# UTAH FOREST HEALTH REPORT

## A BASELINE ASSESSMENT

1999-2001

State of Utah
DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FORESTRY, FIRE AND STATE LANDS

Rocky Mountain Research Station
Forest Health Protection
Forest Health Monitoring

## Authors

Colleen Keyes, Dept. of Natural Resources, Division of Forestry, Fire and State Lands, Salt Lake City, Utah

Paul Rogers, USDA, Forest Service, Rocky Mountain Research Station, Ogden, Utah

Leon LaMadeleine, USDA, Forest Service, State and Private Forestry, Forest Health Protection, Ogden, Utah

Vick Applegate, USDA, Forest Service, State and Private Forestry, Northern Region, Missoula, Montana

Dave Atkins, USDA, Forest Service, State and Private Forestry, Forest Health Monitoring, Missoula, Montana

## Acknowledgements

*We would like to acknowledge the dedication and hard work of the 1999 Forest Health Monitoring field and quality assurance crews in Utah. Mark Rubey, Rocky Mountain Research Station, made significant contributions in processing and managing field data. Dennis Collins, also from the Rocky Mountain Research Station, provided assistance in map compilation for this report. John C. Guyon II and Elizabeth G. Hebertson from USDA, Forest Health Protection, Ogden Field Office, made significant contributions to the Insect, Disease, and Plant Disturbances section. Finally, we want to thank the report reviewers for their helpful suggestions and comments: Michael Kuhns, Extension Forester and Associate Professor, Utah State University; Renee A. O'Brien and Larry T. DeBlander, Rocky Mountain Research Station; Rebecca Hutchinson, Law Student, University of Utah; Ann B. Price, David C. Schen, Ron L. Gropp, and Clint Reese, Utah Department of Natural Resources, Division of Forestry, Fire and State Lands.*

**Photo credits: E.H. Holsten, USDA Forest Service-page 19, USDA/APHIS PPQ Archives-page 23.*

# UTAH FOREST HEALTH REPORT

A BASELINE ASSESSMENT

1999 / 2001

Date Published: 01/03 Salt Lake City, Utah

# Table of Contents

# Table of Contents

Forests cover about one-third of Utah's landscape and provide important recreational opportunities, wildlife habitat, aesthetic benefits, timber products, and watershed values. Impacts from native and non-native insects and diseases, air pollution, fire suppression, poor management practices, and climate change are some of the primary stressors that may affect forests. Monitoring forest ecosystems is an important first step in fulfilling stewardship responsibilities. This baseline report will act as a benchmark for comparison of future Forest Health Monitoring efforts.

## Overview of the FHM Program

Forest Health Monitoring (FHM) is a national program designed to evaluate the status, changes, and trends in forest health conditions on an annual basis across all land ownerships. The United States Forest Service is working cooperatively with state natural resource entities, as well as other federal agencies and universities, to implement FHM at four principle levels: Detection Monitoring, Evaluation Monitoring, Intensive Site Monitoring, and Research on Monitoring Techniques.

The purpose of this initial Utah Forest Health Monitoring report is to highlight the prominent forest health issues in the state and to provide a baseline summary of field plot and survey activities associated with Detection Monitoring. If unexplained changes are detected, Evaluation Monitoring may be activated to investigate the extent and severity of changes. Intensive Site Monitoring involves a national network of sites for research on ecological processes related to elements of change in specific ecosystem types. Finally, Research on Monitoring Techniques is responsible for developing reliable forest health indicator measurements.

FHM reports forest-related health issues on a large scale. The principle levels of reporting are state, regional, and national/international (*see sidebar, Forest Sustainability Criteria, page 2*). Local or special evaluations, surveys, and reports augment FHM data as necessary and are produced as issues arise and where FHM data sets are appropriate for the area of consideration.

**What do we mean by "forest health?"**

There are many definitions and opinions about what is meant by "forest health". In this report we use forest health in the following context:

A healthy forest displays resilience to disturbance by maintaining a diverse set of structures, compositions, and functions across the landscape. Secondly, it is hoped that healthy forests meet the current and future needs of people in terms of values, products, and services. These two elements of a healthy forest are interrelated, but may oppose each other.
A healthy forest may be able to meet societal needs indefinitely, but only with sustained ecological capacity to recover from human or natural disturbance.

## Data Sources

FHM Plot Network: The FHM plot network consists of a series of field plots established in forested areas at approximately 18-mile intervals. A plot is a permanent sample location measured on a regular cycle. The sample area of a plot is approximately 2.5 acres (1 hectare). Field crews gather data on tree diameters, crown conditions, tree damage, lichen communities, ozone bioindicators, and soils. These measurements are used as indicators of forest health. Because the program is still developing, new indicators, such as understory vegetation and woody debris were added in 2001 to supplement the current suite of field measurements.

The FHM plot network was established in Utah during the 1999 field season. Beginning in 2000, annual sampling of one-fifth of the original plots (plus a cumulative additional 50 plots) will provide a continual monitoring effort in the state. A complete re-measurement will yield about 200 plots by 2004 (exact number is not known until all potential plots are field checked). Re-measurements of specific forest indicators allow researchers to assess trends in forest health conditions. This report contains data from first-time, or single visit FHM measurements (summarized in Appendices A-F) as well as data gathered through other state and federal programs.

Survey Component: The survey component of FHM may include state or federal: (1) ground surveys for specific insect or disease activity such as gypsy moth (*Lymantria dispar*), dwarf mistletoe (*Arceuthobium spp*.), mountain pine beetle (*Dendroctonus ponderosae*) and others; (2) analysis of other plot-based data from Forest Inventory and Analysis (FIA), National Forest inventories, and Forest Health Protection (FHP) insect and disease plot inventories; (3) service trip reports and technical reports for historical data or trends; and (4) aerial detection surveys flown over extensive portions of Utah forests. The survey component provides a record of widespread disturbance events, such as large-scale insect or disease incidence. It can also provide early identification of developing outbreaks through the work of state and federal partners as well as detecting localized damage that may not be detected by the FHM plot network. Survey information provides a context for interpreting plot data and for identifying likely factors that contribute to forest health changes.

**Forest Sustainability Criteria**

The United States is committed to reporting on the criteria and indicators of sustainable forests found in the Santiago Declaration-Montreal Process (Anonymous 1997). These internationally agreed upon indicators of forest health are biological diversity, productive capacity, ecosystem health and vitality, soil resource, water resource, and global carbon cycles. Utah's forest health evaluations closely parallel the criteria and indicators found in this agreement and allow some comparisons with other national and international trends. Data summaries found in state and regional reports contribute to national reporting efforts in accordance with the Santiago Declaration.

## Scope of Report

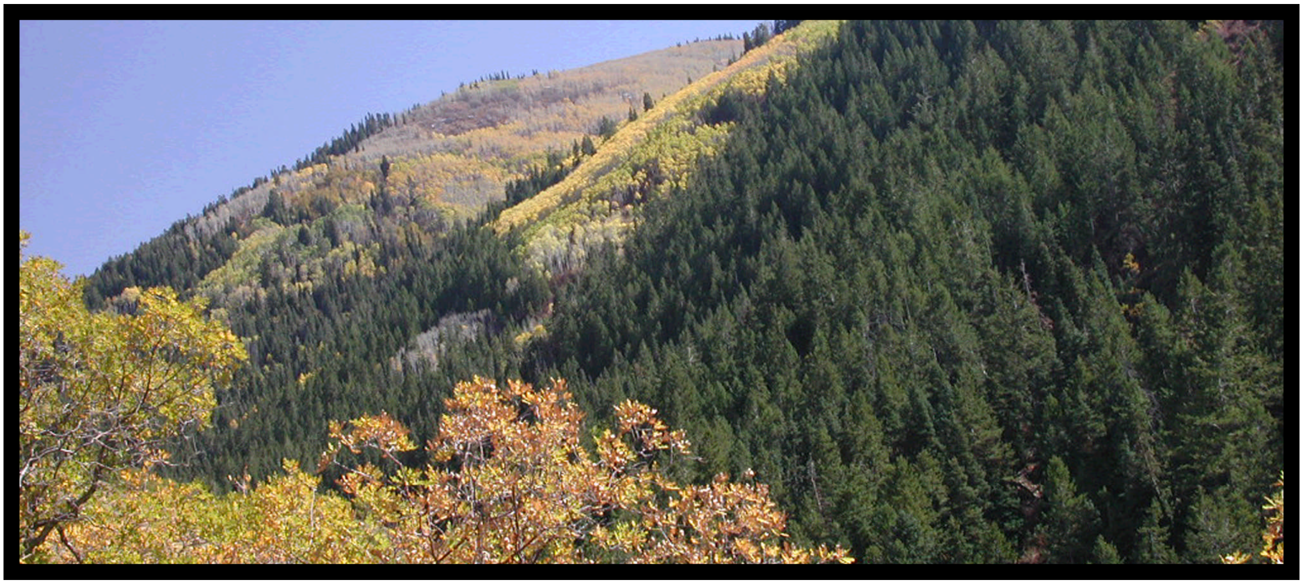
This report addresses forest health in two ways: by discussion of forest-related issues and by data summaries in several appendices. FHM is a long-term monitoring program and therefore, the data presented in this report must be viewed in that light. This report presents a first-time, or baseline summary. Subsequent reports will address changes over time as plots and other detection surveys are conducted and re-measured.

Prior to issue discussions, a general description of the forest resource is provided to familiarize the reader with forest cover, ecoregion, and ownership patterns within Utah. A previous FIA report describes the forest resources of Utah in depth and provides more detail on ownership, forest cover, and many other forest attributes (O'Brien 1999).

Issues of concern today are more fully understood through the collection and analysis of long-term data sets, such as those being provided by FHM. We expect forest health issues to change in the future. This program will continue to monitor issues identified here as they evolve, or new issues as they arise. The body of this report will focus on the following forest-related issues of concern in Utah today:

- Forest Cover Change— Forest cover change addresses changes in species composition and structure that appear to significantly deviate from patterns found a century ago.
- Insect, Disease, and Plant Disturbances— Insects, diseases, and invasive or noxious weeds are disturbance agents that fluctuate over time. How does the role of insects, diseases, and invasive or noxious weeds relate to the health of forests?
- Development and Wildland Interface— Interface areas are a concern with regard to human safety, watershed protection, wildlife habitat, insect and disease management, and fire protection and management. A healthy residential forest may look different from a remote forest simply because property and safety interests often warrant more active management.
- Forests and Watershed Health— This is a critical issue throughout the Interior West. How do disturbances and human activities in forests affect watershed health?
- Biological Diversity— In general, Utah forests are very diverse. However, human actions appear to be affecting some forest communities through the introduction of invasive species, suppression of fires, harvesting patterns and practices, and human development.
- Air Quality— Air quality can affect the health and vigor of forests. FHM measures impacts of air quality on forest ecosystems using lichens and biological indicator plants.

# Utah Forest Resources



Most people have a clear image of what constitutes a forest. For Utahans, that image may be tall fir and spruce near a favored camping area, or open stands of ponderosa pine *(Pinus ponderosa)* found in a southern locale. In reality, the forests of Utah come in such varied forms as pinyon-juniper, gambel oak *(Quercus gambelii)*, quaking aspen *(Populus tremuloides)*, and a handful of other conifer types. Because forests react differently, depending on their physical and cultural characteristics, this report will address them based on logical divisions. This section will briefly describe the forest types, ecological divisions, and land ownership patterns that often frame and complicate issues.

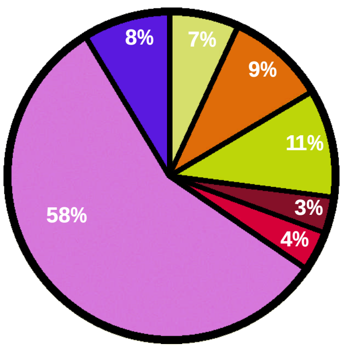
## Forest Types

Forest type is generally synonymous with forest cover, or the dominant tree species in the overstory at a given site. Forest types are influenced by factors such as climate, elevation, aspect, soil type, and disturbance history. Figure 1 (page 6) portrays an overview of forest types in Utah based on satellite imagery and Figure 2 (page 6) shows the percentage of forested area covered by the major forest types. Forest types taken from field surveys are a convenient way for analysts to group land covers, although forest types commonly contain more than one species. For example, the Douglas-fir (*Pseudotsuga menziesii*) forest type may contain limber pine (*Pinus flexilis*), lodgepole pine (*Pinus contorta*), aspen, and bigtooth maple (*Acer grandidentatum*).

## Ecoregions of Utah

Forest health issues often extend across forest type, ownership, and political boundaries. Therefore, a practical approach to assessing large-scale forest health issues is to use non-political land divisions, such as ecoregions. An ecoregion approach allows analysts to monitor forest conditions objectively based on similar conditions. Bailey's (1995) *Description of the Ecoregions of the United States* presents a hierarchical framework for delineating ecological regions based on their unique combinations of physiography, soil type, potential vegetation, and climate. The ecoregions of the United States are classified, in descending order, by domains, divisions, provinces, and sections. The entire state of Utah lies within the Dry Domain of Bailey's ecoregions. There are six distinct provinces found in Utah. All but the American Semi-Desert and Desert Province (southwest Utah) contain forest conditions that are sampled by FHM. Locations sampled thus far and ecoregion provinces are shown in Figure 3 (page 7).

Figure 2. Major forest types by %




Forest types key

- Pinyon - juniper
- Misc. species / oak
- Douglas-fir
- Aspen
- Spruce / fir
- Lodgepole pine
- Ponderosa pine

Figure 1. Major forest types in Utah

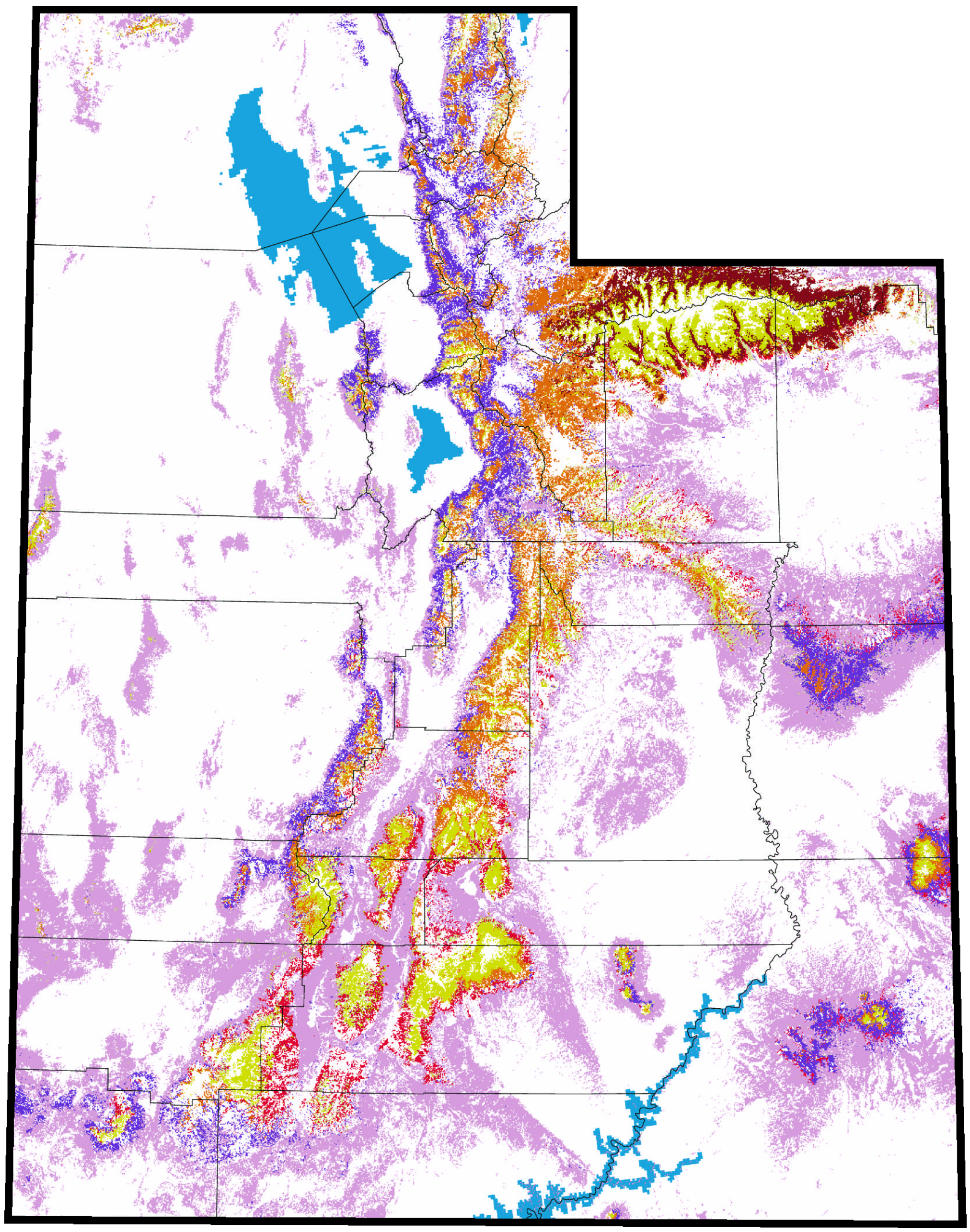
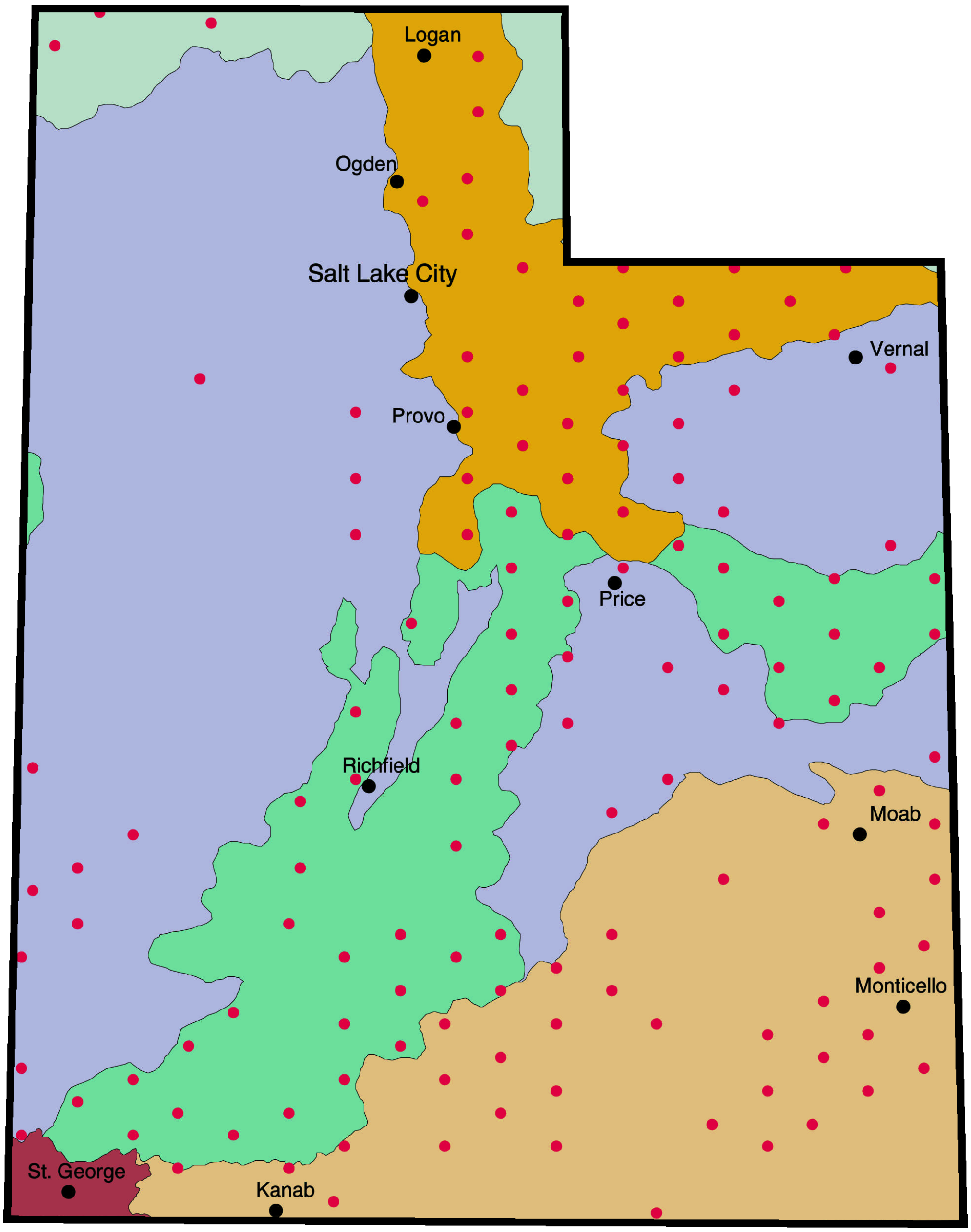


Figure 3. Ecoregion provinces of Utah and approximate locations of forested FHM plots.




Plot totals by ecoregion

Plot locations

| | Number | Percent |
|---|---|---|
| | 0 | 0 |
| | 34 | 24 |
| | 29 | 20 |
| | 3 | 2 |
| | 44 | 31 |
| | 32 | 23 |
| | 142 | 100 |

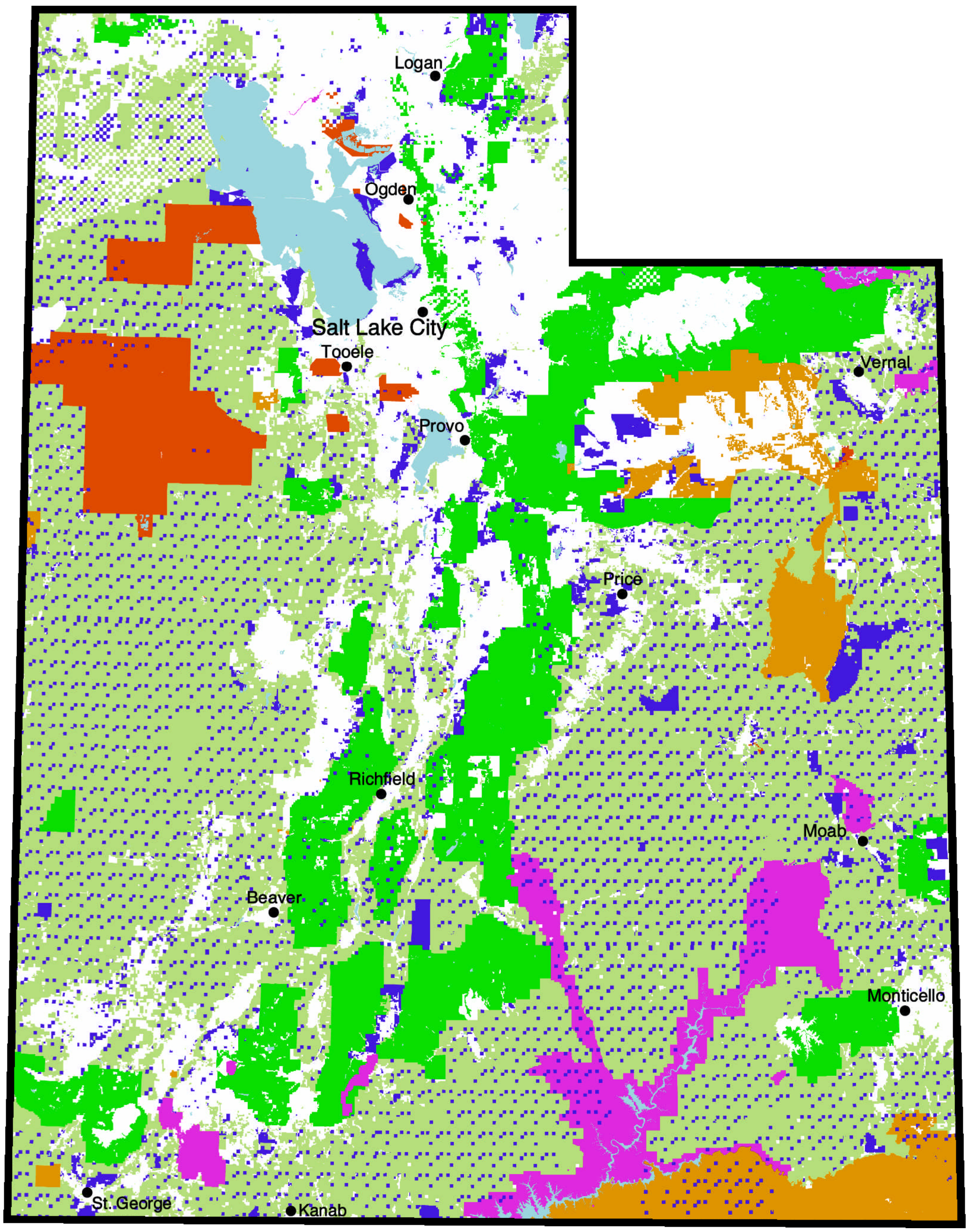
Ecoregion key

- American Semi Desert/Desert
- Colorado Plateau Semi-Desert
- Intermountain Semi-Desert/Desert
- Intermountain Semi-Desert
- Nevada-Utah Mountains
- Southern Rockies

## Land Ownership

Utah has about 16 million acres of forested land (O'Brien 1999). FHM samples all categories of forested lands regardless of ownership. Permission is obtained prior to sampling privately owned forests. The map of Utah shown in Figure 4 depicts the mosaic of land ownership. Approximately 64 percent of forested lands in Utah are managed by the federal government (Riebsame and Robb 1997). The remaining portions of the forested land base consist of State, Tribal Trust, and miscellaneous private, municipal and other public properties. Management of forested land across the state is complicated by a variety of ownership philosophies and directives.

Figure 4. Land ownership in Utah




Landowner key

- Forest Service
- National Park Service
- State of Utah
- Tribal Trust
- Miscellaneous federal
- Bureau of Land Management
- Privately owned

*Fir encroachment into aspen*

## Forest Cover Change

To many people, Utah's forests may appear stable and unchanging. Only with large-scale effects from insects, disease, fire, wind, or human activities is change evident. Actually, the forests have been changing slowly over millennia (Tausch 1999). However, during the last 150 years some of our forests appear to be experiencing dramatic changes in forest cover, structure, and composition.

Fortunately, most forest ecosystem processes remain intact, providing necessary habitat for native plants and animals. However, in some Utah forest ecosystems, significant changes raise sustainability concerns, such as increasing risk for catastrophic wildfire, insect and disease outbreaks, maintaining wildlife habitat, and maintaining the many values humans place on natural resources. These concerns have created the need to focus on monitoring and evaluating change. Forest health issues in aspen, pinyon-juniper, and ponderosa pine forests in Utah will be discussed further, but it is clear that the recent interactions of forests, humans, and climate change are responsible, in unknown portions, for changes in forest cover.

## Aspen Forests

In Utah, aspen forests are found predominantly in the Southern Rockies and Nevada-Utah Mountain ecoregion provinces. Aspen forests provide biological diversity and numerous resource benefits including wildlife habitat, livestock forage, water retention, wood resources, recreational opportunities, and scenic beauty. Recent research suggests that the area dominated by aspen forests has declined substantially over the last 100 years and this decline may continue without some type of natural or human caused disturbance (Kay 1997; Bartos and Campbell 1998; O'Brien 1999; Rogers 2002).

Aspen forests cover 1.4 million acres in Utah today. Utah aspen forests may have once covered as much as 2.9 million acres (O'Brien 1999). Though it is difficult to measure the amount of change since European settlement, researchers agree that increased browsing of aspen shoots by wildlife and livestock, coupled with significant decreases in natural fire spread and human fire use, have resulted in a net change favoring conifer species (Kay 1997; Bartos and Campbell 1998; Rogers 2002). This change in forest type may have a considerable impact on water yield because the transpiration rate of conifers such as spruce and fir may be twice that of aspen (Long 1994).

Successful aspen regeneration is dependent on regular disturbance events. Aspen forests are primarily composed of genetically identical groups of individuals, or clones. These clones self-perpetuate from parent root systems for centuries. Frequent disturbance of above ground stems stimulates regeneration from clonal root systems. Wildfire, wind damage, avalanches, insects, and wood harvesting are disturbances that may stimulate new shoot growth. Aspen reproduction from seed is uncommon, but possibly significant from a long-term and large-scale sustainability perspective (Romme and others 1997).

Aspen trees are relatively short-lived, commonly surviving less than 150 years. Beyond 80 years aspen trees become more susceptible to a variety of forest pathogens. Without major disturbance, aspen stands often become heavily diseased and decadent (Hinds 1985). In Utah, aspen have a high rate of canker, decay, and root rot fungi when compared to other species (Appendix E). FHM data shows that the average age of all stands with aspen present is 104, while stands where aspen dominate average 82 years. These data suggest that even the plots dominated by aspen forest have an average stand age that is increasingly susceptible to disease incidence and severity.

A more detailed analysis of FHM plots in adjacent states examined several factors related to aspen dynamics, including presence and regeneration of other tree species, canopy conditions, stand age, damages, disturbance, and aspen regeneration. Findings in

Colorado, Wyoming, and Idaho indicated that about two-thirds of all plots with aspen present were either already dominated by conifers or appeared to be shifting toward conifer dominance. The study labels this second condition as “unstable plots in aspen forest type,” since they are being overtaken by conifers or show very little aspen regeneration (Rogers 2002).

The apparent decline of aspen forests in Utah (and in the Intermountain West) is a forest health concern. Ultimately this decline may lead to loss of community diversity and other important resource values. Due to the nature of aspen reproduction, we can tell something about the recent trends in aspen community dynamics, even with a single point-in-time measurement.

## Pinyon-Juniper Forests

Pinyon-juniper forests contain an association of trees including common pinyon pine *(Pinus edulis)*, singleleaf pinyon *(Pinus monophylla)*, Utah juniper *(Juniperus osteosperma)*, and, to a much lesser degree, Rocky Mountain juniper *(Juniperus scopulorum)*. Juniper forests basically contain only juniper species. Together juniper and pinyon-juniper forests make up Utah's pinyon-juniper forest type.

Pinyon-juniper forests occupy the driest forested sites in Utah and provide a wide range of important resources for people, wildlife, and plants. These forests cover approximately 9.1 million acres and comprise 58 percent of Utah's forest cover (O'Brien 1999). Some of the oldest forests in Utah are pinyon-juniper with some stands ranging from 500-700 years old. However, over two-thirds are less than 150 years old and over three-fourths are less than 200 years old (O'Brien and Woudenberg 1999). These relatively young ages may reflect both an expansion of the pinyon-juniper community and a re-establishment of trees after extensive harvesting for wood products around the turn of the century (Creque and others 1999).

Pinyon-juniper forests possibly encompass up to three times more area than they did prior to European settlement. These forests appear to be expanding into areas where sagebrush-grass and other plant communities previously dominated. Pinyon-juniper expansion may be in response to a warming of the climate since the Little Ice Age 150-550 years ago (Tausch 1999). In addition to an expanded range, pinyon-juniper forests are increasing in tree density and crown cover. Increasing crown cover in pinyon-juniper communities decreases the number of understory species and seeds in the soil (Laycock 1999). Livestock and wildlife grazing may also play a significant role by reducing herbaceous ground cover and encouraging woody growth. A decrease in wildland fire in pinyon-juniper forests is another factor that may contribute to expansion (Tausch 1999).

*Pinyon-juniper fire*

Fire is a significant agent in the ecology of pinyon-juniper forests. Historically, these forests burned about every 8 to 40 years, with fires from low to moderate intensity (Bradley and others 1992). In densely stocked pinyon-juniper forests, understories are often very sparse. Therefore, fires are much more difficult to ignite and maintain at ground level. Once ignited, however, these forests often support high intensity, stand-replacing crown fires covering large landscapes, especially when wind driven. Such fires are increasing in size within the Intermountain West (Tausch 1999; Gruell 1999).

The introduction of cheatgrass, a rapidly growing exotic annual grass, into pinyon-juniper forests has resulted in more intense and more frequent fires. The combination of dense overstories and sparse understories slows recovery by native species and provides a prime opportunity for cheatgrass invasion. Cheatgrass produces seed and then dries by early summer becoming very flammable. The result can be a shorter fire cycle, possibly from 2 to 4 years in some sites. This may decrease perennial shrubs and grasses while increasing annual plants that degrade site productivity and lead to unstable pinyon-juniper forests (Graham and others 1999).

## Ponderosa Pine Forests

Ponderosa pine forests cover nearly 600,000 acres, about 4 percent of the forested area of Utah (O'Brien 1999). Many ponderosa pine forests have changed in species composition, size, and density over the last 150 years (Arno 1988; Graham and others 1999; Bradley and others 1992; Harrington and Sackett 1992; Ogle and DuMond 1997).

Historical records and recent research indicate before European settlement, many ponderosa pine forests contained old large diameter trees and grew with varying densities and openness (Arno 1988; Bradley and others 1992; Madany and West 1983). Some accounts of early foresters describe evidence of frequent wildland fire and open stands of ponderosa pine. For example, the 1911 survey of the Manti-LaSal National Forest described ponderosa pine forests as "very open and patchy…trees of 4-5 feet in diameter were reported though it is more common to see 3.5 feet. Almost all are fire-scarred" (Ogle and DuMond 1997). However, other studies indicate that some ponderosa pine forests developed as dense stands that were subject to infrequent stand replacing fires (Arno and others 1997; Shinneman and Baker 1997). Likely, some mix of dense and open stands existed depending on local burn conditions.

Today, without frequent fire, many of the ponderosa pine forests are more densely stocked with smaller diameter ponderosa pine and shade tolerant species such as white fir (*Abies concolor*), Douglas-fir, subalpine fir (*Abies lasiocarpa*), and Engelmann spruce (*Picea engelmannii*) (Graham and others 1999). The increasing density of shade tolerant species can place greater stress on larger old trees, mostly due to between-tree competition for water. Consequently, trees under stress are generally more susceptible to insect and disease attack.

Dense undergrowth of shade tolerant species can also increase the risk of mortality from fire. Greater fuel loading and multiple-storied forest structures provide conditions for much higher wildland fire intensity. High fire intensity results in a majority of the forest trees being killed due to increased heat around the roots, lower boles, and upper crowns. This appears to contrast with conditions in the mid-19th century when some larger ponderosa pine trees would likely have survived ground fires because of their thick bark and scarcity of lower branches.

*Spruce beetle outbreak on the Dixie National Forest*

## Insect, Disease & Plant Disturbances

In addition to fire; insects, diseases, and weeds act as important disturbance agents in Utah forest ecosystems. Fire suppression has altered the occurrence, severity, and intensity of fire. This, along with climate fluctuations may have contributed to increased insect and disease activity in certain forest types. Noxious and invasive weeds in Utah are spreading at an alarming rate, displacing native species and disrupting normal ecosystem function.

Insects and diseases can adversely affect visual quality and recreational opportunities of places we value—our favorite fishing hole, campsite, ski area or the view from our back porch. These agents, however, also play an important role in the function of forest ecosystems. They kill trees, creating snags that provide habitat for a variety of wildlife species. Raptors use dead trees for perches and decayed trees provide homes for cavity nesting birds. Insects and diseases serve an integral role in nutrient cycling of forests.

The vigor of trees is an important factor in determining their susceptibility to attack by insects or diseases. In a healthy forest, endemic levels of insects and diseases serve to remove weakened and stressed trees, thus thinning the forest and reducing competition for light, water, and nutrients. Dense forests are more susceptible to insect and disease outbreaks. Landscape scale overstory losses similar to the scene depicted above, may increase the susceptibility of stands to fire.

## Native Insects & Diseases

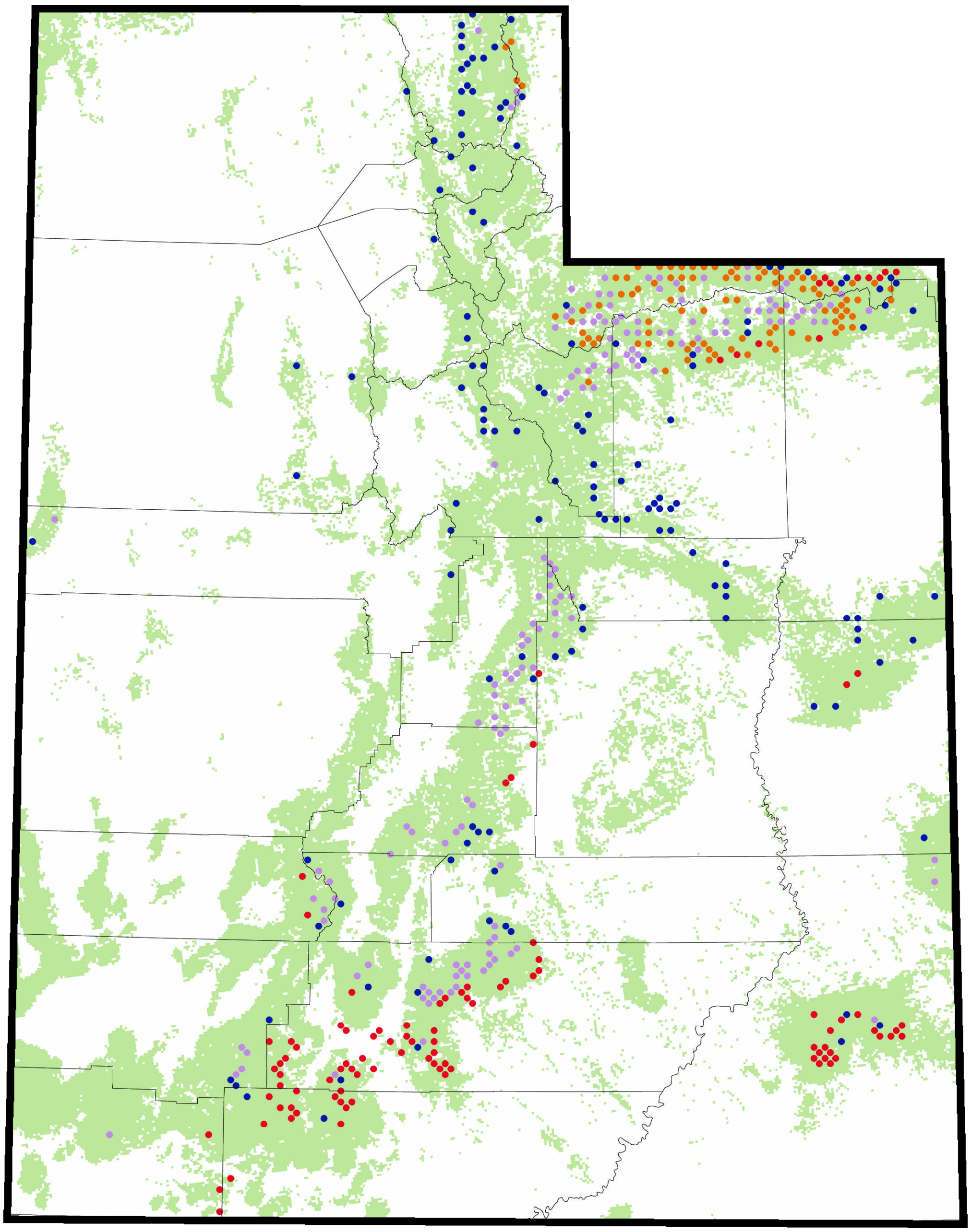
### Insects

Insect caused tree mortality at landscape scales is a significant concern in Utah forests. The most serious forest insect disturbance agents are bark beetles. Other damaging insects include defoliators such as the Douglas-fir tussock moth (*Orgyia pseudotsugata*) on Douglas-fir; western spruce budworm (*Choristoneura occidentalis*) on Douglas-fir, all true firs, and spruce; and the fall cankerworm (*Alsophila pometaria*) on oak and maple.

Endemic populations of bark beetles are present in most forests. Stand structure and composition often determine whether an insect population will reach epidemic levels. Specific attributes of inventory data collected from programs such as FHM and FIA may be used to hazard rate stands for some species of bark beetles. Hazard ratings identify stands where substantial losses can be expected if an outbreak occurs. In an effort to evaluate the vulnerability of Utah forests to bark beetle attack, FIA strategic level plot data were used to rate the hazard of spruce-fir forests to spruce beetle (*Dendroctonus rufipennis*), Douglas-fir forests to Douglas-fir beetle (*Dendroctonus pseudotsugae*), lodgepole pine to mountain pine beetle (*Dendroctonus ponderosae*), and ponderosa pine forests to mountain pine beetle and western pine beetle (*Dendroctonus brevicomis*) (After Steele and others 1996). Some variables were modified by S. Munson, Entomologist, USFS, to reflect Utah stand and site conditions. These forest types were assigned bark beetle hazard rating classes of high, moderate, or low. Stands with a high hazard rating are very susceptible to bark beetle outbreaks where extensive mortality could occur (O'Brien 1999).

Figure 5 shows the general location of forested FIA plots with a bark beetle hazard rating of moderate to high (O'Brien 1999). Using the results of the analysis, area estimates were calculated for susceptibility to attack by bark beetles. The acreage of each forest type, by bark beetle hazard category is divided into owner group in Table 1. This table also includes: (1) the acreage of each forest type where 80 percent of the trees were already dead due to either fire or bark beetle outbreak, and as a consequence now have a low susceptibility to bark beetle attack; (2) the acreage of each forest type that was not evaluated because the stands did not have trees that met the minimum size criteria and, therefore, were not used in the hazard rating calculations; and (3) the percentage of forest types where the hazard rating was moderate to high (O'Brien 1999). Since this analysis was completed, more areas throughout the state have experienced bark beetle outbreaks where subsequent tree mortality has occurred, thus lowering the hazard rating in those areas.

Figure 5. Approximate locations of FIA forested plots where the bark beetle hazard rating for four tree species was moderate or high (O'Brien 1999)



Moderate to high hazard rating

- Douglas-fir
- Lodgepole pine
- Ponderosa pine
- Spruce

Table 1. Acres of forest type by bark beetle hazard category and percent forest type in moderate or high hazard category (O'Brien and LaMadeleine1997).

## National Forest Systems

| Forest type | Low risk | Moderate risk | High risk | 80% dead | Not evaluated | Total acres | % Type moderate or high risk* |
|---|---|---|---|---|---|---|---|
| Spruce | 299,026 | 485,674 | 44,806 | 11,011 | 260,100 | 1,100,617 | 63 |
| Lodgepole pine | 53,057 | 336,460 | 25,586 | 37,029 | 12,377 | 464,509 | 80 |
| Douglas-fir | 90,534 | 172,811 | 250,799 | 9,582 | 34,059 | 557,785 | 81 |
| Ponderosa pine | 74,612 | 140,724 | 159,182 | 6,260 | 17,873 | 398,651 | 79 |

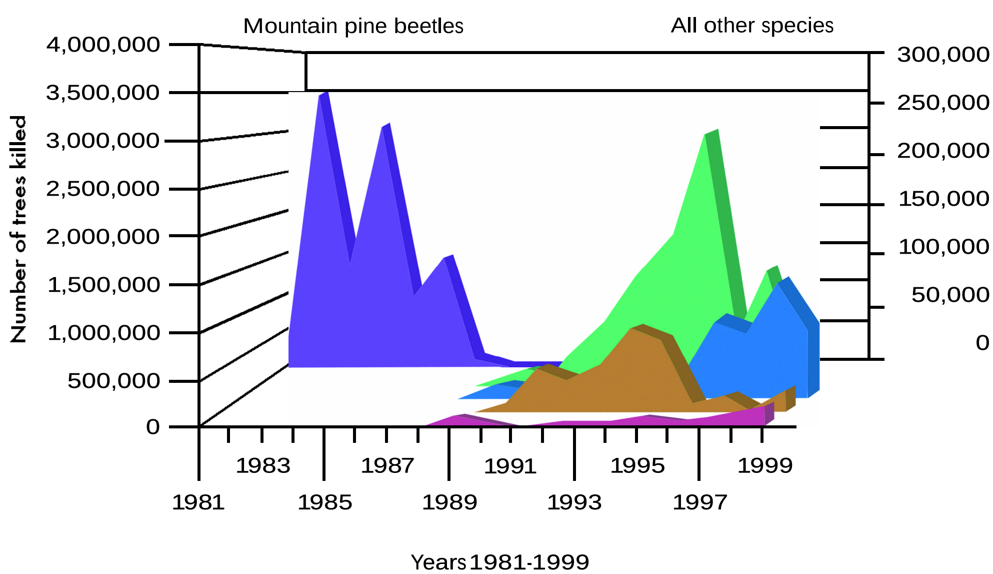
## All other ownerships

| Forest type | Low risk | Moderate risk | High risk | 80% dead | Not evaluated | Total acres | % Type moderate or high risk* |
|---|---|---|---|---|---|---|---|
| Spruce | ** | 39,935 | 6,976 | ** | 61,709 | 108,620 | 100 |
| Lodgepole pine | 12,715 | 6,298 | 10,346 | ** | ** | 29,359 | 57 |
| Douglas-fir | 107,141 | 211,434 | 191,765 | 7,242 | 53,033 | 570,615 | 78 |
| Ponderosa pine | 53,591 | 74,392 | 58,513 | ** | 9,289 | 195,785 | 71 |

*The percent of type at moderate or high risk will change as a result of current outbreaks.

Figure 6.

Trees killed by bark beetles in Utah between 1981 and 1999 (USDA, FHP aerial survey data)




Bark beetle species

- Mountain pine beetle
- Fir engraver beetle
- Subalpine fir mortality complex
- Douglas-fir beetle
- Spruce beetle

Long term monitoring of damage documented through the FHM and FIA plot networks in conjunction with annual USDA Forest Health Protection (FHP) aerial surveys provide a concerted approach to detect insect and disease or other mortality events. Figure 6 provides an overview of bark beetle-caused mortality in Utah from 1981 to 1999, as detected through FHP aerial surveys covering 9-10 million acres annually.

In the 1980s a mountain pine beetle outbreak on the Ashley and Wasatch-Cache National Forests caused extensive lodgepole pine mortality. FHP surveys estimate that between 1983 and 1986 mortality reached 70 to 90 percent on approximately 40,000 acres.

**Spruce beetle*

Since the late 1980s, the spruce beetle has caused extensive mortality in spruce-fir forests throughout much of Utah. FHP surveys indicate that the spruce beetle has caused up to 80 percent mortality on approximately 130,000 acres between 1987 and 2000 in and around the Manti-LaSal National Forest; 50,000 acres between 1988 and 2000 in and around the Dixie National Forest; and 5,000 acres between 1994 and 2000 in and around the Fishlake National Forest.

During severe outbreaks, spruce beetles may attack small diameter spruce (down to 4 inches in diameter) although progeny generally do not develop in small diameter spruce. The removal of overstory trees results in a modification of stand structure and species composition through a reduction in average diameter, height, basal area, and age of live spruce (Veblen and others 1991; 1994). Heavy mortality can adversely affect watershed, timber, wildlife, aesthetics, and recreational resources. Spruce beetle mortality can also alter fuel loads, potentially resulting in high fire hazard over time (Schmid and Frye 1977; Jenkins and others 1998).

## Diseases

There are many forest diseases present in Utah and they fill a number of ecological roles. The impacts of forest diseases are subtle and difficult to assess accurately. Forest diseases may reduce host vigor and weaken wood tissues. Structurally unsound trees can become hazard trees, particularly around cabins or in high-use recreation areas. Under certain conditions, some diseases may eventually kill the tree. However, many of the organisms that cause forest diseases act as saprophytes decaying organic material and promoting nutrient recycling.

Dwarf mistletoe is one of the more serious diseases in the state. Dwarf mistletoes are parasitic plants that grow on branches or stems of coniferous trees. Heavy mistletoe infections can stress host trees resulting in slow growth rates. Dwarf mistletoes can also kill trees directly or predispose them to attack by other insects and diseases. These parasitic plants are generally host specific, meaning that a specific dwarf mistletoe will typically infect only one host species. For example, lodgepole pine mistletoe (*Arceuthobium americanum*) will not usually occur on Douglas-fir or spruce trees. Dwarf mistletoe benefits some bird species by creating desirable nesting habitat. Survey results in Utah National Forests (Table 2) indicate the average percent incidence of dwarf mistletoe infection was 24 percent in Douglas-fir, 20 percent in ponderosa pine, and 48 percent in lodgepole pine (Hoffman and Hobbs 1978).

Table 2. Percent incidence of lodgepole pine, ponderosa pine and Douglas-fir dwarf mistletoe infection by National Forest in Utah (Hoffman and Hobbs 1978)

### Dwarf mistletoe incidences in Utah National Forest

| National Forest | Lodgepole pine % infected | Ponderosa pine % infected | Douglas-fir % infected |
|---|---|---|---|
| Ashley NF | 58 | 08 | 21 |
| Dixie NF | N/A | 10 | 89 |
| Fishlake NF | N/A | 66 | 23 |
| Manti-LaSal NF | N/A | 34 | * |
| Uinta NF | 38 | * | 0 |
| Wasatch Cache NF | 49 | 0 | 09 |
| **Average Infection** | **48** | **20** | **24** |

N/A = Not applicable  * Insufficient data

Other important diseases in Utah include root diseases, stem decays, and canker diseases. The majority of root diseases in most locations in Utah act as weak parasites causing some mortality, recycling underground woody organic material, and stressing host trees. Root diseases also play an integral role in maintaining endemic populations of bark beetles (Tkacz and Schmitz 1986). The most common root diseases in Utah include: Armillaria (*Armillaria ostoyae*) on many hosts; Annosus (*Heterobasidion annosum*) primarily on true firs and spruce; and Tomentosus (*Inonotus tomentosus*) primarily on blue spruce (*Picea pungens*) and Engelmann spruce.

*Dwarf mistletoe shoots on Douglas-fir*

Stem decay is caused by fungal pathogens capable of enzymatic breakdown of wood. The impact of this type of disease in any given area is difficult to assess without detailed wood volume studies using destructive sampling techniques. Several stem decays are common in Utah and include: white trunk rot of aspen (*Phellinus tremulae*); red ring rot (*Phellinus pini*) on several conifers; and Indian paint fungus (*Enchinodontium tinctorium*) on several true firs.

Many canker diseases favor trees under stress, and thus are more active when trees suffer from frequent drought or other stress factors. The most important canker diseases in Utah are found on aspen. Only a few canker diseases are important on other hosts. The most common canker diseases on aspen include: sooty bark canker (*Encoelia pruinosa*), Ceratocystis canker (*Ceratocystis fimbriata*), and Cytospora canker (*Cytospora spp*). Common canker diseases on other hosts in Utah include: Cytospora canker on various species of true firs, and Atropellis canker (*Atropellis piniphila*) on ponderosa and lodgepole pines.

Other minor diseases include foliage diseases and rusts. A large number of foliar pathogens are present in Utah. These diseases can be found in any forest, but only become a serious concern when they cause repeated defoliation over several consecutive years. Several rust diseases are present in Utah in various forest types. These diseases may cause serious impacts in geographically isolated areas (Peterson 1966; Ziller 1974; Van der Kamp 1988).

## Non-native Diseases, Insects & Plants

Many insects, diseases, and plants which significantly impact our forests have been introduced from other continents. Introduced or non-native diseases are especially damaging to forests because native trees have not had the opportunity to develop resistance to the non-native disease agent (Tainter and Baker 1996). Furthermore, in their native environments, these agents have natural enemies (parasites and predators) that keep their numbers in balance. In this country, the absence of host resistance and natural enemies has allowed non-native agent populations to expand rapidly. Non-native species may persist for long periods causing severe damage to host species, or out-competing other native plants and animals for valuable resources.

### Diseases

White Pine Blister rust (*Cronartium ribicola*) is a fungal disease native to Eurasia. It was introduced into western North America in 1910. The fungus infects trees through the needles. It grows down the center of the needle and into the stem, producing cankers that may kill the tree. In much of the United States this non-native disease has caused serious mortality in several five needle pine species and has changed ecosystem functioning in Montana and Idaho (Tainter and Baker 1996; McConnell 1999). Five needle pines in Utah, primarily limber pine (*Pinus flexilis*), bristlecone pine (*Pinus longaeva*), and white bark pine (*Pinus albicaulis*) are susceptible to white pine blister rust. However, this disease is conspicuously absent from Utah forest containing susceptible hosts (Smith and Hoffman 2000). Several factors may be limiting the spread of white pine blister rust into Utah. Five needle pines in Utah have a limited, discontinuous distribution, and do not appear to be located near infected species in other states. Additionally, white pine blister rust is a cool-wet weather disease (Tainter and Baker 1996) and the relatively arid, cold forests in Utah are not ideal habitat for this disease. If white pine blister rust were to become established in Utah, it could cause serious changes in forest composition. Early detection would be the key to successful management.

Dutch elm disease (*Ceratocyctis ulmi*) was introduced from Europe into the United States around 1930. In the western United States, Dutch elm disease has eliminated American elm (*Ulmus Americana*) as a desirable ornamental tree species. Although American elms can occasionally be found in Utah, they are no longer recommended as ornamental plantings.

## Insects

The most recently introduced threat to Utah forests is the gypsy moth (*Lymantria dispar*). Within the United States the gypsy moth caterpillar feeds on over 500 species of deciduous trees and shrubs. In the east, millions of dollars each year are spent to eradicate or suppress this voracious defoliator.

Introduction of gypsy moth occurred in Utah during the mid- to late-1980s. In 1988, three sperate gypsy moth infestations were detected in Bountiful, Salt Lake City, and Provo. A five-year eradication program successfully eliminated the pest from approximately 30,000 acres until another small introduction was detected in 1996. This infestation encompassed about 800 acres northwest of Big Cottonwood Canyon in the Knudsen's Corner area of Salt Lake City. The infestation was successfully eradicated by 1998 through interagency cooperation and public support. Monitoring and subsequent eradication programs are ongoing to prevent the establishment of this non-native species.

**Gypsy moth, adult male and female*

The Asian long-horned beetle (*Anoplophora glabripennis*) and the balsam wooly adelgid (*Adelges piceae*) may pose a threat to Utah forests. The Asian long-horned beetle was recently introduced into Chicago and New York City in solid wood packing material from China. This beetle prefers maples and other broadleaved trees. Many important ornamentals may be damaged or killed by beetles boring into the trunk and branches. Balsam wooly adelgid causes damage and mortality to several fir species by feeding on the stem, branches, and twigs. It was introduced from Europe into northeastern North America around 1900. Since then, it has become established in several western states including Idaho. Presently, neither species has been found in Utah.

## Weeds

Noxious and invasive weeds may affect native ecosystems by reducing biological diversity, modifying wildlife habitats, altering fire and nutrient cycles, and degrading soil structure. Utah currently has 18 declared noxious weeds and another 14 weeds that have been identified as new and invading (UDAF 2001). Common attributes of invasive species include rapid growth, short life-cycles and abundant seed production, allowing these weeds to expand at an alarming rate. Invasion statistics for National Forest System lands in Utah show that in 1996 approximately 82,000 acres were infested. In 2001, these infestations have expanded to approximately 138,900 acres (Johnson 2001). A coordinated effort to assess acreage of infestations on state and private lands has not yet been implemented. Cooperative, integrated pest management programs are presently being developed between agencies to treat noxious and invasive weeds using various methods of eradication and control.

*Wildland interface forest*

## Development and Wildland Interface

Urban-wildland interface and developed forest conditions exist where human development meets or intermixes with wildland. In Utah, approximately 374,000 acres are considered to be in urban-wildland and developed interface conditions (Dalrymple and Grierson 2000).

In 2000, Utah population estimates neared 2.23 million. This is approximately a 30 percent increase from 1990 (U.S. Census Bureau 2000).

With land values increasing, there is more pressure to make land parcels smaller. This development can make public safety, proper stewardship, and management of these lands extremely challenging.

Some forest health issues in interface areas include:

- Fire management
- Insect and disease management
- Maintenance of wildlife habitat
- Protection of soils, waterways, and watersheds

## Fire Management

Federal, state, and local fire fighting agencies are charged with protecting life, property, and natural resources in developed forests. When structures and people are intermingled with fire-susceptible forests then several problems arise, which include: (1) vegetation near a structure reduces the ability of firefighters to provide protection; (2) fire suppression costs per acre in developed forests may be 8-10 times higher than suppression costs in non-developed wildlands due to the increased need for resources to protect structures (Dalrymple 2001); and (3) it is a challenge to provide trained wildland fire fighting personnel needed to keep up with the continuing increase in wildland interface and developed forests.

## Insect & Disease Management

Insect and disease-induced mortality during outbreaks is often extensive and may cover large landscapes. Insects and diseases do not recognize land ownership boundaries. Therefore, any management to prevent or control pest outbreaks must be a cooperative effort among many landowners and land management agencies. For example, bark beetle control strategies often require landscape level management across ownership boundaries. Private landowners have many differing views on pest control. Some are concerned about pests and would attempt control through thinning or use of pesticides, and others would not. This variety of landowner values complicates landscape level strategies required to prevent or control pest outbreaks.

## Maintenance of Wildlife Habitat

Another challenge in the interface relates to wildlife corridors needed by some species. Land use boundaries, fences, and vegetative partitions can severely hamper the movement or migration of some wildlife species. Ultimately, this can lead to habitat loss and species decline and to increased wildlife and human conflicts such as deer browsing on domestic shrubs or predator attacks on family pets or people.

## Protection of Soils, Waterways & Watersheds

Increases in population density and ensuing construction can cause damage to soils, waterways, and entire watersheds while increasing the requirement for additional services and creating greater demand on resources. Different landowner perceptions regarding their rights and the rights of land management agencies can make watershed and soil protection more difficult.

## Forest & Watershed Health

A watershed is composed of a landscape that drains to a specific point on a stream, creek, river, pond, lake, reservoir or other feature that contains or seasonally contains water. Watersheds provide drinking water and support aquatic and wildlife species, recreation, aesthetics, employment, agricultural production, and vital plant communities.

A healthy watershed absorbs normal snow and rainfall, while supplying a steady flow of water that sustains dependent species without degrading the quality of its soil, despite disturbances like floods or fire. Symptoms of poor watershed health may include declining water quantity and quality, decreasing stocks of native fish and wildlife, and increasing disturbances such as urban development, insect outbreaks, and catastrophic wildfire.

Utah is the second driest state in the nation, with high elevation forests as the principle source of water. Therefore, anything that affects forest health affects watershed health. For example, water yields are often associated with forest type. The transpiration rate of conifers such as spruce and subalpine fir may be twice that of aspen (Long 1994). On many watersheds aspen is gradually being replaced by conifer species, as mentioned in the previous Forest Cover Change section. This change in forest type may have a considerable impact on water yield.

The importance of the connection between forests and water resources was recognized very early in this country's history. In the mid 1880s, attention was being drawn to the degradation of watersheds by the unscrupulous treatment of the land. In response to some of these concerns the USDA Organic Act of 1897 was enacted, in part, to "secure favorable conditions of water flow" (USDA, FS 1998).

Under the Utah 1998 Clean Water Action Plan (UDEQ, Appendix II 2000), natural resource agencies were directed to develop State Unified Watershed Assessments. Twelve state and federal agencies participated in this watershed health assessment. Figure 7 shows Utah watersheds by priority for restoration or protection. Some of the key factors used to place a watershed in the highest priority for restoration were: (1) that watersheds have current or pending water quality or other resource improvement projects that would improve or protect water quality; (2) continuing or previous population growth and development that could impact water quality in the near future; and (3) there is widespread local support for improving natural resources in the watershed. For a better understanding of this assessment, refer to the Utah Clean Water Action Plan, Utah Unified Watershed Assessment and Watershed Restoration Priorities (UDEQ, Appendix II 2000).

Utah surface water resources are summarized as follows (UDEQ, Appendix III 2000):

- Rivers and Streams: 16,457 miles
- Lakes and reservoirs: approximately 3,000
- Wetlands: 510,039 acres and 1,902 linear miles of streams and rivers
- Groundwater: A small quantity throughout the state but in some counties makes up almost 90 percent of the drinking water supply

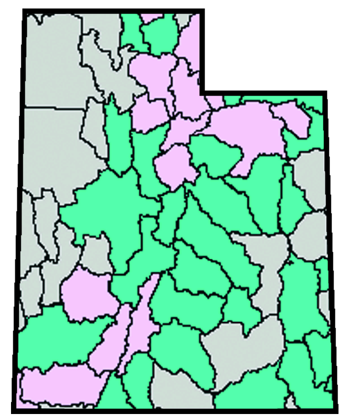
Crucial water supplies can be affected by over 64 different impairments. Nutrients are the largest impairment for lakes, estuaries, and wetlands. Sedimentation, nutrients, pathogens, toxic metals, organics, and inorganics top the list for impairing streams and rivers. Climactic disturbance events, such as floods, tornadoes, microbursts, and avalanches, can increase erosion and sedimentation. Disturbances from improper harvesting activities, forest development, insect- and disease-caused mortality, and large fires can also have adverse effects on water resources (UDEQ, Appendix III 2000).

The following challenges confront Utah citizens, legislators, and land management agencies:

- Increasing watershed effects caused by from the gradual change in aspen forest type to conifer species
- Forest development
- Insect and disease outbreaks
- Undesirable fires
- Recreation, and other resource uses

It is the responsibility of Utah citizens, landowners, legislators, and land management agencies to work cooperatively and determine appropriate management strategies to enhance and maintain watershed health. FHM, FIA and other federal and state programs often provide the base information needed to help facilitate land management decisions.

Figure 7. Utah watersheds by priority for restoration or protection



Unified water assessment classifications

| Classification | Count |
|---|---|
| Highest restoration priority | 14 |
| Other restoration needed | 28 |
| Meeting standards | 0 |
| Very high quality | 0 |
| Need more information | 26 |

## Biological Diversity

Conservation of biological diversity (biodiversity) is one of seven criteria being assessed internationally under the Santiago Declaration (Anonymous 1997). Measures of biodiversity may act as direct indicators of forest health. Biodiversity may be measured in terms of composition, structure, or function of a given system (Helms 1998; Lindenmayer and others 2000). Scientists often characterize biodiversity as having four primary levels: (1) genetic (2) species (3) community-ecosystem (4) landscape (Langner and Flather 1994; Gaines and others 1999). FHM does not attempt to assess genetic diversity, and is not designed to address individual species. At larger scales, the overall health of our forests determines what species they can support and the resiliency of forests to human or environmental disturbances.

FHM plots are designed to measure vegetative structure and composition. This data provides a measure for determining species diversity and ecosystem or community diversity. Additionally, species tallies may be applied to the question of state or regional impacts from exotic species (Stapanian and others 1998). Changes in numbers and frequency of species, as reflected in tree tally over time, may be used to determine biological diversity trends (Stapanian and others 1997).

As plants and wildlife respond to differing vegetation communities, structures, and age classes, the ensuing changes in these communities can affect biological diversity. Short- and long-term monitoring is important in detecting or predicting these changes.

Many associate biological diversity with the loss of habitat for high-profile species, such as northern goshawk, lynx, or American marten. Large-scale monitoring of habitat can be greatly enhanced using satellite imagery (Homer and others 1997). Combining monitoring data, satellite imagery, and rare species inventories is a promising avenue for broader habitat and threatened species assessments.

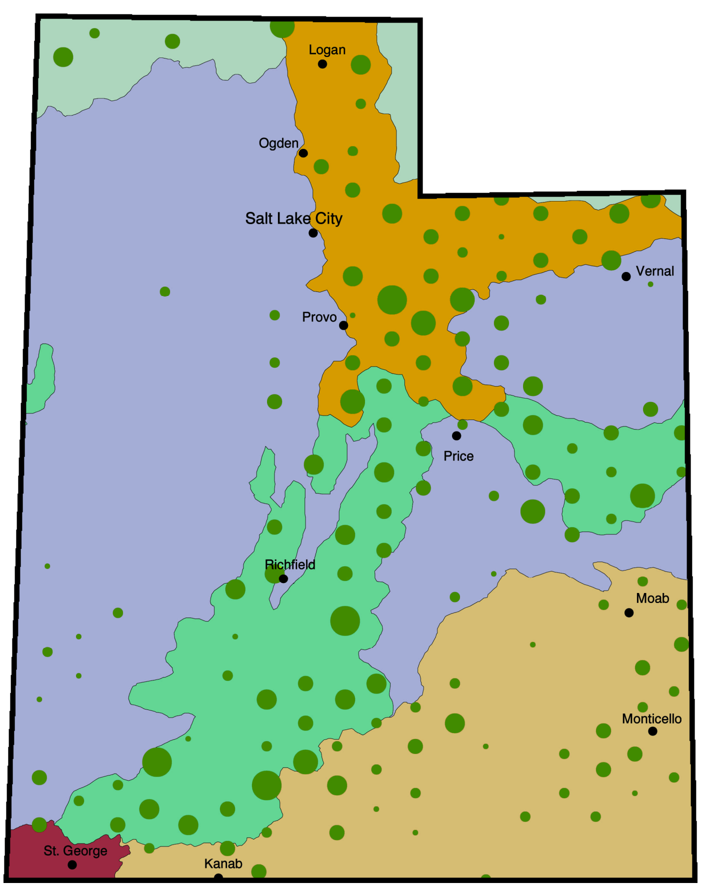
## Air Quality

FHM is concerned with the impact of poor air quality on forest health. In addition to directly damaging vegetation, poor air quality may predispose plants to other forest disturbances (Smith 1985). FHM monitors air quality impacts on forest health through lichen sampling, ozone biomonitoring, and tree crown and damage surveys.

### Lichens

Lichens add significantly to forest diversity, enhance nutrient cycling, and are an important food source for wildlife (McCune and others 1998). Because lichens subsist almost exclusively on nutrients in the atmosphere, they may be used as indicators of air quality (Smith and others 1993; van Dobben 1993). In general, greater variety of species and increased abundance of lichens, while accounting for variability associated with climate, indicates better air quality (McCune 1988).

Figure 8. Lichen species richness as found on FHM plots throughout the state of Utah



FHM crews collect lichen samples and rate their abundance on all field plots. Lichen specialists identify species and calculate species richness. The map in Figure 8 shows the range of lichen species richness throughout the state. On a national scale, species richness for Utah is quite low because of the relatively dry climate. Air quality scores at the plot level are relative to local climates and potential abundance of lichens. Plot scores will be adjusted based on the pollution tolerance of individual species as derived from a local species gradient model.

## Ozone Biomonitoring

Certain plant species are sensitive to ozone and can be used as biological indicators (bioindicators) of poor air quality. In areas of consistently poor air quality, plants such as the shrub ninebark (*Physcocarpus malvaceus*) or ponderosa pine are discolored or show dieback (Mavity and others 1995; James and Staley 1980).

High ozone levels have negatively affected plant and tree health in the eastern United States and southern California for decades (Smith 1985). The U.S. Environmental Protection Agency estimates that plant-damaging levels of ozone are exceeded several times annually along the Wasatch Front (U.S.EPA 1996; Wager 1999). However, recent reports suggest that ozone pollution has dropped along the Wasatch Front in the last decade (UDAQ 1998).

Field crews examine bioindicator plants for ozone damage near plot locations to detect and monitor trends in air quality. Thus far, ozone damage has not been detected near FHM plots in Utah. Preliminary data from a special study conducted in 2000 near Salt Lake City (not part of the FHM sampling grid) has confirmed some ozone damage to non-native ponderosa pine in a small park (Wager 1999). Further monitoring of FHM plots, along with special plots, will yield ongoing estimates of statewide ozone effects on forest health.

## Tree Crown and Damage

Some trees, sensitive to poor air quality, exhibit symptoms such as thinning crowns and discolored foliage. Visual crown ratings and damage surveys have been successfully applied to forest health evaluations in mixed hardwood stands in Europe and eastern North America since the mid 1980s (Tomlinson and Tomlinson 1990).

Field crews in the Interior West estimate density, dieback, and transparency of crowns (Appendix D) and make damage assessments (Appendix E) of all mature sample trees. Data collected thus far in Utah show no clear signs of thinning crowns or foliage damage. Future assessment of pollution on forest health will compare FHM crown data with information from state and federal agencies that monitor air quality.

## Emerging Issues

Emerging issues are those that FHM has not looked at thus far, but that we hope to address in future reports. Among these is forest fragmentation—the break up of large expanses of forest habitat into two or more patches separated by different types of habitat (Wilcove and others 1986). While closely related to biodiversity and forest health, forest fragmentation may provide beneficial habitat for some wildlife species or have detrimental effects for others. Plot and remotely sensed data may be applied to this issue in future publications.

Other potential forest health issues addressed in the Santiago Declaration (Anonymous 1997) are global carbon cycles and soil resources. Measuring global carbon cycles involves monitoring the balance of carbon going into and coming out of forest systems. Carbon is stored in biomass above ground and below ground in roots and organic material (live and decaying dead organisms). Future FHM surveys plan to measure understory vegetation and down woody debris. This information, combined with current tree measurements, will assist analysts in calculating state and regional carbon budgets. "Soil health" will give us information on the quality of the soil resource that supports the forest. Loss of topsoil or contamination by foreign chemicals could significantly degrade forest sustainability. In Utah, FHM soil sampling began during the 2000 field season. We expect to summarize soil data in an upcoming forest health report.

# Summary

Consistent long-term monitoring across the entire state is crucial to understanding how forests function. The detection of changes, both desirable and undesirable, are needed so that solid information can be used in the decision making process by landowners, resource managers, and policy makers. FHM was conceived to detect changes at ecoregional, regional, and national levels. In effect, both the plot and survey components of FHM act as a "broad net approach" to monitoring forests. Enabling federal land management districts, state offices, or research institutions to gain a perspective on issues of local concern. A list of some possible contacts is given at the end of this report (Appendix G).

This baseline report presents an overview of current forest health issues affecting Utah forests and provides a basis for comparison through time. Issues of concern today may only be fully understood through the collection and analysis of long-term data sets such as those being provided by FHM. We anticipate forest health issues changing in the future. The FHM program will continue to monitor new and evolving issues. Subsequent reports will indicate how these issues have changed and address new issues that arise.

Some Utah forests may have changed substantially during the past century and a half. Aspen forests appear to have declined during the past 100 years. This change has implications for wildlife habitat, plant community diversity, scenic beauty, water production, and recreational opportunities. The reduction in fire and increased foraging by livestock and wildlife may have resulted in more conifer trees and fewer aspen.

Pinyon-juniper forests appear to have expanded greatly in the past 150 years, resulting in less grass and sagebrush lands. A reduction in the density and diversity of understory plants changes wildlife habitat and the fire regime, which has gone from low or moderate intensities to high intensities. The change in fire regime increases potential invasion by aggressive exotic plants such as cheatgrass.

Ponderosa pine forests, because of harvesting and fire suppression, appear to be denser and younger in some places than in the late 1800s. The result may be a forest condition at risk to insect outbreak and greater fire intensity.

Evaluation of potential bark beetle mortality in Utah forests indicates moderate to high hazard sites range across all ownerships. In the spruce-fir forest types, moderate to high hazard ratings in spruce beetle infested forests equate to extensive mortality of the spruce component.

Introduced or non-native pests are a major concern that can and does effect Utah forests. The gypsy moth has been eradicated twice in the last decade after introductions have been detected. Numerous invasive weeds pose a risk to wildlife habitat, plant community diversity, recreation, and other forest values. Their continuing spread across all ownerships provides a significant challenge to land managers and owners.

Population growth and expanding human development into and adjacent to forests creates numerous concerns including; protection of property and lives from fire, effects on wildlife habitat, and the potential hazard associated with trees damaged or killed by insects and diseases.

Forest health issues are often complex. This initial Utah forest health report has likely raised more questions than it has answered. Moreover, human values regarding what actions to take, or not to take, complicate forest-related issues and decisions. The intent of this report was to remain objective in describing issues and not to provide management prescriptions. Individuals and organizations concerned with forest management must decide for themselves where and if action is warranted based on existing information and objectives.

Please note that we are interested in your suggestions and feedback regarding this report. Appendix G includes names of individuals to call for further information.

A Reader Feedback card is included on the back page of this report along with the website to access this report or to register comments. www.nr.utah.gov/slf/fhm.htm

# References


Anonymous, 1997. First approximation report on the Montreal Process. Working group on criteria and indicators for the conservation and sustainable management of temperate and boreal forest, The Montreal Process Liaison Office, Natural Resources Canada, Canadian Forest Service, Ottawa, Canada. 47 p. (See also, [Anonymous. 1995] Sustaining the worlds forests: The Santiago Declaration. Journal of Forestry 93(4): 18-21.

Arno, Stephen F. 1988. Fire ecology and its management implications in ponderosa pine forests. In: Baumgartner, David M.; Lotan, James E. Ponderosa pine the species and its management symposium: proceedings; 1987 Sept. 29-Oct. 1; Pullman, WA: Washington State University. 133-139 pp.

Arno, Stephen F.; Smith, Helen Y.; Krebs, Michael A. 1997. Old growth ponderosa pine and western larch stand structures: Influences of pre-1900 fires and fire exclusion. Res. Pap. INT-RP-495. Ogden, UT: Intermountain Research Station. 20 p.

Bailey, R.G. 1995. Descriptions of the ecoregions of the United States. Misc. Pub. No. 1391 (2nd ed.). USDA, Forest Service, Washington, DC 108 p.

Bartos, Dale; Campbell, Robert B. 1998. Decline of quaking aspen in the Interior West-example from Utah. Rangelands 20(1): 15-22.

Bradley, Anne F.; Noste, Nonan V.; Fischer, William C. 1992. Fire ecology of forests and woodlands in Utah. Gen. Tech. Rep. GTR-INT-287. Intermountain Research Station. 128 p.

Creque, Jeffrey A.; West, Neil E.; Dobrowolski, James P. 1999. Methods in historical ecology: A case study of Tintic Valley, Utah. In: Monsen, S.; Stevens, R., ed. Ecology and management of pinyon-juniper communities within the Interior West symposium: proceedings; 1997 September 15-18; Provo, UT. RMRS-P-9 Ogden, UT: Rocky Mountain Research Station. 121-133 pp.

Dalrymple, David; Grierson, David. 2000. Urban Interface Mapping Project. Utah Department of Natural Resources, Division of Forestry, Fire and State Lands, Salt Lake City, UT.

Dalrymple, David. 2001. [Personal communication]. Utah Department of Natural Resources, Division of Forestry, Fire and State Lands, Salt Lake City, UT.

Gaines, W.L.; Harrod, R.J.; Lehmkuhl, J.F. 1999. Monitoring biodiversity: Quantification and interpretation. Gen. Tech. Rep. PNW-GTR-443. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. 27 p.

Graham, Russell T.; Rodriguez, Ronald L.; Paulin, Kathleen M.; Player, Rodney L.; Heap, Arlene P.; Williams, Richard. 1999. The Northern goshawk in Utah: Habitat assessment and management recommendations Gen. Tech. Rep. RMRS-GTR-22. Rocky Mountain Research Station. 48 p.

Gruell, George E. 1999. Historical and modern roles of fire in pinyon-juniper. In: Monsen, S.; Stevens, R., ed. Ecology and management of pinyon-juniper communities within the Interior West symposium: proceedings; 1997 September 15-18; Provo, UT. RMRS-P-9 Ogden, UT: Rocky Mountain Research Station. 24-28 pp.

Harrington, M.G.; Sackett, S.S. 1992. Past and present fire influences on southwestern ponderosa pine old-growth. In: Kaufmann M.R.; Moir W.H.; Bassett R.L. Tech cords. Old-growth forests in the Southwest and Rocky Mountain regions workshop: proceedings; 1992 March 9-13; Portal AZ. Gen Tech Rep RM-213. U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins CO. 44-50 pp.

Helms, J.A. 1998. The dictionary of forestry, Society of American Foresters. Bethesda, MD. Published by the Society of American Foresters. 210 p.

Hinds, T.E. 1985. Diseases. In: DeByle, N.V.; Winokur, R.P., eds. Aspen: Ecology and management in the western United States. Gen. Tech. Rep. RM-119. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 87-106 pp.

Hoffman, James T.; Hobbs, LaGrande. 1978. Dwarf mistletoe loss assessment survey in Region 4. Report R-4, 79-4, U.S. Department of Agriculture, Forest Service, Forest Health Protection (formerly Forest Insect and Disease Management). Ogden, UT. 11 p.

Homer, C.G.; Ramsey, R.D.; Edwards, T.C. Jr.; Falconer, A. 1997. Landscape cover-type modeling using a Multi-scene Thematic Mapper Mosaic. Photogrammetric Engineering and Remote Sensing. 63: 59-67.

James, R.; Staley, J. 1980. Photochemical air pollution damage survey of ponderosa pine within and adjacent to Denver, Colorado: A preliminary report. R2-80-6. Denver, CO: U.S. Department of Agriculture, Forest Service, Forest Insect and Disease Management Biological Evaluation. 21 p.

Jenkins, M.J.; Dicus ,C.A.; Hebertson, E.G. 1998. Post fire succession and disturbance interactions on an intermountain subalpine spruce-fir forest. In: Pruden, T.L.; Brennan, L.A. eds. Fire in ecosystem management: shifting the paradigm from suppression to prescription. Tall Timbers Fire Ecology Conference Proceedings, No. 20. Tall Timbers Research Station, Tallahassee, FL. 219-229 pp.

Johnson, Curt. Rangeland Ecosystem Specialist. 2001. [Personal communication]. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Region, Range Management.

Kay, C.E., 1997. Is aspen doomed? Journal of Forestry. 95(5): 4-11.

Langner, L.L.; Flather, C.H. 1994. Biological diversity: Status and trends in the United States. Gen. Tech. Rep. RM-244. Fort Collins, CO: U. S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 24 p.

Laycock, W.A. 1999. Ecology and management of pinyon-juniper communities within the Interior West: Overview of the ecological session of the symposium In: Monsen, S.; Stevens, R., ed. Ecology and management of pinyon-juniper communities within the Interior West symposium: proceedings; 1997 September 15-18; Provo, UT. RMRS-P-9 Ogden, UT: Rocky Mountain Research Station. 7-11 p.

Lindenmayer, D.B.; Margules, C.R.; Botkin, D.B. 2000. Indicators of biodiversity for ecologically sustainable forest management. Conservation Biology 14: 941-950 pp.

# References


Long, James. 1994. Chapter 8, The middle and southern Rocky Mountain region. In Barrett, John W., ed. Regional silviculture of the United States, 3rd edition. 1995. New York, NY: John Wiley and Sons, Inc. 375 p.

Madany, M.H.; West, N.E. 1983. Livestock grazing–fire regime interactions within montane forests of Zion National Park, UT. Ecology 64(4): 661-667.

Mavity, E.; Stratton, D.; Barrang, P. 1995. Effects of ozone on several species of plantswhich are native to the western United States. Unpublished report on file at: U.S. Department of Agriculture, Forest Service, Center for Forest Environmental Studies, Dry Branch, GA. 62 p.

McConnell, T. 1999. Montana: Insect and disease conditions and program highlights. Forest Health Protection, Northern Region Report 00-02. Available at: http://www.fs.fed.us/r1/foresthealth/fhc/mtcond99/mt99tit.htm

McCune, B. 1988. Lichen communities along O3 and SO2 gradients in Indianapolis. The Bryologist 91: 223-228.

McCune, B.; Rogers, P.; Ruchty, A.; Ryan, B. 1998. Lichen communities for Forest Health Monitoring in Colorado, USA. A report to the U.S. Department of Agriculture, Forest Service, Forest Health Monitoring National Office, Southern Research Station, Research Triangle Park, NC. 29 p.

O'Brien, Renee A.; LaMadeleine, Leon A. 1997. Forest health in Utah: an assessment. Unpublished report (draft, not published) U.S. Department of Agriculture, Forest Service, Utah Rocky Mountain Research Station and Forest Health Protection, Ogden, UT.

O'Brien, Renee A. 1999. Comprehensive inventory of Utah's forest resources, 1993. Resource Bulletin RMRS-RB-1, Ogden UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 105 p.

O'Brien, Renee A.; Woudenberg, Sharon W. 1999. Description of pinyon-juniper and juniper woodlands in Utah and Nevada from an inventory perspective. In: Monsen, S.; Stevens, R., ed. Ecology and management of pinyon-juniper communities within the Interior West symposium: proceedings; 1997 September 15-18; Provo, UT: RMRS-P-9 Ogden, UT: Rocky Mountain Research Station. 55-59 pp.

Ogle, Karen; DuMond, Valerie. 1997. Historical vegetation on National Forest Lands in the Intermountain region. U.S. Department of Agriculture, Forest Service, Ogden, UT. Intermountain Region. 129 p.

Peterson, R.J. 1966. Limb rust damage to pine. Research paper INT-31. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 10 p.

Riebsame, W.; Robb, J. (eds.) 1997. Atlas of the New West: portrait of a changing region. New York, NY: W.W. Norton and Company. 192 p.

Rogers, Paul, 2002. Using Forest Health Monitoring to assess aspen forest cover change in the Southern Rockies ecoregion. Forest Ecology and Management 155(1-3): 223-236.

Romme, W.H.; Turner, M.G.; Gardner, R.H.; Hargrove, W.W.; Tuskan, G.A.; Despain, D.G.; Renkin. R.A. 1997. A rare episode of sexual reproduction in aspen (*Populus tremuloides* Michx.) following the 1988 fires. Natural Areas Journal 17(1): 17-25.

Schmid, J.M.; Frye, R.H. 1977. Spruce beetles in the Rockies. Gen. Tech. Rep. RM-49. Denver, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 38 p.

Shinneman, D.J.; Baker, W.L. 1997. Nonequilibrium dynamics between catastrophic disturbances and old growth forest in ponderosa pine landscapes in the Black Hills. Conservation Biology 11(6): 1276-1288.

Smith, W.H. 1985. Forest and air quality. Journal of Forestry 83: 82-92.

Smith, C.; Geiser, L.; Gough, L.; McCune, B.; Ryan, B.; Showman, R. 1993. Species and communities. Chapter 4, Lichen as Bioindicators of Air Quality. Gen. Tech. Rep. RM-224. U.S. Department of Agriculture, Forest Service.

Smith, Jonathan P.; Hoffman, James T. 2000. Status of white pine blister rust in the Intermountain west. Western North American Naturalist 60(2): 165-179.

Stapanian, M.A.; Cassell, D.L.; Cline, S.P. 1997. Regional patterns of local diversity of trees: associations with anthropogenic disturbance. Forest Ecology and Management 93: 34-44.

Stapanian, M.A.; Sundberg, S.D.; Baumgardner, G.A.; Liston, A. 1998. Alien plant species composition and associations with anthropogenic disturbance in North American forests. Plant Ecology 139: 49-62.

Steele, Robert; Williams, Ralph E.; Weatherby, Julie C.; Reinhardt, Elizabeth D.; Hoffman, James T.; Their, R.W. 1996. Stand hazard rating for central Idaho forests. Gen. Tech. Rep. INT-GTR-332. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 29 p.

Tainter, F.H.; Baker, F.A. 1996. Principles of Forest Pathology. New York, NY: John Wiley and Sons Inc. 805 p.

Tausch, Robin. 1999. Historic pinyon and juniper woodland development. In: Monsen, S.; Stevens, R., ed. Ecology and management of pinyon-juniper communities within the Interior West symposium: proceedings; 1997 September 15-18; Provo, UT. RMRS-P-9 Ogden, UT: Rocky Mountain Research Station. 12-19 p.

Tkacz, B.M.; Schmitz, R.F. 1986. Association of an endemic mountain pine beetle population lodgepole pine infected with Armillaria root disease in Utah. Research Note INT-353 Ogden UT: U S. Department of Agriculture, Forest Service, Intermountain Research Station. 7 p.

Tomlinson, G.; Tomlinson, F. 1990. Effects of acid deposition on the forests of Europe and North America. Boca Raton, FL: CRC Press, Inc. 215-224 pp.

United States Census Bureau 2000. http://www.census.gov/

United States Department of Agriculture (USDA), Forest Service. 1998. A nation's natural resource legacy. Washington, DC: Publication FS-630, October, 1998.

United States Environmental Protection Agency (USEPA). 1996. Report PB92-190446.

Utah Department of Agriculture and Food (UDAF) 2001. The Utah Noxious Weed Act, Title 4-Chapter 17, and rule R68-09.

Utah Department of Environmental Quality (UDEQ), 2000. Utah nonpoint source pollution management plan, prepared by Department of Environmental Quality in cooperation with the Utah Nonpoint Source Task Force, January 28, 2000 Draft. Appendix II, Utah unified watershed assessment and watershed restoration priorities, clean water action plan, October 01, 1998. Appendix III, Utah water quality assessment report to Congress, November, 1998.

Utah Division of Air Quality (UDAQ). 1998. Annual report, 1996. 32 p.

Van der Kamp, B.J. 1988. Temporal and spatial variation in infection of lodgepole pine by western gall rust. Plant Disease 72: 787-790.

van Dobben, H. 1993. Vegetation as a monitor for deposition of nitrogen and acidity. Netherlands: Utrecht University, privately published. 214 p. PhD Dissertation.

Veblin, T.T.; Hadley, K.S.; Reid, M.S.; Rebertus, A.J. 1991. The response of subalpine forests to spruce beetle outbreak in Colorado. Ecology 72: 213-231.

Veblin, T.T.; Hadley, K.S.; Nel, E.M.; Kitzberger, T.; Reid, M.S.; Vilalba, R. 1994. Disturbance regime and disturbance interactions in a Rocky Mountain subalpine forest. Journal of Ecology 82: 125-135.

Wager, D.J. 1999. Monitoring ozone concentrations and assessing risk to vegetation in the central Wasatch Mountains. Logan, UT: Utah State University, Dept. of Forest Resources. 16 p. Thesis.

Wilcove, D.S.; McIellan, C.H.; Dobson, A.P. 1986. Habitat fragmentation in the temperate zone. In: Sole, M.E. ed. Conservation Biology; The science of scarcity and diversity. Sunderland, MA. Sinauer Press. 237-256 pp.

Ziller, W.G. 1974. The tree rusts of western Canada. Canadian Forest Service Publication 1329. 272 p.

# APPENDIX A:

## Utah's FHM plots in a regional context

### Plot distribution in the Interior West by state and land use

*(totals are in fractions of plots*)*

| Land use category | Colorado | Idaho | **Utah** | Nevada | Wyoming | Region |
|---|---|---|---|---|---|---|
| Timberland | 91.59 | 124.76 | **36.28** | 5.25 | 50.40 | 308.28 |
| **Woodland | 46.02 | 8.25 | **86.99** | 58.51 | 7.87 | 207.64 |
| ***Inaccessible | 9.25 | 3.00 | **11.03** | 26.00 | 4.25 | 53.53 |
| Non-forest | 267.14 | 188.99 | **200.70** | 359.24 | 329.48 | 1345.55 |
| Totals | 414.00 | 325.00 | **335.00** | 449.00 | 392.00 | 1915.00 |

**Fractions of plots arise when more than one land use is found on a plot for example: two-thirds of the plot is in timberland and one-third of the plot is in non-forest*

***Woodland tree species such as juniper, pinyon pine, maple, mountain mahogany, mesquite, oak brush, and locust, commonly have multiple stems near their base.*

****Inaccessible plot locations were not visited because private landowners denied access or plot locations were difficult to sample safely (for example, steep terrain).*

# APPENDIX B:

## Distribution of forest land in Utah by stand-level categories

| Stand-level category | % of plots |
|---|---|
| **Forest type group** | |
| Douglas-fir | 5.98 |
| Ponderosa pine | 2.43 |
| Lodgepole pine | 1.62 |
| Spruce/fir | 9.53 |
| White fir | 2.77 |
| Misc. sfwd. timberland | 1.01 |
| Aspen | 5.68 |
| Misc. hrwd. timberland | 0.41 |
| Pinyon-juniper | 59.17 |
| Misc. hrwd. woodland | 11.40 |
| **Stand origin** | |
| Natural | 100.00 |
| Planted | 0.00 |
| **Stand size** | |
| Large trees (≥10"diameter) | 75.12 |
| Moderate trees (5" to10"diameter) | 19.28 |
| Seedling/Sapling (1" to 4.9") | 5.27 |
| Non-Stocked | 0.33 |
| **Stand age*** | |
| 0 - 50 | 3.45 |
| 51 - 100 | 49.26 |
| 101 - 150 | 30.76 |
| 151 - 200 | 6.20 |
| 201 - 250 | 2.06 |
| 250+ | 8.27 |

| Stand-level category | % of plots |
|---|---|
| **Seedlings/acre** | |
| 0 - 999 | 74.58 |
| 1000 - 1999 | 10.95 |
| 2000 - 2999 | 5.24 |
| 3000 - 3999 | 4.06 |
| 4000 - 4999 | 0.00 |
| 5000 - 5999 | 0.81 |
| 6000+ | 4.36 |
| **Snags/acre** | |
| 0 | 33.62 |
| 1 - 24 | 45.76 |
| 25 - 49 | 12.88 |
| 50 - 74 | 5.31 |
| 75 - 99 | 0.81 |
| 100+ | 1.62 |
| **Basal area/acre**** | |
| 0 - 39 | 21.35 |
| 40 - 79 | 20.37 |
| 80 - 119 | 29.36 |
| 120 - 159 | 15.13 |
| 160+ | 13.79 |

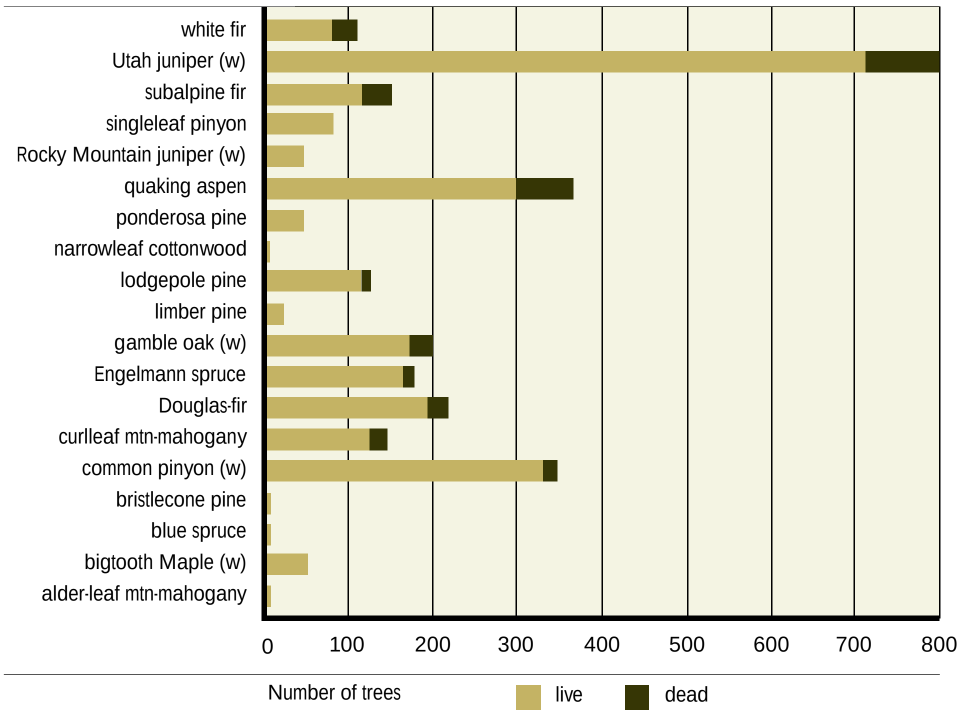
** Woodland forest types are excluded from stand age.*

*** Woodland species are included in these calculations by substituting diameter at root collar (drc) for diameter at breast height (dbh).*

# APPENDIX C:

## Tree and regeneration counts

**Trees***

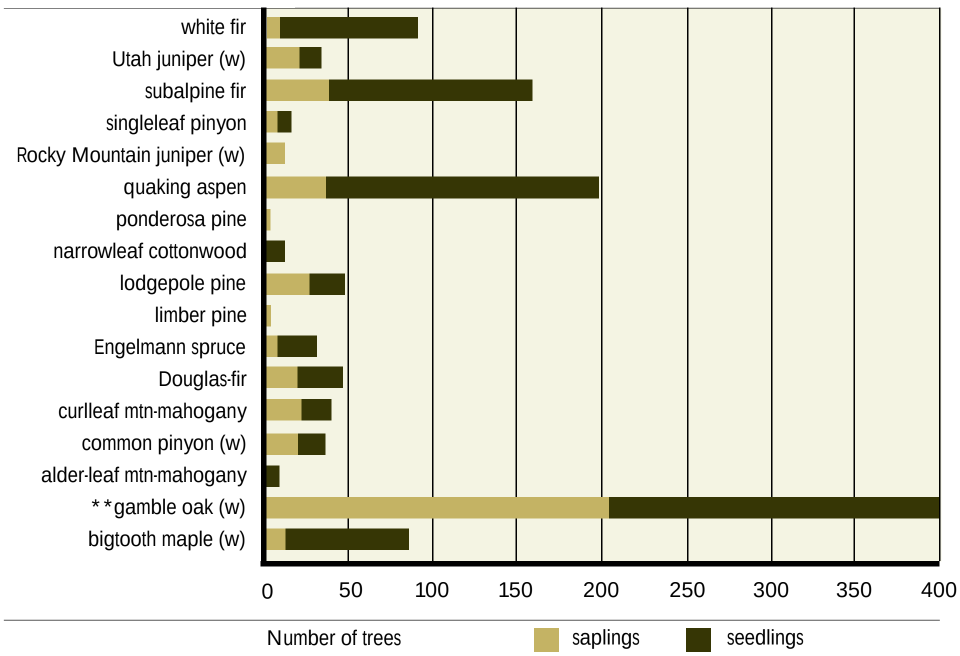



** Trees = moderate to large trees greater than or equal to 5.0 inches at breast height or root collar. Species marked with a (w) were measured at root collar due to typical multi-stem woodland species form.*

# APPENDIX C:

## Tree and regeneration counts (continued)

**Regeneration***




**Seeding and sapling trees are a sample of regeneration. Saplings are trees with diameters between 1.0 inches and 4.9 inches at breast height or root collar. Saplings marked with a (w) were measured at root collar due to typically irregular form at breast height. Seedlings are trees less than 1.0 inches at breast height or root collar and greater than 1 foot in total height.*

***Actual number of gambel oak seedlings is 976. The full number was not displayed here to improve the overall graphic.*

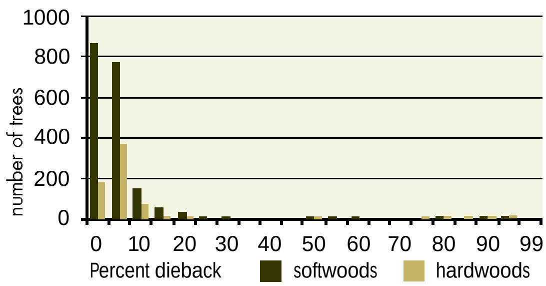
# APPENDIX D:

## Crown conditions in Utah

| | |
|---|---|
| * Total live crowns sampled: | Hardwoods = 654<br>Softwoods = 1,898<br>Total = 2,552 |

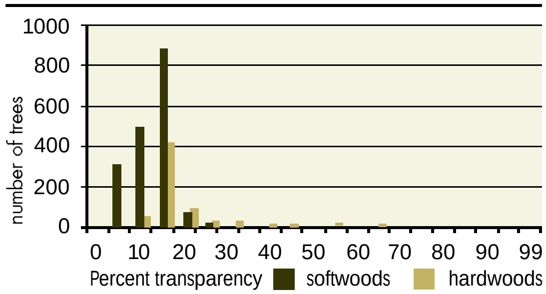
***Dieback** *is a measure of the percent of tree crown that has died from the branch tips inward toward the center of the crown. The graph here shows that most trees in Utah have little or no dieback. Only 1.6% of all trees have dieback of more than 25%. Dieback over 25% is more prominent in hardwoods (2.6%) than softwoods (1.2%).*

**Crown Dieback**




***Transparency** *is the percent of light that passes through the foliated part of the crown, excluding tree branches and main stems. Most trees in Utah have transparencies from 10-20%. Overall, 0.9% of trees have greater than 25% transparency. Hardwoods (3.1) have a significantly greater percent of transparency ratings over 25% than softwoods (0.12).*

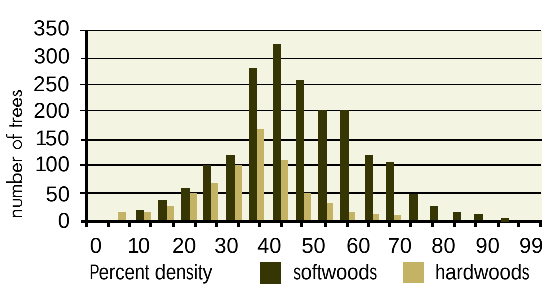
**Foliage Transparency**




**Note:**
*Trees with transparency greater than 25% are likely showing symptoms of thinning or defoliation.*

***Density** *refers to the percent of the crown area that blocks light from passing through. This rating includes the woody portions of the crown, so is not the exact opposite of foliage transparency. Currently, 91% of Utah trees have 25-75% density. A higher percent of hardwoods (16.2) than softwoods (5.9) have density ratings below 25%.*

**Crown Density**




**Note:**
*Trees with less than 25% density are likely showing symptoms of severe decline, while most trees with greater than 75% density are generally vigorous.*

# APPENDIX E:

## Distribution of damage types by species for live trees (5" dbh / drc & larger) in Utah

Damage type frequency

| | trees with no damage (%) | # of damages recorded* | cankers | conks and decays | open wounds | resinosis | cracks & seams |
|---|---|---|---|---|---|---|---|
| **Softwoods** | | | | | | | |
| Douglas-fir | 176 (91) | 27 | 1 | 1 | 1 | 1 | 0 |
| Ponderosa pine | 44 (96) | 2 | 0 | 0 | 2 | 0 | 0 |
| Lodgepole pine | 89 (75) | 39 | 6 | 1 | 16 | 0 | 0 |
| Subalpine fir | 95 (82) | 29 | 7 | 9 | 6 | 0 | 2 |
| Engelmann spruce | 143 (86) | 31 | 2 | 2 | 13 | 0 | 0 |
| Other softwoods | 85 (87) | 17 | 2 | 0 | 7 | 0 | 2 |
| Softwood woodland | 637 (55) | 768 | 6 | 6 | 402 | 6 | 0 |
| Subtotal, softwoods | 1269 (67) | 913 | 24 | 19 | 447 | 7 | 4 |
| **Hardwoods** | | | | | | | |
| Aspen | 164 (55) | 214 | 90 | 58 | 11 | 0 | 1 |
| Cottonwood | 2 (100) | 0 | 0 | 0 | 0 | 0 | 0 |
| Oak woodland | 90 (52) | 0 | 0 | 7 | 8 | 0 | 0 |
| Other hardwood woodland | 124 (70) | 71 | 0 | 5 | 27 | 0 | 0 |
| Subtotal, hardwoods | 380 (58) | 385 | 90 | 70 | 46 | 0 | 1 |
| **Totals** | **1,649 (65)** | **1,298** | **114** | **89** | **493** | **7** | **5** |

| | broken bole | brooms on bole | broken roots | loss of apical dominance | broken branches | excessive branching | damaged shoots | discolored foliage |
|---|---|---|---|---|---|---|---|---|
| **Softwoods** | | | | | | | | |
| Douglas-fir | 0 | 0 | 0 | 8 | 5 | 10 | 0 | 0 |
| Ponderosa pine | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lodgepole pine | 0 | 0 | 0 | 4 | 0 | 12 | 0 | 0 |
| Subalpine fir | 0 | 0 | 1 | 2 | 1 | 0 | 0 | 1 |
| Engelmann spruce | 0 | 0 | 0 | 11 | 3 | 0 | 0 | 0 |
| Other softwoods | 0 | 0 | 0 | 0 | 3 | 2 | 0 | 1 |
| Softwood woodland | 12 | 0 | 3 | 79 | 232 | 16 | 2 | 4 |
| Subtotal, softwoods | 12 | 0 | 4 | 104 | 244 | 40 | 2 | 6 |
| **Hardwoods** | | | | | | | | |
| Aspen | 0 | 0 | 0 | 21 | 28 | 0 | 5 | 0 |
| Cottonwood | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oak woodland | 0 | 1 | 0 | 17 | 27 | 13 | 25 | 2 |
| Other hardwood woodland | 3 | 0 | 0 | 5 | 29 | 0 | 1 | 1 |
| Subtotal, hardwoods | 3 | 1 | 0 | 43 | 84 | 13 | 31 | 3 |
| **Totals** | **15** | **1** | **4** | **147** | **328** | **53** | **33** | **9** |

Total sample size = 2,552 trees

*Number of damages recorded may include multiple damages, up to 3, for individual trees.

# APPENDIX F:

## Data available from FHM plots

| Variable name | Data type* | Variable name | Data type* |
|---|---|---|---|
| **MENSURATION, CROWNS, DAMAGE** | | | |
| **Plot level** | | | |
| County number | code | Current plot status | code |
| Elevation | num. | FHM region | code |
| Hexagon (location number) | num. | Measurement type | code |
| Overlap | code | Old plot status | code |
| Panel | code | Quality assurance status | code |
| Plot mensuration year | num. | Plot number | num. |
| Plot status | code | Plot type | code |
| Project | code | State | code |
| **Condition level** | | | |
| Condition class | num. | Condition class change | code |
| Density check | code | Disturbance year 1 | num. |
| Disturbance year 2 | num. | Disturbance year 3 | num. |
| Forest type | code | Land use class | code |
| Past disturbance 1 | code | Past disturbance 2 | code |
| Past disturbance 3 | code | Previous stand age | num. |
| Stand age | num. | Stand origin | code |
| Stand size | code | | |
| **Tree level** (trees, saplings, site trees) | | | |
| Basal area factor (site tree) | num. | Cause of death | code |
| Competing basal area | num. | Crown density | num. |
| Crown diameter (mean) | num. | Crown dieback | num. |
| Crown light exposure | code | Crown position | code |
| Crown vigor (saplings) | code | Current tree history | code |
| DBH(diameter breast height) | num | DRC (diameter root collar) | num. |
| Damage 1-3 | code | Description (tree notes) | alpha. |
| Foliage transparency | num. | Ground year | num. |
| Live crown ratio | num. | Location (damage) 1-3 | code |
| Mortality year | num | Nonforest year | num. |
| Old DBH | num. | Old DRC (woodland) | num. |
| Old stem count (woodland) | num. | Old tree history | code |
| Severity (damage) | code | Species | code |
| Stem count (woodland) | num | Tree age at DBH | num. |
| Tree height | num. | | |
| **Understory cover and seedlings** | | | |
| Crown light exposure | code | Crown position | code |
| Crown vigor | code | Percent ferns | num. |
| Percent herbs | num. | Percent moss | num. |
| Percent seedlings | num. | Percent shrubs | num. |
| Seedling count | num. | Species | code |

***Data types:**
num. = numeric value  code = numeric code  alpha. = letters or words

## APPENDIX F:

### Data available from FHM plots (continued)

| Variable name | Data type* | Variable name | Data type* |
| --- | --- | --- | --- |
| **Soils** (soil sampling, erosion) | | | |
| A texture | code | A thickness (N,S,E,W) | num. |
| Depth to subsoil | num. | Litter decomposition | alpha. |
| Litter depth 1-3 | num. | O thickness (N,S,E,W) | num. |
| Percent bare (mineral) soil | num. | Percent litter cover | num. |
| Percent plant cover | num. | Slope length | num. |
| Underlying texture | code | | |
| **Ozone bioindicators** | | | |
| Amount of injury | code | Bio site availability | code |
| Bio site disturbance | code | Bio site status | code |
| First species | code | Number of plants 1-3 | num. |
| Plot moisture | code | Plot size | code |
| Second species | code | Severity of injury | code |
| Soil depth | code | Soil drainage | code |
| Third species | code | | |
| **Lichen communities** | | | |
| Species | alpha. | Abundance | code |

***Data types:**
num. = numeric value     code = numeric code     alpha. = letters or words

# APPENDIX G:

## Contacts for further information

**Directors**

Borys M. Tkacz
National Program Manager, FHM
USDA Forest Service
1601 North Kent Street
RPC, 7th Floor (FHP)
Arlington, VA 22209
(703) 605-5343
btkacz@fs.fed.us

William Boettcher
Director, State and Private Forestry
Intermountain Region
USDA Forest Service
324 25th Street
Ogden, UT 84401
(801) 625-5252
wboettcher@fs.fed.us

Joel Frandsen
State Forester
State of Utah
Department of Natural Resources
Division of Forestry, Fire and State Lands
1594 West North Temple, Suite 3520
Salt Lake City, UT 84114
(801) 538-5555
joelfrandsen@utah.gov

Michael Wilson
Interior West Program Manager
Rocky Mountain Research Station
USDA Forest Service
507 25th Street
Ogden, UT 84401
(801) 625-5388
mjwilson@fs.fed.us

**Authors:**

Colleen Keyes
Forest Health Coordinator
State of Utah
Department of Natural Resources
Division of Forestry, Fire and State Lands
1594 West North Temple, Suite 3520
Salt Lake City, UT 84114
(801) 538-5555
colleenkeyes@utah.gov

Paul Rogers
Rocky Mountain Research Station
USDA Forest Service
507 25th Street
Ogden, UT 84401
(801) 625-5388
progers@fs.fed.us

Leon LaMadeleine (retired)
State and Private Forestry
USDA, Forest Service
324 25th Street
Ogden, UT 84401
(801) 625-5259

Vick Applegate,
USDA, Forest Service
Northern Region
Building # 24
Fort Missoula, MT 59804
(406) 329-3763
vapplegate@fs.fed.us

Dave Atkins
State and Private Forestry
USDA, Forest Service
Federal Building
200 E. Broadway
P.O. Box7669
Missoula, MT 59807
(406) 329-3134
datkins@fs.fed.us

## READER FEEDBACK ON "UTAH FOREST HEALTH REPORT"

**Please take the time to fill out this reader feedback form so that we may better address your concerns in future reports.**

Rate the following subject areas from 1 (poor) to 5 (excellent) by circling the appropriate number:

1. The report adequately explained the FHM program. 1 2 3 4 5
2. Rate the presentation: graphics. pictures, layout, etc. 1 2 3 4 5
3. The technical level was acceptable for a broad audience. 1 2 3 4 5
4. Adequate sources were given for additional information and data. 1 2 3 4 5
5. Judge the content of discussions related to forest health issues. 1 2 3 4 5

What part of the report was most useful to you? Why?

What section of the report needs improvement? How?

What further suggestions would you make to improve future FHM reports?

Complete an electronic version of this questionnaire at our website: www.nr.utah.gov/slf/fhm.htm, you may also fax or mail back a copy of this page to the Utah Division of Forestry, Fire and State Lands at 1594 West North Temple, Suite 3520, Salt lake City, Ut 84114-5703 or Fax to 801-533-4111.

Printed on recycled paper using vegetable-base inks. 3000 1/03