Plenary abstracts (alphabetically by first author)

Anchukaitis, Kevin: HOT DROUGHTS: PAST, PRESENT AND FUTURE (Section II). Tree-ring reconstructions of past precipitation and soil moisture nearly invariably indicate that droughts in previous centuries or millennia were more severe and persisted longer that modern observed events. However, future projections based on climate model simulations anticipate enhanced drying due to increased evaporative demand associated with greenhouse gas emissions. Here, I use tree-ring reconstructions of precipitation and drought indices and climate model simulations of the past, present, and future to place recent and on-going droughts in the context of the last millennium and next century moisture variability. Specifically, the hypothesis that increased temperatures due to greenhouse gas emissions are already exacerbating precipitation deficits is examined using a combination of proxy data and simulation modeling. In light of this, I examine whether we can detect evidence for past 'hot droughts' using a combination of models and proxy data, and what this implies for our understanding of the time stationarity of drought characteristics.

Beach, Tim, Luzzadder-Beach, Sheryl, and Krause, Samantha: ANCIENT MAYA IMPACTS ON THE EARTH'S SURFACE: AN EARLY ANTHROPOCENE ANALOG? (Section V). This presentation re-examines ancient Maya impacts on the environment as a microcosm of the early Anthropocene. Today much of this region, the size of the United Kingdom, is covered by tropical forest or recently deforested, but from 3,000 to 400 years ago it was partly and variably deforested for Maya cities, reservoirs, roads, farms, and fields. The Anthropocene often conveys pejorative connotations but some impacts of Maya Civilization were positive such as long-term impacts of millennia of landesque capital, like wetland field systems, agricultural terracing, and other land uses that over time have enriched many soils and elements of biodiversity. Some impacts were indeed negative such as large- scale soil erosion, toxic metal zones, and eutrophied water bodies. In the modern Anthropocene of the last decades these negative impacts are returning with renewed deforestation and accelerated erosion of the positive aspects of the Maya Anthropocene. Here we synthesize these impacts on soils, erosion, and sedimentation, on water quality, the built environment, ecosystems, and climate. Interestingly, some Classic period (1700-1000 BP) sites with peak human population and land use intensity experienced less soil erosion, perhaps due to soil conservation, post urban construction, and source reduction. Additional evidence suggests that ancient terraced sites and lower slopes that gained upslope sediment and soil nutrients from ancient Maya upslope soil loss have greater biodiversity. Climate also played roles during multiple periods of instability, extreme events like droughts and hurricanes, and stability. Climate change and its attendants provide our clearest comparison with the modern Anthropocene because the ancient Maya also experienced sea level rise and droughts like parts of the contemporary world and they may have warmed and dried their own climate. The “Mayacene” does provide past examples for human resilience to large scale change and adaptation. The final part of this paper assesses ancient wetland field complexes, one key link of the early Anthropocene of the Ancient Maya. We consider their formation and use (focusing on a new complex at Neundorf, Belize), the extent of wetland field systems, and their importance in Maya Civilization. Wetland field systems provide us again with the positive and pejorative Anthropocene. These watery agroecosystems were a successful

adaptation to sea level and water table rise and geochemical change over a wide area. They also challenge some assumptions about trade and food production in Maya Civilization. Nonetheless, these perennial wetland fields declined about 1000 years ago lockstep with the Central Maya cities, during a period when multiple lines of evidence suggest drought, perhaps too intense, long, and widespread for the Maya to reoccupy their iconic central places like Tikal and Calakmul.

Black, Bryan, TRENDS IN ENVIRONMENTAL VARIABILITY AND SYNCHRONY IN A COUPLED MARINE-TERRESTRIAL ECOSYSTEM (Section III). In coastal upwelling zones, alongshore winds lift deep, cold, nutrient-rich waters into the photic zone, fueling phytoplankton blooms that support some of Earth's most ecologically and economically productive marine ecosystems. In the California Current (CC) upwelling zone, seabird breeding success, fish growth-increment chronologies, and copepod community index strongly correlate through their shared sensitivities to variability in wintertime sea level pressure (the North Pacific High). These same atmospheric patterns also drive the onshore flow of precipitation and thereby influences tree growth, inducing synchrony across marine and terrestrial biological indicators. However, the degree of synchrony within and across ecosystems is not constant over time. Variability in wintertime climate indicators including drought, river discharge, upwelling index, sea level, and sea level pressure has significantly ($p < 0.01$) increased over the course of the 20th century. This rise in variability has coincided with a rise in synchrony within and among marine and terrestrial physical indicators, as measured by significant ($p < 0.01$) increases in mean pairwise correlations among variables. A rise in synchrony is also evident among winter-sensitive tree-ring chronologies and winter-sensitive rockfish chronologies. These results suggest that rising climate variability is more strongly limiting biological variability with implications for ecosystem resilience and degree of coupling across the land-sea interface.

Blois, Jessica L., Fitzpatrick, Matthew C., Nieto-Lugilde, Diego, Maguire, Kaitlin C., and Williams, John W.: USING PALEODATA TO TEST THE ASSUMPTIONS AND ACCURACY OF BIOGEOGRAPHIC MODELS (Section III). Species distribution models (SDMs) remain among the most widely used methods for forecasting regional- to global-scale changes in species distributions, assemblages and patterns of biodiversity in response to climate change. SDMs assume species exist in isolation and do not influence one another's distributions, potentially limiting their ability to predict biodiversity patterns. Community-level models (CLMs) are emerging approaches that, like SDMs, model distributions of species along environmental gradients, but CLMS additionally use species co-occurrences to fit shared environmental responses of species and communities. In theory, the additional information used by CLMs should result in more robust and transferable models across space and time. However, the predictive skill of CLMs may be reduced if climate change causes large changes in species co-occurrences. The choice of modeling approach thus may influence inference of both past and future distributions of species, given known and projected amounts of climate novelty. Here we compare a suite of CLMs to traditional SDMs through the last 21,000 years in eastern North America. We test model transferability against observed fossil pollen and mammal records and compare model performance to the magnitude of climatic novelty in each time period examined. We then extend our results to the future by examining the underlying drivers of climate novelty over the next few decades (until AD 2100), under two IPCC AR5 Representative Concentration Pathway scenarios (RCP4.5 and RCP8.5). Finally, we determine whether the paleodata-

model comparison supports use of a particular modeling approach for estimating biodiversity patterns in an era of global change.

Across the late Quaternary, we found that both SDMs and CLMs performed poorly when projected to time periods that are temporally distant and climatically dissimilar from those in which they were fit. However, CLMs generally outperformed SDMs in these instances (Maguire et al. 2016). Additionally, CLMs did not over-fit training data, unlike SDMs. This paleodata-model comparison help establish limits to predictability, indicating that the predictive skill of SDMs and CLMs decreases rapidly beyond thresholds of climatic and community novelty. Climate novelty will increase in the next 100 years compared to the present day, but even with the higher-end RCP8.5 scenario, future climate novelty is expected to be only half that experienced over the past 21,000 years, at least at the sites in our pollen dataset. Given this level of future climate novelty, the paleodata-model comparison suggests that CLMs may be a better choice of biogeographic model than most SDMs. The expected emergence of novel climates presents a major forecasting challenge for all models, but CLMs may better rise to this challenge by borrowing information from co-occurring taxa.

Maguire K.C., Nieto-Lugilde D., Blois J.L., Fitzpatrick M.C., Williams J.W., Ferrier S., Lorenz, D.J., 2016. Controlled comparison of species- and community-level models across novel climates and communities. Proceedings of the Royal Society B 283(1826), 20152817.

Bowen, Gabe: PALEO AND MODERN ISOSCAPES: AN ARRANGED MARRIAGE (Section IV). Paleo science is increasingly seeking to document and understand Earth's past in terms of complexes of change across regions, rather than changes in local conditions over time. The spatiotemporal information embodied by such reconstructions embeds signals of dynamical responses within and among systems and, in ideal situations, can reveal the mechanistic drivers of past Earth system change with greater fidelity than can site-based reconstructions. Over the past decade isoscapes – spatial models of isotopic distributions in environmental substrates – have emerged as tools for visualization and analysis of isotopic signatures of spatially distributed climatological, geological, and ecological processes. Although their application has been focused primarily on movement, connectivity, and spatiotemporal mass and energy fluxes in modern systems, the process of documenting and understanding modern isoscapes provides a basis for the interpretation of paleo-isotopic data in a similar, spatially-explicit context. For a number of isoscape systems increasing emphasis is being placed on multiple scales of temporal variation, in both modern and pre-modern data. Here I will discuss examples associated with hydroclimatological and ecosystem change that demonstrate the use of paleo-isoscapes and other spatially-oriented interpretations of paleo-isotopic data to reveal coordinated changes in Earth systems, potentially increasing our depth of knowledge of past environmental change and allowing systematic hypothesis-testing beyond what has been accomplished in many traditional studies.

Bush Mark B.: IDENTIFYING THE ONSET OF THE ANTHROPOCENE IN TROPICAL SOUTH AMERICA (Section III). Discussions regarding the establishment of the Anthropocene as a new geological time unit, and identifying when it began, have been frequent in recent literature. Competing views suggest that there is no need for an Anthropocene as it is already encompassed by the Holocene, that it should replace the Holocene, that it may begin in the mid-Holocene with the dawn of agriculture, that it should align to the

expansion of transatlantic maritime trading, that it be coincident with the industrial revolution, and lastly with the intensification of synthetic chemical production. Each of these views has merit, and the paleoecological evidence to support each in South America is reviewed.

Humans have been present in South America for at least the last 14,000 years, and in that time have played a role in megafaunal extinction, introducing fire to lowland rainforest, introduced exotic species, deforested landscapes, and gone through their own population boom, bust, and boom again cycle. Each of these events set off trajectories of ecological change, yet do any conform to our expectations for a golden spike?

Megafaunal population collapse occurred prior to human arrival in the Americas, with attendant changes in fire frequency and no-analog floras. Humans altered the recovery from these population lows, but did not account for changes in chemical cycles that accompanied the loss of the megafauna. Crops were transported between continents before 6000 BP. It was highly probable that weed species and other biota were similarly transported accidentally.

The extent to which native populations manipulated Holocene forests in lowland Amazonia is actively debated. Abundances of fruiting and 'useful' trees may have been enriched by native Americans. Proponents argue that there were no natural Holocene forests, while a more conservative view is that human impacts were predictable and local to rivers and lakes. Charcoal datasets revealed a trajectory of increased fire frequency associated with human arrival. High Andean grasslands burned more frequently as humans occupied landscapes with many sites showing substantial modification by 7000 BP. Studies of the timber line, however, have failed to show any real impact on the upper limit of the forest edge. Great cultures rose and fell along the South American coast and in the Andean highlands, but their ecological significance was essentially local.

Humans have undoubtedly impacted the states and processes of ecosystems for millennia, and it is important to understand those impacts. From our anthropocentric view human impacts are profound, though transgressive across time and ecosystem, but when viewed from 65 million years in the future, which of these impacts will appear significant and identifiable? When seen from an almost concurrent vantage point how sharp should the golden spike be?

Conroy, Jessica L., Hudson, Adam M., Overpeck, Jonathan T., Liu, Kam-Biu, Wang, Luo, and Cole, Julia: THE PRIMACY OF MULTIDECADAL TO CENTENNIAL VARIABILITY OVER LATE HOLOCENE FORCED CHANGE OF THE ASIAN MONSOON ON THE SOUTHERN TIBETAN PLATEAU (Section IV). The nature of multidecadal to centennial variability of the Asian monsoon remains largely unknown. Here we use the sediment record from a closed-basin lake in southern Tibet, Ngamring Tso, to assess summer monsoon precipitation from 4100 cal yr BP to present. The first principal component of the Ngamring Tso grain size record correlates significantly with observed June-September precipitation. From CE 1940-2007, grain size decreased with increasing summer precipitation and increased with decreasing summer precipitation. Satellite images of Ngamring Tso suggest precipitation-induced changes in lake depth or area likely govern grain size variability. Prolonged periods of weak summer monsoon precipitation occurred from 2800-2600 cal yr BP, 2500-2300 cal yr BP, and 1600-400 cal yr BP. A trend toward increased summer precipitation began around 1000 cal yr BP, with above-average summer precipitation from 400 cal yr BP to present, peaking between 200-100 cal yr BP. Dry and wet periods are coincident with dry and wet periods in other south-central Tibetan lake sediment records and with regional proxies

of the ISM and EASM, indicating south-central Tibet is influenced by both monsoon subsystems. 20th century precipitation variability in southern Tibet falls within the range of natural variability in the last 4100 years, and does not show a clear trend of increasing precipitation as projected by models. Instead, it appears that poorly understood internal modes of monsoon variability remained influential throughout the last 4100 years. Substantial multidecadal to centennial-scale variability will thus complicate our ability to project future anthropogenic changes in the region's monsoon precipitation.

Dutton, Andrea, Carlson, Anders, Long, Antony, Milne, Glenn, Clark, Peter, DeConto, Robert, Horton, Benjamin, Rahmstorf, Stefan, and Raymo, Maureen: SEA-LEVEL RISE RESPONSES TO POLAR ICE SHEET RETREAT DURING PAST WARM PERIODS (Section II). One of the challenges entailed in projecting the magnitude and timing of future sea-level rise is that humans have not previously witnessed, much less documented, major retreat of the polar ice sheets in Greenland and Antarctica in response to polar temperatures warmer than today. This presents a conceptual hurdle for ice sheet modelers, who strive to make projections of ice sheet behavior but lack comprehensive observational data of all of the physics involved in this process. A complementary approach to projecting how polar ice-sheet retreat will unfold is to integrate observations of sea-level change during past warm periods with models of sea level, ice sheets, and climate to determine the expected response of sea level in the future.

Here, I will summarize results from a recent review that evaluated polar ice-sheet mass loss during several warm periods, including interglacials during the mid-Pliocene warm period, Marine Isotope Stages (MIS) 11, 5e (Last Interglacial), and 1 (Holocene) (Dutton et al., 2015). Magnitudes of sea-level rise during these past warm periods, when global mean temperatures were ~1-3 °C warmer than preindustrial, serve as important benchmarks for ice sheet models and reveal the potential magnitude of long-term sea-level rise commitments. Based on the existing evidence in the geologic record, it is clear that our present climate is warming to a level associated with significant polar ice-sheet loss in the past, equivalent to a global mean sea-level rise of at least 6 meters or more above present.

A key component that has led to recent advances in sea-level reconstructions is the ability to recognize and quantify the imprint of geophysical processes, such as glacial isostatic adjustment (GIA) and dynamic topography, which lead to significant spatial variability in sea level reconstructions. Recent progress has also been made in ice sheet modeling by incorporating processes of hydrofracturing and ice cliff failure that are now able to reproduce targets provided by these benchmarks of sea-level rise in the past (DeConto and Pollard, 2016). This ice sheet model predicts that Antarctica alone has the potential to contribute more than a meter of sea-level rise by 2100. Additional work integrating data on past sea-level rise demonstrates that by the year 2100, we may be committed to 10s of meters of sea-level rise depending on the trajectory of future carbon emissions (Clark et al., 2016). Even with improved interpretation of past magnitudes of sea-level rise, there remain several challenges, including identifying specific ice-sheet sources that contributed to higher sea levels, relating sea level response to concomitant ambient climate conditions, and elucidating past rates of sea-level change. Nonetheless, the paleo record of sea-level rise during past warm periods is able to inform us that our future can be expected to involve continuous global mean sea-level rise that will continue for several millennia, as the polar ice sheets respond to our changing climate.

Dutton, A., Carlson, A. E., Long, A. J., Milne, G. A., Clark, P. U., DeConto, R. M., Horton, B. P., Rahmstorf, S., Raymo, M. E., 2015. Sea-level rise due to polar ice-sheet mass loss during past warm periods. Science, 349(6244), aaa4019.

Clark, P. U. et al., 2016. Consequences of twenty-first-century policy for multi-millennial climate and sea-level change. Nature Climate Change, 6, 360-369.

DeConto, R. M. and Pollard, D., 2016. Contribution of Antarctica to past and future sea-level rise, Nature, 531, 591-597.

Grimm, Eric C., Ashworth, Allan C., Bills, Brian, Blois, Jessica, Charles, Don F., Goring, Simon J., Graham, Russell, W., Smith, Alison J., and Williams, John (Jack) W. (Section III): NEOTOMA PALEOECOLOGY DATABASE: COMMUNITY-LED CYBERINFRASTRUCTURE FOR GLOBAL CHANGE RESEARCH. The Neotoma Paleoecology Database (www.neotomadb.org) is a multiproxy relational database that includes fossil data for the past 5 million years (the Pliocene and Quaternary) and modern surface-sample datasets for calibration. Neotoma is an international collaborative effort among individuals from more than 20 institutions worldwide, including domain scientists representing a spectrum of Pliocene-Quaternary fossil data types, as well as experts in information technology. Neotoma is an open-access community database that provides the underlying cyberinfrastructure for a variety of disciplinary database projects. Neotoma serves as a central repository for existing paleo databases for pollen (the North American, European, and Latin American Pollen Databases), vertebrate fauna (FAUNMAP I & II, MioMap, Mexican Quaternary Mammal Database, ANTIGUA), ostracodes (NANODe), and diatoms (Diatom Paleolimnology Data Cooperative), and continues to develop data cooperatives for new regions and data types, including insects, isotopes, testate amoebae.

Neotoma is essential cyberinfrastructure for global-scale climate-change research. The constituent databases have been the foundation for synoptic paleoclimatic and paleoenvironmental studies that provide understanding of the context for recent global change. These databases are used for almost every aspect of this research, from broad-scale studies to understanding the context of local site studies. Neotoma has the practical objective of providing a common data structure for a wide variety of paleo data types, lowering community-wide paleo data management costs, while at the same time enhancing overall access and analysis tools. The database structure simplifies cross-disciplinary multiproxy analyses and supports the development of common software tools such as Tilia and the neotoma R package that facilitate data ingest, display, discovery, analysis, and distribution. The capacity to analyze multiproxy datasets from multiple ecosystem components has led to important new insights into past changes and relationships between and among Earth system components. These insights would not be possible from the study of one data type alone.

A key design concept of Neotoma as an institutional body is that “stewards” for various data types or constituent databases are able to remotely upload data to Neotoma and manage data already in Neotoma. Paleo-data cooperatives, whether organized by proxy type or geographic region, can appoint their own stewards. Neotoma provides a query and map-based web user interface, Neotoma Explorer, for exploring and acquiring data at the dataset level. Explorer provides tools for displaying stratigraphic diagrams and for plotting taxa occurrences in space and time. New tools under development include Ice Age Mapper, to convey the dynamism of species range shifts during the large climate changes of the last deglaciation, and Niche Viewer, for plotting the distribution of organisms along environmental axes, based on surface-sample datasets.

For developers and for open access to the database, Neotoma provides an Application Programming Interface (API), which is a set of web services that enable remote programmatic access to the database. The Neotoma API is already used by the NOAA National Centers for Environmental Information for searching and serving data from Neotoma and is used by the mobile app "Flyover Country," developed as a tool for geoscientific, spatially-based, data discovery.

He, Feng, Vavrus, Steve, Kutzbach, John, and Ruddiman, William: DID EARLY AGRICULTURE KICK OFF ANTHROPOGENIC GLOBAL WARMING THOUSANDS OF YEARS AGO? (Section V). Since the Industrial Revolution, approximately 1/3 of all anthropogenic carbon emissions have come from land use change (mainly deforestation). Currently, 40% of global land surface have been used for agriculture productions and land use change is the second largest source of anthropogenic carbon emissions behind fossil fuel and cement productions. But before 1950s, land use change associated with the agriculture productions is the dominant sources of global anthropogenic carbon emission. The deforestation associated with agriculture development started during the Neolithic Revolution ~10,000–5000 years ago, when human societies shifted from hunting and gathering to agriculture and settlement and slash-and-burn techniques were used for converting forests into cropland and pastures. Paleoclimate proxy evidence shows that both atmospheric CO2 and CH4 reversed downward trends in the late Neolithic period, with CO2 starting to rise ~8,000-6,000 years ago and CH4 ~5,000-3,000 years ago. Since the observed rise of CO2 and CH4 in the middle-late Holocene is not found in the previous three interglacials, Ruddiman (2003) proposed the "Early Anthropogenic Hypothesis" that deforestation and rice cultivation caused greenhouse gas increases in the Holocene, therefore anthropogenic global warming began thousands of years before the Industrial Revolution. Additional paleoclimate proxies, such as hydrogen isotope ratio in the Antarctic Ice cores and oxygen isotope ratio in marine benthic stack corroborate the Early Anthropogenic Hypothesis with similar distinctive trends in the Holocene (Ruddiman et al., 2016).

The global and regional surface temperature changes due to the Holocene land use change can be quantified using global climate models. Land use change influences global climate through both biogeochemical and biogeophysical feedbacks to the atmosphere. The biogeochemical effects of land use change include emissions of greenhouse gases and aerosols from biomass burning, deforestation, rice cultivation, etc. The biogeophysical feedbacks include modification of the land-atmosphere exchange of momentum and moisture, as well as radiative and heat fluxes. Using the reconstruction of the Holocene land cover changes by Kaplan et al. (2011), we quantified the local and global temperature response induced by Holocene land cover changes in the Community Climate System Model, version 4 (CCSM4) (He et al., 2014). With 1-degree resolution of the CCSM4 slab-ocean model, we find the biogeophysical effect of Holocene land cover change causes a global cooling of 0.17 °C, but the biogeochemical effects of Holocene land use change from carbon emissions dominate the biogeophysical effects by causing 0.9 °C global warming. The net effects of Holocene land use change amount to a global warming of 0.73 °C during the pre-industrial era, which is comparable to the ~0.8 °C warming during industrial times. Therefore, our modeling study supports the Early Anthropogenic Hypothesis that the development of early agriculture started anthropogenic global warming thousands of years before the Industrial Revolution.

He, F., Vavrus, S.J., Kutzbach, J.E., Ruddiman, W.F., Kaplan, J.O., and Krumhardt, K.M. (2014). Simulating global and local surface temperature changes due to Holocene anthropogenic land cover change. Geophysical Research Letters 41, 623-631.

Kaplan, J.O., Krumhardt, K.M., Ellis, E.C., Ruddiman, W.F., Lemmen, C., and Goldewijk, K.K. (2011). Holocene carbon emissions as a result of anthropogenic land cover change. Holocene 21, 775-791.

Ruddiman, W.F. (2003). The anthropogenic greenhouse era began thousands of years ago. Climatic Change 61, 261-293.

Ruddiman, W.F., Fuller, D.Q., Kutzbach, J.E., Tzedakis, P.C., Kaplan, J.O., Ellis, E.C., Vavrus, S.J., Roberts, C.N., Fyfe, R., He, F., Lemmen, C., and Woodbridge, J. (2016). Late Holocene climate: Natural or anthropogenic? Reviews of Geophysics 54, 93-118.

Jackson, Stephen T.: POST-GLACIAL PLANT MIGRATIONS: HOW FAR, HOW FAST, BY WHAT MEANS, UNDER WHAT CONTROLS, AND WHY DOES IT MATTER? (Section III). Late Quaternary plant migrations provide solutions to long-standing biogeographic puzzles, underpin fundamental understanding of the nature of plant communities, and serve as testing grounds for ecological models and theory. More urgently, migration comprises an important mechanism by which species can adapt to climate change, and so studies of past plant migrations can provide critical information on natural capacity for migration, including rates and governing processes.

Understanding past migration requires robust knowledge of where populations were – and were not – in the past. Paleoecological inference of past geographic distributions is subject to false positives (e.g., from redeposition or long-distance dispersal), but of far more consequence are false negatives, which may arise from many sources (e.g., detection limits, sample size, sampling density, sampling-network density, percentage masking). Plant macrofossil records reveal glacial-age populations of several species that went undetected in pollen records, and phylogeographic studies suggest glacial-age populations of species that were not detected in either pollen or macrofossil records. Fundamental questions remain of how far plant species had to migrate after the last glacial maximum, which translates into how quickly they might be able to migrate in the future.

Despite these uncertainties, it is clear that many plant species in both eastern and western North America migrated distances on the order of 102-103 km during the Holocene. For example, all plant populations occupying formerly glaciated terrain migrated from populations somewhere beyond the ice margins. Paleoecological studies of late Holocene plant migrations in the central Rocky Mountains and the western Great Lakes region provide some detailed glimpses into the patterns, rates, and mechanisms underlying plant migrations. Migrations rarely proceeded as waves or at constant rates, but were instead heterogeneous in space and time. Long-distance dispersal events, on the order of 25 to 100 km, occurred for both animal- and wind-dispersed species. Isolated advance populations often played critical roles in subsequent backfilling and further range expansion. Migrations were frequently episodic, paced by climate change and variability. Contingent dynamics, by which migration patterns were determined by previous climatic episodes and disturbance and colonization events, appear to be frequent. Within species, migration modalities changed in space and time.

These late Holocene records indicate that plant migration, like other ecological and biogeographic dynamics, is often complex and situation-dependent, integrating responses to the physical environment, biotic interactions, and chance events, and involving dynamics operating across multiple temporal and spatial scales. Broadening the spectrum of detailed cases studies will allow better understanding of the nature of these drivers and their interactions, which will in turn be valuable in assessing vulnerabilities and adaptive capacities in natural populations. Resources for assisted

migration and similarly intensive interventions are and will continue to be limited. Enhancing understanding of natural migration capacities and limitations will allow better allocation of conservation resources to where they're most urgently needed.

Kehrwald, Natalie, Argiriadis, Elena, Barbante, Carlo, Battistel, Dario, Kirchgeorg, Torben, and Zennaro, Piero: INCREASING FIRE ACTIVITY IN A WARMING CLIMATE? BIOMASS BURNING, CLIMATE AND HUMAN IMPACTS IN HOLOCENE ICE AND LAKE CORES (Section II). Humans, fire and climate have been interconnected for at least the last million years as evidenced by the oldest known hearth in Wonderwerk Cave, South Africa. This minimum of a million years of human control of fire as confirmed by barbeques in caves encompasses the major climatic shifts of ten glacial-interglacial cycles. The climate shifts from ice ages to relatively warm periods and back again was the major control of fire activity over these cycles. However, much of the evidence for the response of fire activity to a warming climate during interglacials is overprinted by subsequent glacial-interglacial cycles.

The Holocene contains the vast majority of evidence for the response of fire activity to a warming climate, but this interglacial also encompasses increased human activity. The northward retreat of the Laurentide Ice Sheet and the thawing of boreal regions opened up vast tracts of land for flammable vegetation, where this combination of a warming climate and increased vegetation resulted in a general mid-Holocene increase in fire activity. However, a growing human population in the Holocene intentionally and accidentally ignited fires where cumulative anthropogenic fire activity can overwhelm the climate-only fire signal. The NEEM ice core integrates fire activity from northern North American and Eurasian sources. Fire activity peaks in the NEEM ice core at ~2500 years BP, where this fire activity cannot be explained by climate variables alone. Vegetation and charcoal syntheses demonstrate the spread of agriculture in Europe and associated land clearing through burning ~3000 to ~2500 yr BP, where models incorporating anthropogenic activities demonstrate maximum land clearance in Europe during this same time period.

Specific molecular markers of biomass burning and the presence of humans (levoglucosan and fecal sterols) in lake cores quantify the arrival of humans to specific catchments and the almost simultaneous increase in fire activity. Small bands of humans were capable of deforesting ~40% of New Zealand in less than a century, where this fire activity existed separately from climate changes. The emissions from these New Zealand fires altered atmospheric chemistry to the point where this biomass burning creates an exponential increase in fire activity in the EPICA, DOME C East Antarctica ice core. Humans therefore fundamentally changed the fire landscape thousands of years ago, where this anthropogenic imprint continues until the present. Incorporating the potential impacts of human activity is essential to determining the complete response of fire activity to a warming climate.

Kelsey, Harvey: THE FREQUENCY OF DEVASTATING TSUNAMIS IN THE INDIAN OCEAN: IMPLICATIONS FOR PREPAREDNESS OF INDIAN OCEAN COASTAL SETTINGS FOR THE NEXT TSUNAMI SIMILAR TO DECEMBER 2004 (Section IV). The December 2004 Aceh-Andaman subduction zone earthquake and tsunami (Mw ~9.2) marked a turning point in scientific attention and hazard assessment of tsunamis in the Indian Ocean. The turning point involved an increase in scientific focus on the Sumatran subduction zone and increased awareness of the importance of a warning system for tsunami hazard in the Indian Ocean. The 2004 tsunami, triggered by the second largest earthquake ever instrumentally recorded,

resulted in a death toll across coastal settings in the Indian Ocean that exceeded 230,000, and affected peoples in Indonesia, Malaysia, Thailand, India, Sri Lanka, the Maldives and east Africa. Paleoseismology can address the question, how frequently do tsunamis of this magnitude occur in the Indian Ocean? In this talk, I focus on an example of the scientific research that was carried out after the earthquake in an attempt to better understand the frequency of large tsunamis. The field area is the Aceh coast of northern Sumatra, a region devastated by the 2004 earthquake and tsunami. Tsunami occurrences are preserved in sand layers in coastal sedimentary sequences, and the sand is similar to the sand deposited on the land surface in December 2004. Detailed micropaleontologic and sedimentologic investigations are necessary to discern tsunami sand from other types of sandy deposits. Coasts with rising relative sea level provide complete records of coastal inundation whereas tsunami preservation is more obscure on coasts with falling or stable relative sea level. At Aceh, detailed investigations at 2 coastal sites 8 km apart revealed the same stratigraphy. In the period of rising relative sea level from 7000-3800 year BP, there were 5-6 instances of tsunami inundation with three of those accompanied by earthquakes large enough to produce long-lasting land level changes. In the ensuing years from 3800 years ago to present, when relative sea level was stable, there were an additional 4-6 instances of tsunami inundation. The evidence for the latter period of tsunamis is a remarkable sequence of massive sand, 1.3-2.0 m thick, that is best interpreted as a sequence of tsunami deposits stacked on top of each other and preserved on an emergent coastal plain during a prolonged time of stable sea level. Taken together, over last 7000 years, there have been between 9-12 tsunamis that have invaded the Aceh coast. Assuming each of these tsunamis was comparable in size to the 2004 tsunami, then an average recurrence interval of such large tsunami inundation events is 600-800 years. However, the average interval means that highly damaging tsunamis could occur as frequently as several in a human life span or none over the course of multiple life spans. Also challenging for Indian Ocean tsunami preparedness is that about 90% of tsunamis have occurred in the Pacific Ocean associated with offshore earthquakes along the subduction zones that encircle the Pacific. Such an observation does not lessen the seismic hazard of the Sumatran subduction zone; to the contrary, the relative lack of tsunamigenic reminders in the Indian Ocean highlights the need for continuing education and maintenance of warning infrastructure so that tsunami awareness in the Indian Ocean is transgenerational.

Kidwell, Susan M.: BIOLOGY IN THE ANTHROPOCENE: EVALUATING HUMAN IMPACTS USING THE YOUNGEST FOSSIL RECORD (Section III). Scientists, environmental managers, and the public increasingly appreciate the diverse and pervasive effects of humans on natural biological systems. However, hard data on rates and patterns of change and on reference (‘baseline’) conditions from even a few decades to centuries ago, crucial to evaluating magnitudes and patterns of change and the likely resilience of modern-day systems to continued stress, are extremely difficult to acquire: direct observation often started long after human stresses began. ‘Conservation paleobiology’ is proving to be a powerful approach in both marine and terrestrial settings, using fossils from the youngest sedimentary record, including remains that are still actively accumulating on modern land surfaces and seabeds. Strong advances both in geochronology and in isotopic and other geochemical proxies now largely liberate fossils from those traditional duties, and a rich body of research has established the temporal and spatial resolution of fossil assemblages and their fidelity to original biotic patterns at the community to regional scale, a persistent data gap even for living fauna. On land, bone assemblages can detect recent

shifts in species' proportions in response to stressors (e.g., invasives, fire) and patterns of habitat use in remote areas (e.g., wintering and calving grounds). In coastal settings, the time-averaged nature of molluscan and other macrobenthic dead-shell assemblages collected in the upper ~10 cm of the seabed is proving to be a powerful means of (i) recognizing that habitats have changed – e.g., by the contrast in the species composition of the death assemblage relative to the current living community – and evaluating (ii) how the system changed (e.g., by nutrient enrichment, based on which species occur dead-only and which occur alive-only) and (iii) when it changed (e.g., the geologic age of the youngest dead shell of a habitat-diagnostic species). Such simple geological methods, even in the absence of cores, are sufficient to discriminate natural and anthropogenic drivers, recognize species not otherwise known to be in decline, and assess the progress of recoveries. Examples from current projects in different settings on several continents demonstrate how the field is now moving from research to direct applications, working with regional stakeholders in biological conservation and environmental management.

McFadden, Leslie D.: NON-STEADY STATE HILLSLOPE DYNAMICS AND IRRREVERSIBLE LANDSCAPE CHANGES AT A SHIFTING PINYON-JUNIPER WOODLAND ECOTONE IN NORTHWESTERN ARIZONA (Section IV). The spatially extensive, soil-mantled pinon-juniper woodlands in semiarid regions of the western U.S. are experiencing a warming climate, and face continuing warming and likely more frequent and severe droughts in the coming several centuries. These climate changes will cause severe reduction or extirpation of woodlands throughout much the American Southwest by the late 21st century, prompting the question of how the disappearance of these woodlands will impact associated hillslope- and soil-forming processes. Studies of landscapes dominated by Jurassic sandstones of the SE Colorado Plateau provide an answer. Critical to these studies is the proposition that hillslope aspect-related topoclimatic variation can provide insights into the impacts of temporal climate variation. Hillslopes with mainly north aspects are typically smooth and curvilinear, soil mantled and pinon dominated. Colluvial transport occurs largely by diffusive, abiotic creep, favored in a relatively mesic environment by rapid weathering of clay cemented sandstone to mobile regolith with A-C-Cr soil profile development by hydration-expansion and dehydration-contraction cycles. Given their capacity to retain water and soils, these transport-limited hillslopes represent a conserving ecohydrologic, steady state system. The geomorphologic behavior of such hillslopes may best be described by a soil production function. Drier south-facing hillslopes have a xerophytic shrub community and are typically steeper, with abundant bare bedrock steps and cliffs. These hillslopes are mainly detachment limited and represent a largely non-conserving ecohydrologic system. The existence of these co-existing, yet fundamentally different hillslope systems is a direct consequence of topoclimatic variation. Measured differences in soil temperatures as a function of aspect are similar to predicted temperature increases. This also implies that the warmer and effectively drier interglacial climate of the Holocene has been conducive to transformation of formerly mesic to xeric hillslopes, and evidence of such hillslope transformation is observed. Future anthropogenic warming is anticipated to accelerate this process, especially in the ecotone between woodland and scrub vegetation. This hypothesis was tested through mapping of soil thickness, dendrochronologically determined soil erosion rates and tree mortality and establishment. Evidence of very recent and ongoing rapid soil loss and bedrock exposure in the ecotone is demonstrated by spatial patterns of cliffrose (Purshia stansburiana) recruitment and root exposure.

Rapid erosion is also exposing calcite-cemented concretions, representing the initial stage of hoodoo evolution, a landform well developed on xeric hillslopes, but absent on mesic hillslopes, where subsurface weathering is sufficient to preclude their formation. The rapidity of hillslope transition also is favored by the lack of strong A-B-C soil profile development. Such soils form over 104 to 105 years by dust incorporation-driven accretionary and inflationary profile development in semiarid regions where favorable rock types produce abundant coarse surface clasts.

Despite having been subject to the effectively cooler and moisture climate during about 70 to 80 percent of the Quaternary Period, hillslope transitions during warmer periods to steeper, bedrock hillslopes is largely irreversible, and therefore cumulative. Rocks with properties comparable to those of Jurassic sandstones occur throughout the American Southwest and similar landscape changes are observed, even in higher elevation ponderosa pine forested hillslopes, indicating that the threshold separating mesic and xeric hillslopes will shift, accompanied by substantial geomorphological changes.

McKay, Nicholas and Emile-Geay, Julien: A GLOBAL MULTIPROXY DATABASE FOR TEMPERATURE RECONSTRUCTIONS OF THE COMMON ERA (Section II). Diverse and distributed observations, and accurate reconstructions, of climate of the past two millennia are critical for placing industrial-era warming in the context of natural variability. In 2013 the PAGES 2k Consortium released a temperature database with more than 500 records from 7 continental-scale regions, along with temperature reconstructions derived by expert groups for each region. A major motivation of this effort was to increase the amount of regional expertise involved in identifying and evaluating paleoclimate records for their use in temperature reconstructions. The project succeeded in highlighting the value of engaging the broad expertise in paleoclimatology; however, the resulting database was somewhat disjoint, as each group assembled data independently with somewhat distinct goals and criteria; which hindered the use of the database to answer questions that span across multiple regions. Moreover, whereas the data the were assembled into a common location, key data (e.g., native measurements, chronological uncertainties) and metadata (e.g., seasonality) were not included. Phase 2 of the PAGES 2k temperature project aimed to improve upon these shortcomings and produce a community-built flexible database that can be used to address major questions about the climate of the Common Era, and the methodologies we use to reconstruct it. Phase 2 of the temperature database includes about 700 temperature-sensitive timeseries, derived from ten archive types, and a rich and well-formatted set of metadata that are readily queried and analyzed. Here we present preliminary investigation of the database, including both an exploration of the fidelity of the records, and first results from investigation of the data. The relationship of the proxy network to a gridded temperature dataset (HadCRUT4.2) is analyzed at seasonal and annual scales, showing that more than 75% of instrumental gridboxes are within 2000 km of a proxy record, with which they share significant common variance, whether at annual or seasonal scales. This represents about twice the spatial coverage of the previous incarnation of the PAGE2k dataset. We present a simple global composite timeseries of annual-mean temperature over the past 2000 years, showing remarkable consistency between high- and low-resolution proxy records in their depiction of the most salient common signal in global mean annual temperature. These first blush analyses, as well as emerging investigations enabled by this dataset, highlight the potential for further discovery with these data, which were assimilated with the primary goal of facilitating and

accelerating discovery in paleoclimate research. We encourage the paleoclimate community and Quaternarists everywhere to take advantage of this open resource to fulfil this potential.

McLachlan, Jason S.: ECOSYSTEM FORECASTING MODELS AND PALEOECOLOGICAL DATA NEEDS (Section III). The paleoecological community has repeatedly pointed out that modeled forecasts of future changes in the Earth's ecosystems are under-informed by knowledge about the deep past. Quaternary paleoecology has the potential to helpfully inform conservation, management, and policy planning in the Anthropocene by quantifying the slow and infrequent ecological processes that can't be easily observed in short term studies and by characterizing the dynamics of past ecosystem change, which serve as imperfect analogs for the future. Although global change forecasters are increasingly recognizing the value of paleoecological insights, few would argue that paleoecology has fulfilled its promise as a quantitative tool for informing forecasts.

My colleagues in the PaleoEcological Observatory Network (PalEON) and I have identified three steps that can help paleoecology inform global change forecasts more directly. First, modern statistical tools allow us to translate paleoecological proxies into the units used by forecast models. Building on existing calibration approaches, PalEON has developed Bayesian statistical tools for estimating NPP and also for disentangling temperature and precipitation signals in tree-ring records. From sedimentary proxies, we have developed statistical estimates of changing biomass, forest composition, and wildfire probabilities. Each of these estimates is now directly comparable to model parameters and outputs.

Second, the uncertainty associated with these statistical estimates allows improved inference about the significance and magnitude of past changes. Statistical models of paleodata allow us to identify the timing and location of past changes in ecosystem state that emerge beyond the noise in the data. This allows better model calibration and validation. Statistical models of paleodata also identify the gaps in data coverage that most urgently need to be filled.

Finally, statistical estimates of past ecosystem state allow us to improve forecasts of the future by combining the real-world information in the paleorecord with the mechanistic framework of ecosystem models through the use of data assimilation. Even the best ecosystem models are coarse simplifications of the real world and forecasts from models alone are subject to the weaknesses of these simplifications. Paleodata, by contrast, record real changes in the past, but do not provide a forecast of future conditions. Joint inference from data and models allows us to produce a mechanistic forecast that is constrained by the dynamics identified in real data. We show that assimilating paleodata into ecosystem models allows improved estimates even of processes like gross primary production, for which no direct paleoecological proxy exists.

Not all inference from paleodata need be statistical, but ecological forecasts do need paleodata to inform the processes that cannot be observed on the modern landscape. Because so much rests on accurate predictions from ecosystem models, it is imperative that these models leverage the information in paleodata in a way that respects both the signal and the noise in the data. This will require collaborative efforts of paleoecologists, statisticians, and ecosystem modelers.

Owen, Lewis A.: RELATING QUATERNARY GEOCHRONOLOGY AND GEOMORPHOLOGY TO RATES AND PROCESSES IN THE ANTHROPOCENE (Section IV). Much debate surrounds whether the Anthropocene should be ratified as a formal division of the geological timescale and, if so, what should be used to

define its base. Defining the timing and rates of natural and human-induced environmental change is critical for characterizing the nature and status of the Anthropocene. Fortunately, newly developing geochronological and geomorphic methods are contributing much in the discussion of magnitude and frequency of natural and human-induced environmental change during the late Quaternary. Advances in geomorphic methods include remote sensing, high-precision airborne and land-based surveying and global positioning systems, digital elevation and terrain modeling, improved landsystems and lithofacies analysis, and numerical modeling. In particular, countless datasets produced by many of these methods are readily and freely accessible to the scientific community and public. Most notable has been the development of high resolution Google Earth images; an incredible resource allowing Earth's surface to be explored at ever increasing detail. The past few decades has also seen a mini-revolution in geochronology, particularly the rapid development of the use of cosmogenic nuclides and optically stimulated luminescence dating. With these advances it is now possible to examine and quantify the complex relationship between humans and surface processes across a broad range of spatial and temporal scales, from an individual location to across the global and real time to across the span of human existence and beyond. Numerous challenges exist in relating geomorphic processes to human-influences despite these advances. Most notably this includes improving the accuracy and precision of dating, and understanding the limitations of the various geochronological methods that are presently applied. However, recent community wide initiatives are helping to address these challenges and are beginning to aid in resolving the complex natural and human forcing inherent in geomorphic systems. As the world's surface continues to rapidly change there is a need to enhance community-wide programs to define the rates and magnitudes of geomorphic change on human timescales. Important research questions that need to be addressed include: i) How do landforms and landscapes arise and what do they tell us about rates of nature and human-induced surface processes? ii) What are the transport laws that govern landform and landscape evolution? iii) How do ecosystems and landscapes coevolve; v) What controls landscape resilience to change? and vi) What do landform and landscapes tell us about the future and how will they may evolve?

Quade, Jay, Abell, Jordan, Stiner, Mary, McIntosh, William, and Semaw, Sileshi: THE EARLIEST ANTHROPOCENE AND THE "AGE OF GARBAGE" (Section II). Field geologists tens of millions of years from now will probably define the base of the Anthropocene by the first appearance of trash, because trash is much more obvious and ubiquitous than hominim fossils. Human trash first appears in Africa during the late Pliocene in the form of stone tools. In this talk I will discuss old stone tools found at Gona in Ethiopia from the perspective of a stratigrapher and paleoecologist: what they are made of (carefully selected raw materials), how they were dated (2.58 Ma: paleomagnetism and 40Ar/39Ar), where they occur on the paleo-landscape (floodplain margins), and the possible reasons for their rather sudden appearance stratigraphically.

Trash really started to pile up in the Neolithic when people settle down, so in the second part my talk I will examine the bulk composition and geochemistry of trash from a Neolithic archeological site, Asikli, in central Turkey. Most archeological tells are just large trash heaps that will really stand out and preserve readily in the future geologic record. Physically, the tell at Asikli is dominated by building debris, wood ash, and minor bone and obsidian. Chemically, the tell at Asikli contains conspicuously high soluble Na+, Cl-, NO3-, and $\delta^{15}N$ values of ≥+13‰. We suggest that these salts derive from urine—

both human but probably mostly animal. The abundance of urine at Asikli is plausibly linked to very early animal domestication and corralling on the site itself.

The first appearance of trash was globally quite diachronous, probably disqualifying trash as a near-term marker of the basal Anthropocene. However, tens of millions of years from now field geologists will chiefly recognize us for our trash, whereby the Cenozoic "Age of Mammals" is succeed by the Garbocene, the "Age of Garbage".

Revkin, Andrew C.: COMMUNICATING IN, AND ABOUT, THE ANTHROPOCENE (Keynote). Humanity has become a global force, changing climate, ocean chemistry, the flows of a host of elements and the course of evolution in ways that will resonate for many millennia and form a distinct signature in layered sediments and, ultimately, rock. But what do humans call this moment, and – more importantly – what do societies do with this knowledge?

For the moment, the operative word is Anthropocene – a word that may eventually formally denote a new geologic period or, in the absence of a better term, simply spread as a name for Earth's turbulent human age.

It's notable that outside of the relatively small community of humans focused on the geologic past and environmental future of the Earth, the word Anthropocene is still largely unknown. It was first uttered (in a way that stuck) at a scientific conference in 2000, when the Nobel laureate and atmospheric chemist Paul Crutzen bridled at the continuing use of Holocene to describe the current human-disrupted era of planetary history. He sputtered out the new term, which had independently, and more quietly, been used off and on by a diatom expert, Eugene F. Stoermer.

Anthropocene began to stick and spread, quietly making it into the Oxford English Dictionary in 2014, along with a batch of far more quotidian terms, including "selfie" and "hip-hopping."

The term has stimulated an expanding corpus in scholarly fields ranging from philosophy to economics to the arts, seemingly shaking things up wherever it is mentioned. This is not surprising given that any neologism related to consequential issues works like a Rorschach inkblot, eliciting a host of values-laden interpretations.

Within the rarefied world of stratigraphy, and at the intersection of this science and the relatively young interdisciplinary field called Earth system science, divisions have formed over the evidence for, and utility of, such a chronostratigraphic designation. Within a few years, or maybe a decade or two the way these things go, the upper-case word Anthropocene could end up formally describing a new epoch in the Geologic Time Scale, cutting short the Holocene less than 12,000 years after that epoch began.

The Anthropocene Working Group, established in 2009 by the Subcommission on Quaternary Stratigraphy of the International Commission on Stratigraphy, met in Oslo in April to gauge next steps in presenting its evidence for such an epoch to the wider geological community. A short summary of the main issues raised there will be used to elicit feedback from the AMQUA audience in hopes of shaping next steps for the Working Group, the wider geosciences community and the word itself.

Shakun, Jeremy, Marcott, Shaun, He, Feng, Mix, Alan, Liu, Zhengyu, Otto-Bliesner, Bette, Eby, Michael, Levermann, Anders, and Winkelmann, Ricarda: FROM THE ICE AGE TO THE ANTHROPOCENE: WHAT THE LAST 21,000 YEARS TELLS US ABOUT 21ST CENTURY CLIMATE CHANGE AND BEYOND (Section II). Climate

over the past 21,000 years spans both the last major global warming event and the Holocene baseline from which the Anthropocene is departing – two key lenses for better understanding the future. An emerging view of the last glacial termination from global proxy records and climate modeling depicts a highly interconnected climate system, with several reinforcing regional-scale feedbacks that transformed a modest radiative perturbation into a global-scale deglaciation primarily through CO2. In keeping with Milankovitch's hypothesis, the sequence starts with rising summer insolation in the northern high latitudes, which initiated pullback of Northern Hemisphere ice by 20-19 ka. The resulting freshwater flux to the North Atlantic weakened the Atlantic Meridional Overturning Circulation, causing bipolar seesaw warming of the Southern Hemisphere. Attendant changes in the Southern Ocean spurred CO2 evasion to the atmosphere, driving global-scale warming and reinforcing northern ice melt at the start of the chain. Despite the apparent precariousness of this causal chain, it may have played out repeatedly over late Pleistocene deglaciations, suggestive of the robustness of these teleconnections and feedbacks. Decreasing Milankovitch forcing triggered no such strong, globally-coordinated feedbacks over the Holocene, however, which was instead characterized by modest regional changes and global temperature variations within perhaps 1°C or so. Given the observed 1°C warming over the past century and the current global energy imbalance, global climate will therefore likely exit the Holocene range within the next several decades, if it has not already. Long-term model projections underscore the longevity of impacts associated with 21st century carbon emissions, which will control the magnitude of warming and sea-level rise for at least the next 10,000 years – a time scale almost wholly missing from public and policy debates on climate change and perhaps mostly easily conveyed through a Quaternary perspective.

Syvitski, Jai P.: SEDIMENT FLUX AND THE ANTHROPOCENE: GRAND CHALLENGES FOR QUATERNARISTS (Section IV). The Anthropocene was formally proposed in 2000 as Earth's newest epoch, a period during which humanity's impact on the planet has rivaled that of the great geological forces. The concept began with Buffon's 1778 'seventh epoch' or Antonio Stoppani's late 19th century 'Anthropozoic'. Humans are changing the Earth's biophysical system — atmospheric and ocean climatology and chemistry, extent of snow cover, permafrost and sea-ice, glacier, ice-sheet and ocean volume, and indeed the hydrological cycle. Some changes are truly global, represented by similar temporal trends — atmospheric greenhouse gases, global surface temperatures, nitrogen fluxes, and species extinctions.

Striking is the extent and rate at which humans have modified Earth's land surface. Humans are now the largest force in the movement of sediment — greater than ice, wind and water. There are millions of abandoned mines throughout the world. We mine more than 9 Gt/y of coal, our aggregate production is 13 Gt/y, hydraulic cement production is 2.2 Gt/y, and global iron ore production is 2.2 Gt/y. The Palm Islands of Dubai required 3 Gt of sand; the Hong Kong airport island required 0.6 Gt of sediment. How large is a Gt? The Great Wall of China is 0.4 Gt of bricks & stone.

Historical deforestation and land clearing have greatly impacted soil erosion, hill slope failure and downstream sedimentation. And climate often amplifies our human footprint — during the Great American Dust Bowl a combination of poor tilling practice and a prolonged drought caused 94,000 km2 or agricultural land to lose 12.5 Gt of topsoil. Human activities have led five Asian Rivers to carry an extra 1400 Gt to the coastal ocean over the last millennium. That is equivalent to an outcrop 1 m thick covering an area of 933,000 km2. Engineered levee systems, some such as along the Yellow River have

become unnaturally super-elevated 5 to 20 m above their floodplain for over a thousand kilometers. Humans have built one large dam every day for the last 130 years. This has changed the hydrology of rivers and trapped Gt/y of sediment within their reservoirs. Deltas are starved of sediment, and in combination with the mining of water, oil and gas, large deltas are sinking four times the rate sea level is rising due to climate change.

This paper outlines the grand challenges to Quaternarists. Future contributions are needed on two fundamental questions. 1) Have humans changed the Earth system such that recent and currently forming geological deposits include a distinct and preservable signature from Holocene and earlier epochs? This formalization question involves standard litho-, chemo- and bio-stratigraphic approaches, though novel phenomena are of interest. 2) When did this stratigraphic signal become recognizable worldwide? This chronostratigraphic question involves correlatory data to the decadal level. Proposals for the start of the Anthropocene include: (i) an "early Anthropocene"; (ii) the Columbian Exchange of Old and New World species; (iii) the Industrial Revolution ~1800 CE; and (iv) the mid-20th century "Great Acceleration" of population growth, industrialization, and mineral and energy use.

Terry, Rebecca C. and Rowe, Rebecca J.: HOLOCENE ENERGY FLOW THROUGH SMALL MAMMAL COMMUNITIES AND MODERN GRASSIFICATION OF DESERT SHRUBLANDS (Section V). Efforts to understand the ecological impacts of environmental change have predominantly focused on short-term species-level responses, leaving the response of aggregate community- and ecosystem-level properties poorly understood. It is often assumed, for example, that properties such as community richness, biomass, and energy flow are robust to environmental change due to compensatory dynamics at the species level. However, many higher-level processes unfold over time-scales too long for direct observation or experimentation.

Here we examine how energy flow within Great Basin small mammal communities responded to climate-driven environmental change from the late Pleistocene through the late Holocene using fossil archives derived from long-term owl roosts. We then compare these long-term baseline dynamics to trends observed over the last century. Our analyses reveal that energy flow through small mammal communities during today's heightened climate warming differs markedly from that experienced during natural rapid climate warming in the past. Specifically, energy flow during rapid climatic warming at the terminal Pleistocene was remarkably stable despite dramatic turnover in the distribution of body size classes and habitat-associated functional groups. Functional group turnover was strongly correlated with climate-driven changes in regional vegetation, with climate and vegetation sequentially preceding energetic shifts. In stark contrast, the dynamics of the last century reveal a substantial reduction in energy flow associated with a rise in the energetic dominance of small-bodied species with an affinity for closed grass habitats.

These results suggest that modern changes in land cover due to anthropogenic activities - particularly the replacement of shrublands by invasive annual grasses introduced to North American deserts a century ago - has led to a breakdown in the compensatory dynamics of energy flow. The result is an energetically novel ecosystem, with human activities modifying the small mammal community in ways that differ from our climate-driven expectations based on the past.

Tierney, Jessica: TROPICAL OCEAN TEMPERATURES DURING THE LAST MILLENNIUM: LATEST RESULTS FROM THE OCEAN2K PROJECT (Section II). Most reconstructions of recent past changes in ocean sea-surface temperatures rely on terrestrial proxy information, which is assumed to provide inference on ocean conditions via ocean-atmosphere teleconnections. It is unclear, however, whether these linkages have remained stationary in time. The goal of the Ocean2K project was to provide assessments on recent past changes in SST that are independent of terrestrial constraints and are based on all available published, publicly-archived data. In this talk, I'll focus mainly on the SST reconstructions derived from coral archives. The O2K coral-based reconstructions provide comprehensive histories of tropical SST variations spanning back to ca AD 1600. The results shed light on how the tropics respond to volcanic eruptions, how The El Niño-Southern Oscillation has varied through time, and the onset of anthropogenic warming.

Van Metre, Peter C.: RECONSTRUCTING ANTHROPOGENIC CONTAMINANT TRENDS USING LAKE AND RESERVOIR SEDIMENT CORES (Section V). Contaminant trends can provide a warning of degradation, indicate success or failure of management and remediation strategies, and improve our understanding of cause and effect. Availability of historical water-quality and atmospheric deposition data for trace contaminants, however, is limited to non-existent. The U.S. Geological Survey is using paleolimnology to evaluate modern (past ~50-150 y) contaminant trends as part of the National Water Quality Assessment (NAWQA) Project. Sediment cores from natural lakes in undeveloped watersheds are used to estimate changes in the rates of atmospheric deposition of mercury, polycyclic aromatic hydrocarbons (PAHs), and other contaminants. Sediment cores from urban lakes and reservoirs are used to determine trends in metals and organic contaminants such as DDT, PCBs, and PAHs in urban streams and lakes in response to urbanization, environmental regulation, and changes in product use and lifestyles. Techniques such as isotopic analyses of metals and receptor modeling of organic contaminant classes are being used to evaluate trends in contaminant sources. Sampling and interpretation approaches for different settings and objectives will be illustrated using data from some of the over 100 lakes and reservoirs sampled by NAWQA from 1992–2012.

Williams, John W., Blois, Jessica L., Goring, Simon, Grimm, Eric C., Jackson, Stephen T., McLachlan, Jason S., Ordonez, Alejandro, and Veloz, Samuel (Section III): LARGE-SCALE SYNTHESES IN THE QUATERNARY: NEW APPROACHES, NEW INSIGHTS. The Quaternary offers multiple advantages for biogeographers and global change ecologists interested in understanding the climatic and biotic processes governing species distributions, community assembly, and species persistence (or extinction) during periods of large environmental change. Climate changes were large, repeated, and abrupt, with regional rates of change similar to those projected for the 21st century. Shifts in insolation and temperature seasonality produced climates with no modern analog. There is a long tradition of data-model comparisons in paleoclimatology, with paleoclimatic proxies used as benchmarks for earth system models, to put recent climate changes into context, and to understand the natural and anthropogenic drivers of climate variations. A new wave of data-model comparisons has emerged over the past decade, primarily focused on testing biogeographic theory and assessing and improving the predictive ability of ecological forecasting models. This new wave is driven by three main factors: 1) The development of paleoclimate model simulations and independent paleoclimatic proxies, which allows paleoecological data to serve as

signals of ecological response rather than as direct paleoclimate proxies, which has traditionally been the case. 2) The on-going assembly of paleoecological data into well-organized and community-curated data resources such as the Neotoma Paleoecology Database (www.neotomadb.org), enabling continental-scale multi-proxy syntheses. 3) The increasing urgency to assess the exposure and sensitivity of species to 21st-century climate change and develop robust science-based adaptation strategies. Examples of continental-scale syntheses of fossil pollen data and their application to test key biogeographic hypotheses include understanding the velocity of species distribution shifts during rapid climate change, the stability of species-climate relationships, and whether we can substitute space for time when building biodiversity models. The development of Bayesian statistical models that incorporate multiple sources of temporal and proxy uncertainty are enabling more comprehensive and more robust inference. This in turn is opening the door to new kinds of data-model assimilation and collaborations with terrestrial ecosystem modelers, in which paleoecological data can be used to initialize, validate, and improve ecosystem models. Additionally, the growth and growing availability of archaeological databases offer the opportunity for new integrated assessments of the interactions among climate, terrestrial ecosystems, and human land use and land cover change.

Poster abstracts (alphabetically by first author)

Anderson, Lesleigh, Berkelhammer, Max, and Mast, Alisa: ISOTOPES IN ROCKY MOUNTAIN SNOWPACK (1993-2014) AND IMPLICATIONS FOR PALEOCLIMATIC RECONSTRUCTIONS (Poster A11). We present ~1300 new isotopic measurements (δ18O and δ2H) from a network of snowpack sites in the Rocky Mountains that have been sampled since 1993. The network includes 57 locations where depth integrated snow samples are collected each spring near peak accumulation for 10-21 years that provide unprecedented spatial and temporal documentation of snowpack values at mid-latitudes. For environments such as the Rocky Mountains where snowfall accounts for the majority of annual precipitation, snowmelt is likely to have the strongest influence on isotope values retained within proxy archives. We have (1) evaluated space for time substitutions traditionally used to establish δ18O-temperature relations, (2) evaluated site-to-site similarities across the network, and (3) examined atmospheric circulation patterns for several years with spatially coherent isotope patterns. Results indicate that snowpack- δ18O is rarely a simply proxy of temperature. Instead, it exhibits a high degree of spatial heterogeneity and temporal variance that reflect additional processes such as vapor transport and post-depositional modification. Despite these complexities, we also identify consistent climate-isotope patterns and regionally representative locations that serve to better define Holocene hydroclimate estimates and their uncertainty. We show this by example for the Holocene Bison Lake calcite-δ18O record located at 3255 m elevation in northwest Colorado. Climate change has and will affect Rocky Mountain snowpack and ongoing and future changes can be better informed by isotope-based Holocene reconstructions that are supported by a process-based understanding of the controls on snowpack isotope ratios.

Balk, Meghan A., Anderson, Robert P., Burger, Joseph R., and Fristoe, Trevor S.: HYSTERESIS IN ISLAND BIOGEOGRAPHY: THE ROLE OF THE PAST IN COMMUNITY ASSEMBLY (Poster B7). Community assembly on oceanic and habitat islands is the balance between colonization and extinction. Most research concentrates on static systems; little research has tackled predicting the identity of candidate species for dynamic island systems. We address this problem by developing a trait-based model to predict species' identity on island communities that experience cyclical climatic or environmental conditions. We use fossil mammal specimens from the western North American sky-islands over the Quaternary as an ideal system to test our model. The Great Basin sky-islands are currently dominated by a mesic habitat, with a xeric intervening matrix. During transitions from interglacials to glacials, species may have colonized these mesic habitat islands via a moving population front from the species source pool to the habitat island. We propose that, over longer temporal periods, colonization probability is based on the ability of a species to cross an intervening matrix between the mainland and island, rather than random dispersal events. Extinction probability, then, is defined as the ability of species to sustain a population given the island area, which changes as environmental conditions change in response to climate. Since different suites of traits influence colonization and extinction, the relative importance of each may alternate through time as climatic conditions change. Surprisingly, the model predicts that for similar

environmental conditions in-between cycle extremes different community assemblages emerge. This dependence on the historical conditions (e.g., entering a glacial or exiting an interglacial) is termed 'hysteresis'. Our Quaternary study system highlights the importance of hysteresis in island biogeography.

Bhattacharya, Tripti and Tierney, Jessica: PALEOCLIMATIC CHANGES IN THE NORTH AMERICAN MONSOON (NAM) IN PMIP3 MODEL SIMULATIONS (Poster A2). In the US Southwest and western Mexico, regional hydroclimate is strongly influenced by the summertime rainfall provided by the North American Monsoon (NAM). This circulation provides 70% of annual rainfall in many regions, making it critical to regional water resources. However, the past variability of the NAM is not fully understood, making it difficult to narrow future prognoses of the monsoon's response to global warming. Much debate in the paleoclimatic literature focuses on the relative importance of summer vs. winter rainfall in the NAM region during the deglacial period and the Holocene. We present initial analyses of the mechanisms underlying LGM and mid-Holocene changes in the NAM, using model simulations from the PMIP3 archive. We test a novel hypothesis that suggests that deglacial changes in the NAM can be tied to changes in the mean latitude of the westerlies. We use diagnostic analyses to evaluate the importance of the advection of cold, dry air by the westerlies in suppressing the NAM during the glacial period. Finally, we explore how paleoclimatic proxy records can be used to validate the accuracy of model simulations of the past NAM. This work advances our understanding of the fundamental climate dynamics underlying the NAM, helping improve the predictability of a circulation critical to water resources in Mexico and the US Southwest.

Bowen, Mark W. and Johnson, William C.: EVALUATING THE EFFECTS OF ENVIRONMENTAL CHANGE ON HIGH PLAINS PLAYA WETLANDS FROM THE PLEISTOCENE-HOLOCENE TRANSITION THROUGH THE ANTHROPOCENE (Poster C11). Playa wetlands are ubiquitous features of arid and semi-arid regions and are of particularly high density on the High Plains on the central United States. In Kansas alone, there are more than 22,000 playas. Consequently, playas are critical wetland resources for the region, providing a range of essential functions (e.g., groundwater recharge, surface water storage, and habitat). Culturally-accelerated sediment accumulation is currently the primary threat to playa functions. The objectives of this project were to: 1) establish long-term trends in environmental change, playa sediment accumulation patterns, and playa functioning; and 2) calculate the amount of culturally-accelerated sediment that has accumulated within playas as a result of land cover change within playas and associated watersheds. To establish long-term trends, radiocarbon, litho- and magneto-stratigraphic, and stable carbon isotope data were analyzed for four playas on the Kansas High Plains. To calculate culturally-accelerated sediment accumulation rates, we surveyed and measured sediment depth throughout 46 playas – 23 playas with grassland-dominated watersheds and 23 playas with cropland-dominated watersheds. Results indicate sediment accumulation rates varied considerably throughout the Holocene with low rates during the cooler-moister early Holocene, sediment accumulation progressively increasing to the warmer-drier middle Holocene and then declining through the late Holocene. By the early 1900s, a dramatic transformation of the landscape from short-grass prairie to row-crop agriculture greatly increased sediment delivery to playas. Playas within cropland-dominated watersheds on average have lost nearly half their original storage volume, while those within grassland-

dominated watersheds have lost only 5 percent storage volume to culturally-accelerated sediment accumulation.

Brice, Becky and Woodhouse, Connie A.: FALL SEASON SOIL MOISTURE RECONSTRUCTION FROM TREE RINGS IN THE UPPER COLORADO RIVER BASIN, U.S.A. (Poster A1). The Colorado River basin is one of the most over-allocated river basins in the world. Year-to-year variability in Colorado River streamflow has far reaching impacts throughout the seven states and Mexico dependent upon its water supply. Streamflow variability related to runoff is influenced by varying seasonal contributions of factors that include spring temperature, antecedent soil moisture, and winter snowpack. Recent research has demonstrated that tree rings can be used as proxies for annual soil moisture. This study investigates the potential to use tree rings to reconstruct fall season soil moisture conditions as part of a broader effort to better understand how the different seasonal hydroclimatic factors contribute to streamflow variability. Most long-term soil moisture data is indirectly modeled and based upon instrumental measurements of temperature and precipitation, and estimated soil moisture capacity. Here, we evaluate the relationship between modeled preceding-fall available water capacity (cm/cm) based upon the McCabe and Wollock monthly time step model for the upper Colorado River basin and a network of existing tree-ring chronologies. We use multiple linear regression to calibrate the tree-ring chronologies with the soil moisture, then we test the model using standard validation techniques. With a long-term reconstruction of antecedent soil moisture for the Colorado River basin, we are able to evaluate the relative contribution of seasonal soil moisture conditions to streamflow prior to the instrumental record. The relationship of soil moisture to streamflow magnitude in the Colorado River may enhance our understanding of hydroclimatic variability and inform future water resources decision-making.

Brunelle, Andrea and Minckley, Thomas: 200 YEARS OF CHANGE: WETLAND ECOSYSTEMS IN THE DESERT SOUTHWEST (Poster B20). Substantial landscape change has occurred in the western United States in the last 200 years as a result of human activity and climate change, including the ecosystems of the desert southwest. This study presents the results of paleoenvironmental reconstructions from the borderlands region of northern Sonora, Mexico and southern Arizona and New Mexico with a focus on the last 200 years. These reconstructions examine changes in fire, erosion, vegetation, woody plant encroachment and saturation of the soils. Hypothesized controls on the changes are presented including grazing, drought, changes in CO2 concentrations, and fire suppression.

Buckle, Nicollette and Overpeck, Jonathan: 500 YEARS OF HYDROCLIMATE IN THE AMAZON, THE SPECTER OF MULTI-YEAR DROUGHT, AND A NEW THREAT TO ECOSYSTEM MANAGEMENT (Poster A10). The Amazon Rainforest is a global carbon sink and a center of great biodiversity, and as such plays a critical role in the global climatological and ecological systems. In the last decade, two widespread regional droughts alerted us to sensitivity of the Amazonian ecosystem. Both droughts were deemed once in a century events that exposed the limited perspective of the 30-year satellite record, paucity of ground-based measurements, and the need for longer records. We have analyzed sediments from Lake Ayauchi, a permanent, closed basin lake located in the Western Amazon basin, to improve understanding of past hydrology. Using precipitation sensitive proxies including grain size, elemental concentration, magnetic susceptibility and biomarker measurements, we have identified several multiyear hydrological events that occurred during the past ~500 years. Identifying and characterizing

these events extends the climatological baseline of observations, quantifies historical variability in the Amazon Basin, and will help us to understand hydrological changes that may occur in a warming world. Our results highlight the possibility that multi-year drought events can occur in the Amazon, and thus such events need to be taken into consideration in carbon management and biodiversity conservation efforts.

Bunbury, Joan, Fisher, Rhiannon Gaia, and Blumenstein, Taylor: AQUATIC ECOSYSTEM RESPONSE TO CLIMATE AND LAND USE CHANGES DURING THE ANTHROPOCENE (Poster C17). Water chemistry and freshwater ostracode assemblage data collected from a series of lakes across the Upper Midwest 25 years ago were available from the Neotoma Paleoecology Database providing an opportunity to revisit sites to evaluate changes to aquatic ecosystems. In July 2013, water chemistry and surface sediment samples were collected from 33 lakes located in Wisconsin, Minnesota and northern Iowa. Multivariate analyses of the environmental data indicate that lakes located on the prairies, on the western margin of the prairie-forest ecotone, and in urbanized southeast Wisconsin have experienced the greatest amount of change. A reduction in ostracode species diversity and altered assemblage composition at various locations across the region has also occurred. Decadal averages of mean July temperatures between the two sampling periods have risen by as much to 1.2°C, with the greatest temperature increase to the west and north, along with a widespread decline in decadal averages of total July precipitation. Developed land has expanded across the Upper Midwest, particularly in urbanized southeast Wisconsin. Results suggest a combination of altered climatic regimes and land use have influenced aquatic ecosystem response, providing insight as to the degree of change that can occur in response to different drivers on short timescales.

Burke, Kevin D., Williams, John W., and Jackson, Stephen T.: HOW NOVEL ARE 21ST CENTURY CLIMATES? A GLOBAL ASSESSMENT OF FUTURE CLIMATES AND THEIR ANALOGS BACK THROUGH THE EOCENE (Poster A14). Climate change is a multivariate process, where changes in the environmental space of a location will likely drive biotic responses of the flora and fauna that inhabit the region. In the face of a rapidly changing climate it is important to understand what the future may hold for ecosystems. One method commonly applied to understand how dissimilar future climates will be relative to the modern period is no-analog analysis. This has been done for 21st century climates relative to the modern period, but has not been extended through the paleorecord. Using the HadCM3, CCSM3 TraCE-21ka, PMIP3, PlioMIP2 and EoMIP climate simulations, we assess global and regional climatic novelty by identifying the closest analogs in these past warm periods for both future (21st century) and modern climates. This baseline offers a full range climate space with significant overlap of modern and future projected climates, and allows us to assess both emergences and disappearances of analog climate conditions throughout the past. Here we calculate dissimilarity to quantify novelty and no-analog conditions using Mahalanobis distance. Our work shows that nearest climate analogs for the modern period, as well as future climates, existed and disappeared during past warm periods. These results suggest that though climate change may be regionally novel relative to the modern period for some locations, analogs do exist through the paleorecord which in some cases reduce novelty. Nevertheless, novelty remains high in some locations suggesting that some future climates may be unprecedented.

Caballero, Margarita, Ortega, B., and Lozano, Socorro: HUMAN IMPACT DURING THE LAST 2,000 YRS IN WESTERN MEXICO (Poster B19). Alberca de Tacambaro, is a small (0.08km2), relatively deep (30m) volcanic lake on the south-western sector of the Trans-Mexican Volcanic Belt. It is located within the Purepecha cultural region of western México (Michoacan), a culture that had its maximum development during the late Post-Classic (1100-1521). The Spanish Conquistadores occupied this region soon after the conquest of the Aztec capital, (Mexico-Tenochtitlan) around 1530. An 8.5 m sediment core was retrieved from this lake for multi-proxy palaeoenvironmental studies. Chronology is given by 12 AMS 14-C dates. Sediment stratigraphy, magnetic susceptibility, titanium, diatoms and pollen contents were studied. Results from the top 2.5 m of this sequence are presented here, which correspond to the last 2,000 yrs. During this time a period of shallower water conditions with a strongly stratified lake is recorded between AD 200 and 900. Our results also show two short periods of human impact at 500 BC and AD 1075, the first during the Pre-Classic and the second at the beginning of the Tarascan expansion during the Post-Classic. A third, most intense episode of human impact is recorded at AD 1540, at the time of the Spanish priests arrival to the area, which historically is documented at AD 1538, when the nearby village of Tacambaro became a centre for evangelization. In this record it is very clear that erosion rates highly increased at the arrival of the Spanish culture to the area.

Collins, Joe D.: CHARACTERIZING SEDIMENTARY PROCESSES OF A PLAYA-LUNETTE SYSTEM USING END-MEMBER MIXING ANALYSIS (EMMA): A CASE STUDY ALONG THE WESTERN MARGIN OF THE HARNEY BASIN, SOUTHEASTERN OREGON (USA). (Poster D16). Playa-lunette systems collect and mix sediments from multiple geomorphic processes (aeolian, fluvial, lacustrine), providing multimodal grain-size distributions (GSD) that reflect paleoenvironmental variations. Here, we use end-member mixing analysis (EMMA) to mathematically unmix measured GSDs of 256 sediment samples from Rimrock Lake (late Pleistocene/Holocene playa-lunette system in the northern Great Basin, southeastern Oregon) to characterize the timing, magnitude, and relationships of sedimentary processes shaping its evolution. EMMA identified six sedimentary end-members (EM) representing 97.76% of the GSD variance, identifying three significant depositional environments: fluvial (EM 1), lacustro-aeolian (EMs 2 and 6), and littoral (EM 5). A relict playa surface, exposed beneath lunette sediments and radiocarbon dated to 6,190 - 5,990 cal. BP., represents a shift to a drier climate causing desiccation of the lake, deflation of the playa floor, and subsequent formation of the lunette dune. The lunette also is characterized by the coarsest end-members, EMs 1 and 5, and the finest end-member, EM 6, representing multiple depositional processes: silt and clay aggregates deflated from the playa floor, washed/inblown material along the lake margin, sediment recycling, and alteration by lake-level rise. Performing EMMA on the playa-lunette GSDs allowed for an unbiased confirmation of the general characterization of paleoenvironmental changes reflected in the playa-lunette system's sediments. Their spatial-temporal association indicate Rimrock Lake existed by c. 18,535 cal. BP., with lake expansion and lake-margin transgression through the Early Holocene, followed by desiccation through the Late Holocene.

Cordova, Carlos, Scott, Louis, Atekwana, Eliot, and Paiziz, Nicole: TERMINAL PLEISTOCENE-HOLOCENE MULTIPROXY RECORD FROM LAKE NGAMI, BOTSWANA: CLIMATE, VEGETATION, FIRES, HERBIVORES AND HUMANS (Poster D13). Pollen, phytoliths, charred particles, coprophile spores, stable isotopes and other proxies from a sediment core of Lake Ngami provide information on paleoenvironments in the area southwest of the Okavango Delta, in the central Kalahari. Supported by eight AMS dates, the chronology of extends from ca. 17,200 cal years BP to the present. Pollen data suggests cool temperatures up until 15,500 cal years BP. The subsequent phases are relatively dry around the lake, but with periodical influx of aquatics increase, probably from the Okavango Delta. A short phase with relatively moist and probably cool conditions is identified between 12,500 and 11,000 cal years BP. Increases in tree pollen frequencies indicate two moist phases in the Holocene around 9000, 6000-5000 and 3500-2000 cal years BP, with the latter period being the wettest in the record. The phytolith record shows that throughout the full time span of the core C4 grasses dominate with no clear evidence of C3 grasses. Periods of high fire incidence coincide with higher plant biomass prevalence, as suggested by the pollen phytolith, and stable isotope records. However, the strongest fire incidence correlates with the archaeological record signaling the arrival of pastoralists between 2000 and 1800 years BP. This also is seen with the increase of coprophile spores. Before pastoralism, the relation between fire proxies (charred particles and burnt phytoliths) and herbivore density (coprophile spores) present an interesting relationship that may help understand the megafauna-fire relation changes at the end of the Pleistocene in North America.

Cox, Thomas E. R., Mathews, Adam J., Cordova, Carlos E., and Bement, Leland C.: 3D IMAGING TECHNOLOGY FOR ANALYZING AND ARCHIVING PALEONTOLOGICAL AND ARCHAEOLOGICAL FINDS: THE CASE OF PRE- AND PROTO-ANTHROPIC MAMMOTH SITES IN OKLAHOMA (Poster D6). Geoarchaeological techniques are becoming ever more important in our understanding of Pleistocene environments. However, as access to equipment and funding becomes more limited in disciplines such as archaeology and paleontology, new affordable methods are sought for analyzing valuable data while maintaining site integrity. 3D imaging is an inexpensive method that allows both researchers and the lay person a way of documenting archaeological and paleontological finds. Not only is this important for capturing significant details, but also for incorporating geolocation and mapping site features. This new approach is important in that many of the fine details that are often lost or improperly recorded can be maintained for later analysis. This new approach uses an inexpensive camera to capture detailed images of remains and artifacts that can then be compiled in a point cloud and portrayed as a 3D image using the Meshlab program or printed as a model using a 3D scanner. Using this method can make remains and artifacts more accessible to a greater breadth of researchers through databases such as NEOTOMA and museum archives, while limiting the amount of handling of archaeological and paleontological materials. In this analysis, we use both the Alva and Buffalo pre- and proto-anthropic mammoth sites in northwestern Oklahoma to showcase the importance of 3D imaging. Each of these localities was analyzed on limited funding. However, the amount of detail captured for analysis rivals that of better funded sites using more expensive equipment.

Curry, B. Brandon and Anderson, Andrew C.: FULL-GLACIAL TEMPERATURES BASED ON OSTRACODE ANALOGS (SPECIES AND ASSEMBLAGES) FROM TWO MIDWESTERN SITES (Poster A15). A limitation of the robustness of analog paleoclimatic reconstructions is the representativeness and quality of the analog database. Here, we explore the apparent improvements in Mutual Ostracode Temperature Range (MOTR) and Mutual Climate Range (MCR) method results after including sites from the United States to a large dataset from Canada as applied to two lacustrine successions deposited under full-glacial conditions spanning from about 24,000 to 20,500 cal yr BP. The analog datasets are composed of ostracode species and environmental data. The sites are located near St. Louis, MO (38.841°N, -90.241°W) and Petersburg, IN (34.481°N, -87.287°W). Full-glacial mean July temperatures estimated from the expanded database (NACODe; Curry et al., 2012) using MOTR is 20.2 ± 1.0 and 20.7 ± 0.4°C, respectively about 2.7°C warmer than indicated previously using MCR methods on the Canadian dataset alone (Curry and Delorme, 2003). We have written script in Excel that allows graphical and statistical evaluation of the reconstructions using either MOTR or MCR.

De Los Santos, Marie and Quade, Jay: EXPLORING SURFICIAL QUATERNARY SOIL CARBONATES IN THE TUCSON MOUNTAINS, SOUTHERN ARIZONA AS A POTENTIAL PALEOCLIMATE ARCHIVE (Poster A8). Pedogenic carbonates are widely distributed throughout the American Southwest in semi-arid to arid regions. However, few studies have thoroughly explored their potential utility as climate records. Because soil carbonates accumulate gradually through slow dewatering and time-progressive stages - from weakly developed clast coatings to strongly developed matrix-cemented accumulations - their oxygen and carbon isotopic compositions can be used as proxy indicators when reconstructing past rainfall compositions and the distribution of vegetation respectively. We are exploring the use of clean, strongly developed and well-stratified pedogenic carbonates from Brown Mountain in the Tucson Mountains area of southern Arizona as a potential paleoclimate archive for the Quaternary. We studied the isotopic compositions of modern surficial soils with weakly developed soil carbonate coatings and compared those values with more developed, well-cemented soils nearby to infer approximate depths at the time of formation. Radiocarbon dates were acquired from a laminar sample and ranged from Late Pleistocene (sample bottom) to Holocene (sample top) in a coherent stratigraphic order. Carbon ($\delta^{13}C$) values suggest the vegetation distribution of C3 & C4 plants has shifted modestly since the Late Pleistocene. Oxygen ($\delta^{18}O$) values in our shallowly buried laminar carbonates represent an undisturbed record of past rainfall while naturally exposed laminar carbonates represent periods of soil erosion. In addition, oxygen values in our shallowly buried laminar carbonates display a ~4‰ increase versus modern values, suggesting a shift toward drier conditions.

Dello-Russo, Robert, Smith, Susan, Yost, Chad, Winsborough, Barbara, Hall, Stephen, McBride, Pamela, Davis, Owen: THE BLACK MAT AT THE WATER CANYON PALEOINDIAN SITE AND A NEW PALEOENVIRONMENTAL RECORD FOR THE PLEISTOCENE-HOLOCENE TRANSITION IN WEST-CENTRAL NEW MEXICO (Poster C3). The Water Canyon Paleoindian site near Socorro, New Mexico, is directly associated with an extensive buried wetland deposit, or black mat (c.f. Haynes 2008; Quade et al. 1998; Pigati et al. 2014). This landscape-scale feature represents the remains of a wetland that was extant across the late Pleistocene–early Holocene transition, and is today an important proxy data archive for environmental, climatic and archaeological investigations. Our paleoenvironmental reconstruction at

the site focuses on the period from ~8300 to 11,100 radiocarbon years ago, and utilizes a range of proxy records, including dated pollen, phytoliths, diatoms, stable carbon isotope values, fossil land snails and macrobotanical remains. The combination of the analytical data from these proxies with the multi-component archaeological remains (Clovis, Folsom, middle-late Archaic activity areas; and Bison antiquus bone beds associated with Cody Complex and late Paleoindian artifacts), is unique west of the Pecos River in New Mexico and affirms that the black-mat forming wetland served as a persistent place of ecological diversity that attracted grazing herbivores and human hunter-gatherers over thousands of years. Our interdisciplinary research provides provocative glimpses of past environments in a heretofore largely understudied region of the American Southwest.

DeSantis, Larisa and Crites, Jonathan: CONSERVATION PALEOBIOLOGY IS CRITICAL TO MODERN CONSERVATION: LATE PLEISTOCENE DIETARY ECOLOGY OF CARNIVOROUS MAMMALS WITH RELEVANCE TO UNDERSTANDING MODERN ECOSYSTEMS (Poster B21). The La Brea Tar Pits in southern California contains more fossil carnivorans than anywhere else on the globe. Spanning the latest Pleistocene, with most fossils deposited approximately 40,000 to 11,000 years before present, La Brea has the ability to unlock our understanding of mammalian responses to climate change and human arrival. The dire wolf (*Canis dirus*), the most abundant carnivoran at La Brea, ranged from Canada to South America during the Pleistocene - yet went extinct. Coyotes (*C. latrans*), a smaller canid, were one of the few carnivorans that survived the late Pleistocene extinction event. Understanding if and how smaller surviving canids responded to the megafaunal extinction is important to testing mesopredator release hypotheses and assessing biotic responses to the loss of apex predators, today. Using dental microwear texture analysis (DMTA) we assessed if and how the textural properties of food consumed changed from the late Pleistocene to today - specifically the degree to which carnivorans consumed flesh (tougher food) or bone (harder food). DMTA data suggests that *C. dirus* consumed harder objects - consistent with moderate bone processing. Co-occurring coyotes consume softer foods during the Late Pleistocene, yet have nearly identical and indistinguishable dental microwear to *C. dirus* when occurring in southern California, today - suggesting a shift towards increased carcass utilization with the local absence of wolves. Coyote access to carcasses may have been limited by the local presence of wolves and/or other large predators. While recent wolf introductions resulted in increased carcass use by coyotes - the opposite was true during the Pleistocene.

Dombrosky, Jonathan, Jones, Emily Lena, Conrad, Cyler, and Pagès Barcelo, Laura: HISTORICAL ECOLOGY OF THE MIDDLE RIO GRANDE: RESULTS FROM THE ISLETA MISSION CONVENTO ICHTHYOFAUNA (Poster B15). Here, stable isotope analysis of seventeenth century fish remains from Isleta Mission Convento (LA 724) is used to establish baseline data on how the Rio Grande functioned prior to the establishment of the acequia system and twentieth century modifications such as dams. We find significant differences in both $\delta^{13}C$ and $\delta^{15}N$ values between the Isleta fishes and modern samples, which suggests a seventeenth century environment characterized by an open floodplain dominated by native grasses, in contrast to the commercial farm and rangeland that typifies the twentieth century Rio Grande environment. Further, more fully understanding the trophic structure of past Rio Grande fish communities has much to offer the study of prehistoric fish

exploitation by human groups along the Rio Grande. The results from Isleta Mission Convento are used to highlight possible sources of error when tracking the trophic position of fishes in the Rio Grande from past to present.

Dorale, Jeffrey: A COMPARISON BETWEEN HOLOCENE AND LAST INTERGLACIAL CLIMATE CONDITIONS IN THE MIDCONTINENT OF NORTH AMERICA (Poster A13). Well-dated stable isotope and detrital flood records from Crevice Cave in southeastern Missouri, USA allow a comparison of conditions during the Holocene and the peak Last Interglacial from 120-130 ka, a period which is often considered an analogue for future climate warming. Using speleothem □13C as a vegetation proxy, the vegetation dynamics of these two periods appear to differ markedly. Unlike throughout the Upper Midwest, where numerous paleoecological sites show replacement of forest by prairie sometime during the middle Holocene, the vegetation dynamics at this southeastern Missouri site during the past 7,900 years are relatively unchanging. In contrast, during the Last Interglacial, prairie appears to replace forest abruptly around 128 ka and prairie persists until around 125 ka. This timing is just slightly lagged behind the summer insolation maximum for this latitude, which was stronger during the Last Interglacial than during the Early Holocene. A second type of climate proxy exists in the form of fine detrital layers preserved in stalagmite calcite, which represent inundation by muddy back-flooded waters during times of high rainfall. Construction of such a flood history reveals that millennial-scale cyclicity is a dominant feature in the record from Crevice Cave throughout the Holocene, and that the frequency/intensity of events increases through the Late Holocene. Perhaps surprisingly, these detrital layers are ubiquitous to Holocene-age formations in the cave, but are absent from much of the last glacial period and parts of the previous interglacial period.

Elliott Smith, Emma A., Tomé, Catalina P., Stafford, Thomas W., Lyons, S. Kathleen, Smith, Felisa A., Newsome, Seth D.: A SHIFTING BASELINE: δ15N ANALYSIS OF INDIVIDUAL AMINO ACIDS TO TRACK ECOSYSTEM CHANGES ACROSS THE LATE PLEISTOCENE EXTINCTION (Poster B11). One of the consequences of the late Pleistocene megafauna extinction was a reorganization of mammalian communities, which likely included trophic shifts of medium and small-bodied mammals. Traditionally, nitrogen isotope ($\delta^{15}N$) analysis of bulk tissues has been used as a proxy for trophic level. Interpreting temporal or spatial changes in consumer $\delta^{15}N$ values is complicated by potential concurrent shifts in (baseline) $\delta^{15}N$ values of primary producers. $\delta^{15}N$ analysis of individual amino acids (AAs) provides a way to simultaneously track trophic level and changes in baseline $\delta^{15}N$ values. 'Source' AAs are routed directly from diet to consumer and so their $\delta^{15}N$ values do not change with trophic level, whereas 'trophic' AAs show a strong relationship between trophic level and $\delta^{15}N$. Here we apply this approach to cotton rat (*Sigmodon hispidus*) fossils from Hall's Cave in west-central Texas, a site that spans from the last glacial maximum through the Holocene. Cotton rats show a wide range in both carbon (~10‰) and nitrogen (~7‰) isotope values over this interval, but the only significant trend is a decline in $\delta^{15}N$ values across the extinction. We found a significant decline in $\delta^{15}N$ of both source and trophic AAs from the mid to late-Holocene, whereas the offset in $\delta^{15}N$ between these AA groups remained constant This indicates that the decline in bulk *S. hispidus* values was driven by a shift at the base of the foodweb, rather than a change in *S. hispidus* trophic position. Our study demonstrates that AA $\delta^{15}N$ analysis of ancient consumers may provide a useful way of quantifying both ecosystem shifts and trophic dynamics.

Elliott Smith, Emma A. and Newsome, Seth D.: QUANTIFYING LATE QUATERNARY ENVIRONMENTAL CHANGE IN A NEARSHORE MARINE ECOSYSTEM USING δ13C ANALYSIS OF ANCIENT SEA OTTERS (Poster B13). Kelp forests are among the most productive but vulnerable marine ecosystems on earth. These regions serve as biodiversity hotspots and CO_2 sinks, but are also highly sensitive to human impacts such as overexploitation and shifting ocean chemistry. Understanding their dynamics is crucial for effective conservation and management. Here, we employ $\delta^{13}C$ analysis of individual amino acids from a top marine consumer, the sea otter (*Enhydra lutris*) to evaluate the importance of kelp forests in the late Holocene (~3500 ybp – present). Since only primary producers and microbes synthesize essential amino acids (AA_{ESS}), consumers typically directly route them into tissues and thus AA_{ESS} are minimally altered as they move up food chains. Moreover, different producers (e.g., phytoplankton and macroalgae) in nearshore marine ecosystems have highly distinct $\delta^{13}C$ values and so the $\delta^{13}C$ values of AA_{ESS} in top consumers can provide a 'fingerprint' of the dominant producers in the local foodweb. We analyzed bone collagen from late Holocene sea otters from two islands (San Nicolas and San Miguel) off the coast of southern California. We also characterized the baseline amino acid $\delta^{13}C$ profiles for modern producer groups: kelp (*Laminaria* and *Nereocystis*), green algae (*Ulva*) and red algae (*Neorhodomela*). We used mixing models to quantify the contribution of each algal group to ancient sea otter AA_{ESS} $\delta^{13}C$ values. As expected, kelps had significantly higher $\delta^{13}C$ values than red and green algae for all amino acids measured. We found ancient sea otters were predominantly feeding in ecosystems driven by kelp production; in some instances, an estimated 99% of consumer essential amino acids were derived from kelp. These findings suggest that at these sites kelp forests may have been more extensive in the late Holocene than they are today. Our study demonstrates the utility of amino acid $\delta^{13}C$ analysis in investigating historical ecological problems that hold relevance for modern conservation biology.

Farley, Scott: PALEOVIEWER: A NEW INTERACTIVE METHOD FOR VISUALIZING MULTIDIMENSIONAL QUATERNARY ECOLOGICAL CHANGE (Poster D2). Paleoecological databases offer our primary information about the spatial responses of species and communities to large climatic changes. However, the spatiotemporal characteristics and high dimensionality of paleoecological datasets create significant challenges for its effective visualization. Given recent rapid advances in interactive cartography, dynamic mapping, and data visualization, there are opportunities to develop new forms of visualizations that effectively communicate ecological trends through space, time, and attribute. New geovisualizations lead to new insights by scientists and the general public. The Neotoma Paleoecological Database contains data on fossil mammals, plants, and marine and freshwater organisms over the last 2.5 million years, tracking floral and faunal community change over major shifts in the earth's climate, and, more recently, shifts in response to anthropogenic change. The work presented here applies the principles of interactive cartography and geographic visualization to develop a platform for communicating the spatial and temporal aspects of species distribution shifts, in both geographic and environmental space. The tool enables users to explore Neotoma's collections to delineate and identify interesting clusters and trends. Contextual layers, including late Pleistocene ice sheets and paleoclimatic visualizations, are included to improve the user's comprehension of landscape- to continental-scale changes. The system runs on an Open Web standard technology stack consisting of open source tools, which promotes community involvement. One primary audience for PaleoViewer is

undergraduate university students, and its development is accompanied by a laboratory exercise that guides its inclusion into a classroom setting.

Fawcett, Peter J., Brown, Erik T., Anderson, R. Scott, Werne, Josef P., and Contreras, Sergio: MILLENNIAL-SCALE CLIMATE CHANGE DURING A MID-PLEISTOCENE GLACIAL (MIS 12): A LACUSTRINE RECORD FROM THE VALLES CALDERA, NEW MEXICO (Poster A12). A high-resolution terrestrial climate record from the Valles Caldera, New Mexico spans 200,000 years through the mid Pleistocene from mid MIS 14 to early MIS 10. The glacial periods exhibit millennial-scale Dansgaard-Oeschger like variability, especially in MIS 12, one of the coldest glacials in the Pleistocene. High resolution proxies from core VC-3 including scanning XRF data, sediment density and color, and magnetic susceptibility show approximately 23 millennial-scale oscillations through MIS 12 with an average duration of 2,300 years. Many of these oscillations are characterized by relatively slow coolings followed by abrupt warmings, similar to D-O events in the Greenland ice core record. MAT estimates from MBT/CBT MAT show stadial to interstadial warmings of up to 6^{o}C. The VC-3 stadials correlate with high percentages of boreal taxa pollen (*Picea*, *Abies*) (up to 25%) while interstadials have lower boreal pollen percentages (~5%) and many correlate with local maxima in *Juniperus* and *Quercus*. Significant changes in the hydrologic cycle also occur at these millennial timescales. Several interstadials correlate with increases in Cyperaceae (sedge) pollen suggesting a shallower lake with a broad marshy zone around its margin. This combination of proxies suggests that glacial stage millennial-scale climate variability in the American southwest was driven by changes in the strength and location of the winter polar jet, which affected the local hydrologic cycle, regional temperature change, watershed vegetation, the amount of fluvial runoff vs. atmospheric dust loading in the Valles Caldera lake, and contributed to the abrupt warmings ending the D-O like cycles.

Guiterman, Christopher H., Swetnam, Thomas W., and Dean, Jeffrey S.: AN 11TH CENTURY SHIFT IN TIMBER PROCUREMENT AREAS FOR THE GREAT HOUSES OF CHACO CANYON (Poster D12). An enduring mystery from the great houses of Chaco Canyon is the origin of more than 240,000 construction timbers. We present the first use of tree-ring width based sourcing in the southwestern U.S. to evaluate probable timber procurement areas for seven great house structures. The Chuska and Zuni Mountains (> 75 km distant) were the most likely sources, accounting for 70% of timbers. Most notably, we found that procurement areas changed through time. Prior to 1020 CE nearly all timbers originated from the Zunis (a previously unrecognized source), but by 1060 CE the Chuskas eclipsed the Zuni area in total wood imports. This shift occurred at the onset of Chaco florescence in the 11th century, a time with substantial expansion of existing great houses and the addition of seven new great houses in the Chaco Core area. It also coincides with the proliferation of Chuskan stone tools and pottery in the archaeological record of Chaco Canyon, further underscoring the link between land-use and occupation in the Chuska area and the peak of great house construction. Our findings, based on the most temporally specific and replicated evidence of Chacoan resource procurement obtained to date, corroborate the long-standing but recently challenged interpretation that large numbers of timbers were harvested and transported from distant mountain ranges to build the great houses at Chaco Canyon.

Heinzel, Chad: INVESTIGATING THE IOWAN SURFACE AND EASTERN IOWA DRIFT PLAIN THROUGH EDMAP (Poster D22). The University of Northern Iowa (UNI) has partnered with the Iowa Geological Survey (IGS) and the USGS to provide its students with real world learning experiences through EDMAP. The UNI EDMAP Team is developing a greater understanding of the Iowan Erosion Surface (IES) and the East Central Iowa Drift Plain (ECIDP). We have mapped the surficial geology of five (7.5") Quadrangles: Waverly (2008-2009), Readlyn (2009-2010), Dunkerton (2010-2011), and Waterloo south (2011-2012), and Hudson (2012-2013) on the Iowa Erosion Surface and are currently finishing our first surficial map on the East Central Iowa Drift Plain, the Maquoketa Quadrangle. These investigations have revealed an interesting yet complex series of Quaternary sedimentation. Sediments commonly lie upon Silurian bedrock (Hopkinton, Scotch Grove and Tete des Morts, and Mosalem Fms.). The uplands are dominated by thick deposits (>4 m) of loess (Peoria Fm.) that are easily eroded by first order stream segments. Substantial eolian deposits have been identified in the northeastern portion of the Maquoketa Quadrangle, east of the confluence of the North and South-forks of the Maquoketa River. A narrow band of the Iowan Erosion Surface has been identified in the southern one-third of the quadrangle. Field samples are currently being characterized through X-ray Florescence, Particle-size (pipette and sieving), and Heavy Mineral Separation analyses. Secondary mapping products also seek to identify the interrelationships of these surficial sediments with flooding events, contaminant transport, and development of Karst topography and to help Iowa's communities develop sustainably.

Heyer, Josh and Brunelle, Andrea: VEGETATION AND COTTONWOOD GALLERY FIRE RECONSTRUCTIONS FROM AN OXBOW LAKE ON THE DOLORES RIVER, UTAH (Poster C4). The vegetation, fire disturbance, and paleoclimate of the north-central Colorado Plateau over the last 10,660 years is reconstructed from an oxbow lake located adjacent to the Dolores River, Utah. This research reconstructs the Holocene landscape and climate conditions of an arid landscape on the Colorado Plateau that has not yet been investigated in paleoecological research. A cottonwood gallery forest dominates the riparian zone, while a juniper/Colorado pinyon forest encompasses the Colorado Plateau surrounding the site. The long-term fire history of cottonwood gallery forests is largely unknown, and will be explored in our study. To the north of the site approximately 5-10km, vegetation changes from a xeric/mesic juniper/Colorado pinyon forest to a xeric landscape. The oxbow lake is located in a transitional vegetation zone where vegetation changes and inferred climate during the Holocene can be explored. Further, the oxbow is located near the confluence of the Dolores River and Colorado River, a fitting location to investigate past fluvial processes related to climate variability, with implications for water resources. Initial results presented will include an age-model, magnetic susceptibility, a high-resolution charcoal record, elemental analysis using X-Ray fluorescence, and a preliminary pollen diagram. This project will contribute to existing paleoecological research on the Colorado Plateau, improving our understanding of environmental disturbances and climate that impacted this area during the Holocene.

Hill, Christopher L., Wilson, Michael C., and Batten, David C.: RADIOCARBON CHRONOSTRATIGRAPHY AND STABLE ISOTOPES OF A LATE QUATERNARY SEDIMENTARY SEQUENCE, BULL MOUNTAIN, SOUTHWEST MONTANA (Poster D15). Radiocarbon and stable isotope measurements underpin a time-model for depositional events reflected in late Quaternary strata at Sheep Rock Spring (Doherty Mountain quadrangle), southwest Montana. Most samples are of charred material, but organic

sediments, bone “collagen” and wood were also analyzed. Based on the set of charred material samples from the sequence revealed in a >5 m deep trench, two main chronostratigraphic units are defined. A final Pleistocene-early Holocene (FP-EH, ca. 10,200-8,700 RCYBP) chronostratum is characterized by alluvial channel and floodplain deposits and paleosols interbedded with or overlying boulders. A mid-Holocene (MH, ca. 6,000-5,430 RCYBP) unit consists chiefly of tributary alluvial fan deposits with paleosols. Measurements from organic sediments are consistent with this age-model (ca. 9,060-8,200 RCYBP for FP-EH, ca. 5,510-4,720 RCYBP for MH). Wood and some measurements on acid-insoluble fractions of bones do not appear to conform to the model, suggesting that water-table fluctuations may have geochemically altered these samples. A measurement of ca. 20,700 RCYBP on bone associated with extinct fauna from sediments among the basal boulders also seems potentially problematic because of a $^{13}C/^{12}C$ ratio of -33.1 $^{o}/_{oo}$. Five samples (charred n = 2, organic sediment n =1, bone n =2) collected from other pit stratigraphic sequences indicated the deposits can be correlated with the MH chronostratigraphic unit, while charcoal dated to ca. 9,420 RCYBP from another stratigraphic trench indicates a correlation with the FP-EH chronostratigraphic unit.

Hockaday, William, Von Bargen, Justin, Yao, James, and White, Joseph: TOWARD A CHEMICAL METHOD FOR RECONSTRUCTION OF PALEO-FIRE INTENSITY (Poster C20). Fire intensity, the energy output of a fire, is thought to be an important factor in post-fire ecological responses. To better understand the underlying mechanisms of above- and below-ground ecological responses, we need tools for quantifying the intensity of both recent and historic fires. Charred organic matter is a long-lasting legacy of fire which may contain information about fire intensity. We are investigating the degree of thermal alteration in charred organic matter as a means of estimating fire intensity (temperature and duration). We conducted laboratory charring experiments to demonstrate the feasibility of relating fire intensity to charcoal chemistry. We then analyzed charcoal samples collected immediately following prescribed fires for which we have thermistor-based records of temperature and duration of heating. We interrogated the chemical structure of the charred organic matter using solid-state nuclear magnetic resonance spectroscopy. The chemical structure of the charred organic matter shows a relationship to thermistor-based intensity measurements. However, the relationship shows greater complexity than the relationship observed for lab-generated charcoals. This presentation will explore the thermodynamics and kinetics of the prescribed fire to explain the chemical legacy of fire in charred organic matter.

Holden, A. R. and Southon, J.R.: SUCCESSFUL METHODS TO RADIOCARBON DATE LATE PLEISTOCENE INSECT CHITIN AND PLANT MATERIAL FROM THE RANCHO LA BREA TAR PITS, SOUTHERN CALIFORNIA. (Poster D1). We present the first successful methods to date, by AMS, insect chitin impregnated with asphalt and various fossil preparation solutions. This controlled method simplifies the problem of lacking reliable stratigraphic methodology at the La Brea Tar Pits due to frequent fossil mixing due to intermittent asphalt flows. The specimens submitted for dating were excavated from multiple pits from the Late Pleistocene Rancho La Brea Tar Pits in southern California. The pre-treatment method successfully removed asphalt and fossil preparation chemicals while requiring relatively little insect chitin for combusting. Because the La Brea Tar Pits lack reliable biostratigraphy, ^{14}C dating accuracy was verified by comparing dates on insect chitin with those based on various types of plant material (seeds and twigs) compacted in a camel skull (also dated) during a rapid entrapment event. All dates fell within

a narrow range of ~ 40-44,000 ^{14}C yr BP, indicating that such methods can be used with confidence on other insect material. These results are of great significance for tar pit paleoecological studies. While collagen dating of the bones of large mammals from Rancho La Brea has shed light on their diet, ecology, and taphonomy, insects are often superior paleoenvironmental indicators in terms of establishing precise data points for climate fluctuations.

Holden, A. R, Erwin, D. M., Schick, K. N., and Gross, J.: LATE PLEISTOCENE GALLS FROM THE LA BREA TAR PITS AND THEIR IMPLICATIONS FOR CYNIPINE WASP AND NATIVE PLANT DISTRIBUTION IN SOUTHERN CALIFORNIA (Poster B3). Thirteen intact cynipine galls (Cynipidae) are identified from the significant Late Pleistocene locality of Rancho La Brea, mostly within the range of approximately 30,000 to 48,000 ^{14}C yr BP. Late Cenozoic cynipids have a poor fossil record; it is thus of great interest that the provisional dates for this fossil gall collection establish that these insects and their hosts were an important part of the Late Pleistocene ecosystem in and around Rancho La Brea. Cynipine host specificity both verifies, as well as augments, the proportionally low record of plants recovered at Rancho La Brea in comparison to records of mammals, birds, and other fauna. Because galler and hosts represent extant species, their climate and habitat restrictions offer a good basis for making paleoecological inferences. In particular, they imply that many of the diverse habitats found in California today, or, at least plant associations with similar environmental restrictions, some presently a distance from the Rancho La Brea Tar Pits, existed in the vicinity of this locality during the Late Pleistocene. This material also includes previously undescribed species, several of which are morphologically similar to extant comparative material that exhibits a “jumping” behavior, previously believed to be unique to *Neuroterus saltatorius* Edwards.

Holmgren, Camille and Borrelli, Michael: WOODRAT DIETARY RESPONSE TO CHANGING PLANT COMMUNITIES: EVIDENCE FROM FOSSIL PLANT CUTICLES SPANNING >55,000 YEARS IN SONORAN DESERT PACKRAT MIDDENS (Poster B2). Plant macrofossils from woodrat (*Neotoma*) middens have been used extensively for developing late Quaternary vegetation histories in arid and semi-arid North America. Although dietary generalists, woodrats still exhibit preferences that can potentially introduce bias into midden records. We analyzed plant cuticles in fecal pellets from 50 woodrat middens from northeastern Baja California, Mexico to explore dietary composition spanning > 55,000 years. Pleistocene cuticles were dominated by extralocals *Juniperus californica*, *Nolina, Agave* cf. *deserti*, and *Salvia.* Cuticles from *Cylindoputia/Opuntia* were also very abundant throughout both the Pleistocene and Holocene. These five species represent the bulk of the woodrats’ diet during the Pleistocene. *J. californica* and *Nolina* cuticles persist >1500 years after disappearing from macrofossils, suggesting they were particularly prized foods. The glacial-interglacial transition shows replacement of extralocals by more xeric species, especially *Acacia greggii*, *Larrea tridentata, Olneya tesota*, *Prosopis glandulosa* var. *torreyana*, and *Simmondsia chinensis.* Important dietary species were all highly abundant as macrofossils. This suggests preferential collection of favored foods likely augments their abundances as macrofossils. Interestingly, *O. tesota* appears in cuticles 4160 years earlier than in macrofossils, possibly reflecting consumption that left little material for incorporation into middens. Cuticle analysis provides complimentary information about woodrat dietary preferences, helps refine the timing of species arrivals/disappearances, and shows how diets shifted with changing climatic conditions. Whether changes in vegetation were accompanied by shifts in *Neotoma* species inhabiting the site is unclear.

Nevertheless, understanding how rodent diets adapt to changing conditions may be increasingly important in the face of anthropogenic change.

Honke, Jeffrey, Daniels, Michael J., Pigati, Jeffrey S., and Skipp, Gary L.: EVIDENCE FOR EARLY PINEDALE (EARLY WISCONSIN, MIS 4) GLACIATION IN WEST- CENTRAL COLORADO (Poster A3). The Ziegler Reservoir fossil site near Snowmass Village, Colorado, in the Elk Mountains, provides evidence of local, glacial activity during Marine Oxygen Isotope Stage (MIS) 4. Fine-grained sediments were deposited in a small, moraine-dammed lake between ~140 and 55 ka (thousands of years before present), recording conditions from the close of the Bull Lake glaciation (MIS 6), through the Sangamon Interglacial period (MIS 5), and into the early Pinedale (early Wisconsin) glacial episode (MIS 4). The high-altitude, ridgetop location provides a climatic record that is typically lost to subsequent Pinedale glacial activity (MIS 2) in the Colorado mountains. The topographic setting of the basin and particle size analysis of the sedimentary units indicate that eolian transport was the dominant mechanism of sediment delivery to the lake. Mineralogical and elemental analyses of the wind-blown sediments match those of the sediments found in the extensive glacial outwash plains of the surrounding valleys. A clay-rich unit at the base of the sedimentary record shows an abundance of clay that was deposited during the latest stages of the Bull Lake glacial period. Sediments deposited during the Sangamon Interglacial were dominated by silt-sized particles, which then gave way to clay-sized sediments between ~75 and 55 ka, or the early Pinedale glaciation. We interpret the increased clay abundance at this time as representing an increased load of glacial flour, and thus glacial activity, surrounding the Ziegler Reservoir during the early Pinedale glaciation.

Hornsby, Angela, Duggan, Ana, Kuch, Melanie, Poinar, Hendrick, Smith, Felisa, and Matocq, Marjorie: USING ANCIENT DNA TO IDENTIFY WOODRATS (*NEOTOMA*) AND CO-OCCURRING SPECIES IN DEATH VALLEY ACROSS 33,000 YEARS (Poster B5). One of the most pressing challenges in ecology and evolution is to understand how species and ecosystems react to major environmental changes. While contemporary biological collections offer insight into biotic change through the recent past, paleoecological collections offer crucial physical evidence of these processes on far longer timescales. North American woodrats (*Neotoma*) provide extensive physical evidence of past processes by building paleomiddens, which contain environmental debris and copious fecal pellets from the woodrats themselves. Using a 33,000-year series of paleomiddens from Death Valley, CA/NV, we isolated ancient DNA from *Neotoma* fecal pellets, prepared genetic libraries for high-throughput DNA sequencing, and generated nearly 40 million sequence reads across 41 samples. Using these data, we reconstruct *Neotoma* species occupancy in the study region through the Pleistocene-Holocene, showing an abrupt transition 13,000 years before present from the montane-adapted *N. cinerea* to the desert-adapted *N. lepida*. With the genetic data, we also uncover information which would be difficult or impossible based on traditional morphological identification of fossils, including the movement of intraspecific phylogenetic clades, identification of plants which were presumably consumed by the woodrats, and presence of numerous endoparasites including roundworms, tapeworms, and flukes. These high-throughput methods for ancient DNA open the door for molecular analysis of past biotic communities that have been preserved in paleomiddens, pitfalls, and similar deposits.

Huckell, Bruce B., Rowe, Timothy B., McFadden, Leslie D., Meyer, Grant A., Merriman, Christopher W., and Muus, Jennifer: THE HARTLEY MAMMOTH SITE, NORTH-CENTRAL NEW MEXICO (Poster B14). A scatter of large mammal bone scrap along a shallow rill led to discovery of the Hartley Mammoth site in north-central New Mexico. Informal testing revealed a shallowly buried partial skull and a group of three rib fragments some 2 m apart. On the surface 9 m away was a small, impact-damaged Clovis point, suggesting the possibility that the mammoth had been the victim of Clovis predation. Excavations in 2015 revealed the remains of a juvenile mammoth, consisting of rib fragments, portions of the skull (including both tusks), part of the pelvis, vertebral fragments, and abundant bone scrap. The remains are contained within a remnant of a buried ephemeral stream channel, perched on an elongated slump block of Triassic sedimentary rock, 20 m below the broad Piedra Lumbre basin surface and 60 m above the Rio Puerco, a tributary of the Rio Chama. The matrix is fine sediment and at least one debris-flow deposit. Although no stone artifacts were found in 2015, more than a dozen mammoth bone "flakes" were recovered. The "flakes" are generally large and most appear to have been detached from limb bones. Whether the bone "flakes" are humanly produced or are the product of scavenging animals or the debris flow itself is not clear. Studies of these specimens, the mammoth remains, plus taphonomic, chronometric, and paleoenvironmental analyses, are on-going and a second field season to complete excavations will occur in 2016.

Hynes, Alyssa Rose: A VEGETATION AND FIRE HISTORY RECORD OF REDDEN SPRINGS PROPER, BONNEVILLE BASIN, UTAH, USA (Poster C19). Up until ~12 ka, Redden Springs Proper, Utah was covered by prehistoric pluvial Lake Bonneville. After 12 ka, Lake Bonneville entered a rapid regressive phase as its hydrologic input was outpaced by its evaporative output. By 11.5 ^{14}C ka B.P., Redden Springs Proper was exposed, as the lake had fallen to levels comparable to the modern Great Salt Lake. Paleoenvironmental studies of a 4.72-meter-long sediment core collected from this area (4430444 m N, 269654 m E, elevation 1288 m) will contribute to the emerging body of work detailing environmental changes in the Bonneville basin, including the vegetation and fire history record of North Redden Springs (Howard, 2015).

Ideker, Carlie, Rittenour, Tammy, Finley, Judson, and Nelson, Michelle: SINGLE-GRAIN OPTICALLY STIMULATED LUMINESCENCE (OSL) DATING OF INTERMOUNTAIN WARE POTTERY, WYOMING (Poster D7). Archaeological sites document extended interactions between humans and the environment and subsequently, contain information relevant to assessing the Anthropocene. However, accurate age control is necessary to maximize recovered data. While the application of radiocarbon dating has become a standard for many areas, problems persist in some locations, such as high-elevation sites in northwestern Wyoming. The presence of prehistoric ceramics, known as Intermountain Ware, at many of these sites provides an opportunity for dating site occupations with optically stimulated luminescence (OSL). This study applies single-grain OSL dating to quartz temper from Intermountain Ware sherds from four sites in northwestern Wyoming. Single-grain OSL has advantages over other methods as it can create a robust dataset from limited material. Additionally, the technique can provide a detailed look into post-depositional thermal resetting of luminescence signals by wildfires. Results indicate single-grain OSL dating of quartz temper from Intermountain Ware ceramics can provide improved accuracy and precision over radiocarbon dating when sherds are not adversely affected by wildfires. These results

underscore the need to sample from subsurface contexts when inventorying sites impacted by high-intensity wildfires. These results also validate single-grain OSL dating of ceramic temper as a valuable chronometric tool for researchers seeking to identify and interpret the Anthropocene through the cultural record.

Jimenez-Moreno, Gonzalo, Camuera, Jon, Ramos-Roman, Maria J., Carcia-Alix, Antonio, Toney, Jaime L., Anderson, R. Scott, Jimenez-Espejo, Francisco, Martinez-Ruiz, Francisca, Kaufman, Darrell, Bright, Jordon, Yanes, Yurena, and Larrasoaña, Juan Cruz: PALEOENVIRONMENTAL CHANGES IN THE MEDITERRANEAN AREA DURING THE MIDDLE AND LATE QUATERNARY: A NEW LONG SEDIMENT RECORD FROM EL PADUL, SIERRA NEVADA (SOUTHERN SPAIN) (Poster C5). Long paleoenvironmental records are necessary in order to understand recurrent climatic or paleoenvironmental changes occurring with a certain periodicity (i.e., glacial-interglacial cycles). In this respect, Padul peat bog has one of the best available records of Pleistocene sediments in semiarid Southern Europe. The sedimentary sequence is more than 100 m thick and has been used to study palaeoenvironmental change for the past ca. 1 Ma. Since the 1960s several cores have already been taken from this basin showing oscillations in many proxies (pollen, organic geochemistry and sedimentation) related with paleoclimatic and paleohydrological changes. However, a more detailed and higher resolution study, using new dating and analytical techniques (AMS ^{14}C, OSL, AAR, continuous XRF-scanning, high-resolution geochemistry and pollen analysis), needs to be done in such an interesting site. Here we present preliminary paleoenvironmental data from a new sediment core, Padul-15-05, which shows significant changes in the lake sedimentation and the environment, probably related with glacial-interglacial climate dynamics during the past ca. 300,000 years. These data confirm that orbital- as well as suborbital-scale variability (i.e., Heinrich events) are recorded in the studied core. This unique record thus has very high potential for paleoenvironmental and paleoclimatic reconstructions for, at least, the two last climatic cycles in this semiarid Mediterranean area.

Kowler, Andrew and Quade, Jay: THE STABLE CARBON AND OXYGEN ISOTOPIC COMPOSITION OF PEDOGENIC CARBONATE AND ITS RELATIONSHIP TO CLIMATE AND ECOLOGY IN SOUTHEASTERN ARIZONA (Poster D9). The stable carbon ($\delta^{13}C$) and oxygen ($\delta^{18}O$) isotopic composition of pedogenic carbonate (pc) in calcic paleosols has been used to reconstruct late Quaternary ecological and climatic/hydrologic conditions, respectively, in desert regions—vital for establishing long-term baseline conditions and identifying changes during the Anthropocene. Both isotopic systems are reasonably well understood, but calibration to extant environmental conditions in specific regions is needed for quantitative reconstructions. Recent work in the southwestern U.S. has revealed unexpected complexity in $\delta^{18}O_{pc}$, suggesting that regions with complex precipitation patterns may not be ideal for extracting paleoclimate information from pedogenic carbonates. Furthermore, using $\delta^{13}C_{pc}$ to quantify former $C_3/CAM/C_4$ plant proportions requires direct knowledge of carbon isotope systematics in modern soils. Toward this goal, we examined soils and vegetation at several sites spanning ~1,200 m in elevation in southeastern Arizona; $\delta^{13}C_{pc}$ and $\delta^{18}O_{pc}$ values range from -9.9 to -0.6‰ and from -9.4 to -1.3‰, respectively. Results will be examined and compared to previous studies in climatically and ecologically disparate regions to assess the viability of $\delta^{13}C_{pc}$ and $\delta^{18}O_{pc}$ as paleoenvironmental proxies in parts of the southwestern U.S. strongly influenced by the North American summer monsoon.

Krause, Teresa R., Jackson, Stephen T., and Willams, John W.: LATE-QUATERNARY VEGETATION AND FIRE HISTORY AT WHITE POND, SOUTH CAROLINA, USA (Poster C15). Revisiting a 'classic' pollen site in the Southeast US (Watts 1980), we reconstructed the late-Quaternary vegetation and fire history at White Pond, South Carolina. Robustly dated fossil pollen and macroscopic charcoal sequences provide new insights into vegetation and fire dynamics in the southeastern US over the last 35,000 years. Prior to 16.2 ka, pollen assemblages dominated by *Pinus*, *Picea*, and herbs (including sandhill taxa) indicate stands of pine and spruce interspersed with prairie and dune communities. Low charcoal accumulation rates (CHAR) suggest little biomass burning due to low terrestrial productivity and/or unfavorable climatic conditions. Hardwood trees expanded into the region beginning 16.2 ka, as indicated by increasing abundance of deciduous tree taxa (e.g. *Quercus, Carya, Ostrya/Carpinus*) in the pollen record and decreasing *Pinus* levels. Biomass burning remained relatively low. Between 13.1-10.4 ka, pollen assemblages featured the highest levels of mesic hardwood taxa, including *Fagus*, and the lowest amounts of *Pinus* in the entire record. A mesic hickory-beech forest likely grew on the landscape at this time, and although terrestrial productivity was high, extremely low CHAR suggests depressed fire activity due to unsuitable, likely wet, climatic conditions. Present-day pine-oak forests developed rapidly after 10.4 ka, indicated by increased *Pinus* levels, while pollen from mesic hardwood tree taxa decreased. At the same time, a step-like increase in CHAR suggests elevated biomass burning that extends to present day. Intermediate climate and fuel abundance likely supports high levels of Holocene fire activity, and the ecosystem is thus particularly sensitive to anthropogenic intervention via fire suppression or increased ignitions. Understanding the range of environmental variability experienced by fire-prone landscapes in the Southeast provides a context for implementing fire management practices that build and support ecological resilience.

Leys, Bérangère, Brewer, Simon C., Mueller, Joshua, McConaghy, Scott, McLaughlan, Kendra, and Marlon, Jennifer: FIRE HISTORY RECONSTRUCTION IN GRASSLAND ECOSYSTEMS (Poster C8). Fire is one of the most important disturbances acting on vegetation structure, composition and dynamics, especially in grassland ecosystems where management must consider historic fire regimes. Past fire regimes are reconstructed using charcoal particles preserved in depositional environments, but the relationship between quantity of charcoal pieces and characteristics of the fire regime remains poorly understood, especially in grassland ecosystems, where charcoal records represent only 8.7% of the Global Charcoal Database. We used two approaches to investigate these relationships. First, charcoal deposited in traps from a native tallgrass prairie in mid-North America was linked with environmental factors including climate, vegetation and landscape variables, and fire parameters. We found that small and large particles of charcoal are well-correlated and likely reflect the same spatial scale of fire activity. Total charcoal amount was well predicted by the area burned <5 km, and regional burning explained the ratio of non-arboreal to total charcoal pieces (NA/T ratio). Charcoal variables, including total charcoal count and NA/T ratio, were not correlated with other fire parameters as well as vegetation cover, landscape or climate variables. Additional charcoal metrics, including the charcoal area and the width to length ratio, are also helpful for assessing grassland fire regimes in the Great Plains. Second, we measured charcoal characteristics found in 52 surface sediment samples from tallgrass, mixed-grass, and shortgrass prairies of the Great Plains of North America. We found that the charcoal characteristics

indicate significant variation in fuel sources among grassland biomes. These results will help interpret the charcoal signal of grassland systems in sediment records covering several millennia.

Loeffler, Shane M. and Myrbo, Amy: FLYOVER COUNTRY: LEVERAGING PALEOECOLOGICAL DATABASES TO MAKE DATA ACCESSIBLE IN THE FIELD (Poster D5). Flyover Country (FC) is an NSF funded mobile app originally developed for geoscience outreach from the airplane window seat. The app presents users with geologic data and maps, allowing them to learn about the world below. Recently NSF has awarded continued funding to develop the app as a data discovery and visualization tool. FC queries geological (Macrostrat), paleoecological (Neotoma and Paleobiology Database), and others (Wikipedia, OpenCoreData, and more) for maps and information about a chosen geographic region. It then saves this content offline and locates the user by GPS, so no data connection is required after initial setup. By exposing previously collected data in a region of interest, scientists in the field can have access to the information already known about a site as they collect new data. This access will allow scientists to understand their new measurements in context, allowing them to make decisions based on both existing measurements and interpretations as well as their newly collected samples, in real time. By leveraging researcher ID systems such as ORCID, the app will also function as a recommendation engine for who to work with, based on who has published data, or submitted datasets to a database, in the region of interest. More data sources are planned for inclusion, and many of them have time and depth components. Visualizing spatial and temporal patterns of complex multidimensional data is one of the central challenges of development.

Long, Colin J., Power, Mitchell J., and Grigg, Laurie D.: A 35,000-YEAR FIRE HISTORY FROM THE OREGON COAST RANGE, USA (Poster C9). We extend a published 9000-year fire history record from Little Lake, in the Oregon Coast Range, to 35,000 years and compare it with the established pollen record from the site. The fire history is based on a high-resolution analysis of charcoal preserved in lake sediments providing a fire history record that spans the last glacial maximum in North America. The data enabled us to address questions regarding the interactions between large-scale climate changes associated with the shift from glacial to interglacial conditions and the accompanying changes in forest vegetation and fire regimes. The vegetation history indicates a change from open subalpine forests to closed western hemlock/Douglas fir forests as climate moved from cold and dry full glacial to warm and wet Holocene conditions. The fire history indicates that although there was more biomass burned in the Holocene, the frequency of fires between glacial and interglacial conditions was not significantly different and that fire frequency did not change in concert with shifts in vegetation. This suggests that fire is a product of shorter-term variations in climate that may not cause significant shifts in vegetation. Also that as short-term climate variability becomes more common in the near future; conditions for fires in these mesic forests may become more common as well.

Loope, Henry, Lowell, Thomas, Curry, B. Brandon, Monaghan, G. William, Huot, Sebastien, Grimley, David, Nash Jr, Andrew, and Wang, Hong: READVANCE OF THE LAURENTIDE ICE SHEET, 22-21 K CAL YR BP, SOUTH-CENTRAL INDIANA (Poster A9). The mechanism driving initial retreat and subsequent readvance(s) of the southern margin of the Laurentide Ice Sheet (LIS) within and south of the Great Lakes basins during the last termination is important to understand ice sheet response to past climate and to improve ice sheet modelling. Robust chronologic data is needed to test these mechanisms.

Toward that end, we investigated glacial stratigraphy and obtained new chronology related to ice margin fluctuations in south-central Indiana. Thirty-three new radiocarbon ages on plant macrofossils and gastropods from below till at three sites indicate a major readvance ca. 22-21 k cal yr BP of the Huron-Erie Lobe of the LIS subsequent to its maximum extent. The presence of two Oxygen Isotope Stage 2 [OIS 2] tills near the limit of OIS 2 glaciation in Indiana has been recognized for over 50 years, but the chronology of ice margin fluctuation has been difficult to interpret from the existing data due to large radiocarbon age errors, unknown/unclear stratigraphic context, and few sites with multiple ages. We revisited the type section for multiple OIS 2 tills and obtained 12 radiocarbon ages on plant macrofossils (*Dryas* leaves, *Picea* needles and stems) and terrestrial gastropods from a fossiliferous silt between tills. These ages bracket ice advance to ca. 21.4 k cal yr BP and agree well with maximum ages of 21.5 k cal yr BP from two additional sites. These sites agree with chronology of ice advance in south-central Ohio, ice-walled lake plain formation and rapid loess sedimentation rates in central Illinois, suggesting a regional response of the LIS to cold climatic conditions.

Lozano-García, Socorro, Caballero-Rodríguez, Dayenari, and Correa-Metrio Alexander: MODERN FOREST ECOSYSTEMS IN CENTRAL MEXICO, A HUMAN LEGACY? (Poster B8). Central Mexico exhibits a unique pattern of biodiversity expressed in a wide variety of forest ecosystems. These floras interact along the steep temperature and precipitation gradients that characterize the Trans-Mexican Volcanic Belt, a geologic province that crosses from the Gulf of Mexico to the Pacific Ocean. Human occupation in central Mexico has been an important factor in the landscape transformation since ca. 6000 years. The agricultural activities have induced deforestation and fires among other effects, changing the plant communities composition. The human impact signal has been documented in the palynological records by high abundance of herbaceous pollen, presence of cultigens as *Zea mays*, and high concentrations of charcoal particles, among other indicators. Pollen data of seventeen fossil pollen records and 40 modern samples for mud-water interphase sediments in central Mexico were analyzed using Detrended Correspondence Analysis and probabilistic methods to identify the patterns of vegetation turnover and analogy during the Holocene. Fossil pollen data were grouped into three altitudinal classes, highlands (HL) above 2500 m asl, midlands between 2000 and 2500 m asl (ML) and lowlands (LL) below 2000m asl. Our results showed that for most of the Holocene vegetation turnover was high. Both vegetation turnover and past vegetation analogy to modern were not synchronous in altitudinal zones, except for the past 2,000 years when pollen assemblages suggest a high vegetation analogy to modern all throughout the region. But the midlands showed the longest history (4200 years) of high analogy between past and modern vegetation, indicating pervasive human impact.

Mandel, Rolfe D., Bettis, E. Arthur, III, and Hanson, Paul R.: CHARACTERISTICS AND GEOCHRONOLOGY OF THE SEVERANCE FORMATION: A NEW MID- THROUGH LATE WISCONSINAN LITHOSTRATIGRAPHIC UNIT IN THE EASTERN PLAINS OF NORTH AMERICA (Poster C18). Thick packages of mid- through late Wisconsinan alluvium and colluvium preserved beneath terraces and footslopes, respectively, are widespread in river valleys of eastern Kansas and Nebraska. Previously, these deposits were generally referred to as the fluvial and colluvial facies of the Gilman Canyon Formation (Mandel and Bettis, 2001), a unit of late Wisconsinan loess on the adjacent uplands. Our investigations have revealed, however, that these deposits, now referred to as the Severance Formation, are a distinctive lithologic unit. The

formation consists of two members: an early member, buried beneath Gilman Canyon Formation loess, and a late member that is immediately beneath a terrace surface or a thin veneer of last-glacial Peoria Loess. OSL ages are pending on the early member, but given its stratigraphic position and the numerical age of the late member, this valley fill was aggrading before ca. 45 ka. Radiocarbon and OSL ages indicate that the late member aggraded between ca. 45 and 13 ka (MIS 3 and 2). Both members of the Severance are oxidized, and the late member typically contains two or more paleosols forming a pedocomplex similar to the one developed in the Gillman Canyon Formation. The paleosols tend to have thick, well-expressed Bt horizons with strong brown to yellowish brown matrix colors; prismatic to subangular-blocky structure; iron and manganese oxide stains and nodules; discontinuous clay films and silans; and many to common macropores. Radiocarbon ages determined on organic carbon from the paleosols in the late member range from ca. 25 to 17 ka.

Marsicek, Jeremiah, Shuman, Bryan, and Brewer, Simon: THE SPATIAL AND TEMPORAL EVOLUTION OF HOLOCENE TEMPERATURES IN NORTH AMERICA AND EUROPE (Poster A19). By reconstructing temperatures from fossil pollen data over the Holocene we can place recent and future warming in a long-term context and evaluate the patterns of past trends, variability, and abrupt changes. To do so, we apply the modern analog technique to systematically reconstruct seasonal temperature changes during the Holocene from 1605 fossil pollen records from Europe and North America. Our uniform application of the approach ensures comparability of results among sites and regions. We use the best available calibrated radiocarbon chronologies for each site, and then minimize spatial biases and local-level ecological influences in the dataset by calculating mean reconstructions for 2° x 2° geographic windows. In doing so, we only averaged reconstructions that were significantly different from reconstructions of random dummy variables. Average annual temperatures derived from the gridded mean reconstructions show >3°C warming from 11 ka to 5.5 ka. The annual temperatures reached their Holocene maximum at 5.5 ka before then declining by ~0.3°C to present. Orbital and ice sheet changes best explain the long term trends, but substantial deviations from the trends also exist in three intervals: 1) a ~0.25°C cooling from 9.3 – 8.5 ka, 2) a ~0.5°C warming from 5.7 – 5.3 ka, and 3) a ~0.3°C cooling from 1.9 ka – present. The reconstructions also contain evidence of meaningful millennial-scale variability represented by quasi-periodic, autoregressive fluctuations with a period of ~2400 years. Bootstrap re-sampling and comparison with marine geochemical records indicates that the deviations represent robust changes.

McLean, Bryan and Cook, Joseph: PATTERN AND PROCESS IN THE PLEISTOCENE DIVERSIFICATION OF SMALL-EARED GROUND SQUIRRELS (*UROCITELLUS*) (Poster B17). The Great Basin (USA) supports a distinct terrestrial mammal fauna that formed via a complex Neogene history of colonization, extinction, and *in situ* diversification. However, actual drivers of the latter process within this ecoregion remain poorly understood, particularly for lower-elevation taxa. We assembled the first comprehensive multilocus genetic dataset from small-eared ground squirrels of the genus *Urocitellus* (5 species), a group of morphologically cryptic sciurids distributed in and peripheral to the Great Basin. We used these data to infer phylogeny, perform species delimitation, and examine paleoenvironmental features that potentially fostered *Urocitellus* evolution in this region. Preliminary results support the existence of cryptic, species-level diversity within the Piute ground squirrel (*U. mollis*), a Great Basin endemic, with divergent populations existing north and south of the Snake River (Idaho). Results also suggest

prominent roles for additional large, persistent paleolakes and paleodrainages in shaping current diversity and distributions in this clade. However, in the case of *U. mollis,* there is little evidence that the aforementioned divergent populations are sister taxa, suggesting that the roles of major paleoenvironmental features in the diversification of extant aridland mammals may be both temporally deeper and more complicated than often realized.

Meredith, Clayton, Merriman, Christopher, and Prufer, Keith M.: IMPACT OF DEFORESTATION ON SOIL CARBON ISOTOPES AND BASIN-WIDE EROSION RATES IN THE CENTRAL AMERICAN TROPICS DERIVED FROM HOLOCENE-LENGTH ALLUVIAL DEPOSITS (Poster C12). Despite a century of research on the ecological impacts of the Classic Maya civilization relatively little is known about their Late Pleistocene and Early Holocene ancestors. Here we discuss recent geoarchaeological investigations in southern Belize from river terraces near the Paleoindian to Archaic site of Tzib'te Yux located in the Rio Blanco watershed and dating between 3000-12500 BP. There, landscape-level vegetation changes are apparent in the form of forest clearance by 5000 BP. Evidence of pedogenesis derived from four years of excavations and sedimentation rates established through modeling and high-precision ^{14}C AMS dating have produced an erosional history of the wider watershed reflecting the extent of land clearance throughout the Holocene. Combined with compelling evidence for contemporaneous human occupation, these data facilitate an assessment of changing niche construction strategies of Paleoindian and Archaic foragers within the area. Stable carbon isotopic signatures of insoluble components of soil organic matter (SOM) reveal the impact of human occupation on vegetation regimes within the Rio Blanco watershed with δ^{13}C values of humins and humates reflecting a C3 dominated landscape prior to a rapid shift of up to 4‰ following the introduction of C4 crops (maize) to the region. Values remain at relatively less negative values through the Classic Period, declining only after the abandonment of nearby Maya polities.

Moretti, John A., Hurst, Stance, and Johnson, Eileen: PALEOINDIAN (~11,500-8,000 C14 YRS BP) LANDSCAPES ALONG THE SOUTHERN HIGH PLAINS EASTERN ESCARPMENT, NORTHWEST TEXAS (Poster C2). The Southern High Plains (SHP) of Texas and New Mexico contain some of the most significant late Quaternary locales in North America. Discoveries in the 1930s thrust the region into the forefront of Paleoindian and megafaunal research, providing foundational data on the Pleistocene-Holocene transition. The latest chapter in this exploration is manifested in research efforts in Spring Creek, along the eastern edge of the SHP (Texas). Located within the Brazos River system, ongoing investigations in Spring Creek have documented a multi-component record spanning ~12,000-8,000 C^{14} yrs BP. At Macy Locality 100, alluvial deposits contain a diverse vertebrate fauna with members from all terrestrial vertebrate classes. This fauna is encased within a stratigraphy of sediments that record the shifting form and capacity of Spring Creek. Complementing the fauna and stratigraphy are a series of radiocarbon ages that span ~12,000-11,000 C^{14} yrs BP. Further downstream (55m), remains of extinct bison accompanied by a cultural flake, along with an associated radiocarbon date of ~10,100 C^{14} yrs BP occur at Macy Locality 349. West (345m) of this ancient bison assemblage, at Macy Locality 10, an isolated Clovis point demonstrates an early Paleoindian presence in the area. Continuing downstream, diatomite deposits (Macy Locality 350) record a 200m-diameter pond whose environs contain potential for additional faunal and cultural discovery. Viewed in combination, these and other isolated locations

within a segment of Spring Creek provide the setting for a robust exploration of multiple facets of the Pleistocene-Holocene transition.

Morgan, Gary: LATE PLEISTOCENE NONANALOG MAMMALIAN FAUNAS FROM HIGH ELEVATION CAVES IN THE SANDIA MOUNTAINS OF NORTHERN NEW MEXICO (Poster C21). Sandia Cave and Marmot Cave are located in the Sandia Mountains of north-central New Mexico at an elevation of 2,165 m. Both caves contain diverse late Pleistocene (Rancholabrean) mammalian faunas: Sandia Cave has 39 species, including 9 members of the extinct megafauna; Marmot Cave has 25 species, all extant. There are 5 radiocarbon (^{14}C) dates from Sandia Cave (11,850–13,700 years before present–yrBP), dating to the Younger Dryas near the end of the last glacial. Marmot Cave has 3 ^{14}C dates (16,290–25,090 yrBP), dating to the Last Glacial Maximum (LGM). Five species of small mammals from Sandia Cave are now extralimital to the Sandia Mountains: *Lepus americanus* (Snowshoe Hare), *Sylvilagus nuttallii* (Mountain Cottontail), *Marmota flaviventris* (Yellow-bellied Marmot), *Thomomys talpoides* (Northern Pocket Gopher), and *Neotoma cinerea* (Bushy-tailed Woodrat). Marmot Cave has 5 extralimital mammals, *Sylvilagus nuttallii, Marmota flaviventris*, and *Thomomys talpoides*, and 2 species absent from Sandia Cave, *Callospermophilus lateralis* (Golden-mantled Ground Squirrel) and *Phenacomys intermedius* (Heather Vole). These mammals now live above 2,500 m in montane coniferous forests in the Jemez, Sangre de Cristo, and San Juan Mountains of northernmost New Mexico, thus exhibiting a nonanalog distribution during the late Pleistocene when they occurred in Sandia and Marmot Caves together with now-allopatric species of mammals still found in the vicinity of these caves. Nonanalog mammal faunas are also typical of late Pleistocene cave deposits in the Guadalupe Mountains of southeastern New Mexico, where some of these same species of extralimital montane mammals (*Sylvilagus nuttallii*, *Marmota flaviventris*, *Thomomys talpoides*, *Neotoma cinerea*) occur farther south and at lower elevations than at present, together with mammals now found in Chihuahuan desert habitats. Small mammal faunas from late Pleistocene cave deposits in New Mexico support other data indicating a cooler, wetter climate during the LGM.

Muus, Jennifer, Meyer, Grant, McFadden, Leslie D., Huckell, Bruce, Merriman, Christopher W., and Rowe, Tim: GEOMORPHIC PROCESSES PROMOTING MAMMOTH BURIAL AND SKELETAL PRESERVATION (Poster D18). Near Abiquiu in northern New Mexico, mammoth skeletal remains were recently discovered in the near surface deposits of a very small alluvial channel. The channel occupies a depression on the back-tilted top of a Toreva slump block, a highly unusual setting for a mammoth burial. Geomorphological investigation of the site has provided insight into processes leading to burial and preservation of the remains, as well as local environmental change. Slumping was likely promoted by wetter Late Pleistocene climate and snowmelt on the northwest aspect. Remnants of thick colluvium are present on the scarp slopes above the channel; we infer that colluvial aggradation occurred mostly in the Late Pleistocene due to greater physical weathering, denser vegetation limiting runoff and erosion, and active aeolian deposition adding fine sand-silt to the colluvial matrix. On the mammoth site slump bench, discontinuous bouldery footslope colluvial deposits show clay films and stage I to I+ carbonate, and were likely most active shortly following slumping due to failure of oversteepened slump scarps. To better understand the geomorphic context of the mammoth remains, local bedrock and six soil pits from varying surficial deposits were analyzed to determine the sequence of hillslope processes.

Field observations, x-ray fluorescence (XRF) and x-ray diffraction (XRD) analyses indicate little chemical weathering has occurred in adjacent finer-grained slope deposits. Particle size analysis results are consistent with XRF and XRD results, suggesting minor soil development has occurred in this dynamic environment, with parent material being the primary factor in determining grain size. The deposit surrounding the mammoth remains consists of cobbles and small boulders of sandstone supported by a muddy matrix; this texture strongly suggests that the mammoth remains were buried by a debris flow. We infer that runoff from the mesa top entrained sediment via incision of gullies in hillslope and footslope colluvium, bulking to debris-flow conditions. The slump depression channel at the burial site is only ~1.5 m wide and as little as 40-50 cm deep. The debris-flow deposit created a high point in the channel, so that subsequent flow was diverted off the downslope edge of the slump block, protecting the mammoth from later erosion. Ped-face carbonate coatings (stage I+) and soil structure in the debris-flow deposit indicate a greater age than the relatively well-sorted and stratified alluvial deposits in the channel above the debris flow, which measures up to 1.2 m deep immediately south of the mammoth remains. ln the Holocene, reduced vegetation cover, intense monsoonal summer convective storms, and depletion of hillslope sediment storage in gullies may have promoted a change to more dilute flows in channels. Following mammoth burial and continuing to the present, deposition of finer footslope colluvium continued in an incremental manner. XRD analysis of an A horizon soil sample from the footslope reveals the presence of illite, which is absent in local bedrock, suggesting the accumulation of non-local dust. Understanding the geomorphic setting and processes at this site may prove useful in locating other atypical preservation sites for Pleistocene megafaunal remains in the Southwest.

Nanavati, William P. and Grimm, Eric: HUMANS, FIRE, AND ECOLOGY IN THE SOUTHERN MISSOURI OZARKS (Poster C10). A multiproxy study from Sweeton Pond, Ozark County, Missouri, provides a high-resolution 1,900-year history of fire and vegetation in the southern Missouri Ozarks, where the modern vegetation is oak-hickory forest. Chronology is based on five AMS radiocarbon dates. Pollen and charcoal data are compared to dendrochronological data to assess the role of climate and fire. The role of humans, particularly the Osage, is assessed from historical accounts and archaeological studies. Increased fire activity and paradoxically fire-tolerant vegetation coincident with the Osage occupation of the Ozarks, during a cooler, mesic period support an anthropogenic-burning hypothesis. Synthesis of the paleoecological, historical, and archaeological records allows us to address the significance of humans on the landscape. Three cultural periods are delineated: (1) Pre-Osage, ending ca. AD 1500; (2) Osage, AD 1500-1820; and (3) Euro-American, since AD 1820. The Pre-Osage period is characterized by open oak-hickory forest thinned by low-intensity fires. Cooler temperatures, 950-500 yr BP, increased the forest understory density and decreased fire frequency. During the Osage period, the southern Missouri Ozarks was mesic, and likely had cooler summer and winter temperatures. Fire frequency increased during this period as Osage expansion brought increased use of fire. Increased fire frequency favored fire tolerant species, such as shortleaf pine (*Pinus echinata*). The Euro-American period is characterized by changes in settlement size and land-use, marked by large increases in disturbance indicators (e.g. *Ambrosia*-type), at the expense of shortleaf pine. During this period, fire was used initially to clear land, and then actively suppressed after 1920.

Nolan, Connor, Shuman, Bryan, Booth, Robert, and Jackson, Stephen T.: COMPARING PALEOHYDROLOGIC RECONSTRUCTIONS BASED ON LAKE LEVELS AND TESTATE AMOEBAE-INFERRED WATER TABLE DEPTH (Poster C16). Sedimentary lake level records and ombrotrophic bog water table depth records both document hydrologic variability over the Holocene. Lake level records preserve low frequency trends and centennial-to-millennial length events best. This is in contrast to the bog records based on testate amoeba community composition which excel at interannual to multidecadal time scales. It would be desirable to use both of these types of records together to get a multi-scale understanding of past hydroclimatic changes. In order to accomplish this we need co-located records as well as detailed modern observations, statistics, and forward models to understand how these proxies record past changes in hydroclimate. Here we show preliminary paleoclimate reconstructions over the past 10,000 years from a co-located pair of sites in Maine: Giles Pond, Aurora, ME, USA and Caribou Bog, Old Town, ME, USA. This is the first time these two types of records have been developed in the same location, thus eliminating the confounding effects of regional climatic differences when comparing existing records. Furthermore, we present analyses of modern observational data of lake level and bog water table depth to understand short timescale relationships between climate and proxy records, new statistical modeling to extract relevant signals with meaningful uncertainties, and forward modeling to better understand how climate signals are recorded and transformed by the proxies. These approaches combined will give us a detailed climate history of Maine and also help to improve the interpretation of lake level and bog water table depth records everywhere.

Pardi, Melissa: FLESH OFF THE BONES: CALCULATING LATE QUATERNARY CANID BODY-SIZES FROM FOSSIL FRAGMENTS FOR PALEOECOLOGICAL STUDY (Poster B1). Mass is an intrinsic characteristic that imposes constraints; from metabolic rates to energy flow through food webs, body-size is a widely utilized ecological character. While mass is easy to measure in living individuals, it is more challenging to measure in the paleontological record. Relationships between skeletal structures and mass have been used to estimate size from fossils, but has been limited to only a few measurable elements. To increase the utility of partial skeletal remains in the study of body-size, modern skeletons were used to establish relationships between mass and 24 skeletal measurements across the Canidae. These included dental, cranial, as well as limb bone and partial ephiphyses that are typically found as fragmented fossil remains. Relationships had high r-squared values of the log standardized data, moderately low average percent standard error of the estimate, and low percent prediction error. These relationships substantially increase the number of elements that can be used to estimate mass in fossil canids. Size estimates were made for canids from seven Pleistocene and eleven Holocene faunas in west central Texas, on the Edwards Plateau. Estimates of mass for the extinct dire wolf were consistent with prior published estimates. Mean mass of extant species did not change significantly over time; however, the Holocene community exhibited a reduction in the abundance of small canids and an increase in medium size canids, including domestic dogs. These changes altered the size profile of the canid community, and likely the ecological function of this guild.

Rittenour, Tammy, Nelson, Michelle, Riley, Kerry, Townsend, Kirt, Huff, William, and Hayden-Lesmeister, Anne: ARROYO CUT-FILL DYNAMICS IN SOUTHERN UTAH, CHRONOLOGY AND CAUSAL LINKAGES (Poster C1). In the late 1800's to early 1900's AD many streams in the semi-arid southwestern US abruptly

entrenched into their alluvial floodplains and formed 5-30m deep steep-walled arroyo channels. Historic arroyo entrenchment is considered one of the most significant geomorphic changes in the region and led to lowering of alluvial aquifers, loss of original wet-meadow and riparian habitat, loss of agricultural and municipal lands and infrastructures, and in some cases, the abandonment of early settlements. While initial speculations suggested that channel entrenchment was due to overgrazing and channel diversions, stratigraphic relationships exposed in arroyo walls indicated natural causes for past episodic entrenchment. Despite over a century of investigation into alluvial records of arroyo entrenchment, a clear linkage to a causal mechanism has not been determined. This research examines the arroyo cut-fill chronostratigraphy of five adjoining catchments in the Grand Staircase region of southern Utah to help better understand the processes of arroyo aggradation and the timing of entrenchment in relationship to regional hydroclimatic forcing, erosion rates and autogenic drivers. Age control for the alluvial deposits come from AMS radiocarbon dating of charcoal (n=170) and single-grain OSL (optically stimulated luminescence) dating (n=130). Results indicate four to five periods of aggradation followed by entrenchment during the past 5-6 ka. High bedrock erosion and flashy discharge are proposed to have fueled mid-Holocene aggradation and created instability that lead to episodic arroyo entrenchment. Individual entrenchment events occurred during high-discharge events once aggradation brought the systems to a threshold in slope.

Rodysill, Jessica, Donnelly, Jeffrey, Lane, Philip, Sullivan, Richard, Toomey, Michael, Woodruff, Jonathon, Hawkes, Andrea, and MacDonald, Dana: HISTORICALLY UNPRECEDENTED NORTHERN GULF OF MEXICO HURRICANE ACTIVITY FROM 650 TO 1250 C.E. (Poster A7). Hurricane activity has varied substantially over the past several decades and is largely controlled by sea surface temperature (SST) variations, thermocline depth, wind shear, and upper tropospheric temperatures. However, how these factors collectively control hurricanes on centennial timescales in the Gulf of Mexico (GOM) region remains unclear. Improvements in hurricane modeling have led to predictions of increased frequency of intense tropical cyclones in the Atlantic Ocean over the next century, yet the trends in frequency and intensity of future hurricanes in the GOM is unknown. Here, we present two new records of hurricane landfalls based on grain size variations in cores from coastal sediments in northwestern Florida for the past 2000 years. These data, along with previous storm reconstructions, show coherent centennial-scale variations in hurricane activity along the northern GOM coast. Evidence indicates that the northern GOM coast experienced a period of heightened hurricane activity from 650 C.E. to 1250 C.E. that is unprecedented in the last 150 years. Hurricane activity in these sediment records varied in accordance with changes in tropical Atlantic and GOM SSTs, GOM thermocline depth and Loop Current variability, and the mean position of the Intertropical Convergence Zone (ITCZ). We propose that enhanced hurricane activity coincides with warm tropical Atlantic and GOM SSTs, a deeper GOM thermocline, and a more northerly ITCZ. Predicted warming of Atlantic SSTs over the coming century could result in more intense Atlantic hurricanes, but predicted Loop Current weakening may restrict GOM cyclogenesis and intensification relative to past active periods.

Routson, Cody C., McKay, Nicholas P., Kaufman, Darrell S., and Ault, Toby R.: CHANGING TEMPERATURE GRADIENTS LINKED TO HOLOCENE MOISTURE TRENDS IN THE NORTHERN HEMISPHERE (Poster A17). The response of mid-latitude hydroclimate to zonal differences in radiative forcing is poorly understood

in part due to a lack of long-term observational data. The mean position of the subtropical jet stream and associated storm tracks are influenced in part by the temperature gradient between the equator and the pole. Climate change is expected to strengthen Hadley circulation while weakening the equator-to-pole temperature gradient, thus shifting the mean position of the subtropical jet northward and causing the sub-tropics to become drier. A similar weakening of the equator-to-pole temperature gradient may have occurred during the early-to-mid Holocene; hence, analysis of zonal temperature gradients and mid-latitude moisture balance during that time period presents a novel test of the robustness of future projected changes in global circulation in a paleoclimate context. We analyzed the evolution of the latitudinal gradients of temperature and moisture in a new compilation of Holocene-length paleoclimate records spanning from 10°S to 90°N. The primary trends in the paleoclimate records agree with future projections showing that weaker early-to-mid Holocene Northern Hemisphere latitudinal temperature gradients (warming of the Arctic with respect to the equator) are linked to substantial decreases in mid-latitude (30°N-50°N) moisture. This result is significant for current warming, as northern high latitudes are warming faster than the equator, decreasing the equator-to-pole temperature gradient to values comparable with the early Holocene. Our results support model-based projections of increased drought risk in the Northern Hemisphere mid-latitudes in the coming decades.

Rust, Robert: CONSEQUENCES OF COUPLED FIRE AND DROUGHT DISTURBANCES ON BIODIVERSITY IN THE SUBALPINE FORESTS OF THE CENTRAL ROCKY MOUNTAINS (Poster C7). Predicting ecological responses to environmental change is a fundamental challenge for ecologists. Understanding the effect of variation in climate and disturbance on biodiversity of forested ecosystems is central to effective management when considering expected accelerating changes. Paleoecological records detail ecological dynamics on deep timescales and are becoming an invaluable arena to test ecological theory. Here we use three sites to investigate the response and resiliency of Central Rocky Mountains subalpine forests to centennial-to-millennial drought and fire frequencies in regards to shifts in alternative stable states and biodiversity. Specifically, we consider: 1) Do drought and fire work in concert to drive changes in vegetative communities in subalpine forests? 2) Is there an amplification of effect when drought and fire work in concert? 3) How is subalpine vegetation diversity affected by the combined effects of drought and fire? To address these questions vegetation and fire histories were independently reconstructed from sedimentary pollen and charcoal counts while historic effective moisture was inferred from sedimentary lake-level indicators at three different locations. We evaluate the ecological difference between communities under drought/wet and fire/fire-free conditions using Hill numbers of pollen richness as an estimate of biodiversity. This will allow us to determine if there is an amplified effect when differing fire regimes are considered in concert with the differing hydrological conditions.

Shuman, Brian, Oslwald, W. Wyatt, and Foster, David R.: MULTIVARIATE CLIMATE CHANGE, THE CLIMATE NICHE, AND THE HOLOCENE HISTORY OF EASTERN HEMLOCK (*TSUGA CANADENSIS*) (Poster D17). We consider how climate shaped the Holocene history of eastern hemlock (*Tsuga canadensis*), and New England forests generally, by evaluating the modern realization of *Tsuga*'s climate niche and then comparing fossil pollen records from eight New England sites with quantitative temperature and effective precipitation reconstructions. The comparisons indicate that multivariate climate change significantly influenced the vegetation history. On average, models based on past temperature and

precipitation changes explain 64.1% of the variance in *Tsuga* pollen percentages (adjusted R^2 = 0.396-0.802), and 69.2-86.2% of the variance of other taxa (adjusted R^2 = 0.321-0.950). Furthermore, our analysis indicates that two persistent features of the climate niche likely shaped *Tsuga*'s history. First, *Tsuga* pollen percentages reach maxima today (>30%) where July temperatures equal 18-20°C, but only where annual precipitation equals either ~1100 or ~775 mm. The bimodality reflects *Tsuga*'s two geographic modes in the Great Lakes and Appalachian regions today, and explains past dynamics, such as short-lived peaks in *Tsuga* abundance before ca. 9800 years before CE 1950 (YBP), which developed as effective precipitation first rose above 775 mm. Second, the distribution of high *Tsuga* abundance within the niche follows a negative correlation between temperature and precipitation. Consequently, rapid cooling at 5200±100 YBP, which occurred just prior to intense regional droughts, facilitated widespread *Tsuga* declines. Cooling without a coincident increase in moisture was inconsistent with the negative correlation in the niche, but a subsequent increase in effective precipitation over the past 4000 years re-established an optimal climate for *Tsuga*.

Shuman, Brian and Serravezza, Marc: PATTERNS OF HYDROCLIMATIC CHANGE IN THE ROCKY MOUNTAINS AND SURROUNDING REGIONS SINCE THE LAST GLACIAL MAXIMUM (Poster A20). The paleohydrologic record of western North America since the last glacial maximum reveals a wide range of hydroclimatic variability and distinctive patterns associated with abrupt climate changes. To improve the understanding of abrupt hydroclimatic shifts and centennial-to-millennial hydrologic variability in western North America, we reconstruct two lake-level histories from small lakes in the Beartooth and Bighorn Mountains of northern Wyoming over the past 17 ka. To do so, we use ground-penetrating radar (GPR) and sediment cores to track the elevations of shoreline sediments within the lakes through time. We compare the stratigraphies with those from four other lakes in Wyoming and Colorado, and find widespread evidence for a Terminal Pleistocene Drought from 15-11 ka, an early Holocene humid period from 11-8 ka, and a period of severe mid-Holocene aridity from 8-5.7 ka. The northern Wyoming lakes also provide evidence of high levels before ca. 15 ka, including rapid hydroclimatic changes at ca. 16.8 ka during Heinrich Event 1. We place the changes in a broad context by summarizing and mapping water-level changes from 107 additional, previously studied lakes. Important patterns include 1) extensive drying across the western U.S. after 15 ka; 2) coherent sub-regional differences during the Younger Dryas and Pleistocene-Holocene transition; 3) a north-south contrast from 9-6 ka consistent with a northward shift in storm tracks as the influence of the Laurentide Ice Sheet diminished; and 4) rapid increases in effective moisture across much of western North America from 6-4 ka.

Simmons, Victoria: ANALYSIS OF THE DYNAMICS OF THE OLD RIVER BED AND PALEO LAKE BONNEVILLE (Poster C6). The purpose of this project is to analyze the relationship between the Old River Bed (ORB) Delta and lake level oscillations of Paleo Lake Bonneville. The ORB is an important feature in the overall history of the basin due to the deposits from overflow of the Sevier Basin into the delta that began during the regressive phase. This record of events occurred when the lake dropped below the ORB threshold. The 118 cm core was retrieved from Dugway Proving Grounds (DPG) in western Utah in the fall of 2014. The location is at the center of the Bonneville Basin and is south of the Great Salt Lake. Paleo analysis of the core has begun and includes charcoal and pollen analysis to reconstruct and refine the chronology of this unique system. Paleo environmental information will help provide a better

understanding of the dynamics between the ORB and the lake levels. This will also assist in understanding the archeology of the region and provide some insight on paleo people of the area.

Smith, Alison J. and Horne, David J.: WIDENING THE FIELD OF VIEW FOR OSTRACODE BIOGEOGRAPHY: HOLARCTIC VIEW OF NONMARINE OSTRACODES REVEALS USEFUL ANALOGS OF CLIMATE AND ENVIRONMENTAL CHANGE (Poster A4). Nonmarine ostracode databases are now available for large scale studies of environmental conditions through open access community databases such as Neotoma (www.neotomadb.org). They offer new opportunities to gain insight into past hydroclimatic states, subject to taxonomic harmonization of datasets. We map selected species with palaeoclimatic significance. Calibration of *Fabaeformiscandona balatonica* (Daday, 1894) for palaeoclimate reconstructions has relied on sparse European records suggesting that it does not live where mean January air temperatures exceed -1^{o}C; investigation of anomalous occurrences in the warmer southern USA proved them to be misidentifications of the widespread *F. caudata* (Kaufmann, 1900). Although useful in the Quaternary of both regions, *Candona neglecta* Sars, 1887 remains widespread in Europe but is now rare in North America. Co-occurrence of *F. caudata* and *C. neglecta* in Late Pleistocene records indicates aquatic settings including streams or rheocrene springs and cool air temperatures. North American records of *Candona rectangulata* Alm, 1914 can be synonymized with *Fabaeformiscandona harmsworthi* (Scott, 1899), an Arctic species with value as a cold climate indicator in Pleistocene assemblages, now be shown to have a circumpolar distribution. Taxonomic harmonization studies also suggest that the European Pleistocene species *Limnocythere suessenbornensis* Diebel, 1968, thought to be extinct, still inhabits North America, where it is known as *L. friabilis* Benson & MacDonald, 1963, in continental climates where mean January air temperatures do not exceed -3 ^{o}C; it occurs today in the Laurentian Great Lakes in association with the above-mentioned *F. caudata* and another species with a circumpolar distribution, *Cytherissa lacustris* (Sars, 1863).

Smith, Felisa A., Catalina P. Tomé, Emma A Elliott Smith, Seth D. Newsome, S. Kathleen Lyons, and Thomas W. Stafford: AFTER THE MAMMALS: UNRAVELING THE ECOSYSTEM CONSEQUENCES OF THE TERMINAL PLEISTOCENE MEGAFAUNAL EXTINCTION (Poster B10). Recent studies connecting the decline of large predators and consumers with the 'unraveling' of ecosystems overlook that this natural experiment already occurred. As recently as 14 ka, tens of millions of large-bodied mammals were widespread across the American continents. Within 1,000 years of the arrival of humans, ~80% were extinct including all species >600 kg. While the cause of the extinction remains contentious, what has been largely overlooked is the consequence of the loss of millions of large-bodied animals. Here, we examine the influence of the extinction at a local community. Our study site is Hall's Cave in the great plains of Texas, which has unparalleled fine-grained temporal resolution over the past 20ka, allowing characterization of the community before and after the extinction. This site experienced catastrophic loss of 80% of large-bodied herbivores and 20% of the apex predators in the ecosystem. Using a series of tightly constrained temporal windows spanning the full glacial to the modern and comprehensive faunal lists, we reconstruct mammal associations and body size distributions over time. We find changes in alpha and beta diversity and the statistical moments associated with periods of climate change as well as with the extinction event. Moreover, employing the null model program PAIRS to our data reveals

interesting temporal patterns in the disassociation or co-occurrence of species through the terminal Pleistocene and Holocene.

Spano, Nicholas, Lindsey, Emily, Villavicencio, Natalia, and Barnosky, Anthony: THE ECOLOGICAL CONSEQUENCES OF LATE-QUATERNARY MEGAFAUNAL EXTIRPATIONS IN SOUTHERN BRAZIL (Poster B4). The Pleistocene-Holocene transition was marked by the extinction of nearly half of all megafauna globally. The loss of large mammals ("defaunation") can influence vegetation dynamics, as has been documented in modern ecosystems with transitions from grasslands to open woodlands following the removal of megafauna such as elephants and wildebeest. Here we present evidence to suggest that the loss of late-Quaternary megafauna could have precipitated the expansion of *Araucaria* forests in early-Holocene southern Brazil. We compared chronologies of megafaunal extirpations in this area against climate proxies derived from speleothems and pollen records between 13,000-6,000 cal yr BP using ^{14}C and U/Th-series dates from published literature. *Araucaria* forests are characterized by slow-growing coniferous evergreen *Araucaria angustifolia* and *Podocarpus* spp. These forests are associated with moist climates and are generally assumed to have started expanding to their current distribution in southern Brazil around 10,000 cal yr BP. However, speleological proxies indicate a paleoclimate inconsistent with changes in pollen records at this time, that is, a much more pronounced expansion of *Araucaria* forests with Holocene wetting than for any previous Pleistocene wetting period. Given a median estimated extirpation date of 9,500 cal yr BP for megafauna in this region, including the potential ecosystem engineers—*Notiomastodon platensis* and *Catonyx cuvieri*—the vegetation trends are more consistent with an ecological release of forest communities followed by later Holocene wetting rather than the latter acting alone. Such information has implications for understanding how current Anthropocene ecosystems will restructure if threatened megafauna become extinct.

Steinberg, Clare and Smith, Felisa A.: LONG-TERM EFFECTS OF CLIMATE CHANGE: PLANT AND SMALL MAMMAL SPECIES TURNOVER IN DEATH VALLEY, CA, USA (Poster D4). Changing environmental conditions can open niches for new species to invade, leading to large-scale community turnover. Understanding how and why such shifts occur is crucial in this era of anthropogenic global change. Paleontological studies provide a valuable long-term perspective of the dynamics of community turnover. Here, we examine changes in the plant and animal community in what is now the northern Mojave Desert. We quantify plant macrofossil diversity along with turnover in *Neotoma* species over the past 34 thousand years. This time period includes the last glacial maximum as well as numerous smaller climatic fluctuations. These data were recovered from 48 *Neotoma* paleomiddens collected in Titus Canyon, Death Valley, California, ranging in age from 33.5 ka ybp to 500 ybp. Overall, we characterize a shift in an ecosystem dominated by juniper (*Juniperus osteosperma*) to one dominated by creosote bush (*Larrea tridentata*). We document the earliest establishment of non-endemic creosote at the edge of its range in the northern Mojave Desert. Interestingly, we find an individualistic response of plant species that does not necessarily track the movements of the dominant shrubs. Instead, shifts in these plants most likely depend on their own physiological limits. Additionally, by measuring fecal pellet size, we find that woodrat species replacement correlates with warming climate. Our results may help predict responses of desert communities to ongoing climatic fluctuations.

Stolze, Susann: LANDSCAPE RECONSTRUCTION AT THE CARROWKEEL MEGALITHIC COMPLEX, COUNTY SLIGO (Poster C14). The Carrowkeel megalithic complex in County Sligo represents one of the major Neolithic (4000-2500 BC) passage tomb sites in Ireland. The cairns are located on the largely peat covered upland plateaus of the Bricklieve Mountains. The position of the cairns implies that these ritual sites must have been widely visible in the Neolithic landscape. This study tests the hypothesis that the upland plateaus represented a visually prominent karst landscape, not unlike the today's limestone pavement of the Burren in County Clare, during the time of construction in the earlier Neolithic when drier and warmer than present climatic conditions prevailed in Ireland (Stolze et al., 2013). To reconstruct the prehistoric vegetation dynamics and soil forming processes, in particular the onset of blanket bog formation, pollen and loss-on-ignition analyses complemented by radiocarbon dating are performed on peat cores retrieved close to the megalithic cairns. The ongoing research reveals a succession from ferns and a few grassland taxa growing on shallow minerogenic soil, followed by expansion of grassland dominated by *Plantago lanceolata*, grasses, and Fabaceae. The accumulation of deeper, organic rich soils and soil acidification supported the establishment of dry heath around 800 BC. The appearance of *Sphagnum* and testate amoebae mark the subsequent transition to wet heathland around 400 BC. These results suggest that the cairns were located in a barren limestone mountain range surrounded largely by wooded lowlands during the time of their construction (cf. Stolze et al., 2012, 2013). A considerable change of the landscape character at Carrowkeel marked by the development of blanket bog coincided with a widespread and prolonged cool and wet phase during the late Bronze Age.

Strickland, Laura E., Schumann, R. Randall, Thompson, Robert S., Anderson, Katherine H. and Pelltier, Richard T.: QUATERNARY PLANT FOSSILS FROM NEOTOMA MIDDENS IN WESTERN NORTH AMERICA: AN UPDATE OF THE USGS/NOAA NORTH AMERICAN PACKRAT MIDDEN DATABASE (Poster D20). Plant remains preserved in the desiccated urine of packrats (*Neotoma* spp.) provide species-level evidence of past plant communities and records of changing plant distributions and climate during the Quaternary in western North America. Middens from the present back to greater than 50,000 yr B.P. collected from caves and rockshelters have been studied from southern Canada to Mexico. Fifty years of midden investigation has produced tens-of-thousands of identified specimens and hundreds of publications documenting distribution histories of over 1800 tree, shrub, and herb taxa. This wealth of data is available in a new version of the USGS/NOAA North American Packrat Midden Database (version 4), accessible online at http://geochange.er.usgs.gov/midden/. Version 4 expands version 3 (2006), providing midden data in a standardized, quality-controlled format, featuring 77 new source references and additional midden samples (682), radiocarbon ages (751), and plant macrofossil taxa (370). The database currently offers midden location, elevation, age, and macrofossil relative abundance data obtained from 317 publications. In total, 3205 samples, 3585 ages, and 1870 synonymized taxa are searchable. Detailed documentation ties each unique piece of data to its source publication(s), allowing comparison of data that have been published with sometimes varying details in multiple reports. Macrofossil relative abundance data can be viewed in original published format or a standardized format wherein original data have been interpreted onto a uniform presence-absence scale. This version of the database offers the most comprehensive, high-quality archive of midden data available for North America, facilitating local and regional scale studies of Quaternary paleoenvironments.

Teed, Rebecca: PRELIMINARY POLLEN ANALYSIS OF SEDIMENTS FROM CRYSTAL LAKE, WESTERN OHIO (Poster A18). Crystal Lakes, in western Ohio (39° N 53', 84° W 01'), are a group of small glacial kettle lakes that formed in the southern edge of the ice margin during the late Wisconsinan, further south than most natural lakes. They're surrounded by a dense residential area, made up of small homes whose property value depends partly on the natural beauty of the lakes. I am analyzing fossil pollen from an 8.7-meter-long core of lake sediment from the largest of the Crystal Lakes: Main Lake. Patterns of forest migration, and responses to events like the mid-Holocene warming that triggered the prairie period in the northern Midwest are poorly understood in the southeastern US. Today, Ohio is considerably south and east of the prairie-forest border, and has less drought, but if pollen in the sediments of Main Lake records changes in terrestrial vegetation, that may allow us to estimate Ohio's sensitivity to 21st-century climate change.

Thompson, Robert S., Oviatt, Charles G., Honke, Jeffrey S., and McGeehin, John P.: COMPARISON OF LACUSTRINE AND VEGETATION CHANGES OVER THE PAST 40,000 YEARS IN THE BONNEVILLE BASIN OF UTAH (Poster D14). Sediment cores covering the past ~40 cal ka (thousands of calibrated ^{14}C years before present) from Great Salt Lake (GSL) in the Bonneville basin provide paleolacustrine and palynological data that are sometimes compatible and sometimes contradictory. Prior to ~28 cal ka, low lake levels and sagebrush dominance in the pollen data both indicate a cold and dry climate. Conifer pollen increased from ~28 to ~18 cal ka, indicating increased moisture, compatible with the rise of Lake Bonneville. This was followed by a period (~18 to ~15 cal ka) of lower conifer abundance and increased sagebrush during the high stands of the lake, with vegetation suggesting drier conditions, whereas lacustrine data imply continuing wet conditions. Although lake level declined between ~15 to ~13 cal ka (suggesting increased warmth and aridity), pine pollen increased (indicating that vegetation was experiencing effectively wetter conditions). A small rise in lake level occurred near the end of the Younger Dryas (~12.9 to ~11.5 cal ka), during a transition from sagebrush into saltbush dominance in the pollen data, indicating a brief cold period followed by increased warmth and aridity. Although there is little evidence of Holocene changes in GSL sediments, the pollen record suggests continuing changes in vegetation and climate. From ~10.6 to ~7.2 cal ka, desert and steppe vegetation dominated the basin, indicating conditions more xeric than today. Pollen spectra younger than ~7.2 ka reflect vegetation similar to today, but with high percentages of juniper pollen suggesting wetter conditions from ~4 to ~2 cal ka.

Tomé, Catalina P.: RESPONSES IN THE COTTON RAT (*SIGMODON HISPIDUS*) TO THE MEGAFAUNA EXTINCTION OF THE TERMINAL PLEISTOCENE (Poster B12). 80% of large bodied herbivores went extinct at the terminal Pleistocene in North America. In addition to decreasing biodiversity, this resulted in the loss of million tons of biomass from the continent. Majority of current research ignores the consequences on the remaining small-bodied community. Our study concentrates the effects of the extinction on the physiology (body size) and ecology (diet) of the rodent *Sigmodon hispidus* (the cotton rat). We sampled bone collagen carbon (δ^{13}C) and nitrogen (δ^{15}N) isotope values from jaw fragments found within the fine-grained temporal record from Hall's Cave in the Edward's Plateau in Texas. From these measurements, we quantified the isotopic (dietary) niche space of *S. hispidus* for the past 15,000 years using Bayesian based ellipse areas. Body size changes were estimated using first molar length and

allometric equations. We find the diet of *S. hispidus* to vary in breadth, sometimes expanding and contracting by twice the area between adjacent time bins. Our results also show time-transgressive decrease in mean $\delta^{15}N$ values, which may relate to an overall shift in the baseline of the plant community. Furthermore, *S. hispidus* shows an overall increase in body size from the early to late Quaternary, despite increasing hemispherical temperatures. These changes suggest a low level of impact from the loss of taxa or a high level of adaptive behavioral plasticity on the part of *S. hispidus* in the response to community-level change.

Toney, Jaime L., García-Alix, Antonio, Jiménez-Moreno, Gonzalo, Anderson, R. Scott, Moossen, Heiko and Seki, Osamu: APPLICATION OF NOVEL BIOMARKERS TO HIGH ALTITUDE, LACUSTRINE SEDIMENTS OF THE SIERRA NEVADA, SPAIN (Poster D3). High-alpine, oligotrophic lakes in the Sierra Nevada are sensitive archives of paleoclimate and paleoecology. Numerous paleoenvironmental reconstructions using pollen, charcoal, and elemental analyses document that a humid phase occurred during the early-mid Holocene with a major transition to increasingly arid conditions in the mid-Holocene. This study identifies the largest changes in biomarker proxies at the mid-Holocene transition between ~6.5 and 5.5ka. Major changes occurred with respect to biogeography and vegetation communities in the Sierra Nevada at this time, but the drivers of change have been unclear. The leaf wax and diol biomarkers help clarify climatological parameters during this transition. Importantly, the H-isotopes of terrestrial and aquatic plant waxes indicate that sustained cold winter conditions at Laguna de Rio Seco reduced terrestrial plant development and enhanced input of meltwater - suggested by low lake-water H-isotope values between ~6.5 and 6.0ka. We assess the novel diol proxy for inferred, snow-free temperature using recent sediments paired with the instrumental record. The diol-inferred temperatures suggest that meltwater lowered the lake water temperature from 6.5 to 6.0ka and subsequently show sustained warming from ~5.7 to 4.2ka. This regional event is espressed locally as a shift to more extreme changes due to the lack of buffering by meltwater once the year-on-year snowpack was depleted. A similar, but more rapid series of events occurred in recent times ~1650 to 1900AD that likely signals the melting of local snowpack built up during the Little Ice Age. Rapid warming since the mid-19th century will be discussed in light of ongoing paleotemperature calibration efforts at LdRS.

Toomey, Michael, Donnelly, Jeffrey, Khan, Nicole, Wallace, Davin, Sullivan, Richard and Cronin, Thomas: MID-LATE HOLOCENE HURRICANE VARIABILITY NEAR PUERTO RICO AND THE VIRGIN ISLANDS (Poster A5). Barrier beach/reef overwash, resulting in the mobilization of sand and its subsequent deposition in adjacent lower energy marshes or lagoons, has been extensively documented during historic hurricane landfalls in the western North Atlantic. However, development of robust storm reconstructions from overwash deposits is greatly complicated by the evolving geometry and sensitivity to inundation of individual back-barrier sites during the geologic past. Here we integrate two new hurricane proxy records developed from coarse-grained deposits in back-barrier sites on the island of Culebra, Virgin Islands (18.3° N, 65.3° W), spanning the last 5000 years, with existing, nearby, overwash reconstructions from Culebrita (5 km NE of Culebra coring sites)[1], Puerto Rico (40 km W)[2], Vieques (35 km SW)[3], Anegada (110 km E)[4] and St. Martin (235 km E)[5]. Taken together, these records overcome the potential limitations set by each site's geometry, allowing us to resolve that storm activity around the Virgin Islands has varied in response to the position of the Inter-Tropical Convergence Zone (ITCZ) and/or

ocean circulation dynamics. Preliminary ^{14}C dating suggests southward-facing sites record at least two multi-centennial increases in hurricane activity (~1000−2500, 3800−4500 yrs BP), potentially related to episodes of ITCZ migration into the Main Development Region (10−20° N, 20−85° W)[6]. In contrast, sites with northern exposure exhibit far fewer overwash events, mostly after ~400 or before 2000 yrs BP, suggesting storm intensification may be favored during passage over the warmer SSTs/deeper thermocline of the NE Caribbean versus the relatively cooler waters of the Puerto Rico Trench.

Wang, Yue, Heintzman, Peter D., Newsom, Lee, Wooller, Matthew J., Culleton, Brendan J., Belmecheri, soumaya, Porter, Warren, Shapiro, Beth, Williams, John W., and Graham, Russell: TIMING AND DRIVERS OF WOOLLY MAMMOTH EXTINCTION ON ST. PAUL ISLAND IN THE LATE QUATERNARY (Poster B18). Understanding the causes and effects of the late Quaternary megafaunal extinctions requires precise estimates of extinction timing and associated environmental factors. On St. Paul Island, an isolated remnant of the Bering Land Bridge, a late-surviving population of woolly mammoth (*Mammuthus primigenius*) persisted into the middle Holocene. Here we present an improved chronology of the timing of St. Paul woolly mammoth extinction based on spore abundances of three coprophilous fungi: *Sporormiella*, *Sordaria,* and *Podospora* from lake sediments, which we compare to newly recovered mammoth fossils dates and ancient DNA presence-absence data. The five independent indicators provide a timing of mammoth extinction at 5,650±100 calendar years BP. Steppe tundra is the major vegetation type throughout the sediment core record, with more grasses in the late glacial and more herbs in the Holocene. Pollen, macrobotanical, and ancient DNA data suggest that St. Paul and coastal Beringia were not refugia for woody plant species except for dwarf willow (*Salix herbacea*), although spruce pollen is found in low concentrations during the Younger Dryas but interpreted as long-distance transport. We then tested hypothesized mechanisms for the extinction event, using vegetation reconstructions, based on fossil pollen data and a physiological model (Niche Mapper) driven by simulated climates and vegetation since the last glacial maximum, and trait data for woolly mammoths. Preliminary simulations point to the importance of net primary productivity and freshwater availability as limits on the carrying capacity of the St. Paul mammoth population, with a low carrying capacity making this population highly vulnerable to extinction.

Watson, Benjamin, Bevington, Joseph, Jackson, Stephen, Lowell, Thomas, Massie, Ashtin, Russell, James, Shane, Linda, and Williams, John: LATE-PLEISTOCENE PALEOTEMPERATURE RECONSTRUCTION IN THE SOUTHERN GREAT LAKES: A COMPARISON BETWEEN POLLEN-BASED RECORDS AND GDGT (Poster A16). Paleotemperature reconstructions in the Midwest during the last deglaciation are primarily based upon fossil pollen data. Fossil pollen records are regionally plentiful, but many have imprecise age models. Pollen-based temperature reconstructions can carry additional uncertainty due to inter-analyst differences in identification, site-specific factors governing nonlinear responses, and the development of no-analog vegetation and climates. Moreover, testing hypotheses about vegetation responses to past climate change requires independent paleoclimatic proxies. Here we introduce a new deglacial temperature record based on branched GDGTs (Loomis et al. 2012) at Silver Lake, OH and compare it to a stacked pollen-based temperature reconstruction from a new Stotzel-Leis, OH record and five other well-dated “golden-spike” sites (Blois et al. 2012). GDGT and the regional pollen-based temperature stack match well, showing accelerated warming from 14.5 – 13.0ka, cooling from 12.8 – 12.0ka, and

gradual warming from 12.0ka into the Holocene. Both indicate an overall rise in mean annual temperatures of roughly 12°C. Pollen-based reconstructions were insensitive to the removal of key no-analog taxa. Individual pollen records and their derived temperature reconstructions, however, show substantially higher variation in rates and amplitudes of temperature change. Inter-site differences in timing and rate of change may be due to geochronological uncertainty, unassessed climatic variables, or influences of site-specific intrinsic thresholds in vegetation dynamics. We partition paleotemperature uncertainty into three components: intra-site and inter-analyst variation, intra-landscape variation in vegetation communities, and intraregional variation in vegetation history and derived temperature reconstructions.

Westover, Marie L. and Smith, Felisa A.: DIETARY VARIATION OF PIKAS (OCHOTONA PRINCEPS) ACROSS A LATITUDINAL GRADIENT AND A CENTURY OF ANTHROPOGENIC CLIMATE CHANGE (Poster B6). Over the past 100 years, average temperatures in NA have increased 1.5°C, with another 1.5-5°C expected in the next century. These shifts in climate have already driven changes in the range boundaries of taxa globally, and it may have also altered life history traits/ecology of many animals. The American pika (*Ochotona princeps*) is a threatened alpine mammal considered to be highly sensitive to climate. In previous work, we have demonstrated upslope elevation shifts over the Holocene, with the rate of range contraction increasing over historic time. However, recent work implicates forage availability and quality, rather than temperature, as the primary driver of pika response. Here, we investigate the interaction between anthropogenic climate change and pika foraging strategies over historic time. Specifically we ask: how much do individual *O. princeps* and population dietary niches vary across their range and across historical time? We characterize the isotopic dietary niche and nutritional quality of pika diet over three time periods using bulk carbon ($\delta^{13}C$) and nitrogen ($\delta^{15}N$) stable isotope analysis (SIA) derived from fur and bone of museum specimens. We focus on six populations along a latitudinal transect spanning the central and southern Rocky Mountains. We find remarkable congruence of the $\delta^{13}C$ values along the geographic gradient; despite variation in both elevation and habitat values mostly cluster between -25 and -23‰. Interestingly, we do find variation in $\delta^{15}N$ values, which are related to variation in temperature and precipitation across sites. Our results strongly suggest that historic and ongoing changes in climate influence aspects of *O. princeps* diet.

Williams, J. Eric and Blois, Jessica: THE EFFECTS OF DISPERSAL ABILITY AND CLIMATE VELOCITY ON THE EXTENT OF SPECIES RANGE SHIFTS SINCE THE LAST GLACIAL MAXIMUM (Poster B9). Understanding how species will respond to future climate change is at the forefront of conservation biology. Although we know species ranges shift as a result of climate change, there is a large amount of unexplained variability in both the direction and distance a species range will shift in response to changing climates. In this study, we assess how climate velocity and dispersal ability affect the extent to which a species shifted its range in response to past climate change. We constructed present-day species distribution models (SDMs) for 122 mammal species from western North America and hindcast them to five different time periods over the past 17,000 years. We then determined the extent to which individual life history traits (body mass and maximum dispersal distance) and local climate velocities influenced the amount of range shift observed in individual species through time using generalized additive models. SDMs indicate that mammals responded in a variety of ways to climate change over the last 17,000 years. Species

generally shifted their ranges following the direction of movement of climate change within a given time period. The largest shifts were observed during the Bølling-Allerød and Younger Dryas episodes with species shifting between 700 - 1200 m/yr. The observed shifts are correlated with both climate velocity and body mass during these two time periods. This study helps generalize the expected responses of species to future climate change and we will expand upon these results by validating them with data from the fossil record.

Williams, Mark R.: PALEOECOLOGICAL AND BEHAVIORAL CHANGES IN NORTHWEST COAST SHELLFISH-HARVESTING PRACTICES DURING THE MIDDLE HOLOCENE: EVIDENCE FROM THE LABOUCHERE BAY SITES, SOUTHEAST ALASKA (Poster B16). Archaeological sites from the Northwest Coast of North America indicate that over the course of the Holocene, human strategies for shellfish gathering underwent a major shift. Early Holocene site assemblages reflect occasional opportunistic foraging in the intertidal zone, while late Holocene sites show signs of organized harvesting and management. It has been suggested that the systematic exploitation of these shellfish beds is associated with the development of sedentary settlement patterns and hereditary social hierarchy, but sites dating to this transition period remain understudied. This poster examines the contents of several archaeological shell middens dating to the middle Holocene (c. 6,500 – 2,500 cal BP) in order to reconstruct coastal paleoecological conditions and examine how human exploitation of these environments changed during through time. This research uses stable oxygen isotope analysis to determine seasonality of site occupation and document changes in ancient sea surface temperatures. Analysis of in the invertebrate faunal assemblages from these sites reveals an increase through time in the relative abundance of soft-substrate species (particularly the clams *Saxidomus gigantea* and *Protothaca staminea*). These data are consistent with a model in which logistical foraging camps became increasingly specialized under the authority of local hereditary chiefs. This trend represents a fundamental turning point in the nature of the relationship between humans and other species in coastal regions.

Wingard, G. Lynn and Bernhardt, Christopher E.: SOUTH FLORIDA ECOSYSTEM RESPONSES TO 126,000 YEARS OF CLIMATE AND SEA LEVEL VARIABILITY (Poster D19). South Florida has been affected by significant changes in climate and sea level during the last 126,000 years, which include the last glacial cycle when sea level was ~125m lower than today, the Younger Dryas, the Medieval Climate Anomaly, and the Little Ice Age. Sediment cores collected from wetland and estuarine ecosystems of south Florida record the responses of physical and biological components of these systems to external drivers. Paleoecologic analysis of mollusks and pollen from cores shows an overall resilience; most species and groups present in south Florida during the late Pleistocene are found there today. The fauna and flora appear to have survived these major environmental changes through local/regional migration. Changes in wetland vegetation correspond to changes in climate and availability of freshwater, and these upstream patterns in the wetlands correlate to downstream changes in freshwater supply to the estuaries as indicated by mollusks. Significant anthropogenic alteration of south Florida began early in the 20th century through land use and construction of water management structures. The record of response to anthropogenic change provides a means to compare pre- and post-alteration components of the ecosystem, including salinity, freshwater flow and stage, biotic assemblages, and diversity. Information on the pre-alteration system is being used by resource managers to set targets and

performance measures for restoration. In addition, insight into past responses to climate and sea level change over the last 126,000 years provides insight into how the system will respond to anticipated changes over the next few centuries.

Woodhouse, Connie A., Pederson, Gregory T., and Csank, Adam: INFERRING THE INFLUENCE OF TEMPERATURE ON COLORADO RIVER FLOW OVER THE PAST FOUR CENTURIES (Poster A6). In the upper Colorado River basin (UCRB), average temperature during the runoff season (March-July) typically accounts for a relatively minor portion of the variance in total water year streamflow. However, recent research indicates that temperature is a stronger influence on flow when streamflow anomalies are greater or less than anticipated, given cool season precipitation totals (Woodhouse et al. 2016). In particular, when water year flows are greater or less than would be anticipated given cool season precipitation, temperatures tend to be lower or higher than the median, respectively. Following this logic, we compare an existing tree-ring reconstruction of Colorado streamflow with a new reconstruction of cool-season precipitation for the UCRB, and use the difference between the two to make inferences about runoff season temperature variability over the past four centuries (1569-1997). Years with less flow than precipitation are interpreted as warmer years. These years are most common in the latter half of the 20th century, but also peak in the mid-17th century, although to a lesser extent. Years with greater flows relative to precipitation, interpreted to be cooler, are most common from about 1750-1900. These two reconstructions also document warm and cool droughts. Instrumental and paleo climate series indicate the 1950s was a relatively cool drought; four other droughts appear to have been relatively cool, compared to 17 warm droughts, over the reconstruction period. Next steps include the generation of a multiproxy spring temperature reconstruction for the UCRB to assess the robustness of these findings.

Yost, Chad L.: PHYTOLITH AND CARBON ISOTOPE ANALYSIS OF YOUNGER DRYAS-AGED TYPE I, II AND III BLACK MATS FROM ARIZONA, NEW MEXICO AND NEVADA (Poster C13). Black mats are typically dark gray to black soils and sediments with increased organic content relative to adjacent strata. They form in wet environments with spring discharge and elevated water tables in central and western North America, and peak in occurrence during the Younger Dryas Chronozone of 11,000 to 10,000 ^{14}C yr BP (12,900 to 11,700 ka). Differences in phytolith assemblages, concentrations, and preservation support the three black mat types defined by Harris-Parks (2016). Black mat phytolith content varied between 0.16 and 9.1% and the unusually high phytolith concentrations (max value 7.11×10^6 per g) in some black mat samples may derive from organic-rich soil shrinkage and compression after dewatering. Phytolith morphotypes indicate that sedges were the dominant vegetation directly associated with black mat formation. Overlying and underlying sediments collected from the Arizona locations indicate that for the grasses, cool season C_3 grasses were most abundant in black mat sediments; however, C_4 xerophytic grasses were dominant on the surrounding landscape, before, during and after black mat formation. C_4^{mesic}/C_4^{xeric} grass phytolith ratios were higher during black mat periods, indicating increased summer precipitation. Soil organic matter (SOM) and phytolith occluded carbon (PhytC) δ^{13}C values from black mat and overlying sediments were highly correlated (r^2=0.97), and when corrected for fractionation, suggest carbon inputs primarily from grasses and sedges. A small but consistent offset between

estimated C_3/C_4 plant biomass from SOM and PhytC $\delta^{13}C$ values suggests that microbial breakdown may have increased SOM $\delta^{13}C$ values by an average of 2.4‰.

Youngblood, Peter, Bruck, Benjamin, Roehner, Clay, Duffin, Jenna, Will, Ryan, and Pierce, Jennifer: DO CHANGES IN SOIL TEXTURE IN A SEMI-ARID WATERSHED CORRESPOND WITH CHANGES IN ELEVATION, ASPECT, OR SOIL CARBON? (Poster D11). Soils serve as a major reservoir for both organic and inorganic carbon. Wind-deposited silt alters soil hydrologic properties, increases soil thickness and may provide a source of calcium for pedogenic calcium carbonate (CaCO3) development. While redistribution of post-fire sediments is well documented in the flat landscape of the Snake River Plain, the rate and spatial variability of silt-sized, aeolian sediment deposition in complex terrain is not well constrained. We examine soil textures in the Reynold's Creek Experimental watershed in southwestern Idaho to test the hypotheses that wind-blown sediments are preferentially deposited at lower elevations and on leeward aspects, and that higher inorganic carbon content corresponds with increased loessal parent material. Although our results suggested no correlation with soil texture and elevation, we found a correlation between silt content and slope aspect. Examination of trends in soil inorganic and organic carbon with silt content is still under investigation. In the Reynold's Creek Experimental watershed there is higher silt content found on northeast facing slopes and lower amounts on southwest facing slopes, which agrees with spatial variability produced using a wind redistribution model.

Zimmerman, Troy and Myrbo, Amy: THE "FROSTBITER" METHOD FOR SAMPLING AND PREPARING WET, UNCONSOLIDATED SEDIMENTS FOR THIN SECTIONS (Poster D10). Making petrographic thin sections from wet lake sediments is a time-, mud-, and chemical-intensive process. Several cm^3 of valuable sediment are are expended to make a thin section less than 100 microns thick, and even at its most conservative the process uses a relatively large volume of hazardous epoxy and often acetone. A new alternative method uses a small aluminum block filled with liquid nitrogen placed on top of a microslide on the split and smoothed core face, freezing a thin layer of sediment directly to the underside of the slide. The sample is freeze dried and embedded with a small amount of Spurr's epoxy inside a vacuum chamber. The cured sediments are then treated like rock chips: lapped to a thickness of ~200 microns and then polished. The "Frostbiter" was tested on several sediment types, and found to be a major improvement in efficiency, using much less sediment and epoxy, and no acetone. The thin subsample on the slide was also found to be less prone to cracking, parting along bedding planes, and "pingo-ing" when subjected to liquid nitrogen shock than traditional ~cm-thick thick freeze dried slabs. The technique cannot easily be used on sediments with very low water content, and coarse grains may be plucked in rock shop processing as they may in other types of thin sections. However, for most later Quaternary lacustrine and marine cores, the Frostbiter represents a significant methodological improvement.