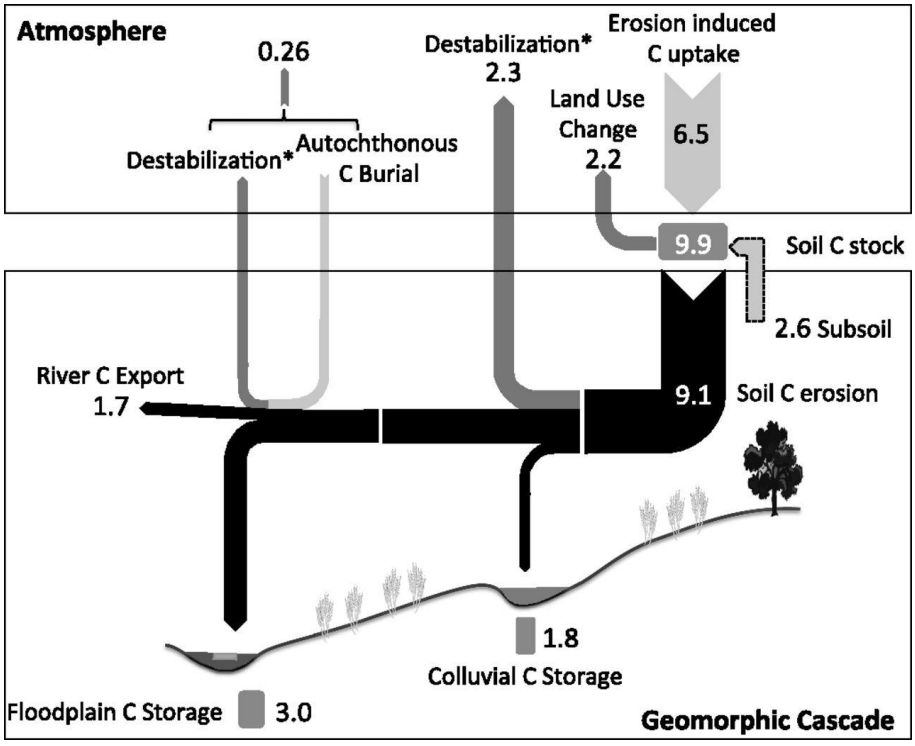
Towards a more accurate quantification of human-environment interactions in the past



Open PAGES Focus 4 Workshop Human-Climate-Ecosystem Interactions

University of Leuven, Belgium

3-7 February 2014

Open PAGES Focus 4 Workshop "Towards a more accurate quantification of human-environment interactions in the past"

University of Leuven, Belgium
3-7 February 2014

Organizing committee

Gert Verstraeten, University of Leuven (KU Leuven), Belgium
Bastiaan Notebaert, University of Leuven (KU Leuven), Belgium
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Cover
Top: The Cistercian abbey of Villers-la-Ville in the southern part of the Dijle catchment, central Belgium, founded in the 12th century and abandoned after the French Revolution at the end of the 18th century.
Bottom: Quantification of carbon fluxes (Tg C) between the soil and atmosphere as a result of human-induced accelerated erosion during the last 6000 years for the Dijle catchment (Van Oost K. et al., 2012, PNAS 109: 19492-19497)

Open PAGES Focus 4 Workshop "Towards a more accurate quantification of human-environment interactions in the past"

Workshop program at a glance

Monday, 3 February 2014

08.00-08.40	Registration and welcome
08.40-10.30	Oral session 1
10.30-11.00	Break
11.00-12.30	Oral session 2
12.30-13.30	Lunch
13.30-15.00	Oral session 3
15.00-15.30	Introduction to poster session 1
15.30-17.00	Poster session 1 and break with refreshments
17.00-18.30	Oral session 4
19.00-20.30	Welcome reception

Tuesday, 4 February 20104

08.30-10.10	Oral session 5
10.10-10.40	Break
10.40-12.30	Oral session 6
12.30-13.30	Lunch
13.30-14.40	Oral session 7
14.40-15.10	Introduction to poster session 2
15.10-16.40	Poster session 2 and break with refreshments
16.40-18.10	Oral session 8

Wednesday, 5 February 2014

08.00-17.30	Field trip Dijle catchment, central Belgium
19.00	Workshop dinner (Faculty Club)

Thursday, 6 February 2014

08.30-09.00	Introduction to discussion sessions (plenary)
09.00-10.30	Disciplinary discussion round 1 in breakout groups
10.30-11.00	Break
11.00-12.00	Disciplinary discussion round 1 in breakout groups (continued)
12.00-13.00	Reporting of discussion round 1 (plenary)
13.00-14.00	Lunch break
14.00-15.30	Interdisciplinary discussion round 2 in breakout groups
15.30-16.00	Break
16.00-17.00	Interdisciplinary discussion round 2 in breakout groups (continued)
17.00-18.00	Reporting of discussion round 2 (plenary)

Friday, 7 February 2014

08.30-10.30	Interdisciplinary discussion round 3 in break-out groups
10.30-11.00	Break
11.00-12.00	Reporting of discussion round 3 (plenary)
12.00-12.30	Final comments and official closing of workshop
12.30-13.30	Lunch
13.30-15.30	Optional session for discussing possibilities for future cooperation

Scientific program

Monday February 3, 2014

08.00-08.40 Registration and welcome (with coffee) (ground floor Erasmushuis)

ORAL SESSION 1
Justus Lipsiuszaal (8th floor Erasmushuis)
Chair: Thomas Hoffman

08.40-08.55 Opening remarks (general workshop info - practical arrangements)
08.55-09.20 **Gert Verstraeten** (KU Leuven): Quantifying human impact on environmental systems: challenges for the future
09.20-09.40 **Kim von Hackwitz** (Uppsula University and IHOPE): Searching the past for clues to the future *(invited)*
09.40-10.00 **Jeroen Poblome** (KU Leuven): Complex adaptive systems as a heuristic framework to approach human impact on the landscape. A Pisidian case-study
10.00-10.30 **Dan Penny** (University of Sydney): Tight feedback between networked infrastructure and the impact of climatic variability at Angkor, Cambodia (14th -15th centuries C.E.) *(invited)*

10.30-11.00 Break (ground floor Erasmushuis)

ORAL SESSION 2
Justus Lipsiuszaal (8th floor Erasmushuis)
Chair: Hans Middelkoop

11.00-11.30 **Patrick Belmont** (Utah State University): Climate and human dynamics as amplifiers of natural change in river networks *(invited)*
11.30-11.50 **Vincent Viel** (University Paris 7): Complexity of Holocene sediment dynamics for two small river catchments in Normandy (Western France)
11.50-12.10 **Valentin Golosov** (University of Moscow): Small river aggradation in different landscape zones of the Russian plain: reasons and consequences
12.10-12.30 **Markus Fuchs** (Justus-Liebig-University Giessen): The temporal and spatial quantification of Holocene sediment dynamics for reconstructing soil erosion: pros, cons and challenges

12.30-13.30 Lunch break (ground floor Erasmushuis)

ORAL SESSION 3
Justus Lipsiuszaal (8th floor Erasmushuis)
Chair: Andreas Lang

13.30-14.00 **Jed Kaplan** (University of Geneva): What role for humans in global land cover change over the Holocene? Insights from models and data *(invited)*
14.00-14.20 **Kees Klein Goldewijk** (Utrecht University): How to quantify human-environment interactions in the past: a global historical land use data set for the Holocene
14.20-14.40 **Marie-José Gaillard** (Linnaeus University): From land cover-climate relationships at the subcontinental scale to land cover-environment relationships at the regional and local spatial scale – the contribution of pollen-based quantitative reconstructions of vegetation cover using the Landscape Reconstruction Algorithm
14.40-15.00 **Anne Birgitte Nielsen** (Lund University): Past land use changes and their effects on carbon pools and coastal ecosystems along the Swedish Baltic coast

POSTER SESSION 1
Chair: Gert Verstraeten

15.00-15.30 Introduction to poster session 1 (Justus Lipsiuszaal, 8th floor)
15.30-17.00 Poster session 1 with break (ground floor Erasmushuis)

P01 **Hema Achyuthan**: Vegetation response to climate and human impact during the last 6000 years BP around Pookode lake catchment area, South India

P03 **Ferran Antolín**: Quantifying the economic importance of large-seeded wild plants in the Neolithic lakeshore site of Zürich-Opéra (Central Switzerland)

P05 **Patrick Belmont:** Moving toward generalizable, geomorphically-informed sediment fingerprinting

P07 **Nils Broothaerts**: Humans reshaped the floodplain geoecology in NW Europe through intense agricultural impact

P09 **Daniel Conley**: Linking land cover changes to eutrophication of the Baltic Sea

P11 **Hanne De Brue**: Impact of the spatial and thematic resolution of Holocene land cover scenarios on modeled soil erosion and sediment delivery rates

P13 **Yannick Devos**: The shaping of the Brussels' urban landscape: an interdisciplinary perspective

P15 **Markus Dotterweich**: Linking geomorphic evidences and historical records of past soil erosion to interpret long-term human-environment interactions

P16 **Markus Dotterweich**: The effects and responses of prehistorical agriculture to soil erosion in Southeastern North America

P18 **Assunta Florenzano**: The development of human-induced environments in the Italian peninsula: the pollen evidence from Bronze age to Renaissance archaeological sites (c. 4200-500 cal. BP)

P19 **Assunta Florenzano**: The site density of archaeobotanical researches as key to the understanding the bio-cultural diversity of the Italian landscapes

P21 **Delphine Frémondeau**: Livestock diet management and landscape use at ancient Sagalassos (Pisidia, southwest Turkey) inferred from stable isotope analysis

P23 **Esther Githumbi**: Human impacts on a peri-urban wetland in central Kenya

P25 **Andreas Heiss**: A Glimpse of Mediterraneanisation? First analyses of Hellenistic and Roman charcoal remains from Terrace House 2 at Ephesos, and their possible implications for vegetation change, woodland use, and timber trade

P28 **Thomas Hoffmann**: Carbon burial in soil sediments from Holocene agricultural erosion, Central Europe

P29 **Geoffrey Houbrechts**: Anthropogenic impact on alluvial sedimentation rates during the last millennia in the Ardennes (Belgium)

P31 **Ellen Janssen**: Estimation of wood use in a Roman Imperial city

P32 **Eva Kaptijn**: Human-environment interaction in a small intramontane valley. Research from the Sagalassos Archaeological Research Project at Bereket (southwest Turkey)

P34 **Renata Kołodyńska-Gawrysiak**: Closed depressions in the Prehistoric landscape of loess area and their influence on settlement location a case study from E Poland

P37 **Gael Le Roux**: Peat cores as archives of environment-humans interactions in the past

P39 **Laurent Lespez**: Alluvial sedimentation rates since the Mid-Holocene along the Yamé river (Mali): towards a quantification of alluvial sedimentation changes in a soudano-sahelian fluvial system in West Africa

P40 **Nicholas Meinzer**: Soil fertility, settlement patterns and human height in early medieval Germany

P42 **Colin Courtney Mustaphi**: Human influences on vegetation and disturbance regimes in East Africa during the late Holocene

P45 **Harm Jan Pierik**: Sea ingression dynamics and its interaction with occupation of the Lowlands between AD 300 and 1000

P47 **Eleonora Rattighieri**: Land use from the archaeobotanical evidence of small Roman farmhouses in central Italy (south-eastern Tuscany)

P49 **Anaelle Simonneau**: Past Holocene detritism quantification and modeling from lacustrine archives as a new way to deconvoluate human-climate interactions on natural ecosystem over long time-scale.

P52 **Matthias Vanmaercke**: Assessing human impacts on catchment sediment yield in Europe: a continental approach

P53 **Dirk Verschuren**: Resolving the timing and relative magnitude of ancient versus modern human impact on East African landscapes: a 3800-year example from western Uganda

P56 **Jakob Wallinga**: Quantifying landscape responses to human action through optical dating; examples from the Netherlands

ORAL SESSION 4
Justus Lipsiuszaal (8th floor Erasmushuis)
Chair: Gert Verstraeten

17.00-17.30 **Petr Kuneš** (Charles University of Prague): Comparing past quantitative land-cover estimates and data on human impact provides novel insights into human-landscape interactions *(invited)*

17.30-17.50 **Jessie Woodbridge** (Plymouth University): The pseudo-biomisation approach to Holocene land-cover reconstruction: application to European pollen records

17.50-18.10 **Michelle Farrell** (University of Hull): Quantitative reconstruction of past vegetation mosaics from pollen data

18.10-18.30 **Jörgen Olofsson** (Lund University): Estimating anthropogenic carbon release in north-western Europe during the Holocene – integrating pollen-based land use reconstructions with a dynamic vegetation model

19.00-20.30h Welcome reception (Museumzaal, University Hall, Naamsestraat 22, Leuven)

Tuesday February 4, 2014

ORAL SESSION 5
Justus Lipsiuszaal (8th floor Erasmushuis)
Chair: Bastiaan Notebaert

08.30-09.00 **Daniel Schillereff** (University of Liverpool): Industry, agriculture and catchment conditioning: lake sediments in the upland rural landscape of Northwest England *(invited*)

09.00-09.30 **Tsige Gebru Kassa** (University of Cologne): Holocene palaeovegetation history of the Tigray Plateau in Northern Ethiopia from buried wood charcoal: implication for climate and land use (*invited*)

09.30-09.50 **Peter Gell** (Federation University of Australia): Widespread change in ecological character of Murray River wetlands: regime shift or species turnover

09.50-10.10 **Angelica Feurdean** (Biodiversity and Climate Research Centre, Frankfurt): Early anthropogenically-induced shift in biome in the lowlands of Transylvania (CE Europe)

10.10-10.40 Break (ground floor Erasmushuis)

ORAL SESSION 6
Justus Lipsiuszaal (8th floor Erasmushuis)
Chair: Gilles Erkens

10.40-11.10 **Gary Stinchcomb** (Pennsylvania State University): Quantifying past human-environmental interactions using mass balance and isotope geochemical methods with examples from northeastern USA (*invited)*

11.10-11.40 **Chun Chang Huang** (Saanxi Normal University): Pre-historical human impact as recorded in soil profiles in China's Yellow River basin *(invited)*

11.40-12.10 **Veerle Vanacker** (UC Louvain): Dynamic soil properties in response to anthropogenic disturbances (*invited*)

12.10-12.30 **Peter Houben** (Leiden University College): Quantifying long-term anthropogenic sediment fluxes in a mountainous watershed (250 sqkm) based on GIS modeling of available soil data (1:50,000)

12.30-13.30 Lunch break (ground floor Erasmushuis)

ORAL SESSION 7
Justus Lipsiuszaal (8th floor Erasmushuis)
Chair: Kristof Van Oost

13.30-14.00 **Timothy Beach** (Georgetown University): The 'Mayacene', an early Anthropocene analog for human impacts on the Earth's surface (*invited*)
14.00-14.20 **Carsten Lemmen** (C.L. Science Consult): Booms and bust in the European Neolithic: population dynamics or palaeoclimate pacing?
14.20-14.40 **Nicki Whitehouse** (Plymouth University): Spatio-temporal patterns of human settlement, landscape and eco-dynamics in Neolithic and Bronze Age Ireland

POSTER SESSSION 2
Chair: Gert Verstraeten

14.40-15.10 Introduction to poster session 2 (Justus Lipsiuszaal, 8th floor Erasmushuis)
15.10-16.40 Poster session 2 with break (ground floor Erasmushuis)

P02 **Oren Ackermann:** High Resolution Method for Distinguishing Natural vs. Anthropogenic Fill: The Case of the Archaeological Site of Tell es Safi / Gath in the Eastern Mediterranean
P04 **Koen Beerten**: Building a conceptual framework for evaluating human-induced hydrological changes during the last millennium in the Mol-Dessel area, NE Belgium
P06 **Samuel Bouchoms**: Modeling the influence of long term human-induced land use conversion on sediment fluxes and carbon dynamics at the catchment scale
P08 **Jennifer Clear**: Human induced fire regimes of Fennoscandia: to burn or not to burn?
P10 **Basil Davis:** The deforestation of Europe: a quantitative approach based on pollen and remote sensing data
P12 **Kristen de Graauw**: Pluvials, droughts, energetics and the Mongol Empire
P14 **Katrijn Dirix**: Chemical and magnetic survey data as indicators of ancient human activity: the suburban Sagalassos case (SW-Turkey)
P17 **Dragana Filipovic**: Integrating archaeobotanical and geomorphological evidence from the Vinča tell in the central Balkans towards the reconstruction of late Neolithic landscapes and land use
P20 **Francois Fontaine**: Study of environmental contamination over the historical period: Trace element and lead isotopic signature in coastal sediments from Cap Corsica (France)
P22 **Giulia Furlanetto**: Early to Late Middle Age agricultural system changes in N-Italy as a main step towards the modern landscape
P24 **Marjolein Gouw-Bouman**: 40 shades of black. Regional differences in vegetation response to a changing human influence in the Low Countries during the Dark Ages (AD 300-1000).
P26 **Felix Heitkamp**: Inaccessibility as a tool to isolate human influence on ecosystems: Millennia of grazing management triggered feedbacks between soil development and nutrient cycling
P27 **Johanna Hilpert**: Upscaling Population Densities of hunter gatherers and sedentary societies - Methods and Results
P30 **Aurelia Huber-Ferrari:** Paleoenvironmental record of the Amik Basin (Amuq Plain, Southern Turkey) over the last 4000 years
P33 **Wiebke Kirleis**: Land use, environmental and societal change in the Northern European Neolithic: On the comparability of palaeo-ecological, climatological and archaeological records
P35 **Annette Kramer**: Neolithic vegetation and settlement history from north-western Germany
P36 **Agnieszka Latocha**: Areas of abandoned agriculture - landscape, geomorphic and sedimentological perspectives (Stołowe Mts case study, SW Poland)
P38 **Frank Lehmkuhl**: Holocene landscape and land-use change under human impact. Examples from Central Europe and Central Asia
P41 **Andrey Mitusov**: Spatial distribution of archaeological monuments on landforms of modern land surface, key region: Lazio, Italy
P43 **Kees Nooren**: Reconstruction of Mayan induced soil erosion during the Pre-Classic and Classic period from world's largest beach ridge plain

P44 **Bastiaan Notebaert**: Non-linearities in Holocene floodplain sediment storage
P46 **Roberta Pini:** Prehistoric human impact at high altitudes: forest clearings, land-cover change and pastoralism in a case study from the western Italian Alps
P48 **Helen Shaw**: Human impact on the vegetation of pastoral uplands: recent centuries of change in the Yorkshire Dales, UK
P50 **Friederike Stock**: Human impact on the environment in the Ephesia, Turkey – an eight thousand yearlong battle
P51 **Maarten Van Loo**: Towards a quantification of agricultural carrying capacity in the past: the application of a soil erosion model to estimate crop productivity
P54 **Gert Verstraeten**: Variability in geomorphic response to anthropogenic disturbance
P55 **Gert Verstraeten**: Humans have impacted atmospheric C-exchange since the introduction of agriculture by changing the geomorphic cascade
P57 **Zhengang Wang**: The fate of buried organic carbon in colluvial soils: a long-term perspective

ORAL SESSION 8
Justus Lipsiuszaal (8th floor Erasmushuis)
Chair: Jeroen Poblome

16.40-17.10 **Amy Bogaard** (University of Oxford): How sustainable were Neolithic European farming economies? Insights from archaeobotany (*invited*)
17.10-17.30 **Manfred Rösch** (Landesamt für Denkmalpflege): Late Neolithic subsistence according to experimental data – 15 years experience in Forchtenberg
17.30-17.50 **Ingo Feeser** (University of Kiel): The glade effect - an unexpected phenomenon interfering with the visibility of early forest opening
17.50-18.10 **Johanna Hilpert** (University of Cologne): Patterns of land use in sedentary societies - LBK vs. 1800 AD

Wednesday February 5, 2014

08.00-17.30 Field trip (meeting point at lowermost side of the 'Ladeuzeplein' in front of the University Library)
Buses leave at 08.00. Please be at the pick-up point 5 to 10 minutes in advance.

FT01 **Jean Poesen** et al.: The importance of old forests for understanding human-environment interactions in Prehistoric and Roman times.
FT02 **Gert Verstraeten** et al.: Holocene erosion and colluviation dynamics
FT03 **Sidonie Preiss and Mona Court-Picon**: The settlement of the Cistercian abbey of Villers-la-Ville in the Thyle valley (Dyle tributary) during the 12th century: Archaeobotanical approaches
FT04 **Nils Broothaerts** et al.: Sensitivity of floodplain geoecology to human impact: a palynological approach
FT05 **Bastiaan Notebaert** et al.: Holocene fluvial dynamics and sediment budget of the River Dijle

19.00 Workshop Dinner at the Faculty Club (Groot Begijnhof, Leuven)
It is a 10-15 minute walk from the city center. Those interested can join the organizers for a walk to the Faculty Club departing at around 18.45 in front of the Medieval City Hall.

Thursday February 6, 2014

08.30-09.00 Introduction to discussion sessions (MSI1 00.28)

09.00-10.30 Disciplinary discussion round 1 in breakout groups (MSI building, rooms 01.20, 01.23, 02.15, 02.18)
Four parallel discussion sessions, which will take place in building MSI. The first discussion round will concentrate on individual disciplines/themes: geomorphology (soils and sediments), land cover, integrated lake studies, archaeological sites and artifacts.

10.30-11.00 Break (ground floor Erasmushuis)

11.00-12.00 Disciplinary discussion round 1 in breakout groups (continued) (MSI building, rooms 01.20, 01.23, 02.15, 02.18)

12.00-13.00 Reporting of discussion round 1 (plenary) (MSI1 00.28)
Each break-out group reports the results of their discussion round to the other groups

13.00-14.00 Lunch break (ground floor Erasmushuis)

14.00-15.30 Interdisciplinary discussion round 2 in breakout groups (MSI building, rooms 01.20, 01.23, 02.15, 02.18)
Four parallel discussion sessions in building MSI. The focus is now on interdisciplinary research.

15.30-16.00 Break (ground floor Erasmushuis)

16.00-17.00 Interdisciplinary discussion round 2 in breakout groups (continued) (MSI building, rooms 01.20, 01.23, 02.15, 02.18)

17.00-18.00 Reporting of discussion round 2 (plenary) (MSI1 00.28)

Friday February 7, 2014

08.30-10.30 Interdisciplinary discussion round 3 in breakout groups (MSI building, rooms 01.20, 01.23, 02.15, 02.18)

10.30-11.00 Break (ground floor Erasmushuis)

11.00-12.00 Reporting of discussion round 3 (plenary) (Justus Lipsiuszaal, 8th floor Erasmushuis)

12.00-12.30 Plenary discussion, final comments and closing of workshop (Justus Lipsiuszaal, 8th floor Erasmushuis)

12.30-13.30 Lunch break (ground floor Erasmushuis)

13.30-15.30 Optional session for discussing possibilities for future cooperation (Justus Lipsiuszaal, 8th floor Erasmushuis)

Abstracts

(Ordered alphabetically by name of presenting author)

Vegetation response to climate and human impact during the last 6000 years BP around Pookode lake catchment area, South India

Veena M.P. Nair[1], Hema Achyuthan[1], Anjum Farooqui[3]

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Palynology study of lake sediment cores help in understanding the vegetation canopy around the lake catchment area and its response to paleoclimate. Pookode Lake, Kerala, South India, is a fresh water lake situated at an altitude of ~770 m.a.s.l. receiving predominantly south-west monsoon rains. A sediment core of nearly 125 cm long retrieved from the lake was radiocarbon dated and analysed for pollen data. Radiocarbon dates obtained on the organic carbon rich sediments range in age from the mid Holocene to more recent (6240 to 565 14C yrs BP; BC 4786 to AD 1434 cal. yrs). Pollen studies reveal that the sediments older than 1500 14C yrs BP were not suitable for the preservation of the pollen assemblages. Occurrence of diatoms in the upper sediment layers indicate shallowing of the lake. The variations in pollen assemblage are attributed to environmental changes in the catchment area since the last ~ 6000 yrs BP. Based on pollen data the sediment core has been classified into four zones. Pollen do not occur in the lower layers of the sediment core while they start appearing only from the 60 cm depth on wards to the surface indicating that the lower sediments and the paleoconditions were unsuitable for the preservation of pollen. High organic matter content and presence of evergreen/ semi-evergreen rain forest tree pollen pollen/spore preservation from ~1400 to 760 yrs BP indicates high intensity of southwest monsoon (SWM). The appearance of Careya in the subsequent younger pollen assemblage zone III (~950 to 280 yrs BP) together with Artemisia and Fuchsia pollen, points to an increase in aridity and cooler climatic conditions. Many evergreen tree taxa that were present in the preceding zone are either reduced in frequency or are absent during this period. Careya is a light demanding tree and is common in primary or secondary seasonal forest. It grows in open margins or along the edge of forest and is devoid in humid rain forest regions. It occurs on well- drained, sandy or even rocky soils. Abundant occurrence of Careya suggest a decline in forest cover perhaps induced by arid climatic conditions and also enhanced by the anthropogenic activity. Pollen study also indicate medieval warm period (MWP) around ~950 yrs BP. Pollen zones II, III and IV correspond with the time of increasing human occupation and agricultural exploitation of the area around Pookode Lake. The appearance Careya in the pollen assemblage of zone III as well as the decline in pollen in Zone IV point out lake is becoming too oxic. Lophopetalum is commonly found in swamps and along streams, up to 900 m.a.s.l. and would thrive in swampy conditions around the lake margin. It is abundant with Careya, but less abundant with the earlier peak abundances of Fuchsia and Artemisia (abundant occurrence of Fuchsia and Artemisia signify drier climate). It is possible that the very presence of the lake is due to damming, which would have occurred at about 1500 years BP.

High resolution method for distinguishing natural vs. anthropogenic fill: The case of the archaeological site of Tell es Safi / Gath in the Eastern Mediterranean

Oren Ackermann[1, 2], Noam Greenbaum[3], Ahuva Almogi-Labin[4] , Avner Ayalon[4], Mira Bar-Matthews[4], Hendrik Bruins[4], Dan Cabanes[6], Liora Kolska Horwitz[7], Naomi Porat[4], Bettina Schilman[8], Ehud Weiss[1] and Aren M. Maeir[1]

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[2]Land of Israel Studies, Ashkelon Academic College, Israel
[3] Department of Geography and Environmental Studies and Department of Natural Resources and Environmental Management, University of Haifa, Israel
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[5]The Jacob Blaustein Institute for Desert Research, Department of Man in the Desert, Ben Gurion University of the Negev, Israel
[6]Department of Prehistory, Ancient History and Archaeology, University of Barcelona, Spain
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The topic of “younger fill” as revealed by Vita-Finzi (1969) has been under discussion for several decades. Deciphering whether the origin of this fill is natural or anthropogenic is a major challenge. The current research presents a concept in which environmental records were examined in conjunction with long and continued human history. The research area is the biblical archaeological site of Tell es-Safi/Gath, in central Israel. The study examines two main geomorphic units: a 2nd order valley at

the footslope of the site and an anthropogenic siege trench on a slope. The sedimentary history of the 2nd order valley shows two primary phases of fill. The first occurred during the Chalcolithic period and Early Bronze Age (~4200-3050 BCE), at a low sedimentation rate of ~0.06 cm/yr. This was followed by stable conditions and soil formation. Renewed sedimentary fill occurred during the Iron Age and up to the Early Arab period (~800 BCE-800CE), at a general low sedimentation rate of 0.06-0.08 cm/yr. Results of the study indicate that natural geomorphic processes were the major factors in shaping the landscape most of the time. Anthropogenic activity was expressed by extremely high sedimentation rates, in localized sites and for a limited time, in two locations only. One location is the anthropogenic siege trench where sedimentation rates exceeded ~0.53 cm/yr (7-8 fold the natural rate) shortly after the destruction of the site by Hazael, king of Aram Damascus (ca. late 9th century BCE), and during the Byzantine period, with a sedimentation rate of ~0.79 cm/yr (11-12 fold the natural rate). The other location is the 2nd order valley where a sedimentation rate of ~0.17 cm/yr (2-3 fold the natural rate) was expressed shortly after the destruction of the site. These results, combined with C isotopic values and a relatively high amount of phytoliths, show that the source of the sediment material is related to the destruction of the site by Hazael. This research reveals how the combined study of human history at an archaeological site and assessment of sedimentation rates through high resolution OSL dating, C isotopic composition testing and phytolith characterization, enables the distinction between natural and anthropogenic causes of sedimentation.

Quantifying the economic importance of large-seeded wild plants in the Neolithic lakeshore site of Zürich-Opéra (Central Switzerland)

Ferran Antolín[1], Christoph Brombacher[1], Marlu Kühn[1], Bigna Steiner[1], Niels Bleicher[2], Stefanie Jacomet[1]

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Excavations conducted in the car park of the Opera House of Zürich during 2010 uncovered several settlement phases of a large Neolithic lake-dwelling site. This presentation is focused on Layer 13, dendrodated to the years around 3230 BC (early Horgen Culture). This is a cultural layer of a maximum of 32 cm of thickness expanding over more than 3000 m2. It consists of organic debris, as well as loam heaps (presumably from hearths) and other mineral components. Layer 4 of the nearby site Kanalisation Seefeld in Zürich is the only comparable settlement phase dated to this period. Lakeshore sites allow an excellent preservation of plant macroremains, therefore they offer a unique opportunity to approach human-environment interactions in a quantitative way. The high concentration of seeds and fruits in the samples has resulted in the generalized study of small samples in most archaeobotanical studies of this type of sites. Nevertheless, after previous work carried out in other lakeshore settlements of central Europe, it was concluded that large-seeded taxa were underrepresented in small samples. Therefore, a new systematic sampling strategy based on bulk samples (of c. 10 litres of volume) was applied on the whole excavated surface. Over 1100 litres of sediment were sieved with the wash-over technique and fully-quantitative analyses were done for the large-seeded taxa (>2 mm). The premise of this study is that the quantified results obtained through this analysis provide a reliable overview of the economic importance of these plant resources at the site. The results obtained show that the role of large-seeded wild plants at the site was of major significance and that their role in the economy might have been underestimated in previous approaches. We may assume that some kind of tending for a better yield of fruit trees as crab apples, acorns, hazelnuts, sloe etc. must have existed. It is for this reason necessary to develop new models for the relationship between Neolithic societies and their environment.

The 'Mayacene', an Early Anthropocene analog for human impacts on the Earth's surface

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The Maya lowlands has been one of the world's most active regions for archaeological and paleoclimatic research, but there has been too little geomorphic and geoarchaeological research that has quantified the breadth and depth of ancient Maya to modern impacts. We present new, updated, and synthesized research on human impacts across the Maya lowlands in the Yucatán of Mexico, Petén of Guatemala, and Belize. We draw from the larger region but also our own field studies from floodplains, lake cores, wetland excavations, alluvial fans, and hill slopes. To understand geomorphic and ecological changes, we examine stratigraphy with relative and radiocarbon dating and a host of paleo-environmental proxies from carbon isotopic ratios, elemental analysis, pollen, phytoliths, macro-botanicals, and other soil analyses. Quantification is always challenging from the small sample of studies, but three markers of the 'Mayacene' show up in many dated depositional sequences: sedimentation and phosphorous increases and bulges of increased δ13C, indicative of C4 species inputs in ecosystems dominated by C3 species

today. Most depositional sequences demonstrate human impacts during the Maya period of the last 3 millennia, though this varies in severity and chronology with surprisingly early impacts from the Preclassic Period, nearly 3,000 years ago. Many of these repositories have organic, slow deposition or stable soil formation before agriculture and fire diffused over the landscape in the Third Millennium BP. This led in some areas from 3000 to 1000 BP to accelerated soil erosion and deposition of 'Maya Clay' layers. We also distinguish human induced from natural changes such as climatic, natural flooding, water-table rise and gypsum precipitation, and volcanic eruptions. Maya farmers responded with soil conservation technologies in many, but not all, areas. After the Maya Terminal Classic c. 1000 BP many landscapes stabilized, again indicated by organic, low deposition rates and steady soil formation. The Late Preclassic around 2000 BP and Late Classic about 1200 BP experienced widespread droughts coupled with intensive human land uses and geomorphic impacts, but intensive climate changes of the Little Ice Ages without intensive human impacts had little geomorphic impact.

Building a conceptual framework for evaluating human-induced hydrological changes during the last millennium in the Mol-Dessel area, NE Belgium

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During the last millennium, the surface environment of the Campine area, NE Belgium, underwent an enormous transformation from an open heather-dominated landscape with pristine Holocene soils and topography to a fragmented landscape with multiple land uses (forest, build area, heather, pasture, artificial lakes…), and heavily disturbed soils (degraded podzols) and topography (drift sand accumulation, ditches, sand quarries…). This transformation is expected to have caused an important change in the regional water balance and groundwater table depth. Understanding the mechanisms and processes that govern such changes is necessary to build a strong phenomenological basis for predicting future hydrological conditions as a result of landscape development (land use and land cover change). The aim of this study is to present initial results of a detailed landscape reconstruction exercise of a sandy interfluve in the Nete catchment and to assess conceptually the hydrological impact of this human-induced landscape transformation. Historical maps, land use data, DTM's and detailed soil and geomorphological data (Beerten et al., 2012; Vandersmissen et al., submitted) were used to produce a set of relevant snapshots over the last 1000 years that are thought to be representative for a given hydrological condition at the studied interfluve. The first geomorphic change investigated is the development of a human-induced drift-sand landscape between 500-250 years ago. The main impacts on the local hydrological conditions are assumed to be the modification of the shape of the groundwater table (being a subdued replica of topography) and the loss of the hydraulic barrier function of podzol soils during extreme events, due to podzol degradation. Undoubtedly, reforestation of the interfluve during the second half of the 19th century had an impact on local recharge rates (i.e. decreasing recharge), resulting in a deeper groundwater table. The construction of ditches, up to 50 cm deep, to drain the newly established pine plantations, would certainly have amplified the lowering of the groundwater table. In the course of the 20th century, the construction of sand pits and the development of new industries (build area) have probably compensated the gradual deforestation with respect to the local hydrology. All these changes are held responsible for the observed discrepancies between the position of the present-day groundwater table and the position of palaeo-wetness indicators observed in soil profiles.

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Climate and human dynamics as amplifiers of natural change in river networks

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River channels naturally change in a variety of ways, adjusting width and depth, bed material composition, and rates of lateral migration in response to changes in water, sediment supply and riparian vegetation. Typically such changes are highly unsteady in time, occurring primarily during infrequent, short duration, high magnitude events. Such changes are also highly non-uniform, with different parts of the channel network adjusting in dramatically different ways, even in response to uniform changes in drivers. There is a pressing need to identify which elements of a river ecosystem are most sensitive to changes in climate and/or human land and water management in the sense that they are likely to respond strongly to changes in these factors. Means of identifying such "hot spots" of sensitivity to change would enable us to target remediation and other management measures

where they will do the most good. Here we discuss channel changes over time throughout the 44,000 km^2 Minnesota River Basin (MRB) in the upper Midwestern USA, where pervasive landscape disturbance has been triggered by several well-documented events. Rapid base-level lowering 13,400 YBP has created a wave of rapid natural erosion propagating up tributary channel networks imparting a distict landscape signature. Pervasive land drainage and row-crop agriculture over the past 150 years, and a spatially varying increase in precipitation and runoff over the past half-century comprise the dominant human and climatic changes. We use a combination of aerial photo and satellite imagery analysis, repeat terrestrial and aerial lidar analysis, multibeam sonar and channel surveys, geochemical fingerprinting, and water and sediment gaging to document how climate and land use changes have translated to adjustments in channel morphology and specifically how the response has been amplified or dampened in different parts of the basin. Finally, we discuss research needs for development of a simple (minimally parameterized), spatially-explicit, network-based modeling framework that is capable of predicting the magnitude as well as the spatial and temporal variability of channel change.

Moving toward generalizable, geomorphically-informed sediment fingerprinting

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The field of sediment fingerprinting has been evolving rapidly over the past decade and is well poised to improve our understanding not only of sediment sources, but also the routing of sediment through watersheds. Such information is essential for understanding human impacts on erosion and sediment routing at the landscape scale. In this study we discuss the role of channel-floodplain processes that may convolute or modify the sediment fingerprinting signature of alluvial bank/floodplain sources. Further, we explore the use of non-conservative tracers, which can be useful to differentiate sediment derived from surface soil erosion from that of near-channel fluvial erosion, provided that the non-conservative behavior is predictable and verifiable. We demonstrate that measurements of long- (Beryllium-10, 10Be) and short-lived (Lead-210 and Cesium-137, 210Pb and 137Cs, respectively) radionuclide tracers associated with suspended sediment can be used to quantify sediment sources and channel-floodplain exchange in two very different rivers, one incising (Le Sueur River, south-central Minnesota, USA) and the other aggrading (Root River, southeastern Minnesota, USA) in response to base level fall and rise, respectively. The Le Sueur River exhibits a remarkably narrow range of tracer concentrations in source areas, which include agricultural fields, alluvial banks, and bluffs. Suspended sediment samples collected immediately above and below the 30 km long incising reach show a systematic shift in terrestrial sources in the downstream direction, indicated by changes in 10Be concentrations. The Root River indicates a more variable erosion history, with significant variability of 10Be concentrations in source areas (agricultural fields, forested hillslopes, and alluvial floodplains and terraces) and inverted 10Be depth profiles (higher concentrations at depth, suggesting unsteady erosion and significant storage of legacy sediment). Both rivers show a systematic disparity in normalized concentrations of conservative versus non-conservative tracers, indicating that significant storage and re-suspension occurs in both systems as the sediment is routed through the channel-floodplain complex. We advocate for the sediment fingerprinting community to develop a geomorphic rationale to explain the distribution of the fingerprinting properties for any given study area, with the intent of developing more generalizable, process-based fingerprinting approach.

How sustainable were Neolithic European farming economies? Insights from archaeobotany

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In this presentation I consider what ecological analysis of ancient weed assemblages and stable isotope investigation of crop remains reveal about the nature and sustainability of Neolithic farming systems in Europe. Using case studies from different parts of the continent, I suggest that early farmers often used labour-intensive management techniques to maintain crop growing conditions and to ensure adequate yields. The specific nature of these management regimes, however, was contingent on local factors, including the predominant crop and livestock taxa concerned. Diversity in management is also evident at the intra-site level, and relates to the social geography of these early farming communities. Stable isotope analysis of Neolithic crops informs assessment of their dietary role, and I discuss the implications of initial findings for understanding the ecological and social sustainability of early farming.

Modeling the influence of long term human-induced land use conversion on sediment fluxes and carbon dynamics at the catchment scale

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Over the past 20 years, there has been increasing evidence of the strong impact of human activities on the landscape, specifically on soil erosion due to the removal of natural vegetation cover for agricultural and urban purposes. The results question the widespread hypothesis of a steady state landscape since it appears that the balance between soil production and erosion may be broken altering the interactions between chemical, physical and biological processes in both soil and landscape system. Yet, the relationship between this accelerated erosion and the carbon dynamics at the landscape scale remains an important area of investigation. Recent attempts to combine geomorphic models, soil redistribution and carbon dynamic has proved themselves valuable in term of supporting the importance of lateral fluxes as a crucial control of carbon dynamic at the landscape scale. We use here a modified version of SPEROS-C - SPEROS LT, which includes dynamic land use and soil physical properties to assess the impact of historical land use conversion on sediment and carbon fluxes in the Dyle catchment. This particular location has experienced a significant human impact since the Roman period undergoing heavy deforestation and expansion of agricultural lands followed by a period of abandonment. The last 400 to 500 years saw a dramatic increase in the intensity of land use conversion associated to population growth leading to forest cleaning and urbanization. Our main objective is to validate the combined geomorphic and soil carbon turnover process descriptions of the model. Land use reconstructions are based on large scale historic data such as HYDE 3.1 downscaled at the DEM resolution. Spatial assignation of the land conversion relies on simple allocation rules based on criteria such as population, distance to settlement or pasture, slope or soil texture. Land use scenarios are constructed for the last 2000 years. We confront the model results with observations and perform a sensitivity analysis. The results indicate that the general trends in sediment production and deposition, as well as soil carbon storage are well predicted by the model. We discuss the key-parameters of the model and the implications of past erosion-deposition for the future C budget of the Dijle catchment.

Sensitivity of floodplain geoecology to human impact: a palynological approach

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Floodplain deposition rates have increased markedly under influence of human impact throughout the Late Holocene in many Western and Central European catchments. These variations in sedimentation rates have changed the geomorphology and ecology of many floodplains. In this study we discuss the human impact and its influence on floodplain geoecology during the Middle and Late Holocene for the Dijle catchment (760 km²), located in the Belgian loess belt. Based on sedimentological and palynological data from 6 study sites, the geoecology of the floodplain and the regional vegetation was reconstructed. Age-depth models for each of the studied sequences were obtained through 60 radiocarbon dates. Human impact in the catchment was (semi-)quantified based on statistical analysis of the pollen data (cluster analysis and non-metric multidimensional scaling). Our data shows that until ca. 2500 cal BP, human impact was nearly absent or localized with no discernible influence on the floodplain geoecology. The river environment was in a stable phase and consisted of a marshy environment were organic material could accumulate, which is interpreted as the natural state of the floodplain. From ca. 2500 cal BP onwards, human impact gradually increased. However, only when human impact in the catchment crossed a threshold, the floodplain geoecology changed with clearing of the Alder carr forest, the dominance of minerogenic overbank sedimentation and the emergence of a single channel meandering river. Spatial and temporal variability in the coupling between increasing human impact and changes in floodplain geoecology can be attributed to differences in timing and intensity of agricultural activities at catchment scale, to differences in the hillslope-floodplain connectivity, or to the location within the catchment. Overall, this study shed new lights on the indirect effect of anthropogenic forces on floodplain geoecology. It also shows that the contemporary morphology of the Dijle River floodplain contrasts widely with that of the Middle Holocene, which was dominated by peat formation in marshes and gyttja deposition in floodplain lakes. These changes in floodplain geoecology are the result of human disturbances in the catchment.

Non-uniform response of floodplain systems to human impact. An example from the Dijle catchment, central Belgium

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Fluvial architecture changed under influence of increasing human impact throughout the Holocene in many NW European catchments. Typically, peat formation – formed in a marshy environment during the Early and Middle Holocene – is replaced afterwards by clastic overbank deposition. In this study we show the importance of a detailed chronology of these floodplain changes, with an example from the Dijle catchment located in the Belgian loess belt. In total 45 radiocarbon ages from 15 alluvial sites were used. Cumulative probability functions were made of the radiocarbon ages of the base (16 samples) and top (29 samples) of the peat layer. The results indicate that peat growth in the Dijle catchment started abruptly from the beginning of the Holocene onwards. The end of peat growth and the transition towards clastic overbank deposition is, however, diachronic at catchment scale, ranging between ca. 6500 and 150 cal BP. This diachronic pattern can be attributed to differences in timing and intensity of agricultural activities at catchment scale, or to differences in the hillslope-floodplain connectivity. In addition, two alluvial sites were studied in detail: one in a small tributary (13 km² catchment area; floodplain width 90 m) and one in the main trunk valley (760 km²; floodplain width 1020 m). In the broad floodplain of the main trunk valley, the top of the peat layer is even diachronic at cross-section scale, indicating that sediment supply starts with low quantities only influencing peat accumulation near the channel, while only later on the distal parts of the floodplain are affected. For the smaller floodplains, the transitions in the floodplain are more abrupt, affecting the entire floodplain width. These results indicate that inferences on changes in sedimentation rate and floodplain changes should be based on a multi-transect and multi-core dating approach, and that a detailed chronology of floodplain changes is necessary to identify all driving forces and processes involved.

Human induced fire regimes of Fennoscandia: to burn or not to burn?

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Fire disturbance is considered vital to promote forest regeneration and floristic diversity in the boreal forest. It is perceived from dendrochronological fire scar records that two centuries of anthropogenic fire suppression has impacted forest biodiversity through favouring the expansion of Picea abies (Norway spruce) and endangering fire-dependent species including fungi, insects and plants. As a consequence recent attempts have been made to re-introduce fire to promote regeneration and restore important natural values, with prescribed burning widely advocated in modern day forest management. Restoring fire to the boreal forest is challenging as knowledge of the optimal fire regime required to enhance the boreal ecosystem is obscured by extensive anthropogenic modification of the natural fire regime. Palaeoecology is rarely considered in forest management and conservation practice yet long-term palaeoecological data can help explore temporal and spatial variability in the fire regime including anthropogenic use of fire and ecosystem modification. Fire regime adaption by humans and the subsequent ecosystem modification is explored at the local scale using stand-scale palaeoenvironmental reconstruction from closed canopy sites in southern Finland. Fire frequency was estimated from the charcoal record with three distinct periods identified:

(1) Pre-2000 cal. yrs. BP semi-natural low frequency (430 year return period), low intensity fires
(2) 2000-750 cal. yrs. BP anthropogenically-driven high frequency (180 year return period), high intensity fires
(3) Post-750 cal. yrs. BP fire absence due to a reduction in human-induced fire or active fire suppression

Vegetation response to changing fire frequency was quantified to land-cover estimates with the human-induced variable fire frequency having a major influence on the forest composition during the last 5000 years. A decline in floristic diversity is associated with an increase in the human use of fire and by using the LPJ-GUESS dynamic vegetation model we quantify fire frequency impacts on vegetation dynamics. Holocene variability in fire is explored using digitised charcoal and fire scar data from 143 sites throughout Fennoscandia and Denmark. The region has experienced episodic variability in the dominant drivers of biomass burning with early-mid Holocene biomass burning driven by fuel availability, climate and dominant vegetation type and mid-late Holocene fire controlled by anthropogenic burning, initially through an increase in ignitions, and subsequently through a reduction in human induced ignitions and fire suppression. The mid-late Holocene expansion of Norway spruce altered the natural fire regime to low frequency, high intensity fires. If fire remains elusive then it is likely that Norway spruce will continue to dominant the landscape thus further promoting low frequency, high intensity fires in the future.

Linking land cover changes to eutrophication of the Baltic Sea

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Although there has been a long history of human habitation in the Baltic Sea watershed there has been little consideration of the impacts of changing land use on nutrient loading. Most previous studies of eutrophication in the Baltic Sea have focused primarily on the rapid increases in nutrient loading with the industrialization of agriculture and fertilizer use. Examination of paleoecological records from lake sediments in the watershed show large-scale changes in land use with the cutting of forests and the opening of agricultural areas. In fact, lakes in the watershed show increases in algal abundance and eutrophication due to increases in nutrient inputs. However, the dogma is that the impacts of changes in nutrient loading are small relative to the large size of the Baltic Sea, such that increases in productivity and symptoms of eutrophication are only recent phenomena. Sediment paleoecological records from the Baltic show the development of hypoxia during the Medieval Warm Period, oxic conditions beginning during the Little Ice Age which persisted for over 500 years followed by intensive development of hypoxia during the last 60 years. Certainly climate has played a role, but nutrients are also necessary to increase water column productivity. We are embarking on a project to reconstruct the history of nutrient loading to the Baltic Sea and to link these developments to changes in eutrophication history. We are examining the level of population growth, technological development and cultural landscape changes during the last two millennia and their implications for the presence of past hypoxia in the Baltic Sea.

Human influences on vegetation and disturbance regimes in East Africa during the late Holocene

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Human use of fire on the landscape has influenced vegetation composition, biomass abundance, and biodiversity in many ecosystems worldwide. Fire activity also has implications for carbon cycling and can result in a net carbon sink or source depending on the alteration of fire regimes and vegetation changes. The major controls of fire activity over centennial to millennial scales are dynamic and are further influenced by human land use and behavioral patterns and have shaped the modern ecosystems. It is often difficult to quantify the anthropogenic influence on biomass burning because the relative importance of natural controls of fire vary over multiple spatiotemporal scales and the analysis of detailed paleoecological data and human cultural information is necessary. Land use and burning practices have changed throughout the Holocene in East Africa and over the coming months we will be synthesizing multiple palaeoecological records of vegetation and fire activity to begin to disentangle the human influences on the environment. Modern biomass burning activity and rapid vegetation changes will be quantified using moderate-resolution imaging spectroradiometer (MODIS) land cover grids (500-m resolution). Multiple records of biomass burning activity are needed to understand the natural controls on fire, such as climate, fuel types and abundance, and topography. The rise of pastoralist societies around 4000 cal yr BP represented a major shift in human impacts on vegetation, fuels, and ignition patterns. By analyzing the natural variability alongside archeological and historical data on human societies it may be possible to characterize the ecological impacts of human burning activities. Demographic changes impacted the environment variably over space and reflected the intensity of land use and the values of those societies. Synthesis of multiple records of biomass burning can be used to understand the broad-scale controls of fire activity. Comparative analysis of fire records at sites across environmental gradients provides insights into the relative importance of natural and anthropogenic controls of fire. Examination of natural and anthropogenic variability on vegetation and disturbance regimes helps us understand the evolution of human-environmental interactions and the processes that have led to the present landscapes. This information is critical to developing sustainable trajectories for land management policy and conservation efforts crucial to the future of East African landscapes experiencing development pressure and rapid climate change.

The deforestation of Europe: a quantitative approach based on pollen and remote sensing data

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It is well established that the present day landscape of Europe has been heavily deforested through the action of humans from early prehistoric times onwards. However, although this interpretation has been based primarily on the palynological record, this has come largely from the qualitative interpretation of individual site records, and there have actually been few attempts to provide a systematic quantitative analysis of the timing and extent of deforestation at the European scale throughout the Holocene. In particular, few studies have undertaken a spatially and temporally continuous gridded approach that allows the quantitative estimate of cleared area through time, and few have calibrated the pollen record to account for bias in common 'quantitative' measures of forest cover such as percent arboreal pollen. Here we present a spatially and temporally contiguous quantitative reconstruction of the deforestation of Europe during the Holocene based on the Best Modern Analogue Approach (Williams et al. 2003). This method reconstructs past forest cover by matching fossil pollen samples with modern pollen samples whose forest cover is known based on satellite-derived measurements of forest cover in the source area of the modern pollen sample. The method has already been successfully applied in North America and Russia (Williams et al. 2013), but its application in Europe has posed particular problems because of the difficulty of finding modern analogues for early-mid Holocene forests in the modern deforested landscape. We overcame this problem by finding analogues in the modern landscape of North America where extensive forested landscapes are still common. The pollen taxa of the two continents are related but not identical, therefore in order to ensure compatibility, we assimilated taxa into common pollen biomes which occur throughout both regions. The results re-affirm much of the established history of deforestation from lowland central-western Europe, but also highlights spatial and temporal differences in other European regions, which are no less important in terms of spatial area and environmental significance.

Impact of the spatial and thematic resolution of Holocene anthropogenic land cover scenarios on modeled soil erosion and sediment delivery rates

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During the last decade, several global Holocene land cover scenarios have been produced that enable to quantify human impact on the landscape since the introduction of agriculture. Application of these land cover maps in geomorphic models may constitute a powerful means to estimate the long-term anthropogenic impact on sediment fluxes and thus to reconstruct changes in landscape morphology through time. However, the former's coarse spatial resolutions of 5 arc-minutes at best question their potential for use in geomorphic models, since sediment redistribution processes operate at much smaller scales. Furthermore, current land cover reconstructions often do not differentiate the typology of human impact (e.g. cropland, pasture or disturbed forests), although the susceptibility of different anthropogenic land uses towards erosion varies greatly. In this study, we assessed the sensitivity of a spatially distributed erosion and sediment redistribution model (WaTEM/SEDEM) to the spatial and thematic resolution of input land cover maps. This was done through a comparison of two sets of geomorphic model runs. First, low-resolution land cover maps, expressed in proportions of anthropogenic vegetation within 5' grid cells, were simply resampled to a spatial resolution of 100 m for application in WaTEM/SEDEM. In a second set of model runs, estimated anthropogenic land cover was spatially allocated to a 100-m grid based on a logistic regression model that relates contemporary land cover types to slope, soil characteristics, landforms and distance to rivers. Since the geomorphic model requires high thematic resolution, different scenarios for the ratio between cropland and pasture were simulated for both types of land cover maps, i.e. low- and high-resolution maps, thus also allowing to assess how land-cover accuracy affects geomorphic model results. The analyses were performed within the Scheldt River basin in Belgium and northern France (19,000 km^2) and for several dates from the Neolithic onwards. Modeled soil erosion and sediment delivery rates for the Dijle subcatchment were subsequently confronted with a field-based, temporally explicit sediment budget for evaluation. Results indicate that application of low-resolution, non-allocated land cover information in a geomorphic model leads to largely overestimated sediment fluxes, whereas spatial allocation of land cover types to a high-resolution grid yields more accurate results. The large variability of model outcomes is related to differences in landscape connectivity between high- and low-resolution land cover. Moreover, geomorphic model results are non-linearly related to the area under cropland. This indicates that there is not only a need for land-cover reconstructions at high spatial resolution but also that thematic differentiation of anthropogenic land cover types is essential for accurate geomorphic modeling.

Pluvials, droughts, energetics and the Mongol Empire

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The success of the Mongol Empire is a historical enigma. At its peak in the late 13th century, the empire controlled or influenced areas from the Hungarian grasslands to southern Asia and Persia. What environmental factors influenced the rise and disintegration of the Mongol Empire? We focus on the Orkhon Valley, the seat of the Mongol Empire, where recent paleoenvironmental and archeological discoveries allow high resolution reconstructions of past human and environmental conditions for the first time. We hypothesize that the arc of the Mongol Empire was influenced by the energy available to nomadic pastoralists for building a mobile military and governmental force sufficient to conquer and govern a significant portion of Asia and Eastern Europe. We also investigate whether the contraction of the empire was related to declines in moisture availability, grassland productivity, and water quality associated with rapid urbanization and climate change in the Orkhon Valley. Until now, little high resolution environmental data have been available to address these questions. Using the framework of ecological economics, we combine tree-ring records of past climate, lake sediment records of water resources and livestock abundance to illuminate the role of energy and water in the evolution of the Mongol Empire. We developed a 2600 year tree-ring reconstruction of warm-season, self-calibrating Palmer Drought Severity Index (scPDSI), a measure of water balance, and NDVI from 107 live and dead Siberian pine (Pinus sibirica) trees growing on a Holocene lava flow in central Mongolia. Trees growing on the Khorgo lava flow today are stunted and widely spaced, occurring on microsites with little to no soil development. These trees are extremely water-stressed and their radial growth is well-correlated with both drought (scPDSI) and grassland productivity (Normalized Difference Vegetation Index (NDVI)). Our reconstruction of scPDSI, calibrated and validated on instrumental June-September (1959-2009), accounts for 55.8% of the variability in the growing season scPDSI, when 73% of the annual rainfall occurs. Our scPDSI and NDVI reconstructions place historic social change in Mongolia in the context of the range of climatic variability during the Common Era. Our record shows that the climate during the conquests of Chinggis Khaan's (Ghengis Khan) 13th century Mongol Empire was an unprecedented period of abundant moisture. Inner Asia in the 13th century underwent a major political transformation requiring enormous energetic inputs that altered human history. We argue that the energy that enabled transformation came from grassland net primary productivity. Future work will integrate modeled estimates of net primary productivity, herbivore productivity and historical and archeological sources on human consumption to understand the environmental trajectory of the empire.

The shaping of the Brussels' urban landscape: an interdisciplinary perspective

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The urban landscape is an extreme example of pronounced human impact on the natural landscape. The actual shape of the Brussels' landscape for example is heavily influenced by a series of human activities. In order to identify the progressive human impact, a research protocol has been developed involving historical research, archaeology, archaeopedology, archaeobotany and archaeozoology (DEVOS et al., 2011). Present contribution will discuss through a series of case studies how and to which extent the human impact on the environment can be measured. One focus will be on the study of urban "Dark Earth". These anthropogenic soils appear to be the result of a complex interplay of human activities and natural events (NICOSIA & DEVOS, in press). Importantly, part of the natural events is clearly human induced. Their study allowed not only to locate and identify ancient activities (DEVOS et al., 2009; in press), but also to measure changes in relief and topography and to detect changes in soil characteristics (soil fertility, …). A second focus will be on the archaeobotanical data (seeds/fruits, wood remains, phytoliths and pollen) that contribute significantly to reconstruct past land cover through time. An increasing availability of those datasets will be helpful also for future quantification of the changing urban environment. A third focus concerns soil pollution in the historical town centre. Ancient texts mention repeatedly nuisances caused by several artisanal activities and the presence of all kind of waste deposits (DELIGNE, 2003). Unfortunately, these written sources do not provide reliable data on the importance of the pollution. We will discuss to which extent soil chemical analyses, in combination with a taphonomical study can help to quantify ancient pollution.

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Chemical and magnetic survey data as indicators of ancient human activity: the suburban Sagalassos case (SW-Turkey)

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Several studies have suggested that multi-element soil geochemical surveying holds potential as an archaeological survey method, complementing more common techniques such as magnetometry and fieldwalking. Despite this, only limited research has been carried out concerning the joint interpretation of these techniques. In this study, we combined geochemical and magnetic survey data from an archaeological site comprising a suburban area of 1.5 ha, situated in the Roman to Byzantine city of Sagalassos (Taurus Mountains, SW-Turkey). For the geochemical survey, a total of 120 soil samples were collected in a grid with cell sizes of 20 m². Al, As, Ba, Ca, Cu, Co, Cr, Fe, K, Mn, Mg, Na, Ni, Pb, P, Sr, Ti, V and Zn were measured by inductively coupled plasma optical emission spectrometry (ICP-OES), using a Varian 720-ES apparatus after Aqua Regia digestion. The magnetic survey was performed using a Geometrics G-858 magnetometer in gradient mode, along 0.5 m spaced transects. The chemical data were analysed for patterns using a contiguity constrained spatial clustering algorithm. The main difference with more standard clustering methods is that this method takes into account the spatial dimensions of the dataset, resulting in clusters that are not only statistically, but also spatially homogeneous The resulting spatial clusters revealed that an area characterised by high-frequency magnetic anomalies was spatially associated with a chemical cluster rich in Cu, K, P, Pb and Zn. We interpreted this as resulting from the accumulation and decomposition of occupational debris. Increased Al, As and Ba concentrations helped interpreting an area with a low magnetic signal as a region where limestone bedrock was located close to the soil surface. Finally, two zones of enhanced magnetization were shown to spatially overlap with two clusters of soils containing elevated levels of Co, Cr, Mg, Mn, Ni, (Fe) and Ti, V, (Fe) respectively, indicating the presence of two different types of mafic to ultramafic ophiolitic bedrock near the soil surface. This study illustrates that multi-element geochemistry has potential as a survey technique, because it offers direct information on soil bedrock or ancient human disturbance, thereby adding an extra dimension to the interpretation of geophysical survey data.

Linking geomorphic evidences and historical records of past soil erosion to interpret long-term human-environment interactions

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Soil erosion threatens the environment and the sustainability of agricultural practices since the earliest societies started modifying their natural environment in the Neolithic. Almost all farming-based cultures in the world, from large civilizations to peasant groups on little islands, have suffered from soil erosion by water. The amounts of soil erosion varied largely through time and space, and extreme events have left a wide variety of imprints on the landscape over millennia. Eroded hillslopes and gullies, deposited sediments in sinks like lakes, footslopes, valleys, floodplains, and river deltas are geomorphic legacies that have been linked to changes in land use and climate by many studies during the last decades. However, a standardized analysis and interpretation of these geomorphic legacies is problematic because of the variety of methodological approaches and the

nonlinearity between soil erosion, climate, and land use. Cascading effects, land use structures, soil management, soil conservation strategies, and long-term system changes have produced different signals over time. Historical records are crucial and an invaluable source to provide alternative proxies about soil erosion in the past. Direct observations of individual soil erosion events may restrict the deposition of a distinct sediment package to a certain time span. They also expand the range of alternative interpretations, particularly with respect to the long-term effects of soil erosion to ecosystem services and socioeconomic processes. However, historical records also need critical analyses regarding their origin, intention, and quality. They were often created in the context of personal interests or political issues rather than being based on scientific facts; and it is often unclear if they represent certain events, narratives, or vague assumptions. I will show examples of geomorphic evidences and historical records of past soil erosion from different areas of the world and discuss if and how such data can be used for the deciphering of long-term human-environment interactions.

The effects and responses of prehistorical agriculture to soil erosion in Southeastern North America

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The significance of soil erosion due to pre-historic land use and possible feedback mechanisms had been hardly recognized in the Southeastern USA. Here, the agricultural practices only began in the second half of the Holocene. Sedentary hunters and gatherers started to domesticate squash and sunflowers. Associated with the expansion of maize cultivation in the Mississippian period between AD 800 and 1100, significant forest clearings took place on the river floodplains. During this time, central settlements with up to 30,000 residences existed and the surrounding ridge and furrow fields extended to up to 30 ha. It is still open to question why these groups already declined in the 14/15th centuries already before the arrival of the Europeans. However, around AD 1540 the conquistador de Soto still reports extended fields with intensive cultivation of maize in the uplands of Northern Mississippi. Despite of this intensive land use by Native Americans, current research gives no indication that these activities had any significant impact on river channel form. Also, no clear evidence exists for distinct channel change occurring in response to any sort of middle Holocene Hypsithermal, Medieval warm period, or the Little Ice Age. We will present results of a current running project which aims to explore erosion forms, colluvial sediments and buried soils in selected 0-order and 1st-order watersheds in the southeastern USA in order to gain, solidify, and evaluate general data on soil erosion during the Native American land use period and its respective long-term effects on the environment. This will be achieved by 1) recording the stratigraphy of colluvial and alluvial sediments and buried soils, 2) mapping the extent of erosional and colluvial forms, 3) analyzing chemical and physical soil and sediment properties, 4) establishing chronological control using various dating techniques including radiocarbon and OSL dating, and 5) quantifying soil erosion using hillslope sediments. The gathered data will be used to i) compare the spatial extent of prehistoric and historic erosion and the short-term and long-term pedological and geomorphological effects of subtle soil erosion against extreme events, ii) assess the feedback-mechanisms of soil erosion on soil fertility and measurable land use changes in prehistorical and historical times, and (iii) estimate the long term effects of soil erosion and sediment deposition on archaeological features. The outcome will provide a decisive step forward to gather new qualitative and quantitative information on soil erosion during the Native American land use period to be able to achieve a better understanding of the long-term human induced landscape evolution in the uplands of the Southeastern USA and deliver data for a better predicting of landscape evolution to future climatic shifts in precipitation regimes.

Quantitative reconstruction of past vegetation mosaics from pollen data

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Pollen analysis is one of the most commonly used methods of investigating past environments. Pollen sequences are often sparsely distributed within a landscape, and they record a single 'averaged' measure of the surrounding vegetation over a wide area. However, the past vegetation of which they are a record would have been present as patches of different communities. Much recent work has focused on developing methods for 'translating' pollen signals into maps of past vegetation community

distribution using models of pollen dispersal and deposition. This presentation will describe the Multiple Scenario Approach (MSA) to quantitative reconstruction of vegetation mosaics from pollen data, illustrated using a case study from Orkney in northern Scotland. A recent review of palaeoecological evidence from Orkney has suggested that a wider range of woodland resources was available to the Neolithic population of the islands, and that patches of woodland persisted in the landscape for longer, than previously realised. This has important implications for the interpretation of Orcadian Neolithic archaeology in terms of resource availability and choice of building materials. Estimates of Relative Pollen Productivity (RPP) for the taxa of interest are essential pre-requisites for the MSA. Any interpretation of pollen data, whether qualitative or quantitative, generally assumes that RPP is constant, both in time and space. However considerable research effort has been invested in obtaining empirical estimates of RPP, and multiple studies in northern Europe have indicated wide variations in estimated values for common taxa. In this presentation we will also present preliminary results from the application of a standardised method to compare estimates of RPP within individual species across a wide climatic range and in different habitats, and discuss the precision with which it is necessary to report RPPs.

The glade effect - an unexpected phenomenon interfering with the visibility of early forest opening

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The early Neolithic in central and northern Europe is hardly visible in pollen proxy records as the beginning of farming and stock breeding seems to have just little effects on the environment. Nevertheless there is a clear record by archaeological findings and features that indicate human presence in the landscape. This raises the question why it is so difficult to detect human impact in pollen diagrams at this early stage of agricultural activities. This paper highlights the potential of pollen influx studies from laminated lake sediments for the evaluation of early human impact. According data from Northern Germany shows increasing influx values (pollen grains per cm2 and year) of arboreal and non arboreal taxa at the transition from Mesolithic to Neolithic at around 4000 cal. BC. First clearings and enlargements of forest glades seem not only to have enhanced the herb flora (i.e. wild grasses), but to have favoured also the pollen productivity of forest trees, in particular Quercus (oak). It is only with the establishment of more widespread permanent open areas in the landscape, reflected by regular records of Plantago lanceolata, that influx of arboreal pollen decreases in context of increasing non-arboreal pollen. We assume that this phenomena reflects increased flowering activity of arboreal taxa in context of an opening of the woodland canopy and the creation of forest glades. A simulation is used to reproduce the under-representation of open land indicators in relation to arboreal taxa during an early phase of landscape opening, i.e. the so-called “glade effect”. This effect hampers a quantification of early forest opening and might explain the problem of detecting human-environment interactions at the Mesolithic-Neolithic transition.

Early anthropogenically-induced shift in biome in the lowlands of Transylvania (CE Europe)

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It has been demonstrated that human land use has created profound changes in ecosystem distribution, diversity, nutrient cycles and climate. Here, we use multi-proxy analysis (pollen, plant macro-remains) of a lacustrine sequence located in the lowlands of Transylvania (NW Romania) combined with vegetation modeling (Regional Estimates of Vegetation Abundance at Large Sites, biome), and global climate simulations to examine: whether i) the Transylvania Plain was ever extensively wooded following the last glaciation and the present day forest steppe is a results of the dry climate condition that predominated throughout the Holocene or ii) the Transylvanian Plain was probably wooded in the early postglacial, but was extensive cleared by humans sometime during the Holocene. Results from the land cover reconstruction and climate simulation show that the current forest-steppe and species rich grasslands in the Transylvanian Plain is man-made, because prior to 3700 cal yr BP woodlands occurred in the region under climatically similar conditions. Woodlands (25-30% openness) composed of mixed deciduous tree species (Quercus, Carpinus betulus, Fagus sylvatica, Fraxinus), and Picea abies have been extensively cleared after 3700 cal yr BP (Bronze Age), and have been replaced by semi-natural-grasslands due to a combination of anthropogenic activities including forest clearance, burnings, animal husbandry and agricultural farming. Following the extensive and sustained land use in the region, also seen proven by rich archeological records, the woodlands were too vulnerable to ever fully recover.

Our new findings of intensive human land use challenge the previous view of a more recent ecosystem / landscape transformation in the region i.e, the past 1000 years by showing that human activities have been intensive and continuous for almost four millennia in this region. Although, the onset of deforestation in the lowlands of Transylvania is consistent with the estimated onset of population growth and cultivated area, our finding of massive deforestation taking place already 3700 years ago is much earlier than modeled for this region. Our results therefore add new insights on the timing and intensity of the anthropogenic transformation and their profound ecological changes on the landscape in this region.

Integrating archaeobotanical and geomorphological evidence from the Vinča tell in the central Balkans towards the reconstruction of late Neolithic landscapes and land use

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Investigations of the c. nine meter-high successive occupation levels of the Vinča tell (c. 5200-4600 BC) on the Danube have been instrumental for the construction of the Vinča culture chronology and the understanding of Neolithic developments in the central Balkan region. Until recently, however, there has been virtually no information on the environmental context of this large long-lived settlement; very little was known about the vegetation, soil distribution, hydrology of the site, and natural resource potential and use. New work at Vinča for the first time includes archaeobotanical sampling and analysis of plant remains, and geomorphological investigations on and off the site. The archaeobotanical record suggests presence and use of a range of vegetation formations, from oak forests and open woodland (wooded steppe) to riparian and wetland sources. In terms of plant-based food economy, the evidence points to the importance of crop cultivation, as well as collection and, in some cases, possible management/cultivation of wild fruit. The results of geomorphological investigations reveal that, in contrast to the previously assumed location of the settlement directly on the Danube, the river course at the beginning of the Neolithic occupation, and likely through the whole history of the site, has been located few kilometers to the north of its current position. This perhaps indicates that the role of the Danube for the Vinča inhabitants has not been life-sustaining. Instead, a small Danube tributary bordering the site to the east may have played a key role for the settlement's location and economy, as it regularly deposited loess-rich alluvium at the confluence. A combination of archaeobotanical and geomorphological data presented here shed new light on the environment of the site and allow for better understanding of the land potential and use in the Neolithic.

The development of human-induced environments in the Italian peninsula: the pollen evidence from Bronze age to Renaissance archaeological sites (c. 4200-500 cal. BP)

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The transformations of natural environments into anthropogenic landscapes are evident from the long-term action of humans who have selected and exploited cultivated and wild plants for millennia in the Mediterranean basin. Pollen data from twenty-six Italian archaeological sites (chronology: from c. 4200 to 500 cal. years BP) were reviewed to investigate the development of human-induced environments through both the presence of selected Anthropogenic Pollen Indicators (API; Mercuri et al. 2013a), and the percentage sum of olive, walnut and chestnut trees (OJC curve; Mercuri et al. 2013b) in pollen spectra. The API records, common in and near archaeological sites, may be useful to reconstruct similarity and differences in the expansion of human landscapes in the Italian peninsula. The most frequent API taxa are: Artemisia, Centaurea, Cichorieae and Plantago, followed by cereals and Urtica, and by Trifolium type. A notable increase of API is observed at the transition from the Early to the Middle Bronze age sites, when the combination of cereal and synanthropic pollen in the records is a clear evidence of human-induced environments. The spreading of olive, walnut and chestnut trees, which have been gathered or cultivated since ancient times, is another important indicator of increasing human activity and anthropization in the Mediterranean area. Olea, Juglans and Castanea pollen grains indicate human activity when their curves rise fairly suddenly and in combination with material cultural evidences. This unequivocally occurs from the Bronze age onwards. The pollen data from the archaeological sites reported in this study, compared with those from three off-site cores (one from Adriatic Sea, and two from Latium lakes) show that the wide distribution in time and space of the pollen of economic/anthropogenic plants is evidence that the cultivation of these trees was already known by local people even before the Romans.

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The site density of archaeobotanical researches as key to the understanding the bio-cultural diversity of the Italian landscapes

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Since the last millennia, Italy (continental Italy, Italian peninsula and its islands), characterized by extraordinary habitat diversity, has seen an outstanding cross-cultural development. The paper reports for the first time the census of the Holocene archaeological sites that have been studied for archaeobotany in Italy in the last quarter-century. Pollen, seeds and fruits, woods/charcoals and other plant remains were analysed in multidisciplinary researches. Fifteen archaeobotanical teams provide more than six hundred sites. The sites are located in the 20 regions of Italy, and in the Republic of San Marino (c. 356 sites in northern Italy, 118 in central Italy, 156 in southern Italy and islands). They belong to several cultural phases, prevalently belonging to a pre-Roman phase. Also Roman/post-Roman sites are represented while a minor number of sites cover a large range of time entering in the two major time-spans. Site distribution is plotted in maps of site density according to geographical districts and main chronological phases. The reference list helps to find analytical data referring to the descriptive papers that may be scattered in monographies and thematic books.

Study of environmental contamination over the historical period: Trace element and lead isotopic signature in coastal sediments from Cap Corsica (France)

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The Mediterranean coasts have been characterised by intense maritime commercial exchanges since Antiquity. Archeological researches reveal that Cape Corsica (France) may have been an ancient Roman harbor. The purpose of this study is first to highlight an anthropogenic contamination due to Roman activities using trace element concentration. Second we aim to identify

the contamination sources through Pb isotope composition. Radiocarbon ages performed on macroremains in coastal sediments from Cala Francese (cores CF10-II and CF10-III) allow the localisation of the Roman Period in the sedimentary columns. In core CF 10-II, two major shifts of trace element concentration (such as Pb, Cu, Zn, As and Sb) have been measured at 60-80 and 140-160 cm, corresponding respectively to the Industrial Revolution and to the Roman Period. The same tendency of the Pb concentration is observed in core CF10-III. In this core, the Roman Period is localised between 80 and 140 cm. A major shift in Pb isotopic composition is observed in both core at 140 cm in CF10-II and 60 cm in CD10-III, with a decrease of 206Pb/207Pb ratios and 208Pb/206Pb ratios. All the Pb isotopic ratios match with Pb Roman time signatures from Greece and Spain. Such significant changes in trace metal content and in Pb isotopic signature of sediments are consistent with Human perturbations of the environment during the Roman and Industrial periods. The Pb isotopic signatures measured in Cala Francese are in the same range as those located in other sites of Cape Corsica, indicating a regional contamination.

Livestock diet management and landscape use at ancient Sagalassos (Pisidia, southwest Turkey) inferred from stable isotope analysis

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The ancient city of Sagalassos is located on the southern slope of the Taurus mountains, about 100 km north of present-day Antalya (Turkey). The area was occupied from Classical-Hellenistic times to the mid-Byzantine period. Nowadays, the surroundings of Sagalassos are quite degraded due to intensive overgrazing, resulting in a short open vegetation. However, the past environment was more wooded, the climate was warmer and more humid and the main river of the nearby valley beneath probably held more water at least up to the late Roman period. Throughout the occupation, the animal economy relied mainly on husbandry with cattle, sheep, goat, pig and chicken providing most of the animal proteins. The analysis of the carbon and nitrogen isotope composition in bone collagen from more than 400 animal bone samples from the nearby Classical/Hellenistic site of Düzen Tepe and from Sagalassos (Roman to mid-Byzantine periods) revealed diachronic and specific variations in the diet of cattle, ovicaprines and pigs, likely reflecting changes in husbandry practices and landscape use. To investigate livestock diet at a seasonal scale, sequential $\delta^{18}O$ and $\delta^{13}C$ analyses are being performed on pig, cattle and ovicaprines teeth, targeting the Early Byzantine period, during which millet (a C_4 plant) appears in the botanical records and could have been used as fodder. The results obtained can be used to better understand pastures management and to document another aspect of human-environment interactions in the past.

The temporal and spatial quantification of Holocene sediment dynamics for reconstructing soil erosion: pros, cons and challenges

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Since the early beginning of farming, humans have a strong impact on the landscape, on its land cover and therefore on the sediment dynamics. It is assumed that an increase of farming activity is documented by truncated soil profiles due to soil erosion on the slopes and deposition of the eroded material as colluvium and alluvium at foot-slope positions and in floodplains of rivers. In this respect, these sediment archives play a major role in reconstructing human induced soil erosion and in establishing catchment wide quantitative sediment budgets. However, the response of sediment archives to an external impact like the human impact on the landscape or climate events is not homogeneous within a catchment, but might be variable in time and space. This is well known and considered in the geomorphological concept of sediment cascade systems and therefore needs to be included as a basic idea in studies on past soil erosion and its driving factors, using sediment archives. However, the identification of representative sediment archives within a catchment and especially their temporal quantification is challenging. In this presentation I will discuss the importance of sediment archives for reconstruction past soil erosion, the significance of these archives for identifying possible causes of sediment redistribution and the pros, cons and challenges, which are involved.

Early to Late Middle Age agricultural system changes in N-Italy as a main step towards the modern landscape

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Most of the available palynological records from Italy provide detailed reconstructions of Late Glacial – Holocene vegetation change but fail in describing properly what happened to landscapes from the Roman Period onwards. Younger periods are infact usually represented in pollen diagrams only in a sketchy way. When did the modern landscape appear in the Po Plain? To answer this question, four sites in east, west and south Lombardy were investigated; respectively Lake Lucone (a former basin located in the western part of the Lake Garda amphitheatre), Bodio Lomnago (on the shores of Lake Varese), Pulignano Park (city of Lodi) and Forcello (near Mantova). Paleobotanical and geochemical analysis on the stratigraphic successions offer insights into the history of landscapes and land use from the Roman Age onwards. After the Roman Age, marked in the pollen records from Lake Lucone and Forcello by the appearance of Juglans regia and Castanea sativa, an unprecedented phase of abandonment is registered, characterized by forest recovery and a decrease of cultivated plants. By this time AP pollen values are comparable with pre-roman ones. This phase of abandonment can possibly correspond to the period of the Langobards Kingdom. A new major phase of deforestation took place soon after, with a decrease of AP values, an increase of field crops (cereals, Cruciferae, Secale cereale and Cannabis) and an expansion of grasslands (traced by Gramineae, Plantago lanceolata-type and Rumex acetosa-type). This phase may historically correspond to the period of foundation of communes and scattered new villages. From XI/XII century AD onwards the history of the country is characterized by deep transformations. As already in the Early Middle Ages, agriculture became the central sector of economy, thanks to a great deal of farming land. Agriculture development, establishment of a watering channel network in the plain, increasing deforestation, new villages foundation, technological progress in agricultural tools and trading of foodstuffs lead to economic growth. This expansion is strictly connected with a major demographic increase, especially in the period between XI to XIII century AD. In this contest some cultivations spread widely: Cerealia, Secale cereale, Cannabis, Cruciferae (e.g. Isatis), supported by an increase in charcoal influx. High values of Cannabis-type pollen in the sediments of Bodio (pollen abundance reaching 20% of the pollen sum), suggest intensive retting by submerging hemp stalks in water. By the same time in the surrounding of Lake Lucone cultivation of Cruciferae strongly developed. At Pulignano Park, on the Po plain cereals were the most important cultivated crop.

From land cover-climate relationships at the subcontinental scale to land cover-environment relationships at the regional and local spatial scale – the contribution of pollen-based quantitative reconstructions of vegetation cover using the Landscape Reconstruction Algorithm

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The Landscape Reconstruction Algorithm (Sugita 2007a,b) includes two models, REVEALS (Regional Estimates of VEgetation Abundance from Large Sites) that estimates vegetation abundance (% cover) within an area of ca. 100 km x 100 km, and LOVE (LOcal Vegetation Estimates) that estimates vegetation abundance at the local spatial scale, i.e. within the Relevant Source Area of Pollen (RSAP sensu Sugita, 2004) that is the smallest area around the study site for which the reconstruction is valid. The RSAP is estimated by the LOVE model and varies between sites and vegetation settings; so far, it was estimated to vary between < 1 - < 10 km in most ecological settings of the Holocene in NW Europe. We used the REVEALS model and over 600 pollen records from pollen data bases and individual researchers to reconstruct land-cover in NW Europe N of the Alps for key time windows of the Holocene in order to assess model-based reconstructions of anthropogenic land-cover change (ALCC) (e.g. Kaplan et al., 2009) and model (LPJ-GUESS) simulations of past potential (climate-induced vegetation), and to study past land cover – climate interactions using a regional climate model (RCA3). We used the REVEALS model and the complete LRA approach (REVEALS + LOVE models) along with two pollen records from large lakes and three pollen records from small bogs to reconstruct the local-scale land-cover in central Småland, southern Sweden, to study the relationship between vegetation composition, fire, climate and human impact at the regional and local spatial scales with the objective to discuss biodiversity issues. Our results suggest that i) past subcontinental to regional ALCC did influence regional climate through biogeophysical processes at the land-

atmosphere interface (Strandberg et al., submitted), and ii) local land-cover change, both natural and anthropogenic, govern environmental changes such as fire and biodiversity (Cui et al., 2013; Cui et al., submitted).

Cui, Q.-Y. et al., 2013, The Holocene, doi; Cui, Q.-Y. et al. submitted, Journal of Biogeography; Kaplan, J.O. et al. 2009, Quaternary Science Review 28, 3016-334; Strandberg, G. et al. submitted, Climate of the Past; Sugita, S. 2007a,b, The Holocene 17, 229-257.

Holocene palaeovegetation history of the Tigray Plateau in Northern Ethiopia from Buried Wood Charcoal: implications for climate and land use

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Anatomical identification of fossil soil charcoal fragments in the highlands of Northern Ethiopia provided clues to reconstruct changes in vegetation and to obtain inferences about shifts in past climate and land use. The sites are presently devoid of trees and most of uncultivated lands are dominated by grassland and acacia woodland. The natural vegetation of the highlands of Northern Ethiopia was previously thought to have been dominated by Juniperus/Podocarpus forest. Nonetheless, this hypothesis is not supported in the vegetation cover now and was scarcely studied in the palaeo record. Juniperus procera occurred in even the youngest samples, although at lower percentages of the total charcoal than in older samples. Nevertheless, rapidly regenerating angiosperms usually dominated or co-dominated charcoal even in some of the oldest strata. Therefore, juniper forest types have long been present at >2200 m in the Tigray Plateau but they have rarely been the dominant natural vegetation. The sediment chronology performed using radiocarbon dates of charcoal ranges from ca. 13,700 to 110 cal yr BP. The charcoal identification along with the percentage of organic carbon from C4 plants and from δ13C values of bulk organic matter and δD analyses of specific fatty acid molecules in the soils of gully walls, suggest that the time prior to 5500 cal yr BP in the Holocene was wetter than afterwards. This suite of analyses made it possible to distinguish the effects of climate from land clearing. Soil erosion due to clearing vegetation in Northern Ethiopia has had a long history and is believed to be a reason for the fall of complex kingdoms. Therefore, our results provide an enlightening basis to discuss potential causes of palaeoenvironmental change in relation to change in vegetation, climate, and land use of the Tigray Plateau and East Africa in general.

Widespread change in ecological character of Murray River wetlands: regime shift or species turnover.

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Sediment records have been extracted from multiple wetlands along the length of the River Murray, from the upper reaches near Albury, to the mouth south of Adelaide. Diatom assemblages have been analysed from all sites while, in some, preserved macrofossils and pollen support diatom inferred changes in wetland condition. Some records span millennia and provide a long term record of variation in wetland condition with known shifts in climate, particularly of effective moisture. The greatest changes have occurred following the development of intensive agriculture in the floodplain, and on account of the regulation of flow and water abstraction. Prior to this development most wetlands reflect clear water systems with abundant submerged macrophytes. Planktonic diatoms dominate after the establishment of structures to regulate river flow from 1922. While abrupt changes are evident, perhaps suggesting regime shifts, gradual turnover of diatom taxa is evident from other sites. Ultimately clear water conditions have been replaced widely by semi-planktonic species that tolerate turbid waters. This is reflective of the classic model of a shallow lake regime shift from aquatic macrophytes to phytoplankton dominance. While the paleo-record has the capacity to unearth such past changes it remains unclear as to whether these changes reflect changing internal dynamics consistent with regime shifts, or merely a persistent response to an ongoing pressure from increased sediment and nutrient flux.

Human impacts on a peri-urban wetland in central Kenya

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Manguo wetland is located in Central Kenya at lat. 010 06' 19.6'' S and long. 36037' 58.44''E at an elevation of 2200 m asl. It occupies an area of 8.1ha and primarily depends on rainfall, surface runoff and underground seepage for its water supply. A study was carried out in August 2011-February 2012 to determine: Manguo vegetation composition and distribution, its soil/water chemical and physical properties, vegetation changes over time and major wetland uses and their impacts. The data sets obtained were:

a) Vegetation data (species sampled, number of individuals) to calculate species abundances, densities, frequencies, diversity, richness and sample similarity.
b) Soil and water data (pH, soil moisture and texture, nutrient levels) to determine the soil/water quality; determine if the soil properties influenced vegetation distribution and check if watershed land use had impacted wetland nutrient levels.
c) Pollen data was used to display vegetation changes over time (pollen diagram) and infer land use changes and climate impacts.

A total of 20 species from 8 orders and 12 families were sampled and the wetland was dominated by herbaceous vegetation particularly sedges. The vegetation abundance was higher during the wet period than the dry period with 6387 and 4272 individuals respectively. The diversity was higher in the wet period than the dry period with HI=1.05 and HI=0.64 in the wet and dry period respectively. However species richness was higher during the dry period at S=4.13 than the wet period at S=3.94. Plant species composition did not significantly change along soil moisture and nutrient gradients. The soils and water were determined to have adequate Ph and nutrient levels suitable for agriculture (main wetland use). The sediment core revealed the vegetation historical succession from high forest species abundance to open grassland at present. The main human uses/impacts identified were poor agricultural practises leading to soil erosion/siltation, overgrazing, garbage dumping and burning, digging of pits for sale of soil, bird eggs collection, uncontrolled water and sedge harvesting due to its unprotected status. The Manguo wetland core revealed a sharp decrease in trees and increased dominance of herbs which could be a result of anthropogenic induced vegetation changes. Significant forest clearance and site occupation occurred in the region in the recent past. This is assumed to be during the second half of the 19th century when there was a high influx of the Kikuyu who were cultivators. The dramatic decline of tree species indicates the influx of humans coupled with the appearance of the exotic species Eucalyptus and Pine and species cultivated for food e.g Zea mays, Amaranthaceae. Ecological information on Manguo wetland was unavailable and the study provided historical and ecological baseline information which can be used for the wetland conservation by Manguo wetland stakeholders.

Small river aggradation in different landscape zones or the Russian Plain: reasons and consequences

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Southern half of the Russian Plain is occupied by forest, forest-steppe and steppe landscape zones. Until the 17th century population density was low and area of cultivated lands was negligible. Area of arable lands increased considerably on the south of forest zone since the beginning of 18th century. Intensive tillage of the forest-steppe and the northern part of steppe zones began in the end of 18th century. Only in the end of 19th century lands of dry steppe zones were cultivated with increasing area of arable lands from 5 to 65% for only 20 years. Some parts of dry steppe in the south-east of Russian Plain and on south of Western Siberia were intensively cultivated only in the middle of 20th century after World War II. So in case of Russian Plain it is possible to evaluate the anthropogenic impact on landscape based on documentary evidence for region scale and in some case for local scale. Analysis of the spatial-temporal dynamics of stream net density (SND) for different landscape zones of the Russian Plain was undertaken using comparison of historical topographic maps for few time intervals since the end of 18th century. It was found that maximum SND decrease is observed at the northern parts of the steppe zone, where total SND in the middle of 20th century was 50-60% of those at the first quarter of the 19th century. It was confirmed that intensive small river aggradation was associated with period of intensive cultivation of basin area, which led to increasing of surface runoff and sediment transport from cultivated lands to the valley bottoms with proportional decreasing of underground runoff, feeding constant flow in the river channels during low water. The highest delivery of basin sediment to the river valley was coincided with periods of gully erosion intensification, which in turn were due to changes in land use (a sharp increase in arable land,

plowing the steep valley sides, increasing the area of individual fields). It was determined that intensive small river aggradation is observed at the river basin with area of arable lands above 40-60% from total basin area. It is confirmed by high coefficient of correlation (r=0,79) between the area of arable lands and the depth of floodplain sediment accumulated since the beginning of intensive cultivation for individual river basin. Quantitative assessment of sediment redistribution within small catchments of the agricultural zones of the Russian Plain was made based on application of different methods and approaches. It was established that about 2-4 m of sediment was deposited in the valley bottoms of drainage net since the beginning of intensive cultivation. Maximum sediment was re-deposited in the zero- and first-order valleys. However in some cases the most part of sediment was transported downstream due to intensive bottom gullies growth. Results of sediment redistribution studies within catchments located in different landscape zones of the Russian Plain will be presented.

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40 shades of black. Regional differences in vegetation response to a changing human influence in the Low Countries during the Dark Ages (AD 300-1000).

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During the Dark Ages, which includes the Late Roman Period (LRP) 300-500 AD and the Early Middle Ages (EMA) 500-1000 AD, large scale vegetation development is characterized by a forest regeneration. This short phase of forest regeneration in between periods of land reclamation gives us an unique chance to study the resilience and the ability of an already altered landscape to return to its original state. This vegetation redevelopment phase was not uniform across the Netherlands. A comparison between existing pollenrecords shows that forest redevelopment started earlier and was more severe in the southern part of the Netherlands than in the eastern coversand region. The prevailing view advocates that the forest redevelopment is the result of a diminishing human influence on the landscape due to the collapse of the Roman empire. Following this view, regional changes in forest regeneration are explained by varying population densities. However, there are indications that climate and changes in the physical landscape also played a role. Existing climate-records indicate a colder and wetter climate during the Dark Ages and the geomorphological record points to a changing landscape. How and to what extent these climatic and environmental changes contributed to the changes in vegetation development or even to the decline of the Roman Empire is largely unknown. To understand the relative importance of the factors (climate, environment, economy and demography) explaining vegetation development it is important to accurately map regional differences in vegetation. To give an overview of the spatial vegetation development all available pollenrecords from the Low Countries are collected. The data is collected from published records and archives from several universities and research institutes. This amounts to a total of ca. 500 sites dating from the Subatlantic period covering the whole of the Netherlands. This unique database can provide us a good overview of the differences in timing and amplitude of the vegetation development during the Dark Ages. In a later phase of the research the spatial differences in vegetation development can be compared to climatic, geomorphological and archaeological records to further understand the factors controlling vegetation development and to quantify the human influence on the landscape.

A glimpse of Mediterraneanisation? First analyses of Hellenistic and Roman charcoal remains from Terrace House 2 at Ephesos, and their possible implications for vegetation change, woodland use, and timber trade

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The Greco-Roman settlement of Ephesos near modern Selcçuk on the Aegean coast of Anatolia has been a target of decades of multidisciplinary archaeological research. But only recently charred wood remains have been analysed. Charcoal from the stratified fillings of a sewer from Unit 7 in Terrace House 2, dating from the second half of the 2nd cent. BCE till the 3rd cent. CE, was extracted and analysed. This material was complemented by charcoal from a pit from the same unit (2nd half of 2nd cent. CE) as well as from a possible votive offering pit from Unit 5 (2nd half of 2nd cent. BCE till first half of 1st cent. CE). The resulting data provide, for the first time, insights into woodland management strategies across the settlement phases. The oldest (Hellenistic) layers are dominated by deciduous and evergreen oak species (*Quercus* sp.), while the earliest Roman deposits are characterised by a remarkably strong dominance (ca. 90%) of the pioneering maritime pine group (*Pinus* Subsect. *Pinaster*). The abundance of these pines is slowly decreasing towards the younger Roman layers. Only in the youngest phase the eu-Mediterranean vegetation, weakly represented in the older layers, gains more diversity and total quantity. Given that the recovered charcoal assemblages do not represent deliberately selected timber for special purposes – which seems ensured by the find contexts – the replacement of oak by pine during the Roman Period may reflect anthropogenically influenced woodland in the surroundings of the city, hence a change in locally available woody species. The second change in charcoal composition in the 3rd cent. CE seems to imply recovery of the eu-Mediterranean vegetation, and therefore its increasing availability for being used in the settlement. It is this period when remains of long-distance traded timber are found: fir/cedar (*Abies*/*Cedrus* sp.) and linden

(*Tilia* sp.) must have been transported to Ephesos from a distance of at least 150 kilometres. Their utilisation (construction timber, furniture, tools, etc.) in Terrace House 2 is, however, still unknown.

Inaccessibility as a tool to isolate human influence on ecosystems: Millennia of grazing management triggered feedbacks between soil development and nutrient cycling

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Mountains are vulnerable ecosystems with extreme importance for several ecosystem services. Moreover, mountains serve as refuge for plants and animals when climate changed. The most prominent agricultural use in mountains is ranching. This management probably led to a decline of the timber line and an increase an man-made grasslands. However, knowledge on processes of carbon sequestration and nutrient cycling in mountain rangeland soils are limited due to their long-lasting management history (centuries to millennia) and the virtual omnipresence of human beings. In the Eastern Cordilleras of the Peruvian Andes (4500 m a.s.l.) sites were identified, which are only accessible with mountaineering equipment. These pristine sites were compared to rangeland which was managed extensively in the traditional way since several millennia. Using the paired plot approach, the following hypotheses were tested:

1. Vegetation and soil development was markedly changed by millennia of grazing;
2. Soil organic carbon (SOC) stocks declined due to biomass removal by grazing;
3. Biogeochemical cycling of C, N and P will be reduced in rangelands and microbial indices will show signs of nutrient and C depletion.

It is hypothesised that natural vegetation in the high Andes would be forest, hosting Polylepis sp., instead of the puna grassland, which is widespread nowadays. On forest and gap plots, species number of vascular plants (herbs and grasses) was between five and ten per square, whereas rangeland plots hosted 30 to 40 plant species. The vegetation differed markedly: forest gaps were dominated by tall bunchgrasses (30 cm) and the soil cover was dense in forest and forest gaps. On the rangeland vegetation was only 3 cm tall and 20% of soil was bare. Pristine soils were classified as Leptic Phaeozeme (Sodic, Laxic), rangeland soils were classified as Leptic Umbrisol (Hyperdystric, Laxic). Cation depletion, finer texture, higher proportions of pedogenic Al and Fe oxides and a trend for higher soil mass indicated advanced soil development of the rangeland soils. Higher weathering may be explained by feedbacks between microclimate (less buffering of extremes) and soil (intense warming of the dark soil). High abundance of pedogenic oxides, especially Al, caused complexation of Al and SOC. Moreover, iron-aluminum-phosphates caused P accumulation in rangeland soils. Although stocks of C, N and P were higher in rangeland soils, indices showed severely hampered microbial cycling. Overall, our study showed that inaccessible sites in mountain regions offer the opportunity to study pristine ecosystems without human influence (besides atmospheric matter fluxes). Human activity (grazing management) induced vegetation change, which triggered the above mentioned processes. Using inaccessible sites as references untouched by humans will enhance our knowledge about anthropogenic effects on ecosystems and may serve as valuable addition to paleo-environmental methods.

Carbon burial in soil sediments from Holocene agricultural erosion, Central Europe

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Natural and human-induced erosion supplies high amounts of soil organic carbon (OC) to terrestrial drainage networks. Yet OC fluxes in rivers were considered in global budgets only recently. Modern estimates of annual carbon burial in inland river sediments of 0.6 Gt C, or 22% of C transferred from terrestrial ecosystems to river channels, consider only lakes and reservoirs and disregard any long-term carbon burial in hillslope or floodplain sediments. Here we present the first assessment of sediment-bound OC storage in central Europe from a synthesis of ~1,500 Holocene hillslope and floodplain sedimentary archives. We show that sediment storage increases with drainage-basin size due to more extensive floodplains in larger river basins. However, hillslopes retain hitherto unrecognised high amounts of eroded soils such that average agricultural erosion rates during the Holocene would have been at least twice as high as reported previously. This anthropogenic hillslope sediment storage exceeds floodplain storage in drainage basins <105 km2, challenging the notion that floodplains are the dominant

sedimentary sinks. In terms of carbon burial, OC concentrations in floodplains exceed those on hillslopes, and net OC accumulation rates in floodplains (0.7 ± 0.2 g C m-2a-1) surpass those on hillslopes (0.4 ± 0.1 g C m-2a-1) over the last 7,500 years. We conclude that carbon burial in floodplains and on hillslopes in Central Europe exceed terrestrial carbon storage in lakes and reservoirs by at least two orders of magnitude, and should thus be integrated in continental carbon budgets.

Patterns of land use in sedentary societies - LBK vs. 1800 AD

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The goal of the archeaological RhineLUCIFS sub-project, funded by the German Research Foundation (DFG), is to model land use systems in prehistoric and premodern times. It is part of the international LUCIFS-research framework, an interdisciplinary cooperation of projects concerning the influence of land use and climate on fluvial systems. Within the scope of the project, a model for land-use systems was developed, drawing on demographic (see poster proposal " Upscaling Population Densities"), archaeozoological and - botanical data as well as ethnographic figures. On one hand, human demand was balanced with the supply of nutrients by plants and animals. On the other hand, agricultural areas were simulated using GIS methods. On the basis of assumptions about food habits, the model reconstructs the size of fields and meadows as well as the stocking rate for different time horizons from ~5.300 BC (Bandkeramik) to 1830 AD (Preindustrial Modern Times). Band widths of demand and production volumes were determined considering regionally differing conditions. Periods under consideration vary greatly regarding their economic and social organisation. This allows diachronic analyses of time immanent patterns as well as general economic trends. The model discloses not yet fully exploited possibilities of visualisation and comparative analysis.

Upscaling Population Densities of hunter gatherers and sedentary societies - Methods and Results

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The work group, consisting of members from the archaeological part of the RhineLUCIFS-project (DFG) and the Joint Research Project "Our Way to Europe" (SFB 806), developed a hierarchical model to estimate population densities. The methodical framework is based on the controlled transfer of data between different archaeological scale levels, applying a bundle of GIS-methods. Raw material catchments form the base of calculations for hunter gatherers. For sedentary societies, data from key areas concerning the number of houses or necropolises are used on the lowest levels of the model. After statistical analysis of the site density, settlement areas are identified and visualised by isolines, based on the distances between sites. The mean figures of number of persons from lower levels are transferred into these areas. In a final step, population density regarding local and global scales is calculated. The method proved to be reliable, within limited error margins, and can be drawn upon to weight factors of source criticism. The results are helping to integrate processes of cultural history into interpretation and are used for analysis of land use patterns (see abstract 'Patterns of land use in sedentary societies - LBK vs. 1800 AD'). Diachronic and regional comparisons reveal population dynamics, that corroborate Gordon Childes concept of nonlinear development, at least in Central Europe.

Quantifying long-term anthropogenic sediment fluxes in a mountainous watershed (250 sqkm) based on GIS modeling of available soil data (1:50,000)

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In the upland-and-basin settings in Germany, millennial-scale cultivation activities involved soil erosion and colluviation of hillsides and alluvial aggradation on valley floors. On the whole, this resulted in a substantial change of once natural soilscape stratigraphies and pattern and meso-scale surface topography. A sediment-budget serves to highlight long-term sediment system working under the influence of human activities in order to compare the relative agency of human versus natural controls in a typical mountain setting. Quantities of input, storage, and output terms of interlinked hillslope, hillslope hollow and valley floor system components are calculated by comparing the pedostratigraphy of the present-day soilscape against an assumed initial condition prior to human disturbance (pristine soilscape model). For practical reasons, to construct a sediment budget for a 250 sqkm mountain watershed (Odenwald Mountains, SW Germany), a GIS data modeling approach was chosen that uses available digital soil data scaled 1:50000 to avoid conducting another extensive field survey. When referenced to a systems-based watershed concept, however, a pilot study revealed basic inconsistencies of the primary soil data. Meaningful sediment budgets for anthropogenic soilscape change only could be approximated when re-interpreting the given data by rigidly applying expert knowledge of the field situation. Applying this procedure to the Odenwald Mts. watershed revealed another major setback that relates to spatially inhomogeneous standards of soil information accuracy when working at larger spatial scales. Therefore, we employed an alternative data modeling approach that refers to the classic soil forming factors concepts and catena principle. We used a blend of automatic topographic landform classifications, land-use data, and near-subsurface geologies that can be related to catenary sequences as derived from field reconnaissance campaigns. This approach yields consistent sediment budgets for subwatersheds; the derived estimates of anthropogenic sediment flux lie in the expected range of values. The results highlight the functioning of different landscape units by highlighting whether these act predominantly as producers, storages or conveyors within the defined human-natural system. The results stress the distinct nature of particulate matter cycling in and its effects on the surveyed coupled human-natural system. This includes insights into the relative importance of socio-agricultural versus topographic controls in different basinal to more sloping upland environmental settings stresses the importance of social-agricultural controls have for irreversible and ongoing human-induced changes to the soil resource. The increasing availability of quantitative field data opens new perspectives on further developing soil erosion modeling toward predicting mid- and long-term effects of human-caused changes to the soil resource.

Anthropogenic impact on alluvial sedimentation rates during the last millennia in the Ardennes (Belgium)

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Alluvial deposits of numerous rivers in the Ardennes have been dated by using iron slag content and 14C. On the basis of these analyses, several periods of increased sediment deposition have been identified. Before the first deforestations, rivers in this region developed multiple channels in alluvial forests (anabranching rivers), which are still distinguishable in the topography of many floodplains by means of LIDAR survey. Moreover, during this period, floodplains were not well-developed and probably very humid, which explains the presence of peat layers within the alluvial sequences. In the Amblève catchment, the first increased sedimentary deposition of the Holocene occurred during the Bronze Age, probably in relation to deforestation and first cropland agriculture in the area. Archaeological data indicate Roman occupation in parts of the catchment, and Roman Period colluvium has been found at one site. Several peat layers have been dated in the Lienne catchment to around 1000 BP and probably indicate very low anthropogenic pressure. From the 11th Century onwards, there was an increase in sedimentation, coinciding with a higher concentration of charcoal in alluvial deposits. In many catchments there is an important increase in the sedimentation at the end of the 14th century, which can be related to the development of numerous iron-working sites. Analyses of slag concentration produced in these sites allow us to reconstruct the evolution of the floodplain topography in relation to the periods of blast furnaces activity. Total sedimentation in the smaller valleys since the initiation of iron industries amounts 0.5 to 1.0 m, which is in most cases about 40% of the total sediment present in the floodplains and corresponds to a mean sedimentation rate ranging between 10 and 20 cm/century. Such values are explained by former agricultural practices and woodland clearance associated with the huge demand for charcoal by the iron industry. For instance,

about 20 ha of forest were cleared for the yearly consumption of a refining forge or a blast furnace and more than three hundred iron factories existed in the Ardenne Massif between the 14th and the 19th century.

Pre-historical human impact as recorded in soil profiles in China's Yellow River basin

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The farmlands consisting of accretionary eolian loess-soils are widely distributed over the Yellow River basin, a region where arable cultivation of millet crops was initiated as early as 8000 years ago. Pre-historical human impacts are recorded by various components identifiable in these loess-soil profiles in which chronological framework can be established by using 14C, OSL and archaeological dating methods. Non-dust colluvial components incorporated in loess-soil sequences have preserved evidence of soil erosion and re-deposition. At several sites, enhanced soil erosion and re-deposition in relation to intensified land use are traced back to 4000 a BP. It is attributed to millet cultivation and human settlement from the early Bronze Age onward. This provides new insights into the history of soil erosion and into the evaluation of human-induced accelerated soil erosion against the background of the natural erosion forced by monsoonal climatic fluctuation. Charcoal preserved in loess-soil profiles has recorded fire history and landscape evolution connected with climatic variations and human activities. The intensity of human disturbance by fire and cultivation increased during the last 3100 years. Local fires occurred most frequently between 3100 a BP and 1500 a BP during the major period of land reclamation for cereal cultivation. Pre-historical ruins and cultural layers are often found in the loess-soil profiles along the riverbanks. In the Lajia Ruins (4200-3950 a BP) on the Yellow River bank at the northeast foot of the Tibetan Plateau, grouped skeletons resting on the dwelling floors show a vivid scene of the mortal struggle of human being during major catastrophes. Detailed sedimentological studies in the loess-soil profiles over the ruins indicates that, immediately followed a major earthquake, the settlement was overtaken by immense mudflows coming along the tributary gullies from the hillsides behind. With referring to the causations of the presently occurred catastrophic debris flows and landslides in the region, it is inferred that the soil erosion, mass wasting and accumulation of debris on the hillsides were intensified largely by human disturbance of the landscape by bush clearance in pre-history. During the climate event of 4200–4000 a BP, enhanced human activities and over-exploitation of natural resources increased the vulnerability of the communities to detrimental environmental change and catastrophe. This means that the prehistorical catastrophic mudflows were created partly by the early settlers themselves. These results are of important implications in understanding human impact and the pre-historical environmental change in the environmentally sensitive zones over the world.

Paleoenvironmental record of the Amik Basin (Amuq Plain, Southern Turkey) over the last 4000 years

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Continous human occupation is attested in the Amik Basin since 6000-7000 BC. The low-lying Amuq plain is covered by tell settlements first explored by Robert Braidwood in the 1930s. The Basin also is crossed by The Dead Sea Fault (DSF), a major neotectonic structure in the Middle East extending from the Red Sea in the south to Turkey in the north. The study focuses on the sedimentary record of the Amik Lake occupying the central part of the Basin. Our objective is to constrain major paleo-environmental changes in the area over the last 4000 years and assess possible human impact. The lake has been drained and progressively dried up since the mid-50s so that it is not watered during the summer season and constitutes a unique opportunity to collect sediment records. Sediments were collected at 1 cm to 2 cm intervals in a trench and in cores up to a depth of 5 meters in the clay deposits. A diverse array of complementary methods is applied to study the records: magnetic susceptibility, grain size, organic matter and inorganic carbon (L.O.I), XRD mineralogy, XRF geochemistry, carbon geochemistry. The age of the record is constrained combining radionuclide and radiocarbon dating. The record shows two intense phases of soil erosion with enrichments in Chromium and Nickel. The most recent erosion phase might be linked with enhanced development during the Roman and the growth of the Antioch City. The oldest one would occur around 3000 BC. The record also allows reconstructing past lake level variations and discusses the results in comparison with variations of the Dead Sea.

Estimation of wood use in a Roman Imperial city

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Wood has been humankind's first source of energy and was by far the most important fuel and an important material for construction during classical antiquity. The Roman Imperial city of Sagalassos, situated in the Taurus Mountains in Southwestern Anatolia, Turkey, has known a long history of intense human activity that had a strong impact on the surrounding forests through the harvesting of wood, land conversion and livestock grazing. Current forests in the Taurus Mountains are heavily degraded but the timing and driving forces of past deforestations are under debate. In order to better understand the effect of wood resources extraction on past deforestation and forest degradation in the territory of ancient Sagalassos, we want to estimate the amount of wood used in and around this Roman Imperial city. For this purpose we are developing a calculation tool estimating the total wood use in a given period, both for energy (e.g. heating, cooking, firing of kilns,…) and non-energy purposes (e.g. construction, carpentry, …). This tool will be made available for archaeologists who can run it in their specific research regions and periods, based on included default values or using specific values derived from their research (e.g. population size, wall thickness of houses, temperature of baths, presence of kilns, …). Based on thermodynamic laws, calorific values and efficiency rates, an estimation is provided of the amount of wood used within one year. Later on, the tool can also be expanded for application in other historic settlements. Because quantitative information on ancient population, architecture, technology and lifestyle is rather scarce and uncertain, input values will consist of ranges. In order to take this uncertainty and variability into account, a Monte Carlo procedure will be included, offering a range of possible outcomes and probabilities. The results of this tool for different periods in history can then be used as input in forest succession models providing insight in the long-term availability of wood for the ancient society of Sagalassos and the sustainability of their natural resources use. In this contribution we present the blueprint for such a calculation tool, and illustrate its functioning and possible outcome with a preliminary submodule for ancient pottery production.

What role for humans in global land cover change over the Holocene? Insights from models and data

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Did humans affect global climate over the before the Industrial Era? While this question is hotly debated, the co-evolution of humans and the natural environment over the last 11,700 years had an undisputed role in influencing the development and present state of terrestrial ecosystems, many of which are highly valued today as economic, cultural, and ecological resources. Yet we still have a very incomplete picture of human-environment interactions over the Holocene, both spatially and temporally. In order to address this problem, we combined a global dynamic vegetation model with a new model of preindustrial anthropogenic land cover change. We drive this integrated model a new synthesis of demographic, technological, and economic development over preindustrial time, and a database of historical urbanization covering the last 8000 years. We simulate land cover and human land use change from 11,700 years before present to AD 1850. Our model results show that climate and tectonics controlled global land cover in the early Holocene. Shifts in forest biomes on the northern continents show an expansion of temperate tree types far to the north of their present day limits. By the early Iron Age (1000 BC), humans in Europe, East Asia, and Mesoamerica had a larger influence than natural processes on the landscape. Anthropogenic deforestation was widespread with most areas of temperate Europe and southwest Asia, east-central China, northern India, and Mesoamerica occupied by a matrix of natural vegetation, cropland and pastures. While we simulate fluctuations in human impact on the landscape, including periods of widespread land abandonment, e.g., during the Migration Period in Europe that following the end of the Western Roman Empire, approaching the Industrial Revolution nearly all of the landmasses of Europe and south and East Asia are dominated by anthropogenic activities. In contrast, the collapse of the aboriginal populations of the Americas following 15th century European contact leads to a period of ecosystem recovery. Our results highlight the importance of the long histories of both climate change and human demographic, economic, and technological history on the development of continental-scale landscapes. We emphasize the need for improved datasets that use archaeological data synthesis and build on recent theory of preindustrial economic and technological change. A large source of uncertainty in our results comes from assumptions we make about the rates and timing of technologically driven intensification of land use, and the importance of international trade for the subsistence of preindustrial societies.

Human-environment interaction in a small intramontane valley. Research from the Sagalassos Archaeological Research Project at Bereket (southwest Turkey)

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The Bereket Valley (territory of ancient Sagalassos, southwest Turkey) has been studied by palynologists, archaeologists and geomorphologists which makes it one of the best researched valleys in the region. The results from these disciplines have provided us with a good understanding of the evolution of human habitation, the local vegetation, geomorphological processes and the interplay between these. Pollen cores from the Bereket valley show that the so-called Beyşehir Occupation Phase, a period characterised by an increase in the amount and variety of indicators for crop cultivation and attested in large tracts of Turkey and Greece, ends somewhere in the first half of the fourth century. Horticulture ends and crop cultivation is largely substituted by pastoralism. This shift occurs at a time when climatic conditions become more ideal for these activities. A somewhat similar decrease in crop cultivation is also observed in Gravgaz marsh. In both valleys, this shift occurs about 300 years earlier than in the rest of the territory of Sagalassos. The pottery collected in the intensive archaeological survey shows undiminished numbers of collected pottery suggesting that human activity continued without significant changes in habitation density. However, also in the fourth century AD, a marked change is visible in the proportion of imported tablewares. Whereas before the fourth century AD the fine tableware was almost exclusively produced at the Potters' Quarter of Sagalassos, after that time other production centres become the dominant suppliers and the Sagalassos pottery almost completely disappears in the Bereket valley. These changes reflect the shift human exploitation of the environment, as well as the changed position of the peripheral valley of Bereket in interregional interaction patterns and towards the regional centre of Sagalassos. Although the reasons for and causality of these changes cannot be determined on the basis of survey pottery alone, the results show how worthwhile integrated multidisciplinary research can be for the understanding of human-environment interactions.

Land use, environmental and societal change in the Northern European Neolithic: On the comparability of palaeo-ecological, climatological and archaeological records

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Main goal of the DFG-Priority Program “Early Monumentality and Social Differentiation 4100-2500 BCE” is an interdisciplinary reconstruction of Neolithic human-environment interactions for Funnel Beaker societies. How many people lived in how big social unites during Early to Late Neolithic? How productive was the economy? Which social and technological changes influenced the human-environmental interaction? How influential were climatic alterations on economies, social organization and cultural developments? For Central and Northern European Funnel Beaker societies, results on land use, environmental and societal change are presented, starting for each data-set from its distinct temporal and spatial resolution. Data from settlement archaeology and material culture studies enable quantitative estimations about site formation, dispersion and agglomeration of settlement systems, and the scale of production and consumption within Neolithic societies. Palaeo-ecological and climatological studies record increasing and decreasing landscape openness, related to a shift in agricultural techniques and social development of FBC societies. Demographical dynamics are reconstructed. As exemplified result in many of the proxies, the time between 4300-2500 cal. BC could be identified as interplay of huge changes in society, land use and environmental conditions. But, it is the fact that not every alteration is recorded in each record that accounts for the need of data integration to create profound implications for the development during the 4th and 3th millennium BC. Thus, the interpretation of society, economy and environmental changes is linked to the need, to combine these different records on the base of a profound socio-environmental theoretical approach.

How to quantify human-environment interactions in the past: A global historical land use data set for the Holocene

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Land use plays an important role in the climate system. Many ecosystem processes are directly or indirectly climate driven, and together with human driven land use changes, they determine how the land surface will evolve through time. To assess the effects of land cover changes on the climate system, models are required which are capable of simulating interactions between the involved components of the Earth system. Since driving forces for global environmental change differ among regions, a geographically (spatially) explicit modeling approach is called for, so that it can be incorporated in global and regional (climate and/or biophysical) change models in order to enhance our understanding of the underlying processes and thus improving future projections. Here I present a tool for long term global change studies; it is an update (v 3.1) of the History Database of the Global Environment (HYDE) with estimates of some of the underlying demographic and agricultural driving factors (Klein Goldewijk et al., 2010; Klein Goldewijk et al., 2011). It is also an attempt to link the socio-economic history of the planet to the environmental history of the planet, and the co-evolution of both is the focus of increasing amounts of research. Some researchers suggest that mankind has shifted from living in the Holocene (~emergence of agriculture) into the Anthropocene (~humans capable of changing the Earth' atmosphere) since the start of the Industrial Revolution. But in the light of the sheer size and magnitude of some historical land use changes some believe that this point might have occurred earlier in time. There are still many uncertainties and gaps in our knowledge about the importance of land use (change) in the global biogeochemical cycle, and it is crucial that researchers from other disciplines are involved in decreasing the uncertainties. Integrated records of the co-evolving human-environment system over millennia are needed to provide a basis for a deeper understanding of the present and for forecasting the future. This requires the major task of assembling and integrating regional and global historical, archaeological, and paleo-environmental records. Humans cannot predict the future. But, if we can adequately understand the past, we can use that understanding to influence our decisions and to create a better, more sustainable and desirable future. Examples will be given of uncertainties and improvements of the HYDE 3.1 data base (Klein Goldewijk & Verburg, 2013) and reflections will be given on possible future developments.

Most important references:

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Closed depressions in the Prehistoric landscape of loess area and their influence on settlement location a case study from E Poland

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Closed depressions are a characteristic element of the loess plateau landscape. Current theories assume a post-glacial origin of the closed depressions in the Polish loess areas associated with development of suffosive processes, occurring within initial depressions in the loess cover. The study was performed in the Nałęczów Plateau, geomorphological mesoregion in East Poland. The study was aimed at the identification of the functions of closed depressions in the prehistoric landscape of this region and the impact of these features on settlement in that period. During the study an inventory in GIS of closed depressions and archaeological sites on the basis of 1: 10 000 topographic maps and a field study in selected closed depressions were performed. Analysed forms are mostly oval shape. The object with a diameter of 25-50 m predominate (53%). The closed depressions are mainly shallow forms, whose depth does not exceed 1,2 m. The occurrence of closed depressions on the Nałęczów Plateau is mainly associated with the loess plateau areas, where 72% of the landforms are found. In modern agricultural landscape these landforms, during spring snowmelt or prolonged rainfall, are filled with water that may stagnate for many weeks. In the primary Eo- and Mezoholocene forest landscape of the Nałęczów Plateau, the closed depressions were waterless landforms. During the Neolithic, their function in the landscape changed; they periodically retained water. This phenomenon was triggered by the changes in the water relations induced by the first Neolithic farming practices and deforestation introduced in order to acquire cropland. The periodically water-filled closed depressions became a permanent element of the Neolithic

culture landscape of the Nałęczów Plateau; some of them determined settlement in the Neolithic and subsequent periods. This is evidenced by the spatial analysis of patterns of distribution of archaeological sites and closed depressions on the Nałęczów Plateau and by comprehensive investigations of sites in the vicinity of the selected closed depressions. Prehistoric sites (77.3%) predominated by settlements (57%) are mostly found near the closed depressions, some of them were particularly popular with settlers of the Nałęczów Plateau, who returned to the area during subsequent settlement phases. The importance of closed depressions for settlement was related to the availability of water that they periodically retained. The development of settlement and agriculture progressing in the modern period, has contributed to intensification of the soil denudation processes; accumulation of series of deluvial deposits in the depressions has led to significant shallowing or complete burying of the forms studied. Consequently, this has limited the role of closed depressions in periodic surface water retention.

Neolithic vegetation and settlement history from north-western Germany

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Within the framework of the DFG Priority Program “Early Monumentality and social Differentiation” Neolithic pollen spectra from several peat profiles were analysed to investigate the impacts the first settlers in northwestern Germany had on the landscape. The profiles were recovered in larger bog complexes to reflect regional vegetation changes in different parts of the study area. Thus, it is possible to get an overall picture of the chronology and degree of vegetation changes during the time of the Funnel Beaker and Single Grave Culture in the area. Based on the analyses obtained so far, regional differences are visible between the most western part of the study area in the Emsland and the sites between the rivers Weser and Elbe in the eastern part. While a clear elm decline as possible indicator for first Neolithic activities is only visible in the Elbe-Weser triangle, elm percentages are decreasing gradual in the Emsland (with general low percentages of elm) after 4250 cal BC. This might be attributed rather to changing climatic conditions as human impact on the vegetation is low in that area. However, the onset of the Funnel Beaker Culture after 3500 cal BC is clearly documented in the pollen spectra with woodland clearings and strong increase of settlement indicators that indicate wood pasture and arable farming. Meanwhile, signs for woodland openings and settlement activities did not appear before 3300 cal BC in areas east to the river Weser. Whether this different chronological development has to be seen as local phenomenon, will be discussed in connection with new results from ongoing archaeological investigations in the area.

Comparing past quantitative land-cover estimates and data on human impact provide novel insights into human-landscape interactions

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In the face of climate change and intensive anthropogenic impact it is important to understand the long-term interactions of climate and human activity with ecosystems, to be able to make future estimates. Vegetation as a key for uncovering past ecosystem changes does not come easy from paleo data, interpretation of which is always difficult. Recent development in pollen analysis provides spatially explicit quantifications of land cover, which allow direct integrations in climate models and comparisons with human settlement density and activities. In this paper we present up to date possibilities and developments in pollen-based quantitative landscape reconstructions. We illustrate their use at different spatial scales. At the continental scale of Northern Europe the LANDCLIM project aims to collect available pollen chronologies and apply them to grid-based quantitative land-cover reconstructions. Previous testing of these reconstructions showed the robustness of such methods and their ability to be incorporated with past climate models. Results of past land-cover reconstructions over Northern Europe perform well when estimating open landscape and are close to other model predictions. Deforestation has found to be essential for interpreting differences in climate parameters (e.g. higher temperatures in summer). In the LONGWOOD project we aim to integrate past vegetation and data on human habitation intensity at more local scale. As an example we show a locality in northern outcrops of Pannonian Basin, where we reconstruct the Holocene vegetation based on pollen and human habitation derived from archaeological data 25 km around the site. In 500 year time intervals we reconstruct ratio of forest and open land including vegetation changes in major tree taxa. Interestingly, ratio of open land does not change dramatically throughout the major part of the Holocene, but is considerably high. Increases in oak representation follow increases in human occupancy suggesting that oak might be dependent on management. The most intense phases of deforestation correlate with the introduction of large cereal cultivation only in the Roman and High Medieval Periods. We compare and relate the vegetation changes with independent Macrophysical Climate Model specific for the studied site. Pollen-based quantitative land-cover

reconstruction has the potential to provide finer scale estimates comparable with detailed historical data. Results can be used for interpreting stand scale changes related to e.g. extent of field cultivation or intensity of local management. We emphasize that multidisciplinary studies on past land-cover are essential for explaining past changes, and have significance for future predictions.

Areas of abandoned agriculture - landscape, geomorphic and sedimentological perspectives (Stołowe Mts case study, SW Poland)

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The Sudety Mts, including the study area of the Stołowe Mts, have been substantially depopulated since the 1880s and especially after the 2nd World War. One of the economic results of the decline of population was the withdrawal of agriculture. The abandonment of the arable lands occurred especially on the most elevated surfaces and on steep slopes. As a result, the forest-arable land boundary has been lowered from 10 up to more than 400 m, depending on local factors. The spontaneous secondary vegetation succession of vegetation developed on former ploughing grounds. At present, the old arable grounds are forested or used as meadows or overgrown with a mosaic of various stages of the secondary vegetation succession. However, in spite of the substantial changes of the land use, there is still evidence of former different land use visible in the landscape. Various methods were used in order to assess the persistence of the traces of the old agriculture in the contemporary environment. They included analysis of old cartographic sources with focus on the type of land cover, detailed geomorphic mapping of anthropogenic landforms and sedimentological analysis of slope covers and fluvial sediments. The general increase of the thickness of fine-grained sediments with charcoal particles (anthropogenic colluvium) and other anthropogenic artefacts (i.e. brick's particles) can be observed downslope. However, within the local flattening of slopes, and especially within the agricultural terraces, the amount of accumulated sediments increases substantially. Depending on the lithology and morphological location of the drilling/pit site, the thickness of the sediments accumulated within the slopes ranges from 25 up to 80 cm. Within the floodplains the accumulation of the sandy-silty alluvia can be also correlated with the past soil erosion from slopes. The thickness of anthropogenic alluvia ranges from 30-40 cm within the granite bedrock up to 50-60 cm within the sedimentary bedrock. Besides of the sedimentological record of the past human-induced erosion, the numerous landforms are also the evidence of former agriculture. They include stone walls and piles, which are made of rock debris collected from arable grounds in order to facilitate ploughing. Their height is from 0.5 up to 3.0 m, while the length of some of the largest landforms is over 100 m. Another geomorphic evidence of more intense human activity in the past is the network of field roads, which are now abandoned and usually overgrown with vegetation. Their previous role as routes for sediment transfer from slopes towards the valley floors and river channels is not active any longer. However, they are still recognizable features in the landscape, especially the road gullies, which are 0.4-4.0 m deep. The scarps of the agricultural terraces are also well preserved in the relief – their height is 0.5-1.5 m.

Peat cores as archives of environment-humans interactions in the past

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Peatlands are very interesting environmental archives because they offer the possibility to combine different proxies: biological, mineralogical and geochemical. In Toulouse, we explore the use of peat records at different scales of time and space: from the local (i.e. Pyrenean valleys) to the global, from the recent (last 200 years) to the entire Holocene. We are grouped together in an informal team named PEAT (Past Environmental Archives Toulouse) and regrouping researchers from 4 labs. We use peat but also other archives such as lake sediments to decipher the interactions between climate, man and his environment. We will illustrate three example of our research:

1. the example of the long metallurgical history of the Vicdessos Valley in the Pyrenees which has greatly impacted the landscape since the Bronze Age like in many mountain locations in Europe,
2. the human impact on the global mercury cycle traced through bogs and mercury isotopes ,
3. the interactions between climate and environment - man in Tierra del Fuego during the Holocene.

Holocene landscape and land-use change under human impact. Examples from Central Europe and Central Asia

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Natural Holocene processes on land surfaces in Central Europe are comparing with those of the Pleistocene relatively weak due to the vegetation cover. In Central Europe the Holocene processes are characterized by (1) soil development, (2) low-moor peat growth in the vicinity of river systems and high-moor peat in regions with higher amount of precipitation and (3) moderate fluvial erosion and accumulation especially in the floodplains. Human impacts on landscapes and soils take place since the Neolithic due to agriculture practice. This induces soil erosion resulting in the accumulation of colluvial deposits, especially in the fertile loess regions. In addition, the accumulation of floodplain deposits increase. In the lower Rhine Embayment as in other parts four main periods of colluvial deposits (Neolithic, Metal Ages, Roman time, Mediaeval time) and four main periods of alluvial and overbank deposits in the floodplains (Early Holocene, Neolithic to Roman time, Mediaeval, Early Modern time) can be divided. In the woodlands strong deforestation took place especially due to the production of charcoal and firewood as well as grazing activities. The development of mining and related industries in the 15th to 16th centuries and further increase in 19th century produces a strong contamination of floodplain deposits. In addition, different periods of the increase of grassland since medieval time cause by socio-economic effects resulting in a reduction of soil erosion can be distinguished. In contrast, in grasslands of Central Asia the changing of the landscape into pastures had a strong influence on vegetation and soil cover. The impact also induces strong soil erosion, which and was enhanced during periods of climate change. Against the background of an immemorial grazing history, Tibet and Mongolia must be seen as a cultural landscape. Geomorphological and palynological research in grasslands of the Russian Altai, Mongolia and Tibet shows an early starting nomadic Anthropocene about 6,000 to 3,000 years ago.

Booms and bust in the European Neolithic: population dynamics or palaeoclimate pacing?

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The expansion of agriculture across the European continent 9000-5000 years ago was not a smooth wave of advantaged farmers from the Near East driving out the resident Mesolithic hunters and gatherers. This expansion was irregular and complex, both in the interaction between people, their environments and climate, as well as in the archaeological record itself. Farming arrived in stages, with noteable stagnation periods in the expansion, which can be explained by abrupt climate change events found in the palaeoclimate records. The transition from a hunting and gathering lifestyle to agriculture occured mostly within a few centuries, but in several regions of Europe, this transition lasted only decades, in others millennia, with long coexistance of the two subsistence styles in several regions of Europe. The chronological density of sites shows boom and bust cycles, which for many regions of Europe show an initial agriculturalization boom and a millennia-long decline of site density during the Neolithic. Are these frequencies a mere artifact of the radiocarbon calibration curve or do they resemble people's reactions to their changing environmental and cultural context? In the Global Land Use and technological Evolution Simulator (GLUES), I confront archaeological and palaeoenvironmental records with a null model of no influence of climates on people: what was the potential population size of Europe, and the distribution of population within Europe before, during, and after the transition to agriculture? Were continent-wide or rather regional climate anomalies triggers for the shift in subsistence, or is a simpler model of no influence of climate more powerful in explaining the Neolithic? What spatial pattern within the continent emerges for potential population, and how does this relate to the density of calibrated radiocarbon date distributions, and to the regional palaeoclimate variabilty reconstructed from different palaeoproxies?

Alluvial sedimentation rates since the Mid-Holocene along the Yamé river (Mali): towards a quantification of alluvial sedimentation changes in a soudano-sahelian fluvial system in West Africa

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In West Africa, studies on fluvial system evolution are rare and were mainly conducted to underline the role of climatic change as single driver. This presentation aims to propose a synthesis of fluvial changes of the Yamé River (Mali) during Middle and Late Holocene. Because of its exceptional preservation including plants and archaeological remains, the Yamé valley deposits permit a high resolution of environmental and human dynamics reconstruction, especially for the last 2 500 years BP onwards) which is, until now, not well documented in West Africa. This study focuses on the whole fluvial system from the upstream sandstone plateau to the downstream Inner Niger Delta. Outcrops profiles and cores, correlated to eight cross sections along the 130 km of the Yamé valley and combined with sedimentological analyses were investigated to appreciate the general pattern of alluvial dynamics and to develop a quantification of alluvial sedimentation rate from upstream to downstream. The comparison of these results with regional and local archaeological and palaeoenvironmental data permits to identify the respective parts of the climatic and anthropogenic variables during the Holocene and within the catchment area. The results highlight a contrasted response of the fluvial system to regional controls such as climatic oscillations and the general increasing impact of societies since the Neolithic. However, natural and human local variables were also identified. Then, the diversity of geological settings and geomorphological inheritance of the Yamé catchment are relevant in determining water discharge and sediment supply. Furthermore, from 3 000 years, the increase of agricultural practices, the emergence of iron metallurgy and more recently the demographic pressure are relevant in determining Yamé fluvial system changes and colluvial development.

Soil fertility, settlement patterns and human height in early medieval Germany

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Were people living in pre-modern times in regions with a higher potential produce of soil healthier and taller, enjoying a higher "biological standard of living" than the inhabitants of areas less suitable for agriculture? Settlement patterns are likely determined by the suitability of soil and natural vegetation to the agricultural techniques of the settlers. For Alamanni tribes in south western Germany, the superior quality of the soil near the earliest settlements has been described by Wacker (1976/78). Using a standard of measurement employed by modern-day German fiscal authorities he claims that the first wave of settlers occupied the most fertile available land not covered by forests in most regions. Other settlements in early medieval times seem to have been places strategically near vital infrastructure such as roman roads or important fords. Koepke and Baten (2008) show that cattle farming, as documented by a larger share of cattle bones among the animal bones in the archaeological record of a region is correlated with the people living there attaining greater heights. The prevalence of dairy farming meant that milk was readily accessible even for poorer people in regions where people herded cattle. Better nourishment for children meant that they had a better chance to grow up to their genetic potential. For more recent times, the anthropometric literature describes differences in average human height between populations from rural areas and cities, especially during early industrialization and before modern sanitation and medicine, and transportation and refrigeration made cities more healthy places to live. Human heights for earlier times are mostly derived from the length of long bones and are used together with other skeletal indicators of health and morbidity while recent data mostly stems from military sources are sometimes also informative about other aspects of health. In addition to data published archaeological evidence from grave fields dating back to the 5th to 8th century, I re-examine the written anthropometric records for the eighteenth and nineteenth century from the same region with a focus on soil quality as a potential determinant of the well-being of populations relying on locally produced foodstuffs. The data on the fertility of the soil itself will be supplemented with established indicators of specific agricultural techniques such as proximity to protein production.

Spatial distribution of archaeological monuments on landforms of modern land surface, key region: Lazio, Italy

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If humans systematically selected one landform type for a given type of land use, it implies that in this landform type environmental conditions were useful for the given type of land use during the given time frames. Based on this hypothesis, a method for the assessment of terrain usefulness for inhabitants was developed. The method consists in correct comparison of the occurrence frequency (FO) of landforms in an archaeological database relatively to the whole terrain. If sampling points are randomly distributed on the land surface the FO of landforms in such database should coincide with the natural background for a given terrain. Any selection of sampling points impacts on the FO of landforms in database. For the case of archaeology, such selections were made by ancient people. The goal of the investigation was to develop a methodology for assessment of usefulness of landforms for different types of former land use. Three types of archaeological monuments as indicators of former land use were considered: fortifications of Medieval - Modern times (50 objects); farms of Roman times (86 objects); settlements of Roman, Medieval, and Modern times (53 objects). Troeh's classification based on signs of horizontal (kh) and vertical (kv) curvatures was used for the identification of landforms on digital elevation models (DEM) with grid spacing: 120, m; 240, m; 480, m; 960, m. Four types of Troeh's land forms occupy 100 % of terrain. However, natural FO of each landform type does not equal 25 % and this impacts on the distribution of landforms in the data base of sampling points. For the correct and quantitative description of the intensity of selection of a given landform type, the Priority Level (PL) was calculated. PL shows how frequently a given landform type occurs in a sampling database relatively to the whole DEM. The first step for calculation of PL is determination of deviations of FO of landforms on DEM from equal probability (1). The second step is correction of FO of landforms in DEM and database of sampling points with following calculation of the final ratio (2).

(1) 25 – FODEM = x;
(2) (FODB+x)/(FODEM+x) = PL,
where:
FODEM, % FO of a given landform type in DEM
FODB, % FO of a given landform type in a sampling database
x, % Deviation of FO of a given landform type in DEM from 25, %

The highest PL of landforms (kh+, kv+) was detected at low grid spacing for fortifications. Landforms (kh+, kv-) at large grid spacing showed the highest PL for settlements. Landforms (kh+, kv-) showed the highest PL for farms, however this PL was relatively stable for different grid spacing of the DEM. Landforms (kh-, kv+) were systematically ignored as a place for all kinds of monuments. Variation of PL on different grid spacing is the result of „dissolving" of smaller landforms in larger ones. Probably, the highest PL indicates the grid spacing close to the spatial scale at which humans perceived landscapes for given types of activity.

Past land use changes and their effects on carbon pools and coastal ecosystems along the Swedish Baltic coast

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Environmental problems related to human-induced eutrophication and anoxic bottom waters are of prime concern in today's Baltic Sea, and the focus of the project "Managing Multiple Stressors in the Baltic Sea". Studies have indicated that past land use changes may have contributed to the occurrence of hypoxia through their effects on nutrient and carbon cycles and sediment transport (Zillén et al 2008, Earth-Science Reviews; Zillén and Conley 2010, Biogeosciences). However, to determine and evaluate this relationship quantification of past land use change and its effect on terrestrial nutrient and carbon cycles is required. Vegetation composition and land use on a regional scale is reflected in subfossil pollen assemblages from large lakes, but to convert pollen percentages to quantitative estimates of past vegetation, it is necessary to consider differences between plant species in terms of pollen productivity and dispersal. This can be done using the REVEALS model (Sugita 2007, Holocene). Once past land use is estimated, it can be incorporated into the dynamic vegetation model LPJ-GUESS (Smith et al. 2001, Global Ecol. Biogeography) to simulate the terrestrial vegetation dynamics and associated carbon pools. This allows us to quantitatively assess the impact of land use on terrestrial carbon pools and to estimate the changes of dissolved organic carbon input into aquatic systems. Focussing on four catchment areas along the Swedish east coast, we present pollen based quantitative landscape reconstructions and associated carbon pool dynamics for the last 2000 years, and attempt to relate them to known periods of hypoxia in the Baltic Sea, and to past changes in coastal ecosystems, as reflected in marine palaeoproxies (biological,

geochemical and physical) which have been studied in sediment cores collected near the Swedish east coast. However, when linking land and sea in a long term perspective, multiple other factors, such as long term climate and sea level changes must also be taken into account. The timing and extent of human impact on the landscape differs widely between the focus areas, being earlier and stronger in the south. In some areas, there is a sign of decreased impact and increased forest cover during the late medieval crisis, which affects the modelled carbon pools and may be related to a period of improved oxygen conditions, while changes in other areas are more subtle.

Non-linearities in Holocene floodplain sediment storage

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Floodplain sediment storage is an important part of the sediment cascade model, buffering sediment delivery between hillslopes and oceans, which is hitherto not fully quantified in contrast to other global sediment budget components. Quantification and dating of floodplain sediment storage is data and financially demanding, limiting contemporary estimates for larger spatial units to simple linear extrapolations from a number of smaller catchments. In this poster we will present non-linearities in both space and time for floodplain sediment budgets in three different catchments. Holocene floodplain sediments of the Dijle catchment in the Belgian loess region, show a clear distinction between morphological stages: early Holocene peat accumulation, followed by mineral floodplain aggradation from the start of the agricultural period on. Contrary to previous assumptions, detailed dating of this morphological change at different sites shows an important non-linearity in geomorphologic changes of the floodplain, both between and within cross sections. A second example comes from the Pre-Alpine French Valdaine region, where non-linearities and complex system behavior exists between (temporal) patterns of soil erosion and floodplain sediment deposition. In this region Holocene floodplain deposition is characterized by different cut-and-fill phases. The quantification of these different phases shows a complicated image of increasing and decreasing floodplain sediment storage, which hampers the idea of increasing sediment accumulation over time. Although fill stages may correspond with large quantities of deposited sediment and traditionally calculated sedimentation rates for such stages are high, they do not necessary correspond with a long-term net increase in floodplain deposition. A third example is based on the floodplain sediment storage in the Amblève catchment, located in the Belgian Ardennes uplands. Detailed floodplain sediment quantification for this catchments shows that a strong multifractality is present in the scaling relationship between sediment storage and catchment area, depending on geomorphic landscape properties. Extrapolation of data from one spatial scale to another inevitably leads to large errors: when only the data of the upper floodplains are considered, a regression analysis results in an overestimation of total floodplain deposition for the entire catchment of circa 115%. This example demonstrates multifractality and related non-linearity in scaling relationships, which influences extrapolations beyond the initial range of measurements. These different examples indicate how traditional extrapolation techniques and assumptions in sediment budget studies can be challenged by field data, further complicating our understanding of these systems. Although simplifications are often necessary when working on large spatial scale, such non-linearities may form challenges for a better understanding of system behavior.

Holocene fluvial dynamics and sediment budget of the River Dijle

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Sediment budgets quantify sediment fluxes (typically erosion and deposition) for a given time period and region. They allow a quantifiable and objective comparison of these different fluxes and the different driving forces. In many cases, however, field data on which the sediment budget relies do not allow to distinguish between the different driving forces. Modeling of the sediment fluxes may provide additional understanding of the different fluxes and their driving forces. Here we present a sediment budget of the Belgian Dijle catchment (760 km²) for the Holocene Period, based on both a modeling and a field study. For the sediment budget, Holocene soil erosion is calculated based on the soil profile truncation method. The depth of soil horizons for 809 hand augerings is compared with the depths of these soil horizons for undisturbed soil profiles, from which the total Holocene erosion and colluviation is calculated. These data are extrapolated to the entire catchment using topographic classes. Time differentiation is based on calculated (relative) sedimentation rates of 4 colluvial and 12 alluvial sites. Average relative sedimentation rates are calculated for different deposition types. The final sediment budget was calculated for three

time periods: 9000-2000 BC, 2000 BC-1000 AD, 1000 AD-2000 AD. Results show an increase in soil erosion and sediment deposition (especially for colluvium) between the first timeframe and the second timeframe. A much more pronounced increase takes place between the second and third timeframe, especially visible for alluvial deposition in the tributaries. This pattern shows a synchronicity with the intensifying human land use. Together with the changing sediment fluxes, also the dynamics of the floodplain change. During the early Holocene floodplains have extensive peat formation and the river exists of a marshy system with diffuse water transport. When local deforestation occur sediment is introduced in the tributaries, resulting in the deposition of clastic sediment. This happens for the first sites around 2000 BC, while in other sites peat formation dominates until ca 1000 AD. Sediment budget data were compared with modeling data. The Watem/Sedem model, a spatially distributed soil erosion and sediment transport model, was calibrated independently. Different scenarios were modeled, representing the variation in land use and climate between ca 5000 BC and 2000 AD. Input data are soil properties, reconstructed land use (based on previous studies) and modeled (daily) climatic data. In addition to the scenario based modeling, also a sensitivity analyses was carried out. Modeling results are in agreement with the results of the field data, showing the increase of soil erosion over time. Moreover, modeling results allow to quantify the influence of land use and climate independently, indicating that since ca 5000 BC, soil erosion has increased with ca 6000 %, while climatologic variations are responsible for an increase in soil erosion of only 9%. The results also allow to understand how land use patterns have a major influence on sediment redistribution, and how the land use related connectivity between hillslopes and floodplains determines the relative importance of colluvial sinks.

Reconstruction of Mayan induced soil erosion during the Pre-Classic and Classic period from world's largest beach ridge plain

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World's largest beach ridge plain in the Usumacinta-Grijalva delta, southern Mexico can be regarded as a highly sensitive recorder of changes in climate and upstream land use since the dawn of Olmec and Maya cultures. Increased sandy sediment supply to the coast during the PreClassic and Classic period (1800 BC - AD 1000) resulted in an exceptionally pronounced progradational sequence of hundreds of sub-parallel beach ridges. It seems likely that periods of human induced soil erosion in the catchment resulted in a larger supply of sandy sediment to the rivers and eventually contributed to the development of a large beach ridge plain. This relationship has been revealed by a high-resolution study of beach ridge formation over the last 4000 years. Along detailed geological sections across the beach ridge plain over 100 sediment cores were taken and over 40 organic debris layers within the sandy deposits were AMS dated to reconstruct a detailed chronology of beach ridge formation. Grain size and heavy mineral analyses in combination with end-member modeling were used to estimate the contribution of the Usumacinta River to the sandy deposits. A digital elevation model reconstructed from Lidar data supported by Ground Penetrating Radar measurements provides a detailed insight into the sedimentary architecture of the beach ridge system. With this study we aim to unravel human-induced variations in sediment supply from climatic driven variability and changes caused by river avulsions and volcanic activity.

Estimating anthropogenic carbon release in north-western Europe during the Holocene – integrating pollen-based land use reconstructions with a dynamic vegetation model

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Early agricultural activities have been suggested to explain the pre-industrial increase of atmospheric CO2 and CH4 concentrations since the mid-Holocene. Several studies have attempted to estimate the effect of past land use on global terrestrial carbon storage, based on spatial estimates of land use intensity primarily inferred indirectly using e.g. historical records, population density and per capita land requirement estimates, soil and climate suitability. However, the estimates on

past human population size and locations incorporate high uncertainty levels, and the actual area of land used per person for agricultural activities is even less known. As a result, the existing global land use datasets show large discrepancies in spatial pattern and intensity of estimates. An alternative, and more direct, approach is to use palaeoecological proxies such as pollen records to quantitatively reconstruct past vegetation including human-induced land cover changes. In this study, a new direct method for quantifying past land use extent has been developed by combining (1) pollen-based quantitative vegetation reconstructions in north-western Europe for five time windows (6k, 3k, 600 and 200 cal. BP, and modern) by applying the REVEALS model and (2) simulated potential natural vegetation using a dynamic vegetation model, LPJ-GUESS. The developed continuous and dynamic land use scheme was applied to estimate the net effect on terrestrial carbon storage using LPJ-GUESS, and compared with results based on the indirect land use datasets HYDE v3.1 and KK10. Sensitivity analyses were performed to separate climate, atmospheric CO2 and land use effects, and to determine the effect of alternative agricultural harvest implementations. All three land use schemes showed a decrease in terrestrial carbon due to anthropogenic land use since at least 4k cal. BP, but the timing and spatial patterns (e.g. Baltic countries, central Europe, southern Scandinavia) of these decreases varied greatly. The impact on terrestrial carbon storage for the newly developed (direct) land use scheme for north-western Europe was found to be substantial, and of the same order as applying the KK10 land use dataset based on indirect methods. The cooling climate was found to be the main driver for carbon storage increase in potential natural vegetation during the mid- and late-Holocene, while atmospheric CO2 became most important only in the industrial era. The carbon storage-enhancing climate and atmospheric CO2 effects were roughly counterbalanced by land use effects since the mid-Holocene. Details in the agricultural harvest implementation were found to have a large impact on the course of terrestrial carbon storage.

Tight feedback between networked infrastructure and the impact of climatic variability at Angkor, Cambodia (14th - 15th centuries C.E.)

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Angkor was the capital to the Khmer kingdom from the middle of the first millennium C.E. to the middle of the second millennium C.E. During that time, the kings of Angkor undertook an infrastructural building program that had no equivalent on Earth, covering an area of nearly 1000 km2 by the end of the 11th century C.E. The water management network achieved an extraordinary scale and level of complexity, comprising massive reservoirs (some up to 16km2 in area), fed by an extensive web of canals and embankments. Regionally, the Khmer kingdom sprawled from the South China Sea in what is now southern Vietnam, to northern Thailand and Laos. By the middle of the 16th century, however, European observers describe Angkor as a ruined city, overrun by the enveloping jungle. Some time between the last dated Angkorian inscription in the early-mid 14th century and the written accounts of European visitors two centuries later, the city of Angkor collapsed, and was abandoned. The demise and eventual abandonment of Angkor was closely coincident a period of weakened summer monsoon rainfall and increased inter-seasonal variability revealed in tropical tree ring indices and numerous other proxy data sources through the tropical Asia-Pacific. Archaeological and palaeo-ecological evidence from Angkor itself indicate that these events had a significant impact on the settlement, particularly its water management system, which may have contributed to a broad agricultural and political collapse. However, no contemporary state-level polity in mainland Southeast Asia endured social upheaval of the same magnitude as apparent at Angkor. I propose that the unique scale and design of Angkor as a massive, low-density settlement, played a significant role in amplifying the effects of climatic variability. In particular, the hyper-coherent network of water management infrastructure, agriculture and residential settlement allowed relatively small impacts to propagate throughout the network, leading to systemic problems that could not be resolved. This model suggests that networked infrastructures can play a significant role in amplifying the effect of systemic change, including climatic change.

Sea ingression dynamics and its interaction with occupation of the Lowlands between AD 300 and 1000

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The Early Middle Ages (ca. 300 - 1000 AD) was a period of severe pan-European economic and demographic change. During this period population declined and human influence on the landscape diminished throughout large parts of Europe (Cheyette 2008). Traditionally archaeologists and historians regard these Early-Medieval developments as the result of cultural processes. However, recent reconstructions show frequent climate fluctuations (Büntgen *et al.* 2011) and dramatic landscape changes in the Netherlands for this period (Vos & Van Heeringen 1997; Stouthamer *et al.* 2011). This suggests that economic and demographic changes might not be induced by cultural processes only, but also by climate and landscape dynamics (e.g. river

flooding, sea ingressions). To determine how and to what extent environmental changes contributed to the Early-Medieval economic and demographic changes, the '*The Dark Ages in an interdisciplinary light*' project was initiated. As part of the project, this contribution shows the landscape dynamics of the Dutch coastal area during the Early Medieval period. In this geomorphological dynamic region, major sea ingressions occurred forming large tidal inlets. Occupation in this region mainly occurred in the supratidal environment, e.g. on dwelling mounds (Vos & Gerrets 2005) and was most likely influenced by these landscape dynamics. Development of the geomorphological elements of these tidal systems (channels, tidal flats and salt marshes) is extensively mapped in a GIS and coupled to a database storing information on age of the tidal system and its individual geomorphological elements. This generates a new integrated overview of the development of tidal systems for every possible time step. Palaeogeographical maps can be derived and the GIS provides the possibility to statistically analyse sea ingression dynamics in the Early Middle Ages and how this differs from other periods of sea level highstand (~last 3000 years). By comparing these maps with archaeological data, possible connections between cultural dynamics and landscape changes can be discovered. At the onset of the Early Middle Ages, first results suggest silting up of former estuaries, both in the western part and the northern part of the Netherlands. Meanwhile, large scale extension of tidal systems at the expense of habitable land occurred in the SW part of the Netherlands (Vos & Van Heeringen 1997). Adversely, at the end of the Early Middle Ages, some large sea ingressions took place in the northern part of the Netherlands (Middelzee, Lauwerszee), while the SW part of the Netherlands mainly silted up (Van der Spek 1995). In a later phase of this research, the extensive dataset allows thorough comparison with archaeological data (e.g. development of dwelling mounds, large scale peat drainage) and comparison between different coastal regions. Besides, it forms a tool for site selection to perform more detailed research (fieldwork and dating) to better pinpoint the relation between geological and archaeological events.

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Prehistoric human impact at high altitudes: forest clearings, land-cover change and pastoralism in a case study from the western italian Alps

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The use of the alpine space in prehistoric times is a relevant topic for archaeologists and paleoecologists. Human presence is testified at several high-altitude sites, where hearths remnants, lithic industries and artefacts dating from the Neolithic onwards were found. In a few cases, such findings indicate specific human activities (hunting gears, arrows, etc.), but more often the reasons beyond the presence of men at mountain sites remain unclear. Can we obtain information on past human activities from paleoecological proxy data? We provide an example of coupled paleoecological - archaeological investigations from the western italian Alps. Above 2000 m on the Mont Fallére Massif (Aosta Valley) several sites yield evidence of anthropic presence since Neolithic times, but no traces of specific human activities have been so far found. Paleobotanical and chemical analysis on the stratigraphic succession of a nearby mire at 2365 m asl offer insights into the history of vegetation and landscape during pre-anthropic and prehistoric anthropic times. Pollen data, matched with chemical and geochemical analysis (phosphorous compounds, water, total organic matter, carbonates and silicoclastic residue contents) suggest a major shift in the structure of

subalpine vegetation starting from the end of the Neolithic. Increased fire frequency led to the demise of pristine conifer forests dominated by Pinus cembra and the expansion of herbaceous vegetation rich in pastures species, which took place during the Eneolithic. Increasing P content in sediments and enhanced influx of coprophilous fungi spores support the hypothesis that the subalpine belt of Mont Fallére was used for summer transhumance and alpine farming from the Eneolithic to Roman times. Low charcoal influx during the Eneolithic may suggest that pastures were kept open and clear from woody vegetation thanks to the impact of grazing livestock. Increased charcoal influx during the Bronze and Iron Ages may indicate that this purpose was achieved by coupling grazing and intentional fires. In order to improve our capabilities to recognize and characterize past human activities, the integration of paleoecological techniques and archeological data is necessary. The application of chemical analysis may be possibly extended to other elements and their compounds, which could provide further indications on land-use, manure and smelting activities, cultivations, etc.

Complex adaptive systems as a heuristic framework to approach human impact on the landscape. A Pisidian case-study

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Complex adaptive systems is fairly new as a concept to archaeology and the discipline of archaeology is fairly new to complex adaptive systems. This paper proposes to consider whether aspects of complex systems theory, representing a conglomerate of converging theories from ecology and social sciences, might have applicability in archaeology, and more specifically in modelling trajectories of regions as dynamic socio-ecologic systems. In contrast to other (complex) systems, complex adaptive systems are open and adapt to new challenges and problems. Complex adaptive systems are non-linear in trajectory, not predictable in behaviour, yet self-organised in the sense that they enhance co-evolution between entities in the system, improving their performance and strengthening complexity. The properties and behaviours of complex systems cannot be attributed to any particular part, but only to the system as a whole. Ecological and social systems are not only complex, they are also integrated as social-ecological systems. The focus on sustainability and resilience in the study of social-ecological systems seems most compatible with interdisciplinary approaches of past regional development. The source and role of change in complex adaptive systems has been conceptualized under the heading of panarchy theory. The central conceptual tool in panarchy is the adaptive cycle. This combines the factors of the rising/declining potential of systems with their degree of connectedness and their rising/declining resilience. Another attractive consideration, which fits in well with archaeology, is that adaptive cycles never exist in isolation but are nested in a hierarchy of slow, large and small, fast adaptive cycles. This nested hierarchy of adaptive cycles represents a panarchy, potentially spanning a large spatial range, from soil bacteria to the entire planet, and an equally vast temporal range, from seconds to geological epochs. This notion is highly compatible with the concept of multi-scalarity in archaeological analyses. As a result, adaptive cycles can work as heuristic tools to describe socio-economic complexity, with archaeological phenomena as proxies for the potential, connectedness and resilience of a given society. Archaeological regions, for instance, could be seen as panarchies, with linked adaptive cycles represented by households, communities and empires, and regional development traced in order to establish shifting balances in social-ecological systems and the sustainability of regions. This paper wishes to reflect on the methodological possibilities and pitfalls of linking complex adaptive systems with archaeology. The many inconsistencies and particularities of archaeology are best approached from a particular case-study, which in this case is inspired by the ancient region of Pisidia and its long-term evolution between Iron Age and Mid Byzantine times.

The importance of old forests for a better understanding of human-environment interactions in Prehistoric and Roman times.

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Reconstructing rates and patterns of erosion processes in the distant past is often complicated by the fact that subsequent erosion in later periods destroys former erosion features. For instance, permanent gullies which form during intense rainfall events on agricultural land are being infilled by the gradual delivery of sediment during less intense rainfall events. Similarly,

traces of human impact in the landscape become obliterated due to continuous cultivation practices (tillage erosion and deposition). This is especially the case for the loess belt in NW Europe, including those in central Belgium, which have been cultivated very intensively since the Roman and Medieval Periods. However, some traces of ancient erosion phases and human activities are still preserved under old forests. The Meerdaal Forest in central Belgium offers a unique setting to study such gully erosion phases and other traces of human impact, such as closed depressions testifying ancient quarrying for calcareous loess, as it has been under forest at least since the 12th century. The spatial pattern of gully systems and closed depressions can be related to the spatial patterns of human occupation and ancient road networks. Radiocarbon and OSL dating of gully fan deposits, artefacts and the infill of closed depressions point out that some of these features were formed in the Bronze Age, Iron Age and Roman Period. Contemporary gully erosion studies allow one to better understand the land use and rainfall conditions that lead to the development of these gullies. This suggests that parts of the landscape that are nowadays covered by old forests must have been used more intensively in previous periods. More geomorphic research in old forests is needed to better understand human-environment interactions in prehistoric and historic times.

The settlement of the Cistercian abbey of Villers-la-Ville in the Thyle valley (Dyle tributary) during the 12th century: Archaeobotanical approaches.

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The Cistercian abbey of Villers-la-Ville, situated between Brussels, Charleroi and Namur in Belgium, was founded in the 12th century and abandoned after the French Revolution at the end of the 18th century. The construction, architecture and distribution of buildings, courtyard and gardens of the abbey are recognized as very remarkable and exceptional. The site has also been classified as historical monument and remarkable site in 1972. The ruins of the abbey of Villers-la-Ville has been excavated for a long time. Since the end of the 19th century, it has been punctually excavated by some architects and religious. However, all of these results have never been published. It is only from 1985 that, thanks to the work of the Governance of Buildings to the consolidation of the ruins of the abbey, ongoing and regular excavations are undertaken. Indeed, since then, the History Center of Architecture and Building assumes an archaeological mission to support this project and since 1988 the Archaeological Service of Wallonia has excavated many parts of the site. While most of these excavations concern the architecture of buildings, for their restoration and rehabilitation, none of them, up to now, was interested in the period before and during the settlement: Why did the monks choose this site? How was the natural environment when they arrived? And how the abbey' settlement affect this environment? To answer this question, several archaeobotanical analyses (pollen, fruit and seeds, wood and wood charcoal) have been undertaken for the first time in two different sectors of the abbey. The samples come from mechanical deep coring which have recently been done at the Gate of Brussels, the main gatehouse situated at the western part of the abbey, and at the former major mill situated more at the south.

Land use from the archaeobotanical evidence of small Roman farmhouses in central Italy (south-eastern Tuscany)

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The contribution presents archaeobotanical analyses carried out on six excavations of archaeological sites located in the province of Grosseto-Tuscany. This study is part of the "Roman Peasant Project" and National Science Foundation Project "The Archaeology of Rural Rome", directed by Kimberly Bowes (School of Classical Studies American Academy in Rome; www.sas.upenn.edu/romanpeasants/). The projects combine archaeological excavations with geomorphological, archaeobotanical, zooarchaeological and micro-topographical analyses, focussing on the descriptions of the peasantry in the Roman world: their diet, exploitation of local resources, social dynamics and economy. The sites analysed were probably occupied during seasonal agricultural works, a peculiar typology of site that has not been usually identified in Roman sites of central Italy. The integrated analyses of pollen, non pollen palynomorphs, charcoal particles and seeds/fruits help to obtain interesting details on the site function, land use and palaeoenvironment of these archaeological contexts. The archaeobotanical reconstruction shows that the landscape was fairly treeless. Pastures surrounded the small buildings while cereal fields were probably less extended or further away than legume fields cultivated to forage. Shrubs and some fruit trees might mark boundaries of fields, while the woods, including oak woods, were distributed far from the sites. Anthropogenic pollen indicators, spores of coprophilous fungi and parasite eggs point to the presence of excrements in the sites suggesting that the small buildings were used as small barns for domestic animals, or a temporary shed.

Late Neolithic subsistence according to experimental data – 15 years experience in Forchtenberg

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For a better understanding of Neolithic land use, our multi-disciplinary research group conducts agricultural experiments in a forested area near Forchtenberg, South-West Germany since 1998. According to archaeobotanical data from Lake Constance, shifting cultivation with slash-and-burn is the most probable hypothesis to test, but other cultivation methods as shifting cultivation with hand tillage, permanent cultivation with hand tillage, and permanent cultivation with burning are executed in Forchtenberg as well. During and after the experiments, soil, vegetation, pollen and charcoal data were recorded, as well as the yields and the time needed to carry out the different actions necessary for crop cultivation, from cutting the trees to harvesting, using Neolithic tools and practises. No fertilizers were applied. As cereals Triticum aestivum, Hordeum vulgare, Triticum turgidum ssp. dicoccon and turgidum, and Triticum monococcum were grown, as old as well as modern races. The modern race of Triticum aestivum has the highest yields. With all cultivation methods, the yields depend on the soil quality. Permanent cultivation with tillage results in very low yields on all soil types and seems not practicable. Permanent cultivation with annual burning using wood from the surroundings, but without crop rotation or short fallow phases resulted first in high, but later in yearly decreasing yields. Shifting cultivation with tillage with one growing season and afterwards a long fallow phase gave medium yields only on the best soils. On worse soils, this method seems also not practicable. The best results, with yields between more than 1500 and more than 8000 kg/ha, were attained with the slash-and-burn method and annual shifting of the field. With this method, the time required to produce 200 kg cereals varies between 28 days on the best and 78 on the worst soils. Shifting cultivation with tillage on the best soils results in 95 working days. The main reasons for the good results of slash-and-burn are nutrient mobilisation from the topsoil by increased temperature during burning, increase of pH, weed suppression, and high soil temperature on account of the black soil surface in spring. The main disadvantage of the slash-and-burn system is a huge wood consumption. Therefore 97% of a forested area was used to produce wood to burn the other 3% for effective crop production. Nevertheless, slash-and-burn is an effective and easy-going method for crop production in a densely forested landscape with a not too big human population.

Industry, agriculture and catchment conditioning: lake sediments in the rural upland landscape of northwest England

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Sedimentary archives can provide data at both temporal and spatial scales to discern environmental changes driven by human activity where multiple proxy measurements are integrated with good chronological control. Upland lake basins offer especially high-quality data because: they are geographically widespread and span many environmental settings, they offer a non-fragmentary catchment-averaged signal of landscape evolution and precise, high-resolution chronologies can be developed. Hence lakes can yield accurate sediment budgets and inventories of carbon burial or pollutants and increasingly they are an important tool for validating landscape evolution models. We illustrate these using case studies from northwest England. Crosemere: Geochemical measurements along a continuous Holocene sediment sequence from Crosemere, Cheshire, reveal multiple phases of elevated zirconium (Zr) concentrations representing greater erosion intensity within the catchment. These correlate to known phases of human activity in the region, and the greatest response appears to have been triggered by the first expansion of human activity during the Bronze Age. Successive phases show a lesser response and the key question is whether this is due to comparatively reduced human impact or altered catchment conditioning. Brotherswater: Precise correlation using geochemical profiles between twelve sediment cores extracted from Brotherswater, English Lake District, reveals a highly variable spatial pattern of sediment accumulation across the basin. Coupled with a well-constrained chronology developed using artificial radionuclides (210Pb, 137Cs, 241Am), high-precision radiocarbon (14C) dates and elemental signatures that reflect local mining activity (Pb, Ba, Cu, Zn), accurate inventories of mining-derived Pb deposition in Brotherswater have been calculated.

Importantly, these data show that extracting multiple cores is essential or otherwise calculated inventories will vary significantly. Thermogravimetrically measured particulate carbon flux to the lake bed is dominated by catchment-derived organic matter and the tight chronological control enables carbon budgets to be calculated at up to sub-decadal scale. In terms of erosion, phases of increased concentrations of terrigenous geochemical tracers (Zr, Ti, K) and enhanced soil carbon flux appear to coincide with known periods of agricultural expansion in the English Lake District (Roman, Norse, Medieval). These fluxes increase to an even greater extent, alongside a contemporaneous coarsening in the calibre of deposited sediment, coinciding with the first mining activity, despite the documented small-scale nature of ore extraction. Hydrogeomorphic models help assess the relative importance of human activity, climate or extreme events in driving landscape evolution. Brotherswater cores show exceptionally similar sediment flux values to CAESAR model scenarios of the fluvial system, thus offering effective model validation.

Human impact on the vegetation of pastoral uplands: recent centuries of change in the Yorkshire Dales, UK

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Traditional management systems in cultural landscapes provide a powerful, persuasive driver in policy development and land management decision-making. However, traditional management is not static; activities change through time as adaptive management regimes driven by social forces and feedbacks between environmental change and ecosystem service provision. Despite the universality of policy on traditional land management there is a need to understand and respond to local conditions. For most areas, we are only just beginning to understand, in any detail, human influence on biodiversity over centennial timeframes. Even when management practices are known in some detail, ecological inventories may be sparse. We simply do not know the effects of management on ecology through relevant decadal and centennial timescales. Case studies of site histories combining documentary and palaecological records can be useful in highlighting periods of change and stasis and thus have impact on the ability of policy to set, and to achieve, objectives for resilient and adapted social-ecological systems. Interdisciplinary research into ecological or environmental change, and changes in the social systems of management, provide an important, challenging perspective to policy as well as to socially embedded ideas of traditional landscape among stakeholders. Regional level variation of management as well as the trajectory of recent impact must be incorporated into flexible policy systems. Comparisons between landscapes with different histories are important for this. At a local level, a strong evidence base must inform stakeholders in order for rational decisions about cultural landscape management. This paper presents a case study combining historical records with palaeoecological analysis in upland Yorkshire, UK. Data show that scrub and tree presence declined in a period when the landscape was perceived to be open. Tree cover in the uplands of the UK has often been considered innapropriate due to to the long history of grazing. Scrub and tree cover is seen as a regressive step by many farmers. The evidence presented from this palaeohistorical study provides a point of discussion. Results may help land managers to argue for a more mixed structure to the ecology of grazed upland landscapes in the future. Part of this study focussed upon further developing an understanding of the pollen vegetation relationship. A new approach to Indices of Association was piloted over increasing source areas to clarify the representation of rare-type pollen grains and to clarify the extent to which diversity change can be discussed within the palaeorecord. This forms an important part of providing the rigorous evidence base required for applied palaeoecology.

Past Holocene detritism quantification and modeling from lacustrine archives as a new way to deconvoluate human-climate interactions on natural ecosystem over long time-scale.

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Water budget is one of the main challenges to paleoclimate researchers in relation to present-day global warming and its consequences for human societies. Associated soil degradation and erosion are thereby becoming a major concern in many parts of the world and more particularly in the Alps. Moreover, humans are considered as geomorphologic agents for few thousand years and it is now recognized that a such impact on natural ecosystem profoundly modified soils properties as well as aquatic ecosystems dynamics over long-term periods. The quantification of such inference over long time-scale is therefore essential to establish new policies to reduce mechanic soil erosion, which is one of the dominant process in Europe, and anticipate the potential consequences of future climate change on hydric erosion. The mechanical erosion of continental surfaces results from climatic forcing, but can be amplified by the anthropogenic one. We therefore suggest that quantifying and modelling soil erosion processes within comparable Holocene lacustrine archives, we are able to estimate and date which and

when past human activities have had an impact on soil fluxes over the last 10000 years. Based on the present-day geomorphology of the surrounding watershed and the evolution of the vegetation cover during the Holocene, we develop an interdisciplinary approach combining quantitative organic petrography (i.e. optical characterization and quantification of soil particles within lake sediments) with high-resolution seismic profiling, age-depth models and erosional susceptibility modeling, in order to estimate the annual volume of soil eroded over the last 10000 years, and in fine to quantify the volume of human-induced soil erosion during the Holocene period. This method is applied to close but contrasted mountainous lacustrine environments from western French Alps: lakes Blanc Huez and Paladru, sensitive to same climatic influences but where past human activities were different (mining versus agriculture, respectively). Lakes Blanc Huez and Paladru are defined by good Holocene chronologies and well detailed lithologies. Both archaeological evidences and interdisciplinary characterizations of the two systems demonstrated that Lake Blanc Huez sedimentary infill is only sensitive to climate forcing and that soil fluxes are therefore only proportional to snow and/or water rainfalls, whereas the sedimentation recorded within Lake Paladru results both from climate and anthropogenic forcing. Results demonstrate that around Lake Paladru, human-induced soil erosion is effective since the Neolithic period and the beginning of agrarian activities. Following our quantification and modelling, human activities were able to explain up to 50% of soil fluxes in particular between the Bronze Age and the Middle Age suggesting that the actual geomorphology of the drainage basin is inherited from several millenary and not only from modern activities.

Quantifying past human-environmental interactions using mass balance and isotope geochemical methods with examples from northeastern USA

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Akin to paleoclimate research, predicting human impact on the landscape and vegetation requires a quantitative understanding of past human-environmental interactions. In this study, mass balance and isotope geochemical techniques are used to quantify the past human-environmental interactions with examples from the Delaware River valley in northeastern USA. Using a mass-balance approach to calculate molar flux, the maximum likely Pb addition to one alluvial pedon that formed ~1.8 ka was estimated at 6.74e-5 mmol cm-2. Conversely, the maximum Pb likely added to an alluvial pedon that formed during the Industrial era was estimated at 0.029 mmol cm-2, three orders of magnitude higher than the pre-Industrial 1.8 ka soil. The large molar flux in the Industrial-era soil is related to aerosol output from nearby factories processing lead. The mass-balance results show that historic Pb additions to alluvial soils are unlike anything documented prior to the Industrial Era. Using an isotope geochemical approach, the δ13C of soil organic carbon and phytolith analysis are useful proxies for estimating the above-ground concentrations of C3:C4 biomass in buried soils and their potential relationship to land-use. A compilation of δ13C data from alluvial soils along the Delaware River shows a 59% increase in C4 relative to the late Holocene (~4.0 – 0 ka) mean (C4mean = 22%) during the period 0.6 – 0.4 ka. This increase in C4 biomass coincides with documented occurrences of maize in northeastern USA, substantial increases in population and shifting settlement patterns during the Late Woodland cultural period, 1.0 – 0.5 ka. These associations suggest that prehistoric people influenced the δ13C values during portions of the late Holocene prior to the arrival of Euro-Americans. Both mass balance and isotope geochemical approaches presented here provide quantitative and semi-quantitative measures of human impact, one in mmol cm-2 Pb added to the soil and the other in percent change in C4 biomass. The combined data shows that although prehistoric people modified the Delaware River riparian C3:C4 biomass, they had little to no known effect on Pb additions like that of Euro-American Industrialization. Because human impacts can significantly modify chemical systems in multiple ways, a multi-proxy approach is necessary for quantifying the history of human-environmental interactions.

Human impact on the environment in the Ephesia, Turkey – an eight thousand year long battle

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During Antiquity, Ephesos was an important harbour city. The maximum Holocene transgression about 7 millennia ago reached c. 20 km inland. Due to the progradation of the Küçük Menderes delta and its tributaries the coastline has continuously shifted westwards since then. Especially during Hellenistic time, the delta advanced for about 1.5 km, most probably because of human impact. Our interdisciplinary geoarchaeological research focuses on (i) the detection of spatial and temporal shifts in the coastline during the past millennia, together with the calculation of sedimentation rates; (ii) the human impact on the landscape, especially in the environs of the Roman Harbour; (iii) the reconstruction of the vegetation history of the Ephesia.

More than 30 corings were retrieved from geo-archives. For a better understanding of the depositional environments, geochemical, sedimentological and palynological analyses, as well as the determination of the macro- and microfossils were carried out. Besides diagnostic ceramic finds, AMS-14C dating was used for the chronological framework. Our drill cores enable us to reconstruct the coastline changes during the last millennia and to quantify sedimentation rates. Low sedimentation rates occurred from the 5th millennium BC to the Geometric period; this fact contrasts with higher rates thereafter (most probably due to human activities as deforestation and agriculture). The second aim of the studies is to identify the anthropogenic influence in the sediments of the Roman Harbour. A stratified layer of 1.30 m thickness clearly proves the intensive harbour use between the 2nd cent. BC and the 5th cent. AD, the prosperity period of the city. The stratification probably results mainly from the discharge of sewage and waste of the city into the harbour. Heavy metal concentrations as lead and copper also rise in this layer. In the harbour canal, we also assume strong human impact: an intestinal parasite (Trichuris cf. trichiura), fruit tree as well as sugar melon pollen were found in the cores. Third aim is to reconstruct the vegetation history during the last millennia with palynological tools. Three drill cores were analyzed for pollen remains dating back to the 6th millennium BC. The first results reveal the dominance of deciduous oak, in a landscape with human impact, already from the 6th millennium BC onwards. In one core, we detected a rapid decrease in pollen grains, coinciding with the appearance of volcanic ash of the Santorin explosion in 1630 BC. From Hellenistic and Roman times on fruit trees (olive, chestnut, walnut) appear next to crop and pasture farming. After the destruction of the city by earthquakes in the 3rd cent. AD, pine trees became dominant, presumably on abandoned land.

Dynamic soil properties in response to anthropogenic disturbances

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Anthropogenic disturbance of natural vegetation can profoundly alter the physical, chemical and biological processes within soils. Rapid removal of topsoil during intense farming can result in an imbalance between soil production through chemical weathering and physical erosion, with direct implications on local biogeochemical cycling. However, the feedback mechanisms between soil erosion, chemical weathering and biogeochemical cycling in response to anthropogenic forcing are not yet fully understood. In this paper, we analyze dynamic soil properties for a rapidly changing anthropogenic landscape in the Spanish Betic Cordillera; and focus on the coupling between physical erosion, soil production and soil chemical weathering. Modern erosion rates were quantified through analysis of sediment deposition volumes behind check dams, and represent catchment-average erosion rates over the last 10 to 50 years. Soil production rates are derived from in-situ produced 10Be nuclide concentrations, and represent long-term flux rates. In each catchment, soil chemical weathering intensities were calculated for two soil-regolith profiles. Although Southeast Spain is commonly reported as the European region that is most affected by land degradation, modern erosion rates are low (140 t ha−1 yr−1). About 50 % of the catchments are losing soils at a rate of less than 60 t km−2 yr−1. Our data show that modern erosion rates are roughly of the same magnitude as the long-term or cosmogenically-derived erosion rates in the Betic Cordillera. Soils developed on weathered metamorphic rocks have no well-developed profile characteristics, and are generally thin and stony. Nevertheless, soil chemical weathering intensities are high; and question the occurrence of past soil truncation.

Towards a quantification of agricultural carrying capacity in the past: the application of a soil erosion model to estimate crop productivity

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Humans have impacted their environment throughout history, especially since the introduction of widespread agriculture and the associated forest logging activities, thereby creating anthropogenic landscapes in which environmental processes are no longer in equilibrium. Under certain conditions, this has led to a drastic reduction in carrying capacity with negative feedback to the sustainability of society. Soil erosion and the resulting reduced agricultural productivity has been pushed forward as one of the contributing factors responsible for the collapse of ancient societies. Yet, quantitative data supporting these hypothesis is still lacking. Furthermore, more attention was recently given to the resilience of ancient societies against soil erosion and its negative consequences, challenging the ideas of collapse. In order to tackle these questions, local site-specific information on land use and soil erosion needs to be upscaled to entire regions or territories. A modeling approach can help to achieve this. The territory around the ancient city of Sagalassos (Taurus Mountains, SW Turkey) was selected to quantify crop productivity through space and time. In order to simulate erosion, the spatially distributed soil erosion & sediment delivery model WaTEM/SEDEM was used. Results show how land cover variations and the depletion of soil reservoir have a larger influence on the central valley sedimentation rates in comparison to climatic variability. The general amount and spatial pattern of net erosion was well reproduced by the model, although it failed to capture the more detailed field work derived sedimentary

chronologies. The soil erosion model offers the opportunity to get information on soil depths in both space and time, which can be used as input for the crop productivity model. The model results from the Gravgaz catchment show how deforestation and agriculture led to the depletion of the existing soil reservoir while creating agricultural potential in the central valley's through the accumulated sediments. Although preliminary results show that soil thickness on its own isn't a strong predictor for crop yields, future work will include soil thickness at least as one of the factors controlling crop productivity. Promising soil properties – crop yield relations can be found in literature, but they still need to be verified for the territory of Sagalassos. Hence, present day crop yield data need to be collected to form a basis for model validation. Furthermore, soil properties of ancient soils will have changed throughout time. Therefore, the model will have to include the dynamic properties of soils over time.

Assessing human impacts on catchment sediment yield in Europe: a continental approach

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Both from a scientific and environmental management perspective, there is a large need to better assess the magnitude of human impacts on catchment sediment yield (SY, t/km²/y) and to identify the factors that control this magnitude. Quantification of these impacts is generally impeded by the lack of reliable SY data under "pristine" conditions, i.e. before the catchment was significantly affected by humans through land use changes or reservoir construction. Based on a dataset with SY-measurements from 146 mainly forested catchments in Europe that were not affected by reservoirs, a regression model was developed. This model allows estimating pristine SY, based on the catchment topography, lithology and the degree of seismic activity. Validation of this model indicated that this model is robust and generally produces SY-predictions that deviate less than one order of magnitude from their measured SY-value. Hence, the application of this model to a large (> 200) number of European catchments for which measured actual, i.e. "disturbed", SY-data were available allowed to quantify the effects of human impact on SY and their controlling factors under a wide range of environmental conditions. It was found that catchment area has a strong control on catchment sensitivity to human impact. Whereas in small (< 1 km²) disturbed catchments actual SY can be up to 100 times larger than their modeled pristine SY-value, a clear human impact is generally difficult to detect for catchments > 100 km². Furthermore, a clear positive relationship between the degree of SY disturbance (i.e. the ratio between the actual and the pristine SY) and the fraction of disturbed land use in the catchment was observed. Catchments with a high fraction of arable land (> 50%) also showed a stronger decrease in the degree of disturbance with increasing catchment area. The relation between the degree of disturbance and the presence of reservoirs, climate, as well as the land use history was also investigated but yielded less clear results. Overall, these findings confirm reported field observations, indicating that hillslopes and small catchments are very sensitive to erosion, but that these impacts on SY may become strongly buffered in larger catchments.

Resolving the timing and relative magnitude of ancient versus modern human impact on East African landscapes: a 3800-year example from western Uganda

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General uncertainty of whether anthropogenic global warming will cause drier or wetter tropical climates at the regional scale increases the stakes to better understand the relative impacts of climate change and local human activity on the functioning of natural tropical ecosystems, and resultant carbon-cycle effects. This is particularly challenging in sub-humid and semi-arid tropical regions such as equatorial East Africa, where large natural rainfall variability at decadal and longer time scales has driven major long-term ecosystem changes independent of human activity. Also within the last millennium all climate zones of equatorial Africa, from rainforest to dry scrub savannah, are now known to have experienced episodes both significantly drier and wetter than today, with significant impacts on terrestrial ecosystems in the form of fire regimes and the position of vegetation ecotones. This evidently complicates assessment of how much today's pervasive ecosystem changes are in fact due to human activities. It is clear that i) even in certifiably 'pristine' locations, tropical African ecosystems cannot be assumed to have had their modern characteristics for any length of time; ii) in disturbed locations, the ecosystem condition which existed immediately before the documented onset of local human impact cannot be assumed to represent its mean long-term natural condition; and iii) given potentially ancient but often intermittent occupation by indigenous people, the ecosystem condition which existed immediately before the colonial period (often, pre-1900) cannot be considered to represent the undisturbed condition. Assessing the true timing and relative magnitude of such indigenous (i.e., pre-colonial) impact on East African landscapes requires high-quality paleoenvironmental records sufficiently long and detailed to document local ecosystem response to natural climate variability, upon which the various phases of human impact on these ecosystems were and are

superimposed. Also essential are a toolkit of paleoenvironmental proxies which can reliably identify and quantify the unique fingerprint of diverse human activities such as land-cover change and burning. Here we present a state-of-the-art example from western Uganda in equatorial East Africa, using geochemical and aquatic-insect proxies of climate-driven moisture-balance change, fossil assemblages of plant pollen and phytoliths as proxies of vegetation change, and fluxes of macrocharcoal as proxy for fire frequency and intensity.

Variability in geomorphic response to anthropogenic disturbance

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Humans have greatly impacted the processes and intensities of erosion, sediment transport and storage since the introduction of agriculture. However, the relation between the intensity of anthropogenic disturbance and the magnitude of change in sediment dynamics is highly non-linear due to the importance of intrinsic controls on sediment propagation. Especially the buffering capacity of slopes and floodplains can be held responsible for this non-linearity, as both sinks store the produced sediment temporarily, obscuring the relation between sediment production and sediment output. Slope-stream connectivity, but also the duration and typology of anthropogenic disturbance controls the existence of thresholds that need to be crossed before significant changes in downstream sediment dynamics are recorded following human impact. Many internal feedback mechanisms, such as those between erosion and soil thickness, further complicate the story. Several concepts have been developed over the last few decades to explain the complex behavior of sediment transfers in the combined hillslope-fluvial system, including the 'sediment cascade' model and the 'fast-in, slow-out' model. However, none of these concepts seems to hold universally when reconstructing historical sediment dynamics for contrasting environments, as is illustrated with case-studies from a range of environments in Belgium, Turkey and the USA. Detailed field-based sediment budgets from these contrasting settings combined with spatial modeling of sediment fluxes covering time periods ranging from 200 to over 5000 years, as well as the use of pollen and sediment provenancing techniques, shows that no overarching concept of sediment source-to-sink following anthropogenic disturbance can be established. Rather, depending on the duration and typology of anthropogenic disturbances, in combination with local environmental conditions, unique patterns of geomorphic process response emerge. As a result, unravelling the human impact from current-day sediment archives and predicting the impact of future human disturbances on river and sediment behavior remains a major challenge. This has important implications for interpreting contemporary sediment yields as well as downstream sediment records in large floodplains, delta's and the marine environment, in terms of changes in the drivers of environmental change.

Humans have impacted atmospheric C-exchange since the introduction of agriculture by changing the geomorphic cascade

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Early human impact on the global C cycle through deforestation has been demonstrated and it is estimated that between 50 and 357 Pg C have been released from vegetation and soils to the atmosphere in the pre-Industrial era. However, the contribution of erosion and sediment storage on C exchange between terrestrial ecosystems and the atmosphere has not been accounted for, although long-term sediment budget studies show that large volumes of soil material have been mobilized since the introduction of agriculture. Furthermore, through human impact also the geomorphic setting itself has changed thus altering ecosystems such that the C exchange with the atmosphere changed as well. For the 780 km² Dijle River catchment in the western European loess belt, the impact of human induced soil erosion on C exchange with the atmosphere was quantified by combining a sediment budget with detailed inventories of C in soils and sediments. For the period 4000 BC to AD 2000 it was estimated that anthropogenic erosion induced a net C sink, offsetting 39% of the C emissions due to land cover change since the advent of agriculture. However, this sink is limited by a significant loss of buried C in colluvial settings lagging the burial: ca. half of the original C buried in the colluvial stores remains after 500 years. Contrary to colluvial settings, C burial in alluvial settings appears to be more conservative, which is most probably related to higher autochthonous production and preservation rates in

wet floodplain soils. Data from the floodplain sediments also indicate that human induced high rates of minerogenic sedimentation since the Middle Ages were able to capture more C in the floodplain than the Mid-Holocene natural wetlands through peat formation. The result for the Dijle River catchment, with a long history of human impact, can be used to estimate the longer term impact of the major agricultural expansion of the 19th and 20th century worldwide on global C budgets.

Holocene erosion and colluviation dynamics in the Dijle catchment, central Belgium

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Since the introduction of agriculture in the Belgian loess belt, ca. 5-7 ka BP, erosion and sedimentation processes have altered the soilscape and topography at far greater rates compared to pre-Neolithic conditions. As a result, soil profiles on moderate to steep hillslopes are truncated, whereas early Holocene soils in dry valley bottoms are nowadays buried under colluvial deposits of several meters thickness. Anthropogenic induced soil erosion has thus smoothened landscape topography. Soil erosion and hillslope sediment storage are quantified by extrapolating detailed data obtained from soil profile truncation studies in three representative zero-order sub catchments. The hillslope sediment budget shows that ca. 40% of the soil eroded during the Holocene is redeposited as colluvium on hillslopes and in dry valley bottoms. A chronology for the valley evolution was established based on AMS 14C dating of charcoal fragments and optical dating of colluvial sediments. The first sediment deposition occurred in the late Bronze to early Iron Age, with an average sedimentation rate of approximately 3.4 ± 1.3 t/ha per yr. This increased to c. 5.4 ± 2.2 t/ha per yr during the Roman Period and further to 18.0 ± 2.2 t/ha per yr in the Middle Ages.

Quantifying human impact on environmental systems: challenges for the future

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Since the introduction of agriculture, humans have profoundly changed the natural environment through land cover change and subsequent changes in soil and sediment properties as well as aquatic ecosystems. Furthermore, these long-term changes have been argued to be responsible for significant changes in the global carbon cycle with feedbacks to climate, suggesting that the Anthropocene era began long before the Industrial Revolution. However, the extent to which humans have impacted the environment at regional to global scales long before the modern era is still under debate. Different estimates of regional and global land cover histories do exist but often with large discrepancies between them. An accurate quantification is necessary though in order to fully grasp to what extent humans have impacted climate and/or terrestrial and aquatic ecosystems on the one hand, but also to explore the feedback mechanisms between environmental change and societal development, collapse or resilience. The uncertainty on past human impact complicates the use of research on the past in order to better understand and manage terrestrial ecosystems in the future. A more detailed integration of data from both environmental sciences as well as from humanities is needed to resolve these issues

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Searching the past for clues to the future

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Historical ecology is a research framework that integrates the history of the Earth´s biophysical system with the history of human life in all its aspects. This holistic perspective draws from the biophysical sciences, social sciences, and the humanities, and necessitates the use of diverse data such as documents, archaeology, environmental information, and local knowledge. Landscapes and regions, studied at different scales across time and space, offer a human-scale focus for the study of change and place-based ideas for future innovation, design, and management.

Complexity of Holocene sediment dynamics for two small river catchments in Normandy (Western France)

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Geomorphological and palaeoenvironmental research on Holocene sedimentation in the valleys of Normandy provides evidence for long term fluvial system changes related to climate and human activities. In order to evaluate erosion rates evolution and subsequent sedimentation on slopes and the valley bottom, an Holocene sediment budget based on field data have been conducted for two small catchments localized on the sedimentary Paris Basin (NW France).
An extensive geomorphological survey was carried out for the Thue (80 km²) and the Mue (100 km²) river catchments. Data from 41 cores and 11 hand auger cross-sections, regularly placed among the valley bottom were used to quantify the alluvial storage and identify the stratigraphy. In total, 18 AMS radiocarbon dating on organic samples from core drilling were used to define the chronology of the alluvial filling. Slope erosion was determined using 230 soil profiles description from auger coring transects within a small sub-catchment (9 km²) and extrapolated to the entire river basin according to a soil erosion model. Results underline an important evolution of sedimentation into the valley bottom moving from tufa and organic remains to a widespread silty deposit (overbank and colluvial material). Available radiocarbon datings on the last organic deposit also date the onset of silty deposits and the increase of sedimentation rate in between 800 BC and 500 AD, like in many European countries. Sediment budgets also indicate that 90% of eroded sediments are stored as alluvial and colluvial deposits in the watershed. Results and causes of this widespread change are discussed with the available archaeological and palaeonvironmental data. These data clearly stresses the main role of the land use and subsequent connectivity changes within the river basin but the role of a wet oscillation registered by numerous fluvial systems in the Paris basin is also evocated. They also suggest an important complexity slope erosion processes and sediment redistribution into the catchment during the Holocene due to different periods characterized by stable phases, favoring pedogenesis, and erosion phases.

Quantifying landscape responses to human action through optical dating; examples from the Netherlands

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Although it is widely recognized that humans alter the landscape both directly and indirectly, quantification of the induced landscape dynamics remains problematic. Suitable organic material for radiocarbon dating is often not available, either because the sediment of interests lacks organic material (e.g. drift sands), or because the age of the incorporated organic material does not reflect the timing of the landscape response (e.g. fimic soils). Over the past years, we have gained experience in quantifying anthropogenic induced landscape dynamics through the use of optically stimulated luminescence (OSL) dating methods. In this presentation we will present two examples based on multiple site studies: Firstly, we show how OSL dating provides accurate ages for the time of deposition and burial of Holocene reactivation phases of aeolian sand deposits (drift sands). We use the established chronologies to determine the rates of drift sand accumulation as well as periods of reduced aeolian activity. Such quantitative information is essential to make inferences about causes for drift sand activation (climate vs. human), and feedbacks involved. Secondly, we present OSL chronologies obtained for the build-up of fimic anthrosols through plaggic agriculture. In many places in NW-Europe, heath sods and manure were used to fertilize sandy soils, resulting in elevated fields suitable for agriculture. In these systems, resetting of the OSL signal takes place during ploughing of the fields, and OSL ages reflect the time that a soil horizon is buried below the plough depth. We find that OSL methods are particularly successful for determining the accumulation rate during later stages of plaggen agriculture; methodological challenges remain to accurately determine the timing of initiation of these agricultural systems. Combined modelling of landscape evolution and soil development, informed and constrained by dating results, can allow testing of hypotheses about this initiation.

Spatio-temporal patterns of human settlement, landscape and eco-dynamics in Neolithic and Bronze Age Ireland

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Archaeology has much to contribute to our understanding of the development of the cultural landscape and changing land cover over the course of the Holocene. Until recently, there has been relatively little attempt to examine the archaeological record in tandem with the palaeoecological record on a temporal and spatial scale that allows the exploration of the large-scale effects of archaeological activities on land cover changes. This is partially as archaeologists and palaeoecologists tend to work at different spatial and temporal scales. Recently there have been important developments in this respect and an enhanced appreciation by archaeologists of the need to create synthetic narratives of the archaeological record that are at the spatial and temporal scales necessary to address questions of land cover change. Improved understanding and new approaches to chronology, especially Bayesian approaches, have been critical in this respect, allowing the tempo and pace of change of the archaeological and palaeoecological record to be assessed on a common time-scale. Such long-term perspectives allow a more nuanced understanding of the human-environment relationship and the adaptability and resilience of communities to outside stimuli that can often be surprising and unexpected. Often, these run contrary to progressive evolutionary expectations that may be implicit in some land cover change models. These new approaches offer significant insights into our understanding of issues such as intensity of agricultural usage, practice and change over long time scales, which have important implications for our understanding of changing Holocene land cover and the carbon cycle. We explore some of these issues by drawing upon a multidisciplinary research project that has integrated archaeological (settlement data, C14 dates, archaeobotanical data) and palaeoecological datasets (largely palynological) to examine spatio-temporal patterns of Neolithic and Bronze age settlement and farming in Ireland and further afield. Pollen-based modeling has facilitated a comparison between land cover changes with the archaeological record. Bayesian analyses of palaeoenvironmental and archaeological C14 data have allowed us to examine linkages between environment, climate, farming and settlement within a much stronger chronological framework, allowing us to explore the temporal and spatial character of this highly resolved dataset.

The pseudo-biomisation approach to Holocene land-cover reconstruction: application to European pollen records

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The need for accurate land-cover datasets extending beyond the period covered by remote-sensing has encouraged the development of various reconstruction approaches to past vegetation. The pseudo-biomisation (PBM) approach (Fyfe et al., 2010; Woodbridge et al. 2013) was developed to provide a simple and easily applied transformation of fossil pollen data into land-cover classes in order to reconstruct broad-scale anthropogenic land-use change through time. The PBM has been tested and refined through application to an extensive modern pollen dataset (Davis et al., 2013) and comparison with Corine remote-sensed land cover maps. The method has now been applied to 982 European Pollen Database records. Regional comparisons indicate that forest decline and increased semi-open and open land cover can be detected since at least ~6000 BP in Central and Northwest Europe. In addition to Europe-wide synthesis, we present a number of case study areas in order to explore regionally-specific land-use change, and compare these with other, non-pollen based estimates of past land cover and demographic change.

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The fate of buried organic carbon in colluvial soils: a long-term perspective

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Colluvial soils are enriched in soil organic carbon (SOC) in comparison to the soils of upslope areas due to the deposition and subsurface burial of SOC. It has been suggested that the burial of SOC has important implications for the global carbon cycle, but the long-term dynamics of buried SOC remain poorly constrained. We addressed this issue by determining the SOC burial efficiency (i.e., the fraction of originally deposited SOC that is preserved in colluvial deposits) of buried SOC as well as the SOC stability in colluvial soils. We quantifed the turnover rate of deposited SOC by establishing sediment and SOC burial chronologies. The SOC stability was derived from soil incubation experiments and the δ13C values of SOC. The C burial efficiency was found to decrease exponentially with time reaching a constant ratio of approximately 17% by about 1000 – 1500 years post-burial. This exponential decrease is attributed to the increasing recalcitrance of buried SOC with time and a less favourable environment for SOC decomposition with increasing depth. Buried SOC was found to be more stable and degraded in comparison to SOC sampled at the same depth at a stable reference location This is due to preferential mineralization of the labile fraction of deposited SOC resulting in enrichment of more degraded and recalcitrant SOC in colluvial soils. Our study shows that SOC responds to burial over a centennial time scale: however, more insight into the factors controlling this response is required to fully understand how this timescale may vary, depending on specific conditions such a climate and depositional environment.