Restoring the West Conference 2017

Forest Restoration: What's Working, What's Not?

October 17-18, 2017, Utah State University, Logan, Utah

www.restoringthewest.org

2017 Restoring the West Conference

Planning Committee

Kendall Becker, Graduate Student, USU
Mark Brunson, Professor, Environment & Society Department, USU
Julia Burton, Research Assistant Professor, Wildland Resources, USU
Megan Dettenmaier, Forestry Extension Educator, USU
Lauren Nicole Dupéy, Graduate Student, USU
Tucker Furniss, Graduate Student, USU
Robbie Gerber, Conference Services, USU
Mike Kuhns, Professor, Wildland Resources Department Head & Forestry Extension Specialist, USU
Darren McAvoy, Committee Chair, Extension Assistant Professor of Forestry, USU
Paul Rogers, Director, Western Aspen Alliance, USU
Larissa Yocom, Assistant Professor, Wildland Resources, USU

Thank you to our Sponsors:
USU Cooperative Extension, USU Forestry Extension, USU Quinney College of Natural Resources, USU Department of Wildland Resources, USU Ecology Center, USDA Forest Service State & Private Forestry, Western Aspen Alliance, Utah Biomass Resources Group, Society for Ecological Restoration (SER), Great Basin chapter, Great Basin Fire Science Exchange, Southern Rockies Fire Science Network.

Agenda

Tuesday, October 17, 2017
USU Eccles Conference Center

7:30 - 9:00 a.m.	**Registration Open**
8:30 - 8:35 a.m.	**Welcome**, Chris Luecke, Dean, Quinney College of Natural Resources, Utah State University, Logan, Utah.
8:35 - 8:40 a.m.	**Conference Overview**, Darren McAvoy, Extension Assistant Professor, Forestry, Utah State University, Logan, Utah.
8:40 - 9:20 a.m.	**Keynote:** Managing for Forest Resilience Under Global Change: the Power of Fire Refugia. Crystal Kolden, Associate Professor, Forest Rangeland and Fire Sciences, University of Idaho, Moscow, ID.
9:20 - 9:50 a.m.	Embracing Partnership and Realizing the Co-benefits of Collaboration. Spencer Plumb, National Forest Foundation, Southern Rockies Region, Flagstaff, AZ.
9:50 - 10:20 a.m.	**Break**
10:20 - 11:00 a.m.	**Keynote:** Forest Restoration at the Landscape Scale across Land Ownerships: How to get there from here? Susan Charnley, Research Social Scientist, Forest Service, Pacific Northwest Research Station, Portland, OR.
11:00 - 11:30 a.m.	Forest Restoration from the District Ranger Chair. Elizabeth Davy, District Ranger, United States Forest Service, Island Park, ID.
11:30 - 12:00 p.m.	Restoring Pattern, Structure, and Function in Dry Forests: the ICO Approach. Derek J. Churchill, Forest Ecologist and Silviculturist, School of Environmental and Forest Sciences, University of Washington, Seattle, WA.
12:00 - 1:30 p.m.	**Poster Session and Lunch**
1:30 - 2:00 p.m.	Accelerating Restoration - The Challenges and Successes of the Nation's Largest Collaborative Restoration Project. Dick Fleischman, Operations Coordinator, Four Forest Restoration Initiative, United States Forest Service, Flagstaff, AZ.
2:00 - 2:30 p.m.	Beyond Collaborative Decision-Making: Practices for "Matching" Ecological and Social Systems in Forest Restoration. Jesse Abrams, Research Associate, Institute for a Sustainable Environment, University of Oregon, Eugene, OR.
2:30 - 3:00 p.m.	Forest Structure Outcomes After Mixed-Severity Wildfire: Do They Meet Restoration Goals? Mike Battaglia, Research Forester, United States Forest Service, Fort Collins, CO.
3:00 - 3:30 p.m.	**Break**
3:30 - 4:00 p.m.	If the Trees Don't Pay for Restoration What Will? Diane Vosick, Director of Policy and Partnerships, Ecological Restoration Institute, Northern Arizona University, Flagstaff, AZ.
4:00 - 4:30 p.m.	Handshakes and Head Fakes: When Social Dynamics Intersect with Institutional Processes in Collaborative, Adaptive Forest Restoration. Tony Cheng, Professor, Department of Forest and Rangeland Stewardship, Colorado State University; Director, Colorado Forest Restoration Institute, Fort Collins, CO.
5:30 - 7:30 p.m.	**Reception, Cafe Sabor (600 W Center St. Logan) Minibus shuttle departing from University Inn starting at 5:20, return trips as needed.**

Wednesday, October 18, 2017
USU Eccles Conference Center

8:00 a.m.	**Registration Open**
8:30 - 8:35 a.m.	**Welcome**
8:35 - 9:15 a.m.	**Keynote:** Restoring Fire-prone Inland Pacific landscapes: Seven Core Principles. Paul Hessburg, Research Landscape Ecologist, Pacific Northwest Research Station, United States Forest Service, Wenatchee, WA.
9:15 - 9:45 a.m.	Restoring the Landscape – San Carlos Apache Reservation. Dee Randall, Forest Manager, San Carlos Apache Tribe, San Carlos Reservation, AZ.
9:45 - 10:15 a.m.	**Break**
10:15 - 10:45 a.m.	Accelerating Forest Restoration in Northern Arizona. Northern Arizona Program Restoration Manager. Neil Chapman, The Nature Conservancy, Flagstaff, AZ.
10:45 - 11:15 a.m	Integrating Science with Restoration in Colorado's Front Range Collaborative Forest Landscape Restoration Project (CFLRP): some of our greatest hits. Jenny Briggs, Research Ecologist, Geosciences and Environmental Change Science Center, US Geological Survey, Denver, CO.
11:15 a.m. - 12:05 p.m. **Up and coming research from graduate student scientists**	1) Does Bark Beetle Disturbance Alter Forests' Protective Effects Against Snow Avalanches? Michaela Teich, Post-doctoral scholar, Wildland Resources. 2) Low-severity Fire Impacts Snag Dynamics in an Old-growth Forest: Does Tree Neighborhood Matter? Kendall Becker, PhD Ecology student, Wildland Resources. 3) A Seedling-based Approach to Aspen Restoration in the Interior West. Alex Howe, MS Ecology student, Wildland Resources.
12:05 - 1:00 p.m.	**Lunch**
1:00 -1:30 p.m.	Perspectives of a Land Manager. Craig Taggart, Environmental Manager, Tercio & Trinchera Ranches, Fort Garland, CO.
1:30 - 2:00 p.m.	Impacts of Low-severity Fire and Fuel Treatments on Ponderosa Pine Resistance to Mountain Pine Beetle. Sharon Hood, Research Ecologist, Rocky Mountain Research Station, United States Forest Service, Missoula, MT.
2:00 - 2:30 p.m.	Clearing the Way: Revealing and Removing Hidden Barriers to Private Land Forest Restoration. Leslie Allison, Executive Director, Western Landowners Alliance, Santa Fe, NM.
2:30 to 3:00 p.m.	**Break**
3:00 to 3:30 p.m.	Increasing the Pace and Scale of Forest Restoration and the Breadth and Depth of Forest Restoration Partnerships in Idaho. John Robison, Lemhi Forest Restoration Group and Idaho Forest Restoration Partnership, Salmon, ID.
3:30 to 4:00 p.m.	Application of International Standards for Ecological Restoration to the Western US. Cara Nelson, Associate Professor of Restoration Ecology, University of Montana, Missoula, MT.
4:00 to 4:40 p.m.	**Keynote & QCNR Seminar Speaker:** The Ongoing Promise & Emerging Perils of Western Forest Restoration in a Global Change World. Craig Allen, Research Ecologist, U.S. Geological Survey, New Mexico Landscapes Field Station, Los Alamos, NM.
6:30 to 8:30 p.m.	**Special evening presentation: Era of Megafires, a multimedia learning experience. Change the way wildfire comes to your community.** Paul Hessburg, USFS will give this special presentation at the Riverwoods Conference Center, 615 Riverwood Pkwy, Logan, UT. Join us for this free, public event, all are welcome to attend.

Speaker Abstracts

In order of presentation

Keynote: Managing for Forest Resilience Under Global Change: the Power of Fire Refugia. Crystal Kolden, Associate Professor, Forest Rangeland and Fire Sciences, University of Idaho, Moscow, ID. ckolden@uidaho.edu.

Wildfires and bark beetles and drought…oh my! Forest resilience is a top concern for managers tasked with maintaining it both in the US and globally in an era of rapid global change. Fire refugia are islands within fire perimeters that are either unburned or only minimally burned so as to maintain key ecosystem functions. They are critical landscape elements by which ecosystems can maintain biodiversity and resilience to disturbances. As climate change alters fire regimes and increases the frequency of so-called megafires, however, there is little understanding of what the impacts may be on fire refugia and their stationarity over time. This knowledge gap persists, in part, because fire refugia have been largely understudied across large spatial extents at the landscape-scale. Recent findings demonstrate that fire refugia have not declined as a proportion of area burned across the Inland Northwestern US, and initially do not appear to be well-correlated to top-down climatic controls. This would suggest that fire refugia are facilitated by bottom-up factors such as topography, vegetation, and human engineering of the landscape. For land managers who are tasked with preserving key sites or conserving specific ecosystem functions and services, undertaking to support fire refugia may be one of the avenues to develop and maintain forest resilience. Translating this understanding to management strategies, however, will require focused research in this arena to develop comparative crosswalks between analyses focused on species versus those focused on landscape pattern.

Dr. Crystal Kolden is a Pyrogeographer who studies fire at the socio-ecological nexus across the globe. She started her career as a wildland firefighter with the US Forest Service, and was later an ecologist with USFS and USGS. She is an associate professor in the Forest, Rangeland, and Fire Sciences department in the College of Natural Resources at the University of Idaho, where she runs the Pyrogeography Lab and tries to understand how we humans can better live with fire. She and her husband and their twin boys live in northern Idaho, where they enjoy good fishing, good food, and no traffic.

Embracing Partnership and Realizing the Co-benefits of Collaboration. Spencer Plumb, National Forest Foundation, Southern Rockies Region, Flagstaff, AZ**.** splumb@nationalforests.org

Public land management agencies face mounting challenges that include rapid ecological shifts, increases in the number and types of users, declining budgets, and demands for restoration to ensure the continued delivery of ecosystem services. The added management pressure faced by federal land agencies highlights the need for social and institutional changes. One positive institutional change driven by the need for increasing capacity has been the emergence of a variety of collaborative partnerships between federal agencies and national, state and local level organizations. In the case of the Forest Service, the National Forest Foundation is developing a variety of partnership models across the country that connect with businesses, municipalities, state agencies and other nonprofits. From running collaborative workshops to managing thinning contracts, this presentation will highlight examples of the different approaches and discuss the conditions that help make these working relationships successful. Sharing land management and stewardship responsibilities represents an opportunity to deepen the interdependent relationships between public land management agencies and the communities they operate in and serve.

Spencer Plumb is a social scientist specializing in forest and water policy. He earned his Ph.D. in Natural Resources from the University of Idaho in 2016 and holds a Master's degree in Environmental Science and Policy from Northern Arizona University. He is currently the Southern Rockies Program Associate at the National Forest Foundation working out of Flagstaff, Arizona.

Keynote: Forest Restoration at the Landscape Scale across Land Ownerships: How to Get There From Here? Susan Charnley, Research Social Scientist, Forest Service, Pacific Northwest Research Station, Portland, OR. scharnley@fs.fed.us.

Over the last decade, the "all hands, all lands" approach has gained prominence as a means for restoring forests and grasslands in the American West at the landscape scale. This approach means that land owners, managers, and stakeholders with management interests in a shared landscape jointly plan and/or implement forest management activities to achieve common goals. Ideally, best available science guides the strategic placement of restoration treatments in a manner that optimizes desired outcomes. Yet landscapes in the American West often consist of a mosaic of different land ownerships owing to the way in which property rights historically developed. Implementing an all lands approach is challenging because it requires land owners, managers, and stakeholders with diverse interests, management approaches, and capacities to act collectively. Science-based restoration treatments in multi-ownership landscapes will only be successful if they are socially feasible and the benefits outweigh the costs. This talk draws on research from Oregon and California to identify social factors that are important for successful all hands, all lands approaches to wildfire hazard reduction. These include supportive policy, funding for restoration on multiple land ownerships, strategic partnerships, common acknowledgment of existing wildfire hazard, intermediary organizations to increase capacity, strong outreach and communication, and local business capacity.

Susan Charnley is a research social scientist with the US Forest Service's Pacific Northwest Research Station in Portland, OR. She holds a PhD in Anthropology from Stanford University. Susan's research investigates how best to achieve the dual goals of environmental conservation and rural community well-being. Most of her work takes place in the western USA and in Africa.

Forest Restoration from the District Ranger Chair. Elizabeth Davy, District Ranger, United States Forest Service, Island Park, ID. edavy@fs.fed.us.

I am a Ranger, but I am a forest ecologist as well. When I functioned as a specialist and spoke for the trees and their ecosystems, it seemed so simple. Act on the research, maintain HRV, keep your landscapes resilient to perturbation, and mimic Mother Nature. Now that I am a manager of all resources it becomes much more complicated or at least for me it does; balancing competing interests, goals and objectives from resource specialists and the public. I will highlight some of our successes and our challenges we face with restoration projects. Of course since I am a forester it will be all about trees and that landscape!

Currently I am the District Ranger for Ashton/Island Park Ranger district on the Caribou-Targhee National Forest in southeastern Idaho. I manage approximately 650,000 acres and over 25 employees. I have been in this job for seven years. Prior to Rangering, I was and still am a Forester and Silviculturist. Forest restoration and ecology is my passion and prime interest. I have worked for the Forest Service for almost 30 years and most of that time has been spent in the Greater Yellowstone Area. I live in Driggs and Ashton, Idaho. My husband and I have two dogs and enjoy outdoor sports including cross-country skiing, biking, hiking, gardening and playing with our grandchildren.

Restoring Pattern, Structure, and Function in Dry Forests: the ICO Approach. Derek J. Churchill, Forest Ecologist and Silviculturist, University of Washington, Seattle, WA. derekch@uw.edu

Managers and stakeholders across the Interior West are increasingly focused on managing for the uneven-age, mosaic patterns of individual trees, tree clumps, and openings (ICO) associated with frequent fire forests. These stand level patterns influence key processes and functions such as fire behavior, drought resistance, snow retention, wildlife habitat, and stand development. Until recently, methods to incorporate targets for spatial pattern into treatments were not well developed. To inform such methods, we reconstructed and stemmaped 55 x 4ha historical reference sites from frequent fire forests across interior Washington and Oregon. Reference sites show a definable envelope of patterns that can serve as targets for treatments. We developed a silvicultural tool that incorporates spatial pattern targets from reference stands into prescriptions. Results from treatment implementation indicate that explicit targets for spatial variability, in the form of clumping and opening targets, can be achieved in a practical, operational-scale manner. We also developed field based and LiDAR monitoring tools to compare spatial pattern from any treatment to reference conditions. Results from monitoring of 38 treatments, including prescribed fire, show that strict basal area and spacing based treatments do not restore reference spatial patterns, while approaches with explicit pattern objectives generally do.

Derek Churchill is both a forester and scientist who focuses on applying ecological knowledge to on-the-ground forest management challenges across the Pacific Northwest. He has run a forestry consulting company for 10 years that specializes in ecological forestry on public and private land. He has done a wide variety of projects on National Forests throughout Washington, Oregon, and California, and has worked extensively with forest collaboratives. He is also a research scientist at the School of Environmental and Forest Sciences – University of Washington. His research focuses on stand to landscape restoration and management of fire prone forests, including using LiDAR in management applications. He also teaches forest management classes at UW. He lives on Vashon Island where he works with the Vashon Forest Stewards; a community forestry group that manages several community forests on Vashon as well as forest operations for small private, non-industrial forest landowners.

Accelerating Restoration - The Challenges and Successes of the Nation's Largest Collaborative Restoration Project. Dick Fleischman, Operations Coordinator, Four Forest Restoration Initiative, United States Forest Service, Flagstaff, AZ. dfleishman@fs.fed.us.

The 2.4 million acre Four Forest Restoration Initiative (4FRI) is the largest collaborative forest restoration project in the United States. The objective of 4FRI is to restore ecological resilience and function across 2.4 million acres of northern Arizona's ponderosa pine forest and to attract appropriately sized industry to the region and to increase the pace and scale of our efforts to meet the objectives above.

Tackling this large of a project is challenging, as is defining and measuring what success is across the landscape. The talk will focus on various ways to define success (acres treated, meeting desired conditions, and outcomes) and where we are as a project to date with these various measures. Finally, the talk will look at challenges facing 4FRI including 110+ years of Forest Service tradition, how do we accelerate restoration with low value material and biomass, how do we accelerate the use fire across the landscape, how do we integrate monitoring into management and NEPA. For each of the topics, there will be a discussion of the each of these challenges, how are we getting to success with these challenges, and where there is more work to be done.

Dick Fleishman is the Operations Coordinator Four Forest Restoration Initiative, the largest forest restoration project in the history of the Forest Service. Prior to this position, Dick worked as a hydrologist, a pre-sale forester, a timber sale administrator, and in Forest planning on the Coconino National Forest. Dick has a Bachelor of Science in Forest Management, as well as a Master's in Public Administration from Northern Arizona University. Dick may be contacted at dfleishman@fs.fed.us, or at 928 226-4687.

Beyond Collaborative Decision-Making: Practices for "Matching" Ecological and Social Systems in Forest Restoration. Jesse Abrams, Research Associate, Institute for a Sustainable Environment, University of Oregon, Eugene, OR. jabrams@uoregon.edu.

The forest decision-making paradigm in the West has shifted over time, with collaborative models having become institutionalized in the contemporary era. However, other elements beyond collaborative decision-making are needed for successful forest restoration. In this presentation, I will provide insights from restoration endeavors across the West to highlight the issues of local legitimacy and capacity that are often crucial to forest restoration success. Legitimacy is enhanced through the involvement of credible intermediaries, the incorporation of local knowledge, and the authority to adapt broad rules to the local context. Capacity includes not only the physical infrastructure to generate economic benefits from restoration but also the organizational infrastructure needed to navigate complex institutional settings and to fill critical gaps in the public, private, and civil society sectors. The development of these capacities and authorities may be an important strategy for "matching" ecological and social systems in western forests.

Jesse Abrams is a Research Associate with the Ecosystem Workforce Program, Institute for a Sustainable Environment at the University of Oregon. His research centers on community-based natural resource management, rural development, and environmental policy and governance. He holds a B.A. in Environmental Studies from New College of Florida and M.S. and Ph.D. degrees in Forest Resources from Oregon State University.

Forest Structure Outcomes After Mixed-Severity Wildfire: Do They Meet Restoration Goals?
Mike Battaglia, Research Forester, United States Forest Service, Fort Collins, CO. mbattaglia@fs.fed.us

Over the past several decades, Western U.S. ponderosa pine forests have experienced a series of wildfires that have resulted in landscapes with burn mosaics ranging from low to high severity. Recent wildfires, while seemingly incompatible with management goals, may help advance them in some circumstances. Most focus their attention on the large high-severity portions of recent large fires, however, significant portions also burned with a finer, more heterogeneous mosaic of burn severities. In this research we examine the post-wildfire spatial and non-spatial patterns of residual forest and post-fire regeneration in low to moderate severity areas and compare it to historical reference conditions. Post-fire residual forest structure was dominated by ponderosa pine and some Douglas-fir with tree densities ranging between 164 to 331 trees hectare-1, and clear differentiation in both horizontal and vertical forest structure. Tree regeneration was dominated by ponderosa pine within 15 m of a surviving tree. These results suggest that low and moderate severity fire is moving the forest structure closer to restoration goals and show how quantifying the structural outcomes of wildfire provides a better understanding of how wildfires are supporting restoration objectives.

Mike Battaglia is a research forester with the USFS Rocky Mountain Research Station in Fort Collins. His research is focused on developing innovative management strategies aimed at enhancing forest resiliency to disturbance. He works across the Interior West in a variety of ecosystems spanning from low elevation ponderosa pine forests to subalpine Spruce-fir forests.

If the Trees Don't Pay for Restoration What Will? Diane Vosick, Director of Policy and Partnerships, Ecological Restoration Institute, Northern Arizona University, Flagstaff, AZ. Diane.Vosick@nau.edu

In the late 1990s proposals to mechanically thin and restore public land forests generated intense conflict and litigation. Yet today, there are over 500,000 acres of restoration-based mechanical thinning treatments approved by NEPA in northern Arizona. This accomplishment is evidence for the level of support that exists for restoration. Having lowered much of the social conflict associated with restoration thinning the next barrier to success is economic.
When the Four Forest Restoration Initiative (4FRI) began in 2009 the stakeholders and Forest Service believed that wood harvested during forest restoration would pay-for, or at a minimum, substantially offset some of the cost of treatments. At the time, the 4FRI set an ambitious goal of accomplishing 50,000 acres of mechanical treatments annually. Unfortunately, the number of acres completed annually during the intervening time has never exceeded 16,000 acres. Why?

The trees removed from forest restoration treatments in the Southwest are a combination of small, mostly unmerchantable logs and huge volumes of biomass. The low value of the wood is a function of both quality and size. Without significant investment in value-added processing making a profit is difficult. Entrepreneurs are reticent to invest in expensive value-added infrastructure without guaranteed large volumes of wood, risk-sharing and contracts that exceed 10 years. This presentation will examine different approaches for improving the economics of restoration and explore whether or not it is time to create a different economic model to achieve restoration goals.

Diane Vosick is the Director of Policy and Partnerships for the Ecological Restoration Institute at Northern Arizona University. In that capacity she works with policy makers, environmental stakeholders, business interests and land managers to achieve the goal of ecological restoration of frequent fire forests. Her work includes translating and communicating the biophysical and social science that support restoration to key audiences. She has spent her entire career in the field of conservation and ecological restoration. She has a MA in Geography from the University of Minnesota and a BA from the Evergreen State College.

Handshakes and Head Fakes: When Social Dynamics Intersect with Institutional Processes in Collaborative, Adaptive Forest Restoration. Tony Cheng, Professor, Department of Forest and Rangeland Stewardship, Colorado State University; Director, Colorado Forest Restoration Institute, Fort Collins, CO. tony.cheng@colostate.edu.

The Collaborative Forest Landscape Restoration Program (CFLRP) has created the conditions in which collaborative adaptive management (CAM) approaches in forest restoration can be tested. In theory, CAM engages stakeholders to collectively: define forest landscape restoration goals, assumptions, uncertainties, and options; develop and implement a science-based monitoring strategy to assess restoration effects; deliberate the effects of actions on goals, assumptions, and uncertainties; and recommend changes in goals, assumptions, and actions based on the "best available science". In reality, since people are involved, things get messy, fast.
My presentation addresses two questions: 1) In what ways do multi-stakeholder group dynamics interact with federal agency institutional and organizational processes?; and 2) To what extent do these interactions facilitate or frustrate collaborative adaptive management on federal landscapes? Drawing on experiences and perspectives of colleagues involved with the Colorado Front Range CFLRP, the Four Forest Restoration Initiative, and the Uncompahgre Plateau CFLRP, I discuss social group dynamics and institutional/organizational factors affecting CAM across these cases. A key take-away is that in order for CAM to realize its potential for integrating science into forest restoration decision-making, CAM participants need to be intentional and reflexive about social group dynamics and institutional/organizational processes.

Tony Cheng is Director of the Colorado Forest Restoration Institute and Professor in the Department of Forest & Rangeland Stewardship at Colorado State University. His primary research interest is in forest governance, policy and administration, with a focus on multi-stakeholder collaborative approaches to promote resilient social-ecological systems linked to forest landscapes. In his capacity as director of CFRI, Tony oversees programs to develop, compile, and apply locally-relevant scientific information to achieve forest restoration and wildfire hazard reduction goals. His research publications appear in a wide diversity of interdisciplinary journals, such as Ecology and Society, Environmental Management, Forest Ecology and Management, Forest Policy & Economics, Forest Science, Human Dimensions of Wildlife, Human Ecology Review, Journal of Forestry, and Society & Natural Resources. Born and raised in eastern Washington's Palouse country, Tony has a PhD in Forestry from Oregon State University, a MS in Forestry from the University of Minnesota, and a BA in Political Science from Whitman College in Walla Walla, WA.

Keynote: Restoring Fire-prone Inland Pacific Landscapes: Seven Core Principles. Paul Hessburg, Research Landscape Ecologist, Pacific Northwest Research Station, United States Forest Service, Wenatchee, WA. phessburg@fs.fed.us.

More than a century of forest and fire management of Inland Pacific landscapes has transformed their successional and disturbance dynamics. Regional connectivity of many terrestrial and aquatic habitats is fragmented, flows of some ecological and physical processes have been altered in space and time, and the frequency, size and intensity of many disturbances that configure these habitats have been altered. Current efforts to address these impacts yield a small footprint in comparison to wildfires and insect outbreaks. Moreover, many current projects emphasize thinning and fuels reduction within individual forest stands, while overlooking large-scale habitat connectivity and disturbance flow issues. We provide a framework for landscape restoration, offering seven core principles. We discuss their implication for management, and illustrate their application with examples. Historical forests were spatially heterogeneous at multiple scales. Heterogeneity was the result of variability and interactions among native ecological patterns and processes, including successional and disturbance processes regulated by climatic and topographic drivers. Native flora and fauna were adapted to these conditions, which conferred a measure of resilience to variability in climate and recurrent contagious disturbances. To restore key characteristics of this resilience to current landscapes, planning and management are needed at ecoregion, local landscape, successional patch, and tree neighborhood scales. Restoration that works effectively across ownerships and allocations will require active thinking about landscapes as socio-ecological systems that provide services to people within the finite capacities of ecosystems. We focus attention on landscape-level prescriptions as foundational to restoration planning and execution.

Dr. Hessburg is a research landscape ecologist with the USDA-Forest Service, PNW Research Station. He is stationed in Wenatchee, WA, where he has lived and worked for the last 25 years. Paul is also a Professor (Affiliate) at the UW, WSU, and UI, where he has collaborative research projects with faculty and students. His areas of research interest are the landscape and disturbance ecology of historical, contemporary, and future western US forests, natural wildfire resilience mechanisms of western forests, and landscape restoration in coupled human-natural systems. He has 37 years of professional forestry experience in the West, has authored and co-authored >165 research articles and book chapters, including a recently released Springer title on decision support modeling entitled "Making Transparent Environmental Management Decisions". Today he will be speaking to us about Living in the Era of Megafires.

Restoring the Landscape – San Carlos Apache Reservation. Dee Randall, Forest Manager, San Carlos Apache Tribe, San Carlos Reservation, AZ. drandall@forestry.scat-nsn.gov

San Carlos Apache Reservation - There is in essence one natural resource: The Natural World. We often think of it as separate parts based upon the different ways we use the resource, and the different types of expertise that are required to manage this resource. The health and quality of the natural world hinges on the balance of ecological, geological, hydrological, human, and other processes. San Carlos Forest Resources Program strives to use this knowledge to guide management of the natural resources.

Logging occurred since 1900 with the establishment of the Clover sawmill. The Bureau of Indian Affairs managed the forestry programs to promote timber industries; and foresters at San Carlos did what foresters everywhere did: they fought fire.

Fire has always been part of the ecosystem and large landscape fires that were frequent with low to moderate intensity. The establishment of the reservation and forest management practices of suppressing fires has caused fuel loading to increase and the forest to become unhealthy. Fires have been a part of Apache country, but Apaches did not set large fires. What they wanted from the land was edible wild grasses, game animals, shrubs for baskets, many dependent on routine burning that occurred from natural starts.

Current forest silvcutural practices have fire as part of the treatment, not only to treat the slash from logging, thinning or fuelwood activities, but to go beyond the commercial acreage. Using natural starts with a confine and contain strategy help us to treat areas that are not feasible. In areas with no structures, using roads or natural features as containment lines has reduced the cost of fire suppression. Challenges we are faced with come from modern thinking of smoke and fire as always bad, as it is seen on the news, goals that conflict with policy, and the ever increasing human population demanding from mother earth that she provide for our every need. Fire is a natural tool and has been part of the landscape, with current conditions of our forest we must be able to the natural process as the most appropriate way to restore our forest to its healthiest most sustainable and resilient state.

Dee Randall is the Forest Manager for the San Carlos Apache Tribe. He started his career working as a ranch hand for the Ash Creek Cattle Association at age 9 and throughout high school during the summer months. Seeing the country from an early age strengthened his interest in natural resources. Dee's forestry career started in Fire Management and later working as a Forestry Technician for the Tribe. He received his Bachelor of Science degree from the University of Arizona in 1989 and started as the Forest Development Forester at San Carlos. Dee is a San Carlos Apache Tribal member.

Accelerating Forest Restoration in Northern Arizona. Neil Chapman, Northern Arizona Program Restoration Manager. The Nature Conservancy, Flagstaff, AZ. nchapman@tnc.org.

The Nature Conservancy in Arizona is working to transform the way national forests are managed by forming strategic partnerships, developing advanced technology, and modernizing business practices using the 2.4 million-acre Four Forest Restoration Initiative as a demonstration site.

Current Forest Service economic and management models are based on logging practices designed for the harvest of commercially valuable, large trees. These practices often do not account for the emerging technologies and new economic realities of ecological restoration.

The Forest Service can effectively mobilize when the incentives and expectations are in place. This is clear in how they expertly fight multiple large fires by bringing all their resources to bear. Forest restoration activities need to become just as adept.

The Nature Conservancy in Arizona and the US Forest Service Region 3 are entering into an agreement to catalyze this change - to attract new investment and sustain existing investments in wood products by creating a more reliable flow of wood at a reasonable cost and at a scale large enough to make a difference. Together we will create forests that protect our future and sustain and protect water supplies, air quality, communities, jobs, wildlife and recreation.

Neil Chapman is The Nature Conservancy's Northern Arizona Program Restoration Manager based in Flagstaff, Arizona. After receiving a B.S. from Colorado State University, Neil's career with The Nature Conservancy began at the Nachusa Grasslands in northern Illinois where he supported the stewardship of tall grass prairie and oak savannah restoration projects. In 2006, Neil began managing ecological restoration projects throughout Arizona. Neil's current role involves forestry and fire management programs in northern Arizona's forests and grasslands.

Integrating Science with Restoration in Colorado's Front Range Collaborative Forest Landscape Restoration Project (CFLRP): Some of Our Greatest Hits. Jenny Briggs, Research Ecologist, Geosciences and Environmental Change Science Center, US Geological Survey, Denver, CO. jsbriggs@usgs.gov.

In 2010, the USDA Forest Service (USFS) initiated the national 10-year Collaborative Forest Landscape Restoration (CFLR) program to increase the pace and scale of ecological restoration efforts in forests with pressing needs for treatment to offset the effects of past anthropogenic stressors. Following several major wildfires, a mountain pine beetle epidemic, and rapid expansion of the wildland-urban interface, the Front Range of the southern Rocky Mountains in Colorado was one of the first landscapes in the US to receive CFLR funding. Over the past 8 years, CFLR funding has catalyzed efforts by a diverse collaborative group (USFS, other resource managers, scientists, and stakeholders) to implement and monitor restoration treatments in ponderosa-pine dominated forests along the Colorado Front Range. This talk describes the progress and challenges experienced by the collaborative, focusing in particular on how more than 10 scientific studies and monitoring efforts have been developed and integrated – with varying degrees of success! - into both the adaptive management and adaptive monitoring processes.

Jenny Briggs joined the US Geological Survey in 2008 as a Research Ecologist and works at the interdisciplinary Geosciences and Environmental Change Science Center in Denver, Colorado. She holds a B.A. in Human Biology from Stanford University and a Ph.D. in Ecology, Evolution, and Conservation Biology from the University of Nevada, Reno. Her research investigates the interaction between ecological and anthropogenic disturbances in forested ecosystems. Recently, she has focused on the dynamics of insect epidemics, fire, and forest management (e.g. restoration, fuel reduction, and prescribed burning) in Colorado. She welcomes opportunities to work collaboratively with management agency partners and educators on questions of concern to resource management decisions, and participates in several regional interagency research-management teams that are part of national programs.

Does Bark Beetle Disturbance Alter Forests' Protective Effects Against Snow Avalanches? Michaela Teich, Post-doctoral scholar, Wildland Resources, Utah State University, Logan, UT. michaela.teich@usu.edu

Healthy, dense forests growing in avalanche terrain reduce the likelihood of avalanche release by inhibiting the formation of continuous weak layers and a homogenous snow stratigraphy. Associated with warming temperatures, bark beetle attacks have increased in higher elevations, which profoundly affects snowpack in mountain forests and may alter the effects of forests in protecting people, settlements and infrastructure against avalanches.

We examined the snowpack under canopies of Engelmann spruce forest stands in the Uinta Mountains in Utah using a snow micro penetrometer (SMP). Repeated SMP measurements were recorded in winters 2015 and 2016 in study plots beneath canopies of recently infested trees, trees 3+-years after spruce beetle infestation, a harvested forest stand, and a non-forested meadow. To quantify changes to snow stratigraphy at our study plots, we applied a new method to match and combine several SMP measurements.
Our results suggest that recently killed trees can still maintain avalanche protection, but the snowpack was consistently more homogeneous in the harvested stand despite small-diameter trees and woody debris being present.

As mountain forests become more prone to mass attacks associated with climate change, changes in snowpack properties needs to be considered for avalanche control, winter backcountry activities, and protection forest management.

I'm holding B.S (2004) and M.Sc. (2006) degrees in Forestry from Technische Universität Dresden, Germany, but already moved for my Master thesis project to the WSL Institute for Snow and Avalanche Research SLF in Davos, Switzerland. I continued working at the SLF as a student intern, research assistant, and later a PhD student in the research group "Mountain ecosystems". I got my Dr. sc. degree from ETH Zurich, Switzerland in 2014 (Dissertation: "Snow avalanches in forested terrain"). I moved to Utah in January 2015 to start a Postdoc with Dr. Mike Jenkins on "Investigating forest-snowpack interactions in relation to avalanche hazard".

Currently, I'm working together with Dr. Jim Lutz and Dr. Sarah Null at USU. We are studying seasonal snowpack in different forest ecosystems including forests that have been recently disturbed by bark beetles and fire to quantify and model snowmelt runoff volume and timing from forest snowpack, which is important to manage water resources sustainably in a changing environment.

Low-severity Fire Impacts Snag Dynamics in an Old-growth Forest: Does Tree Neighborhood Matter? Kendall Becker, PhD Ecology student, Utah State University, Ecology Center and Department of Wildland Resources, Logan, UT. becker.kendall@gmail.com

Disturbance and legacy creation represent a widely referenced but poorly understood phase of forest development. Biological legacies that remain after a disturbance in the form of snags and logs function as structural components that provide habitat, affect snow retention, promote soil development, and influence fire spread. We present the trajectories of 34,246 trees and 4,426 snags before and after a low- to moderate-severity fire burned our 25.6-ha permanent study area in an unlogged, 500-year-old *Abies concolor–Pinus lambertiana* (white fir–sugar pine) forest in Yosemite National Park. Mean pre-fire tree mortality and snag fall rates were 1.6% and 5.4% for *Abies concolor,* and 2.2% and 4.3% for *Pinus lambertiana*; fire-year tree mortality, snag fall, and snag consumption rates were 65.1%, 9.2%, and 29.3% for *A. concolor*, and 55.2%, 11.6%, and 29.1% for *P. lambertiana*. Snag consumption rates increased with decay class, were negatively correlated with diameter for stems in early stages of decay, but were independent of diameter for stems in advanced stages of decay. These results show that low- to moderate-severity fire increases the snag population and shifts snag demography toward smaller, less decayed constituents.

Kendall has a B.S. in Applied Physics from Yale University and an M.S. in Ecosystem Analysis from the University of Washington. Since 2011 she has spent her summers in the Sierra Nevada studying the effects of fire on forests. She is currently pursuing a PhD in Ecology at USU.

A Seedling-based Approach to Aspen Restoration in the Interior West. Alex Howe, MS Ecology student, Wildland Resources, Utah State University, Logan, UT. alex.a.howe@gmail.com

Traditional silvicultural practices to regenerate quaking aspen (*Populus tremuloides*) focus on inducing asexual suckering, but these methods can reduce genetic diversity over time and are limited to existing stands. Planting of nursery-grown aspen seedlings for restoration has proven effective in mined-land reclamation in the boreal forests of Canada, but protocols have yet to be developed for the western US where seedling establishment may be more challenging. Here, results from an ongoing study testing seedling-based aspen restoration in southern Utah will be discussed. Survival during the first two years varied substantially between planting locations, and mortality was dominated by rodent herbivory and early summer drought. Additionally, uneven responses among seedling sources in the nursery suggest further protocol optimization will be necessary for western US aspen. Despite these initial challenges, further refinement of seedling-based aspen restoration techniques in the western US could prove to be a useful supplemental tool for increasing resilience through active management of this keystone species.

Since completing his B.A. in Biology from Macalester College in St. Paul, MN, Alex has worked as a botanist with the BLM in central Utah and western Nevada, as well as with the Forest Service in central Oregon on the Ochoco National Forest. He also served as an agroforestry extension volunteer in Senegal with the Peace Corps for 2 years teaching rural farmers and leading workshops on tree nursery management and planting techniques. He is currently in his final year pursuing his M.S. degree in Forest Ecology at USU.

Perspectives of a Land Manager. Craig Taggart, Environmental Manager, Tercio & Trinchera Ranches, Fort Garland, CO. Craig.Taggart@trincheraranch.com.

A lightening-caused wildfire in 2002 burned through a third of the 22,000 acre Tercio Ranch in Southern Colorado. Restoration efforts included contour felling, chipping/mulching, and aerial seeding to stabilize the steep ground. Subsequent efforts included forest treatments in strategic locations to reduce the potential for further loss. Significant among these was the work done over succeeding years to protect and regenerate aspen. Work on aspen regeneration has continued on the 172,000 acre Trinchera Ranch, which itself suffered a 14,000 acre wildfire in 2006. That work now includes experimentation on opening exclosures to allow limited ungulate access and a cooperative study with USU to better understand the aspen-elk dynamic. This presentation will address a variety of post-fire restoration techniques, forest treatments, and aspen management practices that have been used on these two ranches over the past 13 years, with observations on both the successes and the "learning opportunities".

Craig comes from a diverse educational background (degrees in zoology and landscape architecture) and a broad history of work experience, including three years with the BLM, 25 years consulting as an environmental planner, and the last 14 years in private land management. Craig serves as the Environmental Manager for the 172,000 acre Trinchera Ranch in southern Colorado. This diversity of experience has led to an appreciation of the complex interactions at play in western land management and a creative, solutions-based approach to addressing them. Craig also serves on the board of the Western Landowners Alliance.

Impacts of Low-severity Fire and Fuel Treatments on Ponderosa Pine Resistance to Mountain Pine Beetle. Sharon Hood, Research Ecologist, Rocky Mountain Research Station, United States Forest Service, Missoula, MT. sharonmhood@fs.fed.us.

Fire frequency in low-elevation coniferous forests in western North America has greatly declined since the late 1800s. In many areas, this has increased tree density and the proportion of shade-tolerant species, reduced resource availability, and increased forest susceptibility to forest insect pests and high-severity wildfire. We investigated how low-intensity fire affects tree defenses and whether fuel treatments in ponderosa pine forests impact resistance to a mountain pine beetle outbreak using a combination of sampling in natural stands for which we had multi-century fire histories and an experimental design of four thinning and burning treatments. Fire stimulated tree resin duct defenses and areas with long-term fire exclusion showed lower defenses. Trees surviving mountain pine beetle attack produced larger and more resin ducts than trees that died from beetle attack. In the experimental treatments, ponderosa pine mortality from the insect outbreak was 50% in the denser, untreated control and 39% in the burn-only, compared to almost no mortality in the thin-only and thin-burn treatments. This study suggests that fuel and restoration treatments designed to reduce fire intensity in fire-dependent ponderosa pine forests can also function to increase resistance to mountain pine beetle outbreaks.

Sharon Hood is a Research Ecologist for the US Forest Service, Rocky Mountain Research Station's Fire, Fuel, and Smoke Science Program in Missoula, MT. She studies how fire impacts trees and forest dynamics. Her research to date has focused on fire-induced tree mortality, fire-bark beetles interactions, and fuel treatments. Sharon received a PhD from the University of Montana in Organismal Biology and Ecology, a MS from Virginia Tech in Forest Biology, and a BS from Mississippi State University in Forest Management.

Clearing the Way: Revealing and Removing Hidden Barriers to Private Land Forest Restoration. Leslie Allison, Executive Director, Western Landowners Alliance, Santa Fe, NM. lallison@westernlandowners.org

Most public policy discussions on forest restoration tend to focus on federal land issues. However, there are approximately 109 million acres of privately owned forests in the western U.S., many of them in the wildland-

urban interface and many in important watersheds. Yet while virtually every state and county land use plan calls for healthy, well-managed forests and watersheds, landowners seeking to restore their forests often face a maze of obstacles. Many of these are not immediately visible to the public or to policy makers but can create significant impediments to management and restoration. One decades-long journey to restore a forested watershed reveals the many hidden challenges landowners face and how state and local governments could help clear the path.

Lesli is a founding member and executive director of the Western Landowners Alliance, an organization of landowners working to advance the ecological health and economic prosperity of working lands in the American West. She is also a founding member of the Chama Peak Land Alliance. Through both organizations, Lesli has worked extensively with private landowners and multiple stakeholders to advance conservation, sustain working lands and support rural communities.

Prior to her work with these organizations, Lesli managed a large ranch the southern San Juan Mountains of Colorado. During her 16-year tenure, Lesli implemented progressive conservation management through award-winning programs in restoration forestry, prescribed fire, grazing, stream restoration, hunting and wildlife management, and scientific research and monitoring. Lesli holds a B.A. from Columbia University and an M.A. from St. John's College, Santa Fe.

Increasing the Pace and Scale of Forest Restoration and the Breadth and Depth of Forest Restoration Partnerships in Idaho. John Robison, Lemhi Forest Restoration Group and Idaho Forest Restoration Partnership, Salmon, ID. jrobison@idahoconservation.org.

In 2012, high winds drove the Mustang Fire out of the Selway-Bitterroot Wilderness and toward Gibbonsville, Idaho. When the fire hit the Hughes Creek drainage, it encountered an open stand of large Ponderosa pine that had been recently thinned. The treated area provided safe access to the fireline, helped protect structures, and provided an opportunity for back burning and aerial ignitions. The fire dropped to the ground and no structures were harmed.

The Hughes Creek restoration project was the first commercial timber project in the area that had not been appealed in over a decade. A local collaborative group, the Lemhi Forest Restoration Collaborative Group, played a key role in developing this project. Since then, this collaborative has helped craft several other landscape scale projects, including one in an Inventoried Roadless Area.

This is not an isolated story. Several other collaborative groups have formed in Idaho to develop forest restoration projects and shepherd them through implementation. The Idaho Forest Restoration Partnership (IFRP) is an umbrella group which supports these different collaboratives and helps them tell their stories. John Robison is a member of both the Lemhi group and the IFRP and will discuss the trends in forest restoration in Idaho.

John Robison is the Idaho Conservation League's Public Lands Director. John has been working on forest restoration issues for the Idaho Conservation League since 2002. John has served on the Lemhi Forest Restoration Group, the Payette Forest Coalition and the Idaho Forest Restoration Partnership. John first came to Idaho in 1991 on an 11-day kayaking and fishing trip. John has a master's degree in botany from the University of Vermont's Field Naturalist Program and a BA in biology from Bowdoin College. Before moving to Idaho in 2001, he ran a field science program for the Canyonlands Field Institute in Moab Utah and taught forest ecology at the Teton Science School. When not working to protect and restore Idaho's public lands and rivers, he is out enjoying them. He lives in Boise with his wife and twin daughters.

Application of International Standards for Ecological Restoration to the Western US. Dr. Cara R. Nelson, Associate Professor of Restoration Ecology, University of Montana, Missoula, MT. cara.nelson@umontana.edu

With increasing investment in ecological restoration activities, there is a need for improving understanding about the definition and goals of ecological restoration as well as related restorative activities. There have been several recent advances in the field, including the development and adoption of international standards for ecological restoration. These standards include guidance for using restoration interventions that are consistent with two aspects of ecosystems: they are inherently dynamic and complex. Thus the repair of degraded ecosystems must include goals that both account for and allow ecosystem change and have broad goals in terms of ecosystem structure, composition, and process. This presentation will discuss the relevance of international standards to current forest restoration activities in the western United States, as well as current initiatives to improve the quality of restoration practice.

Dr. Cara R. Nelson is an Associate Professor of Restoration Ecology in the Ecosystem and Conservation Sciences Department at University of Montana (USA), a past Chair of the international Society for Ecological Restoration and the current Chair of the Ecological Restoration Thematic Group for IUCN's Commission on Ecosystem Management. Her research focuses on increasing knowledge about ecological processes and their application to restoration of terrestrial ecosystems. Specifically, she and her students study ecosystem responses to abiotic and biotic disturbance and the efficacy and ecological impacts of ecological restoration. Cara teaches undergraduate and graduate courses in ecological restoration and restoration ecology, as well as courses in sampling methods for assessing the efficacy and effects of management activities. She is also active in efforts to increase awareness among educators and decision makers about knowledge and training needed to improve the quality of restoration practice.

Keynote & QCNR Seminar Speaker: The Ongoing Promise & Emerging Perils of Western Forest Restoration in a Global Change World. Craig Allen, Research Ecologist & Station Leader, U.S. Geological Survey, New Mexico Landscapes Field Station, (Fort Collins Science Center), Los Alamos, NM. craig_allen@usgs.gov

Craig D. Allen has worked as a place-based field ecologist for the U.S. Dept. of Interior since 1986, co-located with land managers at Bandelier National Monument in the Jemez Mountains of northern New Mexico – a landscape that has been subject to multiple ecological disturbances (significant drought, forest dieback, fires, floods) since 1996. Craig conducts research on the ecology and environmental history of Southwestern US landscapes, and the responses of Western mountain ecosystems and forests globally to climate; he also provides technical support in the areas of ecosystem management and restoration to diverse land management agencies in the region. Recent and ongoing research activities, involving diverse collaborations, include: determination of global patterns, trends, and drivers of climate-induced tree mortality and forest die-off; forest and fire ecology in Southwest US landscapes; ecological restoration of Southwestern forests and woodlands; and developing long-term ecological monitoring networks in New Mexico. https://www.usgs.gov/staff-profiles/craig-d-allen

Poster Abstracts

In alphabetical order by presenting author's last name

Gambel Oak Ecology and Management in the Southern Rockies: An overview of current knowledge, climate models, and future research

Gloria J. Edwards[1], Kyle Rodman[2], Merrill Kaufmann[3]
[1]Southern Rockies Fire Science Network Program Coordinator, Department of Forest and Rangeland Stewardship, Colorado State University. Fort Collins, CO. gloria.edwards@colostate.edu
[2]PhD Candidate, Department of Geography, University of Colorado, Boulder, CO.
[3]Research Forest Ecologist (Emeritus), USDA Forest Service, Rocky Mountain Research Stateion, Fort Collins, CO.

Gambel oak (*Quercus gambelii*) is one of the most widespread mountain shrub species through the Central Rockies region. Although it is ubiquitous, surprisingly little research has been devoted in Colorado and Utah to understanding Gambel oak ecology, habitat management, or the dynamics of fire behavior in pure Gambel oak or mixed mountain shrub stands. The need for in-depth research on Gambel oak as well as comprehensive understanding of current management strategies is underscored by changes in climate, increase in drought, changing forest conditions and health, and the dramatic spread of homes and structures in the wildland-urban interface in Gambel oak habitat. What are the ecological similarities and differences in various Gambel oak habitat compositions? What do we know about fire behavior in Gambel oak? What are the challenges and obstacles in landscape management? How do we successfully manage Gambel oak in the wildland-urban interface? This poster presents current status of knowledge as well as preliminary results of a Graduate Research Innovation study on understanding the factors that lead to successful seedling establishment in post-fire environments in the Southern Rockies and how these factors vary across the landscape, helping to understand potential responses to future fire events. https://www.frames.gov/documents/catalog/kaufmann_et_al_2016_srfsn-pub-2016-1_gambel-oak-ecology-management-southern-rockies.pdf

Guidelines for Aspen Restoration in Utah and the Intermountain West

Stanley G. Kitchen[1], Patrick N. Behrens[2], Sherel K. Goodrich[3], Ashley Green[4], John Guyon[2], Mary O'Brien[5] and David Tart[2]
[1]USDA Forest Service, Rocky Mountain Research Station, Provo, UT.
[2]USDA Forest Service, Intermountain Region, Ogden, UT.
[3]USDA Forest Service, Ashley National Forest (retired), Vernal, UT.
[4]Utah Division of Wildlife Resources, Salt Lake City, UT.
[5]Grand Canyon Trust, Castle Valley, UT.

As highly productive and biologically diverse communities, healthy quaking aspen (*Populus tremuloides*; hereafter aspen) forests provide a wide range of ecosystem services across western North America. Western aspen decline during the last century has been attributed to multiple causes and their interactions including: altered fire regimes, drought, excessive use by domestic and wild ungulates, and conifer encroachment. Today's managers need science-based guidance to develop and implement strategies and practices to restore structure, processes and resilience to the full range of aspen functional types across multiple spatial scales. We propose a step-by-step decision process for aspen restoration including: 1) assessment of aspen condition, 2) identification of problematic conditions, 3) determination of causal factors for decline, 4) selection of appropriate response options, 5) monitoring for improvement, and 6) assessment and adaptation. We encourage the establishment and use of reference areas in which the full range of natural environmental conditions and ecosystem processes associated with aspen can be observed and quantified. These guidelines provide a road map for decision makers to adaptively manage aspen in a time of increasing environmental stress and in anticipation of an uncertain future.

(notes)

(notes)

Thank you to our Sponsors:
USU Cooperative Extension, USU Forestry Extension, USU Quinney College of Natural Resources, USU Department of Wildland Resources, USU Ecology Center, USDA Forest Service State & Private Forestry, Western Aspen Alliance, Utah Biomass Resources Group, Society for Ecological Restoration (SER), Great Basin chapter, Great Basin Fire Science Exchange, Southern Rockies Fire Science Network.

UtahStateUniversity
FORESTRY EXTENSION

UtahStateUniversity
DEPARTMENT OF WILDLAND RESOURCES

FOREST SERVICE
US
DEPARTMENT OF AGRICULTURE

S.J. & JESSIE E. QUINNEY
COLLEGE of
NATURAL RESOURCES
UtahStateUniversity

GREAT BASIN
FIRE SCIENCE
EXCHANGE

SER
SOCIETY FOR
ECOLOGICAL
RESTORATION
GREAT BASIN

Western
Aspen
Alliance

SOUTHERN ROCKIES
FIRE SCIENCE
NETWORK

UtahState
University
ECOLOGY CENTER

EXTENSION
UtahStateUniversity

UTAH
BIOMASS
RESOURCES GROUP