. Population and percent by race in the assessment area, New Mexico, and the U.S. (2013)[1]

Race/Population	Assessment area (pop.)	New Mexico (pop.)	U.S. (pop.)	Assess-ment Area (%)	New Mexico (%)	U.S. (%)
Total population	91,390	2,069,709	311,536,594	--	--	--
White Alone	62,784	1,511,087	230,592,579	68.7	73.0	74.0
Black or African American Alone	392	42,196	39,167,010	0.4	2.0	12.6
American Indian Alone	8,332	189,953	2.540,309	9.1	9.2	0.8
Asian Alone	425	28,034	15,231,962	0.5	1.4	4.9
Native Hawaiian & other Pacific Island alone	12	1,477	526,347	0	0.1	0.2
Some Other Race Alone	17,020	233,341	14,746,054	18.6	11.3	4.7
Two or More Races	2,425	63,618	8,732,333	2.7	3.1	2.8

The third highest racial percentage in the assessment area can be found among the Native American Tribes at 9.1 percent. Though this percentage may seem small, the Native American

[1] The data in this table are calculated by ACS using annual surveys conducted during 2008-2013 and are representative of average characteristics during this period (US CB 2014).

culture is a significant part and influence in the assessment area. This has been touched upon in the Cultural and Historic Resources and Use Associated with the Carson National Forest section (p. 312) of this chapter and more discussion can also be found in the Areas of Tribal Importance section (p. 424).

Table 61 shows the Native American composition of the assessment area. While it is comparable to the State of New Mexico, it shows a much higher concentration when compared to rest of the United States.

Table 61. American Indian and Alaska Native population and percent by race in the assessment area, New Mexico, and the U.S. (2013)[1]

Native American and Alaska Native Population	Assess ment area (pop.)	New Mexico (pop.)	U.S. (pop.)	Assess-ment Area (%)	New Mexico (%)	U.S. (%)
Total population	91,390	2,069,706	311,536,594	--	--	--
Total Native American	8,332	189,953	2,540,309	9.1	9.2	0.8
American Indian Tribes	7,885	180,834	1,997,487	8.6	8.7	0.6
Alaska Native Tribes	37	283	108,836	0	0	0
Non-Specific Tribes	333	6,014	363,000	0.4	0.3	0.1

In addition to racial identification, there is also cultural identification or ethnicity. Within the assessment area, nearly 62.9 percent of the population identifies itself as Hispanic or Latino, while just over 16 percent of the United States identifies as such. The term “Hispanic” refers to a cultural identification, and Hispanics can be of any race according to how this data was collected. The portion of the New Mexico population that is of Hispanic descent is increasing. In 1990, 38 percent of New Mexico’s population was Hispanic, and by 2010, 46 percent of people identified themselves as Hispanic. Racial composition of New Mexico has also experienced change. The portion of the population that self-identifies as “White", fell from 76 to 68 percent between 1990 and 2010. This decline has been offset by minimal increases among other racial groups; most notable are those who self-identified as “Other".

Although Hispanics represent nearly 63 percent of the population living in counties associated with Carson NF, the percentage of Hispanics that make up the population has been declining since 1990. The decline in the prevalence of Hispanics has been most notable in Taos County, where the percent of the population that is Hispanic declined by 7 percent, between 1990 and 2000, and by another 2 percent, between 2000 and 2010. These changes in the ethnic composition of Taos County are likely driven by net migration patterns and an influx of non-Hispanics. The decline in the prevalence of Hispanics among the assessment area population is in stark contrast to New Mexico; the portion of the state's population that is Hispanic has been increasing since at least 1990. The predominance of Hispanics is most notable in Mora County (which in 2010 had a population that was 81 percent Hispanic). Colfax County is the only county in the Carson NF

[1] The data in this table are calculated by the ACS using annual surveys conducted during 2008-2013 and are representative of average characteristics during this period.

with a population that is less than 50 percent Hispanic. This cultural significance within the assessment area will be discussed in terms of social and cultural conditions of the Carson NF later in this chapter. Table 62 shows the number of people who self-identify themselves as Hispanic in the assessment area, New Mexico, and the U.S. The information is also presented according to race.

Table 62. Those who self-identify as Hispanic, within the assessment area (4 counties), New Mexico, and the U.S. (2103)[1]

Hispanic & Race/Population	Assess-ment Area (pop.)	New Mexico (pop.)	U.S. (pop.)	Assess-ment Area (%)	New Mexico (%)	U.S. (%)
Total population	91,390	2,069,706	311,536,594	--	--	--
Hispanic/Latino (any race)	57,501	966,268	51,786,591	62.9	46.7	16.6
Not Hispanic or Latino	33,889	1,103,438	259,750,003	37.1	53.3	83.4
White Alone	24,649	828,574	197,050,418	27.0	40.0	63.3
Black or African American Alone	367	36,710	38,093,998	0.4	1.8	12.2
American Indian Alone	7,411	177,269	2,061,752	8.1	8.6	0.7
Asian Alone	422	26,202	15,061,411	0.5	1.3	4.8
Native Hawaiian & other Pacific Island Alone	12	1,160	488,646	0	0.1	0.2
Some Other Race Alone	65	3,599	606,356	0.1	0.2	0.2
Two or More Races	963	29,924	6,387,422	1.1	1.4	2.1

When comparing Table 60 and Table 62, there are discrepancies between the numbers of White Alone, Black or African American Alone, American Indian Alone, Asian Alone, Native Hawaiian and Other Pacific Island Alone, Some Other Race Alone, and Two or More Races. All of the numbers in Table 62 are lower than those found in Table 60, because this table separates the number from each racial category who identify ethnically as Hispanic/Latino. For example, the difference between the two tables for White Alone for New Mexico is 682,513. This would be the number from the White Alone category in Table 60 who identify as Hispanic/Latino. By adding all of the differences for each racial group between the two tables, the result would be 966,268 people who identify as Hispanic/Latino as depicted in Table 62, when keeping with the New Mexico example. The same is true across Table 62, which serves to break out those who identify ethnically as Hispanic/Latino from the total racial numbers in Table 60.

[1] The data in this table are calculated by ACS using annual surveys conducted during 2008-2013 and are representative of average characteristics during this period.

Language

Over 50 percent of people who live within the assessment area primarily speak English (Table 63). Spanish is spoken by 43 percent of those who speak another language. Just over 5 percent of the assessment area speaks a language other than English or Spanish. Given that the assessment area's population is close to 10 percent Native American, one might assume that the other languages may also include Native American languages. When compared to the percentages across the State of New Mexico and the United States (Table 63), the culturally rich and diverse population in the assessment area is evident by the percentage of people who speak a language in addition to English.

Table 63. Language spoken at home in the assessment area, New Mexico, and the U.S. (2013)[1]

Language	County Region (%)	New Mexico (%)	U.S. (%)
Only English	50.7	63.9	79.3
In addition to English	49.3	36.1	20.7
Spanish or Spanish Creole	43.5	28.7	12.9
Other Indo-European	0.7	1.2	3.7
Asian & Pacific Island	0.4	0.9	3.3
Other languages	4.7	5.2	0.9
Speak English less than "very well"	6.5	9.6	8.6

Education

Educational performance is an area the State of New Mexico has historically struggled in as a whole, including the assessment area. Year after year New Mexico ranks near the bottom, compared to the rest of the United States. The Education Research Center gave New Mexico a "D+", when it comes to a student's chance for success. The index measures the role of education in a person's life from cradle to career (Daniels 2014). New Mexico does rank fourth in the nation for the number of people holding PhDs (Chokshi 2014). For the four counties making up the assessment area, those with a high school degree or higher make up slightly over 83 percent of the population over 25 years of age (Table 64).

[1] The data in this table are calculated by the ACS using annual surveys conducted during 2009-2013 and are representative of average characteristics during this period.

Table 64. Education attainment within the assessment area, New Mexico, and U.S (2013)[1]

Education/Population	Assess-ment Area (pop.)	New Mexico (pop.)	U.S. (pop.)	Assess-ment Area (%)	New Mexico (%)	U.S. (%)
Total population 25 years or older	64,296	1,347,229	206,587,852	--	--	--
No high school degree	10,469	220,516	28,887,721	16.3	16.4	14.0
High school graduate	53,827	1,126,713	177,700,131	83.7	83.6	86.0
Associate's degree	5,432	101,660	16,135,795	8.4	7.5	7.8
Bachelor's degree or higher	13,807	347,670	59,583,138	21.5	25.8	28.8
Bachelor's degree	8,349	198,521	37,286,246	13.0	14.7	18.0
Graduate or professional	5,458	149,149	22,296,892	8.5	11.1	10.8

New Mexico's population has become more educated during the last two decades. As detailed in Carnevale and others (2012), lingering effects of the Great Recession will likely continue to create an incentive for individuals to obtain higher education. It is expected that educational improvements will continue throughout Carson NF's associated counties, and perhaps most notably in Taos County, which offers economic opportunities that are more likely to require higher education levels than the economic opportunities offered in more rural Mora and Colfax counties.

Employment

Prior to this century, New Mexico's unemployment rate typically exceeded that of the United States as a whole. The relationship changed after 2002. Since 2006, the New Mexico unemployment rate has been considerably below that of the rest of the Nation. The gap between New Mexico and U.S. unemployment rates grew during the Great Recession, as the U.S. unemployment rate rose faster than New Mexico's. The gap between the two was greatest in 2009, when New Mexico had an unemployment rate of 6.8, while the U.S. unemployment rate was 9.3. In 2011, both the New Mexico and U.S. unemployment rates began to fall from their 2010 peaks. The U.S. rate fell more rapidly than the New Mexico rate, narrowing the gap between the two. As of 2011, the U.S. had an unemployment rate of 8.9, while New Mexico had a rate of 7.4. As the economy continues to recover from the Great Recession, unemployment rates are expected to continue declining.

Since 1990, the annual unemployment rate in the assessment area has ranged from a high of 16.1 percent in1992 to a low of 4.4 percent in 2007 (Figure 67). The Great Recession is also represented in Figure 67 by the sharp increase in unemployment, beginning in 2008. Recent trends starting around 2011 are beginning to show a decrease in the unemployment trend for the assessment area (NM DWS 2014).

[1] The data in this table are calculated by the ACS using surveys conducted during 2009-2013 and are representative of average characteristics during this period.

Employment within the assessment area is primarily in the management and professional fields (34 %); service and sales and office occupations (26 and 21%, respectively); and construction, extraction, maintenance and repair occupations (11%). Between 1970 and 2013, employment in the assessment area grew from 17,678 to 42,715 jobs, a 142 percent increase.

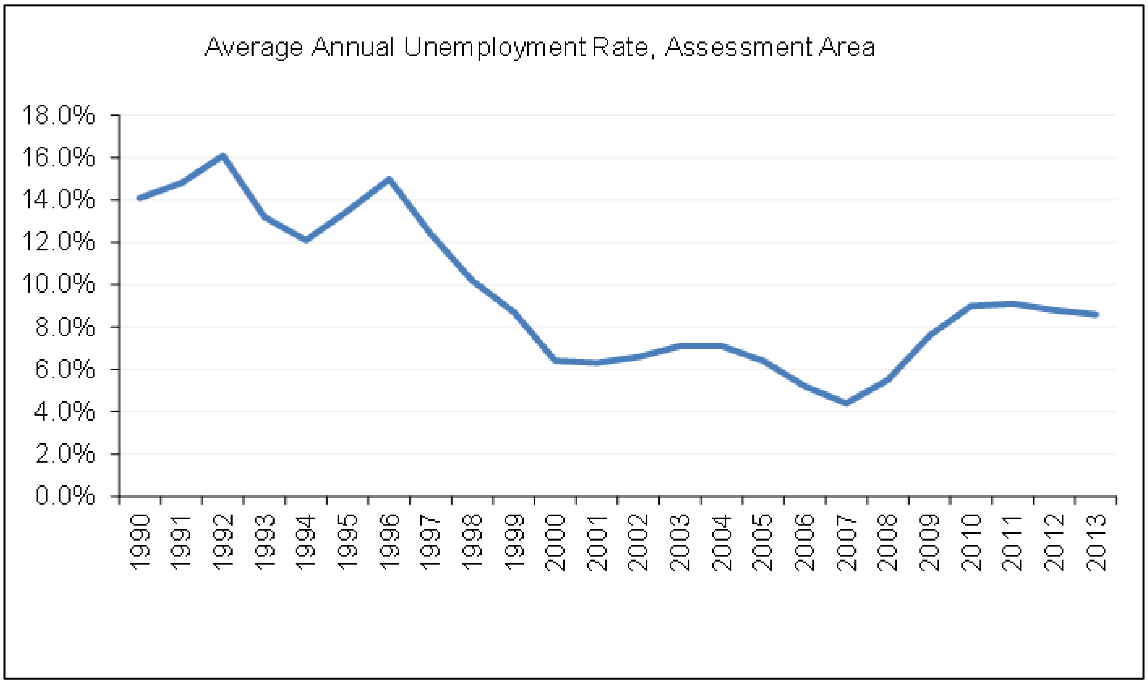


Figure 67. Average annual unemployment rate for the assessment area (1990-2013) (NM DWS 2014)

Income

New Mexico is considered to have a "lopsided" economy. While this economic condition is evident in all states to some degree, New Mexico is listed in the top ten with the most income disparity. According to the Economics Policy Institute (Sommeiller and Price 2014), the top one percent average income is 15.6 times greater than the average income of the bottom 99 percent. New Mexico also has one of the highest top-to-bottom ratios at 8.0. An average income of $118,608 among the top 20 percent of families is 8 times the average income of $14,798 in the bottom 20 percent (NM Legislative Council Service 2012).

In the assessment area, most households earn less than $35,000 (over 45%), while the top one percent earns $200,000 or more (Figure 68). Over 16 percent earn between $50,000 and $74,999.

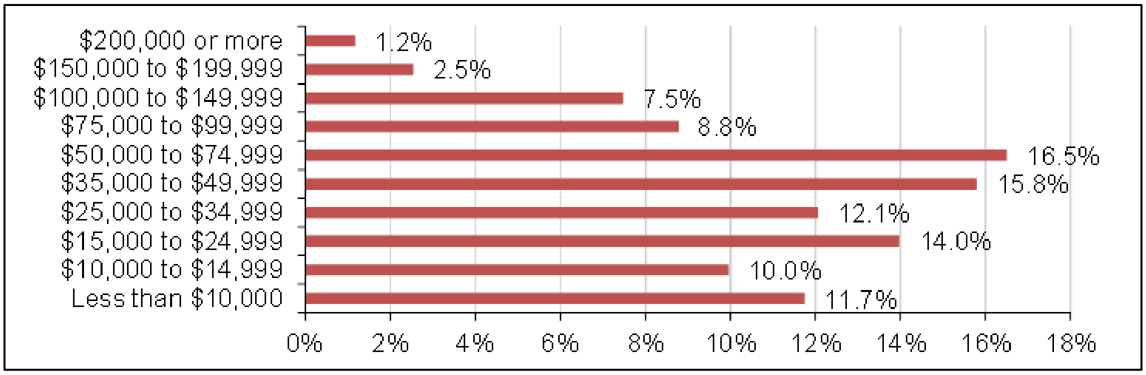


Figure 68. Household income distribution within the assessment area (2013)[1]

When looking at poverty levels (Figure 69), both individuals and families have higher poverty rates within the assessment area than in the State of New Mexico or the rest of the United States. Trends in personal income are also plateauing with a slight decrease in 2012, after showing a strong growth trend from 1970 into the early 2000s (Figure 70).

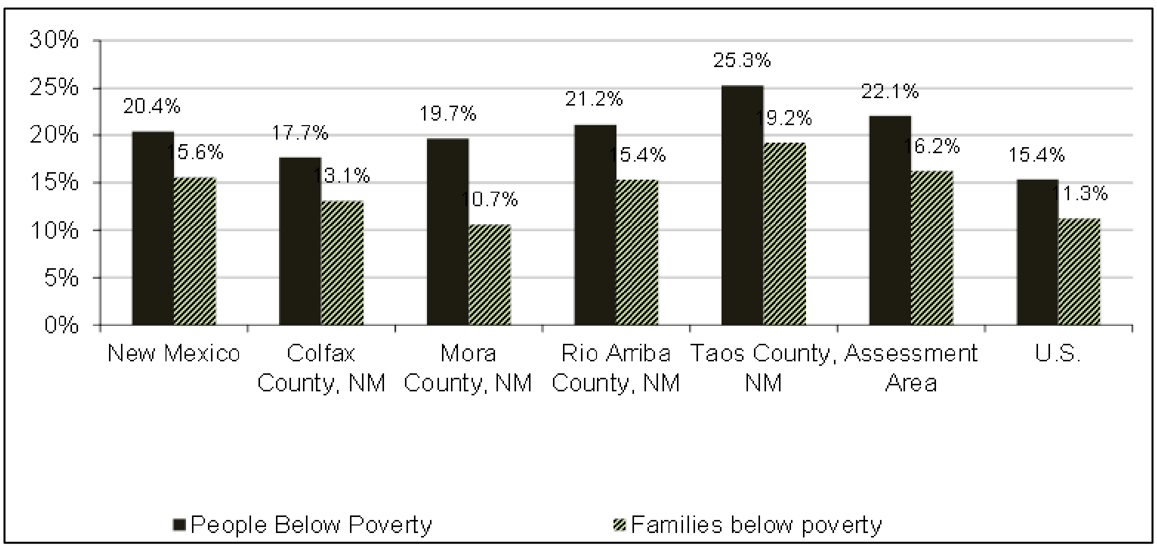


Figure 69. People and families below poverty level within the assessment area (2013)[2]

[1] The data in this table are calculated by ACS using annual surveys conducted during 2009-2013 and are representative of average characteristics during this period.

[2] The data in this table are calculated by ACS using annual surveys conducted during 2009-2013 and are representative of average characteristics during this period.

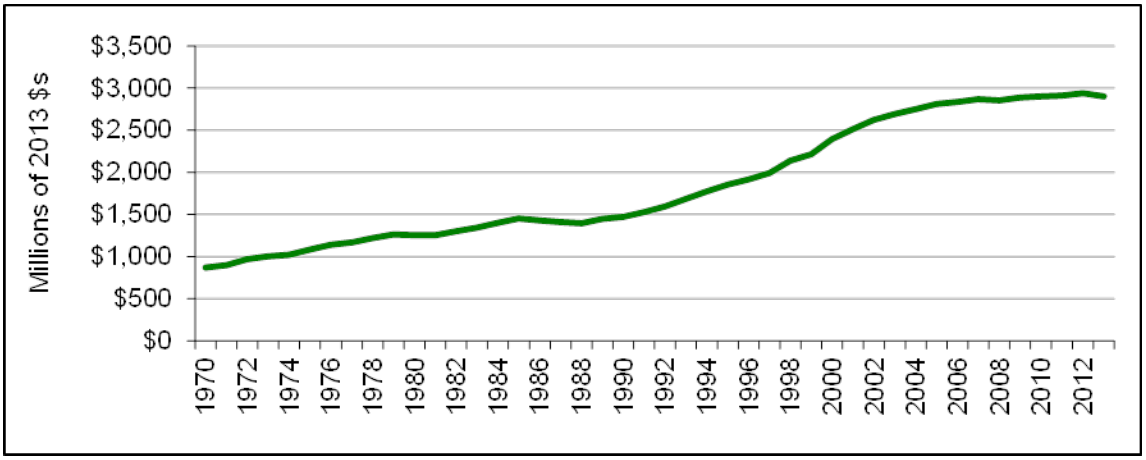


Figure 70. Total personal income trend for the assessment area[1]

Sectors of the Economy

Considering the assessment area is generally made up of small and often rural communities, there are a wide range of industries represented. The majority of industries tend to be in the services sector versus the non-services sectors. The four largest sectors of the economy in the assessment area are (Table 65):

- Government (21.4 percent)
- Accommodation and food services (10.6 percent)
- Retail (10 percent)
- Health care and social assistance (10 percent)

Table 65. Employment by industry in the assessment area

Industry Sector	2001	2013	Change 2001-13	2001 (%)	2013 (%)	% change 2001-13
Total number of jobs	42,697	42,715	18	--	--	--
Non-services related	8,345	7,538	-807	19.5	17.6	-9.7
Farm	2,878	3,259	381	6.7	7.6	13.2
Forestry, fishing, & related activities	404	305	-99	0.9	0.7	-24.5
Mining (including fossil fuels)	701	710	9	1.6	1.7	1.3
Construction	3,069	2,430	-639	7.2	5.7	-20.8
Manufacturing	1,293	834	-459	3.0	2.0	-3535

[1] The data in this table are calculated by ACS using annual surveys conducted during 2008-2013 and are representative of average characteristics during this period.

Industry Sector	2001	2013	Change 2001-13	2001 (%)	2013 (%)	% change 2001-13
Services related	25,176	25,583	407	59	59.9	1.6
Utilities	291	316	25	0.7	0.7	8.6
Wholesale trade	475	441	-34	1.1	1.0	-7.2
Retail Trade	4,969	4,268	-701	11.6	10.0	-14.1
Transportation & warehousing	724	522	-202	1.7	1.2	-27.9
Information	454	431	-23	1.1	1.0	-5.1
Finance & insurance	939	1,073	134	2.2	2.5	14.3
Real estate & rental & leasing	1,407	1,648	241	3.3	3.9	17.1
Professional & technical services	1,398	1,609	211	3.3	3.8	15.1
Management of companies & enterprises	51	24	-27	0.1	0.1	-52.9
Administrative & waste services	1,395	1,353	-42	3.3	3.2	-3.0
Educational services	332	516	184	0.8	1.2	55.4
Heath care & social assistance	4,008	4,329	321	9.4	10.0	8.0
Arts, entertainment, & recreation	1,714	1,959	245	4.0	4.6	14.3
Accommodation & food services	4,453	4,532	79	10.4	10.6	1.8
Other services, except public administration	2,566	2,562	-4	6.0	6.0	-0.2
Government	9,273	9,132	-141	21.7	21.4	-1.5

Table 65 displays how the industry sectors made up of services, non-services, and government have trended from 2001 to 2013. The service industry has experienced a 2 percent increase from 25,176 to 25,583 jobs. Non-services dropped from 8,345 to 7,538 jobs, a 10 percent loss, and government fell from 9,273 to 9,132 jobs, a 2 percent decrease. Figure 71 graphically depicts employment by industry category trend in the assessment area from 2001 to 2013.

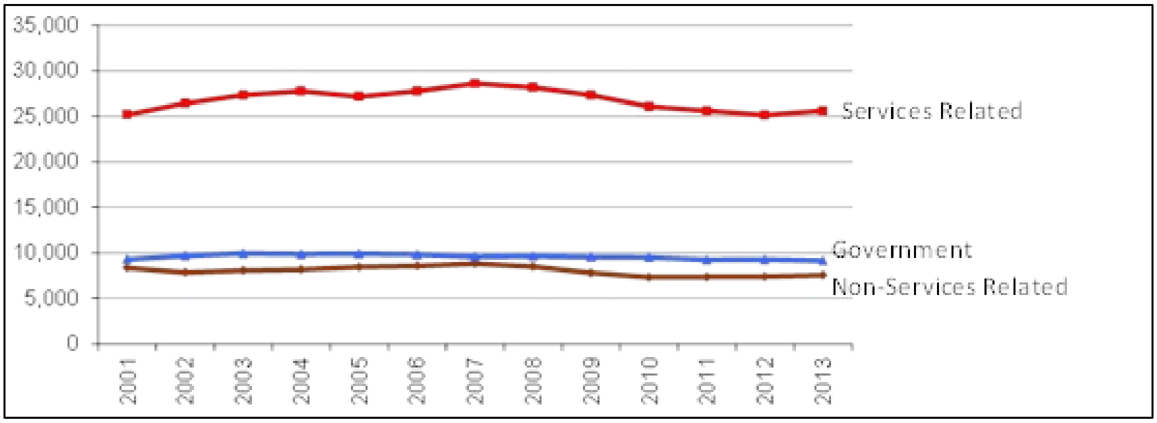


Figure 71. Employment by industry category trend in assessment area (2001-2013)

Housing

Housing statistics for the assessment area show close to 33 percent of current housing is vacant (Table 66). A large portion of vacant homes are seasonal, recreational use, or occasionally used homes. For over 38 percent of households within the assessment area, housing costs account for more than 30 percent of household income (Table 67).

Table 66. Housing characteristics for the assessment area (2013)

Housing Characteristic	Assessment area (#)	Assessment area (%)
Total housing units	52,854	--
Occupied	35,227	66.6
Vacant	17,627	33.4
For rent	1,456	2.8
Rented, not occupied	91	0.2
For sale only	825	1.6
Sold, not occupied	308	0.6
For seasonal, recreational, occasional use	10,353	19.6
For migrant workers	140	0.3
Other vacant	4,427	8.4

Table 67. Housing costs as percent of household in assessment area compared to New Mexico (2012)

Housing Characteristic	Assessment Area (%)	New Mexico (%)
Monthly cost <15% of household income	22.9	22.3
Monthly cost >30% of household income	38.4	33.7
Gross rent <15% of household income	13.5	12.4
Gross rent >30% of household income	42.5	44.9

According to a research study conducted for the Bipartisan Policy Center (Pendall et al. 2012), Hispanic Americans saw a substantial increase in house ownership from 1993 to 2005. During the housing crisis from 2007 to 2012, not only were all of those gains lost, but homeownership for Hispanics now lags 25 percent behind non-Hispanics. As a result of this set-back in home ownership, the median wealth of Hispanic people has fallen by 50 to 65 percent. During 2005 to 2009, Hispanics saw their median wealth drop by 66 percent, when compared to 16 percent by the white population. This is significant to the assessment area, because well over one-third of the population is made up of Hispanic people (Table 62), as is over half of the county population in Rio Arriba and Taos counties and nearly 80 percent in Mora County.

Seasonal and Recreational Homes

The number of seasonal and recreational homes in the assessment area consistently increased from 1990 to 2000 and from 2000 to 2010, although the rate of increase during the latter decade slowed (Figure 72). The slower increase between 2000 and 2010 is consistent with state-level trends, and is likely a result of the effects on the housing market during the Great Recession. As economic constraints imposed by the Great Recession ease, the number of seasonal and recreational homes may increase more rapidly.

During both decades, the percentage increase of such homes was greater in the assessment area than in the state (54 and 24% in the assessment area, compared with 46 and 14% in New Mexico). Taos County was the cause of the more rapid growth between 1990 and 2000, while Rio Arriba County was the cause of more rapid growth between 2000 and 2010. The number of seasonal and recreational homes in Taos County increased from 1,127 in 1990 to 2,968 in 2000 (a 163 percent increase) and 3,164 in 2010 (mere 7% increase). In contrast, in Rio Arriba County the number of such homes increased from 658 in 1990 to 1,042 in 2000 (58%) and to 1,709 in 2010 (64%).

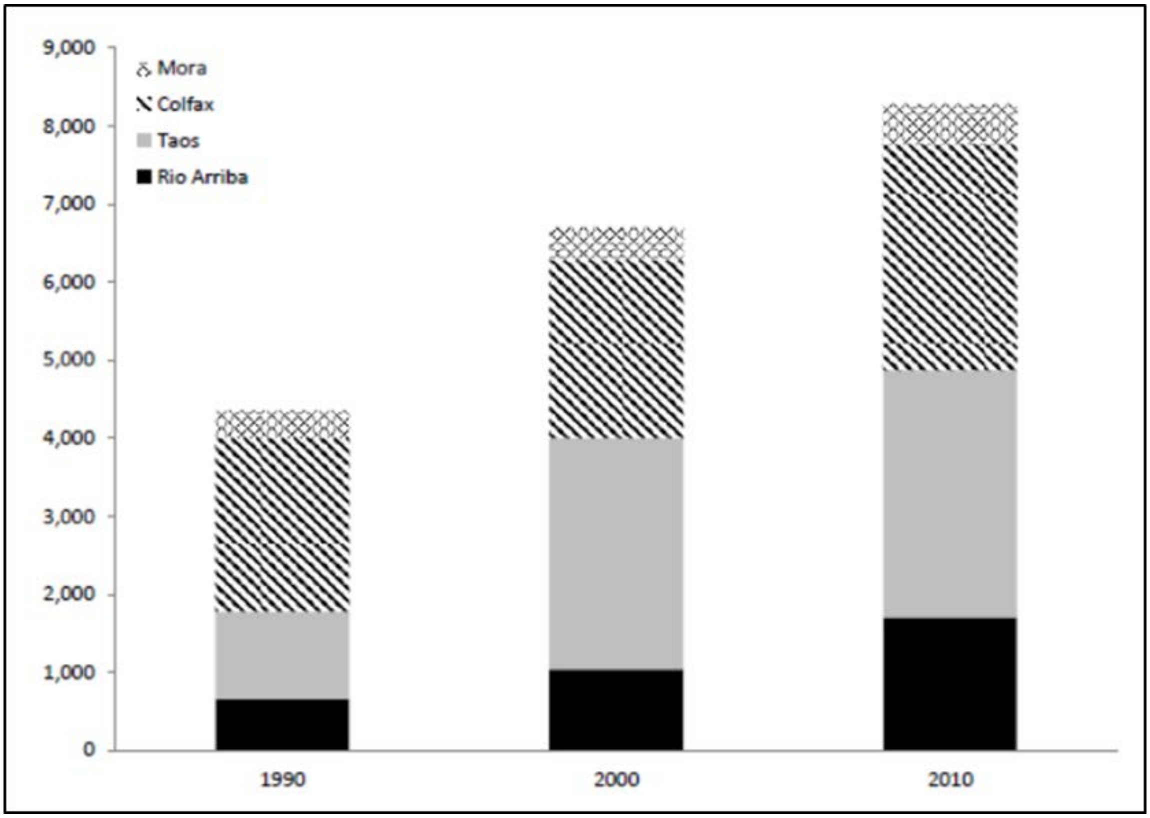


Figure 72. Seasonal and recreational homes in the assessment area[1]

Colfax County is an anomaly in a number of ways. First, a relatively large portion of Colfax County houses are classified as seasonal and recreational homes (29% in 2010). In contrast, 16 and 4 percent of all houses in the assessment area and New Mexico, respectively, are classified as seasonal and recreational homes (Figure 72). Additionally, in 1990 Colfax County contained 51 percent of all such homes in the assessment area, while Rio Arriba and Taos counties contained 15 and 26 percent, respectively. County-level differences in growth patterns for such homes had notably changed the distribution across the assessment area by 2010. In 2010, 38 percent of seasonal and recreational homes were located in Taos County, 35 percent in Colfax County, 21 percent in Rio Arriba County, and the remaining 6 percent in Mora County. Questa RD (associated with Colfax and Taos Counties) has, therefore, consistently contained approximately 75 percent of the area's seasonal and recreational homes. These homes are likely associated with the vacation communities of Red River, Angel Fire, and Eagle Nest.

[1] Source: U.S. Census Bureau, Decennial Census, 1990, 2000 and 2010, Summary File 1 (US CB 2015)

Homes within the Wildland-Urban Interface

It is common to have a large number of homes, second homes, and vacation homes bordering or surrounded by public lands in the western United States. These homes are especially vulnerable to the risk of wildfire, and are said to be within the wildland-urban interface (WUI). A WUI refers to the zone of transition between unoccupied land and human development. Communities that are within 0.5 miles of the zone may also be included.

Around 32 percent of U.S. housing units and one-tenth of all land with housing are in the WUI and housing growth is expected to continue (Stein et al. 2013). While the degree of risk may vary from one place to another, given the right conditions wildfire can affect people and their homes in almost any location where wildland vegetation is found. Even structures not immediately adjacent to wildland vegetation are at risk of damage from fire, because embers can be transported by wind and ignite vulnerable homes a mile or more ahead of the flame front (Stein et al. 2013). As more people live or work in the WUI, fire management becomes more complex and the costs to reduce fire risk, fight wildfires, and protect human lives and homes have risen sharply in recent decades (Stein et al. 2013).

Ten percent of the homes found within the assessment area are located in the WUI. It is estimated that 47 percent of those homes are second homes. In recent years, the Forest Service, including the Carson NF, has planned and implemented many projects that specifically decrease the potential undesirable effects of wildfires within these areas (e.g., prescribed burning and mechanical treatments to reduce fuels).

Table 68. Total homes and wildland-urban interface homes in the assessment area and New Mexico (Headwater Economics 2015)

	Assessment Area (# homes)	New Mexico (# homes)	Assessment Area (%)	New Mexico (%)
Total number of homes	53,158	901,388	--	--
Homes within WUI	5,500	27,387	10.3	3.0
Second homes within WUI (percentages are second homes as % of WUI homes)	2,598	10,924	47.2	39.9

Demographic Summary

The demographics of the assessment area provide a context for the region for which the Carson NF serves. Within this area, one will find a population that is made up of various races and ethnicities. Hispanic, Native American, Anglo, and a small number of other cultures combine to make the assessment area a multi-cultural center in northern New Mexico. The influence of these cultures is also represented by the number of people who speak languages (particularly Spanish) in addition to English, as compared to the rest of New Mexico and the United States.

The assessment area does have hardships as shown in the demographic data. The educational system is rated one of the lowest in the nation; however, more students are becoming more educated as recovery from the Great Recession continues and economic opportunities requiring higher levels of education become more available. This trend is expected to continue within the assessment area.

Employment within the assessment area was also heavily impacted during the Great Recession, as evidenced by the spike in unemployment from 2008 to approximately 2011. This unemployment trend is starting to improve as the area recovers. The main two industry sectors that support local economies and employment are services and government. While services have experienced a slight 2 percent increase in recent years, government has posted a 2 percent decrease. Overall, the assessment area is not known for employment opportunities, which results in people leaving the area to pursue them elsewhere.

Income is another demographic characteristic where the assessment area faces hardships. Over 45 percent of local households earn less than $35,000 per year, and over 22 percent of the assessment area lives below the poverty level. Personal income is also showing signs of flattening, with a hint of decrease in 2012.

Over one-third of housing units within the assessment area sit vacant, though the majority of these homes are seasonal or recreational homes. Over 35 percent of households spend more than 30 percent of their household incomes on housing costs.

Overall, the assessment area has many struggles in terms of education, employment, and income. Yet, it is rich in diversity and culture. As these characteristics define the area, they also represent the communities in which the Carson NF is an integral part.

Carson National Forest's Contribution to Social, Cultural, and Economic Conditions

Every forest in the National Forest System (NFS) possesses an individual characteristic specific to the area in which it is located. Some forests are predominantly timber forests, others are range forests, and others are recreation forests. While the Carson NF offers many of these qualities, it is largely a community forest. For over a century, communities have relied on, and identified the Carson NF as a source of subsistence. This has manifested through various means ranging from utilizing the natural resources on the forest for survival; creating community synergy around issues and events; offering a place for groups to commune, work, and recreate together; to providing solitude, peace, and relaxation for individuals who want to get away from the social pressures and pace of their everyday world.

At a public meeting during the development of this assessment, a participant described the importance of the Carson NF by stating that the local communities are who they are because of the Carson NF. While ways and means may have changed over time, this sentiment is still reflected in the activities people enjoy doing on the forest. Fuelwood gathering is regarded as a traditional family activity, since many local residents still rely on wood to heat their homes during the cold winter months. The Carson NF is a major source of vigas (heavy logs that support the roof) and latillas (peeled pieces of wood laid between vigas) that are essential in building and renovating pueblo-style or territorial-style adobe homes, so characteristic in northern New Mexico. Recreational group sites are heavily used by families and friends who come together and celebrate weddings, birthdays, life-changing events, family reunions, and holidays. Permitted livestock grazing on the Carson NF is unique to northern New Mexico. Many of the grazing allotments on the forest are managed as a "community" allotment, where each individual rancher has a permit for a certain number of head, along with as many as 10 to 15 other permittees on the same allotment. In addition, local residents rely on the Carson NF for parts of their livelihood, by capitalizing on the opportunity to provide tourist activities and other services on NFS lands. Forest management continues to bring communities together over issues that affect them or to foster involvement through volunteer work on their favorite part of the forest. Others continue to engage in some of the more traditional uses.

This section will explore the relationship between the Carson NF and its local communities, by examining the benefits the Carson NF offers its communities; the demands placed on the Carson NF by local communities; how social and cultural conditions influence the forest; and finally, how the Carson NF contributes to the economies of the assessment area. This section is based on what the Carson NF heard during 27 community listening sessions (January and February 2014); 2 collaboration stakeholder workshops (March 2014); and 14 community meetings (June 2014). In addition, this section uses information from *Values, Attitudes and Beliefs Toward National Forest System Lands: The Carson National Forest*[1] *(USDA FS 2006)* and two Forest Service General Technical Reports by Raish and Sweeney, *Economic, Social, and Cultural Aspects of Livestock Ranching on the Española and Canjilon Ranger Districts of the Santa Fe and Carson National Forests: A Pilot Study (Raish and McSweeney 2003)* and *Social, Cultural, and Economic Aspects of Livestock Ranching on the Santa Fe and Carson National Forests (McSweeney and Raish 2012)*.

[1] Data collection for this 2006 report was accomplished by a combination of individual interviews and small group discussions within the assessment area.

Benefits People Obtain from the Carson National Forest

The Carson NF is rich in unique cultural and traditional heritage that has blended with modern uses throughout northern New Mexico. The forest continues to provide (to varying degrees) benefits that have been historically significant, as well has offering modern benefits that present day northern New Mexico culture has come to desire, expect, or rely upon.

From a cultural and social standpoint, the best source to identify these benefits comes from the people and communities who directly benefit from them. At 14 public meetings conducted for this assessment in June 2014, stakeholders of the forest had the opportunity to share what those benefits were (USDA FS Carson NF 2014a, 2014c). Some of what the Carson NF heard at those meetings includes:

Traditional Benefits

- Gathering firewood
- Harvesting lumber for vigas, latillas, and other construction needs
- Livestock grazing
- Hunting and fishing
- Collecting medicinal herbs and clay for pottery making
- Irrigating with acequias (historic water ways for irrigation still in use today)

Natural Resource Oriented Benefits

- Clean water
- Wildlife habitat
- Fresh air

Nature Benefits

- Being away from civilization
- Solitude

Recreation Benefits

- Hiking
- Biking
- Camping
- Horseback riding
- Skiing
- Off-highway vehicle use
- Wildlife watching
- Sight-seeing
- Hunting

Wilderness Benefits:

- Enjoying wilderness values
- Biodiversity that comes with the wilderness designation

Lifestyle Benefits:

- Providing business and income opportunities (e.g., commercial services) through special use permits
- Family bonding through outdoor activities
- Spiritual connections
- Economic growth from tourism from people outside of the community visiting the Carson NF

Extraction Benefits

- Natural gas drilling
- Recreational prospecting
- Flagstone and decorative rock for personal use

While these are benefits offered by the Carson NF, more accurately, they are considered to be ecosystem services. Ecosystem services are defined as the benefits people obtain from ecosystems. The four categories of ecosystem services are explained in Chapter I. Introduction, Ecosystem Services Framework (p. 5). All benefits obtained from the Carson NF fall into all four categories: provisioning (clean air, water, wood, forage, etc.), regulating (long-term carbon storage, climate regulation, flood control, water filtration, etc.), supporting (pollination, seed dispersal, soil formation, nutrient cycling, etc.), or cultural (spiritual and recreational experiences) services. Chapter II. Ecological Integrity and Sustainability of this document address ecosystem services from an ecological perspective. The following sections on multiple uses (p. 354) and national forest resource areas (p. 424) will look at ecosystem services from a cultural, social, and economic perspective.

Demands and Concerns on the Carson National Forest

The demands placed on the Carson NF are virtually synonymous with the benefits discussed in the previous section. These benefits will continue to be desired, making them de facto demands. As such, the forest will be expected to continue to provide these benefits presently and into the future.

While not specifically "demands", participants at the public meetings for the assessment discussed concerns as they relate to both the Carson NF and to natural resource management in general. These concerns are relevant in that they express underlying needs or demands that may need to be addressed in the near or more distant future. Interestingly, many of the concerns expressed are also shared by the forest. Many of the concerns expressed in the 14 public meetings in 2014 (summary on page 9) conducted for the assessment are summarized below (USDA FS Carson NF 2014a, 2014c):

- How much use of the forest is sustainable in various resources areas, such as water, timber, and mineral extraction? How are these uses impacting forest and watershed health?
- People are worried about diminishing water supplies and water quality, which affect water available for irrigation, livestock, fish and wildlife, and domestic use.
- There is concern that fire management is not doing enough to reduce the risk of wildfires that could potentially have devastating effects on the forest and adjacent communities.
- To what extent should the Carson NF be used for local economic development?
- Can recreation activities on the forest provide needed economic benefits to local communities? If so, what activities and to what extent?
- Some people feel the travel management process reduced motorized access by too much on the Carson NF, while others feel the transportation system should be further reduced.
- People want more trails and different types of trails, but will new trails be an added financial burden for the forest?
- How much investment and focus should there be on road, trail, and facility conditions and maintenance (including signage)?
- Some people want more wilderness areas, while others feel they are being locked out of the forest by the addition of more wilderness areas.
- Some people would like to see less elk on the landscape to reduce competition for forage, while others believe there is an appropriate amount of elk for elk hunting opportunities.
- How should invasive plant and animal species be controlled to protect ecosystem integrity?
- How will climate change affect the forest, forest health, and the surrounding communities that rely on the forest?

- There is a need for better communication and working relationships between the Forest Service, local communities and governments, special interest groups, and members of the public who are interested or affected by management activities on the Carson NF.
- Many people acknowledge the Forest Service is operating in a time of declining budgets and recognize the need and desire for more partnerships between the Forest Service, local governments and communities, and special interest groups.
- Some people want to see more education, specifically on the cultural significance of the area, ecosystems, and proper use and appreciation of the forest.
- Some believe there is not enough enforcement of the rules and regulations on the Carson NF and want to see "bad behavior" that takes place on the forest addressed. Others think there are too many restrictions and rules limiting their ability to use and access the forest.

When the Carson NF held public meetings on the draft assessment in May and June 2015 (Public Participation, p. 9), many of the same concerns were voiced as above and were carried over for consideration in the Carson NF's Need for Changing Management Direction of Its Existing 1986 Forest Plan.

Relationship of the Carson National Forest to Local Cultural and Social Conditions

Since its inception in the early 1900's as the Taos Forest Reserve, the Carson NF has been the sole source provider for many of the needs essential for settling this region of the southwestern frontier. It served Native American tribes, Spain, and Mexico long before it became a United States property and its borders were established. The heritage, culture, traditions, and values that grew from this time period were handed down over generations and still exist in northern New Mexico today. On the other hand, while those historical values are still prevalent, the social and cultural environment has evolved into the modern age. By this virtue, the Carson NF has the unique challenge of serving two different eras through present day management.

Aside from time steeped heritages and traditions, the Carson NF has a diverse community composition, where Native Americans, Hispanic, Anglo, and a minority of other cultures have combined to make northern New Mexico a multicultural center. All of these cultures have ties to the forest through strong attachments to the land that may be generations old or a new found discovery.

In addition to serving the local population, the Carson NF also offers visitors, who travel to the region, a unique experience in culture, exploration, wilderness, and other activities such as skiing and snowboarding. Collectively, the assessment area and the Carson NF are strongly influenced and shaped by local time honored traditions, cultural diversity, and by those who wish to experience this unique setting from other areas around the country.

Traditions

Residents of communities surrounding the Carson NF have a strong connection to the land and its resources. There is also a strong sense of community across all of the diversity that exists within the assessment area. Both sentiments date back centuries, before the United States acquired this part of the country. Local passions continue to demonstrate these time honored connections to the land and culture, thereby giving long-lasting vibrancy to deeply rooted traditions and ways of life. The Carson NF has been an integral part of this history and continues to play a prominent role in the longstanding traditions and uses of the assessment area.

There is a strong sense of attachment to the land that is the Carson NF. There are three major components that characterize this sense of attachment. The first comes from traditional users having a sense of personal ownership, based on historical associations with NFS lands (USDA FS 2006). There is a significant generational element to this theme, which dates back to the time before the Carson NF was designated. The second component is derived from historical practices around the use of natural resources. These traditional users believe their first-hand knowledge and self interest in management of forest resources results in a culturally based understanding, and attachment to, forest lands (USDA FS 2006). The third component views the Carson NF as a legacy. It is viewed that this land has been inherited and is a unique resource that should be cared for and passed down to future generations (USDA FS 2006).

Likewise, these historical connections to the land have been instrumental in giving the Carson NF a large part of its character. They still influence the forest in present day terms, through various means, especially through *land grants*, *acequias*, and *traditional uses*.

Land Grants

Land grant history within the assessment area has a significant bearing on social and cultural conditions as they relate to the Carson NF. Land grants were issued by Spain and Mexico before the United States entered the Southwest, and they have been the topic of deliberation and controversy since the Treaty of Guadalupe Hidalgo in 1848 (US GAO 2004).

From the late 17th century to the 19th century, Spain and Mexico issued three types of land grants, to encourage settlement in the Southwest, to give as rewards, and to create buffer zones between Indian tribes. They included: (1) individual lands grants for private landownership; (2) community land grants for community development and use; and (3) land grants for pueblos, which Spain issued before Spanish settlers began to arrive.

When the United States took over ownership of much of the Southwest in 1848 through the Treaty of Guadalupe Hidalgo, it agreed to recognize property rights awarded under established land grants. Two successive confirmation processes were used by U.S. Congress in the 1800s and 1900s, to determine whether to recognize and confirm or to reject land grants in New Mexico.

Many issues have arisen over the confirmation of land grants. The legitimacy of the processes utilized and of those who utilized them have been questioned, and land grant heirs were concerned the United States did not properly protect land grants as required under law. Concerns were also expressed over boundaries. The fairness and equity of the processes used were also questioned.

In total, over 17.9 million acres were claimed as land grants with 9.9 million acres (55%) confirmed and awarded by Congress. Currently however, only 6 percent of the community land grant acres remain in land grant status. The remaining 94 percent was lost over time to attorney's fees during the confirmation process and to partitioning suits, taxes, foreclosure, and real estate transactions, which occurred after the two successive confirmation processes. The Carson NF has since been put into stewardship over some of the lands in question. This has led to resentment over property some believe was wrongfully taken, though how the land was lost may be in question.

Acequias

Acequias are the historic ditches that bring water from rivers and streams to communities for irrigation purposes. They are generally community run through associations headed by the majordomo (ditch-master) and date back to the time of Spanish settlement in the 1500s. These waterways are still in use today for the original purposes for which they were established. They are also a representation of how important water is in the desert Southwest and were instrumental in the settlement of the Southwest. Those who use and maintain these ditches serve to protect their historic values, as well as their utilitarian purposes. These values are also recognized by the State of New Mexico through the New Mexico Acequia Commission.

Acequias are vital institutions in New Mexico, and have their origins dating back to the Moors of North Africa, who introduced this type of water conveyance system to Spain. Spanish settlers brought this tradition to New Mexico in 1598, inspired in part by techniques that Pueblo Indians developed. Acequias are considered political subdivisions of the state and are collaborated with as local governments. Acequias are vital in the production of crops and livestock, they are inherently special riparian areas for many species of wildlife and plants, and they provide spiritual and aesthetic value.

Acequias are an integral part of the cultural and traditional heritage identified in the assessment area. The Carson NF plays a role in this heritage by working with acequia commissions to support ongoing maintenance and accommodate access and needed infrastructure for historic ditches that are located on NFS lands.

Acequias that predate the National Forest Reservation are afforded special rights and status under NFS management. Under the Chief's Policy relating to the Act of July 26, 1866 (Revised Statute 2339), continuing routine operation and maintenance of acequias is allowed without special-use authorization being required. A special use authorization is the legal instrument that allows acequias to perform activities other than routine operation and maintenance on NFS lands. Acequia activities, such as construction or reconstruction, changes in the acequia alignment, or additional infrastructure outside the original footprint or established right-of-way, require special use authorization.

The Carson NF has approximately 36 acequia permits it administers. There are additional acequias on the Carson NF, but they are not all identified in the database of the Office of the State Engineer.

Traditional Uses

Traditional uses as they relate to the Carson NF are uses that have strong cultural ties to northern New Mexico's heritage. They hold historic significance, since they were necessities for survival, and many uses defined a way of life. While their prevalence has diminished over time, those with cultural ties to the assessment area still engage in these uses and view them as a part of their heritage. Most of these uses can be linked back to the days when land grants were used to settle this land. Those who have a cultural investment in the traditional uses of the assessment area look to the Carson NF to continue providing these opportunities as a matter of right. These uses consist of livestock grazing, hunting and fishing, medicinal herb gathering, firewood gathering, open forest access, and wood harvesting for commercial uses.

Transition in Time

In addition to traditional uses that continue to weather the test of time, the Carson NF has also experienced a progression more contemporary in nature. There has been a shift toward more of a recreation-tourism economy, and when asked, the public generally views the Carson NF with a strong recreation emphasis (USDA FS 2006: p. 2). There is a charm found only in northern New Mexico that attracts visitors from all over the county. Many come to visit the cultural distinctiveness that gives the assessment area an almost mystical and mythical quality, others come to partake in various outdoor summer and winter pursuits, and the beauty of the landscape is an attraction in and of itself. For these reasons, recreation and tourism have become focal points on portions of the Carson NF, incorporating its unique social and cultural setting.

The assessment area and the Carson NF elicit a strong sense of connection that is not only traditionally based, but is also shared by those who are considered “non-traditional” users and live in the area or visit the forest. Many of these connections are based on interactions with the forest and its resources, as well as personal experiences and values. Some users have special places on the forest, while others speak of the inspiration, solitude, and appreciation they feel by being in the Carson NF (USDA FS 2006). Despite a gradually more contemporary setting of the assessment area, there is still a strong attachment to the land, though the reason for the attachment has shifted. Uses and activities provided by Carson NF are growing more recreation based and tend to support tourism in the assessment area. This is a perceived change in the social setting by some local residents.

Switch to Recreation Emphasis

In the past, communities and families who lived within the assessment area relied on natural resources to get by. The main activities were logging, mining, grazing, ranching, and farming. Now, recreation and tourism are the mainstays. The shift from land based dependency to recreation and tourism has transitioned over the last two generations, but has seen a dramatic increase in the rate of change over the last several decades (USDA FS 2006). Approximately one million people visit the forest each year with 89 percent of those visits being for recreational purposes (UNM 2014, 2015).

Tourism Support

With a shift to recreation and tourism, the assessment area has become a support mechanism for this up and coming industry. This is especially evident in two ways. First, local businesses and entrepreneurs look to the Carson NF for permits that allow them to host tourist types of activities on NFS lands. Some rely on this as a main portion of their income. Secondly, local communities, including existing land grants, are looking for economic development for their small communities, by becoming gateways to the Carson NF.

Change in Social Setting

There is a perception within the assessment area that a transition is occurring within the social fabric of the communities. This shift involves the exodus of younger people and the influx of newcomers. Younger people are believed to be leaving the area in search of jobs, which are limited within the assessment area. Despite a strong sense of attachment, many of these young people rarely make it back. It is also believed that newcomers are increasing in number; however, there is also a perceived turnover in newcomers, because they leave when their expectations of rural living are not met. These perceptions imply there is also a transition occurring in values based on tenure, including those related to natural resources. It is held that newcomers may not have the same land ethic as longer term residents, and they may not have an appreciation for traditional uses (USDA FS 2006). While these perceptions may or may not be supported by data, they do indicate a social scenario where communities are feeling a change, and possibly a loss of traditional ways of life. Alternatively, community members perceive increased involvement and cooperation with each other around natural resources issues. This is perceived to be bridging the gap between social differences and value conflicts within communities (USDA FS 2006).

Carson National Forest’s Contributions to Local Economic Conditions

The Carson NF makes up nearly 1.5 million acres or 16 percent of the assessment area, making it an important contributor to the local economies within the assessment area (UNM 2014, 2015). The forest’s economic influence on the assessment area has direct, indirect, and induced impacts where:

- **Direct impacts** are the value of goods and services that are directly provided by Carson NF.
- **Indirect impacts** are from linkages to other industries, not directly associated with the Carson NF. For example, a tourist may spend money on food in a local restaurant. This will increase the demand for raw materials needed to produce food. Increased demand for raw materials will increase the demand for labor to produce them. The increase in the number of jobs from the increased demand for raw materials is the indirect impact.
- **Induced impacts** occur when labor income increases, resulting in increased demand for goods and services in the local economy, creating additional employment and output.

All three types of impacts are measured in employment, labor income, value added, and output.

- **Employment** measures the number of jobs generated in the economy by Carson NF. These numbers are in terms of number of jobs and not in terms of full-time equivalent employees.
- **Labor income** is income earned by the labor force because of the Carson NF’s presence.
- **Value added** by the Carson NF is the total amount paid for all factors of production (inputs that are used in the production of goods and services) in the impact area including labor. It is a measure of Carson NF’s contribution to the local economy.
- **Output** is the value of industry production in the impact area measured in producer’s price. Producer’s price is the amount received by a producer by selling one unit of goods or services produced minus any value added tax or other deductible taxes.

In 2012, the total economic impact of the assessment area from the Carson NF was estimated to be nearly 200 million dollars (Table 69). The Carson NF generates more than 2,600 jobs, with over 2,100 of these jobs generated in the recreation and tourism industry.

Table 69. Summary of the Carson National Forest's total economic impact on the assessment area (UNM 2014, 2015)

	Employment	Labor Income	Value Added	Output
Tourism	2,101	$51,758,969	$89,567,054	$153,689,861
Grazing	292	$3,869,866	$5,766,913	$25,149,792
Timber sales	40	$1,734,100	$2,423,352	$5,458,569
Oil and gas	18	$731,527	$977,488	$1,176,471
FS expenditure	185	$7,897,286	$10,770,598	$13,519,645
Total	2,636	$65,991,748	$109,505,405	$198,994,339

Tourism

The Carson NF has the greatest economic impact on the assessment area through tourism. With over one million people that visit the forest annually, it adds over $153,689,800 to the local economies (Table 69). It also adds over $10,575,000 to state and local taxes and over $10,730,000 to federal taxes.

Table 70 shows the various types of economic impacts produced by tourism in 2012, according to the four measures (UNM 2014, 2015).

Table 70. Carson National Forest's economic impact on the assessment area from tourism (UNM 2014, 2015)

Impact Type	Number of Jobs	Labor Income	Value Added	Output
Direct impact	1,738	$41,174,719	$67,507,249	$116,126,534
Indirect impact	179	$4,866,375	$9,755,615	$18,294,473
Induced impact	184	$5,717,876	$12,304,190	$19,268,855
Total impact	2,101	$51,758,969	$89,567,054	$153,689,861

Livestock Grazing

Livestock grazing is one of the traditional uses of the Carson NF. Despite the change over time in the prevalence of grazing on the forest, it remains an activity that adds economic benefits to the assessment area (Table 71). In 2012, grazing generated nearly 300 jobs to the local economies and over $25,149,000 in output. Table 71 summarizes the economic impact from livestock grazing on the Carson NF in 2012 (UNM 2014, 2015).

Table 71. Carson National Forest's impact on the assessment area from livestock grazing (2012)

Impact Type	Number of Jobs	Labor Income	Value Added	Output
Direct impact	202	$2,353,116	$2,853,368	$16,766,092
Indirect impact	76	$1,085,432	$1,985,538	$6,929,969
Induced impact	14	$431,318	$928,007	$1,453,732
Total impact	292	$3,869,866	$5,766,913	$25,149,792

Timber

While a smaller program, timber sales on the Carson NF do produce some economic impact to the assessment area. Of all the timber sold on the Carson NF, 75 percent of the timber cut was from fuelwood sales. Timber sales generated more than $623,000 in tax revenues in 2012. Nearly 60 percent went to state and local governments and the remaining 40 percent was to the federal government. Table 72 summarizes the economic impact based on market values from timber sales on the Carson NF in 2012 (UNM 2014; 2015).

Table 72. Carson National Forest's economic impact on the assessment area from timber sales (2012)

Impact Type	Number of Jobs	Labor Income	Value Added	Output
Direct impact	10	$1,057,407	$1,467,960	$3,857,355
Indirect impact	24	$482,441	$537,482	$946,439
Induced impact	6	$194,253	$417,909	$654,774
Total impact	40	$1,734,100	$2,423,352	$5,458,569

Oil and Gas

Oil and gas development takes place only on the Jicarilla RD of the Carson NF, where there are over 830 active natural gas wells. The local economy benefits from tax disbursements generated by the oil and gas industry. In 2013, more than $200,000 was produced in taxes, with 24 percent of that going to state and local governments. Table 73 summarizes the economic impact on the assessment area from oil and gas development on the Carson NF (UNM 2014, 2015).

Table 73. Carson National Forest's economic impact on the assessment area from oil and gas development (UNM 2014, 2015)

Impact Type	Number of Jobs	Labor Income	Value Added	Output
Direct impact	15	$643,678	$790,089	$878,434
Indirect impact	0	$7,221	$13,891	$26,334
Induced impact	3	$80,628	$173,508	$271,703
Total impact	18	$731,527	$977,488	$1,176,471

Carson National Forest Expenditures

In addition to contributions that come from the programs and resources it manages, the Carson NF has direct expenditures that contribute to the local economy. In 2012, 153 employees worked for the Carson NF and the Forest Service spent $16,543,101 on their wages and salaries. This generated a total of 185 jobs and more than $13,500,000 in output. Table 74 summarizes the economic impact from for expenditures from the Carson NF (UNM 2014, 2015).

Table 74. Carson National Forest's economic impact on the assessment area from total expenditures (UNM 2014, 2015)

Impact Type	Number of Jobs	Labor Income	Value Added	Output
Direct impact	153	$6,904,670	$8,661,451	$10,139,424
Indirect impact	4	$121,739	$235,075	$445,498
Induced impact	28	$870,877	$1,874,072	$2,934,724
Total impact	185	$7,897,286	$10,770,598	$13,519,645

Tax Revenues

Tax revenues are another economic contribution the Carson NF makes to the assessment area. Taxes generated from the various economic activities on the Carson NF equated to just over $24,000,000. Of that, 47 percent went to state and local governments, with the remainder going to the U.S. Treasury. Tourism accounted for 86 percent of the total tax, which ultimately contributed over $10 million to state and local governments. Table 75 summarizes the tax income generated from various activities in the Carson NF.

Table 75. Tax income (dollars) generated from various activities in the Carson National Forest (UNM 2014, 2015)

	Tourism	Grazing	Timber Sales	Oil & Gas	FS Expendi-tures	Total
Total State & local tax	10,576,723	2,351	370,755	41,300	493,003	11,484,132
Total Federal tax	10,731,876	629,703	252,828	134,585	1,459,034	13,208,026
Total	21,308,599	632,054	623,583	175,885	1,952,037	24,692,158

Total Federal Land Payments

Federal land payments are payments made by the federal government to state and local governments to compensate for non-taxable federal land within their borders. These payments are made either by federal appropriations or through revenue sharing from receipts received from activities that occur on federal land. In the assessment area, the Forest Service makes contributions through both appropriations and revenue sharing via various programs, such as the appropriated Payment in Lieu of Taxes (PILT), and revenue sharing programs, such as the Secure Rural Schools program, and for county roads.

Forest Service Contributions to Payment in Lieu of Taxes (PILT)

The Forest Service makes up over 55 percent of PILT funds based on acres and other factors such as population caps and past revenue sharing totals. Table 68 offers a breakdown and comparison to other federal agencies. Figure 73 provides total payments in lieu of taxes per fiscal year in the assessment area since 1986.

Table 76. Payment in lieu of taxes eligible acres by agency (FY 2013)

Agency	Assessment Area	U.S.	Assessment Area (%)	U.S. (%)
Total eligible acres	4,331,054	605,353,942	--	--
BLM	$1,853,102	$241,711,116	42.8	39.9
Forest Service	$2,394,791	$189,274,098	55.3	31.3
Bureau of Reclamation	$50,215	$4,030,856	1.2	0.7
National Park Service	$30,086	$76,781,845	0.7	12.7
Military	0	$328,157	0.0	0.1
Army Corps of Engineers	$2,860	$7,969,080	0.1	1.3
US Fish & Wildlife Service	0	$85,235,272	0.0	14.1
Other eligible acres	0	$23,518	0.0	0.0
PILT payment	**$6,962,237**	**397,256,089**		
Avg per acre payment	**1.61**	**0.66**		

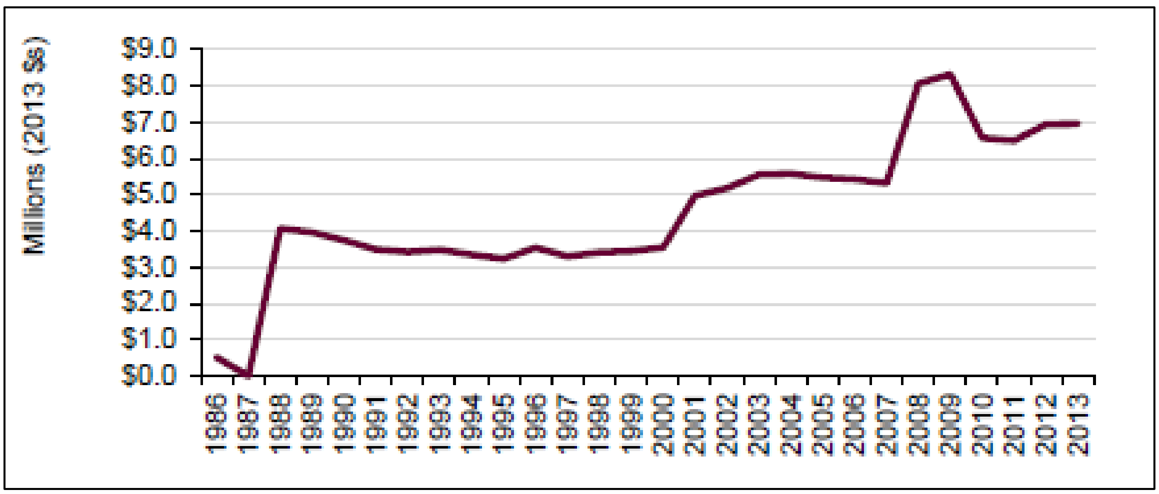


Figure 73. Total payments in lieu of taxes (PILT) per fiscal year for the assessment area

Forest Service Revenue Sharing

The Forest Service contributes to several national revenue sharing programs, which include the Secure Rural Schools and Community Self-Determination Act, 25% Fund, and Forest Grasslands, where receipts from activities on Forest Grasslands are shared directly with county governments. For the assessment area, the Forest Service provides 100 percent of its revenue sharing funds allocated to the Secure Rural Schools Program. This program has three titles that provide funds for specific purposes. Title I funds must be dedicated to funding roads and schools; Title II funds are retained by the federal treasury to be used on special projects on federal land; and Title III payments may be used to carry out activities under the Firewise Communities program, to reimburse the county for search and rescue and other emergency services, and to develop community wildfire protection plans. In Fiscal Year 2013, Secure Rural Schools contributions to the assessment area totaled nearly $3.3 million, with Title I receiving 85 percent of those funds, Title II receiving 9 percent, and Title III receiving almost 6 percent.

Forest Service Gross Receipts from Commercial Activities

The Carson NF provides various economic opportunities to surrounding communities. These income producing opportunities for local businesses range from timber harvesting, ranching, and providing recreation services to the visiting public. Figure 74 shows the gross receipts collected by the Carson NF and deposited into the National Treasury as fees collected from those who utilize such opportunities. Timber, primarily from fuelwood permits, generates the largest share of gross receipts, with recreation related activities coming in second.

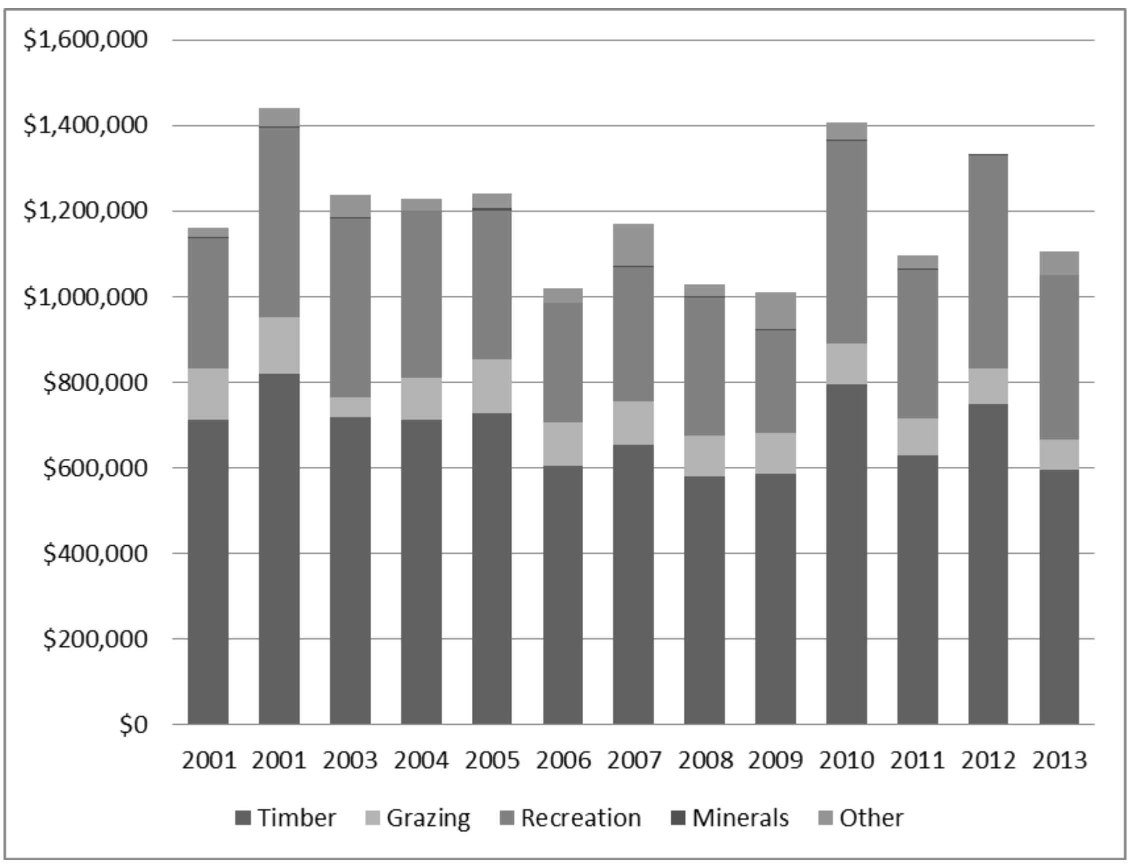


Figure 74. Carson National Forest gross receipts by source, 2001 to 2013

Employment

Table 77 represents the number of persons employed by government entities in the assessment area. Carson NF employees would be included in the Federal Government sector. The Government sector makes up nearly 22 percent of employment within the assessment area. Federal government employment only accounts for 1.7 percent of all employment within the assessment area. The number of government jobs within the assessment area has been between 20 and 25 percent since 1980 (Figure 75).

Table 77. Employment in government (2013)

	Assessment Area (# people employed)	Assessment Area (%)
Total employment	42,715	
Government	9,132	21.4
Federal	714	1.7
Military	248	0.6
State and local	8,170	19.1
Private Sector	33,583	78.6

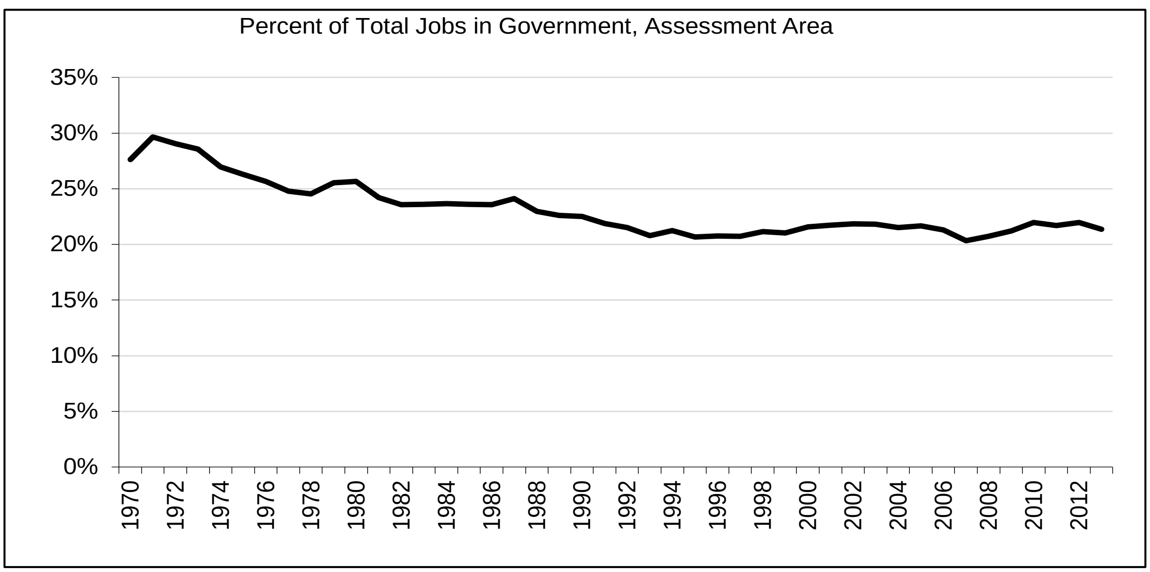


Figure 75. Percent of total jobs in government within the assessment area, 1970-2013

Infrastructure

The Carson NF's infrastructure plays a negligible role in providing economic contributions to local economies. There is some income to the concessionaires who manage Forest Service campgrounds (approximately $138,000); however, infrastructure primarily supports current Forest Service management and activities, such as roads for access. See the Infrastructure section for a more detailed discussion.

Aesthetics

Scenery and aesthetics are an important component of the Carson NF and the assessment area. The forest is perceived as having a range of aesthetic resources that are valued by both local residents and by those who visit the area. Scenery is also believed to attract new residents to the assessment area (USDA FS 2006). Scenery viewing accounts for 31 percent of the recreation use on the forest, by both residents and non-residents (UNM 2014, 2015). The scenery and perceived beauty of the area contributes to the recreation and tourism industry in the assessment area. For example, the Carson NF is a scenic back-drop to many communities within the assessment area and influences the value of real estate, especially in the Taos area. Property adjacent to or near the forest boundary can sell for a much higher price than a similar property located further away. As stated previously, recreation and tourism is the largest area of economic contributions made by the Carson NF. Scenery is discussed in more detail in the Outdoor Recreation section, which describes various parts of the forest according to their scenic values.

Summary

In a social context, the Carson NF offers a unique setting in terms of history, diversity, and economic conditions. There is strong attachment to the land by the residents within the assessment area and traditional uses are held in high esteem. The area is experiencing a shift to recreation and tourism, which take advantage of the history, culture, and natural environment in and around the Carson NF.

In addition to the attachment people have to the land, there are also benefits derived from and demands placed on the Carson NF that the public communicated during the course of this assessment. Many of these include traditional benefits, natural resource oriented benefits, nature benefits, recreation benefits, wilderness benefits, and lifestyle benefits. The demands were generally expressed as concerns or desires. In summary, the public's main interests were related to (1) roads, trails, and facility maintenance; (2) trail opportunities; (3) travel management; (4) climate change; (5) fire management; (6) diminishing water supplies; (7) sustainability of the forest; (8) invasive plants and animals; (9) support for economic development; (10) recreation; (11) wilderness; (12) better communication with the forest; (13) more educational opportunities; (14) volunteer opportunities; and (15) law enforcement.

The demographics of the assessment area reflect an area that is culturally and economically diverse. They also highlight some of the hardships people face, especially in terms of income (over 20% of the population lives in poverty), and a struggling educational system. Most people in the assessment area work in the services industry or for local government, and wages tend to be lower compared to the State of New Mexico and the nation. There is little opportunity in the assessment area, and younger generations are perceived to be leaving the area in search of better jobs. However, personal incomes are increasing (Headwater Economics 2015), along with a decreasing trend in the unemployment rate. Overall, population in the assessment area is decreasing, but a rich diversity remains, with Hispanic, Native American, Anglo, and other cultures represented.

The Carson NF also offers a demographic profile that provides economic benefits to the assessment area. Economic contributions from the forest provide benefits to the assessment area from direct, indirect, and induced impacts. Overall, the forest contributes over 2,600 jobs and $190 million to the local economies. Grazing, timber, oil and gas, and forest expenditures also provide economic contributions, though to a lesser extent. However, recreation and tourism contribute more than all of the other resource areas combined. The Carson NF also contributes more than $2 million to local counties for payments in lieu of taxes and over $3 million to the Secure Rural Schools program. The Carson NF itself received just over $641,000 in gross receipts from income generated by timber, grazing, and special uses, among other smaller programs.

When considering the social context, the attachment people have, and the contributions the Carson NF makes, it is evident that the forest is not separate from the communities it serves, but is an integral part of them. Reliance on NFS lands in some form or another is part of the culture within the assessment area and will continue to be so for as long as the forest remains in place.

Social, Cultural, and Economic Contributions of Multiple Uses from the Carson National Forest

The Forest Service is a multiple-use agency providing benefits from various forest resources. These benefits are referred to as ecosystem services and include social and economic benefits, as well as ecological benefits. This section evaluates the social and economic benefits from recreation, grazing, minerals, timber, water, and wildlife. Trends, benefits, and sustainability are included as an integral part of each resource and use area.

Outdoor Recreation

The Carson NF offers a wide spectrum of recreational opportunities. Its varying elevations and climatic zones allow year-round visitation. Elevations range from 6,000 to over 13,000 feet, including Wheeler Peak (13,167'), the highest peak in New Mexico. The east side of the forest (Questa and Camino Real RDs) has the majority of motorized and non-motorized trails, developed recreation facilities, three alpine ski areas, and one Nordic ski area. The forest's high elevation alpine environment draws visitors from several states (e.g., New Mexico, Texas, Oklahoma, and Louisiana) to escape from the heat during the summer and for the snow sport opportunities in the winter (USDA FS 2009a).

The Carson NF contains a large portion of the headwaters of the Rio Grande and Rio Chama and is the source of water for many other lakes and streams. The abundance of water is a big draw for visitors coming to the forest. Most developed recreation facilities are located to take advantage of these features. The forest also offers exceptional opportunities for dispersed recreation and for solitude. The east and west side of the forest both provide dispersed recreation; however, the west side (Tres Piedras, Canjilon, and El Rito RDs) is known for offering a wide variety of dispersed activities and is heavily used during the fall hunting season. The few developed recreation facilities on the west side are extremely popular, especially among local residents from nearby urban areas of the state (e.g., Albuquerque, Santa Fe, Los Alamos). This section identifies and evaluates:

- Ecosystem services that outdoor recreation provide on the Carson NF
- Outdoor recreation opportunities the Carson NF has to offer
- Types of settings where outdoor recreation takes place on the Carson NF
- Scenery of the Carson NF
- Important outdoor recreation sites and areas on the Carson NF
- Compatibility among different types of outdoor recreation use on the Carson NF
- Access and infrastructure related to outdoor recreation
- Trends in outdoor recreation on the Carson NF
- Social, cultural, and economic contributions of outdoor recreation
- Sustainability of outdoor recreation on the forest
- Outdoor recreation enhancement opportunities
- Nearby outdoor recreation opportunities
- Summary of outdoor recreation on the Carson NF

Outdoor Recreation Ecosystem Services

Outdoor recreation provides a variety of ecosystem services, including:

- **Provisioning:** Recreational gathering of firewood and plant materials provide products from the forest for people's enjoyment and use.
- **Cultural:** From a cultural and social perspective, recreation on the forest offers services for both summer and winter recreational activities, opportunities for scenic viewing, and places to connect with nature and spirit. It also offers rejuvenation and escape from urban environments and lifestyles sought by visiting recreationists. The recreation program also contributes to tourism and economies of the local communities.
- **Regulating:** Hunting and fishing are two recreational activities that have regulating functions for ecosystems. They help control wildlife populations and can aid in the reduction of spread of disease amongst wildlife.

Outdoor Recreation Opportunities

Approximately one million people visit the Carson NF annually, with 89 percent of them visiting specifically for recreation. Non-local and local recreational visitors are fairly evenly split at 43 and 42 percent, respectively. The remaining 15 percent come to the Carson NF for reasons other than recreation. Figure 76 shows use on the forest by recreational activity.

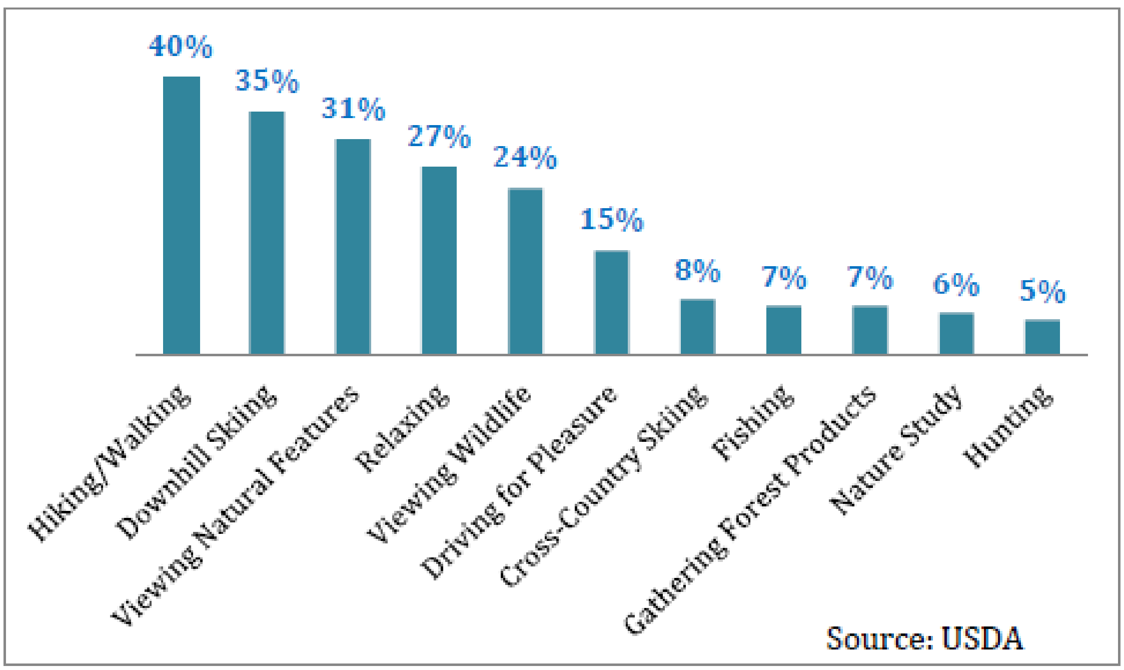


Figure 76. Use by recreational activity on the Carson NF (USDA 2012)

Recreationists on the Carson NF have multiple opportunities to choose from any time of the year. Both summer and winter activities offer the outdoor enthusiast an array of settings, challenges if so desired, and occasions to enjoy spectacular views and wildlife throughout the forest. Opportunities can be grouped into one of the following recreation types: (1) dispersed recreation; (2) developed recreation; and (3) motorized recreation. Settings and experiences are defined by the Recreation Opportunity Spectrum and scenery is classified through the Scenery Management System.

Dispersed Recreation

Dispersed recreation is the most popular form of recreation on the Carson NF and includes, dispersed camping, hiking, scenic viewing, wildlife watching, equestrian use, fishing, hunting, and cross-country skiing. Among all of the dispersed uses across the forest, trail use rates the highest in both the summer and winter. The forest is also popular for large family groups that enjoy dispersed camping adjacent to Forest Service roads or water sources.

Use trends tend to follow the population centers around the forest for dispersed recreation. Higher use rates occur near the small towns where people can go out for a quick outing without having to venture far. Trails around local communities are popular for quick hikes over shorter distances. Likewise, many of the associated impacts are more concentrated around communities, such as illegal trash dumping, unmanaged motorized use off designated routes, and the unauthorized construction of mountain biking features along trails.

With trail use making up the most popular dispersed recreation activity on the Carson NF, trail opportunities lag user demand. For example, mountain biking opportunities on the forest are scarce compared to the demand. The same is true for motorized trails across the forest. As a result, forest trail users are creating new trails and opportunities for their specific use, or riding on closed routes.

Trail maintenance is also behind the maintenance needs on the Carson NF. One trail crew works approximately half of the year, and the destination hikes such as Wheeler Peak, Hondo Canyon, and Pecos Wilderness usually receive annual routine maintenance, while other trails on the forest receive little to no maintenance, despite trail use being one of the largest demands on the forest.

Group camping is another activity enjoyed in forest areas that have no developments. Some of the most popular dispersed camping tends to take place by water features, such as streams or around riparian areas, by larger groups. The Carson NF is often sought for large family camping and group gatherings. Group camping in wet areas causes negative ecological impacts, including soil compaction, sanitation issues, and contamination of water.

When the Carson NF went through the evaluation process to comply with the Travel Management Rule (36 CFR Parts 212, 251, 261, and 295), the public was very concerned over the elimination of motorized cross-country travel. In the past, people drove off a forest road and camped in the woods. To address this historic use during the travel management review process, corridors were identified along open forest roads, where motorized camping would be allowed. The final travel management decisions for the Carson NF designated 785 miles of open road with 300-foot corridors and 451 miles of open road with 150-foot corridors, where people are allowed to drive off the road with their truck or motor home and camp.

Developed Recreation

The Carson NF has many developed campgrounds, trailheads, interpretative sites, and fishing sites (Table 78 and Figure 77, p. 360). Most developed campgrounds on the forest are managed by a concessionaire. The remaining fee sites are managed by the forest through the Recreation Enhancement Act program. The developed campgrounds are typically open from Memorial Day through Labor Day weekend. Use is highest during the month of July and on holiday weekends. Some of the campgrounds on the forest use the Reserve America reservation system. The Carson NF intends to eventually add most campgrounds to this reservation system.

Most developed trailheads are near state highways and can be accessed year-round. Remote trailheads accessed from forest roads are typically inaccessible in the winter, due to seasonal closures or poor road conditions.

Participating in snow skiing is the second most popular activity on the forest. Taos Ski Valley, Red River Ski and Summer Area, and Enchanted Forest Cross-country and Snowshoe Area are located on the Questa RD. Sipapu Ski and Summer Resort is on the Camino Real RD. The three downhill ski areas offer year-round recreation opportunities.

Table 78. Developed sites on the Carson National Forest

Site Name	Campground	Picnic Area	Day Use	Group Site	Trailhead	Interpretive Site	Fishing Site	Ski Area	Snow Play Area	Concessionaire Managed	On Reservation System
Canjilon Lakes Picnic Site		X									
Canjilon Lakes Campground	X										
Trout Lakes Campground	X										
Echo Amphitheater Campground	X										
Echo Amphitheater Day Use			X								
El Rito Campground	X										
Buzzard Park Campground	X										
Cedar Springs Campground	X										
Duran Campground	X									X	
Upper La Junta Campground	X									X	
La Junta Canyon Campground	X									X	
Agua Piedra Campground	X									X	
Comales Campground	X									X	
Santa Barbara Campground	X									X	
El Nogal Trailhead					X						

Site Name	Campground	Picnic Area	Day Use	Group Site	Trailhead	Interpretive Site	Fishing Site	Ski Area	Snow Play Area	Concessionaire Managed	On Reservation System
Las Petacas Campground	X									X	
Capulin Campground	X									X	
La Sombra Campground	X										
Hopewell Picnic Site		X								X	
Hopewell Campground	X									X	X
Hopewell Group Site				X						X	
Lower Hondo Campground	X										
Cuchillo Del Medio Campground	X										
Twining Campground	X										
Cabresto Lake Campground	X										
Elephant Rock Campground	X									X	
Fawn Lakes Campground	X									X	X
Junebug Campground	X									X	
Goat Hill Campground	X									X	
Columbine Campground	X									X	X
Lagunitas Campground	X									X	
Trampas Trailhead					X						
Fiechado Picnic Site		X									
Agua Piedra Picnic Site		X								X	
Pot Creek Interpretive Site						X					
Los Pinos Campground	X										
Cimarron Campground	X									X	X
McCrystal Campground	X										
Cebolla Mesa Campground	X										
Shuree Ponds Picnic Site		X								X	
Taos Ski Valley Resort								X			
Red River Ski & Summer Area								X			
Sipapu Ski & Summer Resort								X			
Tres Piedras Rocks		X									

Site Name	Campground	Picnic Area	Day Use	Group Site	Trailhead	Interpretive Site	Fishing Site	Ski Area	Snow Play Area	Concessionaire Managed	On Reservation System
La Bobita Campground	X									X	
Upper Cuchilla Campground	X										
Red River Winter Trail System									X		
Enchanted Forest XC & Snowshoe									X		
Eagle Rock Lake							X				
Agua Piedra Group Area				X						X	X
Santa Barbara Trailhead					X						
Elliott Barker Trailhead					X						
US Hill Snow Play Area									X		
Amole Trailhead					X						
Cruces Basin					X						
Middle Fork Trailhead					X						
East Fork Trailhead					X						
Middle Fork Lake							X				
Goose Lake							X				

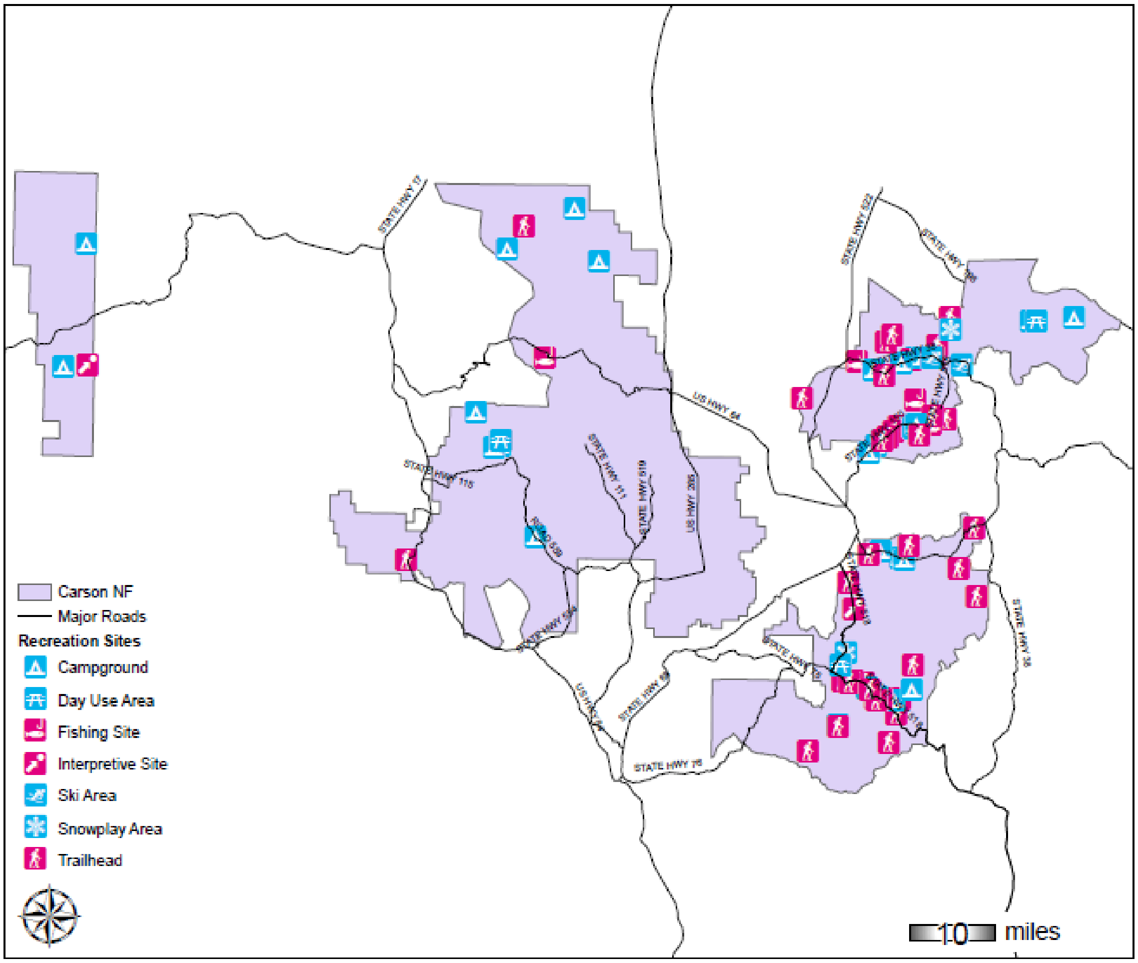


Figure 77. Distribution of developed sites across the Carson National Forest

The condition and use of the developed recreation facilities on the Carson NF vary greatly. This can be dependent on several factors, such as location, access, and opportunities provided by that particular facility. For example, the Red River corridor is highly popular and overused. It is also very easily accessible. On the other hand, Valle Vidal is more remote and has low use. Hopewell Lake Campground generates the most revenue of all the campgrounds on the forest and is in a highly desirable setting, with easy access and space for RVs. Conversely, the Agua Piedra Campground, while also being in a highly desirable setting with RV camping, has a non-functioning, odorous water system and difficult access, resulting in low visitation. Campgrounds that offer RV camping also receive higher use than those that offer single vehicle tent camping, as evidenced by a trend away from tent camping in developed sites to more RV use.

On the Carson NF, group size has also become a consideration pertaining to developed recreational facilities. The Carson NF is very popular for large family camping, or larger group camping in general. Campgrounds that also have group sites are in constant demand, with more sites needed to accommodate group use.

Recreational facility maintenance is also an issue for developed recreation. Given the limited resources for such needs in today's Forest Service environment, actual maintenance performed has fallen behind maintenance needs, resulting in what is called deferred maintenance. The forest does however have a Recreation Facility Analysis (USDA FS Carson 2015) that analyzes each developed facility on the forest for its deferred maintenance needs, or if the facility should be repurposed because of low demand based on usage.

In terms of fees, only one half of the developed campgrounds on the forest require a fee for camping.

Motorized Recreation

Motorized recreation is popular across the Carson NF during the summer and fall. The Town of Red River draws a large number of visitors, who participate in motorized recreation activities during the summer months. In the fall hunting season, a significant increase in the use of off-highway vehicles (OHVs) occurs across the forest. Motor Vehicle Use Maps indicate where motor vehicle use is allowed on the forest and can be found on the Carson NF's Website.

The Carson NF also provides snow-mobile opportunities in the winter. Recent below normal snowfall and above normal temperatures in most of New Mexico have resulted in few places that have reliable snowpack for snowmobile use. Portions of the Tres Piedras, Questa, and Camino Real ranger districts are destinations for winter motorized recreation on the forest.

Illegal motorized use consisting of riding on closed roads, riding on non-motorized trails, and creating unauthorized routes is one indicator that the forest is not meeting the demand from motorized users. This particular user group has grown steadily in popularity; however, the forest does not have adequate planning and infrastructure to support the use. The majority of the illegal motorized use occurs on old logging roads that are no longer open to motor vehicles. Reclaiming these old roads proves to be a challenge, since motorized users perceive roads closed to motorized use as a loss of access and opportunity. Although unauthorized motor vehicle use occurs elsewhere on the forest, it is especially prevalent on the Camino Real RD, where there are a higher number of closed roads and intermixed communities within the forest. Despite the Camino Real RD having the highest number of designated motorized trails, nearby residents seek illicit motorized opportunities.

Road maintenance is another issue that is found across the forest as a whole. With decreasing budgets, only a small number of roads receive maintenance in a year. This not only degrades the motorized experience though poorly maintained infrastructure, but it also impacts the natural resources through soil erosion and compaction. In some cases, motorized users will independently perform minor maintenance, such as removing downed trees to keep roads accessible for their use.

Some towns within the assessment area, particularly Red River, rely on the Carson NF for motorized tourism by supporting businesses that rent ATVs to be used on the forest. Other communities, such as Angel Fire, are building a motorized tourism based industry that would rely on NFS lands.

Outdoor Recreation Settings

The Recreation Opportunity Spectrum (ROS) is a framework for defining classes of outdoor recreation settings, activities, and experiences. The spectrum ranges from providing a recreational experience that is primitive to one that is developed, and everything in between. There are seven classes within the ROS that define what recreation experiences should be managed for in a particular area of the forest. Table 79 displays the seven classifications and their characteristics.

Table 79. Definitions for each of the ROS classes

P Primitive	SPNM Semi-Primitive Non-Motorized	SPM Semi-Primitive Motorized	RN Roaded Natural	RM Roaded Modified	R Rural	U Urban
▪ Very high probability of experiencing solitude, freedom, closeness to nature, tranquility, self-reliance, challenge and risk. ▪ Unmodified natural or natural appearing environment. ▪ Very low interaction between users. ▪ Minimal evidence of other users. ▪ Restrictions and controls not evident after entry. ▪ Access and travel is non-motorized on trails or cross country. ▪ No vegetative alterations.	▪ High probability of experiencing solitude, closeness to nature, tranquility, self-reliance, challenge and risk. ▪ Natural appearing environment. ▪ Low interaction between users. ▪ Some evidence of other users. ▪ Minimum of subtle on site controls. ▪ Access and travel in non-motorized on trails, some primitive roads or cross country. ▪ Vegetative alterations: sanitation salvage to very small units in size and number, widely dispersed and not evident.	▪ Moderate probability of experiencing solitude, closeness to nature, tranquility. High degree of self-reliance, challenge and risk in using motorized equipment. ▪ Predominantly natural appearing environment. ▪ Low concentration of users but often evidence of others on trails. ▪ Minimum on site controls and restrictions present but subtle. ▪ Vegetative alterations very small in size and number widely dispersed and visually subordinate.	▪ Opportunity to affiliate with other users in developed sites but with some chance for privacy. Self-reliance on outdoor skill of only moderate importance. Little challenge and risk. ▪ Mostly natural appearing environment as viewed from sensitive roads and trails. ▪ Mostly natural appearing environment as viewed from sensitive roads and trails ▪ Interaction between users at camp sites is of moderate importance. ▪ Some obvious on site controls of users. ▪ Access and travel is conventional	▪ Opportunity to get away from others, but with easy access. Some self-reliance in building own camp site and use of motorized equipment. Feeling of independence and freedom. Little challenge and risk. ▪ Substantially modified environment except for camp site. Roads, landings, slash and debris may be strongly dominant from within yet remain subordinate from distant sensitive roads and highways. ▪ Moderate evidence of other users on roads. Little evidence of others or interaction at camp sites. ▪ Little on site	▪ Opportunity to observe and affiliate with other users is important as is convenience of facilities. Self-reliance on outdoor skills of little importance. Little challenge and risk except for activities such as downhill skiing. ▪ Natural environment is culturally modified yet attractive (i.e. pastoral farmlands). Backdrop may range from alterations not obvious to dominant. ▪ Interactions between users may be high as is evidence of other users. ▪ Obvious and prevalent on site controls.	▪ Opportunity to observe and affiliate with other users is very important as is convenience of facilities and recreation opportunities. Outdoor skills, risk and challenge are unimportant except for competitive sports. ▪ Urbanized environment with dominant structures, traffic lights and paved streets. May have natural appearing backdrop. Recreation places may be city parks and large resorts. ▪ Interaction between large numbers of users is high. ▪ Intensive on site controls are numerous.

P Primitive	SPNM Semi-Primitive Non-Motorized	SPM Semi-Primitive Motorized	RN Roaded Natural	RM Roaded Modified	R Rural	U Urban
			motorized including sedan, trailers, RVs and some motor homes. ▪ Vegetative alterations done to maintain desired visual and recreational characteristics.	controls of users except for gated roads ▪ Conventional motorized access including sedan, trailers, RVs, ORVs and motor bikes. ▪ Shape and blend vegetative alterations. Maintain camp sites and immediate foreground to site in natural appearing state.	▪ Access and travel facilities are for individual intensified motorized use.	▪ Access and travel facilities are highly intense, motorized and often with mass transit supplements. ▪ Vegetation is planted and maintained.

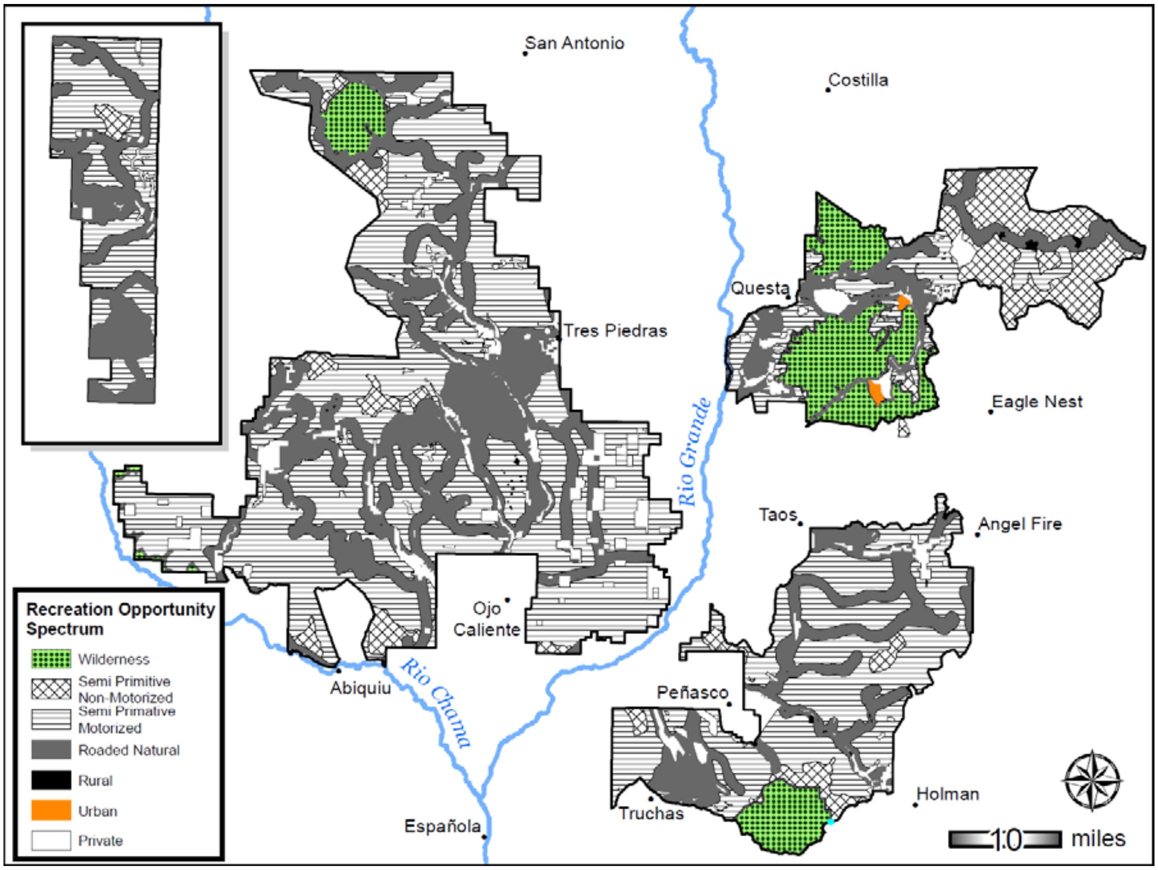


Figure 78. Recreation Opportunity Spectrum class distribution across the Carson National Forest

Figure 78 displays the distribution of ROS classes on the Carson NF. Table 80 provides the proportion of the forest in each classification. Semi-Primitive Motorized (SPM) makes up over half of the Carson NF. SPM areas offer a natural setting and encounters with others will be low with a moderate chance at solitude. There is minimal to no development in SPM areas, but motorized use is allowed along unpaved roads. The second largest ROS class on the Carson NF is Roaded Natural (RN) at 35 percent. One can still find a natural setting under this classification, but RN areas start to become more concentrated with other users and there might be more development in place compared to SPM.

Combined, these two ROS classifications make up 90 percent of the forest. They also characterize the uses and settings that make up the most popular recreational uses on the forest. It is in these settings that one will find the most dispersed camping, trail uses, and motorized uses. When planning recreation projects, the values that make up these ROS classes are preserved so that settings are available for these recreational experiences.

Rural and Urban settings are the least abundant on the forest and make up less than one percent of the landscape. These areas tend to have higher levels of development (e.g., campgrounds with amenities) and are typically found near other areas that have higher levels of development, such as towns or city type settings. Given the rural nature of the Carson NF, these settings do not generally fit in with the landscape. The two small Urban areas found on the forest are associated with two highly developed ski areas, Taos Ski Valley Resort and Red River Ski and Summer Area, both administered by the Questa RD.

Table 80. Percent of Carson National Forest in each ROS class

ROS Class	Percent of Forest
Primitive[1]	0.0
Semi-Primitive Non-Motorized	9.5
Semi-Primitive Motorized	55.2
Roaded Natural	35.0
Roaded Modified	0.0
Rural	0.16
Urban	0.13

Scenery

Some of the finest mountain scenery in the Southwest is found across the Carson NF. Elevations rise from 6,000 to 13,161 feet at Wheeler Peak, the highest peak in New Mexico. The forest offers breathtaking views of far off mountains, the valley below, and unsurpassed sunsets from almost every elevation. Green forests with lingering mountain meadows, streams, colorful wild flowers, and vibrant fall colors are all peppered throughout the Carson NF's broad landscape. The forest also offers open landscapes full of desert vegetation and beautiful canyon backdrops rich in colorful clays. At night, the stars are unhindered by urban lights and provide a spectacular light show.

The scenic characteristics of the forest are important for setting the sense of place that the Carson NF offers local people and visitors alike. They contribute to the special places people have come to identify with on the Carson NF, and they provide a sense of attachment to nature and a sense of serenity or excitement depending on the purpose of the visit. Scenery provides the backdrop and the setting for the entire forest while defining its character, and it largely contributes to the experiences people have and seek on the forest.

The Forest Service recognizes the importance of scenery and currently manages the scenery resource through the Scenery Management System (SMS). Before the SMS was implemented in 1995, the Visual Management System (VMS) was used from 1973 until the adoption of the SMS. The VMS and SMS are both structured to emphasize "natural appearing" scenery, but SMS more broadly recognizes scenery as the visible expression of dynamic ecosystems functioning within "places" that have unique aesthetic and social values. It recognizes that in addition to naturally occurring features, positive scenery attributes associated with social, cultural, historical, and spiritual values, including human presence and the built environment, can also be valued elements of the scenery. The SMS also allows for "seamless" analysis and conservation beyond national forest lands into adjacent communities and other jurisdictions, through the application of varying scenery "themes" within a single analysis (USDA FS Carson NF 2009).

[1] Does not include wilderness areas.

The Carson NF's current forest plan was finalized in 1986 and provides management direction for scenery under the VMS. The forest completed its SMS inventory in June 2009 and it will be finalized and incorporated into the forest plan revision process.

Scenic Character

The 2009 SMS inventory replaces the VMS used in the current forest plan and provides for a more comprehensive framework for the inventory, analysis, and management of scenery. This management system applies to every acre of the Carson NF and to all Forest Service activities including, but not limited to, timber harvesting, road building, stream, range, and wildlife improvements, special use developments, utility line construction, recreation developments, and fuels management.

Existing Scenic Character

As described earlier, there are spectacular scenic viewing opportunities on the Carson NF. The SMS helps to map these areas based on several characteristics. Scenic Class is used for this discussion and Figure 79 and Table 81 show the forest broken down by its Scenic Class rating. Scenic Classes are used as a measure of the value of scenery in a national forest. They measure the relative importance or value of discrete landscape areas having similar characteristics of scenic attractiveness and landscape visibility. The components of Scenic Classes are Scenic Attractiveness and Landscape Visibility. Generally Scenic Classes 1-2 have high public value, Classes 3-5 have moderate value, and Classes 6 and 7 have low value.

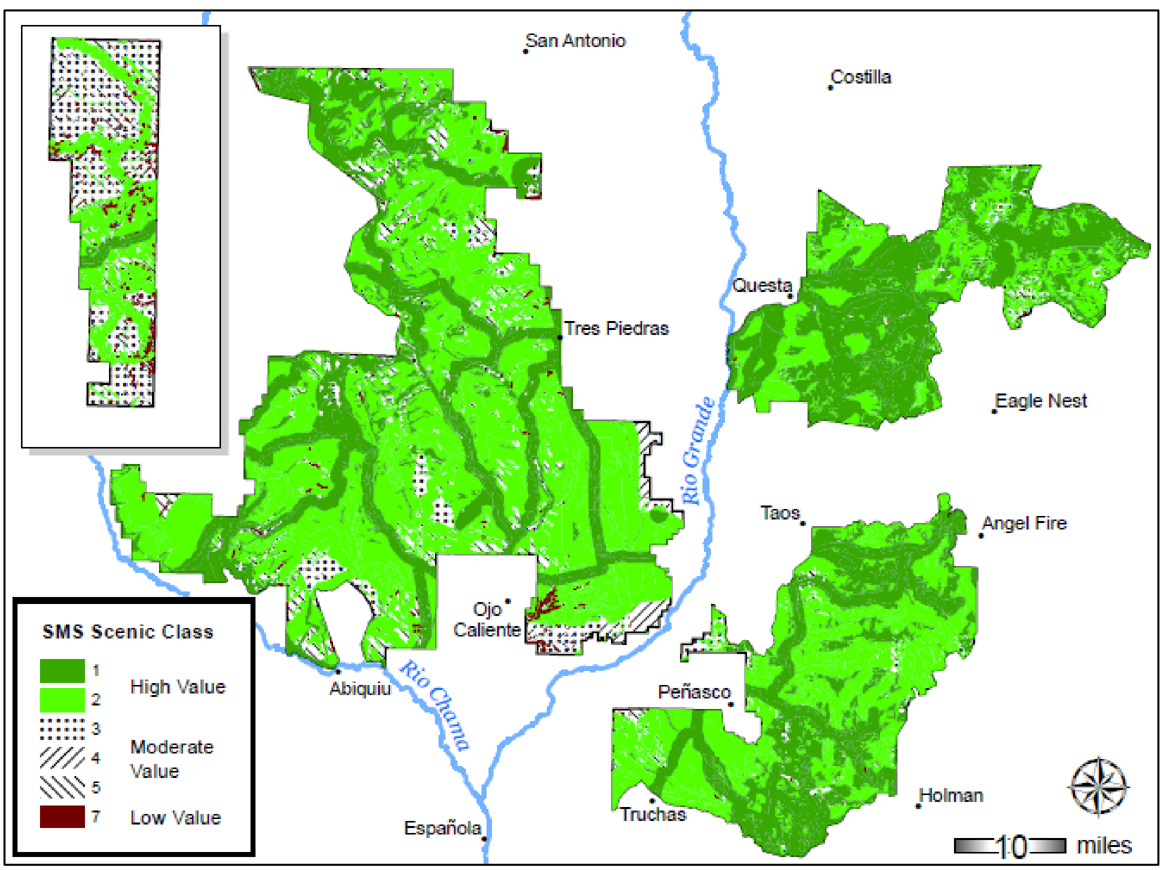


Figure 79. Scenic Class distribution across the Carson National Forest

Table 81. Percent of Carson National Forest in each Scenic Class

Scenic Class	Percent of Forest[1]
1	33.06
2	52.07
3	7.75
4	1.34
5	5.58
6	0
7	0.20

The vast majority (85%) of the Carson NF is made up of scenic classes 1 and 2 (Table 81). These are the classes that have high public value when combining scenic attractiveness and landscape visibility. Generally, these areas are seen in the middle ground and far off distances. On the scenic class distribution map (Figure 79), they are within the Class 2 category and encompass large portions of the forest. The Class 1 areas on the same map include the scenery that the public would enjoy along major travel routes.

Scenic Classes 3 to 5 hold moderate value to the public. These classes make up approximately 15 percent and are predominately found on the west side of the forest, which varies in landscape compared to the east side. The small amounts of the moderate scenic classes that occur on the east side are found in small random patches and are generally surrounded by Class 1 and 2 areas.

Classes 6 and 7 make up less than 1 percent of the forest. These are the areas that would have low public value and are small enough that they are difficult to find. This small percentage, when compared to rest of the forest, also implies that all of the Carson NF has scenic value for the public.

Potential Scenic Character

With the existing scenic landscape characterized and mapped through the SMS, the SMS also recognizes that there can be potential impacts to scenery that can alter its scenic character. Construction of infrastructure, timber harvesting, natural events (e.g., fires, landslides, and floods), and a host of other activities occurring on the landscape can impact the scenery the public and agency have identified as being important. In this regard, the SMS is integrated into planning projects and forest resource management so concerns can be addressed.

Another potential relating to scenic character is that it can be promoted and in some cases improved through management activities. For example, some forest management may include restoration activities, recreational maintenance activities, and interpretive and educational activities. All of these can offer opportunities for volunteers and partners to become more

[1] The remaining 6.46% is made up by private land and does not have an SMS classification.

involved in the management of their public lands, fostering a greater connection to nature and to the Carson NF.

Conditions Affecting Scenic Character

One way to relate the current condition of the scenic resource on the Carson NF is by using the scenic integrity inventory provided in the SMS. Scenic integrity represents the current status of the landscape and takes into account the “wholeness” of that landscape. Scenic integrity is defined as the degree of direct human-caused deviation in the landscape that detracts from its “wholeness”. Examples of deviations include activities such as road construction, timber harvesting, or activity debris; however, it does not include variations that are naturally caused (USDA FS 1995). Scenic integrity uses 6 ratings. These are:

1. **Very High -** Landscape character is intact with only minute if any deviations. Landscape character and sense of place is expressed at the highest level possible.
2. **High -** Landscape character appears intact. Deviations may be present but at a scale that they are not evident.
3. **Moderate -** Landscape appears slightly altered. Noticeable deviations are subordinate to the landscape character being viewed.
4. **Low** - Landscape character appears moderately altered. Deviations begin to dominate the landscape but are compatible or complimentary to the character within.
5. **Very Low -** Landscape character appears heavily altered. Deviations may strongly dominate the landscape.
6. **Unacceptably Low -** Landscape character appears extremely altered. Deviations are extremely altered. Landscapes at this level of integrity need rehabilitation.

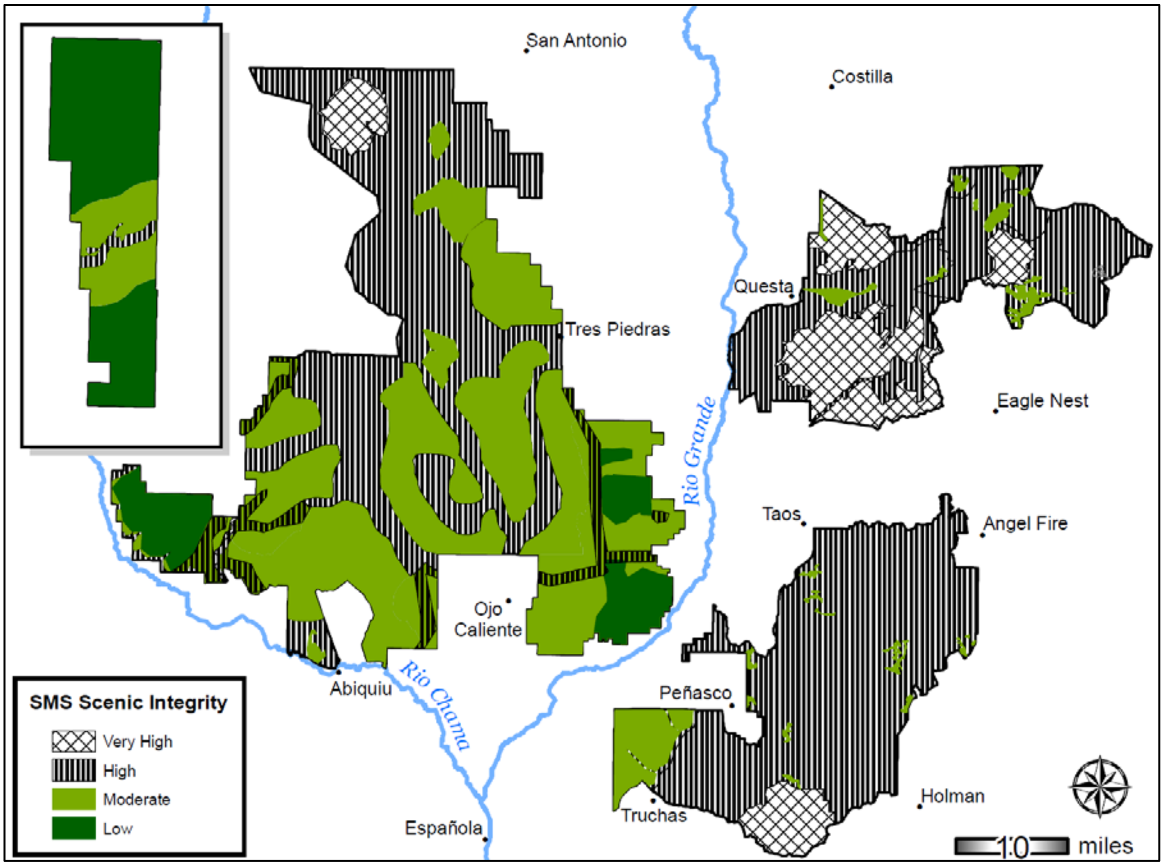


Figure 80. Scenic integrity rating for the Carson National Forest

Largely scenic integrity for the Carson NF rates as very high and high. While the vast majority of the forest is high, it does have interspersing of moderate throughout. The very high ratings can be found in Valle Vidal and five of the six wilderness areas. The Columbine-Hondo Wilderness Area was recently designated (2014) after the SMS was instituted on the forest and will be analyzed in the forest plan revision process. Low ratings are generally found on the Jicarilla RD of the forest, which has a high concentration of oil and gas development. The forest does not have scenery that rates as very low or unacceptably low.

Given that these ratings describe the condition of the scenic resource, it can be established that scenery on the Carson NF is in good to high standing and that it is also important to the public, when accounting for scenic class as well.

Trends Affecting Scenic Character

Any trend that affects the landscape has the ability to affect scenery. These trends can be both human caused and naturally caused. For the Carson NF, the most predominant trends affecting scenery are environmentally driven and include factors, such as drought and warmer shorter winters. These environmental influences and trends impact scenery by affecting the landscape characteristics that give it its scenic appeal. On the Carson NF, this is largely caused by deviations in the view by tree mortality, either defoliation or fires. All of which are influenced by the current drought, which is expected to continue as described in the Water Quantity section (p. 144).

On the west side of the forest, trees that have been made susceptible by drought suffer from insect infestations, such as the spruce budworm, western tent caterpillar, and large aspen tortrix, which have caused both tree mortality and defoliation of pine and aspen. The El Rito and Canjilon areas of the forest have the greatest impact, but these impacts are moving to the Tres Piedras portion of the forest as well. The *Ips* beetle, which effects piñon-juniper, can be found throughout the forest, but is concentrated in the southern Tres Piedras and southern El Rito parts of the forest. As stated earlier, warmer and shorter winters, in addition to drought conditions, will likely continue these trends. As such, the scenic landscape these trees occupy will become degraded as these conditions continue into the future.

Wildfire is another impact to scenery by leaving behind fire scars that break up visual landscapes. The Carson NF has had two such large wildland fires that have affected scenery in two parts of the forest. These include the 1996 Hondo Fire in the Questa area and the 2002 Ponil Fire in Valle Vidal. Smaller fires have occurred across the forest, but they are small in size with relatively little impact to scenery. Should fire trends begin to increase in size and number on the Cason NF; this would begin to impact scenery on a greater scale as well.

Aside from environmental influences, humans also impact scenery through development and forest management activities. Some examples of such activities include:

- Recreation facility development
- Development from special uses such as ski area expansion, utility poles, communication towers
- Land conveyances to municipalities surrounded by the forest for community development
- Infrastructure such as buildings, roads, and trails
- Development for mineral extraction such as oil and gas
- Fuel treatment and reduction activities

Trends in human activities that could impact scenery on the Carson NF pose little threat to the scenic resource across the forest however. Current budget reductions are expected to continue and offer little support for infrastructure construction be it for recreation, roads, or other needs. Timber projects on the forest are small in scale and have little impact on scenery. Additionally, projects and special uses are planned project by project in which scenery is considered.

A new trend that is taking place on the forest will have positive benefits to scenery. This trend is expected to continue into the foreseeable future and involves the restoration of landscapes across the forest as needs are identified. This new trend will serve to increase scenic integrity where it is already high and improve scenic integrity in areas where it is currently low.

Despite the negative trends and impacts to scenery such as those previously discussed, the sustainability of the scenic resource on the Carson NF is viable well into the future barring any significant natural phenomenon. The sustainability of this resource is greatly supported by three factors. One factor is the protection offered to scenery by certain designated areas. The forest has several designated areas, including six wilderness areas; eight miles of wild and scenic rivers; a national scenic trail; one proposed research natural area; and the Enchanted Circle Scenic Byway (see Designated Areas, pp. 442-461). These special designations and their associated management protect their scenic qualities and will continue to do so for as long as the special designation remains in place.

The second factor that supports the sustainability of scenery into the foreseeable future is the SMS. The SMS is used not only to inventory, analyze, and monitor scenery, but it is also used to ensure high-quality scenery for future generations (USDA FS 1995). By applying the SMS on the forest, sustainable scenery is built into project planning and resource management. Though VMS is used in the current forest plan, the Carson NF has since incorporated the newer SMS into its management and it will be included in the forest plan revision.

The third factor was discussed earlier and consists of the shift to landscape restoration as a regional priority in the management of the national forests in the Southwestern Region, including the Carson NF. This is a trend that will benefit the landscape and therefore benefit scenery.

Social and Economic Contributions of Scenery

Scenery and the enjoyment of scenery offer several social and economic benefits to the local communities and visitors the Carson NF serves. Scenery by itself is a draw to the forest with over 30 percent of recreation visits specifically for viewing natural features (Figure 76, p. 355).

In the social context, high quality scenery, especially scenery with natural-appearing landscapes, enhances people's lives and benefits society (USDA FS 1995). The Forest Service’s “Landscapes Aesthetics, A Handbook for Scenery Management” states,

> *Research findings support the logic that scenic quality and naturalness of the landscape directly enhance human well-being, both physically and psychologically, and contribute to other important human benefits. Specifically, these benefits include people's improved physiological well-being as an important by-product of viewing interesting and pleasant natural appearing landscapes with high scenic diversity.*
>
> *Findings from psychological and physiological studies of people under stress, people recovering in hospitals, people in recreation settings, and people in other various settings, prove that natural landscape scenes have restorative and other beneficial properties. This is particularly important when contrasted with built urban environments such as pedestrian malls and commuter traffic routes.*

The Carson NF is a significant contributor to these social benefits, considering 85 percent of the forest ranks high in terms of scenic value to the public and scenery is the main attraction to over one-third of the recreating public. These benefits not only apply to forest visitors, but also relate to many communities where the Carson NF is a beautiful everyday backdrop for the homes of local residents.

Economically, viewing scenery is an activity that mainly contributes to recreation and tourism, which are the largest economic contributors to the local economies made by the Carson NF. This means scenery plays an important role in the 2,100 jobs and over $150 million the Carson NF contributes to the communities in and surrounding the forest from its recreation program, scenic setting, and support to the local tourism industry.

Important Outdoor Recreation Sites and Areas

The Carson NF offers quality recreational experiences and facilities across the forest. Some, however, stand out as exceptional in that they provide significant contributions to the assessment area. The four ski areas, Taos Ski Valley Resort, Sipapu Ski and Summer Resort, Red River Ski and Summer Area, and Enchanted Forest Cross-country and Snowshoe Area, are vital to the economy of the assessment area. According to the 2007 Socioeconomic Assessment of the Carson NF, ski visitors generated a total of $74.1 million in revenues, 1,140 jobs, and $32.1 million in additional labor income. Visitor spending (including that generated by skiing) contributes a total of 84 percent of the employment and 82 percent of the labor income impacts (UNM-BBER 2007). Since its inception in the 1950s, Taos Ski Valley Resort has been a preeminent player in a relatively small and unique group of North American resorts that are renowned for abundant quality snow, steep, challenging terrain, and uncrowded slopes. Taos Ski Valley Resort attracts skiers from across the United States, Canada, Mexico, and Europe. Many of the skiers that come to Red River Ski and Summer Area, Enchanted Forest Cross-country and Snowshoe Area, and Sipapu Ski and Summer Resort are from Texas, Oklahoma, and Louisiana and other parts of Southwest. Skiing makes up over one-third of the recreational use on the forest. To further capitalize on their visitor base, all of the alpine ski areas are developing and offering summer activities as well. While these ski areas are privately operated through special use permits, they are all located on NFS lands.

In addition to skiing, the Carson NF also offers exceptional trail opportunities, with an extensive trail network of varying difficulty. Hiking and walking make up the greatest recreation use (40%) on the forest. Trail use is so popular on the forest that users have created their own trail networks to accommodate demand. Within its trail program, the Carson NF also has trails with national significance and recognition. These include three National Recreation Trails (Columbine-Twining, South Boundary, and Jicarita trails), two National Historic Trails (The Camino Real de Tierra Adentro Trail and the Old Spanish Trail), and one National Scenic Trail (Continental Divide Trail), one of the most popular trails in the nation.

The wilderness areas on the forest offer significant recreation opportunities, in terms of quality of experience and popularity. Another area outside of wilderness is the Echo Amphitheatre on the Canjilon RD. This day-use site is surrounded by the intense red, pink, orange, and yellow sandstone hills made famous by the artist Georgia O'Keefe.

Above all, the largest draw to the Carson NF is its dispersed recreation opportunities. As a whole, dispersed recreation, especially hiking and camping makes up the most important aspect of the recreation program for the forest. People come to the Carson NF to recreate in activities that offer the ability to experience the solitude, beauty, and openness of the forest. Visitors from local communities, in addition to out-of-state residents, have long used the forest to escape from the heat, attend large family gatherings, and participate in a wide variety of recreation activities. Dispersed recreation use is the highest near water and along trails.

Outdoor Recreation Compatibility

Authorized recreation activities within the assessment area experience few user clashes. Confrontational encounters between horseback riders and mountain bikers are the most common and generally rate from low to moderate in intensity. Illegal motorized recreational use is an exception, and is a problem across most of the Carson NF. This is primarily due to the openness of the terrain in some areas and the large number of closed logging roads that provide access to "closed to motor vehicle use" areas. Illegal motorized use includes both off-highway recreational vehicles and four-wheel drive pickup trucks. Hunting and forest product gathering are the leading activities that involve illegal motor vehicle use. Utilization of routes that are not part of the designated transportation system (according to the MVUM) is increasing, as more visitors have access to off-highway vehicles, and old road closures along logging roads are becoming ineffective in stopping new types of motor vehicles, designed to go over just about anything. Since it has the largest number of decommissioned logging roads on the forest and they are close to populated areas, illegal motorized use is highest on the Camino Real RD. Wildlife disturbance, erosion, riparian impacts, and other resource impacts have occurred as a result of illegal motorized use. There is demand to incorporate additional motorized trails into the system and some of the decommissioned logging roads could be utilized. By providing additional motorized trails resource impacts could be reduced across the forest.

Outdoor Recreation Access and Infrastructure

The condition of recreation facilities and associated infrastructure on all districts is monitored through a deferred maintenance program, in which facilities are inspected and evaluated. Facility conditions range from excellent to poor. Annual and deferred maintenance needs and costs are identified and tracked in a national infrastructure database (INFRA), where information on many Forest Service programs is housed. The growing backlog of deferred maintenance needs presents a challenge to management. One concessionaire manages a majority of the developed recreation sites on the Questa and Camino Real RDs. A percentage of revenue associated with fees charged at concession operated sites is used to address deferred maintenance. However, the revenue that is available is not sufficient to address all the deferred maintenance on the forest. For more information on recreation facilities, see the Infrastructure section (p. 466) of this report.

Additionally, the Carson NF participates in the Recreation Enhancement Act program and charges use fees at a limited number of developed recreation areas. The revenue generated is used to enhance the recreation opportunities and amenities provided at the areas. Currently, there is only a small amount of revenue generated, and the funds are primarily used to provide minimal maintenance. The forest is beginning the process of adding more recreation sites to the Recreation Enhancement Act program, to help ensure the facilities will remain open and well maintained.

There are 684 miles of trail on the Carson NF, 599 miles are non-motorized and the remaining 85 are motorized. Forest trails offer a variety of experiences in a variety of terrain. Trail based recreation activities are some of the most popular on the forest; however, some trails were not properly designed or located in sensitive areas. This has created issues with erosion and other environmental impacts. Some trails on the forest are minimally utilized, while others have so much use that there is a need to redesign and harden various segments. The most popular trails are typically maintained on an annual basis, the trails that receive less use receive maintenance less often. This has led to some trails becoming revegetated and difficult to navigate. For more information on trails and trail conditions, see the Infrastructure section (p. 466) of this report.

The Carson NF has 2,612 miles of road open to motor vehicle use. Much of the road system (84%) is designed and maintained for use by high clearance vehicles where user comfort is not a consideration. Most recreation sites, areas, and trails are accessed from level 2 roads. The condition of the roads in some cases has deteriorated to a point that visitors are not comfortable attempting to drive to these locations. Lack of signage also contributes to visitors not feeling comfortable attempting to access certain facilities or trails. For more information on roads and conditions, see the Infrastructure section (p. 466) of this report.

Outdoor Recreation Trends

The most apparent recreation trends on the Carson NF center on increased mountain biking, motorized recreation, and hunting. These three activities continue to increase every year, with mountain biking and motorized use being the most prominent. Conversely, equestrian use is decreasing across the forest, except in wilderness areas.

There are long-term recreation trends as well. The Carson NF continues to be a destination forest for those from neighboring states. During the summer, many visitors from other parts of New Mexico, as well as other states, seek the mountains to escape the summer heat.

Another long-term trend observed on the forest is more social in nature. The Carson NF has been popular for large family gatherings and for extended family gatherings for many generations. Group sites are in high demand for this purpose and there is no decrease expected in the future. In actuality, the forest could use more group sites, just to accommodate the current need.

Contributions of Outdoor Recreation to Social, Cultural, and Economic Sustainability

Connecting with nature and having opportunities for solitude were some of the highlights about the Carson NF that people shared at the public meetings for the assessment. As stated earlier, those within the assessment area and those who travel to it, have a strong attachment to the land. Part of that connection includes going to the forest to experience nature, solitude, and for various other reasons as noted in those meetings. Outdoor recreation opportunities on the Carson NF support and contribute to the goals identified in the New Mexico State Parks Statewide Comprehensive Outdoor Recreation Plan 2010-2014 (ENMRDSPD 2009). The many trails, campsites, and scenic vistas provide communities opportunities for connecting with the land, experiencing nature, and promoting health and fitness.

The Carson NF also offers the Ski with the Ranger and the Youth Conservation Corps (YCC) programs that specifically connect people with nature and the forest. The Ski with the Ranger program gives the public an opportunity to ski with Forest Service personnel, while learning about the environment in which they are skiing. The YCC program gives youth from around the country a chance to learn and work in the natural environment during the summer. Some of the participants go on to natural resource management fields as their career choice.

Another program that offers opportunities for people to connect with nature is the recreation special uses program. There are approximately 100 recreation special use permits on the forest. These permits are issued for a wide variety of activities, such as hunting, jeep tours, horseback riding, hiking, and motorized recreation. Issuing these permits enables the Forest Service and its partners to serve visitors and local communities by providing a broad range of nature- and heritage-based outdoor recreation and tourism opportunities that promote the responsible use and enjoyment by local communities and their visitors. These permits also promote economic sustainability in local communities through fee retention. Permit fees from many, though not all, recreation service providers are returned to the forest and used to improve services and facilities for those permit holders, their clients, and the public. Income to the Carson NF from recreation special uses program varies between $245,000 and $400,000 per year (Figure 74, p. 350).

Timber production and ranching were once the primary emphasis of the Carson NF, in terms of social and economic contributions to the assessment area. Over the past several decades, however, that emphasis has slowly transitioned to recreation. Recreation on the forest now contributes over $150 million in various economic impacts and over 2,100 jobs to the assessment area. This marks the largest program of impact for the entire Carson NF. This trend is expected to continue, as recreation and tourism is the largest draw to the assessment area, as well as being highly valued by the local people. See the Tourism section (p. 345) of Carson National Forest's Contribution to Social, Cultural, and Economic Conditions for more discussion on this topic.

Outdoor Recreation Sustainability

The Carson NF has provided recreation opportunities since its inception. Over time, the recreation program has grown to be a significant contributor to the assessment area. In terms of sustainability, however, there is concern whether these opportunities can endure into the future. Specific areas of concern include: (1) having facilities that are outdated and underutilized; (2) supporting a trail system that is not sufficiently maintained and a large number of user-created trails; and (3) the ability to remain relevant by being responsive to changing trends and demands. There are also concerns regarding the ability to be adaptable to administrative changes, such as budget driven cycles and personnel needs.

The forest has developed a sustainable recreation strategy to address these issues, with the intent of providing and managing for recreational opportunities that are both relevant and viable for present and future generations. To achieve this intent, the forest is striving to meet five desired conditions. These conditions include a recreation program that: (1) is responsive; (2) has relevant and viable recreation opportunities available; (3) has good data; (4) meets assigned performance measures; and (5) contributes both internally and externally.

Outdoor Recreation Enhancement Opportunities

The Carson NF is always striving to better it recreation program. Many times this means just trying to keep up with current maintenance, use demands, and impacts with limited resources. Should future opportunities arise, there are specific enhancements the forest can pursue.

Trail use is the highest use on the forest, but the forest's trails management program has experienced stagnation, despite the need for improvement and expansion. Annual trail maintenance occurs on the most popular trails, yet there has been little trail planning and implementation to keep up with growing user demands. The forest would like to plan and create a trail system that meets demand and is sustainable. This means building new trails, decommissioning lower quality trails, and using volunteers to maintain the system. There is also an opportunity to continue work on the Continental Divide Trail, which will open the west side of the forest to more visitations.

For motorized recreation, there is a need to enhance off-highway-vehicle opportunities for all-terrain vehicles, full size vehicles, and dirt bikes. Motorized recreation on the Carson NF has seen an increase in popularity over the past several decades. Recreation planning, however, has not kept up with this trend, resulting in unmanaged use and degrading resource impacts. The forest needs to plan for dedicated motorized opportunities that would fulfil the unmet demand, while being sustainable and appropriate for the landscape.

Another recreation enhancement would be to repurpose underutilized facilities into sites that are relevant and desired by the public again. Older facilities on the forest that once served their purpose are outdated and no longer used as they were in the past. The forest could update these or change their use type, so that they meet current recreation demands and needs. In 2008, the Carson NF conducted a Recreation Facility Analysis that analyzed visitor use and conditions at all forest recreational facilities.

Lastly, the forest could create a cabin rental program to enhance its recreation program. Several historic cabins would be eligible and given their significance, such as the Aldo Leopold house, would act as a draw to recreationists, both within and out-of-state.

Nearby Outdoor Recreation Opportunities

Other agencies surrounding the Carson National Forest have areas and/or facilities that have heavy recreation emphasis or are primarily managed for recreation. Many of these sites compliment the recreation opportunities on the Carson National Forest. For example, at peak times of the year, surrounding recreation areas can help pick up heavy use for day use, camping, and fishing opportunities. Surrounding recreational areas such as the Rio Grande del Norte National Monument can also offer opportunities that are not as available on the Carson NF, such as river rafting. The areas of greatest influence to the plan area are managed by the Bureau of Land Management and the State of New Mexico and are as follows:

Bureau of Land Management

The Bureau of Land Management is the federal land management agency that administers the Rio Grande del Norte National Monument, which lies between the east and west sides of the Carson NF. The monument includes most of the Rio Grande Gorge, Rio Grande Wild and Scenic River, and an extensive volcanic field known as the Taos Plateau. The Monument hosts several recreation opportunities, such as camping, boating, hiking, hunting, birding and biking. It received over 180,000 visits in 2013.

State of New Mexico

The recreational sites and State Parks (NM State Parks 2012) nearest the assessment area that are managed by the State of New Mexico are:

Harold S. Brock Fishing Area

Morphy Lake Fishing Area

Red River State Hatchery

Rio Costilla Fishing Area

Springer Lake State Park

Cimarron Canyon State Park

Coyote Creek State Park

Eagle Nest Lake State Park

El Vado Lake State Park

Heron Lake State Park

Navajo Lake State Park

Vietnam Veterans Memorial

Rio de los Pinos Wildlife and Fishing Area

Summary

The Carson NF serves over one million people per year. Eighty-nine percent of forest visitation is for recreational use, with half of that use coming from local residents. Hiking is the principal use, but visitors also enjoy camping, scenic viewing, picnicking, skiing, bird watching, hunting, fishing, off-highway-vehicle driving, and a host of other activities all throughout the forest.

Recreation and tourism are the largest economic contributors to the assessment area. The recreation program on the Carson NF supports more jobs and economic benefits than all other programs on the forest combined. In addition to the economic benefits, there are also the social benefits associated with recreation. People have expressed these in terms of solitude, relaxation, connection, and having a place to spend time with families, to name a few (USDA FS Carson NF 2014a). Trends indicate recreation will continue to be an important contributor to the assessment area.

Apart from being a major contributor, the recreation opportunities offered by the Carson NF are also all inclusive. The forest serves an area that is rich in cultural diversity and minority presence. Income levels for the assessment area are also just as diverse from some of the lowest in the country to those who are top earners. No matter where one falls in the demographic picture, the Carson NF offers recreation opportunities for everyone. As such, the forest is also the first choice for many in the assessment area that may not have the ability to partake elsewhere, given their financial circumstances.

Despite the significance of the forest's recreation program, management issues have the potential to impact the program's sustainability, specifically insufficient resources and budget needed to keep up with basic needs, such as facility maintenance, signage replacement, and other fundamental operating requirements. While the Carson NF works to keep up with day-to-day operations, it is falling behind in meeting emerging demands. This has two implications. One is the forest will lose its relevancy as a recreation forest and there will be a decrease in the contributions the forest makes to the surrounding area. These contributions are significant to local communities and to the people recreating for both economic and social reasons. The other implication will result in the growing amount of resource damage from unmaintained facilities and infrastructure (such as campgrounds and roads), in addition to the recreating public creating its own opportunities to fulfill unmet demand. These issues are expected to accrue, as budgets and resources are predicted to decline into the future.

Range

Multiple use management on the Carson NF includes producing forage for wild ungulates and domestic livestock. The Forest Service began administering grazing on NFS lands in 1906. The ranching culture and tradition in northern New Mexico and southern Colorado is deeply rooted in history. Families have been grazing in the assessment area for generations. Livestock ownership and ranch life are powerful forces that bind communities and families. As the majority of land ownership in the assessment area is either federal, state, or tribal, many ranching operations rely on public lands for livestock grazing. The ability to provide forage for wild ungulates and domestic livestock and maintain the sustainability of other ecological resources is important for providing this social and economic benefit for local communities. This section identifies and evaluates:

- Ecosystem services that come from grazing
- Current grazing on the Carson NF and within the broader landscape
- Range condition and trends on the forest
- Contributions of livestock grazing to social, cultural, and economic sustainability
- Impacts of livestock grazing on ecological integrity and species diversity
- Summary of rangeland and livestock grazing on the Carson NF

The Carson NF is made up of nearly 1.5 million acres, of which 93 percent are suitable for livestock grazing. The remaining 7 percent includes developed recreation and administrative sites, ski areas, highway right-of-ways, and administrative horse pastures. The land suitable for livestock grazing is divided into grazing allotments. There are 75 allotments on the Carson NF on the six ranger districts. Five allotments are currently closed and nine have been placed in long-term non-use (Table 82).

Although the entire Carson NF is considered suitable for grazing, allotments have been closed for various reasons, often due to low economic return on allotments with small isolated meadows, disproportionate amount of dense forest, steep slopes, and high elevation that makes the allotment difficult to manage for rangeland grazing and unprofitable. Permittees who grazed cattle on these allotments in the past requested and were granted transfers to new areas.

Individual permittees may place an allotment or their permitted number into non-use for either personal convenience or for resource protection. Nine allotments have been placed in long-term non-use for resource protection, due to drought, overpopulation of wild horses, and/or inadequate infrastructure (i.e., fences, water sources, corrals). Carson NF policy allows personal convenience non-use for up to six consecutive years.

For administrative purposes of livestock management, there are two animal units used for distinct purposes:

1. **Head month (HM)** is used only for billing purposes and is a charged for each month of grazing by adult animals, if the grazing animal (1) is weaned; (2) is 6 months old or older when entering NFS lands; or (3) will become 12 months old during the period of use.

2. **Permitted numbers** represent the total number of livestock pairs or individuals permitted to grazed on a given grazing allotment.

3. **Authorized numbers** represent the year to year actual stocking on the allotment, based on forage and water availability, condition of range improvements, climatic conditions, personal convenience for the permittee, or resource protection.

Table 82. Grazing allotments on the Carson National Forest by ranger district

Status/RD	Canjilon	El Rito	Jicarilla	Camino Real	Tres Piedras	Questa
Active	12	9	4	13	14	9
Closed	0	0	0	2	0	3
Non-use	0	0	2	0	3	4

Although 93 percent of the Carson NF is identified as suitable for grazing, permitted livestock do not routinely graze areas on slopes over 40 percent. About 71 percent of the Carson NF grazed by livestock is under 40 percent slope (Table 83). These acres are primarily located on active allotments.

An area may be deemed suitable for use by livestock, a project-level analysis evaluating the site-specific impacts of the grazing activity, in conformance with NEPA, is required in order to authorize livestock grazing on specific allotment(s).

Table 83. Proportion of the Carson National Forest lands with slopes under 40 percent slope

	Acres	Percent of Forest
Total acres of Carson National Forest	1,486,372	--
Total acres of Carson National Forest under 40% slope	1,054,694	71

Range Ecosystem Services

Carson NF rangelands provide many ecosystem services from which society derives enjoyment or benefit. Related to the concept of ecosystem services (discussed in the introduction of this report), rangelands and managed grazing of domestic livestock provide:

- **Supporting** ecosystem services of range to society in that they contribute to nutrient cycling, soil development, and plant production.
- **Regulating** ecosystem services of range, as they contribute to carbon storage, air quality, erosion control, and water purification.
- **Provisioning** ecosystem services of range by managing domestic livestock and wildlife that consume rangeland forage and browse produce food and personal items for people in the form of meat, hides, and other animal products.

- **Cultural** ecosystem services of range to society in a multitude of ways. For example, rangelands contribute to a historically western, traditional way of life and have been and are essential for the survival of many small ranching operations. In northern New Mexico, livestock grazing is viewed as a cultural resource. In addition, rangelands provide an educational stage for evaluating positive and negative impacts of differing grazing management approaches and rangelands provide aesthetics (scenery) and recreational (e.g., hunting, wildlife viewing) opportunities to the public. Not to be overlooked, rangelands have an intrinsic value of their own as a unique vegetation and animal community.

Current Grazing on the Carson National Forest and Within the Broader Landscape

Permitted Livestock Numbers

As of November 2014, the Carson NF permits 94,381 HMs of cattle and sheep on the six ranger districts. There are 195 permits, with 167 permits for cow/calf pairs, 20 for bulls, and 8 for ewe/lamb pairs. A number of these permits are issued to grazing associations with multiple members. A grazing association is a group of several members who share the use of an allotment under one grazing permit. The Carson NF administers 16 association allotments. Associations are self-governed and determine how many head of livestock each member can graze within the authorized or permitted number for the allotment. The Forest Service officially recognizes the association as the sole permittee and often deals directly with association officers for annual authorization, billing, and operating instructions. In addition, the Carson NF administers 24 community allotments. These are allotments with multiple permittees, each with his/her individual permit for a set number of head. These community allotments will have an association bull permit, as well. The Carson NF administers 21 allotments with only one permit holder. Bulls are counted along with the cow/calf numbers for allotments where no bull permit exists.

There are over 300 actual permitted users who could operate on the Carson NF. Currently there are 179 permits issued to individuals and 16 issued to grazing associations. The upper limits for any permittee on the Carson NF are 400 cattle and 3,000 sheep.

Grazing permittees that are permitted to graze livestock on NFS lands are assessed an annual bill for collection for all livestock they graze in a year. This is assessed by animal pair over a specific period of time or HMs. The grazing fee is based on a multitude of indices that dictate the fee on an annual basis. For example in 2015, the grazing fee for cattle is $1.69/HM and for sheep it is $0.34/HM; prior to 2015, the grazing fee for cattle was $1.35/HM and for sheep it was $0.27/HM.

Table 84 shows the current numbers of livestock permitted on the Carson NF, while Table 85 (p. 381) shows the livestock permitted HMs since 2004 to current. The HMs are derived from the permitted number and grazing season dates.

Table 84. Permitted livestock on the Carson National Forest

Location	Cow/Calf	Bulls	Sheep	Total HMs
Canjilon RD	2,533	75	900	16,830
El Rito RD	2,388	75	1,079	17543
Jicarilla RD	731	0	0	3,842
Camino Real RD	1,483	62	0	6,194
Tres Piedras RD	7,689	62	5,658	43,608
Questa RD	1,619	0	0	6,364
Carson NF	16,443	274	7,637	94,381

Since 2004 on the Carson NF, permitted cattle HMs have slightly increased and permitted sheep HMs have decreased by over 50 percent (Table 85 and Figure 81). Sheep permits have declined over time and are currently only issued on the Canjilon, El Rito, and Tres Piedras RDs (Table 85 and Figure 81). Several factors are contributing to the decline in sheep numbers on the Carson NF: (1) permittees have elected to convert from sheep to cattle operations using a 5 to 1 ratio, due to market conditions favoring cattle production over sheep (The National Academies 2007); (2) domestic sheep are no longer allowed to graze the fragile alpine tundra; and (3) disease carried by domestic sheep can threaten wild bighorn sheep populations.

Table 85. Permitted and authorized livestock (HMs) by year on the Carson National Forest (2004-2014) (USDA FS 2014h)

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Permitted Cattle	77,667	77,761	77,761	77,761	77,761	78,254	77,910	77,637	77,818	77,818	77,818
Authrzd Cattle	66,422	65,708	68,321	65,716	68,406	64,740	69,910	71,849	69,352	59,625	57,571
Permitted Sheep	31,091	31,091	31,091	31,091	28,811	21,207	21,207	18,698	18,698	16,568	16,568
Authrzd Sheep	20,945	18,664	15,154	16,303	15,279	14,785	8,332	8,519	14,161	7,890	8,463

For each allotment, numbers of permitted livestock and the grazing season dates are evaluated in a NEPA analysis and subsequent environmental assessment (EA) and are occasionally adjusted, depending on range condition, management infrastructure improvements, and other multiple use considerations. Northern New Mexico has experienced persistent drought conditions over the last 15 years (see Water Quantity section). Over the last several years, the drought has impacted range conditions and resulted in livestock numbers (particularly authorized) to be adjusted downward.

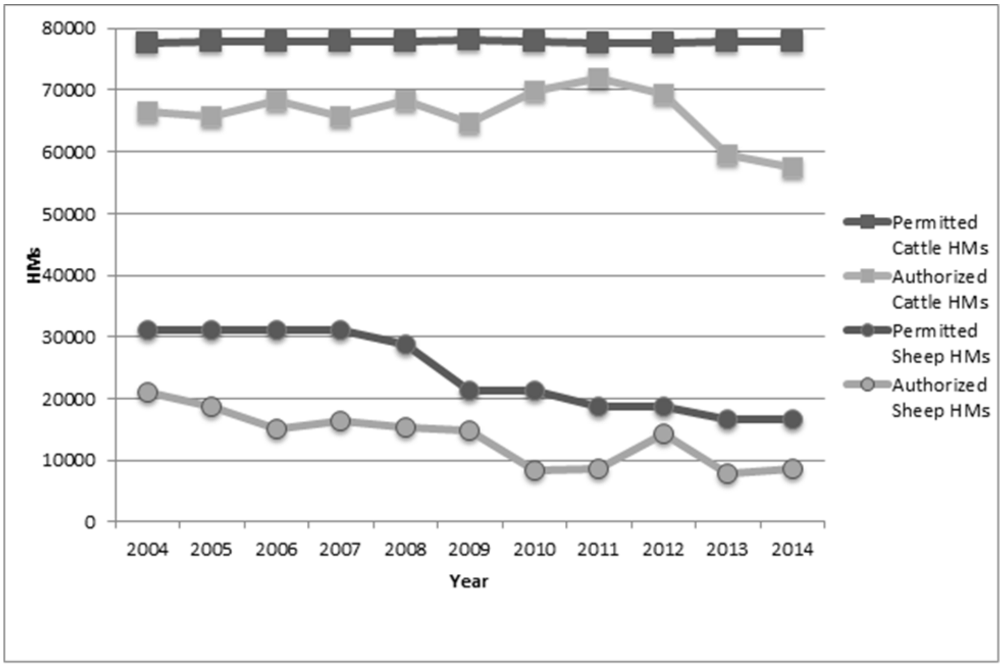


Figure 81. Permitted and authorized livestock (HMs) by year on the Carson National Forest (2004-2014)

Annually Authorized Livestock Use

Within permitted numbers, the permittees requested annually for the number of animals they choose to graze on the national forest, and negotiate that number with the Forest Service at annual operating meetings. It is the policy of the Carson NF to offer annual meetings early in the winter, so the permittees can make other arrangements for any extra animals they own that may not be authorized to graze on the allotment the following spring.

The annually authorized number of livestock and the grazing season dates are set in the annual operation instructions (AOIs). From 2004 to 2014, authorized numbers have averaged 85 percent of the current permitted cattle numbers, and 56 percent of the current permitted sheep numbers, due to drought conditions or permittee voluntary preference (Table 85 and Figure 73).

Grazing Activity within the Broader Landscape

In 2014, over 300 individuals and/or families had grazing operations on the Carson NF. The 2012 Census of Agriculture shows there are 2,570 beef farms and 410 sheep farms in the surrounding counties of northern New Mexico and southern Colorado that have permittees grazing livestock on the Carson NF (Table 86)(USDA Census of Agriculture 2014a, 2014b).

As of 2014, the Carson NF has 195 permits for 16,443 cow/calf pairs and 7,637 ewe/lamb pairs (USDA FS. 2014h). In 2012, the surrounding counties reported over 90,000 cow/calf pairs and 14,000 ewe/lamb pairs (USDA Census of Agriculture 2014a, 2014b). It is estimated that as many as 18 percent of the cattle and 55 percent of the sheep in the surrounding counties graze on the Carson NF for a portion of the year.

Table 86. USDA Census of Agriculture 2012 numbers of beef and sheep farms and numbers of cows/sheep for counties adjacent to the Carson NF (USDA Census of Agriculture 2014a, 2014b)

		Beef Farms	Cow/ Heifers That Calved	Cow/ Heifers That Calved	Sheep Farms	Ewes 1 year or older	Ewes 1 year or older
State	**County**	**2012**	**2007**	**2012**	**2012**	**2007**	**2012**
NM	Colfax	160	20,202	11,597	1	254	76
NM	Mora	287	9,910	8,664	4	224	86
NM	Rio Arriba	621	17,647	18,717	29	3,198	1,883
NM	San Juan	710	N/A	13,895	305	7,202	6,536
NM	Taos	287	5,161	5,787	22	492	381
CO	Alamosa	78	6,459	5,927	20	1,555	1,685
CO	Archuleta	161	3,072	4,904	17	499	634
CO	Conejos	176	20,338	18,106	7	6,477	2,722
CO	Costilla	90	5,180	4,172	5	251	990
	Total	**2,570**	**87,969**	**91,769**	**410**	**20,152**	**14,593**

Wildlife and Wild Horses

Since 1986, elk numbers have increased on the Carson NF by around 40 percent (see Contributions of Commonly Enjoyed Species to Social and Economic Sustainability, Elk section, p. 414). Elk compete for forage with cattle and other ungulates. Mule deer, prairie dogs, grasshoppers, and other herbivores rely on the forage base as well. It is the Carson NF's policy to strive for light to conservative livestock grazing intensity, in order to provide forage to these other grazers and to stabilize and improve ecological conditions and sustainability. Other grazers will also utilize areas on slopes greater than 40 percent, where cattle typically do not graze. This helps limit competition for forage preferred by permitted cattle.

In addition to wildlife, there are wild horses that occupy two wild horse territories, which were congressionally designated after passage of the 1971 Wild Free Roaming Horses and Burros Act.

The 75,986-acre Jicarilla Wild Horse Territory on the Jicarilla RD has an appropriate management level (AML) of 50 to 105 horses (2004 decision). Just to the west on public lands, the Bureau of Land Management (BLM) has the 8,019-acre Carracas Mesa Herd Area. The AML for this herd area is 23 horses. Currently, the Jicarilla Wild Horse Territory and the Carracas Mesa Herd Area are managed jointly. Together they are called the Jicarilla Joint Management Area and have an AML of 73 to 128 horses. The BLM is in the process of analyzing its herd area's AML and is proposing not to change it. In April 2015, the population for the Jicarilla Joint Management Area was estimated to be between 342 and 502 horses. A fertility control program for the Jicarilla herd has been reinstated in the last two years. About sixty percent of the mares have only been treated with a primer dose of Porcine Zona Pellucida (PZP), an immune-contraceptive treatment, while the other 40 percent have been treated with a dose of PZP22, which includes time released pellets and does not require a primer. Over 100 mares have been inoculated, but further study is needed to determine the success of this program.

The 23,882-acre Jarita Mesa Wild Horse Territory and 31,010-acre Herd Use Area (54,889 acres total) on the El Rito RD has an AML of 20 to 70 horses (2002 decision). In December 2014, the population for the Jarita Mesa Wild Horse Territory was estimated to be 163 horses. Reproduction for this herd is usually at about 15 to 20 percent, but is currently estimated to be only 10 to 15 percent, because of the aggressive fertility control program that has been in place for approximately 5 years and the harsher terrain and environment on the Jarita Mesa Wild Horse Territory tends to produce a lower foaling rate than the Jicarilla herd. The numbers for the Jarita Mesa herd are firmer than those on the Jicarilla herd. The PZP mares have been followed and their foaling rates have been the subject of in-depth studies by interns from Cummings School of Veterinary Medicine at Tufts University.

Since 2003, there have been ongoing efforts to gather and adopt wild horses off these territories. The intent of the gathers is to reduce the current wild horse populations to the approved AML. The removals have not kept pace with the reproduction rates of either herd. Situations such as weather delays and less adoption demand have led to the gathering of fewer horses. More bait trapping removal is planned over the next several years.

Range Condition

Range condition can be described as the "state of health" of the range. More specifically, range condition is an ecological measure of the current condition of the range as compared to the potential (often called "climax"). Plant species composition is the criteria used to make this determination (McGinty and White 2015). Range condition is evaluated for each allotment on the Carson NF.

As range condition improves, the variety of plant species growing on a specific allotment or pasture within an allotment generally increases. Greater species diversity improves both the stability of the plant community over time, and the quantity and quality of forage available to the grazing animal. Overall plant production and stability of an allotment generally improves as range condition improves, because shallow rooted plants (annuals or sod forming perennials) are replaced by deeper rooted, perennial bunch grasses (Finch 2004). Associated with this species shift are better overall soil hydrologic conditions. Rainfall infiltration rates increase, while evaporation and soil erosion decrease (Finch 2004). These factors, coupled with more efficient use of water within the soil profile by deeper rooted plants, result in greater forage production and stability (Finch 2004).

In describing how range condition relates to the production of livestock, McGinty and White (2015) state, "Higher range condition classes are generally associated with improved livestock production." They go on to say, "Livestock are selective grazers. At higher condition classes, grazing animals are able to select from a greater diversity of plant species, thus maintaining a more optimum plane of nutrition. Diet quality levels will also vary less from season to season and year to year as compared to lower range condition classes."

Current Range Conditions

After centuries of grazing, there are parts of the Carson NF that are still in good to excellent range condition, and others that are in poor or fair condition. Although the indications of historic overgrazing cannot be reversed simply by performing assessments or removing livestock, new science and intensive management have led to improved range condition in some areas, stabilized trend in others, and the identification of areas in poor condition. Monitoring data continues to accumulate, and the prospects are good for adaptive management to lead to further improvement.

Range condition on the Carson NF has been improving since the 1950s, when the first long-term monitoring transects were established. Since 1995, all the grazing allotments on the Carson NF have undergone recent NEPA analysis (EAs), with new decisions regarding permitted numbers, season of use, and grazing management.

In those EAs, each allotment was evaluated on a case-by-case basis applying best available science and the latest range management practices. Considerations for each allotment included probable forage production, current range condition and trend, carrying capacity, livestock distribution issues, and range improvement possibilities. There has also been a heavy emphasis in adaptive management options to give flexibility to producers and managers alike.

The Carson NF's current forest plan (USDA FS Carson NF 1986, p. C. Forest-wide Prescriptions Range-3) prescribes management to, "Strive to attain good to excellent range condition." Overall, Carson NF allotments are in fair to good range condition and the trend is generally stable or up, however, many forest ecosystems that are used for livestock grazing are currently departed from reference condition (see Chapter II. Integration and Risk Assessment, p. 298). Forest openings are reduced in size and abundance, which has reduced the quantity of available grasses that are necessary to provide sustainable forage for livestock and wildlife grazing. Ponderosa pine forest and mixed conifer, with frequent fire ecosystems have become denser and more even-aged, increasing the threat of stand replacing fire. Encroachment and infill by woody species, forage competition by other species, and reduced soil stability all contribute to the reduction in the availability of grass cover. Recent drought has contributed the decrease in quality and quantity of available forage. Installation of water tanks for livestock and wildlife use are altering hydrologic flow and may also concentrate grazing pressure, leading to water quality, soil, and vegetation impacts.

Trends Influencing Range Condition

Recent trends influencing range condition include those actions that degrade it, those that improve it, and those that temporarily alter it, and are described in more detail below:

Degradation: Woody species encroachment is degrading range condition by transforming former grassland to forest, and is widespread across the Carson NF. Encroachment constrains wildlife and livestock into smaller areas with forage, leading to competition between livestock and wild ungulates, potentially degrading range condition. Although wild ungulates are managed, short-term adjustments are not possible and it takes several years for issues to be identified.

Improvement: The recent completion of NEPA analysis for all Carson NF allotments and the implementation of their associated NEPA decisions, as well as adaptive management, are leading to improved range condition. The increase in non-use by permittees for either resource protection or personal convenience is also improving range conditions.

Temporary Alterations: The Carson NF is increasingly managing restoration projects at a landscape scale, which improve forest health and provide potentially grazing lands. Over the past several years, the forest has implemented grassland restoration in sagebrush areas. About 2,000 acres are mowed and seeded with native species annually. This is 1/10 of a percent of the forest, and can only be considered a temporary improvement in range condition. Likewise, transitional range from timber sales, thinning, and similar forestry projects temporarily improve range condition. The Carson NF treats about 4,000 acres annually, which is 2/10 of a percent of the forest. Temporary alterations can last 20 to 50 years before seral state changes decrease available forage.

Contributions of Livestock Grazing to Social, Cultural, and Economic Sustainability

Ranching in northern New Mexico is more than a business or a way to supplement income. It is a way of life. It is an integral part of the identity that defines the people of this region. Ranching connects them to the land. It unifies and binds families together and helps develop a sense of community. The small communities and towns around the forest rely upon the Carson NF for available rangeland to graze their livestock. The availability of forage and water on the Carson NF contributes to this way of life.

Most of the Carson NF's grazing permittees are descended from long time ranching families who have transferred permits down from previous generations, since the Forest Service first started managing grazing in the early part of the 20^{th} century. Between 2004 and 2006, McSweeney and

Raish (2012) completed extensive interviews and administered a questionnaire survey to permittees on the Santa Fe and Carson NFs. The survey results describe the situation and history of the Carson NF permittees.

Answers to the survey had a recurring theme of attachment to the land and deep sense of belonging to a place. Ninety-one percent of the respondents reported great grandparents or even earlier relatives living in the communities of northern New Mexico, with many having ancestors in the area as far back as the 1600s and 1700s. Seventy-six percent of the permittees surveyed held Forest Service permits in their families for over 50 years. Fifty-two percent had a history of grazing their animals on these lands prior to the Carson NF's inception in 1906. Commitment to remaining in the local community is very strong among the permittees and their families.

McSweeney and Raish (2012) discovered that although herd size and land holdings vary between permittees, monetary return seemed to be somewhat overshadowed by the enjoyment of where and how the ranchers live and work. They described that the sense of place transcends the delineation between private and public lands. A common Spanish word "querencia" was used repeatedly by permittees to describe their relationship to the land, which includes both the ranch and the allotments. "Querencia, donde quieres estar" is the place where you want to be, the place you go about the tasks of daily life.

While there are ranchers who depend upon ranching as their primary source of income, the vast majority within the area rely upon the ability to raise livestock as a supplemental income. The supplemental income of smaller ranchers is important for supporting their families. The animals make a substantial contribution to household income. McSweeney and Raish (2012) found that money generated by the ranching operation was often used for basic living expenses, household improvements, family emergencies, children's college education, and special expenditures.

See Livestock Grazing (p. 346) in the Carson National Forest's Contribution to Local Economic Conditions section of this report for the economic impacts of grazing.

Social Concerns Regarding Livestock Grazing

The following are summary statements of key ecosystem and management landscape-level drivers and stressors that affect rangeland and its foraging habitat:

- Water diversions and drought can affect stream flow, which affects the availability of water for livestock.
- Preventing and controlling invasive weeds/species are important, since they often move in and replace native species that are more beneficial to livestock.
- Fire is a key landscape driver that contributes to ecological integrity and sustainability, as well as providing forage for livestock. Fire suppression, reduced tree harvest/thinning, and not enough prescribed burning have created increased tree encroachment in meadows and aspen stands, a long-term decline in early seral vegetation (i.e., forage), and less forage production.
- Climate change is a key landscape stressor affecting long-term ecological conditions, including areas grazed by livestock. Confirmed temperature increases and declining snow packs, as well as potentially greater drought cycles, are changing the availability of foraging areas for livestock.

- Use of roads and indiscriminate gate closing by recreationists can negatively affect livestock behavior, distribution, and management.
- Administrative restrictions to protect and enhance threatened, endangered, or sensitive species habitat, as well as other resource concerns (e.g., water quality), can negatively affect a permittee's livestock operation.
- Rural communities continue to depend on ranching for their economic, social, and cultural sustainment.
- Changing and erratic livestock markets can negatively affect a permittee's operations.

Impacts of Permitted Livestock Grazing on Ecological Integrity and Species Diversity

Permitted livestock grazing has both beneficial and adverse impacts on ecological integrity and species diversity. Some of the beneficial impacts from conservative grazing include aeration of the soil through hoof action, invasive plant control, reduction of fine fuels (decadent grasses and forbs), maintaining open space off forest through base property ownership, and increased water developments in uplands.

Adverse impacts from range activities are often localized and can look dramatic, but the overall impacts are small at a forest-wide scale. Reduced areas with forage (i.e., denser forests, infill, meadow encroachment); poor distribution of livestock (e.g., livestock staying in meadows and along riparian areas, where it is easy to graze and access water); and lack of water in upland areas during drought periods are the primary reasons for localized overgrazing. Overgrazing can modify the structure of individual plants and plant communities, as well as remove most of the vegetation and cause greater soil erosion. Repeated hoof action from livestock that stay in localized areas can compact riparian soil, which reduces water infiltration. Repeated trampling of streambanks reduces or eliminates vegetation along banks, increases water temperatures and sediment loads, widens stream channels, and alters riparian vegetation communities. Overgrazing in localized areas can modify the natural flood regime by inhibiting the development or riparian woody species, as well as reduce the height and ground cover that provides nesting and hiding cover for various birds, small mammals, and prey base for larger wildlife species.

Summary

The Carson NF and surrounding public lands are a key resource for grazing livestock by local ranchers. Permitted numbers have remained fairly constant over the last 10 years, without measurable increases or decreases. From 2004 to 2014, authorized numbers have decreased on average by 15 percent from current permitted cattle numbers, and 44 percent of current permitted sheep numbers, due to drought conditions or permittee voluntary preference. Wild ungulates are increasing in number and creating competition for forage on the forest. Range condition is considered good overall, but much of the rangeland vegetation types are considered departed or at risk of departure, due to historic activities such as grazing (see Chapter II. Terrestrial Ecosystems, p. 16) and Riparian Ecosystems, p. 102). The ability to continue to provide sustainable forage for both domestic livestock and wild ungulates is at risk.

Timber and Special Forest Products

The ability to gather firewood for heating and cooking is important for many of the families and communities around the entire assessment area. Firewood gathering is often a family social event, but more importantly, firewood from the Carson NF is how many people heat their homes at a large economic savings over propane, natural gas, and electricity. Other wood products that come off the forest, such as latillas and vigas, are culturally and economically important as well. The Carson NF has increased the number of forestry treatments it implements, to improve forest health, reduce potential for uncharacteristic wildfire, and make forest products more available. This section discusses the current condition and trends of timber and special forest products on the Carson NF by identifying and evaluating:

- Ecosystem services from timber and special forest products
- Current condition of forested areas within the plan area
- How Collaborative Forest Restoration Program, Stewardship Blocks, and Vallecitos Sustain Yield Unit fit into the management of timber and special forest products
- Contribution of timber management to ecological sustainability
- Current timber and special forest product production in the plan area and broader landscape
- Trends influencing supply and demand of timber and special forest products coming from the plan area.
- Contributions the plan area makes to social, cultural, and economic sustainability
- Summary of timber and special forest products on the Carson NF

Timber and Special Forest Products Ecosystem Services

Timber provides many ecosystem services on which other life forms (including humans) depend, including:

- **Supporting** ecosystem services of timber and forest products at the most basic level convert sunlight and carbon dioxide into oxygen and carbohydrates (primary production).
- **Regulating** ecosystem services of timber and forest products are key to soil formation and stability, thermoregulation (shading and evaporative cooling), nutrient and hydrologic cycling, and energy flow.
- **Provisioning** ecosystem services of timber and forest products provide wildlife habitat (cover, nest sites), food (piñon nuts for humans and other animal species, browse for wildlife), and fiber (lumber, paper, fuel).
- **Cultural** ecosystem services of timber and forest products (e.g., Christmas trees, botanical remedies, and aesthetics) are especially important to humans and society.

Current Conditions and Trends of Forested Areas

The Carson NF encompasses almost 1.5 million acres, predominantly comprised of relatively dry ponderosa pine and mixed conifer forests, spruce-fir forest, piñon-juniper woodlands, open meadows, and sagebrush steppe. Nearly 1.2 million acres (80%) are considered to be forested, of which about 380,000 acres (26%) are designated as suitable for timber production (USDA FS 1986). An annual forest inventory of New Mexico's forests is conducted by the National Forest Inventory and Analysis (FIA) program.[1] FIA plot data were summarized using Forest Inventory Data Online (FIDO) standard reports from 2005 to 2013 inventory data.[2] According to these data,[3] gross standing tree volume on the Carson NF consists of about 1,936 million cubic feet (MMCF). These data also indicate average annual mortality of 27 MMCF on the forest.

The Carson NF's 1986 forest plan (USDA FS Carson NF 1986) provides timber resource direction that generally prescribes a sustained yield from scheduled harvesting, while considering other resource needs. In September 1996, the forest plan was amended to incorporate Regional guidance for northern goshawk habitat and Mexican spotted owl recovery (USDA FS 1996). As a result, the Carson NF forestry program shifted emphasis from predominantly even-aged to predominantly uneven-aged forest management practices. In combination with waning budgets, the Carson NF gradually declined in forestry staffing, outputs, and accomplishments. Although projects and activities addressing hazardous fuel loading had been a part of the vegetation management approach since at least the 1980s, the 2000 National Fire Plan[4] provided directional emphasis to reduce the impacts of wildfires on communities and to restore fire-adapted ecosystems to healthy conditions. The directive of the Carson NF's new forestry program was to further integrate with the wildlife, watershed, and fuels management programs, subsequently providing wood products as a byproduct of other management objectives rather than a primary objective.

Approximately 37,000 acres of vegetation were treated on the Carson NF from fiscal year (FY) 2005 through FY 2014. Treatments include activities such as timber harvesting, fuelwood gathering, small diameter thinning and/ or mechanical fuels treatments, and prescribed burning (Table 87).

[1] FIA data are publicly available from the national FIA Website at fia.fs.fed.us. This site includes data downloads; online tools that allow users to perform custom queries; and documentation of FIA's field inventory protocols, database structure, and publications.

[2] Available: Forest Inventory Data Online Website.

[3] Tree species at least 5 inches diameter at breast height or diameter at root collar.

[4] The report entitled "Managing the Impact of Wildfires on the Communities and the Environment", was released September 8, 2001. This report, and a set of corresponding agency strategies, formed the basis of what is now known as the National Fire Plan.

Table 87. Carson National Forest's management activity (acres) by ERU[1] (see Terrestrial Vegetation, p. 34) from FY05 to FY14

Management Activity	MSG	SFF	MCW	MCD	PPF	PJO	PJS	SAGE	Total
Harvest-thinning	8	40	158	877	1,909	603	0	0	3,596
Harvest-uneven-aged	10	0	0	2	79	0	0	0	90
Burning-prescribed	790	0	29	2,622	13,189	36	85	77	16,829
Harvest-commercial thin	16	0	0	359	2,453	20	1	1	2,851
Fuels treatment	56	107	664	3,152	5,235	960	53	4	10,231
Revegetate-planting	0	0	0	294	2,335	639	55	0	3,323
Total	880	147	852	7,306	25,200	2,258	195	82	36,920

General management objectives for the Carson NF have largely revolved around forest ecosystem restoration, which includes improving forest resilience, watershed condition, and wildlife habitat, while reducing fire hazard (fuels) and providing wood products to local communities. Sale volume associated with these projects (i.e., timber sales, commercial and personal use fuelwood sales, post and pole permits, and other convertible product sales) averaged about 2 MMCF annually between FY 2005 and FY 2014 (Table 88). Fuelwood sales (personal and commercial) accounted for about 80 percent of the volume during this 10-year period.

[1] Ecological Response Unit - Montane Subalpine Grassland (MSG), Spruce-Fir Forest (SFF), Mixed Conifer, with Aspen (MCW), Mixed Conifer, with Frequent Fire (MCD), Ponderosa Pine Forest (PPF), Piñon-Juniper Woodland (PJO), Piñon-Juniper Sagebrush (PJS), and Sagebrush (SAGE).

Table 88. Volume sold on the Carson National Forest by product and fiscal year in hundred cubic feet (CCF)

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total	10-yr avg
Sawtimber	1,933	5,677	0	0	1,535	0	0	918	0	8,243	27,451	1,830
Pole	1,119	692	1,351	1,141	2,532	1,562	1,376	1,589	1,368	607	20,170	1,355
Post	47	41	19	32	38	7	7	12	3	5	388	29
Fuelwood	10,147	10,669	13,035	16,121	18,487	20,710	20,318	19,495	19,058	17,957	234,276	15,106
Misc. Convertible	37	21	115	561	21	0	0	22	51	67	1,653	120
Total	13,282	17,099	14,519	17,855	22,613	22,279	21,521	22,036	20,480	26,878	283,937	18,465

The Carson NF is adjacent to two other national forests (Santa Fe NF and Rio Grande NF), as well as BLM, tribal, state, and private owned lands. Within the broader landscape, timber production is a minor component of employment. In 2012, timber-related jobs accounted for less than one percent of private sector employment within Colfax, Mora, Rio Arriba and Taos counties (Headwater Economics 2015). There are no industrial timberlands within the four county areas. Collectively, timber harvest within these counties averaged 1.6 MMCF per year from 2002 through 2012. From 2002 through 2012, tribal and private timberlands provided an average of 73 percent of the timber products received by New Mexico mills; whereas, the national forests provided 26 percent of the volume on average (Sorensen et al. 2012). According to the University of Montana's Bureau of Business and Economic Research, there were eight active primary wood products facilities within Colfax, Mora, Rio Arriba, and Taos counties in 2012 (Sorensen et al. 2012). Wood products from these facilities include lumber, vigas, latillas and other products.[1]

As implied by the amount of harvest activities, the timber base largely draws from the MCD and PPF ERUs (Table 88). Both MCD and PPF are abundant on the landscape, yet underrepresented relative to historic extent. They are also highly departed from historical conditions, largely due to interruptions to the natural fire regime and/or influences from land management activities. Both ERUs are vulnerable to widespread, high severity wildfire and susceptible to a variety of insect and disease mortality, due to changes in species composition and forest structure. Widespread, high severity wildfire and insect and disease mortality can reasonably be expected to occur in these ERUs in the future, potentially exacerbating a current trend of even-aged, relatively young stands at a broad extent that did not exist in the reference condition. Large scale disturbance could potentially affect the availability of timber resources on the Carson NF, shifting harvest activities to other ERUs. Harvest activities from other ERUs would be far more challenging, as traditional use of species from within PPF and MCD ERUs is driven in part by ease of access (i.e., close

[1] Other products include posts, poles, log homes, firewood, pellets, shavings and/ or bark products. Other products were associated with two mills in Colfax County.

proximity to communities, generally modest slopes, and higher road density). A more detailed analysis of ecological condition and trend by ERU can be found in the Terrestrial Vegetation section (p. 34) of this document.

Timber and Special Forest Products Management on the Carson National Forest

Collaborative Forest Restoration Program

In 2000, Congress passed the Community Forest Restoration Act (Title VI, Public Law 106-393). The Act authorized the establishment of the Collaborative Forest Restoration Program (CFRP) in New Mexico, to provide cost-share grants to stakeholders for forest restoration projects on public land designed through a collaborative process. These projects may be entirely on any combination of federal, tribal, state, county, or municipal forest lands, and must include a diverse and balanced group of stakeholders in their design and implementation. Each project must also address specific restoration objectives including: (1) wildfire threat reduction; (2) reestablishment of historic fire regimes; (3) reforestation; (4) preservation of old and large trees; and (5) increased utilization of small diameter trees.

Since 2001, 49 CFRP grants have been awarded on the Carson NF, totaling $13 million in funding and 8,427 acres treated. There are currently 12 open CFRP projects[1] associated with the forest, treating approximately 3,240 acres.

Stewardship Blocks

For the past 10 years, the Carson NF has managed a successful community partnership program, which is referred to as the stewardship block program. The majority of the program has been executed on the Camino Real RD, with a smaller program on the Canjilon RD. The intent is to make wood available for firewood, vigas, and latillas to communities, in return for restoration work. Community members pay a minimal permit fee for the opportunity. The forest identifies and marks trees in one- to four-acre segments, which will yield 5 to 10 cords of wood. The permit holder typically has one year to remove identified trees. The goal of the Camino Real RD is to provide 10 to 20 blocks per year. The district administrates and monitors the work.

Vallecitos Federal Sustained Yield Unit

The Sustained Yield Forest Management Act (SYFMA) of 1944 authorized the Secretaries of Agriculture and Interior to establish cooperative sustained yield units, encompassing both public and private lands. Congress passed the SYFMA to, "promote the stability of forest industries, of employment, of communities and of taxable forest wealth through continuous supplies of timber" (16 U.S.C. 583).

Established in 1948, the Vallecitos Federal Sustained Yield Unit (VFSYU or “Unit”) was the first Federal Sustained Yield Unit instituted by the Forest Service (Krahl and Henderson 1998). The VFSYU is 73,400 acres and is located on the El Rito RD (Figure 82). It is comprised of mixed conifer forests, ponderosa pine forests, grasslands, and piñon-juniper woodlands. Since its inception, the Unit has provided timber and other wood products intermittently, due to a variety of regulatory and provisional requirements that have proved difficult to fulfill and maintain

[1] These are projects that are still being implemented, but grant money was distributed from 2011 to 2014.

(Krahl and Henderson 1998). The Carson NF's 1986 forest plan sets three distinct allowable annual cuts for two designated entities of the Unit:

- **The designated operator** is allowed to harvest 5.5 MMBF of sawtimber from the Unit;
- **Local responsible operators**, which are small, local businesses that establish primary manufacturing facilities within Area A, are allowed a total of 1.0 MMBF of sawtimber and 1.1 MMBF of small forest products from the Unit.

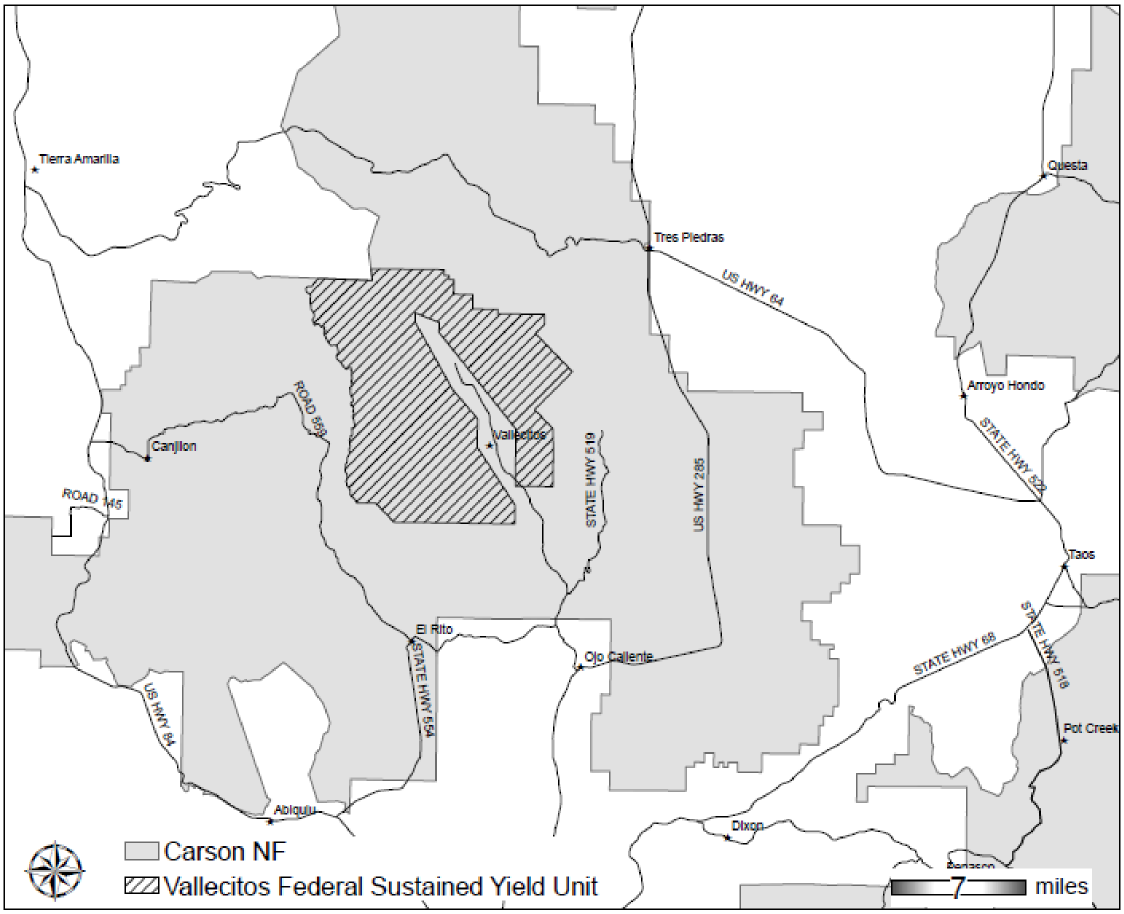


Figure 82. Location of the Vallecitos Federal Sustained Yield Unit on the El Rito Ranger District, Carson National Forest

Currently, there is not an operable sawmill in the vicinity of the VFSYU to manage the Unit as it is currently designated. The Carson NF does continue to perform thinning and fuel reduction projects within the VFSYU. Many of these projects are carried out to decrease fire risk and maintain the health of the forested ecosystems in the Unit. The additional purpose and benefit of many of these projects is to make firewood accessible and available for the surrounding communities. Table 89 provides a list of projects completed within the last 10 years.

Table 89. Timber and fuelwood projects on Vallecitos Federal Sustained Yield Unit, 2005-2015

Treatment	Area (acres)	Project	FY Completed
Harvest - Commercial Thin[1]	107	Valle Grande Fuelwood	2012
	53	Valle Grande Fuelwood	2012
	87	Valle Grande Fuelwood	2014
	83	Peak Fuelwood	2013
Total	**330**		
Harvest - Thin[2]	216	Agua/Caballos	2005
	150	Agua/Caballos	2006
	140	Agua/Caballos	2007
	234	Agua/Caballos	2009
	131	Agua/Caballos	2010
	76	Agua/Caballos	2010
	63	Agua/Caballos	2011
	50	Agua/Caballos	2013
	85	Ensenada Ecosystem Restoration	2006
	45	Ensenada Ecosystem Restoration	2006
	45	Ensenada Ecosystem Restoration	2006
	212	Ensenada Ecosystem Restoration	2010
	103	Ensenada Ecosystem Restoration	2010
	85	Ensenada Ecosystem Restoration	2011
	87	Ensenada Ecosystem Restoration	2011
	60	Ensenada Ecosystem Restoration	2011
	87	Ensenada Ecosystem Restoration	2012
	37	Ensenada Ecosystem Restoration	2012
	23	Ensenada Ecosystem Restoration	2013
	68	Ensenada Ecosystem Restoration	2013
	96	Ensenada Ecosystem Restoration	2013
	102	Ensenada Ecosystem Restoration	2014

[1] These activities were conducted under green fuelwood block permits.

[2] Some materials from these activities were sold as personal-use dead and down fuelwood.

Treatment	Area (acres)	Project	FY Completed
Total	**2,195**		
Burning - Pile	50	Ensenada Ecosystem Restoration	2012
	145	Ensenada Ecosystem Restoration	2013
	78	Ensenada Ecosystem Restoration	2014
Total	**273**		
Burning - Prescribed	935	Petaca/Las Tablas II	2011
	700	Petaca/Las Tablas II	2012
Total	**1,635**		

Contributions of Timber and Special Forest Products to Ecological Sustainability

Land managers are often concerned about a forest's resilience to disturbances like insect, disease, and wildfire. These concerns are commonly addressed by thinning forests, as tree density is the major factor that a forester can manipulate (Daniel et al. 1979). Tree vigor can increase the availability of defense mechanisms used to protect against insects and diseases (Oliver and Larson 1996). Vigor is improved by reducing competitive pressure between trees, thereby reallocating growth potential (and defense mechanisms) to the residual trees. Thinning also helps to improve overall stand vigor, by removing less vigorous individuals. Wildfire hazard can be addressed through thinning, by removing ladder fuels (smaller trees in the understory and mid-canopy that can carry a surface fire into the forest canopy) and decreasing canopy bulk density. Canopy bulk density refers to the volume of canopy fuels. Canopy bulk density is important to consider, as it is the primary controlling factor of crown fire behavior (Graham et al. 1999). Commercial harvesting of mid- and overstory trees helps to reduce canopy bulk density, thereby reducing potential for sustaining crown fire.

Mechanical thinning is a selective process, where undesirable characteristics can be selected against; conversely, desirable characteristics can be retained or promoted. For example, thinning tactics can prescribe removal of weak, diseased, and dying individuals, or species and individuals with characteristics that are more susceptible to drought, fire, and/or insect mortality. Thinning strategies can prescribe preferential retention of disturbance resilient species, such as ponderosa pine. Thick bark, self-thinning crown (i.e., foliage and branches farther from the ground), deep taproot, and stomatal control make ponderosa pine more resistant to fire and drought perturbations. Thinning allows for manipulation of species composition and residual stand structure, such that appropriate conditions can be attained in order to promote desirable ecological processes (e.g., disturbances) and function (e.g., food webs and wildlife habitat).

Recently, momentum has increased for a more holistic approach of forest restoration (e.g., GTR-310, Reynolds et al. 2013). Generally, thinning and its objectives are utilized in forest restoration; however, more emphasis is placed on developing diversity in forest structure, age classes, and species composition akin to historic conditions. This approach includes selective cutting methods paired with prescribed burning, intended to develop and maintain uneven-aged forest conditions that are considered more resilient to natural disturbance, thus more sustainable long-term. The intended ecological benefits of vegetation treatments are essentially only beneficial where they occur and their extent covers a small fraction of the landscape. Treatments are limited in part by workforce capacity and current forest plan standards that are very prescriptive, restraining management options across broad extents. The magnitude of prescribed burning accomplishments is swayed by weather and other environmental factors that can be highly variable year to year, is limited by air quality regulations, and to a lesser degree, workforce capacity and concerns over public safety and values at risk.

Impacts of Timber Harvest on Ecological Integrity and Species Diversity

Past management activities have altered stand structure, composition, and fire occurrence patterns on the Carson NF, as described in the System Drivers and Stressors for Terrestrial Ecosystems section (p. 25) of this document. Current ponderosa pine and dry mixed conifer stands are overstocked, have an overabundance of shade tolerant species, and are often even-aged and multi-storied, with few examples of the historic open, fire-maintained stand conditions remaining. Current stands contain more small trees, and fewer large trees than existed in the past, increasing the amount of ladder fuels. In each of the vegetation types described, dead forest fuels have accumulated from plant senescence and plant mortality. Relatively drier climatic conditions and slow decomposition rates, combined with the interruption of historical fire return intervals, have resulted in large accumulations of burnable materials. Current tree growth rates are commonly slow, and stand vigor is declining as competition for water, nutrients, and growing space has increased as a result of higher tree density. The low level of tree and stand vigor makes trees more susceptible to insect attack and disease mortality, combined with increased density of vegetation and continuity of fuels coalesces in an increased probability of severe effects from wildfire.

Timber management activities on the Carson NF are trending toward targeting improvements to forest structure and function. Addressing mid- and overstory conditions is critical to these restorative efforts, as this affects overstory species composition, stand structure, potential crown fire initiation and propagation, stand density, and influences on understory conditions. Relying on other vegetation management methods, such as understory burning, does not necessarily have the same selective capacity, especially with regards to the overstory.

Short-term negative impacts to forest soils and hydrology can be expected. Limited soil compaction and waterway sedimentation may occur, due to disturbances from logging equipment, skidding, landings and temporary road construction, and use. These effects are typically mitigated by limiting ground-based operations to relatively gentle slopes, as well as establishing limits to extent of disturbance and proximity to riparian and/or other sensitive areas. Long-term benefits to ecosystem resilience, disturbance regime, nutrient cycling, biodiversity and food webs, old-growth condition, overall hydrologic function, wood products, and aesthetics and recreation outweigh short-term negative impacts as outlined in GTR-310 (Reynolds et al. 2013).

Trends Driving Supply and Demand of Timber and Special Forest Products

The supply and demand for timber is driven by regional, national, or global forces. Local drivers are small in scope and scale, and generally have inconsequential effects on the overall market for timber and lumber products. Demand for woody material from the Carson NF is largely driven by fuelwood needs. This demand is made evident by the proportion of volume sold as fuelwood as discussed above (Table 88). Other local demand for woody material comes from two small mills that generate rough cut lumber, fuelwood, and other specialty products for use in local custom-built homes. The need and desire for firewood by families and communities has remained stable to slightly increasing over the last five years.

The Forest Service recently acknowledged the critical need to increase the pace of restoration, to address a variety of threats including fire, climate change, and bark beetle infestations (USDA FS 2012b). Across the nation and in the Southwest, there is broad public support for actively managing forests to be more resilient to these threats. In response, the Carson NF is generally shifting planning and implementation efforts to encompass larger landscapes. This broad recognition is piquing interest in the feasibility of commercial use of traditionally sub-merchantable materials, such as small diameter dimensional lumber and wood-based energy production. For example, a recent wood utilization study considered potential biomass prospects for the Chama, NM area including wood pellet manufacturing, a biomass power plant electricity facility, cellulosic ethanol production, biomass-based chemical production, and biochar production (WELC 2013). This study highlights interest in large-scale wood product utilization and demonstrates a trend for potential future growth in facilities and production.

The near-term potential for impacts to the Carson NF is probably low, as the establishment of any of these manufacturing facilities is extremely speculative and would likely require years of effort to become established. What is clear is that the Carson NF intends to manage NFS lands such that species composition, structure, and function are more akin to historical conditions, and to do so at a broad scale. This would make more wood products available than the current local manufacturing facilities can support.

Contributions of Timber and Special Forest Products to Social, Cultural, and Economic Sustainability

The Carson NF administers its lands for a variety of objectives that can generally be described as forest ecosystem restoration. Woody material is largely derived as a byproduct of restoration and other activities. There has been a long-term historic demand for firewood, which continues to this day. The ability to access the forest and gather firewood is very important for local communities. The Carson NF makes firewood available throughout the forest as part of CFRP projects, stewardship blocks, and designated areas for those with a permit to gather firewood. Timber production is a minor component of private sector employment. Two wood processing facilities operate within the assessment area, with little demand for volume from the Carson NF. There is a broad interest in increasing the pace of restoration activities, which may pave the way for additional, potentially innovative facilities in the future.

The ability to access the forest and gather firewood is very important traditional use for families and communities surrounding the forest. Often firewood gathering is a family event. The use of firewood for heating saves many families money over the cost of using utility sources for their heating.

See Carson National Forest’s Contribution to Local Economic Conditions, Timber section (p. 346) of this report for the economic impacts of timber and special forest products.

Summary

The Carson NF's primary contribution of timber and forest products is to local communities around the forest for firewood, latillas, and vigas. An increased emphasis in land restoration projects should allow for the continued ability to contribute to this demand. The forest should be able to continue to contribute to the two mills, which operate adjacent to the plan area. There is potential to support and provide timber from the VFSYU, but unless an approved mill is constructed, no timber can be harvested. An increase in forest restoration projects will be vital to help sustain forest and watershed health, reduce potential for uncharacteristic wildfire, and improve or maintain wildlife habitat.

Water

Water and water resources are of incredible importance, not only ecologically, but to the human and social fabric of the plan area as well. This is evident through the construction of acequias (irrigation ditches) in the 1500s that are still in use on the Carson NF today. Community and state resource plans are focused solely on the protection and use of water resources, and the politics around water can often become passionate. Water rights are held tightly and regarded with high value, socially if not monetarily. When one looks at the settlement patterns within the plan area, almost all are near some kind of water source. Special laws govern water, which further illustrates the status assigned to this resource. “AGUA ES VIDA” or “Water Is Life” is a common bumper sticker on many vehicles within the assessment area. The importance of water is equally applied to the Carson NF. The forest plays a significant role, if not the most significant role, in providing water within the assessment area, since the vast majority of water originates on the forest.

This section of the assessment report will briefly describe the water resources, conditions, uses, and trends on the Carson NF, in addition to looking at the social aspects of water related to the forest. The Aquatic Ecosystems section (p. 134) in the previous chapter provides greater detail pertaining to the ecological facets of this resource across the assessment area. This section addresses:

- Ecosystem services from water
- Water rights
- Carson NF’s water resources, including water quality and supply
- Wastewater on the Carson NF
- Water demand of the forest
- Current condition and trend of water
- Contributions of water to social, cultural, and economic sustainability of the assessment area
- Summary of water resources in social, cultural, and economic context on the forest

Water Ecosystem Services

In this same regard, water offers several important and significant ecosystem services across the ecological and social landscape of the forest. Some of these include:

- **Supporting** ecosystem services of water is one of the most critical elements. Not only is it needed to support healthy functioning ecosystems, but it is also needed to sustain all life.

- **Regulating** ecosystem services of water provide storage for current and future use of domestic and agriculture needs, water diversions, and for flood and drought control.

- **Provisioning** ecosystem services of water supplied from the Carson NF is critical for domestic and agricultural use, since it originates on the forest before reaching its end users.

- **Cultural** ecosystem services offered by water range from recreational in nature to historical in terms of traditional uses. Water holds high recreational value and attracts various recreation interests including rafting and waterside camping. Historically, acequias (historic water ditches) helped shaped the settlement of the assessment area and are still in use today. Bodies of water are sacred to local pueblo communities and water is necessary to sustain local agricultural economies.

Water Rights

Water is owned and managed by the State of New Mexico. The NM Office of the State Engineer is the agency responsible for administering the state's water resources. It has the authority over the supervision, measurement, appropriation, and distribution of all surface and groundwater in New Mexico and also administers water rights across the state. Water rights are a legal right to use a specific quantity of water, on a specific time schedule, at a specific place, and for a specific purpose (NMOSE Website; NM OSE/ISC 2014b).

The Carson NF has what is referred to as reserved water rights on the NFS lands within its borders. These water rights provide an exemption to state control and must be granted by the President or U.S. Congress for specific management uses. When the forest uses its water rights on NFS lands, it coordinates with the State Engineer's office on specific locations, uses, etc. Private water rights are found in inholdings within the Carson NF and are also adjudicated[1] by the state throughout the assessment area. The vast majority of water rights within the assessment area are for livestock grazing, acequias, mining, and for surface water bodies, such as lakes for recreation, fish, and wildlife use.

About one-third of the Carson NF has been adjudicated for water rights. The two adjudicated areas on the forest include the Red River and Cimarron Basins. Approximately 75 percent of the forest is currently undergoing adjudication and are awaiting decision. The areas currently undergoing adjudication on the forest include the Chama, San Juan, Santa Cruz/Truchas, and Taos/Hondo Basins.

Water Resources

Water resources on the Carson NF consist of groundwater and surface water. Surface water includes waters from perennial streams, seeps and springs, wetlands, and other waterbodies that are replenished by precipitation and groundwater. Figure 35 (p. 143) shows where perennial streams are located across the forest. Therefore, approximately 1,044 miles of perennial streams and 4,558 miles of both intermittent and ephemeral streams are on the forest. The Carson NF supports 1,565 water bodies (lakes, ponds, etc.) that cover over 1,308 acres and 659 documented seeps and springs. Water storage is minimal on the forest, with three small reservoirs (Cabresto Lake, Canjilon Lakes, and Hopewell Lake) totaling of 48.7 acres. Within the assessment are, water storage typically takes place off the forest.

Water Quality and Quantity

The Aquatic Ecosystems section (p. 134) of the previous chapter offers a detailed analysis of water quality and quantity for the Carson NF and the assessment area and risks. In an effort to protect and enhance water resources on the Carson NF, the Forest Service engages in management activities that maintain ecosystem conditions, so that water quality is maintained or improved. Some of these activities include forest restoration projects, thinning projects, and utilizing best management practices, as outlined in the Forest Service's 2012 technical Guide (USDA FS 2012d).

[1] Adjudication is a judicial process that reviews and defines water rights.

Water Supply

While the Carson NF does not have any designated municipal watersheds, communities do rely on the water supply that comes from the forest. These include local communities within the assessment area that range from several hundred people around Trampas or El Rito, to several thousand in the Taos area. It also includes communities outside of the assessment area, such as Albuquerque, which serves over 500,000 people. Figure 46 (p. 162) depicts well locations adjacent to the Carson NF, but does not include water for any other uses. The density of domestic wells shows how communities within the assessment area rely on water from the Carson NF.

Wastewater

The Carson NF has wastewater facilities scattered throughout the forest. The majority of these are associated with recreational and administrative facilities. There are also two waste water treatment plants for the Town of Red River and the Village of Taos Ski Valley that were conveyed in 2014 to municipal ownership by Congress. More information on these can be found in the Infrastructure section (p. 466) of this document.

Many private land inholdings are widespread throughout the forest. Almost all that have developments have some type of wastewater system, such as a septic tank, or some other means of disposing wastewater. These systems come under the State of New Mexico permitting authorities and are not administered by the Forest Service. If any of these private systems were found to have leaking septic tanks, they could impact NFS lands, but the conditions of these systems or impacts to the forest are currently unknown.

Water Demand

Water is an essential resource required to sustain life, which makes the demand for water a commonality among all living things. The demands for water will fluctuate according to population numbers, needs, and usage requirements. Within the assessment area, water demands come from agricultural needs, mining, drinking and domestic usage, recreation, and for fish and wildlife. Ecosystems also have water demands (see Aquatic Ecosystems, p. 134).

Agriculture, including livestock grazing, represents approximately 90 percent of water use within the assessment area (NM OSE/ISC 2010). Most of this use takes place off of the Carson NF. The water originates on the forest and is rerouted through headgates and ditches to private land off the forest. This water is primarily used for irrigation and livestock purposes. Domestic and drinking water make up the second highest water use within the assessment area, though the volume is much less than agricultural use.

Water demand for recreation is also important in the assessment area. Given the Carson NF is in the arid Southwest, people seek out its lakes and streams for recreational enjoyment, such as for camping, picnicking, and fishing. Water is also supplied at many of the developed campgrounds through water systems that are maintained by the Carson NF. More information can be found on these water systems in the Infrastructure section (p. 466).

Aside from human uses, fish and wildlife within the plan area also have demand and need for the water originating on the Carson NF. Fish and wildlife use of water and water bodies include habitat for some or all life stages (such as fish and amphibians), water sources for drinking, and habitat for a species' food sources (such as raptors that eat fish).

Current Conditions and Trends of Water

The Watershed Condition Framework is a process for rating the condition of watersheds across the Carson NF. There are three ratings under this framework. Functioning properly means the watershed is rated Class 1 and exhibits high geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. Functioning at risk are Class 2 watersheds that exhibit moderate geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. Impaired defines Class 3 three watersheds that exhibit low geomorphic, hydrologic, and biotic integrity relative to their natural potential condition. When a watershed is functioning properly, it has five important characteristics (USDA FS 2011b):

1. It provides for high biotic integrity, which includes habitats that support adaptive animal and plant communities that reflect natural processes.
2. It is resilient and recovers rapidly from natural and human disturbances.
3. It exhibits a high degree of connectivity longitudinally along the stream, laterally across the floodplain and valley bottom, and vertically between surface and subsurface flows.
4. It provides important ecosystem services, such as high quality water, the recharge if streams and aquifers, the maintenance of riparian communities, and the moderation of climate variability and change.
5. It maintains long term soil productivity.

Figure 50 (p. 192) displays watershed conditions for the Carson NF. In total, the forest's watersheds and sub-watersheds are rated as:

- 19% Functioning Properly
- 80% Functioning at Risk
- 1% Impaired Function

See the Watersheds section (p. 191) of the previous chapter.

While the watershed condition provides valuable information on the ecological condition of a watershed, it also provides valuable information from the social and economic perspective. With 80 percent of the watersheds functioning at risk, a focus can be made on what needs to be done and where to bring the watershed back up to functioning. The forest uses this information for planning restoration projects. It also shows where the risks are to domestic water use and consumption, agricultural use, and recreational use in terms of water quantity and quality based on watershed condition.

Trends in water conditions and water use can be characterized simply; water demands are increasing, while supply is decreasing. When analyzing state water plans within the assessment area, a troubling trend emerges related to supplying water to ever increasing. This is especially a concern given New Mexico is experiencing a drought. Since 1996, water supplied from the Carson NF has dropped from 356,734 acre-feet of water to 95,515 acre-feet, in just the Rio Grande and Rio Chama watersheds alone (see Surface Water, Streams, p. 141). Other prevalent trends can also be found in:

Surface water diversions and use - These uses are generally for irrigation, wildlife, and livestock. As more water is taken from surface resources, water quality and quantity will be affected, and the ecological resource will become degraded, through reduced water availability, reduced groundwater recharge, higher stream temperatures, and an increase in the concentration of pollutants.

As explained in the Surface Water Trend section (p. 161), there are few withdrawals within the forest boundary, as most occur on private inholdings or adjacent private lands. These privately owned lands are not regulated by the Forest Service; however, they do have influence on the overall health of the water ecosystem. Presently, in some areas, mainly at lower elevations, these withdrawals significantly reduce instream flows. Furthermore, withdrawals on the Carson NF are predicted to increase 25 to 50 percent by 2060, as a result of climate change (p. 161).

Groundwater extraction - Over 90 percent of drinking water within the assessment area comes from groundwater (NM OSE/ISC 2010). The number of groundwater wells is a contributing factor to the health of aquatic ecosystems. Like surface water, groundwater withdrawals can degrade the water resource, by reducing water availability, creating higher water temperatures, and concentrating pollutants. The number of wells within the assessment area continues to increase in places where water is already overallocated. Though these wells are located on private lands adjacent to the forest boundary, they can affect the forest's ecological health, by drawing down groundwater supply (p. 161). Groundwater discharge can also lead to a lowered water table, increased pumping cost, less available water for discharge to streams and lakes, and land subsidence (p. 138).

National Forest System (NFS) roads and trails and stream crossings - Road densities and stream crossings degrade water resources by increasing sedimentation and transporting sediment to streams. Consequently, this degrades floodplain and channel function (US EPA 2012). The Carson NF has road system and travel management policies in place; however, as illegal routes are created or existing routes receive more use from the rising and unmet demand of motorized recreation watershed concerns on the forest will continue. This, coupled with a lack of road maintenance from budget restraints, further contributes to a declining trend. See Integration and Risk Assessment in Chapter II (p. 303) for more information on how roads and trails are stressors to water resources on the Carson NF.

Ungulate foraging and grazing - Ungulate foraging by either wildlife or domestic livestock degrades the water resources within the assessment area. Grazing or foraging reduces riparian vegetation that provides bank stabilization and shade. This ultimately can result in channel downcutting and a dysfunctional floodplain. Restoration activities implemented on the Carson NF are aimed at reversing these effects. See Integration and Risk Assessment in Chapter II (p. 303) for more information on how grazing is a stressor to water resources on the Carson NF.

Climate change and temperature - Climate change is already affecting and will continue to negatively affect water within the assessment area well into the future. The forest is currently under drought conditions, which began in 1996 (p. 144). These conditions have been characterized by several years of above average temperature and were exacerbated by subsequent below average precipitation and continued heat (Figure 37, p. 145). Stream gauge data from across the forest reflects this same drop in available water (Table 22).

Furthermore, climate models forecast changes in the Southwest, including increased warming and drying, intensification of droughts, and increased variability in precipitation. As a result, there will be less runoff, a decrease in snowpack, and variances in streamflow patterns in the future (US EPA 2015c). See the Climate Change section in Chapter II (p. 275) for a more in depth discussion of climate change on water resources on the Carson NF.

Contributions of Water to Social, Cultural, and Economic Sustainability

Without water, there is no life. Water is such an important life sustaining requirement that the Forest Service was created in the 1890s (then as forest reserves), specifically in response to social concerns regarding the adequate supply of water (USDA FS 2000). The Carson NF continues in this critical mission, by managing, protecting, and restoring the water resources across the forest so that water quantity and quality are sustained for future use.

Water is considered an ecological resource and with it comes ecological characteristics, benefits, principles, concerns, and management strategies. Given that it is also a life sustaining necessity, water also takes on a social and economic multi-faceted component. The following discussion focuses on some of these components within the assessment area.

Social Concerns Regarding Water within the Assessment Area

Issues surrounding water have been at the forefront of the assessment area for centuries, even before the United States took ownership of this part of the country. Given what precious commodity water is, especially within the desert southwest where the Carson NF is located, the complexity of those issues continues to evolve as social pressures mount. The most prominent of these issues within the assessment area are described below.

Population Growth

Population growth creates an increase in the demand for water, putting pressure on water supply. Many of the regional water plans within the assessment area discuss concerns with meeting water demand as populations continue to increase. They also mention another issue in that water is already over appropriated (Colfax County 2004; Rio Arriba County 2008; Taos County 2004).

Drought

The State of New Mexico, and hence the assessment area, is currently experiencing a drought. Additionally, droughts are now expected to be more common with climate change. This creates a reduction in water supply, with no sign of a corresponding decrease in demand (US EPA 2014). If anything, regional plans expect demand to continue to increase (Colfax County 2004; Rio Arriba County 2008; Taos County 2004).

Threats to Water Quality

Threats to water quality can include both natural threats and human threats. Climate change and human damage to ecosystems are prominently addressed in management plans, restoration projects, and regional water plans, in hopes of protecting water quality within the assessment area.

Affects from People

Most of the human impacts on water are water withdrawals from both surface and groundwater sources, which deplete the water necessary for ecosystem health, which then further degrades water quantity and quality. Infrastructure, livestock grazing, land use, fire suppression, water diversions, water storage such as dams, and other human alterations in the assessment area also impact water sources and ecological health.

Aquatic Ecosystems in Chapter II (p. 134) further defines these and other risks to water. Given that water is a must-have for human survival, all of these risks can be considered social concerns regarding water within the Carson NF and the surrounding area it serves.

Acequias

Water allocation of delivery using acequias (constructed ditches) has a long standing history in New Mexico. These historic ditches have the same social importance today as they did when they were established as early as the 1700 and they continue to be a resource, bringing water to local communities for irrigation and other water needs. With over 800 acequias in the plan area, these constructed waterways are a significant part of the history and culture in and surrounding the Carson NF. Acequia associations have representation in the New Mexico State government, and are committed to ensuring the continued use of these historic ditches well into the future.

Many acequias are on NFS lands within the Carson NF. The forest maintains relationships with acequia associations through permits that allow non-routine maintenance of the ditches on NFS lands, such as realignment or reconstruction of the ditch (see Acequias, p. 342). Since acequias were grandfathered in when the Carson NF was established, routine maintenance does not require a permit. Given their historical significance, they have been granted special laws protecting their existence and use.

Outstanding National Resource Waters

Another example of the importance of water is the designation of the Outstanding National Resource Waters (ONRWs) within the State of New Mexico. These are specially designated waters within the state that are given the highest level of protection against degradation. These waters have exceptional recreational or ecological significance and are high quality waters that have not been significantly modified by human activities. The importance of these waters, both socially and ecologically, have warranted them special protections and designations.

On the Carson NF, the state has designated all of the waters within the wilderness areas, all waters in Valle Vidal, and the Rio Santa Barbara (in and out of wilderness) as ONRWs. The forest works within the requirements of this special designation, to maintain these waters at the highest quality possible. See Outstanding National Resource Waters in the Designated Areas section for more information.

State Water Plans

The State of New Mexico’s regional water plans depict the social complexities of managing and allocating water, while ensuring its availability for the near and long-term future. There are five regional state water plans that cover the assessment area. All of these plans address specific regional issues and concerns about water, water supply, future water demand, and how the region will meet that demand.

The five plans that cover the assessment area include the Taos, Rio Chama, Colfax, San Juan, and Mora-San Miguel-Guadalupe water plans (NM OSE/ISC 2014a). Each one of these plans speaks to the social context within it boarders. While they are unique in terms of population, water resources, uses, and cultures, they all provide strategic plans on how to supply, conserve, and protect water in their particular region. It is important to reiterate that the Carson NF plays a key role in water supply to these regional areas.

Economic Contributions of Water

Determining the economic value of water is often the topic of economic research studies, since the value of water is more than just a consideration of price. One could easily determine the dollar cost by multiplying cost per acre-feet by how many acre-feet come off the forest; however, this is only a determination of economic cost and does not determine economic value. In the assessment area, water provides value based on the social context it serves. Values such as cultural attachment to historic uses of water (such as for acequias), recreation, domestics use, agricultural uses, and the value of water rights provide just some examples of water value considerations. Unfortunately, this type of study has not been conducted for water supplied by the Carson NF, so these values are not known.

In addition to direct economic value of water, water from the Carson NF also makes indirect economic contributions to the assessment area. The forest provides economic benefits in a number of areas such as recreation/tourism (p. 345), livestock grazing (p. 346), and oil and gas development (p. 347), and limited timber (p. 346) contributions. Water is required in all of these areas of economic contribution. It is a major draw to recreation and tourism on the forest; livestock require water for survival; mining and oil and gas development use water in mineral extraction and drilling; and trees need water to live and grow to provide timber value, even if it is for firewood after they fall.

Summary

One of the most important resources on the Carson NF is water. This importance is evident, both ecologically and socially. Water is a key ecosystem resource as explained in Chapter II as well as a key component in the cultural development and settlement of the assessment area, in the past and still today. Aside from its historical cultural importance, water remains a prominent social issue, not only because of its requirement for life, but also because of concerns regarding degrading water quality and quantity from ecological pressures and increasing human impacts. These trends are expected to continue making water a social concern as supply is decreasing with no apparent relief in demand.

Wildlife, Fish, and Plants

The ability to fish, hunt, and gather plants is an integral part of the lives of people living in northern New Mexico. These activities contribute to economic, nutritional, and social benefits. The Carson NF comprises some of the most productive and important watersheds in the landscape of the southwestern United States, and is an important component for biological diversity. The forest is inhabited by over 1,000 taxa (species, subspecies, varieties) of vascular plants, hundreds of bryophytes species (mosses, hornworts, and liverworts), and hundreds of lichens and fungi species. There are also approximately 750 species of fish, wildlife, and invertebrates, which includes 27 fish species, approximately 45 amphibian and reptilian species, over 200 bird species, more than 90 mammal species, and over 400 invertebrate species (Arctos 2014; BISON-M 2014; Cartron 2010; Degenhardt et al. 1996; Larson 2008; Lee et al. 2006; NMDGF 2014a; Sublette et al. 1990).

The variety of vegetation, wildlife, and aquatic species present in the plan area provide the public with many opportunities for passive and spiritual recreation, such as nature watching, and active and direct recreation through fishing, hunting, and plant gathering. This section will discuss the current condition of hunting, fishing, wildlife viewing, and plant gathering in the plan area, and the Carson NF's contribution to these activities and its ability to sustain that contribution. This section identifies and evaluates:

- Ecosystem services of wildlife, fish, and plants
- Contributions of commonly enjoyed species to social and economic sustainability
- Current conditions, trends, and risks to wildlife, fish, and plants on the forest
- Impacts of hunting, fishing, and plant collection on ecological integrity and species diversity
- Summary of wildlife, fish, and plants as they relate to social, cultural, and economic resources of the assessment area

Wildlife, Fish, and Plant Ecosystem Services

Wildlife resources have long been directly used by Americans, providing substantial economic and nutritional benefits. Traditionally, views on wildlife resources were utilitarian and commodity-oriented, but values about wildlife have diversified over the past several decades. Transitions away from utilitarian views have been noted across the United States. Over the past several decades, there has been an increasing recognition of the broader ecosystem services provided by wildlife, including:

- **Supporting** ecosystem services of wildlife, fish, and plants deliver nutrient cycling and seed dispersal.
- **Provisioning** ecosystem services supply game meat, antler or bone.
- **Regulating** ecosystem services of wildlife, fish, and plants provide herbivory and pollination.
- **Cultural** ecosystem services of wildlife, fish, and plants offer recreation, cultural, or spiritual inspiration.

Contributions of Commonly Enjoyed Species to Social and Economic Sustainability

Wildlife, fish, and plants on the Carson NF contribute to social wellbeing and quality of life by promoting recreational and educational opportunities. The opportunity to hunt, fish, or just commune with nature is a very important tradition for many of the families and communities who live around the forest. Many families have been here for generations and these activities have become part of the social fabric in developing and growing family relationships. Many Native Americans rely on resources within the plan area for cultural and traditional uses (see Areas of Tribal Importance, p. 424).

Wildlife, fish, and plants in the plan area contribute to economic sustainability through employment opportunities, support of small businesses, and federal receipts shared with local governments. The 2011 National Survey of Fishing, Hunting, Wildlife-Associated Recreation found that 783,000 New Mexico residents and nonresidents fished, hunted, gathered plants, or nature watched in New Mexico that year (USDI FWS et al. 2011). Around 566,000 of the residents and non-residents participated in wildlife-watching activities, which include observing, feeding, photographing wildlife, and wildflower viewing. Many of these activities occurred in remote areas, requiring the use of horses and outfitting services (USDI FWS 2011). These participants contributed to economic sustainability in the plan area by spending approximately $881 million in 2011 (USDI FWS 2011).

The Carson NF plays a valuable role for game and fish management in New Mexico. The ability for visitors to hunt, fish, trap, and participate in wildlife viewing is very popular in the assessment area and a vital asset to the local economy.

In 2013, NMDGF commissioned a study of fishing, hunting, and trapping to estimate county-level and state-wide contribution to the state's economy (Southwick Associates 2014). The study found 247,600 New Mexico residents and nonresidents fished (160,000), hunted (86,000), or trapped (1,600) in New Mexico in 2013. Of these participants, 42 percent (103,710) fished, hunted, or trapped in the four counties encompassing the Carson NF (Table 90). These participants spent approximately $84,814,599 on these activities in these four counties (Table 90) (Southwick Associates 2014). In 2013, the effects of direct expenditures made by sportsmen who fish, hunt, and trap, along with the associated multiplier effects in the four county area supported more than 1,111 full- and part-time jobs, providing more than $29 million in labor income and adding $15 million in tax revenue (Table 91) (Southwick Associates 2014).

Table 90. Sportsmen participation and expenditures by county in each activity in 2013

County	Fishing (#)	Trapping (#)	Hunting (#)	Fishing ($)	Trapping ($)	Hunting ($)
Colfax	11,427	44	4,862	8,973,310	29,379	10,205,634
Mora	9,857	15	2,373	3,498,128	1,443	3,551,841
Rio Arriba	34,677	182	15,179	12,628,806	86,529	22,212,895
Taos	25,450	36	4,421	14,314,724	47,963	9,263,884

Table 91. Total number of jobs, income, and taxes generated by county from hunting, fishing, and trapping in 2013

County	Jobs	Income ($)	State & Federal Taxes ($)
Colfax	269	6,914,969	3,247,554
Mora	69	2,149,489	1,342,965
Rio Arriba	478	11,036,650	6,727,604
Taos	295	9,032,642	3,744,534

Social Concerns Regarding Hunting, Fishing, and Plant Gathering

The following are summary statements of key ecosystem and management landscape-level drivers and stressors that affect hunting, fishing, wildlife viewing, and plant gathering species and their habitats.

- Effects to stream flow, (through diversions and drought) and water temperatures.
- Effects to riparian areas by grazing, ditches, roads, timber harvest, and recreational activities.
- Excessive sediment yield into streams remain a widespread water-quality problem.
- Introduced aquatic species. Introduction of non-native fishes (primarily trout) has greatly altered aquatic ecosystems through impacts on native fish, amphibians, and invertebrate assemblages.
- Managing to prevent and control invasive weeds/species is important, as these species often move in and replace native species. Botanical diversity is also benefitted and flowers are more abundant when riparian and meadow ecosystems are managed to restore watershed function.
- Local degradation of habitats has led to impacts on aquatic invertebrates. Due to food chain relationships, impacts to aquatic invertebrates have significant cascading effects on other animals.
- Fire is a key landscape driver in how it contributes to ecological integrity, sustainability, and quality of wildlife habitats. One such concern is the long-term declining trend of early seral vegetation (e.g., forage habitat) from fire suppression and reduced tree harvest and thinning in some areas. Specific examples of declining habitat for deer and other species include past and current loss of meadow and shrub habitat as a result of tree encroachment.
- Vegetation and ecosystem management actions can affect the quality and connectivity of habitats.
- Climate change is a key landscape stressor affecting long-term ecological conditions, including habitats used by wildlife species. Confirmed temperature increases and declining snowpack, as well as potentially greater drought cycles will change habitats and influence wildlife species.

- The amount of human uses in or near species habitats, such as the amount of roads and their use, can affect the behavior and energy expended by hunted and non- hunted wildlife species.
- Hunting/fishing regulations and harvest affect species populations, as well as prey species used by some of those populations.
- The availability of floral diversity for the public to view and enjoy is maintained and enhanced by following many of the ecosystem management practices the Forest Service is striving to implement in accordance with the most recent science. Forested ecosystems with fire return intervals similar to what existed prior to European contact would theoretically maintain naturally abundant amounts of flowering herbs and shrubs. Timing of burning and other management activities is important for enhancing flowering herbs. Burning in the spring can affect the viability of native wildflower seeds, compared to burning later in the year when burns would have occurred naturally.
- Continued fire suppression, particularly when coupled with little or no prescribed burning, poses a threat to the sustainable production of plants in both quantity and quality. In the absence of fire or forest thinning, many of these species will decline in abundance and/or mature to a condition where the plant material is not suitable for traditional cultural uses.

Hunting

Wildlife species hunted on the Carson NF are broadly classified by NMDGF as: Big Game, Small Game, and Furbearers. The state agencies collect annual data for hunting and angling permits and harvest records (NMDGF 2013a), as well as providing some general population estimates for some species by state and regional areas. The Forest Service is responsible for managing NFS lands, including wildlife and aquatic species' habitats (FSM 2601.2 and FSM 2610.3). In contrast, the actual populations of wildlife and aquatic species (fish) on the Carson NF are managed by state agencies, specifically the NMDGF.

Game Management Units (GMUs) or zones have been established by NMDGF and encompass multiple land designations, including Forest Service, Bureau of Indian Affairs, BLM, State, private, and other government agency lands (NMDGF 2014a). Hunting regulations and population estimates are established by the state agencies. Hunting may not be authorized in some areas of GMUs, such as on private lands. It is also noted that when determining population estimates or observation by species that NMDFG does not collect this data for every species, in every hunt unit, or every year (Darr 2015; Quintana 2014).

Big Game

The Carson NF is divided into 9 GMUs in a variety of habitat types. Big game species utilize the Carson NF's habitat year-round. They migrate elevationally within the forest, depending on the season. The Carson NF administers about 35 percent of the land within GMUs 2, 5B, 45, 49, 50, 51, 52, 53, and 55A (Table 92).

Table 92. Big game hunting information for mule deer, elk, Rocky Mountain bighorn sheep, cougar, turkey, pronghorn, and black bear

Big Game Species	General Habitat Used	Game Unit/Zones (Herd Hunt Name)	Total Acres of Herd Unit	Total Carson NF Acres within Herd Unit
Mule deer (*Odocoileus hemionus*)	Early seral montane shrubland vegetation (oakbrush, sagebrush) and forested areas for fawning (aspen). Occupying higher elevations in the summer and low elevations in the winter.	2B	477,804	144,247
		2C	516,714	13,555
		5B	264,601	533
		45	973,899	135,475
		49	271,624	198,758
		50	590,047	103,211
		51A	508,939	461,764
		51B	125,790	41,415
		52	269,213	211,562
		53	437,822	174,725
Elk *(Cervus elaphus)*	Habitat generalist. Occupy higher elevations in summer and low elevations in winter.	2 (Jicarilla/San Juan Herd)	994,518	157,802
		5B, 50, 51,& 52 (Chama/San Antonio Herd)	1,758,590	818,485
		45 (Pecos Herd)	973,899	135,475
		49 (Peñasco Herd)	271,624	198,758
		53	437,822	174,725
		55 (Valle Vidal)	1,006 (609)	101,794
Rocky Mountain bighorn sheep *(Ovis canadensis canadensis)*	Visually open areas along steep cliff-faces at higher elevations in the summer and lower elevations in winter	45 (Pecos Herd)	135,475	135,475
		53 (Wheeler/Latir Herd)	174,725	174,725
Pronghorn antelope *(Antilocapra americana)*	Shortgrass plains and meadows below piñon-juniper woodlands	2	994,518	157,802
		50 & 52	859,260	314,773

Big Game Species	General Habitat Used	Game Unit/Zones (Herd Hunt Name)	Total Acres of Herd Unit	Total Carson NF Acres within Herd Unit
Wild turkey *(Meleagris gallopavo)*	Old growth pine with large trees for roosting	2, 5B, 45, 49, 51, 52, 53, & 55A	3,946,407	1,482,034
Cougar *(Puma concolor)*	Habitat generalist	A	994,518	157,802
		B	1,489,376	606,923
		C	1,683,345	508,958
		N	269,213	211,562
Black bear *(Ursus americanus)*	Habitat generalist usually located in forested areas.	1	1,168,543	715,274
		2	994,518	157,802
		3	1,299,493	476,694
		4	973,899	135,475
		5 (Valle Vidal)	1,466,606	101,794

Mule Deer

Mule deer use habitats on the Carson NF year-around. They migrate from higher elevations in the summer to lower elevations in the winter. They use a variety of different habitat types, but prefer open areas and patch edges with a higher preponderance of shrubs and forbs (BISON-M 2014). This species has been identified by NMDGF as a State Species of Greatest Conservation Need (NMDGF 2006b). They are predominately browsers and their diets consist of forbs (broad-leaf, non-woody plants) and browse (leaves and twigs of shrubs and trees) (NMDGF 2006b). Mule deer habitats are currently departed from historical habitat and under current management are predicted to become more so over time. Threats to mule deer habitat include habitat alteration caused by drought, fire suppression, woody species encroachment, invasive plant introduction, and/or insects and diseases (Heffelfinger et al. 2006).

Mule deer numbers have continued to decrease in New Mexico since 1986; There is no specific mule deer population trend estimates for the Carson NF, but it is assumed to be decreasing to stable (Darr 2015). From 2008 to 2011, deer observation in hunt units that contain the Carson NF was between 803 and 1,003; while between 2012 and 2013, deer observation was between 939 and 1,239 (Table 93, p. 416), with a harvest estimate of 1,548 for those years. Starting in 2006, all deer hunts on the Carson NF have been subject to a Public-Land Deer Draw Permit system and now NMDGF has adopted antler point restrictions, so only three point or better bucks are taken, further reducing hunting pressure on mule deer populations (NMDGF 2014a). Mule deer numbers in general have decreased over the past decade across the western United States. The early and mid-successional habitats preferred by mule deer are being lost, due to a lack of disturbance either from fire and/or mechanical (timber harvest) treatment (Heffelfinger et al. 2006).

Elk

Elk use a variety of different habitats on the Carson NF. They typically utilize higher elevation meadows and forest with grass understories (BISON-M 2014) in the summer and migrate to lower elevation piñon-juniper woodlands and sagebrush shrublands in the winter. Elk forage predominately on grass, but rely on denser areas of shrubs and trees for cover. Habitat conditions are being sustained for elk on the Carson NF, and current management is expected to continue to provide suitable habitat for elk.

Since 1986, elk numbers have increased in New Mexico and on the Carson NF (Quintana 2014). In 2002, the estimated elk population in GMUs containing the Carson NF was between 26,202 and 29,100 (NMDGF 2002).[1] The estimated elk population for the Carson GMUs surveyed in 2012 to 2013 was between 42,476 and 47,928 elk (Table 93, p. 416), with a harvest estimate of 7,797 for those years. The 2002 Elk Operation Plan sets the combined pre-hunt goal for the hunt units of the Carson NF at 24,500 elk (NMDGF 2002), but it is important to note this plan has not been updated recently. The New Mexico Game Commission has directed the NMDGF to decrease elk numbers across most of New Mexico and increase the number of permits offered. For GMUs on the Carson NF, an average of 14,781 public elk hunting permits was made available between 2012 and 2013, compared to 14,076 in 2010 and 2011. Forest management will likely increase elk habitat quality and forage availability, which should increase potential carrying capacity.

Rocky Mountain Bighorn Sheep

Rocky Mountain bighorn sheep inhabit open, steep mountainous habitat, either above timberline or in open canyons and slopes within forest and woodlands (NMDGF 2005). Bighorn sheep rely on keen vision to detect predators and rapid mobility on steep terrain as their principal predator evasion strategies. Bighorn sheep predominately eat forbs, followed by grasses, and lastly browse. Threats to bighorn sheep include recreation use, fences, poor range conditions, drought, fire suppression, wood species encroachment, and diseases (NMDGF 2005). Suitable habitat for bighorn sheep on the Carson NF is limited and is almost exclusively found in the alpine/tundra habitat of the Pecos, Wheeler Peak, and Latir Wildernesses. Habitat condition for bighorn sheep is being sustained on the Carson NF and current management direction is expected to continue to provide suitable habitat.

Bighorn sheep were successfully reintroduced to the Carson NF in 1966 (NMDGF 2005), and their numbers have steadily increased in New Mexico and on the Carson NF (Rominger 2015). Bighorn sheep numbers on the forest have remained stable since 2004, with several successful transplants from the Carson NF herds to other areas, on and off forest (NMDGF 2013b). In 2004, the estimated total bighorn sheep population for the Pecos, Latir, and Wheeler Peak herds was around 778. In 2014 the estimated bighorn population was between 610 and 705 (Table 93, p. 416), with a harvest estimate of 20 (Rominger 2015). Current management direction will likely continue to sustain bighorn sheep numbers and provide suitable bighorn habitat quality and forage availability.

Pronghorn

On the Carson NF, pronghorn are typically found in shortgrass plains and meadows below piñon-juniper woodlands, west of the Rio Grande. Pronghorn eat mostly forbs and weeds, with grasses a minor component of their diet (NMDGF 2007b). Threats to pronghorn include habitat alteration

[1] It is important to note that survey methods were not as accurate prior to 2008 (Quintana 2014).

caused by drought, fire suppression, woody species encroachment, invasive plant introduction, and fencing (NMDGF 2007b). Habitat conditions for pronghorn on the Carson NF are relatively stable and are expected to remain stable into the future.

The pronghorn populations in northern New Mexico and on the Carson NF are currently stable (NMDGF 2007b). In 2008 - 2011, the population estimate for pronghorn was between 957 and 1,069, while in 2012 and 2013, the population estimate was between 776 and 1,146 (Table 93, p. 416), with a harvest estimate of 108. Population numbers for pronghorn on the Carson NF are expected to remain stable, and current management direction will continue to provide suitable pronghorn habitat.

Wild Turkey

Wild turkeys are found throughout the Carson NF and are associated with a variety of different habitat types, including spruce-fir, mixed conifer, ponderosa pine, as well as piñon-juniper woodlands (BISON-M 2014). Ponderosa pine is identified as an important mast tree and favored roosting tree (BISON-M 2014). Habitats and populations are relatively stable and are expected to remain stable over the next 20 years. Annual populations often fluctuate, depending annual nesting success, and are therefore not being collected by NMDGF at this time.

Cougar

Cougars, also known as mountain lions, are found throughout the Carson NF. Cougars are a wide-ranging species and can be found in a variety of habitat types; however, they frequently use rough rocky terrain for denning sites (BISON-M 2014). Mule deer are reported as common prey for cougars in New Mexico (BISON-M 2014). Declining trends in mule deer populations discussed previously may have an effect on cougars. Overall cougar habitat conditions on the Carson NF are stable and are expected to remain stable.

Since 1986, cougar numbers have fluctuated in New Mexico and on the Carson NF, but are currently on the increase (NMDGF 2011). The NMDGF estimate the combined cougar population for the Carson NF's GMUs is presently between 788 and 1,058 (Table 93, p. 416). There were 29 cougars successfully harvested in 2014. Under current forest management, population numbers for cougar are expected to remain stable or increase into the future.

Black Bear

Black bear are common on the Carson NF and are typically found in nearly all forested habitat types (BISON-M 2014). They predominately feed on mid-seral fruit-producing shrubs, grasses and forbs (BISON-M 2014). Black bears have been identified by the NMDGF as a Species of Greatest Conservation Need. Threats to the species include habitat conversion/loss, drought, and human conflicts (NMDGF 2006b). Overall black bear habitat conditions on the Carson NF are stable and are expected to remain stable.

Currently the black bear population within the state and on the Carson NF is stable, but fluctuates depending on forage availability. In 2014, the estimated combined black bear population for the Carson NF's GMUs was between 2,855 and 3,355 (Table 93, p. 416), with a harvest estimate of 318. Under current forest management, population numbers for black bear are expected to remain stable or increase, depending on forage availability.

Table 93. Combined GMU population estimates (or observed=asterisk (*)) since 2004 and trend for each big game species

Big Game Species	Prior to 2004	2008-2011	2012-2013	2014	Population Trend[1]
Mule deer	N/A	808-1003*	939-1,239*	N/A	Decreasing to stable
Elk	26,200-29,100	34,185-45,275	42,476-47,928	N/A	Increasing
Rocky Mountain bighorn sheep	778	520-595	565-655	610-705	Stable to increasing
Pronghorn antelope	N/A	957-1,069	776-1,146	N/A	Stable
Cougar	N/A	N/A	N/A	788-1,058	Stable to increasing
Black bear	N/A	N/A	N/A	2,855-3,355	Stable

[1] Population trends are derived from State-wide population trend estimates and are not specifically for the Carson NF as this data was not available. It is also noted that when determining population estimates or observation by species that NMDFG does not collect this data for every species, in every hunt unit, or every year (Darr 2015; Quintana 2015).

Small Game Hunting

Small game hunting generally includes quail, grouse, migratory birds (mourning dove, waterfowl, and band-tailed pigeon), and tree squirrels (Table 94). Hunt units have been designated by NMDGF for some species, while other species are hunted throughout the state, with no designated hunt units. There are hunting regulations that restrict the daily and possession bag limit for each of these species (NMDGF 2014a).

Table 94. Upland game bird and small mammal hunt information

Upland and Small Game Species	General Habitat Use	Hunt Zone Area
Quail	Quail are generally found in shrubland areas where there is substantial groundcover.	Statewide Nov.15-Feb. 15 Bag Limit:15/day
Grouse	Grouse are found in the spruce-fir and mixed conifer forest habitat of the Carson NF.	GS-1 Sept. 1- Oct. 31 Bag Limit: 3/day
Migratory birds (doves and band-tailed pigeons)	Overall habitat generalist	North Hunt Zone Season and bag limit varies per species
Migratory birds (waterfowl)	Rivers, lakes, and streams.	Central Flyway North Zone Season and bag limit varies per species
Tree squirrels	Squirrels are found in all forested habitat of the forest	GS-1 Sept. 1- Oct. 31 Bag Limit: 8/day

Overall, small game habitat conditions on the Carson NF are stable and expected to remain stable. Threats to the quality of habitat for foraging or nesting of small game include woody species encroachment, the potential for uncharacteristic wildfires (see Terrestrial Vegetation, p. 34), and a potential increase in invasive plant species. Small game populations in the counties around the plan area appear healthy. Population levels do fluctuate drastically from year to year, depending on moisture availability (Frey 2006; NMPIF 2012; Sanders 2014; Seamans et al. 2013; USDI FWS 2014c). For the 2013 hunting season, over 99,000 licenses were sold for small game hunting, generating an income of over $1 million for the State of New Mexico (NMDGF 2013c).

Furbearer

Furbearer hunting is generally the trapping of raccoon, badger, weasel, fox, ringtail, bobcat, muskrat, and beaver (NMDGF 2014a). There are no hunt units established for furbearer, but there are hunting regulations that restrict hunting season for each of these species (Table 95).

Table 95. Furbearer hunting information

Furbearers	General Habitat Use	Hunt Zone Area
Raccoon	Overall habitat generalist	Statewide April 1- May 15 and Sept. 1-March 31 Bag Limit: No bag limit
Bobcat, weasel, and badger	Overall habitat generalist	Statewide Nov. 1- March 15 Bag Limit: No bag limit
Ringtail	Rocky habitat and sheer cliff	Statewide Nov. 1- March 15 Bag Limit: No bag limit
Fox	Open woodlands and shrublands	Statewide Nov. 1- March 15 Bag Limit: No bag limit
Beaver and muskrat	Lakes, streams, and rivers	Statewide April 1-30 and Nov. 1-March 31

Overall, furbearer habitat conditions on the Carson NF are stable and expected to remain stable. Threats to the quality of habitat for foraging or hiding cover for furbearers include woody species encroachment, the potential for uncharacteristic wildfires (see Terrestrial Vegetation, p. 34), and increased invasive plant species. In the counties of the Carson NF, furbearer populations appear healthy and stable (NMDGF 2007a). For the 2013 hunting season, over 1,600 furbearer licenses were sold in the State of New Mexico, an 45 percent increase over the number of licenses sold in 2011(NMDGF 2013c).

Angling

The clear, cold waters that flow through the Carson NF are prime habitat for coldwater salmonid fish. Most of these fish have been introduced into these waters to provide quality fishing experiences. The forest offers suitable habitat for non-native trout species (rainbow, brook, and brown trout) and Rio Grande cutthroat trout (native trout). Many of the high elevation lakes and streams on the forest offer angling opportunities. The Carson NF includes approximately 1,044 miles of perennial streams, and approximately 13,890 acres of lakes and ponds. The majority are open to angling during the open fishing season.

The headwaters for most streams and lakes are located in remote, high elevation wilderness areas, resulting in minimal impacts to water quality. There are few pollutant input sources, such as municipal sources, drainage ways, concentrated livestock industries, manufacturing effluent, etc. Impacts to the water sources do occur in the lower elevation habitats from dams, water diversions, and development, but the water quality is still favorable for growing these introduced fish (see Aquatic Ecosystems, p. 134 and Water Quality, p. 143 sections).

Current management of the majority of fishable waters in the Carson NF is predominately a "Put-and-Take" fishery, where streams and lakes are stocked on a regular basis to augment constant depletion of fish from high volume fishing demands (NMDGF 2009). Streams and lakes are stocked with hatchery-raised rainbow, brown, and Rio Grande cutthroat trout (RGCT). The stocking program allows for the persistence of these species throughout the plan area, and provides angling opportunities (NMDGF 2009). Natural spawning does occur in some streams and lakes, which precludes the need for stocking, especially if the waterbody is not fished above its recruiting potential.

Rio Grande cutthroat trout, the only native trout on the Carson NF, is managed by NMDGF separately from other sport fishery fish, with intent to provide angling opportunities and conservation for this fish. Some Rio Grande cutthroat trout waters are designated as "Special Trout Waters", with angling restrictions. The special designated waters are important refugia and restoration brood stock for RGCT (Alves et al. 2008). The Carson NF administers over 30 miles of "Special Trout Waters", most in Valle Vidal. Currently, there is 136 miles of pure Rio Grande cutthroat streams on the Carson NF. Rio Grande cutthroat trout is found in other streams with non-native trout, but are usually introgressed with rainbow trout or are in low number due to competition with rainbow and brown trout (see Aquatic Biota, Fish Species, p. 177). Introduced species are frequently cited as the most important threat to native aquatic biodiversity in North America, following habitat degradation and loss (Jelks et al. 2008; Wilcove et al. 1998).

The Carson NF is stocked by three state fish hatcheries: Los Ojos, Red River, and Seven Springs. These hatcheries stock the streams and lakes on the forest with "Catchable" (9-inch or longer) or fingerling rainbow and Rio Grande cutthroat trout. These hatcheries produce over 2 million fish per year for the State of New Mexico (NMDGF 2009), and have stocked the Carson NF with approximately 2,383,881 fish, since 2004 (Gallegos 2015). While the creation of nonnative fisheries may support local economies in some areas, annual losses due to introduced fishes are estimated at $5.4 billion (Pimentel et al. 2005).

For the 2013 license year, there were a total of 81,432 angling licenses sold in the counties surrounding the Carson NF (Table 96). Seventy-five percent were sold to residents of New Mexico, and the remaining 25 percent were sold to nonresidents (Southwick Associates 2014). Under current management direction, the ability to sustain angling use remains high. Fishing is recognized as an important economic factor for the local communities, and the Carson NF will continue to provide habitat for fish. Recovery efforts for the native RGCT could lead to reductions in the ability to fish for non-native trout species in some waters, but would increase angling opportunities for the RGCT and other native fish species over time as the population increases.

Table 96. Resident and nonresident angling licenses sales by county overlapping the Carson National Forest

County	Resident Total Licenses Sold	Nonresident Total Licenses Sold	Total Licenses Sold
Colfax	8,577	2,851	11,428
Mora	7,398	2,459	9,857
Rio Arriba	26,041	8,656	34,697
Taos	19,101	6,349	25,450
Total for all Counties	61,117	20,315	81,432

Habitat Stamp Program Wildlife Enhancement Projects

The Sikes Act is a federal law that permits state wildlife agencies to require hunters, anglers, and trappers using Forest Service or BLM lands to purchase a “stamp”, in addition to the normal hunting/trapping/fishing license. Funds collected from these habitat stamps are then redirected to the federal land management agencies and used to construct and maintain habitat improvement projects. Projects are reviewed and prioritized by a Citizen Advisory Committee and are often constructed by volunteers. A number of such projects are located on the Carson NF, including rainwater catchment tanks and drinkers, habitat improvement (e.g., manual thinning or prescribed burning and fence installation to protect sensitive wildlife areas from livestock), and installation of informational signs. The Carson NF receives on average $108,000 per year to spend on wildlife habitat improvement projects (Cortez 2015). Habitat Stamp improvement projects on the Carson NF address habitat limiting factors such as forage and water availability for huntable species. Other projects improve habitat for fish through native fish reintroduction and provide more fishing opportunities for anglers.

Wildlife Viewing and Commonly-Used Plants Species

Bird Watching

With its varied habitat and elevations, the Carson NF is a bird watcher’s paradise. The Audubon Society recognizes areas with unique habitat (i.e., communal nesting areas) or importance (i.e., breeding habitat or flyways for migration) as Important Bird Areas (IBAs). These sites provide essential habitat for one or more species of birds for breeding, wintering, or migrating. IBAs range from a few acres to thousands of acres, and may include public and/or private lands. There are 62 identified IBAs in New Mexico spanning four Bird Conservation Regions: Sierra Madre Occidental, Chihuahuan Desert, Southern Rocky Mountains, and Shortgrass Prairie. These IBAs are used by 375 species on a regular basis (the state has recorded 516 species). Another 140 species are irregular in occurrence or migrants (NM Audubon 2014).

The Upper Rio Grande Gorge, on the Questa RD, is currently the one designated IBA that overlaps portions of the Carson NF. The Upper Rio Grande Gorge features a gorge that ranges 200 to 2600 feet wide and 300 to 800 feet deep, and is carved into the basalt lava flows connected to vast shrub and grass covered, rolling mesas (NM Audubon 2014).

Other Birding Opportunities on the Carson NF include three areas listed on Audubon’s North Central New Mexico Birding Trail (NM Audubon 2014):

- **Taos Canyon** visitors might see grosbeaks, mountain chickadees, Western tanagers, jays, nuthatches, vireos, sparrows, and warblers
- The willows and firs in the **Taos Ski Valley Basin** contain Swainson’s thrush; MacGillivray's, Wilson's and orange crowned warblers; Lincoln's sparrow; Cordilleran flycatcher; warbling vireo; and black-headed grosbeak. Winter visitors may see the gray-crowned, black, and brown-capped rosy finches.
- Visitors to the **NM 518 Marshes** may see yellow warblers, yellow-breasted chats, goldfinches, and willow flycatcher.

Plant Species Commonly Used on the Carson National Forest

For generations, people have been harvesting and utilizing plant species on and around the Carson NF. Whether they were for subsistence, medicinal, or ceremonial purposes, these traditional uses continue to be part of the culture of communities surrounding the Carson NF. Some of these include:

Piñon nuts: Piñon nuts or seeds continue to be a key dietary staple for people of the Southwest. They are available both in grocery stores and at road-side stands, but many locals still harvest their own from the Carson NF. The New Mexico piñon pine tree is a source of pride for many in the state. The New Mexico State legislature passed the Piñon Nut Act in 1978, requiring labeling standards and instituting genetic research for piñon trees in the state.

The collection and sale of piñon nuts are particularly important to many Tribes, especially the Picuris Pueblo, Taos Pueblo, and Jicarilla Apaches, whose lands border the Carson NF. The public may gather piñon nuts for personal use without a permit. Those interested in harvesting for commercial use (harvest of more than 25 pounds of nuts) must get a permit from the Forest Service. Harvests over the last few years have been low, because piñon nuts take approximately two years to mature on the tree and are highly susceptible to drought. Die-off of piñon pines from piñon *Ips* beetle in New Mexico forests has further decreased seed production.

Wildflowers and other botanical sight-seeing: Valle Vidal is the most popular and convenient destination for wildflower viewing, as well as viewing other botanical sites (USDA FS Carson NF 2005). However, phenomenal wildflower viewing areas are found throughout the Carson NF, usually beginning in late-May and early-June.

Plants gathered for medicinal and ceremonial use: Within the Carson NF, there is an active community of people who routinely seek and collect plants for medicinal use. The local herb stores lead yearly “herb walks” on the Carson NF for the purpose of identifying medicinal plants. Tribal members also gather a variety of plant materials for traditional and ceremonial uses including fuel wood, mushrooms, and herbs.

Habitat for rare, endangered, threatened, and narrow endemic plant species: The Carson NF provides the only suitable areas, in terms of altitude, aspect, slope, and soils, for some narrow endemic or rare plant species. Development and habitat conversion on private lands adjacent to and within the plan area emphasize the importance of the Carson NF's role in maintaining habitat for special plants species that may not occur elsewhere.

Summary of Conditions, Trends, and Risks to Wildlife and Fish

Current conditions and trends for wildlife, fish, and plants are summarized above by topic area. Ecosystem services related to wildlife and fish are at risk because the supporting, regulating, provisioning, and cultural ecosystem services of vegetation (wildlife habitat) are at risk (see Summary of Terrestrial Ecological Integrity, p. 99; Summary of Riparian Ecological Integrity, p. 133; and Summary of Aquatic Ecological Integrity, p. 193).

Impacts of Hunting, Fishing, and Plant Collection on Ecological Integrity and Species Diversity

Hunting and trapping are used to maintain the carrying capacity of game and furbearer species. Managed hunting and trapping serve as a method to control species population numbers, which has a beneficial impact on habitat and species diversity. Overpopulation of species can lead to terrestrial and riparian vegetation degradation, overutilization of forage, and can potentially make animals more susceptible to disease causing massive die-offs. The NMDGF works with the Carson NF to understand habitat conditions, when establishing the numbers for hunting and trapping permits.

While many hunters and trappers are good stewards of the land, adverse impacts associated with hunting and trapping do occur. They include unauthorized user-created roads, trails, and camping, which can lead to increased erosion and sedimentation in streams, habitat degradation, and habitat fragmentation.

Streams and rivers closest to population centers and easily assessable are the most heavily used by anglers and receive enough foot traffic to create trails along streambanks. The density of use has resulted in stream bank degradation in some areas, which contributes additional sediment into the stream. Hybridization, depredation, and competition from stocking non-native fish for sport fishing or by accident through bait bucket transport have contributed to diversity and distribution declines in native fish species. The continued stocking of non-native fish is very important for supporting sport fishing, but limits opportunity for the reintroduction of native fish species. The introduction of non-native fish also contributes to changes in the aquatic ecosystem. The increased competition from some species can affect native macroinvertebrate and plant species. Anglers have also been responsible for the spread of aquatic diseases and invasive species into lake and streams by not thoroughly cleaning fishing equipment after each use. See Aquatic Biota section (p. 176) for more information.

Summary

Game animals for hunting are prevalent on the forest and most demonstrate increasing or stable populations. Habitat conditions for mule deer are departed from historic conditions. Habitat for many game species (mule deer, black bear, bighorn sheep, pronghorn, small game species, and furbearers) faces threat from woody species encroachment, uncharacteristic wildfire, drought, and invasive plant species. Habitat for these species on the Carson NF will become more important as land outside the forest becomes more developed.

The Carson NF and other surrounding lands continue to be important for hunting and sport fishing. Native trout need active management to continue to thrive. The ability to harvest plants, herbs, and other flora for traditional and cultural uses may be limited, if departed terrestrial and riparian ecosystems are not restored.

Social, Cultural and Economic Contributions of Other National Forest Resource Areas

In addition to multiple uses, the Forest Service also administers other programs related to forest management. These include historic and cultural areas, specially designated areas, infrastructure, and land status. Some of these are stand-alone resource areas; however, most also support the services that multiple uses offer. Like the multiple uses, each of these resource areas provides social and economic benefits, which will be discussed in this section.

Areas of Tribal Importance

This section discusses the unique relationship the U.S. Government and the Forest Service have with federally recognized tribes. The Forest Service recognizes specific trust in its relationship with the tribes and administers the forest with these responsibilities in mind. Access to the Carson NF for spiritual, cultural, and traditional uses is an essential part of tribal traditional way of life. Tribes today have many of the same concerns as the Carson NF, such as forest health and climate change. These and other issues will be discussed in this section, to understand the shared forest management concerns the Carson NF and the Tribes face in continuing tribal way of life.

Ecosystem Services of Areas of Tribal Importance

The Carson NF provides many ecosystem services from its lands that are important to tribes. Among them are:

- **Supporting** ecosystem services provide tribes with plants that are gathered for food, medicine, rituals, and plant pigments. Stone and minerals are used for tools and agriculture.
- **Regulating** ecosystem services produce climate regulation, water purification, and flood regulation.
- **Provisioning** ecosystem services supply tribes with game and fish for sustenance, fresh water for drinking, and wood and fiber for heating, cooking and construction.
- **Cultural** ecosystem services are in the form of opportunities for religious pilgrimages to place offerings at sacred sites and visits to shrines and springs.

Indian Tribes Associated with the Assessment Area

Currently, the Carson NF consults with 16 federally recognized tribes located in New Mexico, Arizona, Colorado and Oklahoma on all proposed projects, plans, programs, policy development and forest activities. They include:

Comanche Tribe of Oklahoma	Pueblo of Jemez
The Hopi Tribe	Pueblo of Nambe
Jicarilla Apache Nation	Pueblo of Picuris
The Navajo Nation (Diné)	Pueblo of Pojoaque
Ohkay Owingeh	Pueblo of San Ildefonso

Pueblo of Santa Clara

Pueblo of Taos

Pueblo of Tesuque

Pueblo of Zuni

Southern Ute Indian Tribe

Ute Mountain Ute Tribe

These tribes have consistently communicated interests in the natural and cultural resources and management of the assessment area. They recognize the lands managed by the Carson NF as part of their aboriginal or traditional use areas, and they still use these lands and resources for traditional, cultural, and ceremonial activities. Of the 16 Tribes with interests on the Carson NF, only Taos and Picurís pueblos, the Jicarilla Apache Nation, and the Southern Ute Indian Tribe share common boundaries with the forest.

Existing Tribal Rights

None of the 16 Tribes with interest in the assessment area have reserved treaty rights on the Carson NF. However, the U.S. government has identified specific trust responsibilities, based on the unique relationship it has with federally recognized Indian Tribes defined by history, treaties, statutes and court decisions. The federal trust responsibility is summarized by Pevar (2004: p. 33):

> *Broadly, the trust doctrine requires the federal government to support and encourage tribal self-government and economic prosperity, duties that stem from the government's treaty guarantees to 'protect' Indian tribes and respect their sovereignty. In 1977, a Senate report expressed this obligation as follows:*
>
> *The purpose behind the trust doctrine is and always has been to ensure the survival and welfare of Indian tribes and people. This includes an obligation to provide those services required to protect and enhance Indian lands, resources, and self-government, and also includes those economic and social programs which are necessary to raise the standard of living and social well-being of the Indian people to a level comparable to the non-Indian society.*
>
> *Under this broad approach, the federal government's trust duty 'is owed to all Indian tribes', including those that did not enter into treaties with the United States. The trust doctrine "transcends specific treaty promises and embodies a clear duty to protect the native land base and the ability of tribes to continue their ways of life.*

The Forest Service's trust responsibilities are defined primarily by the authorities listed in Forest Service Manual part 1563.03-Policy.[1] The agency's current policy focuses on fourteen key points:

- Maintain government-to-government relationship with federally recognized tribes.
- Ensure that Forest Service employees are familiar with the rights and interests of Tribes, as defined by the Constitution, treaties, statutes, executive orders, and judicial rulings, through training and other efforts.

[1] At this time, Forest Service Manual 1563 and Handbook 1509.03 are under draft revision.

- Implement Forest Service programs and activities consistent with and respecting Indian treaty rights, and fulfilling the federal government's legally mandated trust responsibility with Tribes.
- Manage Forest Service administered lands and resources on which tribal treaty rights exist in coordination with Tribes.
- Coordinate Forest Service land and resource management plans and actions with tribal land and resource management plans and actions to promote the health of ecosystems.
- Administer programs and activities in a manner that is sensitive to traditional American Indian and Alaska Native spiritual beliefs and practices, and assist tribal members in securing ceremonial and medicinal plants, animals, and the use of geographic places, consistent with federal policy under the American Indian Religious Freedom Act and Executive Order 13007 (FSM 1563.01e).
- Protect the confidentiality of tribal information (including information regarding repatriation and reburials) received by Tribes to the extent practicable under the law.
- Assist American Indian and Alaska Native Tribal Governments by providing technical, educational, financial, and other information, and establish information exchanges where mutually agreed to and authorized by law.
- Work to reduce or remove legal or administrative program impediments that inhibit the agency's and Tribe's capacity to work directly and effectively with each other.
- Consult with Tribes on matters that may affect tribal rights and interests, utilizing the principles of compliance, collaboration, timely response, and coordination.
- Ensure that the repatriation of Native American human remains and associated funerary objects, unassociated funerary objects, sacred objects, and objects of cultural patrimony is consistent with the requirements of the Native American Graves Protection and Repatriation Act.
- Support, where appropriate, request(s) for reburial of human remains and cultural items on Forest Service-administered lands received from Indian tribes or lineal descendants. Document and provide explanation to the affected Indian Tribe or lineal descendent for any request(s) that are denied.
- Uphold confidentiality of reburial locations and associated documentation relating to human remains or cultural items reburied on National Forest System land.
- Support reburial of American Indian and Alaska Native human remains and funerary objects on Forest Service administered lands. Consider burial requests for specific locations and provide explanation for requests that are denied.

The Carson NF carries out its trust responsibilities under a variety of authorities. Perhaps the single most import piece of legislation providing for Native American access to NFS lands and forest products, as well as related authorities, is the Farm Bill 2008, Forestry Title VIII, Subtitle B (Sections 8101-8107). The bill specifically addresses:

1. Reburials of human remains and cultural items on National Forest System lands (Section 8103).
2. Temporary closure for traditional and cultural purposes (Section 8104).
3. Providing forest products free of charge for traditional and cultural purposes (Section 8105).
4. A prohibition on disclosure of information pertaining to reburials, sites, or resources of traditional and cultural importance (Section 8106).
5. Protection of all outstanding rights to use NFS land or other public land (Section 8107).

Since the passage of the 2008 Farm Bill, the Carson NF has made a concerted effort to inform each of the Tribes about the authorities specified in the bill. Several of the Tribes have taken advantage of the bill to acquire logs for the reconstruction of their pueblos, a mix of fire wood (piñon, juniper, and ponderosa pine), as well as pitch wood (ocóte) for use in ceremonies, various types of boughs (aspen, fir, spruce, and pines), and clay for pottery and ceremonies.

Areas of Known Tribal Importance Affected by Management of the Assessment Area

Much if not all of the lands managed by the Carson NF have been utilized by Native American people since time immemorial, and are still used today for an assortment of traditional, cultural and ceremonial activities. For countless generations, the Tribes have been hunting and gathering in the forest, collecting wood, medicinal, and food plants, fish, animals and birds for meat, skins and feathers, clay, pigments and other mineral resources, as well as visiting sacred places, springs and shrines for ceremonial practices.

Many of the tribes have traditional cultural properties (TCPs) on the Carson NF, but they are extremely reluctant to share the location of these special places. A TCP is a cultural resource associated with cultural practices or beliefs of a living community that are rooted in the community’s history, and are important in maintaining the continuing cultural identity of tribal people. These TCPs can be places significant in traditional stories, that is “named” locations provide the structural components of Native American world view and sense of place, or localities where specific resources are gathered, archaeological sites that are the homes of ancestors, and topographical and or geological features that “center” the communities in their world. Although the tribes with interests in the assessment area may provide general, non-specific information about the location of these significant places, they rarely if ever share specifics about the “what” or “why” of these localities. Several of the Tribes the Forest Service consults with have stated their concerns for the disclosure of any locational data, as that kind of information can become public knowledge and non-tribal people can intrude and or desecrate sacred areas or collect and even sell plants, minerals, clay, or other resources of profound importance to the tribes.

Currently, only a few TCPs or Sacred Places have been identified by tribal members on the Carson NF, and this information is held in the strictest confidence by heritage staff. The tribes generally prefer not to have their TCPs nominated to the National Register, as they fear the availability of anything entered into the National Register to the general public.

Individual tribal members depend on an array of forest products for personal, ceremonial, and commercial use. For example, many types of clay suitable for pottery are gathered at various locations on the east and west sides of the Carson NF and are transformed by tribal potters into utilitarian vessels and art objects for use within the homes, in ceremonies, or for sale to galleries and private individuals. Other forest products can include, but are not limited to, cota (Indian tea), chokecherries, piñon nuts, cactus, Osha root, wild onions, varieties of grasses, yucca, and willow stems for basketry and a large variety of wood products for heating, ceremonies, construction, and crafts.

Conditions and Trends of Resources that Affect Areas of Tribal Importance and Rights

Geographical, topological, and geological features on the landscape are integral to understanding the history and cultural identity of Native American groups in the Southwest. Vine Deloria Jr. (1994) describes Native American conceptions of history as being geographical rather than chronological, how spatial connections and sense of place are more important for understanding cultural identity than a chronological sequence of events. In this conception of history, stories are linked with the naming of specific places on the landscape. Because of their permanence as geological or topological features, these places are used to recount ancient narratives and traditions and thus become a way of linking the present to the past (Ball 2000). For the Native American tribes that claim affiliation and interests with the Carson NF, there are countless "sacred places" within the plan area that are intimately linked through oral histories and traditional knowledge that connect them to their sacred homeland in the Southwest. Many of the Native American groups associated with the plan area trace their ancestral roots to the American Southwest or areas immediately adjacent, even though origin stories are diverse and varied amongst the different groups.

These creation stories shape the world views that are essential to how these native cultures define their roles and relationships in and with the rest of the living world, viewed as "all my relations." The concept of reciprocal obligation is crucial to how Tribal people survive in their world: for example, when men go hunting they pray for the animal's spirit and give blessings to insure the continuation of the animals kind; or, when women gather clay to make their "potteries" they always thank Mother Earth for the gift of her flesh through prayers, and by leaving food, tobacco or pollen in exchange for the clay. All activities and interactions between "human beings" or "the People"—the terms by which most Tribal groups identify themselves in their own languages—and their world are accompanied by prayers and offerings: reciprocal obligation. These stories are at the heart of an ancient dynamic ecologically sustainable contract and engagement between the People and the natural world.

Native Americans face many challenges within the landscape which conflict with and impact their traditional values and beliefs. Some of the current condition and trends of forest resources impacting tribes include changes in land ownership, the development of private lands, expanding recreation use, changing technologies, energy development, degradation of forest health and watershed conditions, and climate change.

Change in Land Ownership and Access to Land and Resources

Tribal access to and use of the lands and resources now managed by the Carson NF, as well as the general landscape, have been markedly altered over time from a number of factors. Prior to the arrival of Europeans, resources on the land were available to tribes, and they had unrestrained access to these lands for hunting, acquiring construction material, gathering firewood, and collecting resources for food, clothing, medicine, and ceremony. There were often well-established travel routes between communities and prescribed routes to specific locations of tribal importance. As the Spanish, Mexicans, and later the Americans moved into the area, the institution of identifiable bounded private land ownership became increasingly important, a concept that was completely alien to the Native Americans' world view. Privatization and land grants of once open lands diminished the original land base, especially of the Pueblos, depriving them of entry to many of their sacred places and traditional use areas. Access to and use of resources continued to change with the establishment of the National Forest System, in the early 20th century, and the gradual evolution of environmental policy, resulting in the passage of federal laws and regulations and greater federal oversight.

There have been no known restrictions of tribal access to significant locations on the Carson NF since the current forest plan was implemented in 1986. Since then, the sales of private lands around the forest have increased and the potential exists that new owners could restrict access onto NFS lands. The Carson NF continually works with and consults with tribes to preserve access and provide privacy of significant sites. While the Forest Service has the ability under a variety of authorities to assure tribes access to sacred places on NFS lands and to allow tribes to conduct cultural activities in privacy; currently, only one tribe has exercised its rights on the Carson NF by utilizing provisions of authorities specified in the 2008 Farm Bill (specifically Section 8014), to request a temporary closure order to conduct traditional activities in privacy.

Expanding Recreation Use

Recreational use of the Carson NF has seen a marked rise for the last 40 to 50 years. The increase in certain types of activities is reflective of the rising interest in mechanized outdoor recreation, the country's aging population, and greater urbanization of our society. Some of the most popular activities involve day use, such as picnicking, hiking, and trail riding (i.e., riding bicycles and motorized two- and four-wheeled vehicles); extended multi-day backpacking into wilderness areas; driving for pleasure and scenic beauty; wildlife viewing; as well as seasonal hunting and fishing. The forest's high elevation alpine environment draws visitors from several states (e.g., New Mexico, Texas, Oklahoma, and Louisiana) to escape from the heat during the summer and for the snow sport opportunities in the winter (USDA FS 2009a). Additionally the forest is part of the headwaters of the upper Rio Grande and for many lakes and streams. The availability of water is a big draw for visitors coming to the forest.

Most developed recreation facilities are located to take advantage of water features. However, dispersed recreation is equally popular and may impact areas that are of cultural or ceremonial significance to tribes with interests on the forest. On the Carson NF, the designated road and trail system is designated such that motorized recreation avoids cultural sites, identified traditional use areas, and sacred places. Although off-road and off-trail riding is restricted through the Carson NF's Travel Management Plan, there are violations of the rule that may cause damage to cultural resources and sacred places.

Changing Energy Development and Technology

As a multiple use agency, the Forest Service permits a wide variety of activities on NFS lands. Activities such as mineral, oil, and gas exploration and extraction, the construction of transmission or utility corridors; and the development of communication sites have affected, and continue to affect areas of tribal importance.

Several tribal groups have expressed concerns related to the increased drilling and development of infrastructure for natural gas extraction on the Jicarilla RD, despite the Carson NF's concerted efforts and consultation with tribes and the New Mexico Historic Preservation Office, to avoid and protect cultural resources, while authorizing natural gas wells and associated roads and pipelines. Like much of the San Juan Basin, the Navajo, Tewa, Hopi, and Zuni people view the area as ancestral homelands, and they have voiced, albeit only informally, that the continued development is having an adverse effect on the area and the archaeological sites as defined in 36 CFR 800.5a (2)(v) - Introduction of visual, atmospheric or audible elements that diminish the integrity of the property's significant historic features.

In recent years, there has been a greater emphasis on alternative forms of energy development, such as wind, solar, and nuclear power. While many tribes support the development and use of wind and solar power, there is also recognition that these types of energy developments result in a large footprint on the landscape, and often impact the viewshed. However, there are currently no formal plans to for any of these types of power installations on the Carson NF, but they may be brought forward in the near future.

Changes in telecommunication technology over the past century have resulted in a proliferation of communication sites on the forest, most located on high points such as mountain tops. These constructed features are a mixed blessing for the tribal communities. While communication sites make certain technologies readily available to all, they are perceived to cause impacts on the landscape, on wildlife, and tribal traditional use of the land. For example, radio communication sites contain towers that can be seen for great distances, and if taller than 200 feet, will be lit at night per FAA requirements. Tribes that have expressed their opposition to the development of new communication sites have encouraged colocation of users to the maximum extent feasible. Tribes have articulated concern that installation and build-out of such sites will exacerbate visual, audible, and atmospheric interference, further disrupting and displacing prescribed traditional activities that may take place in the high mountain locations.

Places of tribal importance have an integral relationship with a tribe's beliefs and traditional cultural practices, and are viewed as critical to the maintenance of a tribe's cultural identity and transmittal of their beliefs and practices. Practitioners sometimes engage in certain traditional activities that can only be conducted in a specific place. Tribes have voiced concern that as development continues in areas of tribal importance, it forces these individuals to alter their cultural activities, and in time, is seen as a cumulative impact to their cultural activities. Development does not always stop the cultural activities and practices, but is perceived to downgrade the traditional practices and diminish their value.

Large and intrusive development has the potential to affect the integrity of a tribe's relationship with an area of traditional and cultural significance, and risks the disruption and/or alteration of traditional cultural activities that are critical to the continuity of cultural beliefs and practices of these tribes. In the view of the tribes, impacts to a traditional practitioner's ability to conduct traditional cultural activities in the area will render the overall effectiveness of medicine and healing ceremonies less effective.

Forest Health and Watershed Conditions

A few tribal members that rely on the forest to collect plant resources for personal and or ceremonial uses have noted some plant species are more difficult to find than they were in the past. For example, one tribal elder said that wild tobacco appeared to becoming scarce. Some of the problem is due to the general degradation of watershed conditions and forest health of the Carson NF, where tribal members may go to gather the plants. There are a number of factors that have led to the current condition. Broadly speaking, historic agency fire suppression policies, timber harvesting and logging practices, livestock grazing, localized mining practices, and continued natural gas extraction have all contributed to the compromised watersheds and forest ecosystems that the Carson NF experiences today. Much of this occurred during a period when the demand for huge numbers of board-feet of lumber output was a top agency priority, in response to the social and economic mandates of the time. Ground-disturbing permitted activities and dispersed recreation have also contributed to the disturbance and degradation of many locations on the forest.

Forest Service management directly affects the ecology of four tribes with adjacent lands to the forest - the Taos and Picuris Pueblos, the Jicarilla Apache Nation, and the Southern Ute Tribe. Watersheds on the forest contribute to the primary water resources of tribal lands adjacent to the NFS Lands. Other Pueblos not adjacent to the forest rely upon watersheds that flow into the Rio Grande and Rio Chama. Uncharacteristic wildfire has the potential to destroy adjacent tribal lands and affect all 16 tribes who use these lands and resources for traditional, cultural, and ceremonial activities.

Many of the tribes who use the forest have taken a greater interest in the protections of ecological resources on tribal lands and adjacent lands. The Taos Pueblo are an active partner in the current project to protect the Rio Grande watershed. The Taos Pueblo are currently rewriting the land management plan for their tribal lands. The Carson NF is coordinating and will share and provide information from the forest's planning effort to assist the Taos Pueblo. In addition, the Carson NF is working with the Picuris Pueblo to share GIS data to support their ecological planning efforts. The Tribal Forest Protection Act provides funding for tribes to do forest and watershed restoration on adjacent lands that can influence and affect the ecology of tribal lands.

Climate Change

Regardless of the causes, climate change is beginning to have distressing impacts on the forests of the Southwest. Increased drought, beetle-kill, and uncharacteristic wildfires are some of the more obvious impacts on the already fragile desert ecosystems of the assessment area. Essentially, the conditions and trends of resources that affect areas of tribal importance, particularly related to climate change, are the same concerns the agency faces:

> *American Indian and Alaska Native tribes are uniquely affected by climate change. Indigenous peoples have depended on a wide variety of native fungi, plant and animal species for food, medicine, ceremonies, community and economic health for countless generations. Climate change stands to impact the species and ecosystems that constitute tribal traditional foods that are vital to tribal culture, economy and traditional ways of life . . . Tribal participation in*

> *local, regional and national climate change adaption strategies, with a focus on food-based resources, can inform and strengthen the ability of both tribes and other governmental resource managers to address and adapt to climate change impacts. (Lynn et al. 2013: p.1)*

Summary

The Carson NF continues to play an important and vital role in supporting and providing for several tribes, preserving and maintaining their cultural, traditional, and spiritual ways. Access to sacred sites or to resources for traditional uses is increasingly an issue for many tribes. Forest health is important to tribes that are concerned about fire, watershed quality, and a decrease in some traditional use forest products. Tribes have expressed concern that energy and technology developments (e.g., utility corridors, communication towers, and renewable energy sites) have changed the sense of place integral to many of the Tribes' spiritual connections to the land.

Cultural and Historic Resources

Historic properties are defined under the NHPA (54 U.S.C. 300101 et seq. and specifically Section 106 54 U.S.C. 306108) and National Park Service (NPS) Bulletin 15 (National Register of Historic Places Staff 2002) as objects, structures, buildings, sites, and districts' property types, that are National Historic Landmarks, or are listed or eligible for listing on the National Register of Historic Places (NRHP), based on their importance to local, regional, or national history. In accordance with the Region 3 Programmatic Agreement, properties for which eligibility cannot be established ("undetermined" properties) are treated as if eligible for the NRHP, and are included as historic properties in this discussion. Cultural and historic resources can be divided into two overlapping categories, archeological and historic resources and traditional cultural properties (TCPs). These are properties that are entirely or in part eligible to the NRHP, because they are associated with cultural practices or beliefs of a living community (a) rooted in that community's history and (b) important in maintaining the continuing cultural identity of the community (Parker and King 1998).

Also included in this discussion are properties that have been evaluated and found to be not eligible for the National Register of Historic Places (NRHP). Although not considered eligible historic properties under 54 U.S.C. 306108 and NPS Bulletin 15, the information gathered as part of their Section 106 evaluation process can be valuable for the interpretation of historic occupation and use of the plan area and so they are also considered here.

The places and characteristics of the Carson NF that are of cultural and historic significance to the traditional communities in the vicinity of the forest include but are not limited to sacred places, TCPs, and other historic properties. More broadly, characteristics of cultural and historic importance are places within, or qualities of the plan area that are important to maintaining the cultural and historic identity of traditional communities. These characteristics can be defined as historic properties; general areas corresponding to the distribution of physical attributes, such as types of plants, geographic or topographic features; or non-place based characteristics, such as solitude. Presently there are no TCPs that have been listed on the National Register for the Carson NF.

This section will discuss:

- Ecosystem services of cultural and historic resources
- Description of historic properties
- National Register sites, National Register eligible sites, and priority heritage assets on the Carson NF
- Current conditions and trends of known cultural and historic resources on the forest
- Contributions of cultural and historic resources to social, economic, and ecological sustainability
- Summary of cultural and historic resources on the Carson NF

Ecosystem Services of Cultural and Historic Resources

The characteristics described above also describe the ecosystem services associated with cultural and historic resources on the forest. These resources primarily fall in the "Cultural" ecosystem service category and include community identity, cultural tourism, and research and information on human history. Historic preservation, education, and designations of significance are also cultural ecosystem services associated with these resources.

Description of Historic Properties

Approximately 241,800 acres, representing about 15 percent of the Carson NF, have currently been surveyed for heritage resources (Table 97). The majority of the sites occur in middle to lower elevation terrestrial ecosystems, which were identified as being the most departed and having the highest risk to ecological integrity. These sites are impacted by erosion and sedimentation and are at risk from uncharacteristic wildfire.

Table 97. Acres surveyed for heritage resources on the Carson NF by ranger district

Ranger District	Surveys (#)	Ranger District Surveyed (acres)	Extent of Ranger District Surveyed (%)	Extent of Forest Surveyed (%)
Jicarilla	42,869	157,835	27	3.0
Tres Piedras	33,103	387,500	9	2.1
Canjilon	27,189	150,706	18	1.7
El Rito	47,762	280,691	17	2.6
Questa	27,988	276,113	10	1.8
Camino Real	62,868	337,500	9	2.1

Identified sites on the Carson NF follow a locational pattern of distribution that mirrors both the management focus of Section 106 compliance and the prehistoric/historic land use models. The relationship of sites to the Midscale Existing Vegetation Dominance Type Map Units 89 (USDA FS 2010a) database generally coincides with the natural groupings, as a function of the surveys completed and the past use of the ecological zones.

The spatial distribution of Section 106 inventories has influenced to some extent the understanding of the location of historic properties on the Carson NF. There is enough information to describe the nature, cultural affiliation (only in the broadest terms), and distribution of properties on the forest. As of February 2015, a total of 6,303 historic properties (including properties determined not eligible for the NRHP) have been recorded in the plan area. Since almost all of the inventories conducted for historic properties have been carried out for management purposes, most of the properties recorded were located by these inventories.

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Table 98. Type of heritage sites located on the Carson NF, by ranger district

Ranger District	Historic	Multi-Component	Prehistoric	Unknown	Total	Extent on Carson NF (%)
Jicarilla	387	165	1,110	83	1,745	28
Tres Piedras	201	110	904	104	1,319	21
Canjilon	44	78	746	34	902	14
El Rito	224	94	694	32	1,044	17
Questa	298	45	395	28	766	12
Camino Real	233	43	210	22	508	8
Total	1,387	535	4,059	303	6,284[1]	~100
Percent	22	9	64	5		~100

Historic sites, comprising 22 percent of the historic properties on the forest, are any cultural resources that can be identified from the post 1540 period to approximately 50 years ago. This type of site is generally of Hispanic or Euro-American, but can include historic Native American sites that may be associated with Apache, Navajo, Pueblo, Comanche or Ute Tribes. Historic sites can run the gamut, from simple can or trash dumps, to carved aspen trees, to entire mining towns, ranches, and homesteads or even village sites. Prehistoric sites are those properties that can range from approximately 12,000 years before present to A.D. 1540. Prehistoric sites represent the majority of identified properties accounting for 64 percent of the forest's total. Prehistoric sites can include artifact scatters; extensive Archaic period scatters that can be half-mile long; resource gathering/processing camps; pit houses and pueblos; rock art sites, etc. Multi-component sites make up 9 percent of the forest's cultural properties. These sites have both historic and prehistoric elements that share a common area, overlap, or are adjacent to each other. Those sites listed as "Unknown" in Table 98 are generally sites with lithic debitage (flakes of stone formed in the process of making a tool), but in which no temporally or spatially diagnostic tools are present. Those sites with the unknown attribution can also include cairns or other rock features, with no associated diagnostic material.

National Register Sites, National Register Eligible Sites, and Priority Heritage Assets on the Carson National Forest

The Carson NF has five sites presently listed on the National Register of Historic Places:

- Victor Ortega Cabin on Canjilon Mountain (Canjilon RD);
- Pueblito Canyon Ruin, Pueblito Canyon East Site, and Bancos Canyon Site (all on Jicarilla RD); and
- Aldo Leopold Home, also known as the Tres Piedras Old Ranger Station (Tres Piedras RD).

[1] There are 19 sites located in private inholdings with the Carson NF boundary that are excluded from this table.

Approximately 2,277 sites are listed as eligible for the National Register on the Carson NF, 370 sites are listed as ineligible, while 3,640 sites are unevaluated. Currently there are 41 priority heritage assets (PHAs) listed on the Carson NF. These consist of 12 prehistoric sites, including the five National Register sites, and 29 historic sites, including one of the National Register sites.

Current Conditions of Known Cultural and Historic Resources and Trends Affecting Their Condition and Use on the Carson National Forest

The current condition of cultural and historic resources can be characterized by examining the number of historic properties that have been placed on or determined to be eligible for the NRHP, and by examining data and other information on impacts to historic properties and other resources. An historic property that is listed or is eligible to the NRHP reflects the retention of its integrity for the characteristics that make it significant to American history, and thus implies that the property is not in poor condition. Other properties may not be eligible to the NRHP, because they lack integrity and are in poor condition, but such a determination may also be made because the property has no intrinsic significant historic value.

Evaluating the condition of cultural resources, including historic properties, is problematic. For historic properties, objective criteria, such as the evaluation of impacts from natural and human forces can be used to generate statements regarding their condition. However, the nature, intensity, and quality of the evaluation of impacts to properties have changed over the past half-century. Until 1977, plan area historic properties were largely recorded on the State of New Mexico's Laboratory of Anthropology (LA) two page forms. From 1977 to 1990, the Carson NF's Cultural Resources Automated Information System (CRAIS) forms were used, after which recording was accomplished using a detailed newer version of the State of New Mexico's LA form.

All of these forms used different methodologies for assessing site condition. The data from three forms has been normalized in the State of New Mexico NMCRIS and Forest Service INFRA databases, despite the persistence of categorical equivalence; differences in the level of detail; and quality of the data. As such, any determination of the condition of historic properties will necessarily be qualitative and judgmental. For properties and characteristics of importance to traditional communities, their condition is a reflection of the perceptions of that condition by those traditional communities, regardless of the objective conditions of those resources and characteristics, assuming such objective conditions can be measured (e.g., availability of natural resources for collection or quality of noise and viewsheds).

Data on current conditions and trends for historic properties can be examined from the original recording event, any site updates and monitoring documentation of historic properties over the past 50 years (Table 99).

Table 99. Number of site impacts by decade on the Carson National Forest

Decade	# of Visits	Bioturbation[1]	Construction	Water Erosion	Wind Erosion	Unspecified Erosion	Vandalism	Total
2010-2014	490	101	53	55	23	8	9	249
2000-2009	2,522	215	339	778	160	11	32	1,535
1990-1999	1,597	184	501	794	142	147	31	1,799
1980-1989	2,093	135	495	162	38	479	30	1,339
1970-1979	194	5	26	19	1	24	5	80
1960-1969	1	0	0	0	0	0	0	0
Total	6,897	640	1,414	1,808	364	669	107	5,002

Overall, water erosion, including sheetwash erosion, drainage formation, gullying, and arroyo down-cutting, is the most prevalent impact observed at historic properties. It has been noted at approximately 36 percent of original site recordings or site updates. Much of what has been recorded as “unspecified erosion” (this category being a legacy of less precise observation categories on early recording forms), is likely a combination of some wind, but mostly water erosion. In most cases, water erosion at sites consists of sheetwash that ranges from slight to severe. The effects of climate change and the continuing drought in the American Southwest has the potential to exacerbate water and wind erosion, as vegetation is diminished, ground cover is seriously reduced, and the effects of grazing further impact the land.

Bioturbation includes primarily impacts from cattle grazing and feral horse herds and to a lesser extent damage from rodents, insects, and other wildlife. It was recorded on 13 percent of original site recordings, site updates, or monitoring forms. The Jicarilla RD has seen a marked increase in wild horse damage documented within and adjacent to the “Jicarilla Wild Horse Territory.” This is a direct result of horse numbers exceeding the established management level. A single project on the district between 2009 and 2010 documented 295 sites that were updated or recorded and of those 69 sites (23% of total) had some level of impact, ranging from minimal evidence of the horses by the presence of dung to more extensive impacts from trailing and trampling. Additionally, there is documentation of a prehistoric, coursed masonry structure that has been trampled to the point that there is no longer any evidence of the site, except as a scatter of structural rubble. Archaeologists have further noted erosion across sites has accelerated by overgrazing, trailing, wallowing, and trampling from wild horses.

Construction, including land development activities such as road construction, oil and gas development, mining, logging, and other activities, has been noted at approximately 28 percent of all site recordings or updates. The largest numbers of construction/land development impacts are assigned to road construction activities that may have occurred prior to Section 106, but that continue to cause further impacts through time. User-created roads are still a concern within the plan area; however, with the completion and authorization of Travel Management on the entire forest these issues should decline rapidly.

[1] Bioturbation is the physical rearrangement of the soil profile by soil life, including hooved animals, burrowing animals, insects, and plant root systems.

Vandalism, a category that includes looting, the defacement of standing structures and other features (such as rock art), arson, and the collection of surface remains (i.e., pottery sherds, arrow and spear points, bottles, other historic materials) is the least prevalent disturbance category noted during visits, having been observed at approximately 2 percent of the recording, site updates and monitoring events. This is encouraging, given that vandalism impacts can often be severe.

Prior to 2000, the increase in impacts over the past 40 years appears to largely be an increase in number of properties being inventoried, rerecorded, or monitored, and improvements in the quality of observations regarding the condition of these properties. Generally through time, the level and documentation accounting for impacts to sites has gotten considerably better, as a result of a refinement in forms and increased awareness of the need to be more specific in the reporting process.

There are no consistent efforts to record impacts to resources and characteristics important to traditional communities, other than those observed or those that are historic properties. For the general consideration of resources and characteristics important to Native Americans, see Areas of Tribal Importance (p. 424). There has been no assessment of the condition of resources and characteristics important to traditional Hispanic and Anglo-American communities. However, the information collected by Raish and McSweeney (2008) has some bearing on current resource conditions and recent trends for traditional Hispanic communities. In particular, there have been declines in the condition of rangeland and fuelwood resources. The perception is that these resources are currently insufficient to maintain community needs, and their availability has been declining over the past 50 years. It is the belief of communities that this decline is not so much due to declining availability of the resource itself, but is a consequence of increasing access restrictions by the Forest Service.

Throughout the social and economic sections of this assessment, the ability of the Carson NF to contribute to benefits and uses important to traditional users was evaluated. The Range section (p. 378) identifies the forest's ability to support sustainable levels of forage, as a result of less productive grass cover in lower elevation ecosystems, which impacts the ability the forest to support sustainable livestock grazing. Climate change is expected to increase drought conditions, further impacting the ability to graze livestock. Many young people are no longer staying in the communities and continuing the traditional way of life of their parents. Permitted livestock numbers have remained fairly constant on the forest, but authorized numbers have decreased since 2004 as a result.

Threats from uncharacteristic wildfire, woody species encroachment, drought, and invasive plant and animal species contribute to the potential for less productive and/or loss of wildlife and fish habitat, and available plants and herbs important to traditional Hispanic communities. The forest road system is currently in fair condition as discussed in the Infrastructure section (p. 466) of the assessment, but declining resources may impact the ability to maintain all roads to standard, potential limiting access to some parts of the forest. Many forest users have complained firewood is not readily available as result of travel management. Firewood and other forest products are continually made available for the many communities around the forest. These are some of the many traditional uses important for the identity and social fabric of the people and communities around the forest. The inability to maintain a connection to the land and continue these uses impacts family social values and culture.

Contributions of Cultural and Historic Resources to Social, Economic, and Ecological Sustainability

Historic properties on the Carson NF are a record of historic processes and events important in the identity of local communities, New Mexico, the Southwest, and the nation. Contemporary uses of resources in the plan area by Native American, Hispanic, and Anglo-American traditional communities are critical to maintaining the identity of these communities.

Cultural tourism is a significant component of the economy of the assessment area. Tourists are attracted by the nature and significance of historic properties, and by the character of traditional communities, a character maintained by resources and uses of the forest. In addition, historic properties contain a wealth of information for scientific researchers regarding ecological conditions and changes over the past twelve millennia, and human successes and failures in coping with these changes. This information is of value to managers making decisions regarding the contemporary ecological management of the Carson NF. This information is also of value for educating the public about ecological sustainability.

Historic properties are a major source of information regarding the history of the human occupation and use of the area. For the first 11,000 years of human history, the remains found at historic properties are the only source of information, since this is a span of time that has little or no information available from written records or from Native American oral history. Scientific researchers, professional organizations, and cooperating groups that have provided input for this assessment have emphasized the value of historic properties in the plan area for providing information about American history (Bender et al. 2013; Hayden 2013; Huntley 2013; Laumbach 2013; Lekson 2013; McIntosh 2013).

There are several themes in American history for which historic properties can provide, or have provided, important information:

- Settlement and society during the Archaic era (6500 B.C. to A.D. 500), and the origins of farming in North America (all ranger districts).
- Settlement and society among Pueblo peoples.
- Migration and cultural transformation among Pueblo peoples at the end of the ancestral Pueblo era (A.D. 1100 to 1300).
- Pueblo society during the Classic Period (A.D. 1325 to A.D. 1700), and the response by, and effects on Pueblo peoples from early Spanish exploration.
- Spanish settlement, land use, and society during the Land Grant period (A.D. 1692 to 1846).
- The effects of the arrival of Euro-Americans, the development of the Fur Trade after 1821 and the subsequent establishment of the Santa Fe Trail and the Old Spanish Trail.
- The economic, social and economic impacts of commercial mining, railroads and lumbering operations in the late nineteenth and early twentieth centuries.

The Carson NF also contains individual properties that are important to the traditional history of Native Americans, early Hispanics and early Euro-American settlers. The use of historic properties to generate information about the history of the forest, the region, and the nation is vital to maintaining cultural identity at each of these levels. The importance of history to maintaining social sustainability has been cited by members of Hispanic traditional communities (Raish and McSweeney 2008) and scientific researchers. Professional organizations cite strong interest among Native American communities in the historical information generated by researchers that study historic properties (Huntley 2013; Lekson 2013; McIntosh 2013). Interpreted historic properties also afford an opportunity to educate children and the public at large about the history of the forest, the region, and the nation (Bender et al. 2013; McIntosh 2013)

The importance of historic and cultural places and characteristics of the Carson NF for maintaining the identity of traditional communities is well documented. See Areas of Tribal Importance (p. 424) for their significance to Native American traditional communities. Hispanic traditional communities have identified the traditional use of the forest for subsistence economic activities as central to their cultural identity. This includes access to land for grazing; wood for fuel and construction water for the irrigation of crops; plants used in traditional medicine; and areas of traditional religious significance (DeBuys 1985; Gonzales 2003; Raish and McSweeney 2008). While there is little written research, district personnel report that access to resources and characteristics are also important to the maintenance of traditional Anglo-American communities, in particular access to land for grazing, hunting, and recreation.

Cultural and historic resources and uses serve as a driver of economic sustainability in the vicinity of the Carson NF, by fueling cultural tourism. Historic properties are a major attraction for cultural tourism (Lekson 2013). However, there are few historic properties that are interpreted and readily available for visitation by the public on the forest. Tourists are also attracted to the traditional communities that rely on the resources and uses of the forest to maintain their traditional identity. Fine art, handicrafts, foods, religious events, festivals and other cultural events, and other products and activities that attract tourists to these communities all rely on cultural resources and uses within the plan area. See Carson National Forest's Contribution to Social, Cultural, and Economic Conditions (p. 336) for more information on cultural tourism.

The study of historic properties has generated a wealth of scientific information germane to the ecological sustainability of the Carson NF. Places of past human settlement and use contain faunal remains, macrobotanical materials, soils, pollen, and other relics relevant to the reconstruction of the patterns related to ecological change over the past 12,000 years. Scientific investigation of historic properties provides an understanding of how humans have successfully adapted to a changing environment or why they have failed to do so (Bender et al. 2013; Laumbach 2013).

The Carson NF has utilized the Passport in Time program with some success. Two recent opportunities include the use of volunteers to assist doing metal detecting in an area on the Questa RD for what was hoped to be the Old Spanish Trail. Participants provided valuable work, while gaining valuable education. On the Canjilon RD volunteers were used to help uncover prehistoric remains at two high elevation sites. The program is used as a valuable tool to gain valuable help from the public, while providing a tremendous education opportunity. The forest has experienced challenges to initiate more volunteer/education opportunities, due limitations in the availability of forest archeologists to supervise volunteer projects. These programs increase the awareness and knowledge of the public of the valuable cultural and historic resources in the area.

Understanding how past patterns of human land use, such as farming and logging, have influenced current ecological conditions is critical for making decisions about maintaining ecological sustainability in future land management. The interpretation of historic properties also creates opportunities to educate the public about environmental change and human adaptation in the past and ecological sustainability in the future (Bender et al. 2013).

Summary

The Carson NF has over 6,000 historic properties and only 15 percent of the forest has been surveyed. Sixty-four percent of the cultural resources recorded on the forest are prehistoric sites, 22 percent are historical properties, and 9 percent are multi-component sites. The remaining 5 percent are unknown, with no temporally or spatially diagnostic tools present. Additionally, the Carson NF has five sites listed on the National Register of Historic Places, with 2,277 more sites eligible for listing. There are 370 sites not eligible for listing and 3,640 sites that have yet to be evaluated. The conditions of the cultural resources on the Carson NF are most notably impacted by water erosion, construction, and vandalism, which fortunately have not been severe.

The cultural sites on the Carson NF are significant social and economic contributors to the assessment area, region, and nation. They provide opportunities for cultural tourism, education, and research. They are also necessary for maintaining the cultural identity of the traditional communities within the assessment area.

Designated Areas

Every National Forest has areas that contain special, exceptional, or unique values. Many of these areas meet the criteria to be considered special places and are awarded specially designated status. This status can be on a national, regional, or local scale. Designation of these areas undergoes rigorous scrutiny and study that can last years, depending on individual circumstances. They also often require approval at the upper levels of administration, including Congress, and some cases require multiple administrators. The Carson NF has several of these specially designated places, which include wilderness areas, proposed research natural areas, national recreation trail, national scenic trail, and national historical trails, wild and scenic rivers, scenic byways, critical habitat, inventoried roadless areas, wild horse territories, outstanding national resource waters, a zoological area, botanical area, and areas of resource concern. This section will discuss:

- Ecosystem services of designated areas
- Wilderness areas, research natural areas, and national recreation, scenic, and historical trails
- Wild and scenic rivers, critical habitat, and inventoried roadless areas
- Wild horse territories and outstanding national resource waters
- Zoological and botanical areas
- Potential need or opportunity for future designations
- Designated areas near the Carson NF
- Contributions of designated areas to social, economic, and ecological sustainability
- Summary of designated areas on the Carson NF

Figure 83, Figure 84, and Figure 85 on the following pages provide locations of designated areas on the Carson NF.

Ecosystem Services of Designated Areas

Designated areas offer ecosystem services including, but not limited to:

- **Supporting** ecosystem services of designated areas offer nutrient cycling, plant production, soil formation, etc. through the ecosystems they support either directly or indirectly through designation.

- **Regulating** ecosystem services of designated areas provide some level of protection for the values they were designated for. This allows regulating services, such as storage of carbon, water filtration, climate regulation etc. to function with some level of protection.

- **Provisioning** ecosystem services of designated areas are important to water resources that offer provisioning services by providing water for ecosystem and domestic use.

- **Cultural** ecosystem services deliver unsurpassed recreational and scenic opportunities, places to connect with nature and spirit, and contribute to the local tourism industry. They also offer the ability to connect with history and provide places for research.

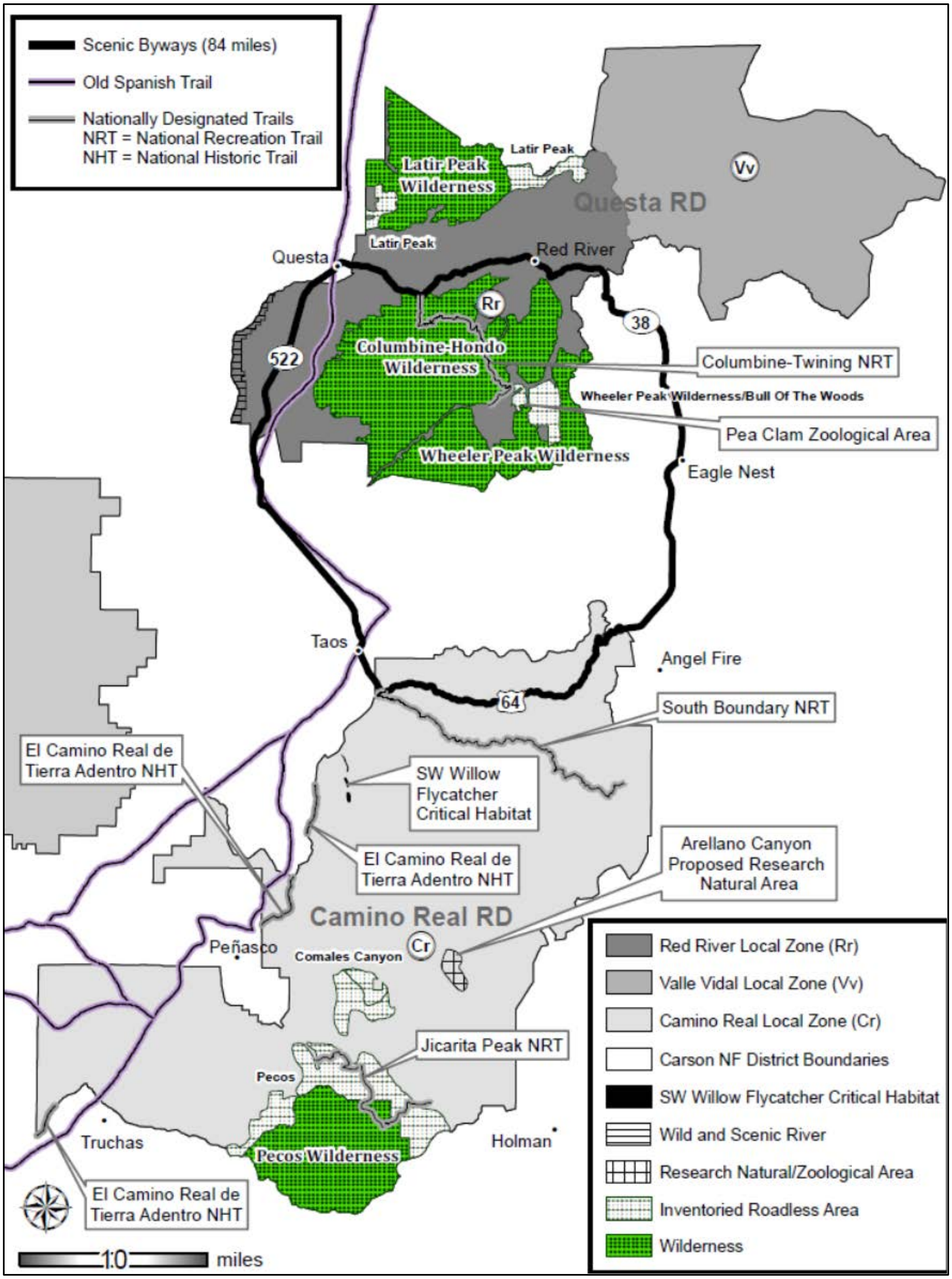

Figure 83. Designated areas on east side (Questa and Camino Real RDs) of the Carson National Forest

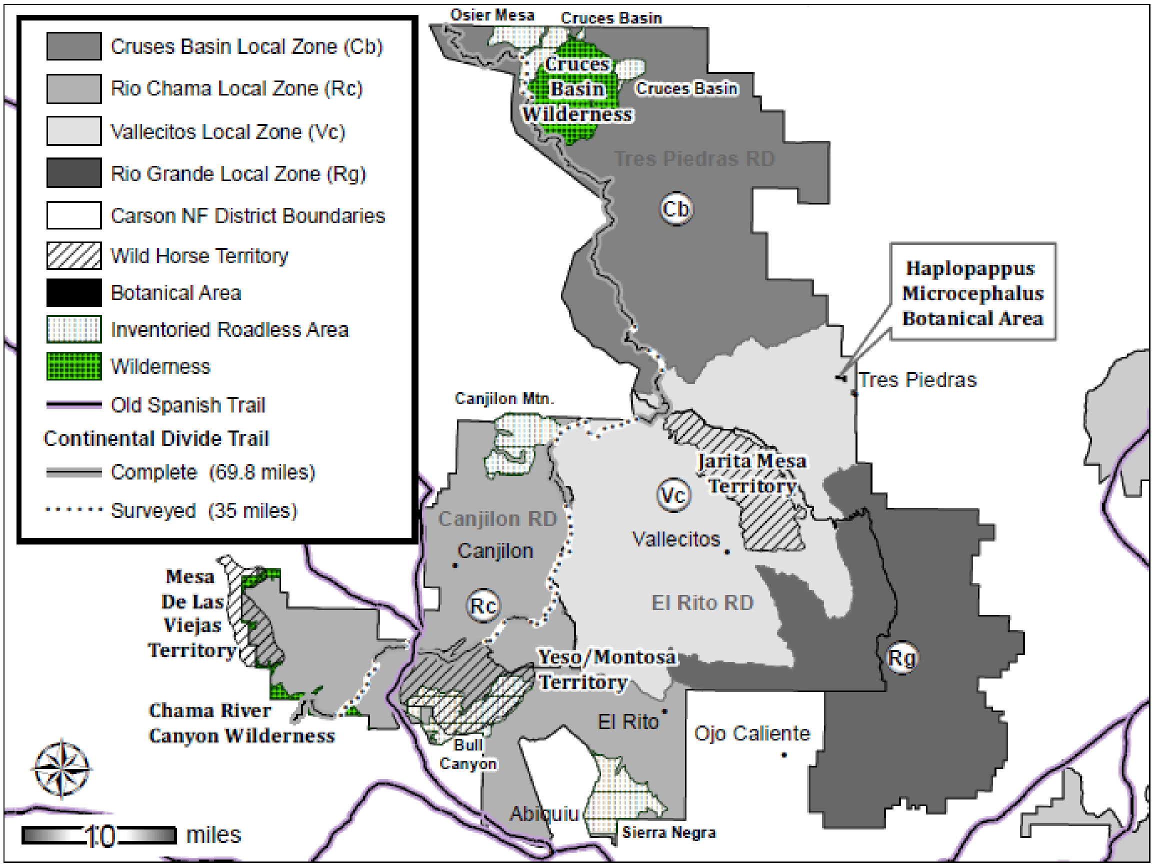

Figure 84. Designated areas on west side (Tres Piedras, Canjilon, and El Rito RDs) of the Carson National Forest

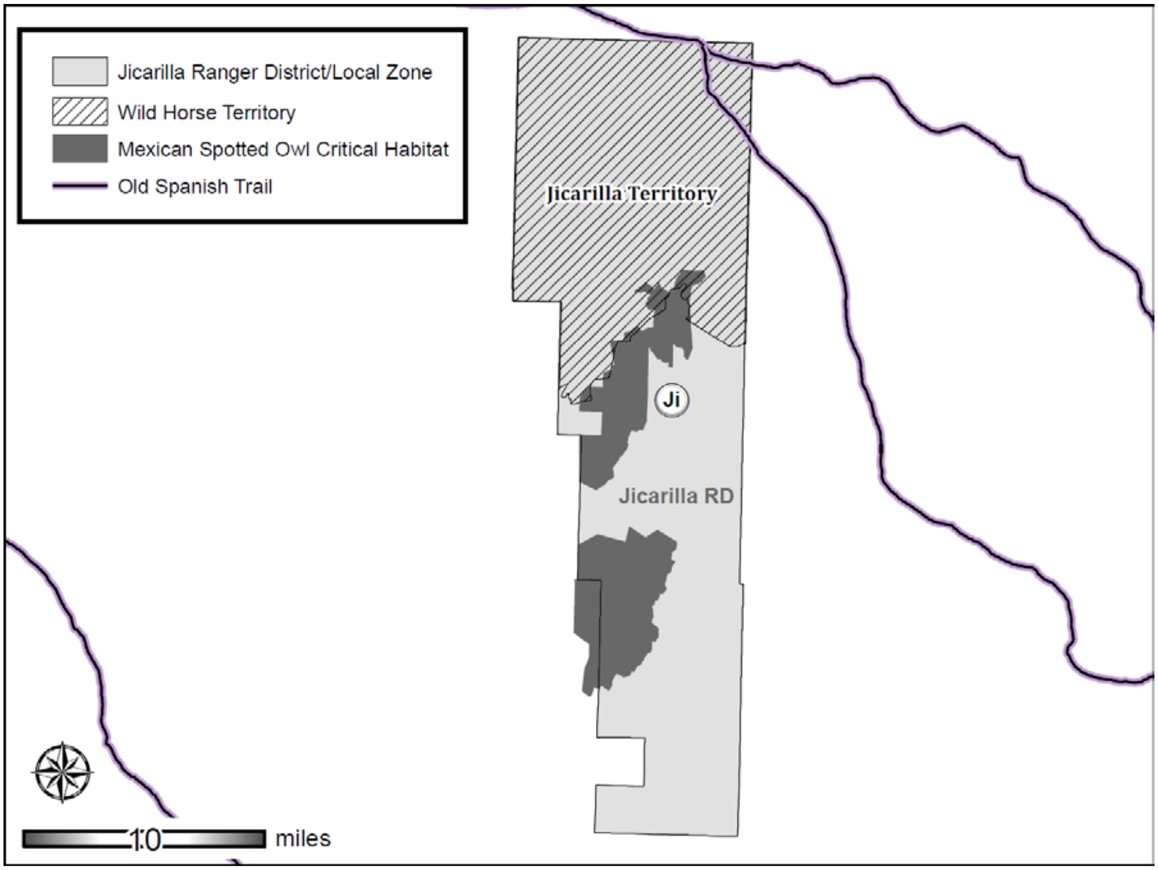

Figure 85. Designated areas on the Jicarilla Ranger District of the Carson National Forest

Wilderness Areas

In 1964, Congress acknowledged the immediate and lasting benefits of wild places, by passing landmark legislation that permanently protected some of the most natural and undisturbed places in America. The Wilderness Act established the National Wilderness Preservation System ". . . to secure for the American people of present and future generations the benefits of an enduring resource of wilderness (US Congress 1964)." Six wilderness areas, totaling around 110,662 acres, or 7.5 percent of the national forest, overlap the Carson NF. Four of these are completely managed by the Carson NF and the other two have shared management with the Santa Fe NF (Table 100).

Table 100. Wilderness areas on the Carson National Forest

Wilderness Area	Size (acres)	Ranger District
Wheeler Peak	18,457[1]	Questa
Pecos (northern portion)[2]	24,735	Camino Real
Latir	20,405	Questa
Cruces Basin	18,867	Tres Piedras
Chama River Canyon[3]	2,949	Canjilon
Columbine-Hondo	43,706[4]	Questa
	110,662	

All of the Carson NF's wilderness areas have the following characteristics in common:

- The majority of the use is day user versus overnight backpacking.
- The majority of camping occurs near water, not only for its desirability, but the terrain is often most suited for camping near water sources. Much of the terrain is steep in the wilderness areas, but offer flatter areas to camp in near water.
- No permits are required to camp in any of the Carson NF's wilderness areas.
- Every wilderness area has outfitters and guides on special use permits that offer services to the public for various wilderness area experiences and opportunities.

[1] These acres will change, since the size of Wheeler Peak Wilderness was altered when the Columbine-Hondo Wilderness Act (S. 776/H.R. 1683), a part of the National Defense Authorization Act (H.R. 3879), was enacted in December 2014.

[2] Total acres = 250,020, management direction in Santa Fe NF forest plan.

[3] Total acres = 50,300, management direction in Santa Fe NF forest plan.

[4] Since this is a new wilderness, its size is an approximation. An accurate number of acres will be determined when the boundary is surveyed.

Wheeler Peak Wilderness Area

The Wheeler Peak Wilderness Area was designated by Congress in 1964. It is located in the Sangre de Cristo Mountains, the southernmost reach of the Rockies and spans 18,457 acres[1] (Figure 83, p. 443). Wheeler Peak, the highest point in New Mexico, is the highlight of this area rising to 13,161 feet above sea level. This feature attracts many visitors, making the Wheeler Peak Wilderness the most heavily used within the Carson NF.

Many of the high peaks and ridges in this area are covered by alpine tundra, rare in the American Southwest. Rocky Mountain big horn sheep are abundant in this habitat type year-round and are generally quite curious, allowing visitors to gain a close look at these interesting residents. The Wheeler Peak Wilderness is also home to elk, mule deer, golden eagles, marmots, martens, picas, mountain lions, and black bears. Perhaps the most unusual resident of this area is the white-tailed ptarmigan found in the alpine tundra. Approximately 40 inches of precipitation fall in the Wheeler Peak Wilderness annually, making the winter months ideal for backcountry and cross-country skiing, as well as snowshoeing.

The Wheeler Peak Wilderness Area is the most heavily used wilderness area on the forest. Aside from having the tallest peak in New Mexico, it also has easy access that is paved up to its trailheads. There are limited opportunities for solitude in this wilderness area, given its high level of use where recreational parties generally run 15 persons or more.

The boundary for the Wheeler Peak Wilderness Area was modified for mountain bike use in 2014 under the same legislation designating the Columbine-Hondo Wilderness Area, which did not result in a net loss of acres. The Wheeler Peak Wilderness Area has a “Limits of Acceptable Change” document (Carson NF 1995) guiding management of the area.

The Wheeler Peak Wilderness Area is in the Red River local zone (Figure 83, p. 443). In addition to the risks associated with the ERUs found within this local zone (Chap. II. Integration and Risk Assessment, p. 307), other risks include impacts from concentrated high levels of use and continued encroachment by mountain biking. Mountain biking is expected to continue to increase in this area and patterns of use into the wilderness have already been established despite the new boundary.

Pecos Wilderness Area

The Pecos Wilderness was also designated by Congress in 1964. Jointly managed with the Santa Fe NF, the Pecos Wilderness spans a total of 250,020 acres in the Sangre de Cristo Mountains, southeast of Peñasco and north of Santa Fe (Figure 83, p. 443). The Carson NF administers about 25,000 acres north of the Santa Barbara Divide Trail, which is the least visited portion of the wilderness. Currently, the northern portion of the Pecos Wilderness is the largest wilderness area managed by the Carson NF.

Elevations in the Pecos Wilderness range from 8,000 to 12,835 feet, atop Jicarita Peak. South Truchas Peak (13,103 feet), the second highest point in New Mexico, is located just south of the Santa Barbara Divide, on the Santa Fe NF side of the Pecos Wilderness. Stands of spruce, fir, pine, and aspen are interspersed with canyons, mesas, rugged peaks and ridges, clear streams, meadows, and multiple lakes. The topography and scenery of this wilderness area are diverse,

[1] See Footnote 1.

creating a myriad of opportunities for recreation and habitat for elk, mule deer, black bear, turkey, and Rocky Mountain big horn sheep.

The Santa Fe NF takes the lead in managing the Pecos Wilderness, but only the Carson NF portion will be discussed in this section. On the Carson NF portion of this wilderness area, the Santa Barbara access is the most popular, along the Middle Fork Trail. The first 3 to 4 miles of this trail is characterized by high use and is popular for larger groups, such as school groups. After the first 3 to 4 miles; however, use drops dramatically. Portions of this wilderness area on the Carson NF are known for their steep and rugged terrain. This serves to funnel use along streams and trails, where the terrain is gentler. Equestrian use is popular on the Carson NF's side of the Pecos Wilderness Area, and many people begin from the Santa Fe NF's southern end and exit north from the Carson NF's side, or vice versa.

The Pecos Wilderness is found in the Camino Real local zone (Figure 83, p. 443) and is characterized by the Alpine and Tundra (ALP) and Bristlecone Pine (BP) ERUs. This local zone also supports the most pristine watershed on the forest (Chap. II. Integration and Risk Assessment, p. 307). The conditions and risks associated with the Pecos Wilderness Area on the Carson NF are the same as those described for the ERUs within this wilderness area (ALP p. 34; MSG p. 37; BP p. 42; SFF p.46; and Chap. II. Integration and Risk Assessment, p. 307). Some of these risks include recreation impacts, insect and disease, and climate change (though to a lesser extent at higher elevations). Overall however, these areas are in good condition as described in the ERU discussions. More information on the Pecos Wilderness Area can be found on the Santa Fe NF's Website.

Latir Wilderness Area

The Latir Peak Wilderness was designated by Congress in 1980 and spans a total of 20,405 acres north of Questa, New Mexico (Figure 83, p. 443). This remote area contains deep forest cover interrupted by meadows and streams, with alpine tundra and alpine lakes found at higher elevations. Cabresto Lake is the most popular access point. From the lake, the Lake Fork Trail follows Cabresto Creek north to Heart Lake, Baldy Mountain, and Latir Mesa, which are all within the wilderness.

The Latir Wilderness Area's primary access is through the Cabresto Lake area. One feature that stands out is an historic cabin characterizing the history of the area. This wilderness area has many trails, but use is comparatively low with respect to the other wilderness areas on the forest, thus providing more opportunities for solitude.

The Latir Wilderness Area is located in the Red River local zone (Figure 83, p. 443). Conditions and risks associated with this wilderness area are primarily the ecological conditions and risks explained for the Red River local zone (Chap. II. Integration and Risk Assessment, p. 307). Mentioned in the risks is the threat to aquatic biota from invasive species, disease and stream impairments from concentrated recreation, roads, and mining impacts. This wilderness area is protected from some of these risks, such as roads and mining, but is still susceptible to other risks, particularly climate change.

Cruces Basin Wilderness Area

The Cruces Basin Wilderness was also designated by Congress in 1980. This is the smallest wilderness on the Carson NF, spanning 18,867 acres, just south of the New Mexico-Colorado border (Figure 84, p. 444). It is located northwest of Tres Piedras, in the southern San Juan Mountains. Lack of designated trails and difficult access contribute to the pristine nature of this wilderness, and provide excellent opportunities for solitude. All trails in this wilderness are either fisherman-created or game trails, with just one well-established route entering the wilderness from Osha Canyon, on the southern border.

Mountain plateau surrounds and forms the boundary between the Cruces Basin and Brazos area, adjoining to the west and southwest. Elevations range from 8,600 to 10,900 feet, featuring spruce, fir and aspen forests, interspersed with grassy meadows and prominent rock features. The lush meadows found throughout the basin provide important summer range for elk. Mountain lions, black bear, and many other birds and mammals can be seen as well. Diablo and Beaver creeks, located in the southern portion of the basin, are popular with fly fisherman, due to their abundance of brook trout.

The Cruces Basin Wilderness Area is the least visited wilderness area on the Carson NF. It is also the most difficult to access, along 15 miles of dirt road that receives little maintenance. Unlike all of other wilderness areas on the forest, Cruces Basin is situated in a bowl and rather than along and around mountainous peaks. It also has no designated trails.

The Cruces Basin Wilderness Area is in the Cruces Basin local zone (Figure 84, p. 444). This zone is one of the lower risk areas ecologically, though there are ERUs at high risk from damaging wildfire on the south side of the zone (Chap. II. Integration and Risk Assessment, p. 306). Detrimental impacts from insects and disease are also likely to continue or intensify for this area. User conflicts with cows are also noted in the Cruces Basin Wilderness Area, since the area is highly used for livestock grazing. Invasive weeds are also a challenge and are treated within small areas by hand-pulling.

Chama River Canyon Wilderness Area

The Chama River Canyon Wilderness Area was also designated by Congress in 1978 and encompasses 50,300 acres, with only 2,949 acres on the Carson NF (Figure 84, p. 444). It is managed entirely by the Santa Fe NF. The Wild and Scenic Rio Chama is popular among river rafters and canoeists and runs through six miles of the wilderness area. Trail access is poor above the colorful sandstone bluffs and impressive rock formations that rise to high rims on both riverbanks.

Varying canyon elevations also provide a wide range of vegetation, from low-lying piñon-juniper woodland to ponderosa pine and fir. Trout often flourish in the river, and onshore residents include mule deer, black bears, elk, coyotes, and mountain lions. Between 70 and 80 different bird varieties are found in the Chama River Canyon.

The small portion of the Chama River Canyon Wilderness Area that is located on the Carson NF is difficult to access along poorly maintained dirt roads and there is little opportunity off of the rim of the canyon where the Carson NF's portion is found. There is one trailhead on the Carson NF, however the trail is in poor condition and is not maintained.

The 2,949 acres on the Carson NF are located within the Rio Chama local zone (Figure 84, p. 444). Most of these risks for this zone are associated with insects and disease, loss of groundcover from piñon juniper, and aspen mortality (Chap. II. Integration and Risk Assessment, p. 306). Other conditions and risks not previously described within this local zone are unknown for the Chama River Canyon Wilderness Area on the Carson NF.

Columbine-Hondo Wilderness Area

Designated by Congress in December 2014, the Columbine-Hondo Wilderness is the newest addition to the wilderness system on the Carson NF (Figure 83, p. 443). Before its designation, Columbine-Hondo was a wilderness study area since 1980 and encompassed 43,706 acres. These acres will change when the area is surveyed using the legal description outlined in the Columbine-Hondo Wilderness Act (Public Law 113-291). The Columbine-Hondo Wilderness Area is adjacent to the Wheeler Peak Wilderness Area in the Sangre de Cristo Mountains. Elevation ranges from 7,600 to 12,700 feet. There is an extensive and popular trail system that accesses the area from various points along NM 150 in Hondo Canyon, as well as other plentiful recreation opportunities, including viewing scenery, wildlife watching, picnicking, camping, and hunting. There are several scenic landmarks, including Gold Hill, Lobo Peak, and Flag Mountain. Elk, deer, bear, coyote, and birds of prey can be found within the area, and beavers have produced small ponds on many of the streams. Wildflowers bloom throughout the spring and summer and a variety of berries, mushrooms, and herbs can be gathered seasonally along the drainages.

The Columbine-Hondo Wilderness Area shares many similarities with the Wheeler Peak Wilderness Area. Both are located adjacent to each other, receive high levels of use, offer easy access to wilderness opportunities, and have a high number of trails popular for day hikes. Like Wheeler Peak, the area is also popular for larger group sizes of 15 people or more, and the occasional school group will visit the wilderness area as well.

Since this is a newly designated wilderness area, the forest is beginning to conduct inventories and address management of its use. Beginning in 2015, signage will be assessed, along with new information released about the newly added wilderness area. When the Columbine-Hondo was designated as a wilderness, there was a boundary modification with Wheeler Peak Wilderness Area, to allow mountain biking within previously used areas that would have otherwise become wilderness. Despite this modification, illegal mountain bike use remains a management challenge that is expected to increase into the future as the activity continues to grow in popularity.

The Columbine-Hondo Wilderness Area is found within the Red River local zone (Figure 83, p. 443). From an ecological perspective, conditions and risks associated with this zone include threats to aquatic biota from recreation use and climate change (Chap. II. Integration and Risk Assessment, p. 307). In addition, the legacy mountain biking is a management concern for this wilderness area. Prior to its wilderness designation, mountain biking use had been allowed in the wilderness study area, and it became popular for mountain bikers. Since it is now a designated a wilderness area, mountain biking use is prohibited, which will require a change in past user dynamics and behavior. Meanwhile this change has yet to happen and mountain bike encroachment into the wilderness area is still occurring.

Research Natural Areas

Forest Service research natural areas (RNAs) are designated for the purpose of permanently protecting and maintaining natural conditions for the conservation of biological diversity, conducting non-manipulative research and monitoring, and fostering education. They are managed to maintain the natural features for which they were established and to maintain natural processes. An RNA must be an area that is unmodified and free of major disturbances for the last 50 years (FS RNA Website; USDA FS 2015c).

The Carson NF has a proposed RNA called the Arellano Canyon Proposed RNA (Figure 83, p. 443). It was proposed in 1986, with the inception of the Carson NF's current forest plan (USDA FS Carson NF 1986). It is 1,158 acres and located on the Camino Real RD. Though it is only proposed, Arellano Canyon is managed to maintain the natural features for which it could eventually be established as an RNA. Activities are limited to research, study, observation, monitoring, and educational activities that are nondestructive, non-manipulative, and maintain unmodified conditions.

The Arellano Canyon Proposed RNA is in the Camino Real local zone (Figure 83, p. 443). Conditions and risks associated with this proposed RNA are primarily the ecological conditions and risks explained for the Camino Real local zone (Chap. II. Integration and Risk Assessment, p. 307). Additionally, this proposed RNA is located in close proximity to a recreational summer home area and people can easily access the proposed RNA on ATVs, resulting in illegal motorized use and impacts in the area. Furthermore, livestock grazing has been an issue within the proposed RNA, because the area is not fenced.

National Recreation, Scenic, and Historical Trails

In 1965, the Secretary of the Interior directed the Bureau of Outdoor Recreation to take the lead in conducting a nationwide trails study. This was in response to President Johnson's "Natural Beauty" message of February 1965, in which he called for development and protection of a balanced system of trails in cooperation with state and local government and private interests. In part, the President said, "we can and should have an abundance of trails for walking, cycling, and horseback riding, in and close to our cities. In the backcountry we need to copy the great Appalachian Trail in all parts of America."

The nationwide trails study led to publication of a 1966 report entitled "Trails for America." The report called for federal legislation to foster the creation of a nationwide system of trails. Earlier that year the Secretary of the Interior had already proposed such legislation to Congress. The report and the legislation proposed three categories of trails for the nationwide system—national scenic trails and two other categories that were different from what eventually came to pass. The report heavily emphasized national scenic trails and the role they should play in meeting the nation's needs for trail recreation. The Appalachian Trail was to be the first national scenic trail. The report proposed three other national scenic trails; one was the Continental Divide Trail, a section of which is on the Carson NF. Congress passed the National Trails System Act in 1968. The Act authorized creation of a national trail system comprised of national scenic trails, national historic trails, and national recreation trails. The Carson NF administers all three types of nationally designated trails (Table 101).

Table 101. Nationally designated trails on the Carson National Forest

Designated Trail	Length on Forest (miles)	Ranger District
Continental Divide National Scenic	105[1]	Tres Piedras/Canjilon/El Rito
El Camino Real de Tierra Adentro National Historic	8.4[2]	Camino Real
Old Spanish National Historic	49[3]	Camino Real
Columbine-Twining National Recreation	14.2	Questa
South Boundary National Recreation	22	Camino Real
Jicarita Peak National Recreation	23	Camino Real

National Scenic Trails

As envisioned in "Trails for America," national scenic trails are to be very special: "A standard for excellence in the routing, construction, maintenance, and marking consistent with each trail's character and purpose should distinguish all national scenic trails (USDA FS 2015b). Each should stand out in its own right as a recreation resource of superlative quality and of physical challenge." According to the Act, national scenic trails "will be extended trails so located as to provide for maximum outdoor recreation potential and for the conservation and enjoyment of nationally significant scenic, historic, natural, and cultural qualities of the area through which such trails may pass" (American Trails Website). National scenic trails are located so as to represent desert, marsh, grassland, mountain, canyon, river, forest, and other areas, as well as landforms that exhibit significant characteristics of the physiographic regions of the nation. The corridor will be normally located to avoid established uses that are incompatible with the protection of a trail in its natural condition and its use for outdoor recreation.

The Continental Divide National Scenic Trail (CDNST) traverses the Rocky Mountains from Canada to Mexico for approximately 3,100 miles (USDA FS 2015b). It travels through portions of 25 national forests, 3 national parks, 4 BLM districts, as well as various private lands in Montana, Idaho, Wyoming, Colorado, and New Mexico. It was established by Congress in 1978 to provide high-quality scenic, primitive hiking, and horseback riding opportunities, and to conserve natural, historic, and cultural resources along the CDNST corridor. The CDNST navigates dramatically diverse ecosystems through mountain meadows, granite peaks, and high-desert surroundings. It is one of the most renowned trails in the United States, for its scenic beauty, recreational opportunities, elevation gains, and primitive character. The Carson NF has completed 69.8 miles and surveyed 35 miles of the CDNST (Figure 84, p. 444).

The CDNST is a popular trail on the forest. Portions of the trail are remote and difficult to access and parts are not finished, yet people drive long distances to recreate on the trail, especially mountain bikers. Every year the forest provides maintenance and constructs unfinished portions of the trail. The forest also manages the trail according to direction provided in The Continental Divide National Scenic Trail Comprehensive Plan (USDA FS 2009a).

[1] 69.8 completed miles and 35 surveyed miles on the Carson NF. Total miles = 3,100.

[2] Total miles = 1,600

[3] Total miles = 2,700

National Historic Trails

Congress amended the National Trails Systems Act in 1978 to create the category of national historic trails. Like national scenic trails, national historic trails can only be authorized and established by Congress and are assigned to either the Secretary of the Interior or the Secretary of Agriculture with most of the same administrative authorities as national scenic trails. To qualify as a national historic trail, a route must have been established by historic use. It must be nationally significant as a result of that use—it must have had a far-reaching effect on broad patterns of American culture (including Native American culture). It must also have significant potential for public recreational use or historic interest based on historic interpretation and appreciation. National historic trails are extended trails that follow as closely as possible and practicable the original trails or routes of travel. The purpose of a designated national historic trail is to identify and protect the historic route and its historic remnants and artifacts.

The El Camino Real de Tierra Adentro National Historic Trail received its national designation in 2000 (Figure 83, p. 443). This trail was used by settlers, missionaries, traders, and the military for almost 300 years. When the railroad reached New Mexico in 1880, the Camino Real gradually fell into disuse. This trail marks the earliest Euro-American trade route in the United States tying Mexico City to New Mexico. The entire trail was over 1,600 miles long, with 8.4 miles on the Carson NF (USDI NPS 2015a).

The Old Spanish National Historic Trail was designated by Congress in 2002 (Figure 85, p. 445) (USDI NPS 2015b). The trail traverses six states (Arizona, California, Colorado, Nevada, New Mexico, and Utah) and was primarily a horse and burro pack route between Santa Fe and Los Angeles, which developed partly from a network of American Indian and Hispanic trade routes in the 1800s (NPS Website). The entire trail (with various loops) transverses 2,700 miles, with 49.6 of those miles on the Carson NF.

Both of the national historic trails on the Carson NF are difficult to access and likely have lower use rates as a result. Access issues stem from the fact that both trails travel through private and tribal lands and don’t have public access on the forest. These issues are currently being addressed, but there is no estimate on resolution.

Currently, the sections of both trails on the Carson NF receive no maintenance. Parts of the tread also need to be relocated, because they are no longer visible on the ground. In addition, the portions of both trails that are on the forest are not covered by management plans. While the Camino Real De Tierra Adentro does have a management plan, only some sections of the trail from Santa Fe to Mexico are covered. The management plan for the Old Spanish Trail is currently a work in progress and has yet to be completed. It is being written by the U.S. Park Service, with administration by the Bureau of Land Management.

National Recreation Trails

While national scenic trails and national historic trails may only be designated by an act of Congress, national recreation trails may be designated by the Regional Forester to recognize exemplary trails of local and regional significance. Through designation, these trails are recognized as part of America's national system of trails and provide for numerous outdoor recreation activities in a variety of urban, rural, and remote areas.

The Columbine-Twining National Recreation Trail was designated in 1978 (USDA FS Carson NF 2015a). It is a difficult trail with the length of 14.2 miles and an elevation gain of 1,500 feet, from 7,900 to 9,400 feet, through Columbine Canyon to the ridge of Rio Hondo Canyon (Figure 83, p. 443). The trail offers hiking through aspens to exceptional views of Lobo Peak and Flag Mountain above tree line.

The first couple of miles of the Columbine-Twining National Recreation Trail receive heavy use on either end, especially by day hikers. The trail is also easily accessible through campgrounds at either end of the trail, the Columbine Campground on the north and the Twining Campground on the south, making it popular among the campers. The trail is in good condition, but it can be difficult to follow along the ridgeline. It has also had four footbridges removed from the sections of the trail that go into the Wheeler Peak Wilderness Area. While only two bridges have been replaced, access is unimpaired.

Designated in 1982, the South Boundary National Recreation Trail is 22 miles long and offers various summer and winter trail opportunities from Taos to Angel Fire, New Mexico (Figure 83, p. 443) (USDA FS Carson NF 2015a). The South Boundary Trail is a diverse tour of the Sangre de Cristo Mountains, crossing ridges, valleys, and several peaks, through dense conifer forests and open stands of aspen. The trail is at its very best in the fall, when aspens along the route turn shades of yellow, gold, and fiery orange. Besides being a wonderfully scenic tour of New Mexico’s Rocky Mountains, this is also one of the state’s best mountain bike rides.

The South Boundary Trail is one of the most popular and heavily used trails on the forest for several reasons. It offers backpacking opportunities, as well as day trips, without having to go to higher elevations, and it is in close proximity to Taos and Angel Fire. It is also one of the premiere mountain biking trails in New Mexico. Mountain bikers travel from many parts of the country to ride this trail. The trail is also long enough to accommodate overnight mountain biking, an increasingly popular form of mountain biking.

The South Boundary Trail is a non-motorized trail; however, illegal motorized use has been increasing along several sections of the trail. This trail travels through a popular dispersed camping area surrounded by roads, making motorized encroachment onto the trail easy. Many people also drive on this trail to collect firewood. The South Boundary Trail is in good condition and receives maintenance regularly with the help of volunteers.

The Jicarita Peak National Recreation Trail was designated in 1979 (Figure 83, p. 443) (USDA FS Carson NF 2015a). It offers a challenging experience in the Pecos Wilderness and spectacular views from atop Jicarita Peak (12,835 feet), looking off to the west across the Rio Grande Valley and north to the Rocky Mountains in Colorado. Fall aspens are especially prominent along this route. Elk, marmot, ptarmigan, deer, and black bear are some of the wildlife to be found in the area. The trail is 23 miles long and starts at 8,860 feet and ends at 12,835 feet in elevation.

The stretch of the Jicarita Peak Trail between the Serpent Lake Trailhead and Jicarita Peak receives moderate use. After reaching the peak however the trail gets very little use. This is because there are a number of Forest Service trails in the area that are more popular. The other popular access point to Jicarita Peak is via the Santa Barbara Trail, from the Santa Barbara Campground on the northern end of Pecos Wilderness Area.

Wild and Scenic Rivers

By the 1960s, concern was growing over decades of damming, diverting, and developing the nation's rivers. In 1968, Congress passed the Wild and Scenic Rivers Act to preserve the beauty and free-flowing nature of some of the most precious waterways in America. To be designated, rivers or sections of rivers must be free-flowing and possess at least one "outstandingly remarkable" value, such as scenic, recreational, geologic, fish, wildlife, historic, cultural, or other feature identified under the act (FS Wild & Scenic River Website; USDA FS 2013b).

The Carson NF includes two river sections designated wild and scenic rivers; however, both are managed by the BLM. One Carson NF segment is approximately 5 miles of the Rio Grande, along the west boundary of the Questa RD, and the other forest segment is the lower 3.25 miles of the Red River, where it meets the Rio Grande (Figure 83, p. 443). Both sections of river are classified as “Wild”, and flow through deep gorges and offer spectacular views anywhere along the gorge rim. The Red River section is within BLM’s Wild Rivers Recreation Area. There is one hiking trail that leads down into the gorge from the recreation area and another from Cebolla Mesa on the Questa RD.

Use along the Forest Service portions of these rivers consists primarily of fishing; however, kayakers may take their boats down the Cebolla Mesa Trail to run a stretch of the Rio Grande above John Dunn Bridge, near Arroyo Hondo. The width of the Red River is too narrow to allow boating. Approximately 200 yards of the Wild and Scenic Red River underwent restoration activities for impairment from the molybdenum mine upstream, which closed in 2014. Otherwise, threats to both of these rivers are minimal, except for parallel running roads and other mining activities that may occur in their vicinity.

In addition to the 5 miles of designated wild and scenic river on the Carson NF, Forest Service personnel conducted an analysis of river and stream segments on the Carson NF to determine wild and scenic eligibility in the 1990s and 2001. This eligibility analysis will be included and the wild and scenic evaluation process that will take place during the Carson NF’s forest plan revision process.

More information on the these Wild and Scenic Rivers can be found on the BLM Website for both the Rio Grande Wild and Scenic River and the Red River Wild and Scenic River. The BLM is presently updating its management plan to incorporate the Rio Grande del Norte National Monument, designated in 2013. This national monument encompasses the entire wild and scenic river sections of the Rio Grande and Red River in northern New Mexico. Use of the Forest Service segments is expected to increase as a result of the Rio Grande del Norte National Monument designation.

Scenic Byways

The Enchanted Circle Scenic Byway is an 84 mile loop of scenic driving from Taos, through Questa, Red River, Angel Fire and back to Taos again (Figure 83, p. 443) (NM Enchanted Circle 2015). It is the only Forest Service scenic byway that travels through the Carson NF. The Forest Service’s Scenic Byways Program is intended to enhance rural community tourism and provide amazing opportunities to explore the beauty, history and natural heritage of the national forests. This is especially true of the Enchanted Circle Scenic Byway, which has outstanding scenery, offers various recreation opportunities, and showcases the unique cultural history of northern New Mexico. Together, the Town of Taos, Village of Taos Ski Valley, Village of Questa, Town of

Red River, Village of Eagle Nest, and Angel Fire Convention and Visitor's Bureau have formed a marketing cooperative to promote the Enchanted Circle Scenic Byway as an extended stay opportunity for visitors in the area, as well as to stimulate visitation to each of the communities along its route and within the region.

The Enchanted Circle is a major attraction on the east side of the assessment area. It receives heavy year-round use by tourists and local commuters alike. All the communities along the circle economically benefit from the visitation this scenic byway generates, and most of the draw is from the scenic and recreational opportunities found on the Carson NF. Conditions of Forest Service camping facilities vary along the byway. Campgrounds within Taos Canyon, between Taos and Angel Fire, are in poor condition, while those along the Red River corridor, between Questa and the Town of Red River, are well maintained and more developed. There is also a lot of access to other roads and trails from the Enchanted Circle that attract high use throughout the year.

The Enchanted Circle is currently a focus of local communities. The chambers of commerce for Taos, Angel Fire, Red River and Questa are beginning to partner and plan ways to add or improve recreational opportunities along the byway, in addition to making it an extended stay location. The Carson NF has been engaged in these discussions and looks to more partnership opportunities in the future.

Critical Habitat

Critical habitat (USDI FWS 2015a) is defined under the Endangered Species Act as a specific geographic area that contains features essential for the conservation of a threatened or endangered species and that may require special management and protection. Critical habitat may include an area that is not currently occupied by the species, but will be needed for its recovery. Critical habitat does not preclude activities within its borders; however, conservation of the habitat for the identified species is of first consideration when planning or allowing activities in these areas. The Carson NF has two identified critical habitat areas. One is for the southwestern willow flycatcher, consisting of 148 acres on the Camino Real RD (Figure 83, p. 443), and the other is for the Mexican spotted owl consisting of 22,954 acres on the Jicarilla RD (Figure 85, p. 445).

The southwestern willow flycatcher territory is located within the Camino Real local zone (Figure 6, p. 28). The habitat is currently in use by the species. Invasive plant species, with the exception of tamarisk, are encroaching on this critical habitat and the vegetation composition is slowly changing as the willows are dying. Beaver dams in the area have also been removed for irrigation purposes, which has lowered the water table used by the birds.

The Mexican spotted owl critical habitat is located within the Jicarilla local zone (Figure 85, p. 445) which is drier and less diverse than rest of the forest (Chap. II. Integration and Risk Assessment, p. 306). There is no known occupation by the Mexican spotted owl within the critical habitat boundaries. Critical habitat for the owl is not favorable for occupation, because the mixed conifer in the area has died off and has been replaced by ponderosa pine.

Inventoried Roadless Areas

The 2001 Roadless Rule establishes prohibitions on road construction, road reconstruction, and timber harvesting on 58.5 million acres of inventoried roadless areas (IRAs) on NFS. The intent of the rule is to provide lasting protection for IRAs within national forests, in the context of multiple-use management. IRAs comprise 2 percent of the land base in the continental United States. IRAs are within 661 of the nation's over 2,000 major watersheds and provide many social and ecological benefits. There are 12 IRAs on the Carson NF, totaling around 105,000 acres (Table 102).

Table 102. Inventoried roadless areas[1] on the Carson National Forest, by ranger district and local zone

Inventoried Roadless Area	Size (acres)	Ranger District	Local Zone
Bull Canyon	11,512	Canjilon	Rio Chama
Canjilon Mountain	7,971	Canjilon	Rio Chama
Osier Mesa	2,840	Tres Piedras	Cruces Basin
Comales Canyon	4,388	Camino Real	Camino Real
Pecos	13,434	Camino Real	Camino Real
Sierra Negra	9,469	El Rito	Rio Chama
Cruces Basin	5,243	Tres Piedras	Cruces Basin
Latir Peak	3,572	Questa	Red River
Columbine-Hondo Wilderness Area	43,738	Questa	Red River
Bull-of-the-Woods	487	Questa	Red River
Wheeler Peak Wilderness	2,677	Questa	Red River

While most of the IRAs on the forest attract little attention by the public, Comales Canyon and Canjilon Mountain IRAs have generated interest from two different industries. The Carson NF's 1986 forest plan identifies a portion of the Comales Canyon IRA as a potential expansion of the Sipapu Ski and Summer Resort's special use permit boundary under "Management Area (MA) 15 – Potential Recreation Sites". In the early 1990s, Sipapu Ski and Summer Resort submitted a proposal to the Forest Service that included a proposed expansion into MA15 and Comales Canyon IRA. Ultimately, the proposal was not approved by the Forest Service. The 2001 Roadless Rule now supersedes this forest plan management area allocation and administration of the entire Comales Canyon IRA comes under the direction of the Roadless Rule.

In addition, an expression of interest for oil and gas leasing was made to lease 23,000 acres of NFS lands on the Canjilon RD, which would have included much of the Canjilon Mountain IRA. In 2014, BLM released a draft reasonable foreseeable development scenario for the South Chama Basin (including the Canjilon Mountain IRA) and found the area had "low potential for oil and

[1] Many of the acres are in designated wilderness areas

gas occurrences" (USDI BLM 2014c). At this point in time, no further interest by industry has been expressed.

While these IRAs do not have separate management plans, management direction is provided by the 2001 Roadless Rule and what is prescribed in the Carson NF's 1986 forest plan for Management Area 20 – Semi-Primitive. The condition of the IRA depends on the local zone it is located in (Figure 83 p. 443; Figure 84 p. 444; Figure 85 p. 445; and Table 102). More information on the ecological condition of local zones can be found in Chap. II. Integration and Risk Assessment (pp. 306-307).

Wild Horse Territories

The Wild Free-Roaming Horses and Burros Act of 1971, as amended by the Federal Land Policy and Management Act of 1976 and the Public Rangeland Improvement Act of 1978, directs the protection and management of wild horses and burros on public lands. The Forest Service, by authority of the Secretary of Agriculture, is responsible for managing the nation's wild horses and burros on NFS lands. The Forest Service administers 37 wild horse or burro territories in coordination with the BLM (USDA FS 2013c). The Carson NF has four designated wild horse territories, but only two are occupied and managed – Jarita Mesa Wild Horse Territory and Jicarilla Wild Horse Territory (Table 103).

Table 103. Wild horse territories on the Carson National Forest

Wild Horse Territory	Size (acres)	Ranger District
Jarita Mesa	23,882	El Rito
Jicarilla	75,986	Jicarilla

More information on the Wild Horse Program for the Carson NF can be found in the Range, Wildlife and Wild Horses section (p. 384). Of the two wild horse territories being actively managed, the Jarita Mesa territory is located within the Vallecitos local zone and the Jicarilla territory is located within the Jicarilla local zone. The Vallecitos local zone is characterized by large amounts of at-risk Mixed Conifer, with Frequent Fire (MCD) ERU (pp. 56 and 302) and Ponderosa Pine Forest, (PPF) ERU (pp. 60 and 302). Montane Subalpine Grassland (MSG) ERU (p. 37 and 303) is also at risk because of tree encroachment, reduced groundcover, shifts in species composition, and degraded soils (Chap. II. Integration and Risk Assessment, p. 306). The Jicarilla local zone is characterized as being drier and less diverse than most of the forest (Chap. II. Integration and Risk Assessment, p. 306). Soil and streams are at risk from sedimentation, water bodies are uncommon, and the area is highly vulnerable to drought and climate change.

Both wild horse territories are overpopulated and significantly over their appropriate management levels. This adds additional stress on the local ecology of the wild horse territories through reduced grass cover, damage to riparian areas, and competition for forage with cattle and other native foragers.

Outstanding National Resource Waters

There are 53 Outstanding National Resource Waters (ONRW) on the Carson NF, as designated by the NM Water Quality Control Commission (Table 104). This designation protects all surface waters within Valle Vidal and perennial rivers and streams, lakes and wetlands within the Wheeler Peak, Latir, northern Pecos, and Cruces Basin Wilderness Areas. ONRWs receive the highest level of protection under the New Mexico's Water Quality Standards, which establish designated uses for water bodies, set criteria to protect those uses, and establish provisions to preserve water quality. ONRWs are subject to the same water quality criteria as other waters with the same designated uses; however, ONRWs receive additional protection aimed at preserving water quality. Degradation of water quality is not allowed in ONRWs except under very limited circumstances. Where water quality meets or exceeds standards, that higher water quality must be protected. Nonpoint sources of pollution in these areas must be minimized and controlled through the use of best management practices (BMPs). Maps and information about these ONRWs can be found on the NM State Environment Department's Website (NMED 2015).

Table 104. Outstanding National Resource Waters (ONRW) on the Carson National Forest

Designated Segment	Ranger District
Valle Vidal (18)	
Rio Costilla	Questa
Comanche Creek	Questa
La Cueva Creek	Questa
Fernandez Creek	Questa
Chuckwagon Creek	Questa
Little Costilla Creek	Questa
Holman	Questa
Gold Creek	Questa
Grassy Creek	Questa
LaBelle Creek	Questa
Vidal Creek	Questa
Middle Ponil Creek	Questa
Greenwood Canyon	Questa
Shuree Lakes	Questa
North Ponil Creek	Questa
McCrystal Creek	Questa
Seally Canyon	Questa
Leandro Creek	Questa
Latir Peak Wilderness (8)	
Bull Creek	Questa
Bull Creek Lake	Questa
Heart Lake	Questa
Lagunitas Fork	Questa
Lake Fork Creek	Questa
Rito del Medio	Questa
Rito Primero	Questa

Designated Segment	Ranger District
West Latir Creek	Questa
Wheeler Peak Wilderness (9)	
Black Copper Canyon	Questa
East Fork Red River	Questa
Elk Lake	Questa
Horseshoe Lake	Questa
Lost Lake	Questa
Sawmill Creek	Questa
South Fork Lake	Questa
South Fork Rio Hondo	Questa
Williams Lake	Questa
Pecos Wilderness[1] (12)	
Rio San Leonardo	Camino Real
San Leonardo Lake	Camino Real
Rio de las Trampas	Camino Real
Trampas Lakes	Camino Real
Hidden Lake	Camino Real
Rio Santa Barbara	Camino Real
West Fork	Camino Real
No Fish Lake	Camino Real
Middle Fork	Camino Real
East Fork	Camino Real
Serpent Lake	Camino Real
Horseshoe Lake (Alamitos)	Camino Real
Cruces Basin Wilderness (6)	
Beaver Creek	Tres Piedras
Cruces Creek	Tres Piedras
Diablo Creek	Tres Piedras
Escondido Creek	Tres Piedras
Lobo Creek	Tres Piedras
Osha Creek	Tres Piedras

The ONRWs in Valle Vidal currently do not meet existing water quality standards. These waters are functioning at risk; however, this trend is beginning to improve from restoration efforts aimed at improving water quality as well as from management changes. The water quality and condition of ONRWs in wilderness areas vary. Many of the water sources have not been assessed. The majority that has been assessed show impairment from turbidity and increased water temperatures, due to lack of shade. The goal of the Carson NF is to return the impaired ONRWs back to functioning condition through restoration efforts and changes in management. All ONRWs on the forest face many of the risks as outlined in Chap. II. Aquatic Ecosystems (p. 193)

[1] Carson NF only – northern Pecos Wilderness

and Chap. II. Integration and Risk Assessment (pp. 303 and 304). Some of these risks include water diversions, climate change, and ungulate foraging and grazing.

Zoological Areas

A zoological area is a designated area that contains animal specimens, animal groups, or animal communities that are significant because of their occurrence, habitat, location, life history, ecology, rarity, or other features (FSM 2372.05 (4)). The Pea Clam Zoological Area is the only zoological area on the Carson NF. The Sangre de Cristo pea clam is on the State's Group 1 Endangered List and only known to occur in the Middle Fork Lake on the Questa RD; however, this pea clam has not been determined as a valid separate species at this time (Lang 2013). The lake, its shoreline, and immediate surrounding drainage are within the designated area as protected habitat for the pea clam. No activity is allowed within the Pea Clam Zoological Area that would alter the water chemistry of the lake.

The Pea Clam Zoological Area is located in the Upper Red River Watershed of the Red River local zone. This watershed is functioning at risk (Table 32, p. 197) meaning it exhibits moderate geomorphic, hydrologic, and biotic integrity, relative to its natural potential condition (p. 403). In terms of ecological integrity, provided the pea clam is a valid species, this is the only location within the State of New Mexico where it is found.

Botanical Areas

A botanical area is a designated area that contains plant specimens, plant groups, or plant communities that are significant because of their form, color, occurrence, habitat, location, life history, arrangement, ecology, rarity, or other features (FSM 2372.05(3)). The Haplopappus Microcephalus Botanical Area is the only botanical area designated on the Carson NF. *Haplopappus microcephalus* is a small-headed goldenweed that is on the State Endangered Plant List. It is only known to occur on the massive granite outcrops northeast and northwest of Tres Piedras. The largest of these outcrops is on the Carson NF. The designated area is 60 acres and restricts any activity that will impact the plant. Recreational rock climbing occurs in the area and plants are monitored for impacts from this activity.

The Haplopappus Microcephalus Botanical Area is located within the Vallecitos local zone on the Tres Piedras Ranger Distract (Figure 84, p. 444). As described earlier, this zone is characterized by large amounts of at-risk Mixed Conifer, with Frequent Fire (MCD) ERU (pp. 56 and 302) and Ponderosa Pine Forest, (PPF) ERU (pp. 60 and 302). Montane Subalpine Grassland (MSG) ERU (p. 37 and 303) is also at risk because of tree encroachment, reduced groundcover, shifts in species composition, and degraded soils (Chap. II. Integration and Risk Assessment, p. 306). The *Haplopappus microcephalus* adds to the ecological integrity of the area, because the three outcrops on the Carson NF are the only place within the State of New Mexico where it has been located.

Potential Need or Opportunity for Future Designations

The Valle Vidal (Valley of Life) Unit was donated to the Forest Service in 1982 by the Pennzoil Company of Houston, Texas. The unit consists of 101,794 acres on the northern part of the Carson National Forest. The Carson forest plan, signed in 1986, does not provide desired conditions, standards, or guidelines for the Valle Vidal Unit (Management Area 21), because there was a lack of resource inventory information when the Valle Vidal was acquired late in the planning process. Currently, the Valle Vidal Unit is managed under forest-wide prescriptions of the Carson forest plan.

There is the potential for a historical landmark to be designated on the Carson NF as well. The Aldo Leopold house on the Tres Piedras RD may be eligible for this designation, given its historical significance in the Aldo Leopold legacy to both the area and the Forest Service.

Other opportunities for special designations potentially include additional wilderness areas and adding more miles to the Wild and Scenic River System. Both of these will be further evaluated in the forest plan revision process through a wilderness inventory and evaluation and a wild and scenic river evaluation. The wild and scenic river evaluation will also include a previous eligibility study that was conducted in 1994 (Camino Real RD), 1996 (El Rito and Tres Piedras RDs), 1998 (Jicarilla and Questa RDs), and 2001 (Canjilon RD) that identified and evaluated the potential of adding additional miles to the current system.

Other potential special designations such as RNAs, National Recreation Trails, zoological areas, and botanical areas will also be further considered and evaluated in the forest plan revision process. The Valle Vidal Unit is recognized as having outstanding resource attributes, such as its bristlecone pine area and habitat for Rio Grande cutthroat trout. It is also known for its exceptional scenic and recreational values. There is a high potential that the Valle Vidal Unit could meet the criteria for a number of special designations upon further analysis during the forest plan revision process.

Groups have also expressed interest in potential designations for wilderness areas and special protections for various wetlands. The NM Wilderness Alliance and Wilderness Society have petitioned the forest to consider designating IRAs as wilderness areas, in particular the Comales Canyon IRA (“Pecos Addition”). Amigos Bravos, a local watershed advocacy group, has expressed interest in adding special protections for certain wetlands on the Carson NF, while participating in the June 2015 public meetings. The northern New Mexico ranching community also requested the Carson NF (and the Santa Fe NF) be identified as designated area for cultural and historic resources to recognize the dependency and use of the forests and their natural resources by Native Americans and Hispanics dating back to the late 1500s. These considerations will be carried forward into the forest plan revision process.

Nearby Designated Areas

In addition to the specially designated areas found within the Carson NF, there are areas specially designated by other agencies that surround the forest. These areas add recreation values, scenic values, wildlife opportunities, and other resources values and complement those of the forest.

Bureau of Land Management

The Rio Grande del Norte National Monument was proclaimed in March 2013 and encompasses over 240,000 acres in north-central New Mexico. It includes most of the Rio Grande Gorge, the Wild and Scenic Rio Grande, and an extensive volcanic field to the west, known as the Taos Plateau. The Monument is administered by the BLM and was created to protect four objects of value: (1) geology; (2) cultural and historic resources; (3) ecological diversity; and (4) wildlife. The BLM is expected to have a management plan completed for this area in 2016. The Monument also hosts several recreation opportunities such as camping, whitewater rafting, hiking, hunting, birding, and biking. The BLM also administers two developed recreation areas within the assessment area – Wild Rivers Recreation Area and Orilla Verde Recreation Area (USDI BLM Taos Field Office 2014b).

State of New Mexico

The State of New Mexico has several areas designated for recreation and for wildlife. The state also has historical markers scattered throughout all of the counties (NM State Parks 2012; NM Stopping Points 2015). Locations of these markers are found on the state's Website. The recreational sites, state parks, and wildlife areas near or in the assessment area are as listed below:

Recreational Sites and State Parks

Harold S. Brock Fishing Area

Morphy Lake Fishing Area

Red River State Hatchery

Rio Costilla Fishing Area

Rio de los Pinos Wildlife and Fishing Area

Springer Lake

Cimarron Canyon State Park

Coyote Creek State Park

Eagle Nest Lake State Park

El Vado Lake State Park

Heron Lake State Park

Navajo Lake State Park

Vietnam Veterans Memorial State Park

Wildlife Areas

Charette Lakes Wildlife Area

Colin Neblett Wildlife Area

Elliott Barker Wildlife Area

Tres Piedras Wildlife Area

Urraca Wildlife Area

Fish and Wildlife Service

The USDI Fish and Wildlife Service administers the Maxwell National Wildlife Refuge in northeastern New Mexico (USDI FWS 2014b). The refuge encompasses 3,699 acres of short-grass prairie, playa lakes, woodlots, wetlands, and crop fields. It is in an open basin, at about 6,000 feet, surrounded by high mesas to the northeast and the Sangre de Cristo Mountains to the west. Since 1965, this landscape has been managed for the benefit of wildlife and has provided feeding and resting habitat for migratory birds.

National Park Service

Located near Los Alamos, the National Park Service's Bandelier National Monument protects over 33,000 acres of rugged canyon and mesa country, as well as evidence of a human presence dating back over 11,000 years (USDI NPS 2014). Petroglyphs, dwellings carved into the soft rock cliffs, and standing masonry walls pay tribute to the early days of a culture that still survives in the surrounding communities.

Northern Rio Grande National Heritage Area

In 2006, Congress designated the Northern Rio Grande National Heritage Area (NRGNHA), which stretches south to north from I-40 in the center of the State to the Colorado border. Area boundaries include all of Rio Arriba, Santa Fe and Taos counties, a total area of 10,000 square miles in north-central New Mexico. This area includes almost all of the Carson NF. The mission of the NRGNHA is to sustain the communities, heritages, languages, cultures, traditions, and environment of northern New Mexico, through partnerships, education, and interpretation. The heritage area's management plan identifies opportunities to enhance recreational resources and develop others through partnerships with federal agencies, such as the Forest Service (NRGNHA 2011).

The Carson NF works closely with all of these state and federal agencies should the need arise in land management planning, either by the forest or by another agency that may have influence or opportunities on the forest.

Contributions of Designated Areas to Social, Economic, and Ecological Sustainability

The designated areas on the Carson NF possess specific criteria that made them eligible for a national, regional, or local designation. They stand out as having exceptional or special characteristics not commonly found across the assessment area. These unique characteristics can be recreationally based, scenery based, culturally based, or ecologically based. By virtue of their exceptional character, they make social, economic, and ecological contributions according to what the area or designation is recognized.

Social and economic contributions are especially evident in the areas and designations that promote recreation and scenery. These include wilderness areas, various designated trails, wild and scenic rivers, scenic byways, and IRAs. These special places or opportunities serve to bring people to the forest. It was stated earlier in this chapter that recreation and tourism (p. 345) are the primary social and economic contributors to the plan area. This industry brings over 2,100 jobs and over $150,000,000 in economic benefits to the communities surrounding the Carson NF. These specially designated areas serve as key attractions and play a vital role in providing these benefits.

The designations that include research natural areas, critical habitat, wild horse territories, outstanding national resource waters, zoological and botanical areas, and areas of resource concern, contribute ecologically by providing protections and restrictions that preserve or maintain ecological traits that have been identified as highly important or sensitive.

Summary

Designated areas on the Carson NF signify exceptional areas that have distinct or unique characteristics warranting special designation. The forest has 14 special designations including:

- 6 wilderness areas
- 1 proposed research natural area
- 1 national scenic trail
- 2 national historic trails
- 3 national recreation trails
- 8 miles of national wild and scenic river
- 1 scenic byway
- 11,785 acres of critical habitat
- 105,331 acres of inventoried roadless areas (these include the wilderness areas)
- 4 wild horse territories
- 6 areas with outstanding national resource waters
- 1 zoological area
- 1 botanical area

The Carson NF also has additional areas that have potential for designation. Some of these areas include Valle Vidal and the Aldo Leopold House, eligible wild and scenic rivers, potential RNAs, and recommended wilderness areas.[1] Designated areas on the forest are important ecologically and socially for the exceptional values they offer and protect. These areas will continue to be important as their contributions will be required to sustain the special qualities they were designated for.

[1] An wilderness inventory and subsequent evaluation are required as part of the forest plan revision process (36 CFR § 219.7(v) and FSH 1909.12 Chap 70).

Infrastructure

Infrastructure refers to the human built property created to support the use of NFS lands. It includes roads, trails, dams, bridges, and administrative and recreation facilities owned and managed by the Forest Service, as well as roads and utility infrastructure owned and managed by other governments and private entities. The plan area infrastructure influences the forest's ability to contribute to the social, cultural, and economic conditions within the plan area and the broader landscape. Infrastructure should allow for sufficient access and use of the forest, to take advantage of the multiple uses and ecosystem services the forest offers. It should be integrated within the landscape, to preserve scenic beauty and unique character and enhance the experience of forest users. Forest infrastructure should be well planned, managed, and maintained, so as not to harm the ecological integrity of the forest and to allow for continued enjoyment and use of the forest. This section identifies and evaluates:

- The current condition and maintenance level of the forest's infrastructure – roads, bridges, administrative and recreation facilities, dams, utility systems, trails and other infrastructure.
- How funding and maintenance trends may affect infrastructure in the future.
- The contribution infrastructure makes to public's ability to use and benefit from forest resources.

Ecosystem Services of Infrastructure

Forest transportation infrastructure supports the ability of the forest to provide ecosystem services by allowing access for Forest Service employees to implement project work, which contributes to the health of forest ecosystems. Healthy forest terrestrial, riparian, and aquatic ecosystems increase the ability of the forest to provide supporting and regulating ecosystem services. Transportation infrastructure allows visitors to gain access to the many provisioning ecosystems services important to them. The trail system, campgrounds, and other recreation infrastructure provide cultural ecosystem services through recreation opportunities, scenic vistas, and enjoyment with nature.

Transportation Infrastructure

Well maintained and sufficient road infrastructure is important for safe, reliable, and convenient access to and within the Carson NF. Transportation infrastructure includes the federal, state, and county roads, which allow visitors to access the forest from all parts of New Mexico, as well as across the country. It also includes the many miles of roads and bridges owned and maintained by the Forest Service, which allow visitors to take advantage of its many uses and enjoy the beauty of the forest.

Primary Access Routes Servicing the Forest

Primary motorized access to and through the Carson NF is by a network of federal, state, and county highways (Figure 86). Visitors, as well as local communities, have ample opportunity to experience, use, and enjoy the forest from all parts of New Mexico and surrounding states. These roads are well maintained and typically open year-round. The high mountain passes through the forest are subject to periodic closure during heavy winter snows. Both maintenance and winter snowplowing of these are the responsibility of the different government entities. Many of these roads serve as primary access for communities in and around the assessment area. Currently there are no new major road or bridge projects planned or underway within the assessment area.

The Carson NF consists of an east side and a west side, separated by the Taos Plateau and Rio Grande Gorge. The west side has four ranger districts – Tres Piedras, El Rito, Canjilon, and Jicarilla. Tres Piedras and Jicarilla RDs are accessible from Taos to the east and from Tierra Amarilla, Bloomfield, and Farmington to the west, via U.S. Highway (US) 64. The ranger districts may be reached from Colorado to the north and Espanola and Santa Fe to the south from US 285. The Canjilon RD is accessible from Tierra Amarilla and Espanola by US 84. Visitors can access the El Rito RD, from US 285 to the east and US 64 to the southwest.

On the east side the Carson NF has two ranger districts, Questa and Camino Real, which are separated by the Taos Pueblo. The Questa RD is accessible from Colorado to the north and Taos to the south via State Highway (NM) 522. NM 38 goes east from the Village of Questa, from NM 522, through the district to the Town of Red River and to Angel Fire, on the far eastern side of the forest. The Village of Taos Ski Valley, located within the Questa Rd, is accessible only from Taos to the south, via NM 150. Valle Vidal, located to the north in the Sangre de Cristo Mountains, is reached through smaller county roads.

The Camino Real RD is accessible from the east and west by NM 75. Access from the south is from NM 76, which continues west to US 68. Camino Real Ranger Station in Peñasco is accessible from Taos by NM 518, also provides access to the Sipapu Ski and Summer Resort, in center of the ranger district.

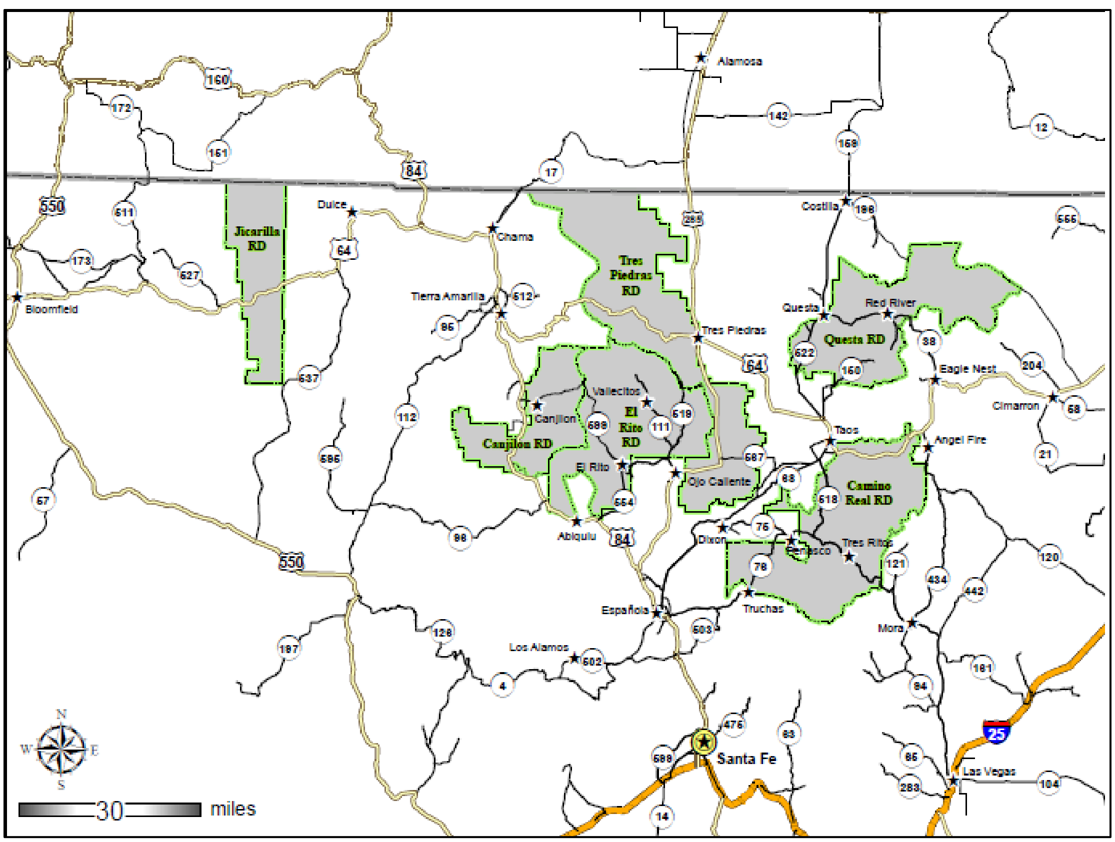

Figure 86. Major access routes in and around the Carson National Forest

Forest Transportation System

The Forest Service uses the term maintenance level (ML) to describe the level of service provided by, and maintenance required for, a specific NFS road. Maintenance levels must be consistent with the intended use of the road and specific maintenance criteria. The ML provides an indication of the level of comfort and safety the user would expect to experience, while operating a vehicle on the road. A high volume road for passenger car use would be set at a higher maintenance level than a road to access an undeveloped remote site.

Roads are assigned ML's 1 through 5. ML 1 roads are closed to all vehicular traffic, but may require basic custodial maintenance to prevent damage to adjacent resources or to preserve the road for future resource maintenance needs. Roads assigned to ML 2 through 5 may provide year-round or intermittent access. ML 2 roads, which are managed for high-clearance vehicles, provide the majority of access to the Carson NF for recreational and other purposes (i.e., hunting, camping, access to trailheads, firewood gathering).

The Carson NF Motor Vehicle Use Maps (MVUMs) identify 2,613 miles of accessible NFS roads on the forest (Table 105). Approximately 2,130 miles (84%) are ML 2. The remaining accessible NFS roads (484 miles) are ML 3 to ML 5 and are managed for passenger car use. Maintenance level 5 roads require the greatest amount of maintenance effort to maintain traffic highway safety standards.

Table 105. Miles of Forest Service roads by maintenance level

ML2	ML3	ML4	ML5	Total
2,130	385	43	55	2,613

Maintenance of forest roads occurs from early May through November, weather permitting. At the high elevations of the Carson NF, heavy winter snows prohibit safe access for crews to evaluate roads conditions and perform maintenance outside this time period. Weather is a major contributor to road conditions on the forest. Day and nighttime temperature extremes during winter months create continuous freeze thaw conditions, which can create potholes and damage roads. Summer monsoons can cause excessive flooding and high water flow, which fills drainage ditches with debris, creates ruts, and erodes road surfaces.

A high volume of dispersed camping along FS roads 437 and 76 has created erosion, trash, and vegetation destruction along these corridors. Forest road 437 runs along the Rio Chiquito where the high vehicle and camping use result in trash problems and erosion and sedimentation into the river.

Forest management prioritizes the maintenance of ML3 to ML5 roads ahead of ML2 roads. These roads must adhere to federal traffic highway standards to ensure public safety. In a given maintenance season, these roads receive all appropriate required maintenance. While adequately maintained, many ML2 roads, which are not subject to the same federal highway standards, do not receive maintenance on a regular interval. Current funding levels do not allow for appropriate maintenance of all NFS roads on a regular basis. Since 2010, funding levels for road maintenance have remained constant and averaged about $711,000 per year. There are indications road maintenance funding will decrease or remain constant in the future. The result may be less regular road maintenance, which could lead to increasing degradation of FS roads over time, particularly ML 3 roads, which typically have gravel or well-compacted dirt surfaces. ML 3 through 5 roads will continue to receive maintenance first, as public traffic safety is a high priority, but the Carson NF may experience longer intervals in the maintenance of some ML2 roads. Approximately 263 miles of ML2 roads on the Jicarilla RD are maintained and funded by the oil and gas industry, as part of their lease operations. Currently, the deferred maintenance backlog for the Carson NF is $4.8 million. The maintenance includes drainage, traffic signage, surface and roadway repairs, and vegetation removal.

Bridges

The Carson NF has 22 road bridges as part of its transportation system. Fourteen of these are rated in "good" condition and eight are in "fair" condition. The bridges in fair condition are currently safe for vehicular travel, but require maintenance to bring them up to the higher standard. Formal bridge inspections are conducted every two years. Any safety hazards are repaired the following year. To date, funding for bridges has been made available to complete all required safety maintenance.

The forest bridges are older infrastructure. All but one of the forest's bridges was built before 1975, with the oldest in 1937. To date, the bridges have been maintained in good working order, but many of these structures will require extensive rebuild or replacement as they get older. The forest is currently completing a $500,000 bridge project on one of the two bridges constructed in 1937. The current deferred maintenance for bridges on the forest is $1.2 million.

Travel Management

The 2005 Travel Management Rule (USDA FS 2005c)requires each national forest and grassland identify a system of NFS roads, trails, and areas for motor vehicle use by vehicle class and, if appropriate, by time of year. Designated roads, trails, and areas are identified on the Carson NF through four MVUMs: (1) Jicarilla RD; (2) Tres Piedras, Canjilon, and El Rito RDs (west side); (3) Questa RD; and (4) Camino Real RD. Consistent with the rule, motor vehicle use off designated roads, trails, and areas identified on an MVUM is prohibited on the Carson NF. The MVUM currently identifies 2,613 miles of NFS roads open to motor vehicle use.

Facilities

Administrative Facilities

The Carson NF has nine administrative sites. The administrative sites include the Supervisor's Office, six ranger stations, the Cañon Administrative Site (Camino Real RD), and one unoccupied visitor center complex (Canjilon RD). The Supervisor's Office in Taos and the Jicarilla Ranger Station are leased, the others are owned by the Forest Service. The Jicarilla RD also leases a seven-acre site from the BLM to house wild horse captures. With the exception of the Jicarilla Ranger Station, the ranger stations are self-contained compounds, typically include an office, warehouse/shop, residences/crew quarters, materials storage sheds, horse facilities, and water/wastewater systems. The Cañon facility includes living quarters for the Carson Hotshots and a house that seasonal employees can stay in during their tour of duty.

The Piedra Alumbre Visitor Center (Canjilon RD), formerly the Ghost Ranch Living Museum, was donated to the Forest Service in the 1960s. The site is currently unoccupied and not in use. It includes a visitor center, auditorium, gallery, living quarters, an historical exhibit building, a mock lookout tower, a warehouse, several outdoor exhibits, a stand-alone water system, and a gravity flow lagoon wastewater system. Under the Forest Service Facility Realignment Act, this facility has been approved for conveyance. Several steps, including a hazardous materials assessment, must occur before this facility can be transferred to another owner.

The Carson NF maintains a total of 99 administrative buildings. Each structure receives a facility condition assessment by qualified personnel every five years. The inspections result in the documentation of all required maintenance needs. The result of comparing the required maintenance to the generated replacement value for each asset is a facility condition index (FCI). The FCI correlates to a facility condition rating of good, fair, or poor (Table 106). A rating of poor typically indicates the need for major repairs.

Table 106. Administrative buildings on the Carson National Forest, with their facility condition ratings

Ranger District	Number of Structures	Good	Fair	Poor
Jicarilla	10	10	0	0
Tres Piedras	13	4	6	3
Canjilon	14	2	8	4
Piedra Alumbre VC (Canjilon RD)	11	1	6	4
El Rito	15	12	3	0
Questa	12	4	5	3
Camino Real	15	6	8	1
Cañon Admin Site (Camino Real RD)	9	3	4	2

The deferred maintenance of administrative facilities on the Carson NF, excluding the visitor center complex, is valued at over $1.6 million dollars. With a limited budget to address all facility needs, prioritization of investment in maintenance occurs according to the following sustainability goals: (1) address existing or potential health and safety hazards; (2) emergency repairs to restore serviceability of building; (3) repair to the existing building and utility system to prevent further damage and deterioration; (4) maintenance of facilities to the objective service level; and (5) improvements to reduce maintenance and operation costs.

Many of the facilities identified as being in poor condition are historic adobe buildings. These buildings are currently being maintained to address only required health and safety issues. Priority for maintenance is given to office, residential, and warehouse buildings. The facilities budget for maintenance of these buildings has not increased in recent years, leading to the significant deferred maintenance backlog. The expectation is that future funding will not increase, resulting in a decline in the condition of other administration facility structures.

Recreation Facilities

The Carson NF has 32 developed campgrounds (p. 357). All of the campgrounds have vault toilets (see Wastewater Systems, p. 471) and 10 provide drinking water (see Drinking Water Systems, p. 471). Four sites have horse corrals and five sites have pavilions with picnic facilities. The majority of these sites have routine maintenance performed by a contracted concessionaire. Major construction and repairs at the sites is performed by the Forest Service. With the exception of several vault toilets that are in poor condition, the campsites are maintained to Forest Service standards and overall are in good condition. The forest's current budget for recreation maintenance is inadequate to properly maintain all recreation facilities. The budget for recreation maintenance has been steadily decreasing. Future funding for recreation maintenance is not expected to keep up with required maintenance needs.

Drinking Water Systems

The Carson NF has 13 drinking water systems - 10 systems serve recreational facilities and 3 serve administrative sites. All of the recreational drinking water systems were developed or improved during the 1990s and are currently in good condition. The administrative sites include the Cañon site, the Tres Piedras Ranger Station and the Piedre Lumbre Visitor Center, which is currently closed. The remaining administrative sites are served by municipal water systems. The Canjilon and El Rito ranger stations are scheduled to have their exterior and interior piping system replaced in FY2015. The water piping feeding the Tres Piedras Ranger Station is supplied by well water a mile away and is currently in poor condition. The maintenance to replace this piping is estimated at nearly $400,000. There are small leaks throughout the length of the pipe. A major leak would result in the shutdown of the system and potentially the ranger station until it is repaired or replaced.

Wastewater Systems

The Carson NF administers 19 wastewater systems. Eighteen are the administrative sites and one is located at the Echo Canyon Amphitheater Day-Use Area. There are 88 vault toilets as part of the recreation facilities (campground, trailhead, or day-use area). Two of the administrative sites are on municipal systems; the others are either the traditional gravity fed septic tank and leach field, or septic tanks with lift stations that move wastewater up to a mounded leach field where high water tables are an issue.

The majority of the vault toilets on the forest were installed in the 1970s and 80s, but have been replaced in the last 20 years as part of campground reconstruction projects. In the 1990s, several new vault toilets were installed as part of new or expanded recreation areas. Vault toilets are an all-inclusive system that contains both the building and the below-ground vault for wastewater. Currently 41 vault toilets are in good condition, 29 are fair, and 18 are in poor condition. The approximate replacement value for one vault toilet is $40,000. Replacement of the 18 poor condition units would cost around $720,000.

The deferred maintenance of septic/wastewater systems on the Carson NF currently is estimated at $280,000. Once a septic tank/leach field system fails, it must be replaced in its entirety. Since wastewater is an important health and safety issue, funding for future administrative wastewater projects is a priority. The 18 vault toilets that are in poor condition will probably not be replaced in the near future, because of limited recreation funds.

Trail Systems

Trails are a part of the recreation facilities. The Carson NF administers a total of 684 miles of trails, of which 85 are designated as motorized trails and 599 as non-motorized trails. Over the past 5 years, the Carson NF has annually maintained 100-110 miles or around 20 percent of its trails to Forest Service standard. The maintenance work has included logging out of felled trees, tread restoration, and brushing back encroaching vegetation. Fallen trees along trails after heavy snows create the majority of maintenance work.

The non-motorized trail system is currently in good shape. Trail crews have been able to provide adequate maintenance on a regular recurring cycle. Trail signage is not in good condition on many trails. Intense sunlight, winter snows, and some vandalism have taken a toll on the signage, and the forest has not been able to keep up with the required repair or replacement. The motorized trail system has many areas in poor condition and most of the trails are deeply rutted and eroded. Maintenance of motorized trails requires mechanized equipment and is more labor intensive. With limited workforce capacity the Forest is challenged in adequately maintaining these trails. The majority of ATV trails are on the Camino Real RD and riding of ATVs on unauthorized trails has resulted in damage to vegetation and increased erosion and sedimentation. With the implementation of the Travel Management Rule, the forest is working to close and prevent access on unauthorized trails and roads.

Over the past five years, the Carson NF has had as many as six and as few as two trail crew personnel. Funding levels dictate how many people can be employed and how much work can be accomplished. Volunteers and partners have been used for trail maintenance, although this has been a limited resource.

Historically, recreation funding has decreased each year. The trend is for funding to continue to decrease. As the emphasis increases on developing a sustainable recreation program, the need for safe, accessible trails, maintained to standard will be an ongoing requirement. The forest cannot currently maintain motorized trails to standard and new signage will be required on a regular basis. The ability to continue to maintain non-motorized trails to standard may also be impacted.

Communication Sites

The Carson NF has two designated communication sites. One is located on San Antonio Mountain and the other on Saw Mill Mountain. These sites are used by other entities for their communication equipment needs. There are 8 administrative sites and 14 remote sites throughout the forest that have communication equipment utilized by the Carson NF. Of the 14 remote sites, two are located on the Santa Fe NF, one is currently on land belonging to the Trust for Public Lands, and another is on the Carson NF located in a building belonging to Taos Ski Valley Resort The site owned by the Trust for Public Lands is part the land Miranda Canyon land acquisition. This site also has communication equipment owned by other entities. Currently, the majority of the communication equipment and sites are all in good condition. The exception is the microwave system that links the forest's dispatch center at the Supervisor's Office in Taos to the tower located on San Antonio Mountain. This system is critical for allowing radio communication between forest dispatch and the rest of the forest.

To date, the Carson NF has been able to readily identify any maintenance issues and keep the sites in good condition. The average age of the communication equipment on the forest is about

10 years. Most of this equipment will be up for replacement in the next five or so years. The cost for replacement is borne by the Forest Service Chief Information Office.

The continued maintenance and service of the communication sites and equipment is critical for Forest Service personnel and public safety. Most of the forest is not accessible to mobile phone service. The current trend is for funding to be available when needed to perform maintenance.

Dams

The Carson NF has 23 inventoried earthen dams located with the plan area. Twenty-two of these dams were constructed to create recreation fishing areas. The Cabresto Dam, located on the Questa RD, was constructed as an irrigation dam for the farmland in the Questa area. This dam is permitted to the Llano Irrigation District, which is responsible for its operation and maintenance. The dam was recently reconstructed by the New Mexico Office of the State Engineer. It is one of two on the forest identified as a high hazard dam, meaning it is inspected annually because a dam breach could be catastrophic. The other, created as a recreational fishing dam, is the Upper Shuree Pond Dam, located in Valle Vidal. This dam impounds the largest body of water on the forest and is currently in need of repairs estimated at 1 million to 1.5 million dollars.

Half of the remaining 21 dams are in need of some repair including: (1) dredging to increase water depth for fish survival through the winter; (2) rodent eradication on the dam face to prevent water intrusion; and/or (3) spillway and outlet reconstruction. The remaining dams need minor maintenance. The deferred maintenance for these dams is $360,000. Failure of any of the 23 recreational dams would result in the loss of recreational fishing opportunities. Failure of the two high hazard dams could result in a loss of life and environmental damage downstream. Failure of any of the five significant hazard dams would potentially cause environmental damage downstream.

Range Infrastructure

The Carson NF’s range infrastructure includes fencing, water developments, cattleguards, and corrals. There are thousands of miles of range fencing on the forest. Most of the fencing is very old and in poor to fair condition. The forest typically provides fencing materials, but permittees are required to provide the maintenance of fences for their allotments. Materials for maintenance and improvement to fencing and other range infrastructure are funded through permit fees, about $30,000 per year. Cattleguards on the forest are structurally in good shape, but require cleaning due to sediment build up. This work is completed by the Forest Service’s road maintenance crew.

Water developments include stock tanks, water wells, windmills, and pipelines. The recent drought conditions have shown a need for additional water developments in numerous locations on the forest. Many existing water developments require maintenance or cleaning. New water developments can cost $15,000 or more. New water developments or repairs to existing water developments are the responsibility of permittees. Most permittees cannot afford the necessary costs and ask for assistance from the Forest Service, which has limited funding available. Some permittees have sought grants or other funding. In Valle Vidal, new water developments are being installed out of riparian areas, to draw livestock away from these sensitive areas.

Climate change is expected to intensify drought conditions in the future. The need for new water developments or improvements to existing will become more important for permittees. Greater emphasis placed on watershed restoration will influence the need for new developments to be located away from water resources. Maintenance of existing fencing will continue to be required to keep livestock on appropriate pastures and allotments. A continuing issue between the Forest Service and adjacent landowners is the encroachment of livestock grazing onto private land from Forest Service allotments. Since New Mexico is a “fence-out” state, adjacent landowners are required to fence livestock out of their private lands from adjacent lands, including NFS lands.

Other Infrastructure

Several electrical, telephone, and oil and gas distribution systems cross the Carson NF, but are owned, operated, and maintained by public utilities or private companies. These systems and other infrastructure require a special use permit or an easement from the Forest Service (see Land Use, p.481). The infrastructure is significant because poor design and/or management can impact forest resources. For example, a power line pole on the Camino Real RD was felled by a beaver and ignited a fire. Hundreds of water guzzlers are also maintained throughout the forest. These are large tanks designed to catch, hold, and dispense water for wildlife. Some locations are fenced in to keep out cattle. Funding to construct and maintain the sites is either through federal, state, or non-profit programs.

Sustainability of the Forest Infrastructure

Over the last 20-years, the Carson NF has invested millions in mission critical and non-critical facilities. Three new ranger station offices have been constructed, and all but two of the crew quarters/residences have been remodeled. The forest’s trail system is in good condition and its roads and bridges are currently safe for visitor travel. However, recent facility budgets are half of what was distributed to the forest in past years. If this trend continues, it is likely that some of the infrastructure will deteriorate beyond repair, which will force decisions on consolidation and possibly relocation.

Contributions of Infrastructure to Social, Economic, and Ecological Sustainability

The Carson NF’s transportation system is integral to supporting the many uses and opportunities enjoyed by the public. Roads allow access to gather firewood, hunt, fish, hike, and recreate. Local businesses and communities benefit from visitors who want to use the forest because they can safely access and experience the forest on NFS roads and trails. Gaining access to the forest through roads and trails is important for local residents to continue their traditional uses, which are integral in maintaining the social and cultural fabric of many forest communities. The trail system allows forest users to hike for exercise or simply to experience the beauty of the forest. Recreation infrastructure (i.e., trails, dams that support fishing areas, roads, campgrounds, and toilet facilities) allow for recreation opportunities, which support communities directly (e.g., ski area and outfitter guide jobs) and indirectly (e.g., increased tourism in community lodging, shops, and restaurants). A well planned, managed, and maintained forest infrastructure allows for these opportunities.

Infrastructure contributes to ecological sustainability when it is properly designed, integrated within the landscape, and well maintained. Transportation infrastructure allows Forest Service personnel to access the forest to perform valuable monitoring and to implement land and water restoration projects. Wildlife guzzlers provide fresh drinking water in times of low rainfall and when natural water sources are scarce.

Negative economic and social contributions would result in having to close sites, because funds are inadequate for appropriate maintenance to keep sites safe for human use. Closures would reduce or limit opportunities to access and gain enjoyment from recreational resources and experiences. Ecological damage would result from a key dam failure, major road or trail erosion, or issues with septic systems.

Summary

Infrastructure in the plan area is being maintained to a good standard overall. Funding is the biggest risk to maintaining infrastructure into the future. Funding levels have decreased in recent years, while the costs to perform maintenance have increased. Closure of infrastructure (i.e., motorized roads, administrative facilities, and campgrounds) could result in reduced access, recreation services, and enjoyment by the public. Deterioration of infrastructure (i.e., roads, dams, and utilities) could result in ecological damage to the forest.

Land Ownership and Status, Use, and Access Patterns

This section discusses existing patterns of land ownership, status, and use both within and near the Carson NF. It explains how land status, ownership, use, and access patterns influence the plan area and how management of the Carson NF may influence land use and access.

Land Ownership

Land ownership is the basic pattern of public and private ownership of surface and subsurface estates. It refers to the ownership of land and interests in land. This section assesses how land ownership patterns both influence and are influenced by management of the Carson NF.

Existing Land Ownership

The Carson NF is located within four northern New Mexico counties– Rio Arriba, Taos, Mora, and Colfax. Table 107 displays land ownership within these counties. The majority of the Carson NF land area resides in Rio Arriba and Taos counties. The forest comprises approximately 23 percent of Rio Arriba County and 37 percent of Taos County. Fifty percent of these two counties combined are federally administered. The Carson NF is the primary holder in both. With the combination of federal, state, and tribal lands, only 23 percent of Rio Arriba and 32 percent of Taos County is privately owned. The amount of the Carson NF within Mora County (1.4%) and Colfax County (2.9%) is less significant. In Mora County and Colfax County respectively, 84 percent and 85 percent of the land is privately owned.

Table 107. Land ownership (percent) in the counties that include the Carson NF (Headwater Economics 2015)

	Colfax County	Mora County	Rio Arriba County	Taos County	County Region	U.S.
Privately Owned	85.4	84.3	23.0	32.8	50.2	58.7
Conservation Easement	0	N/A	0.1	N/A	0.0	0.6
Federal Lands	3.2	9.1	52.4	53.9	33.1	28.8
Forest Service	3.0	8.5	37.3	36.6	23.8	8.4
Carson NF	2.9	1.4	23.4	36.6	16.8	N/A
Santa Fe NF	N/A	6.9	14.0	N/A	6.9	N/A
Kiowa Grasslands	0.1	0.5	N/A	N/A	0.1	N/A
BLM	0.0	0.6	15.1	17.3	9.3	11.1
National Park Service	N/A	0.1	N/A	N/A	0.0	3.4
Military	N/A	N/A	0.1	N/A	0.0	1.1
Other Federal	0.2	N/A	0.0	N/A	0.0	4.7
State Lands	11.4	6.5	3.7	5.1	6.4	8.4

	Colfax County	Mora County	Rio Arriba County	Taos County	County Region	U.S.
State Trust Lands	9.6	5.9	2.3	4.4	5.1	1.9
Other State	1.8	0.6	1.4	0.7	1.3	6.6
Tribal Lands	0.0	N/A	20.9	8.2	10.2	4.0
City, County, Other	0.0	N/A	N/A	N/A	0.0	0.2

The Carson NF encompasses 1,587,097 total acres, with 1,486,372 acres[1] administered the Forest Service and 100,725 acres in other ownership within its boundaries. Many of the other ownership areas are small towns or communities, but a large number are small parcels of privately owned land. These land holdings are typically in the lower elevations. Most of the towns and communities are located along rivers or other water sources.

The forest shares boundaries with other federal, state, tribal, and private lands. The BLM's Rio Grande del Norte National Monument resides between the east and west sides of the forest, in both Taos and Rio Arriba counties. BLM also has land, which borders the west side of the Jicarilla RD. Three Indian Reservations border the forest: (1) the Jicarilla Apache Indian Reservation to the east and south of the Jicarilla RD; (2) the Taos Pueblo, which resides between the Questa and Camino Real RDs; and (3) Picuris Pueblo, which is bounded on three sides by the Camino Real RD. To the north, the State of Colorado borders both the Jicarilla and Tres Piedras RDs. The Tres Piedras RD is also adjacent to the Rio Grande NF in Colorado. The Santa Fe NF, which occupies 14 percent of Rio Arriba County, shares an extensive border with the Carson NF along the southern portion of the Canjilon, El Rito, and Camino Real RDs.

The remaining lands are state and private lands. There are several significant private land holdings within or bordering the Carson NF. The Village of Taos Ski Valley, the Town of Red River, and the recently closed Chevron Questa Mine reside within the Questa RD. Rio Costilla Park, a privately owned recreation area, resides along the north boundary of the Questa RD. The village of Truchas is surrounded by both Carson and Santa Fe NFs. In the western zone of the forest, the Petaca Land Grant resides within the Tres Piedras RD. Several communities, Canjilon and El Rito, are within the forest boundary.

Encroachment onto NFS lands is a recurring issue with many of the private land holdings, primarily those inside the forest boundary. Encroachment issues are typically identified when a property adjacent to the forest is sold and a survey is completed.

Trends Affecting Land Ownership

The Carson NF is currently not actively seeking to expand its land area through either acquisitions or land exchanges; however, the forest has acquired two significant large areas and one smaller area in the last 33 years. In 1982, the 100,000 acre Valle Vidal, north and east of the Questa RD, was donated to the U.S. Department of Agriculture by the Pennzoil Company and

[1] This acreage is calculated using the North American Datum 1983, Universal Transverse Mercator zone 13; however the USDA Forest Service's 2012 Forest Land Areas Report (USDA FS 2012c) states the NFS land area is 1,393,418 acreas with 98,794 acres as other ownership within its boundaries.

placed under the management of the Forest Service through the Carson NF. In 2013, the forest acquired the 4,990-acre Miranda Canyon, which is adjacent to the Camino Real RD, in Taos County. The acquisition was through the Trust for Public Land, a national organization that purchased the property from a private landowner. The Trust held the land until it could be purchased by the federal government using Land and Water Conservation funds. In addition, the Carson NF acquired 900 acres adjacent to the Echo Amphitheater on the Canjilon RD in 2005.

The 1986 Carson forest plan identifies and classifies 25 parcels of land throughout the forest as base in exchange. These are lands (including surface and/or subsurface estates) that are in excess to National Forest needs and may be traded for lands having value for national forest use, management, and enjoyment. The forest plan also identifies 50 parcels of land as recreation acquisition composite areas. These are private landholdings within the forest boundary that would add value to existing NFS lands. The forest is not actively seeking these lands, but would consider any requests from the owners to sell, exchange, or donate these lands to the Forest Service.

Taos Ski Valley Inc. recently changed ownership and the new owner has invested in major construction and renovation projects on private land, as well as within the ski area's permit area on the Carson NF. The ski area and the Village of Taos Ski Valley are looking to upgrade and increase available electric power, as well as provide natural gas and additional broadband services. The improvements and infrastructure upgrades have the potential to increase tourism and residential growth in the area.

Kit Carson Electric Cooperative, the major electrical provider for Taos County is looking to deliver more green power to the area. In addition, both Taos and Rio Arriba counties are working with their respective electrical providers to bring broadband to the many rural communities and the Pueblos their service areas.

Drought and the availability of water affect land ownership. The two most populated counties in the assessment area, Rio Arriba and Taos, have limited land and available water. Both counties carefully manage residential growth and land available for agriculture. Northern New Mexico has experienced drought over the past 15 years (see Chapter II. Water Quantity section, p. 144). The prolonged drought has increased the risk of more severe and intense fire. Colfax, Rio Arriba, and Taos counties each have County Wildfire Protection Plans (CWPP), which seek to control and manage residential growth in the wildfire urban interface.

As land ownership changes around the forest, there is a potential that access to tribal cultural and sacred sites on the forest may be impacted.

Influences of Land Ownership on Social and Economic Conditions

The Carson NF occupies much of the land that provides for the traditional and cultural uses of local communities and families. Generations of users have relied upon the forest for firewood gathering, grazing lands, herb gathering, hunting, and diverting water to acequias. These traditional and cultural uses contribute to the social fabric and support the economies of the families and communities who live near the forest.

With almost 77 percent of Rio Arriba County and 67 percent of Taos County owned by federal and state governments or Tribes, the region lacks private land within and adjacent to existing communities, for expansion and sustainability. Because so little of Rio Arriba and Taos counties are in private ownership, land ownership has a big influence on social, economic, and ecological conditions. The tax base in both counties is very limited, due to the lack of land that is able to be developed. Mora and Colfax are similarly affected even though most of their lands are in private ownership. Most of their populations are centered on lands adjacent to the Carson NF.

The region's unique land ownership pattern also acts as a draw for millions of visitors to the Carson NF each year. Visitors to the forest and its counties generate tourism and recreation jobs and provide tax revenue for local governments. The Carson NF makes payments in lieu of taxes to the counties in which it resides. In addition, the Carson NF makes up 55 percent of the PILT funds provided by all federal agencies residing in the four-county area (see Carson National Forest's Contribution to Local Economic Conditions, p. 344).

Expanding recreation uses both on and off the forest have the potential of impacting adjacent tribal lands. The Taos Pueblo has had hikers in the Wheeler Peak Wilderness and from Taos Ski Valley encroach upon their lands and cultural sites. More visitors and recreationists on the forest increase the potential of wandering onto sacred places or sites with cultural significance. In addition, power and energy corridors and large utility sites need to well-planned and coordinated with tribes so as not to interfere with sacred sites.

Land Status

Land status is defined as the ownership record of title to lands, including withdrawals, rights, and privileges affecting or influencing the use and management of NFS lands. For NFS lands, land status refers to the use or specific designations of a geographic area that provide general guidance and policy for the management of a defined geographic area. This guidance can take the form of use restrictions (e.g., withdrawals or dedication) and encumbrances (e.g., rights-of-way acquired or granted, reservations, outstanding rights, partial interests, or easements). Land status differs from land ownership. Land ownership refers to the ownership of land and interests in land; whereas, land status refers to the legal character or condition of the land.

Information Sources

As established in 36 CFR Part 200.12, the Land Status Records System (LSRS) is the official repository for all realty records and land title documents for NFS lands. The LSRS is maintained at the Regional Office level and is the electronic record for realty information backed up by hard copy records maintained at the region and forest offices. The LSRS records include an account of acreage, condition of title, administrative jurisdiction, rights held by the United States, administrative and legal use restrictions, encumbrances, and access right on land or interest in land in the National Forest System.

Maintenance of the Land Status Records System includes the final review, processing, posting, and permanent retention of records creating any change in landownership status. This includes notation and filing of laws and executive orders affecting landownership and jurisdiction, all landownership adjustments (exchange, purchase, donation, transfer, boundary modification, title claims, sales, grants, excess property), use restrictions (withdrawals, designations, dedications, wilderness, other special areas), encumbrances (rights-of-way acquired or granted, reservations, outstanding rights, partial interests, easements), and changes attributable to resurveys.

The Land Areas of the National Forest System Report (LAR) is an annual publication that tracks NFS system ownership and provides the latest statistics on land areas administered by the Forest

Service. The report provides acreage figures for NFS lands in a variety of ways such as by forest, by state, and for wilderness areas and other special designations.

Existing Land Status

The Carson NF was established on November 7, 1906. It was formed by combining the Taos NF and a portion of the Jemez NF. The original forest comprised 966,000 acres. These lands were “reserved” from the public domain (land owned by the federal government), for the establishment of national forests, giving the lands originally included in the Carson NF Reserved Public Domain status.

Many landownership adjustments (i.e., exchanges, purchases, and donations) have occurred since the creation of the Carson NF. In the case of land exchanges, federal land has been conveyed to the private sector and non-federal land has been received in exchange. The land so acquired takes on the status of the federal land conveyed, which in most cases is Reserved Public Domain. Lands that have come into federal ownership by purchase or donation, have “acquired status” as determined by the Weeks Act Status for Certain Lands Act of September 2, 1958 (16 USC 521a), as amended. Two recent significant land acquisitions were the 100,000 acre Valle Vidal Unit that was donated by the Pennzoil Company to the Forest Service in 1982 and the purchase of the 4,990-acre Miranda Canyon in 2013.

In December 2014, the U.S. Senate passed the Columbine-Hondo Wilderness Act (S. 776/H.R. 1683) as part of the National Defense Authorization Act. Section 3061 designated 45,000 acres of NFS lands in New Mexico as the Columbine-Hondo Wilderness. The Act modified the boundary of the Wheeler Peak Wilderness and provided for the conveyance of several small parcels of NFS lands to the Town of Red River and the Village of Taos Ski Valley.

With the addition of the Columbine-Hondo Wilderness Area, the Carson NF has six designated wilderness areas, totaling approximately 129,119 acres. Lands that have been designated as wilderness areas are withdrawn from all forms of appropriation under the mining laws and from disposition under all laws pertaining to mineral leasing and all amendments thereto (Wilderness Act of 1964). A withdrawal is an action that restricts the disposal and use of public lands and which holds them for specific public purposes and programs.

The 1986 Carson forest plan identifies 64 parcels of land as withdrawn from mineral entry. These parcels are existing developed recreation sites throughout the Carson NF. The forest has since added recreation sites that have also been withdrawn. In December 2006, Congress passed the Valle Vidal Protection Act. The act withdrew Valle Vidal from all forms of mineral entry, with an exception for existing rights.

The forest has eight administrative sites. Two of these sites are leased and six are owned by the Forest Service. Three of these six sites are on NFS lands and three are located off the forest. The two leased sites are also outside NFS lands. An administrative site is typically located outside NFS lands and has a special designation that restricts the area to occupation by support buildings and their grounds.

Trends Affecting Land Status

As part of its plan revision process, the Forest Service is required to inventory, evaluate, and analyze potential wilderness areas on the Carson NF. Any areas of the forest that get through this process would become candidate areas for recommendation as wilderness as part of the final record of decision. The Santa Fe and Rio Grande NFs must go through a similar process. As part of its amendment process for the Rio Grande del Norte National Monument, BLM will look at potential wilderness areas.

Influence of Land Owner Status on Social, Economic, and Ecological Conditions

Land status can restrict certain activities on NFS lands. Most notable of these are areas that are withdrawn from mineral entry, which eliminates commercial mining activity. Conversely, these same designations can provide additional opportunities for the public (see Land Ownership and Outdoor Recreation sections).

Land Use

Land use is how the land is currently zoned or designated, such as for residential, commercial, industrial, or agricultural use. It includes land use, development, and management policies and direction established in formal plans developed by federal, state, county, and municipal governments.

Land Use Policies

Carson National Forest

The 1986 Carson forest plan (USDA FS Carson NF 1986) is the principal document that guides forest managers' decisions about management of the land and resources. The forest plan identifies how resources will be managed forest-wide, through a set of management prescriptions for each resource. The plan subdivides the forest into 21 geographic management areas. These areas specify management prescriptions for the more focused management of resources in a given area. Forest-wide prescriptions supplement and support the prescriptions for management areas.

Prescriptions include a set of desired conditions, objectives, standards, and guidelines, which provide direction on how to manage the resource. Variance from forest-wide prescriptions or management area direction may occasionally be required, due to unforeseen site conditions, unexpected natural phenomena, improvements to existing management direction, and/or changes to policy and regulations. Where variance is unavoidable, the plan can be amended to achieve consistency. Since it was completed in 1986, the Carson forest plan has been amended 16 times. Some of the amendments that have changed the extent and location of various forest-wide and management area prescriptions are:

- A 300-acre Potential Natural Research Natural Area (1989)
- The Pot Creek Interpretive Resource Center (1990)
- The Mexican Spotted Owl and Goshawk Management Plan (1996)
- The Jarita Mesa Wild Free-Roaming Horse Management Plan (2002)
- The Wildland Fire Management Plan (2012)
- The Travel Management Plan (2013)

Other Neighboring National Forests and Federal Land Management Agencies

The Santa Fe NF completed its forest plan in 1987 (USDA FS Santa Fe NF 1987). The Santa Fe National Forest's Land Management Plan identifies 19 management areas. The current plan has 13 amendments, several of which make significant adjustments to management areas. The Santa Fe NF is currently in the process of revising its existing forest plan, similar to the Carson NF. The forests share a large boundary and many of the same forest users. Both forests share designated wilderness areas and water resources. The forests are working together to address similar management issues of many of their resources.

The Rio Grande NF completed its forest plan in 1985 (USDA FS Rio Grande NF 1985). The Rio Grande National Forest's Land Management Plan identifies 8 management areas. The Rio Grande NF is in the process revising its existing forest plan. The plan revision began in FY 2015, one year after the Carson and Santa Fe NFs. Both the Carson NF and Santa NF will work together with the Rio Grande NF to address similar management issues of many of their resources.

The BLM has two field offices that are adjacent to the Carson NF. The Taos Field Office is located in Taos, close to the Carson Forest Supervisor's Office. In 2012, the Taos Field Office published the Taos Resource Management Plan (RMP)(USDI BLM Taos Field Office 2013). The RMP provides broad-scale direction for the management of public lands and resources comprising about 594,700 surface acres and 1.5 million acres of mineral estate ,within Colfax, Harding, Los Alamos, Mora, Rio Arriba, San Miguel, Santa Fe, Taos, and Union counties. The Field Office is in the process of amending its plan to include management for the Rio Grande del Norte National Monument (USDI BLM Taos Field Office 2014a).

The Farmington Field Office published its Farmington RMP in 2003 (USDI BLM Farmington Field Office 2003). The RMP provides guidance for managing approximately 1,415,300 acres of public land and 3,020,693 acres of federal minerals in San Juan, McKinley, Rio Arriba and Sandoval counties.

Counties

Rio Arriba County adopted its Rio Arriba County Comprehensive Plan (RACCP) in 2008 (Rio Arriba County 2008). In both 2009 and 2010 the plan was amended, and is currently being revised. The county is divided into two overlay zone districts, the Energy Resource Development District on the western half of the county, and the Frontier District on the eastern half. The intent is to allow for oil and gas development, while protecting the terrestrial, water, and habitat resources on the east side. The current RACCP expresses a clear desire to protect agricultural lands, the acequia system, and the agricultural traditions and culture of the area.

Taos County adopted its Taos County Comprehensive Plan (TCCP) in 2004 (Taos County 2004). Taos County is currently revising its TCCP. The plan focuses on preserving, protecting, and maintaining existing water resources. It encourages cluster development that integrates with existing development and the landscape. The plan supports the preservation of rural, cultural, and agricultural uses.

Colfax County adopted a Comprehensive Plan for Colfax County (CPCC) in 2004 (Colfax County 2004). Colfax County strongly encourages maintaining its open lands. The plan desires that new developments be closer together and closer to existing towns. They encourage new developments to integrate with existing developments and with the landscape. The county supports agriculture and ranching, which maintain open space in rural areas. In its CPCC, the county encourages cooperation with other government entities in planning land use.

Mora County does not have a published comprehensive plan.

Soil and Water Conservation Districts

The State of New Mexico has required Soil and Water Conservation Districts (SWCD) to write land use plans (LUPs) to promote responsible and effective use and management of the soil and water resources in the SWCDs. East Rio Arriba and Upper Chama SWCDs are actively working with Rio Arriba County to complete a comprehensive LUP. Taos SWCD is currently coordinating to begin the process of writing an LUP and the rest of the SWCDs are planning to write plans in the future. The Carson NF has engaged with the Upper Chama effort to develop its LUP and has actively engaged with the Taos and San Juan SWCD. The forest will continue to actively engage and work with SWCDs, to share resources and work efforts to mutually benefit the conservation and land use efforts of both entities.

State of New Mexico

The New Mexico Statewide Natural Resources Assessment and Strategy and Response Plan was issued in 2010 (ENMRDFD 2010). The plan guides the planning and implementation of natural resource management and restoration activities for the state. The plan also provides strategies of working with and integrating resources across boundaries with federal, tribal, and private landowners. Watershed health and restoration, healthy urban and community forests, and enhanced public benefit from the states natural resources are the primary components of the plan.

Influence of Land Use Planning on Social, Economic, and Ecological Conditions

Due to the large amount of non-private land in both Rio Arriba and Taos counties, changes to land management by public land owners could have a significant influence on both the social and economic conditions in these counties. The private land is a low percentage of the counties and their tax base is very limited, so any changes, particularly acquisition of private land by public land management agencies, could influence the counties' revenue. Mora and Colfax counties are similarly affected, even though most of their lands are in private ownership.

Public lands that have been or could be withdrawn from mineral development may impact the economic well-being of the counties, as these withdrawals have the potential of reducing or eliminating commercial mining or leasing activities and the income associated with them. Any changes to land management across the area of influence in regards to commodity resources could result in negative impacts to the surrounding counties' economic and social conditions. In addition, any changes that cause a reduction in commercial enterprise on public land could have negative impacts on the economy of the counties.

Land Uses

Land uses are authorized uses and occupancy of NFS lands. These include special use authorizations, such as permits, leases, and easements. Special use authorizations are legal instruments, with terms and conditions that are consistent with law, regulation, and policy and are fully enforceable. The Forest Service divides the management of special uses into two categories: recreation special uses and non-recreation (lands) special uses. The lands special uses program permits water transmission lines, acequias, telecommunication sites, research, filming, and road and utility rights-of-way. The recreation special uses include recreational facilities open to the public, such as resorts and ski areas, as well services, such as outfitting and guiding and recreation events. Recreation special uses also include private uses, such as recreational residences and organizational camps. Some types of non-recreational special use are nondiscretionary and require the agency to authorize some uses such as access to private inholdings as required by the Alaska National Interest Lands Conservation Act, Wilderness Act of 1964 (16 U.S.C. 1131-1136), and the National Forest Roads and Trail Act of 1964.

Currently, there are a total of 420 special use authorizations issued on the Carson NF. Some of these special use authorizations may have expired prior to issuance of this report. Of these 420 special use authorizations, 100 are recreation special uses and 320 are lands special uses. Many other temporary uses are not reflected in the total. The forest issues several permits a year for such things as firewood gathering, filming, for ceremonial purposes, and one-time recreation events. Table 108 identifies number of the land use authorizations located by ranger district on the Carson NF.

All Forest Service special use permits have a term limit. The Carson NF evaluates long-term land use and recreation special use permits when the terms of the permit are expiring and apply the same criteria for renewal, as when the permit was first issued. Currently, the Carson NF does not anticipate not renewing any specific permits; however, recently two recreation residences were determined to be abandoned and the forest will reacquire the land and not issue another permit.

Table 108. Long-term land use special use authorizations by ranger district

	Jicarilla	Tres Piedras	Canjilon	El Rito	Questa	Camino Real
Recreation residence	0	0	0	0	20	16
Water development (acequia, waterline, water tank, well, spring, dam, weir)	0	14	13	13	29	11
Access road or trail	2	21	10	7	30	22
Resort, recreation development	0	0	0	0	6	1
Other buildings, warehouse, storage yard	--	2	1	3	7	3
Power infrastructure, oil & gas pipeline, telephone, sewage transmission, other utilities	11	2	13	6	4	8
Communication tower	--	14	1	1	3	--
Cemetery, church	--	--	--	8	4	4

Access to Plan Area

Visitor accessibility to the Carson NF on federal, state, and county roads from outside the plan area is very good (see Transportation Infrastructure, p. 466). Within the plan area, access to the forest on the 2,600 miles of NFS roads is available as designated on the forest's MVUMs. Currently, the Carson NF has issued 92 special use permits to allow access to the many private land holdings, within the forest boundary.

While there are thousands of miles NFS and other roads on the Carson NF, there are some access issues, primarily as a result of the numerous large and small inholdings on the forest. The Carson NF has a large number of ML2 and ML3 roads that travel across existing inholdings (see Forest Transportation System, p. 468). The forest does not have easements for many of these roads. To date, use of these roads has not been an issue, but there is concern that selling of the inholding may cause problems in the future. Many of the inholdings are towns and communities in which there is little concern, but many others are privately owned. When parcels are sold for housing tracts, individual owners often want separate or new access. Developers and real estate agents have come to understand this issue and work with prospective buyers to recognize the limitations of access.

Trends Affecting Access in the Broader Landscape

Access controlled by the state and counties is not expected to change over the next 20 years. For access controlled by the Forest Service, the Carson NF will continue implementation of its motorized travel management decisions by completing mitigations, blocking unauthorized routes, monitoring the effectiveness of closures, and patrolling. Encroachment of forest boundaries by private landowners is an ongoing issue. Given the size of the forest, most encroachment issues are discovered when a property is sold. The forest has seen an increase in properties within the forest boundaries being sold.

Influence of Access on Social, Economic, and Ecological Conditions

Access to both recreational and commercial facilities has a great influence on social and economic conditions. See Infrastructure, p. 466 and Carson National Forest's Contribution to Social, Cultural, and Economic Conditions, p. 336 for further discussion of access.

Opportunities to Provide Open Space Connections

The Carson NF is located between the Rio Grande NF to the north and the Santa Fe NF to the south. The recently designated Rio Grande del Norte National Monument managed by BLM is located in the middle of the Carson NF. Collectively these lands along with State Trust and Tribal Lands and potentially some private lands are a part of the Upper Rio Grande Watershed and maintain an important ecological corridor for wildlife, plants, and water.

The Carson NF manages about 100 miles of the Continental Divide National Scenic Trail (USDA FS 2015b) on the western edge of the forest. The trail traverses the length of the country from Montana to southern New Mexico and provides an open space connection for the public. The majority of the trail is complete and provides a unique opportunity to hike and experience vistas in five states.

Summary

Federal, state, and tribal entities own the majority of land in the assessment area that is suitable for housing, industry, ranching, and agriculture. Communities in the 4-county assessment area are limited in their ability to grow and expand. Communities and local governments rely upon the Carson NF and other federal and state lands for support of their economies, available clean water, and the products integral to supporting traditional and cultural uses. The federal land agencies make payment in lieu of taxes to the counties, which is a vital source of county revenue. Any decrease in these payments could have an impact on the ability of counties to provide public services.

Renewable and Nonrenewable Energy and Mineral Resources

Energy and mineral resources provide ecosystem services that are important to people at a local and, in some cases, regional and even global scales. They are an important contribution to social, cultural, and economic conditions of the assessment area. This section identifies and evaluates:

- The potential for renewable and nonrenewable energy sources on the Carson NF, such as wind, solar, coal, oil, or natural gas. The potential for new transmission corridors is also considered.
- Existing and potential nonrenewable mineral resources, such as locatable mineral deposits, leasable minerals, and mineral materials on the Carson NF and their trends.
- The presence and condition of known abandoned mines and existing geologic hazards in the plan area.
- Impacts of these resources on ecological integrity and species diversity.
- The contribution of these resources to social and economic sustainability.

The Forest Service maintains a national memorandum of understanding (MOU) with the BLM regarding the coordination of locatable/salable mineral resource administration, in concert with the New Mexico Mining and Minerals Division. The Carson NF also coordinates with the New Mexico Oil Conservation Division (NMOCD) on oil and natural gas administration.

The U.S. Mining Laws establish the authority for the appropriation of mineral resources of federal lands, including minerals obtained on mining claims, obtained by mineral lease or obtained by mineral sale. Forest Service Regulations at 36 CFR 228, Minerals, set forth rules and procedures for use of the surface of the National Forest in connection with operations conducted under the U.S. Mining Laws. These regulations cover mineral prospecting, exploration, development and reclamation.

Ecosystem Services of Renewable and Nonrenewable Energy

Energy and mineral resources provide provisioning and cultural ecosystem services important to communities and people around the forest. Provisioning ecosystem services are provided through natural gas deposits, mineral resources, renewable energy generation potential, and electric transmission lines that cross NFS lands. Cultural ecosystem services are provided by clay deposits and other stones used in artwork and traditional practices.

Renewable Energy Sources

Renewable energy resources include biomass, wind, solar, geothermal, and hydroelectric energy. No renewable energy producing sources are currently located on the Carson NF. Two sets of data were used for the assessment of renewable energy sources: (1) Report Assessing the Potential for Renewable Energy on National Forest System Lands (Karsteadt et al. 2005) and (2) the Renewable Energy Atlas of the United States (Argonne National Laboratory 2013).[1] This data

[1] (1) Report Assessing the Potential for Renewable Energy on National Forest System Lands, published by the Department of Energy, National Renewable Energy Laboratory (NREL) and the USDA Forest Service in 2005. This technical report evaluates the potential for solar and wind development on National Forest System (NFS) lands.

(2) The Renewable Energy Atlas of the United States, prepared by Argonne National Laboratory for U.S. Department

shows that there is potential for solar, biomass, and geothermal energy production on the Carson NF, but low potential for wind and hydroelectric energy.

Wind Energy

The Forest Service has not approved any permitted wind power facilities or testing sites on the Carson NF, since the forest has a low potential for wind energy development (Karsteadt et al. 2005). The forest, as well as the greater landscape, has little to no accessible land that meets the criteria for wind power potential.

Solar Energy

There are two general categories of solar technologies: concentrating solar power (CSP) and photovoltaic (PV). CSP technologies use reflective surfaces (usually mirrors) to concentrate the sun's energy to produce heat. The heat then drives either a steam turbine or an external heat engine to produce electricity. In PV technologies, the photons in sunlight are converted directly to electricity. The Carson NF has a high potential for solar development (Karsteadt et al. 2005); however, the forest has not permitted any solar power facilities.

Hydropower

There is no Federal Energy Regulatory Commission licensed hydroelectric power generation on the Carson NF. The forest does not have any water sources that would support commercial hydropower.

Geothermal Energy

Currently, the Forest Service has not permitted any commercial or noncommercial geothermal resource activities on the forest. There are several geothermal projects that occur outside the forest boundary on private lands. The projects utilize low and intermediate temperature resources for agriculture, greenhouses, recreation, and district heating (Fleischmann 2006). The Carson NF has good potential for geothermal energy resources, but the ability to utilize this resource on a larger scale for electrical energy is limited. Issues limiting large scale use are water rights, power transmission, markets, federal regulatory requirements, and a lack of government incentives. The Fleischmann (2006) identified sites in New Mexico with good potential for small and large scale electrical energy production utilizing geothermal resources and none were within the Carson NF. The potential does exist for individual homeowners, businesses, and communities in the assessment area to use geothermal energy as a heating source.

Biomass

The Renewable Energy Atlas identifies Rio Arriba County as a sustainable source for biomass reserves, with estimated resources to produce 150-250 thousand tons of woody biomass per year. In 2013, the Chama Peak Land Alliance completed a USDA wood utilization study for the Chama, New Mexico area (WELC 2013). The study estimates over one million acres of forested land lies within a 50 mile radius of Chama.

No biomass power is currently being produced on the Carson NF or the surrounding assessment area and the future potential is largely unknown. The Chama Peak Land Alliance study found that the Chama region has the wood supply and infrastructure to support a 15 to 20 MW power plant

of Agriculture – Forest Service, Lands and Realty Management, Washington DC.

or a commercial scale biofuel facility, which could be integrated with a wood products facility. The study identified the Carson NF as having 23 percent of the land with available wood supply, and the Rio Grande NF as having 13 percent of the land. Tribal and private lands make up the remaining land sources for wood. No biomass power facilities currently exist in the assessment area, and no investors have stepped up to commit to the development of a biomass power facility.

Transmission Corridors

Currently, there is one large high voltage transmission line that crosses the Carson NF. It is a 115kV line owned and operated by Tri-State Power. The transmission line runs along US 64 in the northern portion of the Camino Real RD and continues across state, private, and BLM lands, crossing the southern portion of the Tres Piedras RD. The Tri-State power line has a 100-foot easement on NFS lands. Kit Carson Electric Cooperative (KCEC), the local electric utility company, has several smaller distribution lines on the forest. The largest follows County Road 150 from Taos to the Taos Ski Valley. KCEC also has a second larger distribution line on the Camino Real RD that follows NM 518. The KCEC power lines have a 40-foot easement. KCEC has several smaller power lines on the Camino Real, Questa, El Rito, and Tres Piedras RDs. As markets change and green energy becomes more prevalent in the future, the potential for new transmission lines is always a possibility on the forest.

Nonrenewable Energy and Minerals

Forest resources included in this section are locatable minerals, leasable minerals, mineral materials, abandoned mine lands, and geologic hazards. Geothermal energy is addressed in the renewable energy section. All federal minerals (which include energy resources) are administered as one of three types: locatable minerals, leasable minerals, or mineral materials. Each of these categories of minerals is administered under separate laws and regulations, and each requires a different means for the public to obtain these resources.

Locatable Minerals

Locatable minerals are defined as hard rock minerals that are mined and processed for the recovery of metals. Certain nonmetallic minerals and uncommon varieties of mineral materials are also considered locatable minerals, such as distinctive deposits of limestone or silica (Forest Service Manual (FSM) 2810, 2007).

Gold and silver: Gold and silver were mined heavily on the Carson NF and the assessment area in the late 1800s and early 1900s. Very little gold was found and the mines were eventually closed. The largest mining operations were on the Questa RD, while other shallower mines were developed on the Tres Piedras RD. There are still recreational miners who pan for gold on the forest.

Uranium: Large uranium deposits are located beneath the Carson NF. In the 1960s and 1970s, extensive testing was conducted on the Canjilon RD and the northeast corner of the Tres Piedras RD to access the potential to extract uranium. The Carson NF has two inactive uranium mines. The Tusas East Slope Mine was mined in 1956 and the J.O.L Mine in 1954 by the Arriba Uranium Company. Both mines are located on the Tres Piedras RD within a mile of each other. Currently, the price of uranium is not high enough to offset the costs of excavation and processing. The prospects are low that uranium will be mined on the Carson NF.

Rare earth: Rare earth minerals, which contain rare earth elements (REE), are needed for cell phones, televisions, computers, I-pods, video games, wind turbines, hybrid/electric cars, solar panels and have been found in pegmatite samples in the Petaca Mining District, which lies west of the Rio Grande near the eastern margin of Rio Arriba County, along the Tusas Range on the Carson NF (Spilde et al. 2011). In a Special Paper on rare earth deposits in New Mexico, McLemore (2014) states, "Although predictions of the amounts of REE needed in the future are uncertain, it is likely that future production can be met by 6-10 new REE mines in the world. The new mines that can meet current regulations and obtain mining permits first will likely be the next REE producers, even if better deposits are discovered later"(McLemore 2014, p. 9). Currently, no proposed plan of operations to mine for rare earth minerals has been received by the Carson NF, but if demand in the U.S. increases, it is possible that further exploration and subsequent extraction may take place in the future.[1]

Leasable Minerals

Leasable minerals include coal, phosphate, sodium, potassium, oil, oil shale, gas, sulfur (in Louisiana and New Mexico) and geothermal resources (FSM 2820, 1994). The only leasable minerals currently administered on the Carson NF are oil and gas. Coal exists under the Carson NF in Valle Vidal on the Questa RD. The coal rights are owned by the Pennzoil Company. There is no indication that Pennzoil has any interest in excavating the coal. The coal is located at levels that make it cost prohibitive to excavate. There is a coal mining facility further east in Colfax County, but it is not being operated at this time.

Oil and Gas

The exploration and production of natural gas and oil on the Carson NF is presently limited to the Jicarilla RD. Mineral lease development and production have occurred on the Jicarilla RD for over 60 years. Jicarilla RD is approximately 153,305 acres, with 3,870 acres of private and 543 acres of state land within its boundary. The district is located in the western portion of Rio Arriba County, on the eastern edge of the San Juan Basin, the most productive coalbed methane basin in North America. All NFS lands on the Jicarilla RD are available for mineral leasing and are currently leased.

In 2008, the Carson NF Supervisor signed a record of decision (ROD) for surface management of gas leasing and development on the Jicarilla RD. The associated final environmental impact statement (FEIS) analyzed leasing of all available unleased lands on the district, as well as the cumulative effects of full field development that was determined by a 2001 reasonable foreseeable development scenario. Based on this reasonable foreseeable development, an estimated 1,509 wells are projected to be drilled on the Jicarilla RD over a 20-year period. As of January 2015, there are 827 active wells (800 on NFS lands) and 208 plugged and abandoned wells located within the Jicarilla RD administrative boundary.

Currently, there are eight approved applications for permit to drill that have not been drilled on the district. The Jicarilla RD has recently experienced a down turn in lease development, with only three wells drilled since 2012, while 20 wells have been plugged during the same time period. The life of a well in the San Juan Basin can extend for more than 50 years. The oldest producing well on the Jicarilla RD was drilled in 1951. Based on operator information, approximately three wells will be drilled on the district in FY 2015.

[1] A participant at a public meeting held in Albuquerque in July 2015, brought the to the Forest Service's attention.

Gas wells on the Jicarilla RD produce primarily from the Pictured Cliffs, Mesaverde Group, Fruitland Coal, and Dakota Formations. Recently, there has been interest in Mancos Shale development within the San Juan Basin, with the current development taking place in the oil plays south of the Jicarilla RD. Mancos Shale gas development is likely to occur on the Jicarilla RD, but due to the current natural gas economic situation, major development is not expected in the next few years.

The average royalties generated from Jicarilla RD mineral leases from 2003 to 2009 were approximately $30 million per year. Table 109 shows the amount of royalties generated on the district from 2009 to 2013.

Table 109. Royalties generated on the Jicarilla RD from 2009 to 2013

2009	2010	2011	2012	2013
$20,200,000	$29,800,000	$28,900,000	$19,500,000	$22,600,000

Resource issues and conflicts surrounding oil and gas development on the Jicarilla RD primarily consist of impacts to cultural resources. Traditionally these resources have been avoided, but in recent years site mitigation has been proposed. The Jicarilla RD has a high site density of archeological sites and cultural resources are often the final driving force for well pad and access road location. Wildlife issues primarily influence projects proposed near northern goshawk or Mexican spotted owl habitat. These issues are mitigated with survey requirements and timing limitations.

As part of oil and gas development, the district has an extensive pipeline system of around 450 miles. This pipeline system is primarily operated under nine special use authorizations. The pipeline system collects natural gas from individual wells on the Jicarilla RD and surrounding areas and transports the gas for off-forest processing. The majority of this system is aging and a considerable amount of annual maintenance is required. In addition to the pipeline system, there is also one power line special use authorization on the district that supports oil and gas development.

The immediate outlook for oil and gas development on the Jicarilla RD is highly variable, with the natural gas economic situation being the primary driving force. Within the last ten years, technological advances have greatly changed the development methods on the Jicarilla RD. During the last decade, the development strategy has gone from drilling vertical wells located on individual well pads to mostly drilling directional and horizontal wells on shared well pads. This has greatly reduced the disturbance footprint. A traditional single well pad encompasses approximately three acres of disturbance, whereas well pads with multiple wells generally reduce the disturbance per well, thus creating less overall disturbance.

Although development has currently slowed on the Jicarilla RD, it is safe to believe that drilling will continue to some degree in the future. The trend toward directional and horizontal drilling and the use of shared well pads will most likely mean less overall disturbance, even at full field development, than what was analyzed in the surface management of gas leasing and development FEIS/ROD.

No proposed or anticipated oil and gas leasing or related activities are occurring on the other districts of the Carson NF. In 2010, an expression of interest was submitted concerning leasing on the Canjilon RD; however, a BLM draft study indicates the potential for oil and gas on the district is low. No analysis has been completed and the area of interest has not been leased at this time.

Natural gas development is occurring in Colfax County, east of the Questa RD and Valle Vidal. There is potential for development in Mora County. No leasing or development is anticipated in Taos County, at present. Oil and gas development is also taking place in southern Colorado, directly north of the Jicarilla RD.

Areas of Resource Concern Related to Oil and Gas Leasing

In 2008, the Carson NF amended its forest plan to identify five areas of resource concern on the Jicarilla RD (Table 110 and Figure 87). These areas were designated to protect their resource values from oil and gas drilling. Alternative drilling technologies and other drilling locations are encouraged within these areas to minimize impacts to the surface resources therein. Leaseholders are also encouraged to prepare a 5-year development strategy prior to proposed development in these areas.

Table 110. Areas of resource concern on the Carson National Forest

Area of Resource Concern	Resource Values
Bancos Canyon	Cultural resources, watershed, wildlife habitat, and seclusion
La Jara Canyon & Valencia Canyon	Undeveloped characteristics, cultural resources, wildlife security, seclusion
Fierro Canyon & Mesa	Undeveloped characteristics
Vaqueros Canyon	Visual resources, wildlife habitat

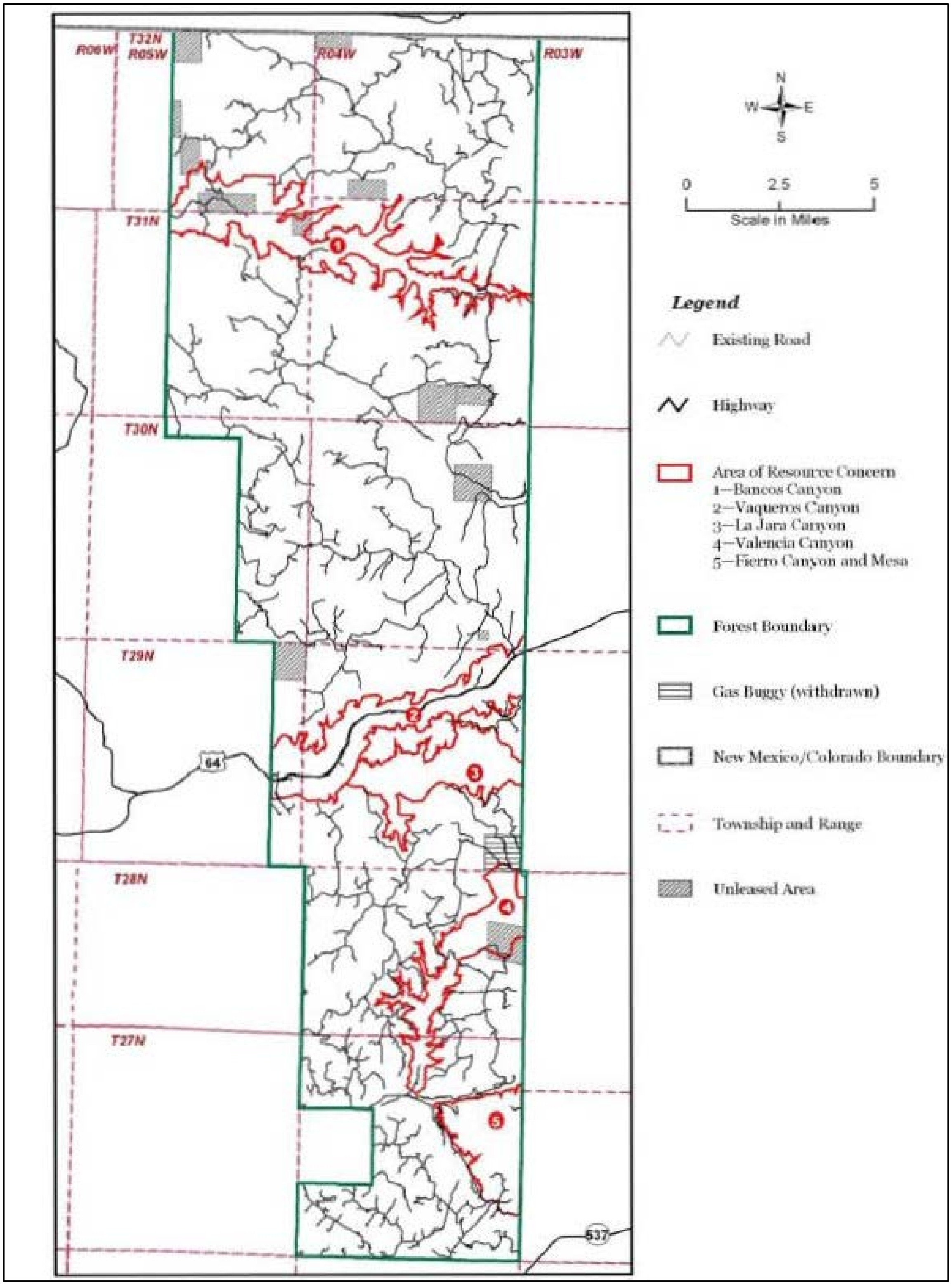

Figure 87. Areas of resource concern on the Jicarilla Ranger District, Carson National Forest

Mineral Materials

Mineral materials are defined as petrified wood and common varieties of sand, gravel, stone, pumice, pumicite, cinders, clay, and other similar materials, and are considered saleable minerals (36 CFR 228). The Carson NF issues contracts or permits to collect mineral materials from certain areas of the forest.

Sand and Gravel

The Carson NF has commercial contracts for sand and gravel and also sells permits for use of four authorized community pits and rock collected along NM 150. Three dual sand and gravel pits are located on the Questa RD and one sand and one gravel pit are located on the El Rito RD. Permits are very inexpensive, as the program is designed to support local communities. The forest operates one sand and gravel pit on the El Rito RD for NFS road repairs. The Jicarilla RD has 11 gravel pits that are operated and used by industry to repair and maintain roads that access natural gas well sites on the district. Sand and gravel is plentiful around the forest and managed availability of sand and gravel for local communities is expected to continue.

Decorative Stone (Moss Rock and Flagstone)

Decorative stone can be found throughout the entire Carson NF. Currently, decorative stone is provided from a single area on the El Rito RD. The forest works to maintain the site to offer a continual source of stone for local communities. The forest limits where stone can be harvested to minimize and control ground disturbance and resource protection; therefore, it is unlikely to develop new sites for decorative stone in the near future.

Clay

The forest provides the opportunity for local communities to harvest clay, particularly micaceous clay, from the Camino Real RD. The forest maintains the site and is expected to continue managing the site into the foreseeable future.

Trends Affecting Minerals Materials Activity

The forest will continue to provide the opportunity for local communities to harvest saleable materials from the forest. The volume sold in a given year is minimal enough that there is no concern of the current sites being overharvested. The volume sold does not create road degradation or create a safety hazard concern.

Abandoned Mine Lands

Abandoned mine lands include areas disturbed by historic mining activities in need of restoration. Many abandoned mine lands contain minerals like arsenic, cadmium, copper, lead, mercury and zinc which can cause human health and environmental hazards as well as other physical safety hazards (USDA FS MGM 2012).

From 2006 to 2012, the Carson NF identified and remediated 31 abandoned gold mines located on the Questa RD. The mines were remediated as part of a Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) project. Periodically, the forest finds abandoned gold and silver mines that are a public safety hazard. The mines are remediated as they are discovered through the states abandoned mine program. Currently, there are no other known abandoned gold mines that pose a safety risk to humans or the environment.

The Carson NF has two abandoned uranium mines on the Tres Piedras RD, the J.O.L. Mine and the Tusas East Slope Mine. In 2013, a preliminary assessment and site inspection were performed to determine the level of hazard (if any) they posed to human health and environmental safety. Both mines pose a health risk to humans and wildlife of uranium and heavy metals exposure, and also pose a potential risk to local groundwater from mine leachate. The assessment is the first phase to establishing long-term site remediation.

The Mica Mine near the Camino Real RD is no longer operating and poses no known threats. The mine did have a permit with the Forest Service to deposit waste material on NFS lands, and his area has since been remediated. The No Agua Peaks perlite mine is adjacent to the Tres Piedras RD in Taos County. The site is still operating, but must periodically do reclamation of mill rejected material. The site poses no known threats. The Chevron Questa Mine site, located within the boundary of the Questa RD, is designated by the Environmental Protection Agency (EPA) as a superfund site. Mining operations at the site began in 1920. Open pit mining was conducted from 1965 to 1983 and resulted in over 328 million tons of acid-generating waste rock being placed into nine piles surrounding the open pit. The Forest Service does not have any direct responsibility for the site, but leakage into the Red River alluvial aquifer and tailing spillage into the Red River have affected NFS lands. Primary pollutants are heavy metals, including aluminum, arsenic, cadmium, chromium, cobalt, fluoride, lead, manganese, molybdenum, sulfate and zinc (US EPA 2015b).

The USGS Mineral Resources Data System (USGS 2014a) shows 267 mine sites on the Carson NF The majority of these are surface prospects or shallow workings that have been reclaimed or naturally remediated, and present no public safety or environmental hazards.

Geologic Hazards

Geologic hazards are defined as those hazards that are geological in nature that pose a risk to human health and safety. They include risks such as earthquakes, floods, avalanches, mud slides, and volcanic activities. Geologic hazards are important in the social context, because they have the potential to affect human safety or the landscape humans use for various needs. On the Carson NF, the specific geological hazards that are relevant to the forest include avalanches, landslides, hydrothermal scars, seismic hazards, and volcanic hazards.

Avalanches and Landslides

Snow avalanches can be extremely destructive due to the great impact forces of the rapidly moving snow and debris and the burial of areas in the runout zone. Structures not specifically designed to withstand the impacts are generally totally destroyed. Where avalanches cross highways, passing vehicles can be swept away, demolished and their occupants killed. Snow avalanches also imperil cross-country skiers, downhill skiers, and snowmobilers and several of the backcountry visitors perish each winter.

The mountains near the Taos Ski Valley are considered a high risk area for avalanches (Figure 88). Taos Ski Valley Resort has an active avalanche detection and prevention program to preclude the likely-hood of an avalanche occurring within the ski area permit boundary. The ski area uses a combination of preventive measures to mitigate risk to skiers. In the early part of the season, boot and ski packing on ski slopes are utilized. As the season progresses and snow buildup increases, explosives are used to trigger avalanches on slopes that are temporarily closed to skiers and boarders. The Red River and Sipapu ski areas are considered low risk areas for avalanches;

however, both areas have avalanche detection and prevention programs that include boot and ski packing of snow, but no explosives.

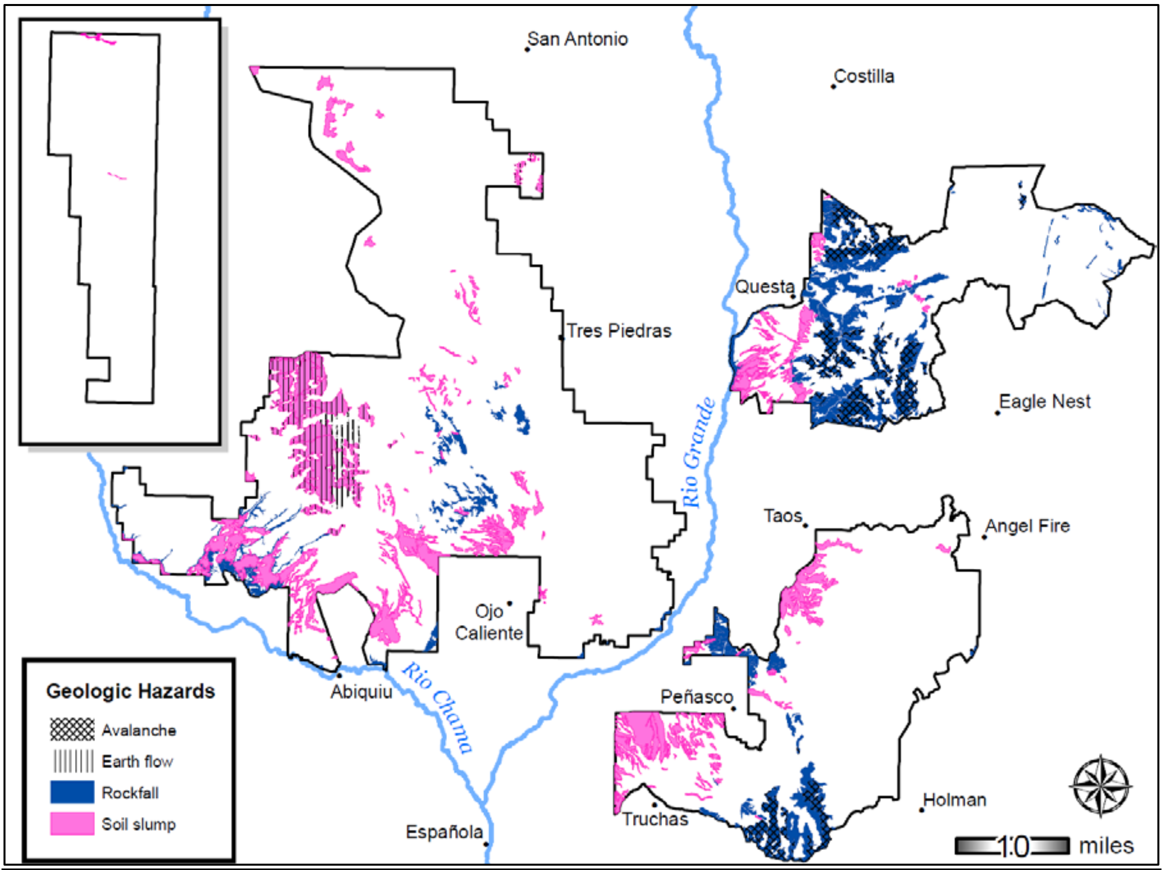

Figure 88. Areas where the potential for avalanches or landslides on the Carson NF is high

The risk of an avalanche occurring in the mountains surrounding the Taos Ski Valley permit boundary is considered high. Much of this area is designated wilderness, where the Carson NF has no avalanche detection or prevention programs. Backcountry skiers who venture into these areas do so at their own risk and are the most likely to impacted in the event of an avalanche.

Earthflows, rockfalls, and soil slumps are considered a type of landslide, each having its own set of characteristics that set them apart from each other. Rockfalls and mudslides are a continual hazard on the Carson NF and frequently occur during the summer monsoon season (Figure 88). Rockfalls are of the greatest concern when they occur along forest and state or county roads with high vehicle traffic. The forest does not provide any engineering controls along forest roads, but quickly responds to any occurrences to make the travel routes safe. Mudslide occurrences can destroy vegetation and impact water quality, and have been known to cross roads, creating a potential safety hazard. Rockfalls and mudflows will continue to occur on the forest. Currently there is little that can be done to prevent these occurrences.

Hydrothermal Scars

Millions of years ago, northern New Mexico was a volcanic hotbed. Evidence of that history is visible throughout the assessment area landscape, most notably on the Questa RD. Hydrothermal scars can be seen driving from Questa to Red River along NM 38. Geologically, the Red River Valley, where these scars are found, is located along the southern edge of the Questa volcanic caldera.[1] These scars were developed on bedrock that has been highly mineralized and altered. The mineralization and alteration were caused by magmatic-hydrothermal fluids released during the crystallization of granitic magma that encroached older volcanic Precambrian rock (Plumlee et al. 2006). The result is depicted in the Figure 89.

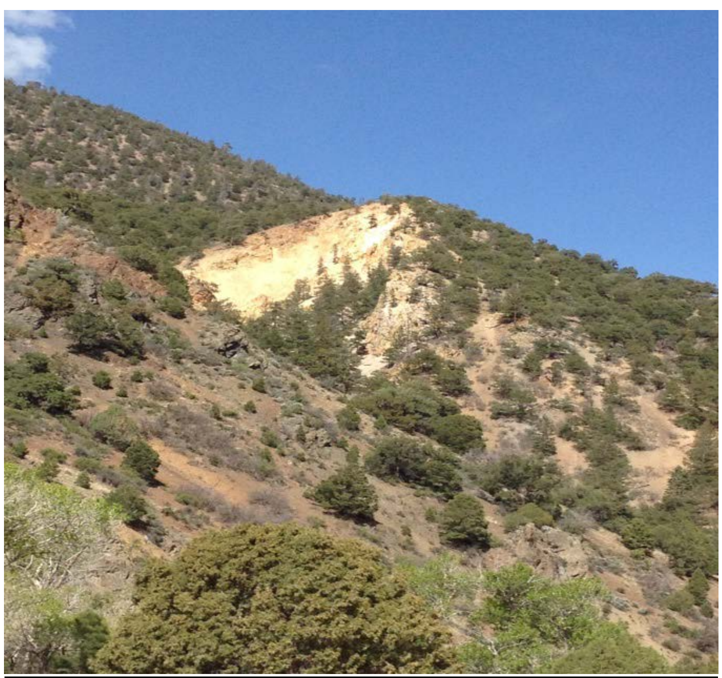

Figure 89. Hydrothermal scar in Red River Canyon on the Carson NF

[1] Calderas are large volcanic craters (Geoscience News and Information 2015).

The geologic hazard these scars pose comes from their acidic soils, particularly when they are washed down during storm and run-off events. They also carry sedimentation during these events that can infiltrate the Red River, which is in close proximity to many of these scars. When driving along NM 38, the river is directly on the south side of the road, and many of these scars are directly on the north side of the road. Debris flows from the hydrothermal scars during storm and run-off events have been known to cross the road and infiltrate the Red River.

Erosion from the scars is a continual threat to the water quality in the Red River, from sedimentation deposits that contain highly acidic and mineralized soils. Debris flows from the hydrothermal scars drop the water pH above neutral (more acidic), until water flow can dilute the pH to more natural levels. Debris flows can plug established channels, causing new channels to be created to transport run-off; thereby, redirecting new debris flows. Additionally, they pose a risk to the forest's recreational facilities along NM 38, namely Junebug and Fawn Lakes Campgrounds, and they can pose a risk to vehicular traffic on the highway.

Seismic and Volcanic Hazards

Parts of the Carson NF, particularly the east side, are located in a geologic setting, known as the Rio Grande Rift. The rift runs from Colorado, through New Mexico, and down into Texas. The rift is still active today; however, the faults usually release their built-up stress as frequent small, imperceptible tremors, rather than as massive, destructive earthquakes (NM BGMR 2014). Historically, the majority of earthquake activity along the Rio Grande Rift has been concentrated in the Rio Grande Valley, between Socorro and Albuquerque (USGS 2015b). Figure 90 shows the probability of an earthquake measuring over 5.0 on magnitude in New Mexico within the next 50 years. The probability of an earthquake strong enough to do significant damage within the assessment area is low.

Volcanoes within the assessment area, particularly the San Luis Basin, have been dormant for millions of years. Research in the USGS Volcanic Hazards Program yielded no threats to the area from volcanos (USGS 2015c).

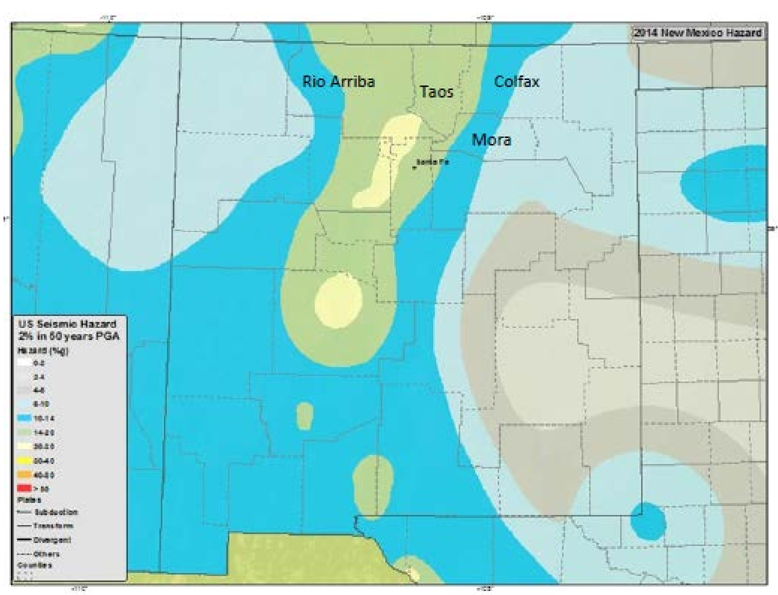

Figure 90. Seismic hazard of an earthquake measure over 5.0 on magnitude in New Mexico over the next 50 years (USGS 2015b)

Impacts of Renewable and Nonrenewable Energy and Minerals Development on Ecological Integrity and Species Diversity

In 2012, the Carson NF completed the cleanup of 31 abandoned gold mines. These mines and mine tailings near water sources had impacted water resources with leachate. The Chevron Mine near Questa is still in remediation. Years of molybdenum mining operations impacted the Red River and its tributaries. The aquatic ecosystems around the Town of Red River on the Questa RD show indications of having poor ecological integrity. Unknown abandoned gold mines on the forest may still pose a risk to groundwater. The two abandoned uranium mines pose a potential risk to wildlife, in the form of ingesting contaminated soils or groundwater.

Oil and gas operations on the Jicarilla RD have continually improved their ability to operate and minimize damage to the environment. The industry works with Forest Service staff on the district to integrate well sites into the landscape. The Jicarilla RD does have poor air quality, but it is primarily due to the coal-fired power plants in far northwestern New Mexico (see Chapter II. Air Resources). There have been no significant oil or gas spills or leaks on the district. The number of wells does lead to heavy vehicular traffic and high erosion of the roads from poor quality soils.

Renewable energies in the form of geothermal or solar energy developed on a large scale disturb soils and potentially displace vegetation. Disturbances occur in the localized area of development, from motorized vehicle access, and the need for transmission lines. These disturbances can impact vegetation, wildlife habitat, and water resources. No renewable energy sources have been developed on the Carson NF and it is not likely there will be in the near future.

Contributions of Renewable and Nonrenewable Energy and Mineral Activity to Social and Economic Sustainability

Oil and gas production provides the largest contribution of energy and mineral activity to economic sustainability in the assessment area. The industry provides good paying jobs, along with taxes for local governments and royalties. The industry is an important economic factor for the cities of Bloomfield and Farmington. There are no other significant nonrenewable energy mineral resources on the Carson NF that support economic opportunity.

The potential for renewable energy sources exist on the Carson NF, but none have been developed to date. Renewable energy sources would provide jobs during initial construction and development and longer term operation. Renewable energy would also contribute to social sustainability, by providing clean energy that does not impact water and air. Long term, these energy sources can contribute to better health and enjoyment of the environment.

Summary

Only a few wells will be drilled on the Jicarilla RD in 2015. The current price of oil and natural gas has made it less profitable to open new wells. The Jicarilla RD has the capacity to potentially support double the number of wells, should the market change. Uranium is the only known locatable mineral of any significance on the Carson NF. There is no current interest to mine uranium on the forest. There is currently little to no renewable energy use on the forest; although, the potential for solar and geothermal energy sources does exist. The forest continues to have recreational prospectors for minerals like gold.

Integration and Risk Assessment

The Carson NF has identified several risks to ecological integrity for terrestrial, riparian, and aquatic ecosystems (pp. 298-307). These risks may impact the forest's ability to contribute too some of the social and economic benefits desired and enjoyed by the public. Three social and economic management focuses that are at risk have been identified as a direct result of ecological conditions: (1) the ability to provide forage for grazing; (2) water for consumption and other uses; and (3) hunting and wildlife viewing. Addressing these risks will require an emphasis on restoring and managing ecosystems, while balancing the management of these resources for public benefit. An additional four social and economic management focuses are at risk for non-ecological reasons: (1) recreation programs and use; (2) infrastructure; and (3) economic and social conditions.

The Carson NF is an integral part of the local cultures and communities it serves. Relationships with local communities and groups are vital in forest management and in providing services to local and visiting forest users. Poor or ineffective communication with the public and the inability to establish partnerships for completing work on the forest were two issues identified by the public, when the Forest Service held community meetings in June 2014. Given the future potential for declining budgets and workforce the Carson NF will need to engage other public and private entities to effectively manage the forest resources to continue to provide for the needs and desires of the public. Through the Collaborative Forest Restoration Program, the forest works with partners on forest restoration projects. It is engaging with private and public entities to acquire funding for watershed restoration work. The forest will need to be creative in identifying other work related to recreation, minor maintenance, and education programs. The challenge for the forest will be in developing the manpower and expertise to identify, plan, and manage new partners and volunteers. The new forest plan for the Carson NF will be successful, if the public and the Forest Service share ownership and implementation of the new forest plan.

Ability to Provide Forage for Livestock Grazing on the Carson National Forest

The ability for the Carson NF to provide adequate forage to contribute to opportunities for livestock grazing in northern New Mexico is at risk of being unsustainable. The departure of many forest ecosystems has reduced the size of forest openings and the quantity of available grasses that are necessary to provide sustainable forage. Ponderosa pine forest and mixed conifer, with frequent fire ecosystems have become denser and more even-aged, increasing the threat of stand replacing fire. Encroachment and infill by woody species, forage competition by other species, and reduced soil stability all contribute to the reduction in the availability of grass cover. Recent drought has contributed the decrease in quality and quantity of available forage. Water tanks for livestock and wildlife use have resulted in an alteration of hydrologic flow and may also concentrate grazing pressure, leading to water quality, soil, and vegetation impacts.

Recent drought, voluntary livestock reductions due to market conditions and changing social dynamics have resulted in the fluctuation of authorized (actual) livestock numbers in the last several years, while permitted numbers have remained constant. The forest has utilized adaptive management to work with permittees to adjust authorized livestock numbers to maintain and protect forage, which has been stressed from recent drought conditions. Vegetation management that focuses on the restoration and maintenance of ecological integrity is required to address this risk.

Water for Consumption and Other Uses

The ability for the Carson NF to supply sufficient surface water and groundwater systems to meet the water needs of local counties and communities is at risk of being unsustainable. The region has experienced drought conditions since 1996, decreasing snowpack and spring runoff necessary for groundwater recharge. Climate change is expected to continue or intensify drought conditions. The high risk of uncharacteristic wildfire in ponderosa pine forest and mixed conifer, with frequent fire forest ecosystems increases the chance of flooding, increased erosion and sedimentation, and reduced groundwater recharge. Riparian ecosystems are at risk, impacting water quality and recharge.

The Carson NF contributes the majority of the water to the Upper Rio Grande Sub-basin and a large portion in the Rio Chama Sub-basin. The forest contributes a smaller portion of water to six other sub-basins. The majority of the population in the assessment area resides within the two primary watersheds. The forest cannot control surface water or groundwater withdrawals once water leaves the forest. To reduce this risk to water availability and quality, the forest can improve the watershed health and function to maintain and recover water retention and infiltration. Vegetation management that focuses on the restoration and maintenance of ecological integrity of terrestrial and riparian ecosystems is required to address this risk.

Hunting and Wildlife Viewing

The ability for the Carson NF to sustain habitat for many game species (mule deer, black bear, bighorn sheep, pronghorn, small game species, and furbearers) is at risk of being unsustainable. Wildlife habitat faces threats from uncharacteristic wildfire, woody species encroachment, drought, and invasive plant species. Loss of habitat could result in the migration of these species off the forest and a decrease in population numbers. Habitat and population loss will decrease hunting and wildlife viewing opportunities. Vegetation management that focuses on the restoration and maintenance of ecological integrity of terrestrial and riparian ecosystems is required to address this risk.

Recreation Programs and Use

The ability for the Carson NF to remain relevant and responsive to changing recreation user trends and demands is at risk of being unsustainable. Current forest recreation programs and opportunities do not adequately meet user needs and desires. The forest has many developed recreation facilities that are utilized below their capacity, are in poor condition, and/or do not meet the needs of today's public. The forest cannot adequately maintain all of its campgrounds to standard. Many of its campgrounds only have single-use occupancy campsites that experience low use, as more users desire group campsites. In some areas, the inability of the forest to meet the need for group campsites has resulted in increased impacts from dispersed camping. Half of the forest's vault toilets are in fair or poor condition. The maintenance backlog has continued to increase resulting in inadequately maintained recreation sites and a poorer recreational experience for users. Much of the forest's trail system is old and does not meet the needs of today's recreation enthusiast. Many trails are poorly designed and located, with limited intrinsic value for hikers looking for scenic beauty and challenging hikes. The forest has insufficient trail systems for an increased mountain biking demand. It does not have adequate or well-planned motorized trails. Most of the trails are in disrepair, not conveniently located for users, and/or provide an insufficient recreational experience. The lack of a good motorized trail system has resulted in users creating unauthorized trails out of old logging roads that cause increased degradation to vegetation, wildlife, and aquatic systems.

The ability of the Carson NF to provide meaningful recreation opportunities and experiences is an important social and economic contribution to local communities and businesses. A sustainable recreation program may require closing underutilized recreation sites, the planning and development of new sites, and/or upgrading existing sites to meet user needs and desires. Many trail systems may need to be decommissioned or upgraded. New trails may need to be designed and built to meet current and future user needs and located where they will get the best utilization. A recreation plan that focuses on providing a sustainable recreation program and opportunities that meet the needs of current users, are economically feasible, and can be adapted to future changing recreation trends is required to address this risk.

Infrastructure

The ability of the Carson NF to maintain its current infrastructure is at risk of being unsustainable. Much of the infrastructure on the forest is old and in continual need of routine maintenance. The backlog of required large maintenance repairs has perpetually increased, and is currently valued at several million dollars. Funding levels have decreased in recent years, while the cost to perform maintenance has increased. The inability to adequately maintain existing infrastructure could result in negative impacts on the management of the forest resources. Closure of infrastructure (i.e., roads, administrative facilities, and campgrounds) could result in reduced access, recreation services, and enjoyment by the public. Deterioration of infrastructure (i.e., roads, dams, and utilities) could result in unsafe conditions for the public and the Forest Service workforce, as well as ecological damage to the forest. A Forest Service program that prioritizes maintenance opportunities, utilizes alternative funding sources, and seeks alternative methods and opportunities to repair and maintain its infrastructure is required to address the risk of not being able to provide a safe and properly maintained infrastructure and access to services and forest users.

Economic and Social Conditions

The ability of the Carson NF to continue contributing the social and economic benefits (e.g., recreation programs and use, infrastructure, ranching and grazing, and recreational hunting) desired by local communities, families, and the visiting public is at risk. These forest uses contribute to the many benefits for communities and families (i.e., local traditional uses, social and family traditional values) and the economic opportunity within the assessment area. Recreation and recreation related activities on the Carson NF contribute the largest economic impact to the local economy, more than all other forest uses combined. The ability to recreate on the forest provides intrinsic values, such as a connection to nature, family togetherness, and improved physical and mental health. Infrastructure provides the ability to access and use the forest. Without safe, available infrastructure forest users would be limited in their ability to maximize the many benefits the forest contributes. For some forest users grazing and ranching are their primary source of income, or an important supplement to their income. Grazing and ranching provide strong cultural and family connections for many communities and families around the forest. Hunting contributes to the economic opportunity for local sportsman, businesses, and outfitters. The State of New Mexico and local communities receive important revenue from sales of licenses, taxes, and other economic activity resulting from wildlife associated recreation including hunting, fishing, and trapping. Hunting provides a strong social and cultural connection for families, to each other and to the land.

The Carson NF is a forest surrounded by many small towns, communities, and peoples who rely upon forest to provide resources and uses important to their social and cultural traditions and way of life, and as a means of contributing economic opportunity. Forest management that focuses on contributing to these needs, while maintaining the ecological integrity of the forest, is required to address this risk.

The Carson NF is an integral part of the local cultures and communities it serves. Relationships with local communities and groups are vital in forest management and in providing services to local and visiting forest users. Poor or ineffective communication with the public and the inability to establish partnerships for completing work on the forest were two issues identified by the public, when the Forest Service held community meetings in June 2014. Given the future potential for declining budgets and workforce the Carson NF will need to engage other public and private entities to effectively manage the forest resources to continue to provide for the needs and desires of the public. Through the Collaborative Forest Restoration Program, the forest works with partners on forest restoration projects. It is engaging with private and public entities to acquire funding for watershed restoration work. The forest will need to be creative in identifying other work related to recreation, minor maintenance, and education programs. The challenge for the forest will be in developing the manpower and expertise to identify, plan, and manage new partners and volunteers. The new forest plan for the Carson NF will be successful, if the public and the Forest Service share ownership and implementation of the new forest plan.

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V. Glossary

Adaptation. Adjustment in natural or human systems to a new or changing environment. Adaptation includes, but is not limited to, maintaining primary productivity and basic ecological functions such as energy flow; nutrient cycling and retention; soil development and retention; predation and herbivory; and natural disturbances. Adaptation occurs primarily by organisms altering their interactions with the physical environment and other organisms.

Adaptive capacity. The ability of ecosystems to respond, cope, or adapt to disturbances and stressors, including environmental change, to maintain options for future generations. As applied to ecological systems, adaptive capacity is determined by:

1. Genetic diversity within species in ecosystems, allowing for selection of individuals with traits adapted to changing environmental conditions.

2. Biodiversity within the ecosystem, both in terms of species richness and relative abundance, which contributes to functional redundancies.

3. The heterogeneity and integrity of ecosystems occurring as mosaics within broader-scaled landscapes or biomes, making it more likely that some areas will escape disturbance and serve as source areas for re-colonization.

Adaptive management. Adaptive management is the general framework encompassing the three phases of planning: assessment, plan development, and monitoring (36 CFR 219.5). This framework supports decision-making that meets management objectives while simultaneously accruing information to improve future management by adjusting the plan or plan implementation. Adaptive management is a structured, cyclical process for planning and decision-making in the face of uncertainty and changing conditions with feedback from monitoring, which includes using the planning process to actively test assumptions, track relevant conditions over time, and measure management effectiveness.

Airshed. A geographic area that, because of topography, meteorology, and/or climate is frequently affected by the same air mass.

Annual maintenance. Work performed to maintain serviceability, or repair failures during the year in which they occur. Includes preventive and/or cyclic maintenance performed in the year in which it is scheduled to occur. Unscheduled or catastrophic failures of components or assets may need to be repaired as a part of annual maintenance (USFS 1998b).

Assessment. For the purposes of the land management planning regulation at 36 CFR part 219 and this Handbook, an assessment is the identification and evaluation of existing information to support land management planning. Assessments are not decision-making documents, but provide current information on select topics relevant to the plan area, in the context of the broader landscape (36 CFR 219.19).

Assessment area. An area influenced by the management of the Carson National Forest (plan area) that is used during the land management planning process to evaluate social, cultural, and economic conditions. The area is usually a grouping of counties. This assessment uses a four-county assessment area that includes: Taos, Rio Arriba, Mora, and Colfax counties

At-risk species. A term used in land management planning and this Handbook to refer to, collectively, the federally recognized threatened, endangered, proposed, and candidate species and species of conservation concern within a plan area.

Best management practices for water quality (BMPs). Methods, measures, or practices selected by an agency to meet its nonpoint source control needs. BMPs include but are not limited to structural and nonstructural controls and operation and maintenance procedures. BMPs can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters (36 CFR 219.19).

Broader landscape. For land management planning pursuant to 36 CFR 219, the plan area and the lands surrounding the plan area. The spatial scale of the broader landscape varies depending upon the social, economic, and ecological issues under consideration.

Candidate species (36 CFR 219.19).

1. For species under the purview of the U.S. Fish and Wildlife Service (USFWS), a species for which the USFWS possesses sufficient information on vulnerability and threats to support a proposal to list as endangered or threatened, but for which no proposed rule has yet been published by the USFWS.
2. For species under the purview of the National Marine Fisheries Service (NMFS), a species that is:
    a. The subject of a petition to list as a threatened or endangered species and for which the (NMFS) has determined that listing may be warranted, pursuant to section 4(b)(3)(A) of the Endangered Species Act (16 U.S.C. 1533(b)(3)(A)), or
    b. Not the subject of a petition but for which the (NMFS) has announced in the Federal Register the initiation of a status review.

Carbon pool. Any natural region or zone, or any artificial holding area, containing an accumulation of carbon or carbon-bearing compounds or having the potential to accumulate such substances. Carbon pools may include live and dead above ground carbon, soil carbon including coarse roots, and harvested wood products.

Carbon stocks. The amount or quantity of carbon contained in a carbon pool. For purposes of carbon stock assessment for National Forest System (NFS) land management planning, carbon pools do not include carbon in fossil fuel resources, lakes or rivers, emissions from agency operations, or public use of NFS lands (such as emissions from vehicles and facilities).

Climate change adaptation. Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. This adaption includes initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Adaptation strategies include the following:

1. Building resistance to climate-related stressors.

2. Increasing ecosystem resilience by minimizing the severity of climate change impacts, reducing the vulnerability, and/or increasing the adaptive capacity of ecosystem elements.

3. Facilitating ecological transitions in response to changing environmental conditions.

Climate envelope. Represents the historic or characteristic climate conditions for key climate variables identified for each major ERU. Climate envelope modeling relies on statistical correlations between existing ecosystem distributions and the selected climate variables to define ecosystem tolerance. By utilizing future climate projections for the same climate variables, vulnerability can be predicted based on the disparity between characteristic climate envelopes and future climate conditions.

Collaboration or collaborative process. A structured manner in which a collection of people with diverse interests share knowledge, ideas, and resources, while working together in an inclusive and cooperative manner toward a common purpose. Collaboration, in the context of the land management planning regulation at 36 CFR part 219 and this Handbook, falls within the full spectrum of public engagement described in the Council on Environmental Quality's publication of October, 2007: Collaboration in NEPA— A Handbook for NEPA Practitioners (36 CFR 219.19).

Connectivity. Ecological conditions that exist at several spatial and temporal scales that provide landscape linkages that permit the exchange of flow, sediments, and nutrients; the daily and seasonal movements of animals within home ranges; the dispersal and genetic interchange between populations; and the long distance range shifts of species, such as in response to climate change (36 CFR 219.19).

Conservation. The protection, preservation, management, or restoration of natural environments, ecological communities, and species (36 CFR 219.19).

Conserve. For the purpose of meeting the requirements of 36 CFR 219.9, to protect, preserve, manage, or restore natural environments and ecological communities to potentially avoid federally listing of proposed and candidate species (36 CFR 219.19).

Consultation (in relation to the Endangered Species Act). See Formal Consultation and Informal Consultation.

Context landscape. For land management planning pursuant to 36 CFR part 219, the context landscape is the plan area and the lands surrounding the plan area (the broader landscape). The spatial scale of the context landscape varies depending upon the social, economic, and ecological issues under consideration.

Critical habitat. For a threatened or endangered species, (1) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 4 of the Endangered Species Act (ESA) (16 USC 1533), on which are found those physical or biological features (a) essential to the conservation of the species, and (b) which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of the ESA (16 USC 1533), upon a determination by the Secretary that such areas are essential for the conservation of the species. ESA, sec. 3 (5)(A), (16 USC 1532 (3)(5)(A)).

Critical habitat is designated through rulemaking by the Secretary of the Interior or Commerce. ESA, sec. 4 (a)(3) and (b)(2) (16 USC 1533 (a)(3) and (b)(2)).

Critical load. The concentration of air pollution or total deposition of pollutants above which specific deleterious effects may occur.

Departure. The degree to which the current condition of a key ecosystem characteristic is unlike the reference condition.

Designated area. An area or feature identified and managed to maintain its unique special character or purpose. Some categories of designated areas may be designated only by statute and some categories may be established administratively in the land management planning process or by other administrative processes of the Federal executive branch. Examples of statutorily designated areas are national heritage areas, national recreational areas, national scenic trails, wild and scenic rivers, wilderness areas, and wilderness study areas. Examples of administratively designated areas are experimental forests, research natural areas, scenic byways, botanical areas, and significant caves (36 CFR 219.19).

Decision document. A record of decision, decision notice, or decision memo (36 CFR 220.3).

Decision memo. A concise written record of the Responsible Official's decision to implement an action that is categorically excluded from further analysis and documentation in an environmental impact statement (EIS) or environmental assessment (EA), where the action is one of a category of actions which do not individually or cumulatively have a significant effect on the human environment, and does not give rise to extraordinary circumstances in which a normally excluded action may have a significant environmental effect (36 CFR 219.62).

Decision notice. A concise written record of the Responsible Official's decision when an EA and finding of no significant impact (FONSI) have been prepared (36 CFR 220.3).

Deferred Maintenance. Maintenance that was not performed when it should have been or when it was scheduled and which, therefore, was put off or delayed for a future period. When allowed to accumulate without limits or consideration of useful life, deferred maintenance leads to deterioration of performance, increased costs to repair, and decrease in asset value. Deferred maintenance needs may be categorized as critical or non-critical at any point in time. Continued deferral of non-critical maintenance will normally result in an increase in critical deferred maintenance. Code compliance (e.g., life safety, ADA, OSHA, environmental, etc.), Forest Plan Direction, Best Management Practices, Biological Evaluations other regulatory or Executive Order compliance requirements, or applicable standards not met on schedule are considered deferred maintenance (USFS 1998b).

Designated road, trail, or area. A National Forest System road, a National Forest System trail, or an area on National Forest System lands that is designated for motor vehicle use pursuant to 36 CFR 212.51 on a motor vehicle use map (36 CFR 212.1).

Desired conditions. For the purposes of the land management planning regulation at 36 CFR 219, a description of specific social, economic, and/or ecological characteristics of the plan area, or a portion of the plan area, toward which management of the land and resources should be directed. Desired conditions must be described in terms that are specific enough to allow progress toward their achievement to be determined, but do not include completion dates (36 CFR 219.7(e)(1)(i)).

Desired conditions are achievable, and may reflect social, economic, or ecological attributes, including ecosystem processes and functions.

<u>Dissection</u>. See habitat fragmentation.

<u>Disturbance</u>. Any relatively discrete event in time that disrupts ecosystem, watershed, community, or species population structure and/or function and changes resources, substrate availability, or the physical environment (36 CFR 219.19).

<u>Disturbance regime</u>. A description of the characteristic types of disturbance on a given landscape; the frequency, severity, and size distribution of these characteristic disturbance types; and their interactions (36 CFR 219.19).

<u>Easement</u>. A type of special use authorization (usually granted for linear rights-of-way) that is utilized in those situations where a conveyance of a limited and transferable interest in National Forest System land is necessary or desirable to serve or facilitate authorized long-term uses, and that may be compensable according to its terms (36 CFR 251.51).

<u>Ecological conditions</u>. The biological and physical environment that can affect the diversity of plant and animal communities, the persistence of native species, and the productive capacity of ecological systems. Ecological conditions include habitat and other influences on species and the environment. Examples of ecological conditions include the abundance and distribution of aquatic and terrestrial habitats, connectivity, roads and other structural developments, human uses, and invasive species (36 CFR 219.19).

<u>Ecological integrity</u>. The quality or condition of an ecosystem when its dominant ecological characteristics (for example, composition, structure, function, connectivity, and species composition and diversity) occur within the natural range of variation and can withstand and recover from most perturbations imposed by natural environmental dynamics or human influence (36 CFR 219.19).

<u>Ecological response unit (ERU)</u>. A classification of a unit of land that groups sites by similar plant species composition, succession patterns, and disturbance regimes, such that similar units will respond in a similar way to disturbance, biological processes, or manipulation. Each ERU characterizes sites with similar composition, structure, function, and connectivity, and defines their spatial distribution on the landscape.

<u>Ecological sustainability</u>. See sustainability.

<u>Ecological system</u>. See ecosystem.

<u>Economic sustainability</u>. See sustainability.

<u>Ecosystem</u>. (36 CFR 219.19) A spatially explicit, relatively homogeneous unit of the Earth that includes all interacting organisms and elements of the abiotic environment within its boundaries. An ecosystem is commonly described in terms of its:

1. <u>Composition</u>. The biological elements within the different levels of biological organization, from genes and species to communities and ecosystems.

2. Structure. The organization and physical arrangement of biological elements such as, snags and down woody debris, vertical and horizontal distribution of vegetation, stream habitat complexity, landscape pattern, and connectivity.

3. Function. Ecological processes that sustain composition and structure, such as energy flow, nutrient cycling and retention, soil development and retention, predation and herbivory, and natural disturbances such as wind, fire, and floods.

4. Connectivity. See connectivity above.

Ecosystem diversity. The variety and relative extent of ecosystems (36 CFR 219.19).

Ecosystem integrity. See ecological integrity.

Ecosystem services. Benefits people obtain from ecosystems, including:

1. Provisioning services, such as clean air and fresh water, energy, food, fuel, forage, wood products or fiber, and minerals;

2. Regulating services, such as long-term storage of carbon; climate regulation; water filtration, purification, and storage; soil stabilization; flood and drought control; and disease regulation;

3. Supporting services, such as pollination, seed dispersal, soil formation, and nutrient cycling; and

4. Cultural services, such as educational, aesthetic, spiritual, and cultural heritage values, recreational experiences, and tourism opportunities.

Ecotone. The transition zone between two adjoining ecological communities.

Endangered species. Any species that the Secretary of the Interior or the Secretary of Commerce has determined is in danger of extinction throughout all or a significant portion of its range. Endangered species are listed at 50 CFR sections 17.11, 17.12, and 224.101.

Environmental assessment (EA). A public document that provides sufficient evidence and analysis for determining whether to prepare an EIS or a finding of no significant impact, aids an agency's compliance with the NEPA when no EIS is necessary, and facilitates preparation of a statement when one is necessary (40 CFR 1508.9; FSH 1909.15, ch. 40) (36 CFR 219.62).

Environmental document. For the purposes of the land management planning regulation at 36 CFR 219: an environmental assessment, environmental impact statement, finding of no significant impact, categorical exclusion, and notice of intent to prepare an environmental impact statement (36 CFR 219.19).

Environmental impact statement (EIS). A detailed written statement as required by section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 (40 CFR 1508.11; 36 CFR 220) (36 CFR 219.62).

Ephemeral stream. A stream that flows only in direct response to precipitation in the immediate locality (watershed or catchment basin), and whose channel is at all other times above the zone of saturation.

Even-aged stand. A stand of trees composed of a single age class (36 CFR 219.19).

Federally recognized Indian Tribe. An Indian Tribe or Alaska Native Corporation, band, nation, pueblo, village, or community that the Secretary of the Interior acknowledges to exist as an Indian Tribe under the Federally Recognized Indian Tribe List Act of 1994, 25 U.S.C. 479a (36 CFR 219.19).

Fire rotation interval. The number of years it would take for an area equal to an entire ERU to burn. A shorter FRI indicates more frequent fire in the system.

Forest land. Land at least 10 percent occupied by forest trees of any size or formerly having had such tree cover and not currently developed for non-forest uses. Lands developed for non-forest use include areas for crops, improved pasture, residential or administrative areas, improved roads of any width and adjoining road clearing, and power line clearings of any width (36 CFR 219.19).

Formal consultation. A process between the USFWS and/or NMFS and a Federal agency proposing an action that 1) determines whether the proposed Federal action is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat; 2) begins with a Federal agency's written request and submittal of a complete initiation package; and 3) concludes with the issuance of a biological opinion by USFWS and/or NMFS, that may include an incidental take statement by the USFWS or NMFS. If a proposed Federal action may affect a listed species or designated critical habitat, formal consultation is required, except when the USFWS or NMFS concurs, in writing, that a proposed action "is not likely to adversely affect" listed species or designated critical habitat (50 CFR sections 402.02 and 402.14).

Functional ecosystem. A system with intact abiotic and biotic processes. Function focuses on the underlying processes that may be degraded, regardless of the structural condition of the ecosystem. Functionally restored ecosystems may have a different structure and composition than the historical reference condition. As contrasted with ecological restoration that tends to seek historical reference condition, function refers to the dynamic processes that drive structural and compositional patterns. Functional restoration is the manipulation of interactions among process, structure, and composition in a degraded ecosystem to improve its operations. Functional restoration aims to restore functions and improve structures with a long-term goal of restoring interactions between function and structure. It may be, however, that a functionally restored system will look quite different than the reference condition in terms of structure and composition and these disparities cannot be easily corrected because some threshold of degradation has been crossed or the environmental drivers, such as climate, that influenced structural and (especially) compositional development have changed.

Geographic area. A spatially contiguous land area identified within the planning area. A geographic area may overlap with a management area (36 CFR 219.19).

Groundwater-dependent ecosystem. Community of plants, animals, and other organisms whose extent and life processes depend on groundwater. Examples include many wetlands, groundwater-fed lakes and streams, cave and karst systems, aquifer systems, springs, and seeps.

Habitat fragmentation. Disruption of the habitat matrix such that (1) less habitat is available, (2) patch size is reduced, and (3) remaining patches are increasingly isolated (Andren 1994). Fragmentation can enhance the effects of habitat loss as habitat becomes scarce. When habitat is common small linear disruptions (dissection) may inhibit movement of some organisms, but impacts are similar to any equivalent loss of habitat (Andren 1994; Hunter 1997).

Head month. A head month is used for billing purposes and is a charged for each month of grazing by adult animals, if the grazing animal (1) is weaned; (2) is 6 months old or older when entering NFS lands; or (3) will become 12 months old during the period of use.

Habitat type. A land or aquatic unit, consisting of an aggregation of habitats having equivalent structure, function, and responses to disturbance.

Hydrologic unit code (HUC). A unique hierarchical hydrologic unit based on the area of land that drains to a single stream mouth or outlet at each level, and nested levels are identified by successively longer codes. A HUC 8 sub-basin is 700 square miles or larger and is divided into multiple HUC 10 watersheds that range from 62 to 390 square miles. HUC 12 sub-watersheds are 15 to 62 square miles and nest inside HUC 10 watersheds.

Informal Consultation. An optional consultation process that includes all discussions, correspondence, and so forth between the FWS/NMFS and a Federal action agency or designated non-Federal representative prior to formal consultation, if required (50 CFR sections 402.02 and 402.14).

Information. For information collection from the public pursuant to 5 CFR part 1320, any statement or estimate of fact or opinion, regardless of form or format, whether in numerical, graphic, or narrative form, and whether oral or maintained on paper, electronic or other media. “Information” does not generally include items in the following categories; however, OMB may determine that any specific item constitutes “information”:

1. Affidavits, oaths, affirmations, certifications, receipts, changes of address, consents, or acknowledgments; provided that they entail no burden other than that necessary to identify the respondent, the date, the respondent's address, and the nature of the instrument (by contrast, a certification would likely involve the collection of “information” if an agency conducted or sponsored it as a substitute for a collection of information to collect evidence of, or to monitor, compliance with regulatory standards, because such a certification would generally entail burden in addition to that necessary to identify the respondent, the date, the respondent's address, and the nature of the instrument);

2. Samples of products or of any other physical objects;

3. Facts or opinions obtained through direct observation by an employee or agent of the sponsoring agency or through nonstandardized oral communication in connection with such direct observations;

4. Facts or opinions submitted in response to general solicitations of comments from the public, published in the Federal Register or other publications, regardless of the form or format thereof, provided that no person is required to supply specific information

pertaining to the commenter, other than that necessary for self-identification, as a condition of the agency's full consideration of the comment;

5. Facts or opinions obtained initially or in follow-on requests, from individuals (including individuals in control groups) under treatment or clinical examination in connection with research on or prophylaxis to prevent a clinical disorder, direct treatment of that disorder, or the interpretation of biological analyses of body fluids, tissues, or other specimens, or the identification or classification of such specimens;
6. A request for facts or opinions addressed to a single person;
7. Examinations designed to test the aptitude, abilities, or knowledge of the persons tested and the collection of information for identification or classification in connection with such examinations;
8. Facts or opinions obtained or solicited at or in connection with public hearings or meetings;
9. Facts or opinions obtained or solicited through nonstandardized follow-up questions designed to clarify responses to approved collections of information; and
10. Like items so designated by OMB (5 CFR 1320.3(h)).

INFRA. The Forest Service's infrastructure database used to store and manage information related to constructed features, such as buildings, dams, bridges, water systems, roads, trails, developed recreation sites, range improvements, administrative sites, heritage sites, as well as general forest areas and wilderness areas.

Inherent capability of the plan area. The ecological capacity or ecological potential of an area characterized by the interrelationship of its physical elements, its climatic regime, and natural disturbances (36 CFR 219.19).

Integrated resource management. Multiple use management that recognizes the interdependence of ecological resources and is based on the need for integrated consideration of ecological, social, and economic factors (36 CFR 219.19).

Intermittent stream. A stream or reach of stream channel that flows, in its natural condition, only during certain times of the year or in several years, and is characterized by interspersed, permanent surface water areas containing aquatic flora and fauna adapted to the relatively harsh environmental conditions found in these types of environments. Intermittent streams are identified as dashed blue lines on USGS 7 1/2-inch quadrangle maps.

Invasive species. An alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health. A species that causes, or is likely to cause, harm and that is exotic to the ecosystem it has infested. Invasive species infest both aquatic and terrestrial areas and can be identified within any of the following four taxonomic categories: Plants, Vertebrates, Invertebrates, and Pathogens (Executive Order 13112).

Key ecosystem characteristic. A specific component of ecological condition that sustains ecological integrity. A key ecosystem characteristic describes dominant, measurable attributes that reflect the composition, structure, connectivity, and/or function of an ecosystem.

Landscape. A defined area irrespective of ownership or other artificial boundaries, such as a spatial mosaic of terrestrial and aquatic ecosystems, landforms, and plant communities, repeated in similar form throughout such a defined area (36 CFR 219.19).

Line officer. A Forest Service official who serves in a direct line of command from the Chief (36 CFR 219.62).

Local scale or zone. The smallest scale at which ecological integrity is assessed. The local scale may be valuable for describing departure patterns for a given ecosystem characteristic and identifying where particular issues may need attention and may drive forest plan components.

Maintain. In reference to an ecological condition: To keep in existence or continuance of the desired ecological condition in terms of its desired composition, structure, and processes. Depending upon the circumstance, ecological conditions may be maintained by active or passive management or both (36 CFR 219.19).

Management actions. Any alterations to ecosystems or activities that the Forest Service conducts or authorizes on NFS lands. These may include mechanical thinning, prescribed burning, permitted grazing, permitted fuelwood gathering, vehicular access, stream restoration treatments, seeding, trail construction, fencing, among others.

Management area. A land area identified within the planning area that has the same set of applicable plan components. A management area does not have to be spatially contiguous (36 CFR 219.19).

Management system. For the purposes of the land management planning regulation at 36 CFR 219, a timber management system including even aged management and uneven-aged management (36 CFR 219.19).

Memorandum of understanding (MOU). Describes a bilateral or multilateral agreement between two or more parties. It expresses a convergence of will between the parties, indicating an intended common line of action. It is often used in cases where parties either do not imply a legal commitment or in situations where the parties cannot create a legally enforceable agreement. It is a more formal alternative to a gentlemen's agreement.

Mitigate. To avoid, minimize, rectify, reduce, or compensate the adverse environmental impacts associated with an action.

Monitoring. A systematic process of collecting information to evaluate effects of actions or changes in conditions or relationships (36 CFR 219.19).

Motor Vehicle. Any vehicle which is self-propelled, other than:

- A vehicle operated on rails; and
- Any wheelchair or mobility device, including one that is battery-powered, that is designed solely for use by a mobility-impaired person for locomotion, and that is suitable for use in an indoor pedestrian area (36 CFR 212.1, 36 CFR 261.2).

Motor Vehicle Use Map (MVUM). A map reflecting designated roads, trails, and areas on an administrative unit or a ranger district of the National Forest System (36 CFR 212.1).

Multiple use. The management of all the various renewable surface resources of the NFS so that they are utilized in the combination that will best meet the needs of the American people; making the most judicious use of the land for some or all of these resources or related services over areas large enough to provide sufficient latitude for periodic adjustments in use to conform to changing needs and conditions; that some land will be used for less than all of the resources; and harmonious and coordinated management of the various resources, each with the other, without impairment of the productivity of the land, with consideration being given to the relative values of the various resources, and not necessarily the combination of uses that will give the greatest dollar return or the greatest unit output, consistent with the Multiple-Use Sustained-Yield Act of 1960 (16 U.S.C. 528–531) (36 CFR 219.19).

National Environmental Policy Act (NEPA). A United States environmental law (42 U.S.C. 4321 et seq.), enacted January 1, 1970 that established a U.S. national policy promoting the enhancement of the environment. Additionally, it established the President's Council on Environmental Quality (CEQ).

National Forest System. Includes National Forests, National Grasslands, and the National Tallgrass Prairie (36 CFR 219.62).

National Forest System Road. A forest road other than a road which has been authorized by a legally documented right-of-way held by a State, county or other local public road authority (36 CFR 212.1, 36 CFR 251.51, 36 CFR 261.2).

National Forest System Trail. A forest trail other than a trail which has been authorized by a legally documented right-of-way held by a State, county or other local public road authority (36 CFR 212.1).

Native species. An organism that was historically or is present in a particular ecosystem as a result of natural migratory or evolutionary processes and not as a result of an accidental or deliberate introduction into that ecosystem. An organism's presence and evolution (adaptation) in an area are determined by climate, soil, and other biotic and abiotic factors (36 CFR 219.19).

Natural range of variation (NRV). The variation of ecological characteristics and processes over scales of time and space that are appropriate for a given management application. In contrast to the generality of historical ecology, the NRV concept focuses on a distilled subset of past ecological knowledge developed for use by resource managers; it represents an explicit effort to incorporate a past perspective into management and conservation decisions (adapted from Weins, J.A. et al., 2012). The pre-European influenced reference period considered should be sufficiently long, often several centuries, to include the full range of variation produced by dominant natural disturbance regimes such as fire and flooding and should also include short-term variation and cycles in climate. The NRV is a tool for assessing the ecological integrity and does not necessarily constitute a management target or desired condition. The NRV can help identify key structural, functional, compositional, and connectivity characteristics, for which plan components may be important for either maintenance or restoration of such ecological conditions.

Objective. A concise, measurable, and time-specific statement of a desired rate of progress toward a desired condition or conditions. Objectives should be based on reasonably foreseeable budgets.

Off-highway vehicle (OHV). Any motorized vehicle designed for or capable of cross county travel on or immediately over land, water, sand, snow, ice, marsh, swampland, or other natural terrain; except that term excludes (A) any registered motorboat, (B) any fire, military, emergency or law enforcement vehicle when used for emergency purposes, and any combat or combat support vehicle when used for national defense purposes, and (C) any vehicle whose use is expressly authorized by the respective agency head under a permit, lease, license, or contract (EO 116-44 as amended by EO 11989). See also FSM 2355. 01 - Exhibit 01.

Online. Refers to the appropriate Forest Service Website or future electronic equivalent (36 CFR 219.62).

Outstanding natural resource water (ONRW). Streams, lakes and wetlands that receive special protection against degradation under New Mexico's water quality standards and the federal Clean Water Act. They are designated by the Water Quality Control Commission. Waters eligible for ONRW designation include waters that are part of a national or state park, wildlife refuge or wilderness areas, special trout waters, waters with exceptional recreational or ecological significance, and high quality waters that have not been significantly modified by human activities (NMED 2015).

Participation. Activities that include a wide range of public involvement tools and processes, such as collaboration, public meetings, open houses, workshops, and comment periods (36 CFR 219.19).

Perennial stream. A stream or reach of a channel that flows continuously or nearly so throughout the year and whose upper surface is generally lower than the top of the zone of saturation in areas adjacent to the stream. These streams are identified as solid blue on the USGS 7 1/2-inch quadrangle maps.

Persistence. Continued existence (36 CFR 219.19).

Primary production. The synthesis of organic compounds from atmospheric or aqueous carbon dioxide. It principally occurs through the process of photosynthesis, which uses light as its source of energy. It also occurs through chemosynthesis, which uses the oxidation or reduction of chemical compounds as its source of energy.

Plan or land management plan. A document or set of documents that provide management direction for an administrative unit of the NFS developed under the requirements of the land management planning regulation at 36 CFR part 219 or a prior planning rule (36 CFR 219.19).

Plan area. The NFS lands covered by a plan (36 CFR 219.19), specifically lands managed by the Forest Service as the Carson National Forest.

Plan components. The parts of a land management plan that guide future project and activity decision-making. Specific plan components may apply to the entire plan area, to specific management areas or geographic areas, or to other areas as identified in the plan. Every plan must include the following plan components: Desired conditions; Objectives; Standards; Guidelines; Suitability of Lands. A plan may also include Goals as an optional component.

Plan development. The second phase in the forest plan revision process. Plan development follows the NEPA process and plan revision requires preparation of an environmental impact statement (EIS). It is grounded in the information developed during the assessment phase and other information relevant to the plan area, it addresses needs for change, and it involves the public. Every plan must have management areas or geographic areas or both and may identify designated or recommended designated areas.(36 CFR 219.7).

Plan monitoring program. An essential part of the land management plan that sets out the plan monitoring questions and associated indicators, based on plan components. The plan monitoring program informs management of resources on the plan area and enables the Responsible Official to determine if a change in plan components or other plan content that guide management of resources on the plan area may be needed.

Planning record. The documents and materials considered in the making of a forest plan, plan revision, or plan amendment.

Plant and animal community. A naturally occurring assemblage of plant and animal species living within a defined area or habitat (36 CFR 219.19).

Productivity. The capacity of NFS lands and their ecological systems to provide the various renewable resources in certain amounts in perpetuity. For the purposes of the land management planning regulation at 36 CFR part 219 and this Handbook, productivity is an ecological term, not an economic term (36 CFR 219.19).

Project. An organized effort to achieve an outcome on NFS lands identified by location, tasks, outputs, effects, times, and responsibilities for execution (36 CFR 219.19).

Proposed species. Any species of fish, wildlife, or plant that is proposed by the U. S. Fish and Wildlife Service or the National Marine Fisheries Service in the Federal Register to be listed under Section 4 of the Endangered Species Act. (36 CFR 219.19)

Public and governmental participation. Phrase used in this Handbook as shorthand for participation by all Tribes and Alaska Native Corporations, other Federal agencies, State and local governments, public and private organizations, and interested individuals. This can include people and government and non-governmental entities in other countries, for example, where plan areas are adjacent or proximate to international borders.

Record of decision. A concise public record of decision prepared by the Federal agency, pursuant to NEPA that contains: (1) a statement of the decision; (2) identification of all alternatives considered; (3) identification of the environmentally preferable alternative; (4) a statement as to whether all practical means to avoid or minimize environmental harm from the alternative selected have been adopted (and if not, why they were not) and; (5) a summary of monitoring and enforcement where applicable for any mitigation (40 CFR 1505.2).

Recovery. For the purposes of the land management planning regulation at 36 CFR part 219 and with respect to threatened or endangered species: The improvement in the status of a listed species to the point at which listing as federally endangered or threatened is no longer appropriate (36 CFR 219.19).

Recreation opportunity. An opportunity to participate in a specific recreation activity in a particular recreation setting to enjoy desired recreation experiences and other benefits that accrue. Recreation opportunities include non-motorized, motorized, developed, and dispersed recreation on land, water, and in the air (36 CFR 219.19).

Recreation setting. The social, managerial, and physical attributes of a place that, when combined, provides a distinct set of recreation opportunities. The Forest Service uses the recreation opportunity spectrum to define recreation settings and categorize them into six distinct classes: primitive, semi-primitive non-motorized, semi-primitive motorized, roaded natural, rural, and urban (36 CFR 219.19).

Redundancy. The presence of multiple occurrences of ecological conditions such that not all occurrences may be eliminated by a catastrophic event.

Reference conditions. Environmental conditions that infer ecological sustainability. When available, reference conditions are represented by the characteristic natural range of variation (NRV) (not the total range of variation), prior to European settlement and under the current climatic period. For many ecosystems, NRV also reflects human-caused disturbance and effects prior to settlement. It may also be necessary to refine reference conditions according to contemporary factors (e.g., invasive species) or projected conditions (e.g., climate change). Reference conditions are most useful as an inference of sustainability when they have been quantified by amount, condition, spatial distribution, and temporal variation.

Representativeness. The presence of a full array of ecosystem types and successional states, based on the physical environment and characteristic disturbance processes.

Resilience. The ability of an ecosystem and its component parts to absorb, or recover from the effects of disturbances through preservation, restoration, or improvement of its essential structures and functions and redundancy of ecological patterns across the landscape.

Responsible official. The official with the authority and responsibility to oversee the planning process and to approve a plan, plan amendment, and plan revision (36 CFR 219.62).

Restoration, ecological. The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Ecological restoration focuses on reestablishing the composition, structure, pattern, and ecological processes necessary to facilitate terrestrial and aquatic ecosystems sustainability, resilience, and health under current and future conditions (36 CFR 219.19).

Restore. To renew by the process of restoration. See restoration (36 CFR 219.19).

Riparian areas. Three-dimensional ecotones [the transition zone between two adjoining communities] of interaction that include terrestrial and aquatic ecosystems that extend down into the groundwater, up above the canopy, outward across the floodplain, up the near-slopes that drain to the water, laterally into the terrestrial ecosystem, and along the water course at variable widths (36 CFR 219.19).

Risk. A combination of the likelihood that a negative outcome will occur and the severity of the subsequent negative consequences (36 CFR 219.19).

Road. A motor vehicle route over 50 inches wide, unless identified and managed as a trail (36 CFR 212.1).

Road Maintenance Levels (ML):

- ML1. Roads that are closed to vehicular traffic intermittently for periods that exceed 1 year. Can be operated at any other maintenance level during periods of use.
- ML2. Roads that are open and maintained for use by high-clearance vehicles; surface smoothness is not a consideration. Most have native material surface (not paved and no aggregate surface).
- ML3. Roads that are open and maintained for use by standard passenger cars. Most have gravel surface.
- ML4. Roads that are open and maintained for use by standard passenger cars and to provide a moderate degree of user comfort and convenience at moderate travel speeds. Most are paved or have an aggregate surface.
- ML5. Roads that are open and maintained for use by standard passenger cars

Routine maintenance. Work that is planned to be accomplished on a continuing basis, generally annually or more frequently (FSH 7709.58, 13.41).

Scenery Management System. A classification system that recognizes scenery as the visible expression of dynamic ecosystems functioning within “places”, which have unique aesthetic and social values. It recognizes that in addition to naturally occurring features, positive scenery attributes associated with social, cultural, historical, and spiritual values, including human presence and the built environment, can also be valued elements of the scenery. The SMS also allows for “seamless” analysis and conservation beyond national forest lands into adjacent communities and other jurisdictions, through the application of varying scenery “themes” within a single analysis. It is structured to emphasize "natural appearing” scenery.

Scenic character. A combination of the physical, biological, and cultural images that gives an area its scenic identity and contributes to its sense of place. Scenic character provides a frame of reference from which to determine scenic attractiveness and to measure scenic integrity (36 CFR 219.19).

Seral state. One of a series of transitional plant communities that develop during gradual successive change following disturbance.

Social sustainability. See sustainability.

Species of conservation concern. A species, other than federally recognized threatened, endangered, proposed, or candidate species, that is known to occur in the plan area and for which the Regional Forester has determined that the best available scientific information indicates substantial concern about the species' capability to persist over the long-term in the plan area (36 CFR 219.9(c)).

Standard. A mandatory constraint on project and activity decision-making, established to help achieve or maintain the desired condition or conditions, to avoid or mitigate undesirable effects, or to meet applicable legal requirements.

Stressors. For the purposes of the land management planning regulation at 36 CFR part 219, factors that may directly or indirectly degrade or impair ecosystem composition, structure, or ecological process in a manner that may impair its ecological integrity, such as an invasive species, loss of connectivity, or the disruption of a natural disturbance regime (36 CFR 219.19).

Suitability of lands. A determination that specific lands within a plan area may be used, or not, for various multiple uses or activities, based on the desired conditions applicable to those lands. The suitability of lands determinations need not be made for every use or activity, but every plan must identify those lands that are not suitable for timber production.

Sustainability. The capability to meet the needs of the present generation without compromising the ability of future generations to meet their needs. For the purposes of the land management planning regulation at 36 CFR part 219 and this Handbook ‘‘ecological sustainability’’ refers to the capability of ecosystems to maintain ecological integrity; ‘‘economic sustainability’’ refers to the capability of society to produce and consume or otherwise benefit from goods and services including contributions to jobs and market and nonmarket benefits; and ‘‘social sustainability’’ refers to the capability of society to support the network of relationships, traditions, culture, and activities that connect people to the land and to one another, and support vibrant communities (36 CFR 219.19).

Sustainable recreation. The set of recreation settings and opportunities on the National Forest System that is ecologically, economically, and socially sustainable for present and future generations (36 CFR 219.19).

Sub-basin. A HUC 8 hydrologic unit, the largest subdivision considered in this assessment.

Sub-watershed. A HUC 12 hydrologic unit, the smallest subdivision considered in this assessment.

Terrestrial ecosystem. All interacting organisms and elements of the abiotic environment in those vegetation and soil types, which are neither aquatic nor riparian.

Terrestrial ecosystem survey (TES). An inventory of soil types or terrestrial ecosystem units (TEUs) on the Carson NF. It contains predictions and limitations of soil and vegetation behavior for selected land uses. This survey also highlights hazards or capabilities inherent in the soil and the impact of selected uses on the environment. At the context scale, upland ecological response units are derived from the Carson NF Terrestrial Ecosystem Survey (USDA 1987).

Terrestrial ecosystem unit (TEU). The classification unit used in the Terrestrial Ecosystem Survey (TES). A spatially explicit area with a similar combination of soils, land types, and vegetation communities.

Timber harvest. The removal of trees for wood fiber use and other multiple use purposes (36 CFR 219.19).

Threatened species. Any species that the Secretary of the Interior or the Secretary of Commerce has determined is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. Threatened species are listed at 50 CFR sections 17.11, 17.12, and 223.102.

Timber production. The purposeful growing, tending, harvesting, and regeneration of regulated crops of trees to be cut into logs, bolts, or other round sections for industrial or consumer use (36 CFR 219.19).

Tribal consultation. A formal government-to-government process that enables Indian Tribes and Alaska Native Corporations to provide meaningful timely input and, as appropriate, exchange views, information, and recommendations on Forest Service proposed policies or actions that may affect their rights or interests prior to a decision. Consultation is a unique form of communication characterized by trust and respect (FSM 1509.05).

Ungulate. A hooved animal, which includes wildlife (e.g. pronghorn, deer, and elk) and domestic livestock (e. g., sheep, cattle, and horses).

Upland. May refer to areas, species, systems, or conditions that are characteristic of terrestrial ecosystems, as opposed to riparian or aquatic ecosystems.

Watershed. A region or land area drained by a single stream, river, or drainage network; a drainage basin (36 CFR 219.19). Specifically, a HUC 10 hydrologic unit, larger than a sub-watershed, and nested in a sub-basin.

Watershed condition. The state of a watershed based on physical and biogeochemical characteristics and processes (36 CFR 219.19).

Wetlands. "[L]ands where saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface…. For regulatory purposes under the Clean Water Act, the term wetlands means 'those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.' [taken from the EPA Regulations listed at 40 CFR 230.3(t)]." (US EPA 2015e) Wetland delineation in this assessment relied on the National Wetlands Inventory (NWI).

Wild and Scenic River. A river designated by Congress as part of the National Wild and Scenic Rivers System that was established in the Wild and Scenic Rivers Act of 1968 (16 U.S.C. 1271 (note), 1271–1287) (36 CFR 219.19).

Wilderness. Any area of land designated by Congress as part of the National Wilderness Preservation System that was established in the Wilderness Act of 1964 (16 U.S.C. 1131–1136) (36 CFR 219.19).

Wildland urban interface (WUI). That area where human development adjoins public or private natural areas, or an intermix of rural and urban land uses. From a natural resource perspective the wildland-urban interface is an area where increased human influence and land-use conversion are changing natural resource goods, services, and management techniques (Hermansen-Baez et al. 2009).