



RESTORING THE WEST
CONFERENCE 2016

**Climate, Disturbance, and Restoration
in the Intermountain West**

October 18-19, 2016, Utah State University, www.restoringthewest.org

2016 Restoring the West Conference

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Agenda

Tuesday, October 18, 2016
USU Eccles Conference Center

7:30 - 9:00 a.m.	Registration Open
8:30 - 8:35 a.m.	Welcome , Mike Kuhns, Department Head and Extension Forestry Specialist, Wildland Resources, Utah State University, Logan, Utah.
8:35 - 8:40 a.m.	Conference Overview , Darren McAvoy, Extension Assistant Professor, Utah State University, Logan, Utah.
8:40 - 9:15 a.m.	The Great Big Context of Climate Disruption . Rob Davies, Physicist, Utah Climate Center, Logan, Utah.
9:15 - 10:00 a.m.	Keynote: Drought-driven Tree Mortality and Climate Change: What Have We Learned so Far? Bill Anderegg, Assistant Professor, Biology, University of Utah, Salt Lake City, Utah.
10:00 - 10:30 a.m.	Break
10:30 - 11:10 a.m.	Keynote: Conservation Paleobiology: Contributions to Understanding Climate, Disturbance and Restoration . Andrea Brunelle, Professor & Chair, Department of Geography, University of Utah, Salt Lake City, Utah.
11:10 - 11:40 a.m.	Understanding the Landscape of Public Attitudes About Climate Change . Peter D. Howe, Assistant Professor, Department of Environment and Society, Utah State University, Logan, Utah.
11:40 - 12:10 p.m.	Restoring the Rivers of the West . Dan McCool, Director, Environmental and Sustainability Studies Program, Professor, Political Science, University of Utah, Salt Lake City, Utah.
12:10 - 1:40 p.m.	Poster Session and Lunch
1:40 - 2:10 p.m.	Grand Climate-adaptation Experiments, Intended or Not, in Post-fire Restoration . Matthew J Germino, Research Ecologist, US Geological Survey, Forest and Rangeland Ecosystem Science Center, Boise, Idaho.
2:10 - 2:40 p.m.	Accelerating Renewables and Energy Efficiency to Mitigate Climate Change . Sarah Wright, Executive Director, Utah Clean Energy, Salt Lake City, Utah.
2:40 - 3:10 p.m.	Weather and Climate Tools for Rangeland Restoration Planning and Assessment . Stuart Hardegree, Plant Physiologist, USDA-ARS, Northwest Watershed Research Center, Boise, Idaho.
3:10 - 3:40 p.m.	Break
3:40 - 4:10 p.m.	Indirect Effects of Climate on Regeneration of Aspen Forests Mediated Through Ungulate Herbivory and Wildfire . Sam St. Clair, Associate Professor, Plant & Wildlife Sciences, Brigham Young University, Provo, Utah.
4:10 - 4:40 p.m.	Climate Change Effects on Water Resources Management and Potential Adaptations for the Future . Sarah Null, Assistant Professor, Department of Watershed Sciences, Utah State University, Logan, Utah.
5:30 - 7:30 p.m.	Reception at Jack's Wood Fired Oven, 256 N Main St, Logan. A minibuss shuttle will depart University Inn at 5:15 and make return trips as needed.

Wednesday, October 19, 2016
USU Eccles Conference Center

8:00 a.m.	Registration Open
8:30 - 8:35 a.m.	Welcome , Paul Rogers, Director, Western Aspen Alliance, Utah State University, Logan, Utah.
8:35 - 9:15 a.m.	Keynote: The Colorado River, Climate Change and Drought. Johnathan Overpeck, Regents Professor of Geosciences, Hydrology and Atmospheric Sciences, The University of Arizona, Tucson, Arizona.
9:15 - 9:55 a.m.	Keynote: Navigating Complex Human-Nature Relationships in Rocky Mountain and Wasatch Communities. Courtney G Flint, Associate Professor of Natural Resource Sociology, Utah State University, Logan, Utah.
9:55 - 10:20 a.m.	Break
10:20 - 10:50 a.m.	Forest Carbon in the Rockies: Past and Future. Michael G. Ryan, Senior Research Scientist, NREL, Colorado State University & Emeritus Scientist, Rocky Mountain Research Station, Fort Collins, Colorado.
10:50 - 11:20 a.m.	Wildlife Response to Climate Change in the Western US: Learning From Indicator Species. Lise Aubry, Assistant Professor, Department of Wildland Resources and the Ecology Center, Utah State University, Logan, Utah.
11:20 a.m. - 12:00 p.m. Up and coming research from graduate student scientists	1) Characterizing Great Basin Bristlecone Pine Chemistry along Environmental Gradients to Assess Response to Climate Change. Curtis Gray. 2) Does Temperature Variation Drive Changes in the Cover of Big Sagebrush (<i>Artemisia tridentata</i>) Across its Range? Andrew Kleinhesselink. 3) Forest Soils in the Intermountain West - Vegetation and Disturbance Effects on Soil Organic Carbon. Antra Boca.
12:00 - 1:00 p.m.	Lunch
1:00 - 1:30 p.m.	Adapting Watershed Management to Climate Change. Marian Hubbard, Watershed Section Manager, Salt Lake County Watershed Planning & Restoration Program, Salt Lake City, Utah.
1:30 - 2:00 p.m.	The Massive Space and Time Scale of Atmospheric Processes that Create Localized Extreme Heat Bursts, Dry Lightning, Wildland Fires, and Debris Flows in the Western U.S. Mike Kaplan, Research Professor, Division of Atmospheric Sciences, Desert Research Institute, Reno, Nevada.
2:00 - 2:30 p.m.	Climate Change, Riparian Vegetation Removal, and Channel Change on the Colorado River. Gigi A. Richard, Ph.D. Professor, Geology, Director, Hutchins Water Center at CMU, Colorado Mesa University, Grand Junction, Colorado.
2:30 to 3:00 p.m.	Break
3:00 to 3:30 p.m.	Decision Support in the Cadillac Desert: Climate Change and Water Supply in the Water Stressed and Politically Charged Western U.S. Paul Miller, Service Coordination Hydrologist, NOAA - Colorado Basin River Forecast Center, Salt Lake City, Utah.
3:30 to 4:00 p.m.	How Will Climate Change Alter the Abundance of Big Sagebrush? Peter Adler, Professor, Department of Wildland Resources and the Ecology Center, Utah State University, Logan, Utah.
4:00 to 4:30 p.m.	Climate Change and Wildland Fire. J. Bradley Washa, Utah BLM State Fuels Specialist, DOI Bureau of Land Management, Utah State Office, Salt Lake City, Utah.

Speaker Abstracts

In order of presentation

The Great Big Context of Climate Disruption. Rob Davies, Physicist, Utah Climate Center. daviesre@mac.com

Human-driven climate disruption poses extreme risks in the coming decades. Indeed some people, societies, species, and ecosystems have already experienced significant, even catastrophic consequences. Recognition of the scale and immediacy of this malady is now driving a new era of mitigation strategies. Climate disruption, however, is not a single ailment that can be treated in isolation. Rather, it is one of a family of existential afflictions, including a massive and accelerating loss of biodiversity, acute ecological overshoot, and intensifying social inequities - emergent from the same underlying pathology. And while some climate mitigation pathways address multiple symptoms synergistically, others exacerbate them. We find ourselves at a crossroads, in need of a map clearly depicting the landscape and a compass to guide us. In this talk I'll introduce one such map - a framework of 'planetary boundaries' ... and one such compass - the concept of a safe operating space for all people. What yet remains is the active participation of a broad spectrum of society to keep the full suite of so-called "wicked" socio-environmental problems clearly in focus as we plot a course forward.

Dr. Robert Davies is a Utah-trained physicist and educator whose work focuses on synthesizing and communicating a broad range of research - including climate, energy, agriculture, economics, and complex systems. His published works include research in the fields of spacecraft / space environment interactions; the fundamental nature of light and information; and Earth's climate system. He is also co-creator of The Crossroads Project, a collaborative communication project combining a hard science narrative with evocative imagery and powerful music, bringing to bear the power of performance art on the topic of human sustainability.

Dr. Davies is an Associate of the Utah Climate Center and adjunct professor in Utah State University's Department of Plants, Soils and Climate. He has taught on the faculty of three universities; worked as project scientist for Utah State University's Space Dynamics Laboratory; as technical liaison for NASA's International Space Station project; and served as an officer and meteorologist in the United States Air Force. He lives and works in Logan.

Drought-driven Tree Mortality and Climate Change: What Have We Learned so Far? Bill Anderegg, Assistant Professor, Biology, University of Utah. anderegg@utah.edu

Widespread forest mortality events of many tree species in the last two decades prompt concerns that drought, insects, and wildfire may devastate forests in the coming decades. In this talk, I will give an overview of what we have learned so far about recent drought-induced tree mortality events in the West, covering our current understanding of the physiology, ecology, and predictive capability of these events.

William Anderegg grew up in western Colorado hiking, backpacking, hunting, and fishing in the forests he now studies. His research focuses on western US forests and climate change. He received his Ph.D. from the Department of Biology at Stanford University and worked as a NOAA Climate and Global Change Postdoctoral Fellow at Princeton University. He is currently an Assistant Professor in the Department of Biology at the University of Utah.

Conservation Paleobiology: Contributions to Understanding Climate, Disturbance and Restoration. Andrea Brunelle, Professor & Chair, Department of Geography, University of Utah. andrea.brunelle@geog.utah.edu

Humans are altering our environment. Climate change resulting from the burning of fossil fuels is documented beyond argument. Landscape modification through grazing, logging, mining and other activities is omnipresent. But what are the actual ecological implications? Can systems recover? Conservation paleobiology is a newly

named field for an application of paleoecology. Conservation paleobiology can take a near-time (<2 million years) or deep-time approach but both provide information on ecological responses to climatic variability. The near-time approach presented here more specifically uses paleoecological data to generate pre-and post-disturbance ecological baselines and natural ranges of variability, describes ecosystem response to disturbances (natural and anthropogenic) and helps develop realistic restoration goals. We will examine “lessons learned” from records spanning woody plant encroachment and desiccation in desert wetlands to high elevation forest sites impacted by beetles and forest fires and discuss how conservation paleobiologists can better work with land managers to use these important data.

I am an Associate Professor and Chair in the Geography Department at the University of Utah. My BS is in Environmental Science (Geology) and my MS is in Quaternary Studies (Paleoecology) from Northern Arizona University in Flagstaff, Arizona. My Ph.D. is from The University of Oregon in Eugene, Oregon in Physical Geography. My research focuses on reconstructions of past environments from lake and wetland sediments with particular interest in projects with management applications. These projects include reconstructions of fire and vegetation regimes from sedimentary deposits, studying past bark beetle outbreaks in the mountain west, studies of southwestern desert wetlands (ciénegas), and human paleoecology. My passion is educating students about the science of climate change.

Understanding the Landscape of Public Attitudes About Climate Change. Peter D. Howe, Assistant Professor, Department of Environment and Society, Utah State University. peter.howe@usu.edu

There is a demonstrated need among decision makers for locally relevant information about climate change. In response to this need, climate scientists have developed a variety of methods of to “downscale” climate model projections from global models to the regional and local scale. However, comparable local data representing the human dimensions of climate change, such as public perceptions and beliefs, has been less fully developed. This presentation describes a new tool for mapping variations in state and local climate and energy opinions within the U.S. Effectively responding to climate change will likely require the enactment of national, state, and local mitigation and adaptation policies as well as changes in individual behavior. This tool provides an important new source of locally relevant information for policymakers, educators, managers, and scientists to more effectively address these challenges.

Peter Howe is an Assistant Professor in the Department of Environment & Society at Utah State University. Dr. Howe is a human-environment geographer specializing in the human dimensions of climate change and environmental hazards. His research focuses on the intersection of human perception and decision-making with societal vulnerability and adaptation to climate change and environmental hazards. Prior to joining Utah State, Dr. Howe was a postdoctoral researcher at the Yale School of Forestry and Environmental Studies. He received his PhD in 2012 from the Department of Geography at Penn State University.

Restoring the Rivers of the West. Dan McCool, Director, Environmental and Sustainability Studies Program, Professor, Political Science, University of Utah. dan.mccool@poli-sci.utah.edu

After 100 years of damming, diverting, and draining western rivers, we are beginning to move into a new era of river restoration. Many of the water projects and dams built in decades past no longer meet the needs of “The New West.” River restoration will help bring western water policy into the 21st Century.

Dan received his Ph.D. from the University of Arizona. He is the author or editor of nine books, including: River Republic: The Fall and Rise of America’s Rivers (Columbia University Press, 2012).

Grand climate-adaptation experiments, intended or not, in post-fire restoration. Matthew J Germino, Research Ecologist, US Geological Survey, Forest and Rangeland Ecosystem Science Center. mgermino@usgs.gov

The reassembly of perennial plant communities after disturbance such as wildfire is a key juncture when climate impacts can quickly become evident. Management responses to fire are thus one of the most important opportunities for adapting both management approaches and plant communities to climate shifts. A large number of post-fire rehabilitation seedings done over hundreds of thousands of acres across the Western US reveal – somewhat unsurprisingly – that climate and weather are pivotal factors affecting establishment of desired perennial species, and, thus restoration success. For example, several published or preliminary studies on past efforts to reestablish big sagebrush after fire show that manager’s decisions on seed source impact restoration success and weather responses of resulting sagebrush. The findings provide key insights on the importance of intraspecific diversity in dominant restoration species, and the challenges and opportunities the diversity present for both policy and practice in wildfire responses.

Matt Germino has served as a Supervisory Research Ecologist with the US Geological Survey’s Forest and Rangeland Ecosystem Science Center in Boise Idaho since 2011. His research focuses on understanding the physical and biological elements of resistant and resilient landscapes in the western US, using a variety of approaches in soil, plant, and physiological ecology. He also serves on special assignment as scientist for the Great Basin Landscape Conservation Cooperative. Prior to joining the USGS, he was a Professor of Biology at Idaho State University, Pocatello.

Accelerating Renewables and Energy Efficiency to Mitigate Climate Change. Sarah Wright, Executive Director, Utah Clean Energy. sarah@utahcleanenergy.org

The US electric grid, which began operations over 100 years ago, is the largest industrial machine in the nation. It contributes 30% of all US Greenhouse Gas emissions, and in 2015 generated 4 trillion kilowatt hours of electricity. To date, the electricity industry has been one of the slowest industries to innovate. Now, with rapidly emerging technologies, declining prices and demand for cleaner resources, we have the opportunity to revamp and decarbonize our electric system. Learn about pricing trends for renewable energy, and growth trends nationwide for renewables, energy efficiency, storage technology, and how these trends are impacting Utah.

As founder of Utah Clean Energy, Sarah has a proven record of accomplishment in the promotion of renewable energy and energy efficiency within the state of Utah. As Executive Director, she has effectively fostered diverse partnerships with state agencies, municipal governments, industry, agricultural groups and community groups to advance clean energy solutions. She is an intervener in regulatory proceedings and a witness in legislative hearings testifying in support of energy efficiency and renewable energy. Sarah brings over fifteen years’ experience with the Utah industry where she served as an environmental consultant providing occupational health and ambient air quality permitting services. Sarah holds a B.S. in Geology from Bradley University, and an M.S. in Public Health from the University of Utah.

Weather and Climate Tools for Rangeland Restoration Planning and Assessment. Stuart Hardegree, Plant Physiologist, USDA-ARS, Northwest Watershed Research Center, Boise, Idaho. stuart.hardegree@ars.usda.gov

Rangeland seeding practices in the Intermountain western United States are typically implemented in a single planting season for the purposes of Emergency Stabilization and Rehabilitation (ESR) after wildfire. This necessarily links restoration and rehabilitation success to the probability of a single year providing sufficiently

favorable microclimatic conditions for desirable plant establishment. Field research studies in rangeland restoration are also typically of limited duration and published results may not represent the full spectrum of conditions likely to be experienced at a given site. Location-specific and temporal weather-analysis may enhance the interpretation of historical planting data, support expanded inferences from short-term field studies, and facilitate meta-analysis of diverse field studies in rangeland restoration. We describe access and use of new databases and tools that can be used for this purpose, and suggest some standard graphs and weather metrics to establish a longer-term perspective for the interpretation of rangeland-restoration field results.

Stuart is a plant physiologist with the Agricultural Research Service in Boise Idaho. His research has focused on characterization of seedbed microclimate and modeling seed-germination and establishment response of intermountain perennial grasses in competition with introduced annual weeds. His current interests include the development of weather and climate tools for diverse agricultural and natural resource modeling applications, but with specific emphasis on rangeland restoration and management.

Indirect Effects of Climate on Regeneration of Aspen Forests Mediated Through Ungulate Herbivory & Wildfire.

Sam St. Clair, Associate Professor, Plant & Wildlife Sciences, Brigham Young University. samstclair1@gmail.com

Co-authors: Aaron Rhodes and Ho Yi Wan

Ecological disturbance strongly influences the regeneration success of aspen forests. In particular increasing wildfire and high abundance of ungulate herbivores are modifying patterns of aspen regeneration in the western US. We summarize the impacts of wildfire size and severity, and ungulate herbivory on aspen regeneration success and explore how climate variability modifies these relationships.

Dr. St. Clair completed his undergraduate and MS degrees at Brigham Young University. His Ph.D work focused on the impacts of soil acidification on the eastern deciduous forests of the US. Dr. St. Clair studied climate change impacts on grasslands of northern California as a postdoctoral researcher. Since joining the BYU faculty in 2007 Dr. St. Clair and his students have established long-term experiments in aspen forests and the Great Basin and Mojave Deserts. Major research themes include invasion biology and plant-animal interactions in the context of changing disturbance regimes particularly wildfire and herbivory by large mammals and how these processes are modified by climate change. Dr. St. Clair works closely with federal and state agencies to translate his research into best management practices.

Climate Change Effects on Water Resources Management and Potential Adaptations for the Future.

Sarah Null, Assistant Professor, Department of Watershed Sciences, Utah State University. sara.null@usu.edu

Climate change, population growth, aging infrastructure, and changing societal values alter how water must be managed in the 21st Century. This talk summarizes recent research modeling hydroclimate change for urban, agricultural, and environmental water users and highlights potential adaptations. As snowmelt-dominated runoff shifts to rainfall-dominated runoff in mountain regions, streamflows peak in winter instead of spring. This affects irrigators and some municipal water users with season-dependent water rights, including the City and County of San Francisco, and water users in the Rio-Grande and South Platte River Compacts. Instream flows for environmental protection will likely be disproportionately reduced with climate change. Dam removal is also evaluated as a potential river restoration approach. Results quantify fish habitat gains from removing dams against water supply and hydropower production losses, highlighting the declining value of reservoir storage when systems are limited by precipitation. Improving water conveyance can sometimes substitute for water storage in storage-rich watersheds. Results are presented for California's Tuolumne watershed, with some preliminary

results for Utah. These findings suggest that hydroclimatic uncertainty can be partially accounted for with simple modifications to existing operating rules for reservoirs, though other approaches are also likely needed.

Sarah is an Assistant Professor in the Department of Watershed Sciences at Utah State University. She received her BA in economics from UCLA, and both her masters and PhD in geography at UC Davis. She worked as a postdoctoral scholar at UC Davis' Center for Watershed Sciences for 3 years prior to coming to Utah State University. Sarah's research interests include water resources systems analysis for people and ecosystems, climate change impacts and adaptations for water resources, stream temperature modeling and monitoring, and improving information-sharing between policy-makers, water managers, and researchers. Field studies, mathematical models, and systems analysis are methods she uses to improve understanding of systems and explore promising solutions to problems.

The Colorado River, Climate Change and Drought. Johnathan Overpeck, Regents Professor of Geosciences, Hydrology and Atmospheric Sciences, The University of Arizona. jto@email.arizona.edu

Many current assessments of future climate and hydrologic change suggest that current drylands around the globe could become drier with continued anthropogenic climate change. In some regions, such as the southwest U.S., there is an observed trend in this direction. This is particularly true for the Colorado River, where the nature of drought is shifting to a more temperature-dominated climate extreme. At the same time, however, some recent and influential scientific assessments suggest that temperature-driven drying could be compensated by large precipitation increases with little net increase to water supply risk. A new approach integrating the examination of temperature, precipitation and drought risk indicate that Colorado River flows, and water supplies in the Southwest more generally, are already being seriously affected, and that continued climate change could result in much larger water supply losses than widely thought, even if mean precipitation increases.

Professor Overpeck ("Peck") is a Regents Professor of Geosciences and Atmospheric Sciences, and also the Thomas R. Brown Distinguished Professor of Science, both at the University of Arizona. He is climate scientist who has written over 200 published works on climate and the environmental sciences, served as a Coordinating Lead Author for the Nobel Prize winning Intergovernmental Panel on Climate Change (IPCC) 4th Assessment (2007), and also as a Lead Author for the IPCC 5th Assessment (2014). Other awards include the US Dept. of Commerce Gold Medal, a Guggenheim Fellowship, the Walter Orr Roberts award of the American Meteorological Society, and the Quivira Coalition's Radical Center Award for his work with rural ranchers and land managers. Peck has active climate research programs on five continents, loves trying to understand drought and megadrought dynamics (and risk) the world over, and is also a lead investigator of the Climate Assessment for the Southwest and the SW Climate Science Center – two major programs focused on regional climate adaptation. He has appeared and testified before Congress multiple times, is a Fellow of AGU and the American Association for the Advancement of Science, and tweets about climate-related issues @TucsonPeck.

Navigating Complex Human-Nature Relationships in Rocky Mountain and Wasatch Communities. Courtney G. Flint, Associate Professor, Utah State University, Department of Sociology, Social Work & Anthropology. Courtney.Flint@usu.edu

For people who live, work, and play in mountains and forests in the Intermountain West, ecosystems disturbances affect quality of life. Yet, navigating the diverse array of often-contradictory local and regional stakeholder perspectives can challenge natural resource management. Values and concerns about natural resource conditions and objectives can vary widely within and across communities and often change over time. Further, individuals, groups, and communities often seek multiple and conflicting resource objectives at the same time. Drawing on

research from Colorado communities experiencing mountain pine beetle disturbance as well as Utah mountain communities anticipating population growth and climate change, findings and observations are offered in this presentation regarding navigating human dimensions of forest resource management.

Dr. Courtney G. Flint is a Natural Resource Sociologist at Utah State University. She has published widely on perceptions and actions of people and communities within changing social and environmental conditions. Her research projects in recent years have focused on community dimensions of forest disturbance in Alaska and Colorado, factors influencing agricultural nutrient management practices in Illinois, and social dimensions of water resource sustainability in Utah. Dr. Flint also serves on the United States Environmental Protection Agency's Board of Scientific Counselors.

Forest Carbon in the Rockies: Past and Future. Michael G. Ryan, Senior Research Scientist, NREL, Colorado State University & Emeritus Scientist, Rocky Mountain Research Station. Mike.Ryan@colostate.edu

Forests store much carbon in their wood and soil. Annual additions to forest carbon in the US take up 10-15% of the CO₂ from our fossil fuel use, mostly because US forests are regrowing after clearing for agriculture and past harvests. When regrowth stops, these annual additions and CO₂ offset will also stop. In the West, the largest challenge for forest carbon is to retain current stocks when fire, bark beetles, and drought are killing many trees, and high intensity fires change vegetation to grass and shrublands in montane forests. Fuel reduction in frequent fire forests may help retain montane forests, but greatly reduces forest carbon stores. Because montane forests are denser now than is sustainable, they have more forest carbon than is sustainable. Over the longer term, fuel reduction may retain more forest carbon by retaining forests at a cost of large current forest carbon loss.

Mike Ryan is a Senior Research Scientist at the Natural Resource Ecology Lab and the Graduate Degree Program in Ecology at Colorado State University and an Emeritus Research Ecologist for the USDA Forest Service, Rocky Mountain Research Station in Fort Collins, Colorado. His research focuses on landscape studies of the forest carbon cycle, and the role of whole tree physiology in forest carbon balance and productivity. He has studied the role of respiration in regulating productivity, the mechanism of tree size-related productivity decline, mechanisms of drought tolerance and mortality, carbon allocation, the role of source versus sink control of plant carbon balance, and forest carbon recovery from fire and bark beetle mortality. Mike studied at the University of Pittsburgh, Northern Arizona University, and Oregon State University.

Wildlife Response to Climate Change in the Western US: Learning from Indicator Species. Lise Aubry, Assistant Professor, Department of Wildland Resources and the Ecology Center, Utah State University, Logan, Utah. lise.aubry@usu.edu

Measuring, Understanding and Predicting wildlife response to climate change is a pressing matter since there is widespread concern about impacts on population persistence and whether or not sensitive species will be able to adapt. Research is needed to inform conservation strategies for species that are most susceptible and indicative of rapid climate change, such as hibernators. We are taking advantage of historical data on Uinta ground squirrel populations (hibernators endemic to the Western US) to 1) Measure climate-driven variability in their phenology and demography over a 50-year period; 2) Understand how ecological processes mediate this variability in light of climate change; and 3) Predict their ability to adapt to climate change using eco-evolutionary models. Our findings will have important conservation implications for hibernating and alpine species in the Intermountain West, worldwide, and for the suite of species that depend on small mammals for persistence.

I am a population ecologist interested in quantifying the impacts of anthropogenic factors such as climate change and habitat fragmentation, on the ecology, demography, and microevolution of wild species, mainly vertebrates. How wild populations respond to management actions (e.g. harvest) and conservation practices is also a topic of great interest. My research calls for the analyses of longitudinal data and methodologies that stem from demography, population ecology, and life history theory. I received my MS from the Universite Paul Sabatier in Toulouse, France, and later complete my PhD at the Max Planck Institute for Demographic Research in Rostock, Germany. After two postdocs at Utah State University funded by the Berryman institute and NSF, I am now an Assistant Professor in the Department of Wildland Resources. <http://liseaubry.webs.com/>

Characterizing Great Basin Bristlecone Pine Chemistry along Environmental Gradients to Assess Response to Climate Change. Curtis Gray, PhD Candidate, Wildland Resources Department, Utah State University. curtis.gray@aggiemail.usu.edu

Most studies that examine forest changes from climate warming focus on species distribution patterns or altered disturbance regimes. This study examines the physiologic process of volatile organic compound (VOC) production along elevational gradients. As an alpine treeline species, Great Basin (GB) bristlecone pine (*Pinus longaeva*) is confined to the highest elevations of Great Basin mountains in the western United States, and have received attention for their potential as biological indicators of climate change. Warming temperatures may increase mortality, change community structure, and affect the interacting role of disturbances such as mountain pine beetle and natural fire regimes. VOCs are important for tree flammability, defense against pests and pathogens, and can be early indicators of abiotic plant stress. To better understand GB bristlecone pine ecology, we collected and examined VOCs emitted under varying conditions along environmental gradients. We hypothesize that warmer temperature will increase VOCs emitted from GB bristlecone pine foliage. We address the following research questions in this paper: Will VOCs decrease with elevation as a surrogate for climate change/temperature? How will GB bristlecone pine respond chemically to a warming climate and how will they adapt? And which VOC ratios are important for GB bristlecone pine evolutionary response? This research helps us understand the biotic and abiotic threats from climate change, which improves methods to reliably assess and predict tree resiliency with climate change.

Curtis is a PhD student in Forest Ecology at Utah State University. He is examining the impact of climate variability on the frequency and severity of ecological disturbances in Great Basin bristlecone pine sky islands. He has a master's degree in Geography (Remote Sensing/GIS) from San Diego State University and a bachelor's degree in Environmental Studies/Geography from UCSB. Prior to his studies at Utah State University he worked as an ecologist for California State Parks and as a GIS consultant for CalFIRE and the US Forest Service Remote Sensing Laboratory. His research interests include forest resource management, forest ecology, disturbance ecology, remote sensing/GIS, and quantitative analysis.

Does Temperature Variation Drive Changes in the Cover of Big Sagebrush (*Artemisia tridentata*) Across its Range? Andrew Kleinhesselink, PhD Candidate, Department of Wildland Resources, Utah State University. arklein@aggiemail.usu.edu. Co-author: Peter B. Adler, Associate Professor, Department of Wildland Resources and the Ecology Center, Utah State University

Sagebrush ecosystems cover vast areas of the West and are home to many species of conservation concern. Unfortunately, distribution models predict that the total area suitable for sagebrush could be greatly reduced over the next 100 years due to global warming. However, these predictions are based on correlation, not causation.

Stronger evidence that above average temperature can actually cause sagebrush cover to change at short timescales would strengthen our confidence in these predictions. We used population models to test how annual temperature variation affected sagebrush cover at 944 monitoring sites across its range. We found that sagebrush cover decreased with above average temperature at hotter sites and increased with above average temperatures at colder sites. This response largely agrees with the predictions made by distribution models and should increase our confidence that the distribution of sagebrush will change in response to climate change in the near future.

Andrew Kleinhesselink is a fifth year PhD student at Utah State University. His research focuses on how plants respond to the direct and indirect effects of annual climate variation and how we can use this information to make better predictions about how these species will respond to climate change in the coming decades. He plans to defend his dissertation at the end of this year and continue his research as a postdoc at UCLA next year.

Forest Soils in the Intermountain West - Vegetation and Disturbance Effects on Soil Organic Carbon. Antra Boca, PhD Candidate, Department of Wildland Resources, Utah State University. ntr@inbox.lv

I am a Presidential Doctoral Research Fellow working in Helga Van Miegroet's lab at USU's Quinney College of Natural Resources. My dissertation research focuses on forest vegetation effects on soil organic carbon quantity and stability. I am originally from Latvia where I received my bachelor's in Environmental Sciences at the University of Latvia. My Master's work on forest soil phosphorus at the University of Freiburg, Germany contributed to my decision to study soils for my PhD at USU. I love nature and outdoor activities, especially in the mountains. I am passionate about teaching, and after graduation would like to stay in academia doing research and teaching.

Adapting Watershed Management to Climate Change. Marian Hubbard, Watershed Section Manager, Salt Lake County Watershed Planning & Restoration Program. mlrice@slco.org

With the ever-changing regulations, priorities and ethics watershed management and planning is a dynamic process. Climate change is one of the most pressing issues affecting watersheds to this day. With recent droughts and floods, climate change has become an even more salient issue. As a result watershed management also needs to also adapt to these prevailing challenges. This presentation discusses some of the challenges and opportunities such as emergency response to environmental events such as flooding, algal blooms, and drought; policy; planning and ecosystem restoration.

Marian Hubbard-Rice is the Watershed Section Manager for Salt Lake County Watershed Planning & Restoration. Her core responsibilities at Salt Lake County include: collaboration with agencies, local stakeholders, and the general public; writing, updating and implementing the Salt Lake Countywide Water Quality Stewardship Plan; performing ecosystem restoration; and water quality monitoring in the Jordan River Watershed. She holds a Bachelor of Science Degree in Biology from Portland State University and a MPA in Natural Resource Management from University of Utah. She is currently working on a Ph.D. at University of Utah focusing on the energy-water nexus, which includes water quality analysis, BMP assessments, environmental policy, environmental justice, as well as an analysis of energy and environmental laws.

The Massive Space and Time Scale of Atmospheric Processes that Create Localized Extreme Heat Bursts, Dry Lightning, Wildland Fires, and Debris Flows in the Western U.S. Mike Kaplan, Research Professor, Division of Atmospheric Sciences, Desert Research Institute, Reno, Nevada. michael.kaplan@dri.edu
Co-authors: Benjamin J. Hatchett, Nicholas J. Nauslar, Nina S. Oakley, Jeffrey S. Tilley, and Craig M. Smith

During the warm season local terrain and ecological disturbances over the intermountain western U.S. are often the result of cascading events that have their origins in atmospheric circulations that span thousands of kilometers in space and as long as a week or more in time. Natural and/or manmade climate forcing establishes these circulations as a downscale dissipative signal in the atmosphere. Thus climate organizes shorter period spatial and temporal weather that targets local complex terrain. Planetary wave breaking (PWB) over the complex terrain of the western U.S. PWB often organizes a cascading group of finer scale circulations and linked natural disasters. PWB occurs over scales ~2500-5000 km and 3-5 days when a disturbance in the jet stream collides with downstream blocking flow. Dry lightning often is the result of PWB during the warm season over the elevated western plateaus triggering wildland fires that produce burn scars resulting in subsequent flash flooding and debris flows days, months, or years later.

Kaplan is a Research Professor in the Division of Atmospheric Sciences at the Desert Research Institute in Reno, Nevada. He also teaches undergraduate and graduate courses in atmospheric dynamics, weather forecasting, and atmospheric numerical modeling in the Atmospheric Sciences Graduate and Undergraduate Programs at the University of Nevada Reno where he advises numerous graduate students. His interests are in synoptic, meso, and multi-scale dynamical meteorology. He has 50 years of experience in this and related problems. During his career he has performed research as an Air Force Weather Officer, small business owner, private consultant, NASA contractor, and Research Professor at North Carolina State University and the University of Nevada Reno. Presently, his main research focus is on multi-scale dynamics, forecasting, and modeling of extreme western weather including heat bursts, damaging wind systems, floods, snowstorms, fire meteorology, debris flows, and tornadic convection. He is an American Meteorological Society Certified Consulting Meteorologist.

Climate Change, Riparian Vegetation Removal, and Channel Change on the Colorado River. Gigi A. Richard, Ph.D. Professor, Geology, Director, Hutchins Water Center at CMU, Colorado Mesa University. grichard@coloradomesa.edu

The introduction and spread of tamarisk (*Tamarix* spp.) in the riparian zones adjacent to the Colorado River and many of its tributaries in the southwestern US has contributed to increased stability of many of these river channels over the last century. Recent and expanding efforts to remove tamarisk from riparian zones may contribute to increase channel mobility and bank erosion. A collaborative effort to better understand channel response of the Colorado River to tamarisk removal has involved field surveys as well as GIS analysis of channel change in areas with and without vegetation removal from historic aerial photos. Preliminary results suggest that erosion rates were higher during the time period with higher peak flows regardless of whether or not vegetation was removed, and that erosion rates were greater in sites where vegetation removal occurred. The potential impact of climate change on streamflow in the Upper Colorado River Basin will also be discussed.

Dr. Gigi Richard is currently the Director of the Water Center at Colorado Mesa University (CMU) in Grand Junction, CO and a Professor of Geosciences at CMU. She holds an M.S. and Ph.D. from Colorado State University and a B.S. from the Massachusetts Institute of Technology, all in civil engineering. Gigi created the Watershed Science program at CMU and co-founded the Water Center at CMU, which facilitates education, research and dialogue on water issues facing the Upper Colorado River Basin. Gigi teaches water and environmental science classes and her research on human impacts on rivers systems includes the study of downstream impacts of dams, levees and other human activities on rivers in Colorado, New Mexico and New Zealand. Recent work has focused on the impacts of vegetation removal on channel morphology of the Colorado River.

Decision Support in the Cadillac Desert: Climate Change and Water Supply in the Water Stressed and Politically Charged Western U.S. Paul Miller, Service Coordination Hydrologist, NOAA - Colorado Basin River Forecast Center. paul.miller@noaa.gov

NOAA's Colorado Basin River Forecast Center provides seasonal water supply forecasts to a wide range of stakeholders in the Colorado River and Eastern Great Basins. These forecasts have traditionally relied on past historical climate information and tools created before widely available remote sensing data. Further, past historical hydroclimatic information, and our reliance on it, may not represent future conditions as climate change impacts are realized. The CBRFC is investigating forecast methodologies to aid stakeholders in decision support using newly available remote sensing information and stochastically generated future weather ensembles. Here, the CBRFC's role in managing water resources is explained, and the challenges ahead for operational forecasts under changing climate conditions are discussed.

Paul Miller currently works for the Colorado Basin River Forecast Center as the Service Coordination Hydrologist in Salt Lake City, Utah. Prior to joining the CBRFC in November 2012, Paul worked for the U.S. Bureau of Reclamation, Lower Colorado Region for about 7 years investigating the impacts of climate change to the Colorado River Basin. Paul received his B.S. in Environmental Hydrology and Water Resources from the University of Arizona in 2003, his M.S. in Environmental Engineering from the University of Notre Dame in 2005, and his Ph. D. in Civil and Environmental Engineering from the University of Nevada, Las Vegas in 2010. His dissertation was titled, "Assessment of Impacts to Hydroclimatology and River Operations due to Climate Change over the Colorado River Basin." He has also taught introductory hydrology and fluid mechanics courses at the University of Nevada Las Vegas.

How Will Climate Change Alter the Abundance of Big Sagebrush? Peter Adler⁷, Professor, Department of Wildland Resources and the Ecology Center, Utah State University, Logan, Utah. peter.adler@usu.edu
Co-authors: Katherine M Renwick¹, Andrew R. Kleinhesselink², Daniel R. Schlaepfer³, Caroline A. Curtis⁴, Bethany A. Bradley⁵, Cameron L. Aldridge⁶, and Benjamin Poulter¹

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Climate change is a primary threat to sagebrush obligate wildlife, but predicting climate change impacts on sagebrush habitat remains a challenge. We rely on models, but every model suffers from problematic assumptions, undermining confidence in predictions. However, by comparing predictions from different modeling approaches, we may be able to increase our confidence in model projections. We compared models based on four very different kinds of information, from spatial and temporal correlations between climate and sagebrush cover to the dependence of sagebrush physiology on moisture and temperature. Despite considerable variation in the predictions of these four models, consistent trends emerged. Warming appears likely to have a positive effect on sagebrush performance in cold locations but a negative effect in warm locations. In addition, changes in temperature will have a greater impact on sagebrush than changes in precipitation. This information may help managers prioritize areas for conservation.

I am a plant ecologist who has been working in the sagebrush steppe for almost twenty years. My current research focuses on theoretical questions about the maintenance of species diversity and more applied questions about the impact of climate change on plant populations and communities.

Climate Change and Wildland Fire. J. Bradley Washa, Utah BLM State Fuels Specialist, DOI Bureau of Land Management, Utah State Office, Salt Lake City, Utah. bwasha@blm.gov

The impacts of climate change upon disturbance are demonstrated in numerous ways through wildland fire. The length of fire seasons have been extended, with snow packs melting earlier in the spring and wildfires continuing well into autumn under warmer and drier environments. Forest health issues from insect and disease infestations to increased fuel loadings are being exasperated by climate change. Invasive species have further increased and expanded across large parts of the west. These conditions impact the severity and number of acres burned on a landscape and regional level. Several recent wildfires and prescribed fires from Utah, along with associated weather data, will be reviewed to demonstrate the impacts of climate change on the wildland fire environment. Understanding the changing environment and management response to wildland fire disturbance is important in implementing management actions by land management agencies in restoring and maintaining resilient landscapes.

Brad's initial interest in fire management began at Mesa Verde National Park on the helitack crew in 1989, continuing as an Engine Foreman and acting Zone Assistant Fire Management Officer on the Arapaho-Roosevelt National Forest, Fire Management Specialist with The Nature Conservancy, various fire positions on the Cibola National Forest, and Fire and Fuels Management Specialist with the Bureau of Land Management on the Medford District. In April 2004, Brad became the Utah BLM State Fuels Specialist. Brad has completed several details: BLM's National Fuels Specialists at the National Interagency Fire Center, National Fuels Coordinator for the DOI Office of Wildland Fire in Washington, DC, Salt Lake Field Office Manager, and BLM Fire Planning and Fuels Management Division Chief at NIFC.

With experience on over 300 wildland fires, qualifications include Operations Section Chief, Burn Boss, Prescribed Fire Manager, Operations Branch Director, Division Supervisor, Fire Behavior Analyst, Incident Commander, Strategic Operational Planner, and Agency Representative. Brad volunteers with the Park City Ski Patrol and returns to Wisconsin to teach at Mayville Public Schools Sixth Grade Camp Program. Brad received his BS in Natural Resource Management and Political Science from University of Wisconsin - Stevens Point with an MS in Wildland Fire Science from Colorado State University. Brad instructs a number of NWCG course and has lectured at UWSP and University of Utah.

Poster Abstracts

In alphabetical order by presenting author's last name

Retrospective Approaches to Evaluate Resilience of Aspen, Mountain Mahogany, and Sagebrush Communities to Drought

Patrick J. Anderson¹ and Timothy J. Assal¹

¹*U.S. Geological Survey (USGS), Fort Collins Science Center, 2150 Centre Avenue, Fort Collins, Colorado 80526, USA*

The Wyoming Landscape Conservation Initiative (WLCI) is a multiagency science-based effort that supports conservation on 19 million acres in southwest WY. WLCI local teams, which are responsible for identifying conservation needs and implementing conservation actions, have posed numerous restoration questions about the resilience of aspen, mountain mahogany, and sagebrush to recent droughts. We present several retrospective approaches in combination with field measurements that we used to evaluate trends in aspen and sagebrush condition, productivity, and mortality prior and after recent droughts. Retrospective analysis included the exploration of the relationship between remotely sensed vegetation indices, drought indices (e.g. Palmer drought severity index), precipitation data, and landscape position. We present select trend observations reflecting resilience of aspen and sagebrush and highlight how this information supports WLCI conservation planning. Future efforts using dendrological methods to evaluate relationships between drought and annual radial growth, establishment dates, and mortality in aspen, mountain mahogany, and sagebrush systems are discussed.

Fire in the West: Risk Perceptions, Attitudes and Other Cognitions of Wildland and Prescribed Burning

Lauren Nicole Dupey, lndupey@aggiemail.usu.edu

To date, human dimensions of wildland fire research has used a diversity of theoretical frameworks to address various research topics on the cognitions surrounding wildland and prescribed fire. This literature has yet to be synthesized through a systematic review. In this research, we compiled all previous empirical research conducted within the western United States that addressed cognitions surrounding wildland and prescribed fire. We assessed four thematic categories through questions and corresponding codes to systematically analyze the literature and provide suggestions for future research. The four thematic categories included: theory and methods used, psychosocial aspects of fire, biophysical aspects of fire, and fire type and management. We identify gaps in the literature within each of these four areas. By doing so, we were able to identify areas where future for research in the western US is needed most.

A Seedling-Based Approach to Aspen Restoration

Alexander Howe, Dr. Simon Landh usser, Dr. Owen Burney, Dr. Karen Mock

Quaking aspen (*Populus tremuloides*) is a foundation species in the western US, however with recent widespread declines and predicted range contractions over the coming century, more proactive management tools may be necessary. Traditional silvicultural practices to regenerate aspen focus on inducing asexual suckering, but these methods reduce genetic diversity over time and are limited to existing stands. Planting of nursery-grown aspen seedlings could address these limitations but protocols have yet to be developed for the western US. To test a seedling-based approach to aspen restoration, over 7,000 nursery-propagated seedlings were planted in southwestern Utah in October 2015. Results from the 2016 growing season indicate mixed outplanting success, with rodent herbivory and early summer drought as the main limiters. Additionally, uneven responses among seedling sources in the nursery suggest further protocol optimization will be necessary. Monitoring will continue in 2017 to assess the ongoing performance of the established seedlings.

Cultivation Legacy Effects On Vegetation Structure and Plant Community Composition Following Shrub Reduction in Utah

Allison Jones , Director, Wild Utah Project; Mary Pendergast, Conservation Biologist, Wild Utah Project; Eric Thacker, Wildland Resources Department Utah State University; Linden Greenhalgh, Extension Associate Professor, Tooele County Extension, Utah State University, Justin Williams, US Department of Agriculture, Agricultural Research Service, Forage and Range Research Lab., Logan, Utah, and Thomas Monaco, US Department of Agriculture, Agricultural Research Service, Forage and Range Research Lab., Logan, Utah

We studied big sagebrush plant community responses to a two-way chain harrow and broadcast seeding of herbaceous species at eight Wyoming big sagebrush sites with the same ecological site classification; five were cultivated for dryland wheat production during the 1950-1980s, then seeded with introduced forage grasses and reverted back to grazing lands, while three had not been previously cultivated. Five years after treatment, densities of sagebrush seedlings and snakeweed plants increased in cultivated sites during the second and third year after treatment. In addition, perennial forb cover increased for cultivated sites, while perennial grass biomass increased for non-cultivated sites. Plant community change after treatment also varied between non-cultivated and cultivated sites, and response to treatment was most strongly correlated with reductions in sagebrush cover, increases in the perennial grass bulbous bluegrass, and increases in 10 herbaceous species—four of which were seeded. Our results emphasize that broad variability in plant community responses to sagebrush reduction is possible within the same ecological site classification, and that cultivation history can leave long-lasting legacy effects.

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Great Basin Bristlecone Pine (*Pinus longaeva*) Historic Fire Regimes and Future Fire Risk: A Multi-Scale Assessment

Stanley G. Kitchen, US Forest Service, Rocky Mountain Research Station

Co-authors: Steven L. Petersen, Gregory W. Taylor, Douglas H. Page, Christopher S. Balzotti, Craig Coleman

Great Basin bristlecone pine (*Pinus longaeva*: GBBP) is an iconic species found in montane habitats of the Great Basin and Colorado Plateau – a region in which wildfire severity and size have increased over the past 30 years. Study objectives were to use multiple lines of evidence to – 1) reconstruct historic fire regime patterns across a range of sites, 2) quantify conifer succession on GBBP sites after stand-replacing fire and 3) assess GBBP wildfire-related risk under contemporary and future environmental conditions. Results from 10 sites reveal that historical fires in GBBP were typically small and of mixed-severity, with moderate to long fire-free intervals. Initial post-fire conifer recruitment for three fires was relatively rapid with GBBP dominant to subdominant. Large size and high severity of recent fires in GBBP habitats suggest that contemporary and future fire risk may exceed historical conditions resulting in GBBP range contractions and possible localized extinctions.

Stanley G Kitchen, US Forest Service, Rocky Mountain Research Station, 735 North 500 East, Provo, UT, 84606, USA. Phone 801-356-5108, Email: skitchen@fs.fed.us

Riparian Vegetation as an Indicator of Riparian Condition: Detecting Departures from Historic Condition Across the North American West

William W. Macfarlane^{1*}, Jordan T. Gilbert¹, Martha L. Jensen¹, Joshua D. Gilbert¹, Nate Hough-Snee¹, Peter A. McHugh^{1,2}, Joseph M. Wheaton^{1,3}, Stephen N. Bennett^{1,2,3}

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Methods that identify local riparian vegetation condition, an effective proxy for riparian health, have not been applied across broad, regional extents. Here we present an index to assess reach-scale (500 m segment) riparian vegetation condition across entire drainage networks. We estimated riparian vegetation condition for 53,250 km of perennial streams and rivers, 25,685 km in Utah, and 27,565 km in twelve watersheds of the interior Columbia River Basin (CRB), USA. The index characterizes riparian vegetation condition as the ratio of existing native riparian vegetation cover to pre-European settlement riparian vegetation cover at a given reach. Roughly 62% of Utah and 48% of CRB watersheds showed significant (>33%) to large (> 66%) departure from historic condition. Through comparisons to ground-based classification results, we estimate the existing vegetation component of the index to be 85% accurate. Our assessments yielded riparian condition maps that will help resource managers better prioritize sites and treatments for reach-scale conservation and restoration activities.

Managing Bark Beetle Impacts on Social-Ecological Systems

Jesse L. Morris, University of Utah, jesse.morris@geog.utah.edu

Recent outbreaks of native bark beetles in North America and Europe have impacted forested landscapes and the provisioning of critical ecosystem services. The effects of outbreaks on ecosystems are often measured in terms of area affected, tree mortality rates, and alterations to forest structure and composition. Impacts to human systems focus on changes in property valuation, infrastructure damage from falling trees, landscape aesthetics, and the quality and quantity of timber and water resources. To advance our understanding of bark beetle impacts, a team of ecologists, land managers and social scientists was assembled to participate in a research prioritization workshop. Using an established methodology, 25 priority questions were identified to address key knowledge gaps in bark beetle research. Our efforts emphasize the need to improve outbreak monitoring and detection, educate the public on the ecological role of bark beetles, and develop integrated metrics that facilitate comparison of ecosystem services across sites.

Quaking Aspen at The Residential-Wildland Interface: Ungulate Herbivory and Forest Conservation

*Paul C. Rogers^{1,2,3}, Allison Jones⁵, James Catlin⁵, James Shuler⁶, Arthur Morris⁷,
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Quaking aspen (*Populus tremuloides* Michx.) forests are experiencing numerous impediments across North America. In the West, recent drought, fire suppression, insects, diseases, climate trends, inappropriate management, and ungulate herbivory are impacting these high biodiversity forests. Additionally, ecological tension zones are sometimes created where the above factors intermingle with jurisdictional boundaries. The public-private land interface may result in stress to natural areas where game species find refuge and plentiful forage at the expense of ecosystem function. We examined putative herbivore impacts to aspen forests at Wolf Creek Ranch (WCR), a large residential landscape in northern Utah. Forty-three ha-1 monitoring plots were established to measure a range of attributes summarizing location description, tree and vegetation condition, and herbivore presence. Additionally, we tested the ability of a stand-level visual rating system to represent more detailed field measures along with aspen forest understory surveys. Elk (*Cervus elaphus* L.) herbivory is currently having a strong effect on aspen in the study area, reducing many locations to single-layer aspen forests dominated by aging canopy trees. Regeneration (< 2 m stems) is experiencing moderate-to-high browse and

recruitment (2 - 6 m stems) are below replacement levels on approximately half of WCR's aspen forests. The condition rating system represented significant trends in forest cover, canopy height, stand aspect, regeneration, recruitment, and tree mortality. Ordination of all plot and forest data found a strong negative relationship between elk presence and recruitment success. We make recommendations for addressing difficult herbivore-aspen interactions where publicly managed wildlife present barriers to conservation of privately owned forest reserves.

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Great Basin Bristlecone Pine (*Pinus longaeva*) Stand Composition and Structure: Variability Reveals Flexibility in Life-history Strategy

Gregory W. Taylor, Masters Student, Brigham Young University

Co-authors: Stanley G. Kitchen, Steven L. Petersen, Douglas H. Page, David A. Charlet, Christopher S. Balzotti

Great Basin bristlecone pine (*Pinus longaeva*: GBBP) is known for its longevity and slow growth. We hypothesize that this conservative life-history strategy is adaptive for individual survival and stand persistence across a range of biophysical conditions. We documented non-riparian GBBP from 1980 to 3535 m above sea level as single-species stands, and in mixed stands of two to seven species (total of 12 tree associates). Species diversity varied by elevation and ecoregion. In 69 representative plots, total tree and GBBP-only density varied from 60-2068 and 15-818/ha, respectively; and was not correlated with elevation. Stand and GBBP basal area varied from 2.7-220.9 and 0.1-206.6 m²/ha, with highest levels restricted to high-elevation, GBBP-dominated stands. Mean age estimates (from a subset of plot trees) were 233 years for all plot trees and 322 years for GBBP only. Results reveal high stand compositional and structural variability across the elevational and geographic range, suggesting substantial adaptive flexibility.

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Effects of Bark Beetle Attacks on Snowpack and Snow Avalanche Hazard

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Unprecedented bark beetle outbreaks across western North America have killed millions of trees, which profoundly affects snowpack in high elevation forests. Bark beetle outbreaks quickly change composition, structure, and functions of forests and may alter their protective effects against snow avalanches.

We examined the snowpack under canopies of Engelmann spruce forest stands in the Uinta Mountains in Utah, USA, using a snow micro penetrometer (SMP). Biweekly-repeated SMP measurements along 20 m transects were recorded in winter 2016 in study plots beneath canopies of recently infested trees, trees 3+-years after bark beetle infestation, a harvested forest stand, and a non-forested meadow. We describe the evolution of the snowpack at our study plots with two-dimensional snow density profiles, which we derived from high-resolution spatio-temporal SMP data.

Considering changes in snowpack properties following bark beetle attack is important for road safety, winter backcountry activities, avalanche forecasting, and ski resort and protection forest management.

(notes)

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(notes)



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