ABSTRACTS OF INDIVIDUAL PRESENTATIONS

Abstracts for individual presentations are listed alphabetically, by presenting author's last name. Abstracts appear unmodified, as submitted by the corresponding authors. The number appearing before the name corresponds to the placement of the presentation in the daily schedule.

263 **Allred, Brady** (Oklahoma State University), brady.allred@okstate.edu

Brady Allred (Oklahoma State University), Samuel Fuhlendorf (Oklahoma State University), David Engle (Oklahoma State University), Dwayne Elmore (Oklahoma State University)

Ungulate response to fire establishes the fire-grazing interaction

The interactions between fire and grazing are widespread throughout fire-dependent landscapes. The utilization of burned areas by grazing animals establishes the fire-grazing interaction, but the preference for recently burned areas relative to other influences (water, topography, etc.) is poorly understood. We determined the strength of the fire-grazing interaction by quantifying the influence of fire on ungulate site selection. We compared the preference for recently burned patches relative to the influence of other environmental factors that contribute to site selection. We also examined forage quality and quantity as mechanisms of site selection. Ungulates preferred recently burned areas and avoided areas with greater time since fire, regardless of the size of landscape, herbivore species, or proportion of area burned. Forage quality was inversely related to time since fire, while forage quantity was positively related. Fire is an important component of large herbivore behavior with a strong influence on site selection. The preference for burned areas drives the fire-grazing interaction. The magnitude of this preference can be used to determine the strength of the fire-grazing interaction within an ecosystem. The fire-grazing interaction is an ecosystem process that supersedes fire and grazing as separate factors, shaping grassland landscapes.

303 **Amato, Victoria** (SWCA Environmental Consultants), vamato@swca.com

Victoria Amato (SWCA Environmental Consultants), David Lightfoot (SWCA Environmental Cosultants), Cody Stropki (SWCA Environmental Consultants), Michael Pease (Central Washington University)

Relationships between tree stand density and fire severity as measured by the Composite Burn Index (CBI) following a Southwestern ponderosa pine forest wildfire.

In April 2008 the Trigo Fire burned 5,548 hectares (13,709 acres) of the Manzano Mountains in central New Mexico. The fire burned with mixed severity through ponderosa pine (pinus ponderosa) and mixed conifer stands on the Cibola National Forest and Grasslands and private lands. The burned area exhibited a spectrum of stand densities enabling this research to quantify the relationship between tree density and burn severity utilizing the Composite Burn Index (CBI) method of burn severity classification. Across 90 CBI plots, high tree density was strongly associated with high levels of burn severity. The CBI method allows classification of burn severity to a range of forest strata per plot; upper canopy tree mortality and duff consumption, measures of burn severity to the overstory and understory strata, are

just two examples of attributes that recorded higher severity in plots with higher numbers of trees per acre. Since the CBI approach is designed for rapid on-the-ground assessments, to compliment this procedure we also tested a rapid ocular classification of stand density to determine its accuracy for land managers. This ocular assessment correlated well with quantitative measurements of tree density.

255 **Anderson, R. Scott** (Northern Arizona University), Scott.Anderson@nau.edu

R. Scott Anderson (Northern Arizona University), Craig D. Allen (US Geological Survey)

Recent expansion of oak in the southern Rocky Mountains: Insights from paleoecology

Gambel oak (Quercus gambelii) is a local dominant woodland species in the southern Rocky Mountains of southern Colorado and northern New Mexico. However, little is known about the paleoecology of the species over the last few thousands of years. Recent analysis of a number of sediment records taken from small lakes and wetlands in the region, initiated in order to reconstruct long-term vegetation, climate and disturbance histories, suggests a substantial increase in the importance of the species since the late 19th century, a period of great environmental change in the Southwest. Forces affecting change during this time period include climatic shifts associated with the end of a multi-centennial cool period called the Little Ice Age (LIA), the widespread introduction of grazing herbivores, and the regional initiation of a policy of fire control and suppression. Our analysis of a detailed pollen and charcoal record from Laguna Tonito, a small pond at 2,569 m elevation in northern New Mexico, shows that a mixed conifer forest assemblage with little oak was rapidly converted to an oak-conifer woodland subsequent to the last documented local fire. A comparison to other paleoecological records in the region, covering the past thousands of years, suggests that such high percentages of oak pollen only occurred at those locations since the late 19th century as well. These data provide additional information important for comparing pre- and post-settlement forest and woodland characteristics.

265 **Augustine, David** (USDA-ARS), David.Augustine@ars.usda.gov

David Augustine (USDA-ARS), Justin Derner (USDA-ARS)

Patch burn grazing management in semiarid shortgrass steppe

Integrated fire and grazing management can potentially generate desirable habitat mosaics for native birds in rangeland ecosystems. We studied patch burn grazing in shortgrass steppe (northeastern Colorado), comparing unburned pastures with pastures where 25% of the area was burned each year. All pastures were grazed at the same moderate stocking rate, and burns were implemented in October or November each year. Burns removed >95% of standing dead biomass and reduced vegetation visual obstruction in mid-June by 48 - 53% but did not influence herbaceous plant production. When vegetation on burns was growing rapidly and unburned areas retained significant standing dead biomass, cattle preferentially grazed on burns. At other times during the growing season, cattle distribution was influenced by topography, but cattle neither avoided nor selected burns. Furthermore, patch burns did not negatively affect cattle weight gains. Pronghorn densities were 21 - 38 times

greater on burned versus unburned pastures in winter, and 3 - 13 times greater in spring. Pronghorn consumption of burned prickly pear cactus (Opuntia polyacantha) during winter significantly reduced cactus density. Grassland birds showed strong responses to patch burn grazing management. Horned Lark (Eremophila alpestris) abundance was negatively correlated with vegetation visual obstruction while lark buntings (Calamospiza melanocorys) were positively correlated. Mountain plovers (Charadrius montanus) only occurred on current-year burned areas. Findings indicate patch burn grazing management can assist in sustaining diversity of semiarid grassland birds. However, fire-grazing interactions are weaker in semiarid versus mesic grasslands, and in the shortgrass steppe operate primarily through pronghorn-induced effects on burned cactus during winter.

334 **Bailey, Jeremy** (The Nature Conservancy), jeremy_bailey@tnc.org

Jeremy Bailey (The Nature Conservancy)

Prescribed Fire Training Events as a Tool for Increasing Local Capacity and Building a Workforce

A barrier often identified as limiting the implementation of prescribed fire is a shortage of qualified fire practitioners during burn windows. In many places around the country and world, one solution is a collaborative approach perhaps best described as neighbors helping neighbors. I will share lessons learned over the past four years of developing experiential learning events in which interagency and international prescribed fire crews work with local landowners to temporarily increase local capacity for burning while engaging in training that advances their professional qualifications and learning about the ecological and socio-economic factors that drive fire management activities and policy. The discussion will cover training events that integrate municipal and volunteer fire departments, ranchers, federal and state fire management agencies, chapters of Student Association for Fire Ecology, non-governmental organizations including The Nature Conservancy and Pheasants Forever, and international fire practitioners from Spain and Latin America; it will include some of the challenges that were addressed to successfully complete these events (e.g. integrating NWCG and private practitioners, planning and logistics, burn plans). Outcomes from the events I will discuss include over 60,000 acres treated with prescribed fire, completed evaluations for position task books, learning between fire cultures (e.g. private vs. public lands burners; between regions or countries), sharing best practices related to integrated fire management, and—perhaps most importantly—the development of a network of practitioners who will have the contacts and experience to collaborate on fire management moving forward.

252 **Baker, William** (University of Wyoming), bakerwl@uwyo.edu

William Baker (University of Wyoming), Mark Williams (University of Wyoming)

Spatially detailed reconstruction of historical landscapes using the General Land Office surveys

Restoration reference information is often from reconstruction studies focused at modest spatial scales, but these provide an incomplete sample of historical structure across landscapes. A solution is to use

more spatially extensive historical data, such as the General Land Office (GLO) survey notes, to reconstruct large landscapes. However, it was hypothesized that GLO surveyors sampled in a biased manner, and survey reconstruction procedures are inaccurate. Here we tested the bias and accuracy of survey data and developed new methods to more accurately reconstruct forest structure. We used three geographically diverse ponderosa-pine landscapes in Arizona, Oregon, and Colorado for testing. We relocated 384 original section corners, where we sampled modern forests using both the methods of the surveyors and more accurate plot methods. To analyze potential selection bias and surveyor error, tree measurements in the survey notes were compared to field measurements we made of surviving historical trees (n=812). We found that surveyors sampled without bias 95-98% of the time and other errors were low. We developed a new density estimator for GLO data that uses the Voronoi area of a tree. Using this new method, we were able to estimate tree density within about 20% of the true value and basal area within 21% of the true value, depending on spatial resolution. The true and estimated composition and diameter-class distributions were 90% and 85% similar, respectively. Using these new methods, forest attributes can be reconstructed across large landscapes with surprising accuracy.

314 **Bates, Rita** (New Mexico Environment Department), rita.bates@state.nm.us

Rita Bates (New Mexico Environment Department)

Panel Discussion on New Mexico 2011 Smoke Response

In New Mexico, the future of smoke management in the human environment and the tools being developed to increase efficiency and capacity are being shaped by past experiences of the 2011 wildfire season. Building a solid smoke management tool box, including external & internal communications, to address smoke issues is a priority. A question and answer session, that is framed around previous presentations about the 2011 Fire Season in Arizona & New Mexico and the interagency coordinated response to the smoke impacts, will give the participants of the SW Fire Ecology conference an opportunity to engage directly with those in New Mexico who dealt with some new smoke experiences during the past fire season. The benefits of having a panel after a presentation are two-fold: 1. Audience participation resulting in increased dynamic interactions on the subject of smoke management and wildfires. 2. Affording the opportunity for greater in depth discussion on the unprecedented response. Agencies on this panel may include the following: New Mexico Environment Department /Air Quality Bureau New Mexico Department of Health Southwest Coordination Center/Predictive Services Pacific Northwest Research Station-Air Fire Team National Weather Service Albuquerque, NM City of Albuquerque United States Forest Service Bureau of Land Management Wildfire Decision Support System/ representative New Mexico State Climatologist

208 **Battaglia, Mike** (USFS Rocky Mountain Research Station), mbattaglia@fs.fed.us

Mike Battaglia (USFS Rocky Mountain Research Station), Katherine Cueno (Colorado State University), Chuck Rhoades (USFS Rocky Mountain Research Station), Paula Fornwalt (USFS Rocky Mountain Research Station), Monique Rocca (Colorado State University)

Tree seedling germination and establishment in masticated forest stands, Colorado

In recent years, fire managers in the western U.S. have increased their use of mastication treatments – the on-site disposal of shrubs and small-diameter trees through chipping and shredding. Mastication is a relatively untested management practice that is now known to alter physical conditions of the forest floor over the short-term. The mulched woody material increases both the load and continuity of surface fuels, and creates a new forest floor layer that may act as a physical barrier to tree germination; however, it also helps to conserve soil moisture and moderate summer soil temperatures, thereby favoring germination. We established 18 pairs of untreated and masticated sites (treated between 2004 and 2006) across four forest types in Colorado. We hypothesize that mulch-free microsites within the masticated areas will provide favorable conditions for tree seedling germination and establishment due to the moderated soil moisture environment from adjacent mulch combined with the lack of a physical woody barrier. In summer 2011, we will inventory seedlings and measure the substrate cover and mulch depth in the surrounding 1 square foot quadrats to examine the influence of environmental factors on seedling occurrence. This information will be compared to substrate cover in randomly selected quadrats to determine if seedlings are located preferentially in particular conditions or randomly dispersed within the plots. Results from this study will help clarify the mechanisms that favor and discourage tree seedling germination and establishment in masticated areas and will provide management recommendations that emphasize how best to distribute mulch across treated sites.

203 **Beauprez, Grant** (New Mexico Department of Game and Fish), Grant.Beauprez@state.nm.us

Grant Beauprez (New Mexico Department of Game and Fish)

Management of lesser prairie-chicken habitat with fire

Little is known of the effects of fire on lesser prairie-chicken (Tympanuchus pallidicinctus) habitat in shinnery oak (Quercus havardii) communities. Prescribed fire is an effective tool to increase abundance of growing-season forbs and sedges, winter forbs, and grasshoppers associated with quality foraging and brooding habitat. Nesting habitat and thermal and escape cover are impacted negatively by fire, particularly spring fire, due to a reduction in overhead and horizontal cover and reduced abundance of important nesting grasses. Landowners should consider using prescribed fire on 20 percent to 30 percent of their management unit each year. The entire area should be burned within a 3- to 5-year period. This will provide both quality nesting cover and early successional brood habitat. Burning more than 50 percent of the area in one year may not provide sufficient cover for nesting and escape from predators. It is very important to retain unburned areas of dense grass within one mile of the leks. A 2- to 3-year recovery period is recommended for nesting habitat following burning. Negative impacts of fire on nesting habitat and thermal and escape cover can be reduced by burning in seasons other than spring, decreasing burn size, and interspersing burned and unburned areas. Fire is an important tool

that can be used to prevent woody species from invading native rangelands. The frequency, size, and pattern of burning or grazing, and their relationship to each other (fire-grazing interaction) must be considered and managed to meet the year-round habitat requirements of the lesser prairie-chicken.

267 **Becerra, Terrie** (Oklahoma State University), terrie.becerra@okstate.edu

Terrie Becerra (Oklahoma State University), Dave Engle (Oklahoma State University), Dwayne Elmore (Oklahoma State University), Sam Fuhlendorf (Oklahoma State University)

Attitudes and Preferences about Heterogeneous Landscapes

The long-time management paradigm for rangeland landscapes has fostered uniformity and homogeneity. It is unclear whether this penchant for uniformity is important for grassland production or whether it is a social construct that has gone unchallenged. To better understand this focus on homogeneity despite acknowledgement that heterogeneity represents greater environmental health, we surveyed three stakeholder groups to evaluate their attitude and perception of heterogeneous landscapes. As part of the survey methodology, participants were presented a series of photographs and diagrammatic images and asked to rate them on a preference scale of 1 (dislike) to 5 (like very much). The photos represented grasslands that ranged from highly homogeneous to highly heterogeneous. Quantitative pattern analysis was conducted in which edge was determined to be a proxy for heterogeneity. Based on edge measurements the photos were ranked in a scale from homogeneous to heterogeneous. Photo preference frequencies for each photo were compiled into a composite preference score. Photo preferences were compared to edge, or homo-heterogeneity scores to ascertain if a relationship exists between preference and hetero- homogeneity. Comparisons of the preference relationship were made across the three stakeholder groups. Preliminary results indicate small preference differences among the three sub-populations. All three groups displayed a trend for decreasing preference as heterogeneity increased. Preference and perception play a role in land management decision-making. Successfully introducing alternative land management practices that foster heterogeneity may require a greater understanding of cultural factors and social constructs affecting management practice decision-making.

115 **Beierle, Micah-John** (Texas Tech University), micah-john.beierle@ttu.edu

Micah-John Beierle (Texas Tech University), Sandra Rideout-Hanzak (Texas A&M University-Kingsville), David B. Wester (Texas A&M University-Kingsville), Carlton M. Britton (Texas Tech University)

Recent Evolution in Distribution of Wildfires in Texas Grasslands

From 1985 through 2011 there have been over 80,000 wildfires reported in counties of Texas where the primary fuel is grasses. We examined wildfire frequency and size throughout the grassland regions of the state during this time. Although some counties probably did not report all small, easily-contained wildfires these data maintained by Texas Forest Service are the best available data. We used non-parametric analyses to examine wildfire occurrence and size by season. Our results indicate that

wildfire distribution has changed across the grassland regions of Texas over the past 26 years. Wildfires have become more common, and significant increases in wildfire size occurred as early as 1988. The past year, 2011, had exceptional wildfire occurrences with approximately 29,540 wildfires impacting over 1.6 million ha by mid-November. Increase in wildfire size and frequency indicates the need for a better understanding of characteristics which influence wildfire ignitions and sustainability.

277 **Belote, Travis** (The Wilderness Society), travis_belote@tws.org

Travis Belote (The Wilderness Society), Gregory Aplet (The Wilderness Society)

Collaborative adaptive management: for whom, of what, and how?

Adaptive management (AM) has been proposed as the preferred method of learning about ecosystems and adjusting actions to meet natural resource and conservation objectives. Collaborative adaptive management (CAM) builds on traditional models of AM by including diverse stakeholders in decision making (i.e., “for whom?”). Challenges to effective CAM programs include unclear objectives at relevant scales (i.e., “of what?”), potential tradeoffs between objectives, lack of clear monitoring goals and inference concerning management impacts, lack of formal mechanisms of information exchange and decision making processes (i.e., “how?”), and the lack of humility, transparency, and trust between members of a collaborative. In the Southwestern Crown of the Continent (SWCC), Montana, a diverse group of stakeholders has organized around the Collaborative Forest Landscape Restoration Program (CFLRP) determined to help protect communities from fire, restore terrestrial and aquatic ecosystems, and prepare communities and ecosystems for climate change, all while facilitating job-creation in local economies. Here, we discuss the challenges of implementing CAM in the context of the SWCC and other ecosystems where we have worked and provide recommended solutions to these challenges. Possible solutions to CAM challenges include: (1) clarifying landscape objectives and acknowledging uncertainty by designing management treatments as experiments to facilitate strong inference at local and landscape scales; (2) acknowledging that different kinds of monitoring should be used to address very different kinds of questions; (3) developing management triggers at appropriate scales that lead to a new approach; (4) including successful CAM strategies in performance measures for managers; (5) and fostering relationships between researchers and managers through regular meetings and field visits.

291 **Betancourt, Julio** (U.S. Geological Survey), jlbetanc@usgs.gov

Julio Betancourt (U.S. Geological Survey)

Wildland Fire in a Changing World: A Personal Retrospective

In October 1997, I attended a conference in Park City, Utah on the Future of Wildland Fire Research. Billed as “an experiment, a beginning,” this seminal workshop developed action plans to create an interdepartmental competitive grants program, a coordinated response to managing fire regimes for ecosystem health, and a framework for management and research collaboration that would integrate the social sciences and assess ecological risk. Here, I will draw on my own personal journey over the past

15 years to (1) identify where we may have succeeded or failed; (2) speculate about unasked questions and hidden surprises; and (3) offer a few ideas for novel action plans, and a way to implement them, to help anticipate and manage wildland fire in a changing and nonstationary world.

133 **Bigio, Erica** (University of Arizona), ebigio@email.arizona.edu

Tom Swetnam (University of Arizona), Chris Baisan (University of Arizona)

Fire History of the Western San Juan Mountains: Results from Tree-Ring and Alluvial Sediment methods

In 2002, the Missionary Ridge Fire burned several tributary watersheds along three main valleys of the western San Juan Mountains near Durango, Colorado. Post-fire debris flows and flooding incised tributary channels and alluvial fan deposits and created exposures of older alluvial sediment deposits. When sediment deposits contain charcoal, they may represent past fire events in each contributing basin. Alluvial sediments were sampled from several exposures within the upland tributary channels and alluvial fans. Low-severity fire events were represented by fine-grained deposits, while high-severity fires were represented by charcoal-rich debris flow deposits. The ages of possible fire-related sedimentation events preserved within the upland tributary channels ranged between 800 – 2,500 14C years before present with increased sedimentation occurring around 800 – 1,100 14C years bp. On the alluvial fans at the watershed outlet, individual deposits ranged between 300 – 2,500 14C years bp, though ages were typically less than 1,000 14C years bp. The range of sediment characteristics represented both low and high severity fires over the study period and the dominance of one fire regime is not evident. Tree-ring material was collected from three tributary watersheds and is composed of both fire-scarred trees and age-structure data. Fire-scar dates indicate that low-severity fires occurred approximately every 20 – 30 years on south-facing slopes, and the location of fire-scarred trees suggests that some north-facing slopes may have experienced high-severity fires within the past 300 years. Age-structure data shows continuous regeneration over 500 years on south-facing slopes with recent, even-aged stand structure on some north-facing slopes.

272 **Binkley, Dan** (Colorado State University), dan@cnr.colostate.edu

Dan Binkley (Colorado State University)

Assessing restoration success across scales of space and time

Land managers always approach decisions with good intentions, but history has shown that good outcomes may not result from good intentions. Classic monitoring for success in forest management typically includes determining whether a prescription was implemented according to specifications. Additional measurements in some cases examine whether the specified treatment led to the desired outcomes, and if any unintended consequences appeared. This approach to monitoring can be challenging, especially given that restoration goals often welcome variations in forest structures and processes. Collaborative landscape-scale forest restoration adds another dimension to assessing

outcomes: how have treatments altered ecological interactions across portions of the landscape? Landscape-scale connections are particularly important for fire behavior, ecosystem response to fire, wildlife habitat, and aesthetic values. Restoration programs at these scales also entail goals that span periods of time that exceed the short-term tenure of most land managers (and citizens). These perspectives show that restoration programs designed for diverse landscapes need to be coupled with creative, flexible schemes for determining success. In this presentation, we'll develop an approach that contrasts with classic efforts that focused on designing desired future conditions; rather than assess progress toward desired conditions, we'll explore assessing how far a landscape has moved away from undesirable conditions. The distinction may seem subtle, but these contrasting perspectives may lead to very different restoration designs and assessments.

268 **Blackwell, Reggie** (USDA - NRCS), reggie.blackwell@ftw.usda.gov

Reggie Blackwell (USDA - NRCS)

Patch Burn Grazing applied within NRCS Conservation Practices

Patch Burn Grazing remains a novel practice within NRCS conservation planning and implementation on private land ownership. However, the application of patch burn grazing is increasing, and considerations of its use have expanded beyond the traditional area of the southern Great Plains. The two primary management Conservation Practices utilized within NRCS resource planning include Prescribed Grazing (CP 528) and Upland Wildlife Habitat Management (CP 645). Patch burn grazing can be incorporated within both of these management practices, both singularly or in coordination of the two practices together. The actual prescribed fire application can be specifically addressed within the NRCS Conservation Practice of Prescribed Burning (CP 338) and supported by the Conservation Practice of Firebreak establishment (CP 394). Applications of patch burn grazing are described for a range of resource management purposes as well as numerous state locations.

201 **Block, William** (US Forest Service), wblock@fs.fed.us

William Block (US Forest Service)

Fire Effects on Mexican Spotted Owls: Is the Sky Really Falling?

The Mexican spotted owl was listed in 1993 as a threatened species under the Endangered Species Act. The primary reasons for the listing were timber harvest practices thought to be deleterious to the owl and the lack of regulatory mechanisms to moderate such practices. The ensuing recovery plan, distributed in 1995, highlighted the threat of stand-placing wildfire as a potential threat to recovery of the owl. Subsequently, the recent 2011 draft revision to this recovery plan placed even greater emphasis on fire by indicating that it was the primary threat to the owl. Since the 1995, a number of large wildfires have burned in the Southwest including, but not limited to, Cerro Grande, Rodeo-Chedeski, Horseshoe 2, and Wallow. These fires burned hundreds of thousands of forested hectares and the presumption by many is that they caused widespread destruction of owl habitat. Whether or

not this is the case is certainly subject of debate. We know that owls evolved with fire, although historical fire regimes differed from those we experience today. We have evidence that in the short term owls continue to occupy burned territories, suggesting that they can tolerate fire to some degree. They key questions, however, are do contemporary fires lead to pervasive territory abandonment and long-term population reductions? Lacking the answers to these questions, managers and the public are left to speculation and debate, and the long-term viability of the owl remains unknown.

279 **Briggs, Jennifer** (US Geological Survey), jsbriggs@usgs.gov

Jennifer Briggs (US Geological Survey), Paula Fornwalt (US Forest Service), Jonas Feinstein (US Department of Agriculture), Tony Cheng (Colorado State University), Craig Hansen (US Fish and Wildlife Service), Paige Lewis (The Nature Conservancy), Sara Mayben and Hal Gibbs (US Forest Service), Greg Aplet (The Wilderness Society)

Collaborative, multi-party monitoring of restoration treatments in ponderosa pine forests of Colorado's Front Range

In 2010, Colorado Front Range National Forests were awarded a Collaborative Forest Landscape Restoration (CFLR) grant to facilitate the implementation of restoration treatments across 32,000 acres of ponderosa pine-dominated forests. A multi-party monitoring plan was developed in 2010-11 by the Front Range Roundtable, an interagency collaborative with representation from 50+ stakeholder groups, to assess the effectiveness of CFLR treatments. To supplement the limited monitoring budget, Roundtable members successfully applied for funding from the Southern Rockies Landscape Conservation Cooperative in May 2011. We used this funding to expand the scope of the CFLR monitoring effort in 5 key ways: (1) to conduct monitoring in restoration treatments implemented on partner agency lands; (2) to conduct monitoring in adjacent areas not planned for treatment (controls); (3) to evaluate changes in within-stand structural heterogeneity due to treatments; (4) to measure the use of treated areas by a diverse suite of wildlife species; and (5) to investigate the effects of treatments on understory plant communities. In the summer of 2011, we collected data on 79 plots and transects divided among 8 treatment units and 8 nearby control areas across the Front Range. When possible, our plot locations overlapped with previously established CFLR monitoring plots. We will re-survey all plots following treatment in 2012, and at 1-5 yr intervals thereafter. Our results will be used to quantify short-term treatment effects, to help refine the long-term CFLR monitoring strategy, and to inform the adaptive management process for future treatment planning.

141 **Brooks, Matt** (U.S. Geoological Survey), matt_brooks@usgs.gov

Matt Brooks (U.S. Geological Survey), Randy McKinley (U.S. Geological Survey), Robert Klinger (U.S. Geological Survey)

The historical and evolutionary context of fire the Mojave Desert

Precipitation is the ultimate driving force behind fuels and fire regimes in any ecosystem, but especially in semi-arid to arid ecosystems such as deserts. In the Mojave Desert, vegetation formations shifted upslope during the course of the Holocene due to an increasingly arid climate. With increased aridity, decreased productivity, and generally harsh conditions that decreased human presence in the region, the spatial extent of fire across the Mojave Desert undoubtedly declined. In addition, changes from perennial grasses to woody shrubs suggests both a shift in fuelbed characteristics from one that was conducive to and adapted to periodic fire to another that was less so, and a shift of the North American monsoon and its high incidence of lighting away from the Mojave Desert. Vegetation types that experienced periodic fire in the past and are somewhat resilient to its effects are currently isolated in disjunct high elevations areas within the basin and range topography of the Mojave Desert. Within these high elevation locales fire may be considered a natural and potentially desirable ecosystem process. In contrast, vegetation types that have experienced extremely infrequent fire in the past and are not resilient to its effects predominate at the lower elevations that typify most of the Mojave Desert. Although fire has had minimal influence on the evolution of most desert species, especially those currently occupying lower elevations, other forces of natural selection such as herbivory, drought, flood, and colluvial substrates may have resulted in adaptations that also increase fire resilience in some species.

149 **Brooks, Matt** (U.S. Geological Survey), matt_brooks@usgs.gov

Matt Brooks (U.S. Geological Survey)

Appropriate management of fire in the Mojave Desert

After decades of limited research on the effects of fire in the Mojave Desert, there was a significant increase in studies following the unprecedented 2005 fires. Information from these studies is just now beginning to emerge and there is a need to adjust fire management plans accordingly. Fire history studies suggest that recent large fires may be unprecedented over the past century, although fire activity has been, and will likely continue to be, highly episodic in this region. Fire effect studies indicate that seedbank densities and annual plant cover can recover within three postfire years, but species composition may not recover for up to 35 years or more. Effects can also vary based on initial burn severity and fire frequency. Burn severity assessments from both satellite and ground based platforms have been shown to provide very useful information for predicting postfire vegetation trajectories. Postfire seeding studies indicated that there have been extremely low establishment rates from aerial seedings, calling into question the cost effectiveness of these management actions. Modeling of invasive annual plant distributions coupled with remote sensing tools will soon allow region-wide fuels monitoring and fire hazards assessments. Integration of this new information into a single fire effects

and hazards model will dramatically improve our ability to forecast where and when fires will occur, what their effects may be, and where postfire management actions may be warranted.

131 **Brown, Peter** (Rocky Mountain Tree-Ring Research), pmb@rmtrr.org

Peter Brown (Rocky Mountain Tree-Ring Research)

Reconstructing Mixed Severity Fire Regimes from Tree-Ring Data

The presence of a fire scar recorded on a tree is strong evidence of surface fire, at least at the scale of the single tree and assuming the scar is correctly identified as having been caused by fire that was hot enough to injure a portion of the tree's cambium but not kill the tree. However, beyond this relatively direct ecophysiological process, what additional evidence can be used to reconstruct past fire behavior, both at stand and landscape scales? In this talk I will review additional lines of spatial and temporal tree-ring evidence that can be used to more fully reconstruct past variations in fire behavior, including some of the limitations to the various data and their interpretations.

250 **Brown, Sara** (New Mexico Highlands University), sarabrown@nmhu.edu

Sara Brown (University of Wyoming), Ingrid Burke (University of Wyoming), Peter Brown (Director of Rocky Mountain Tree-Ring Research), William Lauenroth (University of Wyoming)

Comparing pre-European and contemporary carbon emissions from wildfire in the montane forest of the Colorado Front Range, U.S.A.

Wildfires in the Colorado montane forest burned with no anthropogenic suppression during pre-European years 1700-1900. Fires have been successfully suppressed during contemporary times (1970-2010) in this region, potentially reducing the spatial extent of these fires. The spatial extent of wildfire is positively correlated with C emissions to the atmosphere during combustion. The objective of our study is to determine how C emissions from fires differ between pre-European and contemporary periods in the Colorado Front Range montane forest. LANDFIRE national data sets were used to determine vegetation-type changes across the time periods. We used “biological-physical-settings” (BPS) data to represent pre-European times, and “existing vegetation type” (EVT) data to represent the contemporary time period. Tree-ring data from 84 plots across the study area provided fire frequency and spatial extent estimates of fires during the pre-European time period. Recent fire records from national, private and state lands provide frequency and spatial extent data for the contemporary time period. We developed C emission estimates for both pre-European and contemporary data sets at the vegetation-type level using estimates we derived from previous work. Wildfires were found to be more spatially extensive during the pre-European period (~330 sqkm/yr burned) as compared to the contemporary period (~22 sqkm/yr burned). Average yearly C loss estimates from the Pre-European period were considerably larger (2.5 ± 1.3 Tg/yr) as compared to the contemporary yearly estimate (0.012 ± 0.006 Tg/yr). Our results demonstrate that the large spatial extent of pre-European fires led to higher C emissions from wildfire.

254 **Bukowski, Beth** (University of Wyoming), bspencer@uwyo.edu

Beth Bukowski (University of Wyoming)

Reconstruction of historical fire regimes in four sagebrush landscapes using General Land Office survey data

Historically, fire has been a key factor in determining landscape structure in sagebrush landscapes, which cover approximately 47 million ha of the western United States. Because fires in sagebrush are generally stand replacing, most estimates of historical fire rotations in sagebrush are derived from fire scars in adjacent woodlands. Studies have shown that the resulting estimates are inaccurate and do not provide information about fire size or resulting landscape structure. However, General Land Office (GLO) surveys provide detailed historical vegetation data that can be used to locate historical fires and estimate attributes of historical fire regimes. In this study, data from GLO field notes were used to reconstruct four study areas in the western United States with a total area of approximately 3.6 million ha. The reconstructed landscapes were analyzed for burned areas and post-fire successional characteristics, both of which indicate past fires. These areas were isolated and used to estimate historical fire regimes for each study area. Key reconstructed attributes include number of fire events, fire-size distribution, and fire rotation. Historical fire size distributions were inverse-J shaped, with many small fires and a few large fires. This research will provide baseline data for researchers seeking to understand the historical range of variability (HRV) in sagebrush fire regimes and measure changes to those regimes. It also has direct applications for land managers involved in fire management and prescribed burning.

274 **Cheng, Tony** (Colorado Forest Restoration Institute), Tony.CHENG@colostate.edu

Tony Cheng (Colorado Forest Restoration Institute)

Uncompahgre Landscape Project Monitoring Case Study

Monitoring is a vital component of our landscape restoration approach. We need to know how effective restoration treatments achieve our objectives, and whether any unintended outcomes (such as proliferation of noxious weeds) developed. We have developed a “multi-party” approach to monitoring that ensures high quality information that supports high confidence among all collaborators. The three key pieces of our monitoring approach are: 1) Collaborative development of goals and specific objectives for each major project; 2) Collaborative design of general approaches to monitoring, leading to detailed designs by appropriate experts and stakeholders on behalf of all collaborators; 3) Conducting field measurements; sometimes these are performed by agency personnel as part of normal operations, and other times by combinations of agency personnel, outside experts, and stakeholder volunteers. 4) Synthesis of monitoring data to inform all collaborators about what we have learned, and to support insightful discussions about what we might modify to improve our restoration work. Our multi-party monitoring approach will evolve as we gain experience working together. Baseline data will be recorded prior to treatments. Monitoring will continue periodically over 15 years, following

completion. Permanent transect markers will be established to continue monitoring efforts indefinitely. Colorado Forest Restoration Institute (CFRI) will compile, analyze and store the monitoring data.

128 **Conver, Joshua** (University of Arizona), jconver@email.arizona.edu

Joshua L. Conver (University of Arizona), Donald A. Falk (University of Arizona), Stephen R. Yool (University of Arizona), Robert Parmenter (Valles Caldera National Preserve)

Stochastic Modeling of Fire Regimes in Montane Grasslands and Forest Ecotones of the Valles Caldera National Preserve, New Mexico, USA

Montane ecosystems of the western United States have experienced dramatic changes in their fire regimes over the last 150 years. Fire behavior modeling enables understanding of how ecosystem changes have altered past fire regimes. The Valles Caldera National Preserve in the Jemez Mountains, northern New Mexico, contains one of the largest montane grasslands in North America, complemented by multiple land uses ranging from logging to grazing and recreation. These important ecosystems have experienced increased fuel loads and stem densities resulting from a century of fire exclusion and tree encroachment, resulting in potentially anomalous fire behavior. We investigated whether fire pathways tend to spread along the grassland-forest ecotone or if fire would spread directly across grasslands under extreme fire weather conditions. We used the program FlamMap to model fire behavior under a variety of weather and fuel conditions. Fire spread pathways and burn perimeters were computed for the 50th, 90th, and 99th percentiles of historic weather conditions. The results are compiled into a probability surface that represents the most parsimonious pathways of fire spread in this landscape. We found that pathways were related to the origin of ignition; fires tended to spread around the ecotone, facilitating fire spread to adjacent grasslands. These results, complemented with fire history studies in dendrochronology and empirical observations of the Las Conchas Fire in 2011, further the understanding of the role of fire in maintaining the montane-grassland conifer ecotone, and can guide efforts to restore a landscape suffering from the effects of fire exclusion.

225 **Cooley, Jon** (Arizona Game and Fish Department), jcooley@azgfd.gov

Jon Cooley (Arizona Game and Fish Department), Shaula Hedwall (U.S. Fish and Wildlife Service)

Wildlife challenges and opportunities related to implementation of post-fire emergency rehabilitation actions

After the flames of expansive, high-severity wildland fires are extinguished, emergency rehabilitation actions such as slope stabilization, vegetative treatments, and other site recovery/mitigation measures are conducted with a primary focus of protecting people, communities, and other important resources from post-fire events such as flooding, erosion, mudslides, hazard trees, and the potential degradation of water supplies. These objectives and associated management actions, combined with the means by which they are implemented, can either directly or indirectly produce both positive and negative effects on wildlife. Many of these post-fire emergency response actions can result in long-term benefits to

species and their habitats, particularly successful erosion control aimed at protecting perennial watersheds and rangeland recovery efforts that promote increased vegetative diversity and improved distribution of wildlife forage and cover. These and other management actions, however, may also present negative effects/impacts to wildlife species and their habitats, both in the short-term and over the long-term. Traditional approaches in defining short-term emergency response priorities may also present challenges to effectively incorporate post-fire management of aquatic, T&E listed species, game, and invasive species into post-fire emergency rehabilitation actions. We will provide examples of our experience with recent large fires and burned area rehabilitation efforts and the long-term wildlife management challenges and opportunities that follow these large, landscape altering wildfires. Observations and recommendations on incorporating practical wildlife management objectives into post-fire recovery efforts that promote public safety and property protection objectives will also be discussed.

321 **Cort, Citlali** (Northern Arizona University), taxodium@gmail.com

Peter Z. Fulé (Northern Arizona University), Jherime L. Kellermann (University of Arizona), Donald A. Falk (University of Arizona)

Thick-billed Parrot (Rhynchopsitta pachyrhyncha: Psittacidae) habitat in northwestern México is associated to fire regimes of old-growth forests

Old-growth pine-oak forests of the Sierra Madre Occidental in northwestern México provide vital habitat to the Thick-billed Parrot (Rhynchopsitta pachyrhyncha: Psittacidae), a CITES-listed endangered species. We studied four relict old-growth stands in northwestern Chihuahua, to assess their composition, structure, and age characteristics relative to nesting and foraging habitat requirements of Thick-billed Parrots that we summarized from a literature review. We found large live trees (>40 cm DBH) in the four sampling sites, and two of the sites had densities of five or more large snags (>60 cm DBH) per hectare, an important nest substrate for these birds. Forest overstories were dominated by relatively large conifers (270-335 trees ha-1, 24-42 m2 ha-1). Canopy cover averaged 51-61 %, overstory canopy base heights were elevated and woody debris fuel loadings were low (<20 Mg ha-1), suggesting that these forests were relatively resistant to severe wildfire. Frequent disturbance by surface fires appears to have been consistent with maintaining the open, diverse, and productive forest habitat for centuries. While climate was historically a driver of fire regimes in this region, anthropogenically altered fire regimes have dominated the second half of the 20th century. Age distributions showed canopy recruitment over ~250 years while fires recurred every 6-12 years. Three sites experienced fire regime interruption during the mid-20th century, associated with increased tree establishment. The fourth site had an undisturbed fire regime and showed continuous tree establishment, consistent with the self-reinforcing role of frequent fire in regulating live and dead fuel loads.

251 **Coughlan, Michael** (University of Georgia), coughlan@uga.edu

Michael Coughlan (University of Georgia), Ted Gragson (University of Georgia), Albert Parker (University of Georgia)

Pastoral fire in the French Pyrenees: Implications for understanding the historical ecology of low intensity fire-use in the American West.

This paper presents historical ecological research on fire-use in the Pyrenees. We used historical, ethnographic, and dendroecological data to reconstruct pastoral fire regimes over the last 200 years. We employed a Bayesian weights of evidence approach to model the spatiotemporal distribution of fire. We incorporated ethnohistorical data indicative of changing land- and fire-use associations into the model in order to account for socioeconomic effects on fire. We then compared the model results with dendrochronological data collected from a portion of the study area thought to have experienced significant land use/cover changes. This study's findings have important implications for historical ecological research on pastoral fire and other low intensity fire-use in the American West: (1) the historical ecology of Euroamerican pastoral fire-use in the West cannot be understood without reference to European pastoral burning practices and fire-use rationale, however, typological characterization of traditional land- and fire-use and management may be insufficient for understanding actual socioecological interactions, (2) The spatiotemporal distribution of fire and fire severity may be sensitive to fine scale shifts in land use intensity and, (3) climate-vegetation cycles may be more important than actual ignition practices for predicting the frequency of fire-scars.

302 **Cram, Douglas** (New Mexico State University), dcram@nmsu.edu

Terrell Baker (New Mexico State University)

Using Prescribed Fire to Manage Mixed Conifer Structure and Composition

In the Southwest, mixed conifer forests have not been researched and described as extensively as ponderosa pine forests. Historically, similar to lower elevation pine forests, frequent fire shaped vegetation composition, stand development, and structure in southwestern mixed conifer forests. Fire acted as a natural thinning agent by reducing litter build-up, burning small trees, thinning ladder fuels, and depending on conditions, resulted in overstory mortality. However, a number of factors have combined to change forest structure, understory and overstory composition, and fuel conditions over the last 130 years. Fire suppression and exclusion policies in western forests have created unique ecological conditions and management challenges as a result of increased conifer densities. Consequently, forest managers charged with natural resource stewardship are faced with the threat of stand replacement wildfire over large spatial areas particularly during dry and windy seasons. Managers today are seeking solutions to these problems using silvicultural techniques, including prescribed fire. Our talk will present results from three prescribed fires on three different mixed conifer stands in the Lincoln National Forest, NM. Results will include data collected before and after prescribed fire on understory and overstory composition, structure, and fuel loading. Management implications will be discussed.

280 **Cramer, Jennifer** (Santa Fe National Forest, USDA Forest Service), jennifercramer@yahoo.com

Jennifer Cramer (USDA Forest Service)

Collaborative monitoring for the Southwest Jemez Mountains Landscape Restoration CFLRP

The Southwest Jemez Mountains Landscape Restoration Project on the Santa Fe National Forest is one of ten projects selected nationally for funding as part of the Collaborative Forest Landscape Restoration Program (CFLRP). The goal of the project is to improve the resilience of ecosystems by implementing restoration treatments including forest thinning and prescribed fire, road decommissioning, and riparian zone and fisheries habitat improvement projects. In conjunction to the aforementioned restoration activities, the project includes a comprehensive 15 year monitoring plan that focuses on using a science-based approach to track landscape level changes in a variety of resources while also providing land manager feedback on the success of restoration activities, a necessary component for adaptive management. Collaboration with other government agencies, tribes, and non-government organizations is a crucial component to the monitoring design of the project. These partners will provide expertise and manpower to help implement the monitoring program across a wide range of resources including climate and hydrology, vegetation, wildlife and fish, and social and economic values.

275 **Davis, Cory** (University of Montana), cory.davis@cfc.umt.edu

Cory Davis (University of Montana)

Data management across a large landscape with multiple partners

Monitoring the effects of forest restoration efforts at a landscape-scale can generate large amounts of data. In addition, the public may be understandably wary of monitoring conclusions developed strictly by the management agency conducting the forest treatments. Monitoring the success of restoration efforts is more effective when done collaboratively with partners from multiple agencies, non-profits, universities, and local citizens. To properly analyze and track restoration progress, and build wide consensus on conclusions, a data management approach is needed that allows all partners to access and trust the data that is collected. The Southwestern Crown of the Continent Collaborative recognized the need for a centralized data management approach administered outside of the management agency. Members of the Collaborative's Monitoring Committee developed a strategy that takes advantage of existing partner efforts and emphasizes data accessibility and quality. Data being collected ranges from large, remotely-sensed datasets to reports on social responses to treatments. Collection protocols are aligned with existing Forest Service databases when appropriate, but do not drive the goals of the monitoring efforts. Storage capacity and support is provided by the University of Montana through a partnership agreement. Data cataloguing, internal search capabilities, and technical support are through an existing program developed by the Great Northern Landscape Conservation Cooperative. All data is made available on the Collaborative's webpage. An effective monitoring program will improve forest restoration treatments through adaptive management and a transparent data management approach is a valuable tool in building trust between the agency and the public.

243 **Decker, Lynn** (The Nature Conservancy), ldecker@tnc.org

Anne Bradley (The Nature Conservancy)

Creating Nimble and Effective Collaborations for Sustainable Results

Scientists and managers have learned over the last decade that to restore large watersheds or other landscapes, understanding how to knit together successful working agreements is as critical as practical fire know-how. "Coordination", "cooperation" and "collaboration" are words that are often used interchangeably to describe relationships with people and organizations working toward common goals. They actually describe different kinds of agreements or relationships, each with its own limitations and opportunities. This presentation will help the participant understand the difference, and to make more a more conscious choice based on the kind of outcome desired. The choice of approach and depth of investment affect many project aspects including the project's overall vision and structure, communication and relationships, decision-making authority, accountability, and, importantly, the strength and durability of the outcomes. True collaboration requires deeper investment, frequently challenges, but holds the potential for the greatest rewards. Principles of successful collaborations will be discussed, and this presentation will serve as an introduction to the small group exercises that comprise the rest of this roundtable session. . Participants will be encouraged to talk about their own experiences-both positive and negative, in developing projects with partners and stakeholders. Facilitated small group discussion will give participants experience in dissecting and uncovering solutions to real-life, ongoing collaboration challenges.

139 **Dewar, Jacqueline** (University of Arizona), jdewar1@email.arizona.edu

Jacqueline Dewar (University of Arizona), Donald Falk (University of Arizona), Craig Allen (US Geological Survey, Jemez Mountains Field Station), Robert Parmenter (Valles Caldera National Preserve)

Multi-scale analysis of fire regimes in montane grassland-forests of the Valles Caldera, New Mexico, USA

Montane grasslands are distributed across the Southwest, but there has been little quantitative study despite their biological and economic value. We reconstructed historic fire regimes at multiple spatial scales in ponderosa pine and mixed-conifer forests surrounding the "valle" grasslands in the Valles Caldera National Preserve in northern New Mexico. Temporal and spatial patterns were (1) compared with historical fire patterns recorded by trees more centrally located within forests to assess potential differences between forest and grassland fire regimes, (2) to understand the fire-vegetation-climate relationships that entrained the montane grassland fire regime, and (3) to assess 20th century anthropogenic impacts upon the historic fire regime. Using a spatially-explicit sampling design, we dated 388 fire-scarred samples from the grassland-forest ecotone surrounding nine valles. We identified 181 fire years from an adequate sample size from AD 1601-1902. Preliminary results confirm pre-1900 historic occurrence of high frequency, low-severity surface fires over multiple centuries (MFI = 2.52 yr). In some fire years, synchronous fires burned across the grasslands and into the surrounding forests over

much of the ~40,000 ha Caldera (>25% of total sites burning at ~10.5 year intervals), indicating dominant top-down climate control of fire occurrence. In other years, fires burned relatively small portions throughout the Caldera (between 10-25% of total sites at ~6 year intervals), creating asynchronous burn patterns. Asynchronous fires suggest stronger bottom-up controls driven by fuels, fuel moisture, weather conditions, topography, and human ignitions. Results will assist in planning grassland-forest restoration and reinstituting pre-fire-suppression regimes for prescribed and natural fire management.

145 **Downs, Janelle** (Pacific Northwest National Laboratory), jl.downs@pnnl.gov

Janelle Downs (Pacific Northwest National Laboratory), Jerry Tagestad (Pacific Northwest National Laboratory), Emma Underwood (University of California at Davis), Valerie Cullinan (Pacific Northwest National Laboratory)

Coupling Species Distribution Predictions with Temporal NDVI Response to Evaluate Potential Fire Hazard

Annual fire hazard maps are useful for determining where and when fires are most likely to occur in the Mojave Desert within a given fire season. Such information can be used to adjust fire suppression staffing levels among years and across the region to improve initial attack efforts and prevent fires from spreading into large campaign events. One component of evaluating potential fire hazard involves identifying the extent of non-native invasive annuals (NIA) that contribute fine fuel biomass. We are using weekly MODIS NDVI time-series to discriminate areas with low to high amounts of NIA based on greenness response profiles. Annual species growth and development in much of the Mojave occurs primarily in response to winter and early spring rainfall. Analyses of field-collected data for select years with respect to winter and spring green–up periods identified in an 11-year chronosequence of MODIS NDVI indicates that areas with high cover of invasive annuals (> 25%) can be discriminated from areas with low cover (<10%). Future analyses of NDVI profiles will focus on assessing the relationship between greenness response and field-measured biomass of NIA. Maps of NIA abundance based on NDVI analyses will also be coupled with results of species-specific predictive models for invasive annual grasses based on environmental attributes. We describe plans for incorporating these data combined with other environmental attributes and fire modeling results to create fire hazard assessments for the Mojave Desert.

132 **Dugan, Alexa** (University of Wyoming), adugan@uwyo.edu

Alexa Dugan (University of Wyoming)

Age structure variation and dynamics in ponderosa pine forests across Grand Canyon National Park's South Rim

Fire is a key natural disturbance influencing age-structure variability in ponderosa pine forests. Even-aged forests can result from large, infrequent, and severe fires that kill most trees leading to pulses of regeneration, while multiaged forests may be shaped by frequent, low to moderate-severity fires, which

kill some trees and result in less regeneration. The goal of this research was to reconstruct the age-structure of ponderosa pine forests across the South Rim of Grand Canyon National Park and determine the factors influencing age-structure trends and variability. I established 30 plots across the South Rim each consisting of 25-40 ponderosa pine trees >30 cm dbh. I mapped each tree and collected increment cores and fire-scar samples from all trees in the plots. Samples were crossdated to estimate establishment dates and determine fire years. While most plots consist of multiaged trees, several stands experienced distinct episodes of regeneration. At the landscape scale, a pulse of recruitment began around 1880 and peaked in the early 1900s. To assess the causes of recruitment pulses, (1) I analyzed the spatial arrangement of fire-scars to explore whether nearby fires correspond with the pulses; (2) I compared them with climate variables to research if pluvial episodes correspond with the pulses; and (3) I compared the timing of pulses with the history of EuroAmerican settlement, which brought fire suppression and livestock grazing practices. This research will evaluate whether the age-structure variability was shaped by the historical fire regime or was more related to land use or regional climatic episodes.

331 **Dunn, Bill** (Ecosystem Management, Inc.), billd@emi-nm.com

Bill Dunn (Ecosystem Management, Inc.), Bruce Higgins (Ecosystem Management, Inc.), Matt Brooks (Ecosystem Management, Inc.), Kurt Menke (BirdsEyeView GIS)

Right Under Our Noses: The Treasure Trove of Allotment Monitoring Data and its Value in Tracking Ecological Changes in the Southwestern United States.

The Integrated Landscape Assessment Project (ILAP) has been a 2 year effort led by the US Forest Service in collaboration with private, state, and federal entities to build a model for investigating the long-term dynamics of landscapes in the western United States. To investigate long-term changes in vegetative composition in the southwest, we obtained grazing allotment monitoring data from BLM and USFS offices throughout Arizona and New Mexico. Methods to measure vegetative composition included a wide variety of point and quadrat techniques; species presence within 40x40 cm quadrats placed along 100 m transects was most commonly used. Length, frequency, and intensity of monitoring varied greatly among allotments; nevertheless for a large sample of allotments, data had been collected over multiple decades on several transects. In total, these data likely represent the most extensive range monitoring effort available for any large geographic region. As such, they offer a unique opportunity to explore long term changes across large landscapes in a highly variable environment. In this paper, we discuss what is available in these datasets, how and why collection should continue and be improved, and the contributions and limitations in the ability of these data to detect changes in vegetative composition induced by fire.

301 **Evans, Zander** (Forest Guild), zander@forestguild.org

Zander Evans (Forest Guild)

What Do Fire Return Intervals Tell Us about Managing Mixed Conifer Forests?

Mixed severity fire regimes are more difficult to define and build into management plans because fuel loads, frequencies, intensities, and effects vary significantly across small areas. Pre-settlement, fires in mixed conifer burned in intervals that averaged between eight and 25 years for the Southwestern plateaus and uplands, Southern Rockies, and Sierra Nevada. Low-severity fires were more frequent in some mixed conifer forests, such as the warm–dry type in the Southwest. Historically, even where low-severity fires were relatively frequent, mixed conifer forests tended to be heterogeneous mixtures where species composition, forest structure, and fuel loads changed over short distances. This heterogeneity was reinforced by fires that varied in intensity and severity over short distances. Since Euro-American settlement, mixed conifer forests have become increasingly homogeneous, and many mixed conifer forests, particularly those of the warm–dry type, have increased in tree density. More homogeneous mixed conifer forests can facilitate larger high-severity fires than those that occurred historically. This presentation will discuss the current scientific data on the fire regimes in mixed conifer forests and outline management strategies based on restoration aspirations or at least acknowledgement of these natural mixed severity fire regimes.

111 **Falk, Donald** (University of Arizona), dafalk@u.arizona.edu

Donald Falk (University of Arizona), Thomas W. Swetnam (University of Arizona), Thomas Kitzberger (Universidad Nacional del Comahue), Erica Bigio (University of Arizona)

Reconstructing the historical pyrogeography of western North America, 1600-1900 AD

The Fire and Climate Synthesis (FACS) project is a collaboration of fire ecologists to compile and synthesize fire and climate data for western North America. The FACS PIs and collaborators have compiled over 900 multi-century fire-scar based fire histories from the western United States, Canada, and Mexico, as well as tree-ring based climate reconstructions and modern climate records. Our emphasis is on understanding the role of longer-term (annual to decadal) climate variation in regulating fire occurrence over the past 500+ years, complementing shorter-term fire season and weather outlooks. This extensive network is providing new insights into the pyrogeography of western North America. Annual fire-year maps are available indicating years of widespread regional fire under top-down climatic control. Spatial analysis of large-scale fire occurrence patterns indicates years in which teleconnections of the El Niño-Southern Oscillation (ENSO) regulate widespread regional fire years, through expression of regional drought, while in other years fires are widespread across western North America. Patterns of spatiotemporal similarity in the historical fire record can be compared with similar indices for modern fire occurrence.

214 **Floyd-Hanna, Lisa** (Prescott College), lfloyd-hanna@prescott.edu

Lisa Floyd-Hanna (Prescott College), William H. Romme (Colorado State University), Monique Rocca (Colorado State University)

When is ecological restoration needed in Pinus edulis-Juniperus osteosperma (piñon-juniper) woodlands?

Piñon-juniper vegetation covers a large area in western North America, and exhibits enormous diversity in species composition, historical disturbance regimes, and changes during the past century. Consequently, restoration objectives and methods must be tailored to a particular local situation: "one-size-fits-all" approaches are unlikely to produce satisfactory results. Development of an effective restoration strategy entails understanding the historical conditions and dynamics of the specific area, and distinguishing between passive vs. active restoration, structural vs. functional restoration, and restoration of canopy vs. understory. The Mesa Verde region of southwest Colorado supports pristine old-growth piñon -juniper woodlands where passive restoration is appropriate. In contrast, active restoration of recently (1996, 2000, 2002) burned old-growth piñon -juniper was necessary to reduce exotic invasions. We will present long-term data on the effectiveness of these treatments on exotics and their impacts on native biodiversity and on future fire behavior using fire modeling. Three other case studies will illustrate the range of historical and current ecological conditions and appropriate restoration strategies that managers may encounter in piñon-juniper woodlands of the southwestern U.S. The case studies active restoration of a degraded understory beneath a pristine canopy structure (Glen Canyon National Recreation Area, Utah), active restoration of canopy and understory in a degraded woodland (Mount Trumbull, Arizona) and in a degraded savanna (Pajarito Plateau, New Mexico).

261 **Fuhlendorf, Samuel** (Oklahoma State University), sam.fuhlendorf@okstate.edu

Samuel Fuhlendorf (Oklahoma State University), Brady Allred (Oklahoma State University), R. Dwayne Elmore, David Engle

What is (and isn't) the Fire-grazing Interaction? In Which Grassland did the Interaction Operate Historically?

Most studies of grazing and fire focus on binary (yes or no; a few combining fire and grazing) treatment designs on relatively small uniform experimental units. Typically research focuses on single objectives, such as livestock production or biodiversity, and does not consider dynamic processes or interactive effects. This approach of uniform treatment application is incapable of explaining complex patterns central to the ecological interaction of fire and grazing within the context of a dynamic landscape. Our recent research suggests that fire and grazing are interactive and can lead to a shifting mosaic landscape that is regulated through a series of positive and negative feedbacks. The shifting mosaic of patches across the landscape is driven by the interactive influence of fire and grazing. Thus, characteristics of patches are dictated by time since focal disturbance such that the landscape contains plant communities in patches that have been recently burned and focally grazed and also patches that have not been disturbed for several years. We have developed the fire-grazing interaction model into a landscape

management model capable of enhancing biodiversity while maintaining production of domestic livestock—a model that duplicates disturbance patterns in the evolutionary history of Great Plains grasslands. For this presentation we will explore the strengths of this relationship and develop hypotheses for applying this model to other grassland/savanna ecosystems.

212 **Fulé, Peter** (Northern Arizona University), pete.fule@nau.edu

Peter Fulé (Northern Arizona University), Joseph Crouse (Northern Arizona University), John Roccaforte (Northern Arizona University), Elizabeth Kalies (Northern Arizona University)

Do thinning and/or burning treatments in western USA ponderosa or Jeffrey pine-dominated forests help restore natural fire behavior?

We carried out a systematic review and meta-analysis of the effects of forest thinning and burning treatments on restoring natural fire behavior attributes in western USA pine forests. Ponderosa pine and Jeffrey pine, with co-occurring species, are adapted to a disturbance regime of frequent surface fires, but extended fire exclusion and other factors have led to historically uncharacteristically dense stands and high fuel loadings, supporting severe fires. Treatments to reverse these changes and reduce fuel hazards have been tested experimentally and observations of wildfire behavior in treated stands have also been reported. Using a systematic review methodology, we found 54 studies with quantitative data suitable for meta-analysis. Combined treatments (thinning + burning) tended to have the greatest effect on reducing surface fuels and stand density, and raising modelled crowning and torching indices, as compared to burning or thinning alone. However, changes in canopy base height and canopy bulk density were not consistently related to treatment intensity, as measured by basal area reduction. There are a number of qualifications to the findings. First, because it is not feasible to subject treated areas to severe fire experimentally, inferences about potential fire behavior rely on imperfect modelling techniques. Second, research has not been carried uniformly over the ranges of the pine forests, although we found no significant differences in treatment effects between regions or forest types. Overall, however, meta-analysis of the literature to date strongly indicates that thinning and/or burning treatments do have effects consistent with the restoration of natural fire behavior.

324 **Fulé, Peter** (Northern Arizona University), pete.fule@nau.edu

Peter Fulé (Northern Arizona University), Larissa Yocom (Northern Arizona University), Citlali Cortés-Montaño (Northern Arizona University), Donald Falk (University of Arizona)

Testing a pyroclimatic hypothesis on the México-U.S. border

The “pyroclimatic hypothesis” provides a basis for testable expectations about climatic and other controls of fire regimes. Forests near the México-U.S. border offer a place to test the relative influence of climatic and other control in mountain ranges that are ecological similar and subject to broadly similar to-down climatic influence, but with differing cultural influences such as land use history. We compared fire history information from the Mesa de las Guacamayas, a high mountain range in far

northwestern Chihuahua, with previously published fire data from the Chiricahua Mountains, in southeastern Arizona, approximately 150 km away. We developed a priori hypothetical models of fire occurrence and compared their performance with empirical climate-based models. Fires were frequent at all Mesa de las Guacamayas study sites through the mid-20th century and continued uninterrupted to the present at one site, in contrast to nearly uniform fire exclusion after 1892 at sites in the Chiricahua Mountains. The historical fire regime on both mountain ranges was linked to climate as suggested by a priori model but the actual climate-fire relationships diverged in each country after 1892. The climate-based models predicted continuing fires at the same rate per century as prior to 1892 and fires did in fact continue in México, but ceased in the U.S., most likely due to changes in land use. The cross-border comparison confirmed that a frequent-fire regime could cease without a climatic cause, supporting previous arguments that bottom-up factors such as livestock grazing can rapidly and drastically alter surface fire regimes.

304 **Gauthier, Rory** (National Park Service), rory_gauthier@nps.gov

Rory Gauthier (Bandelier National Monument)

Lessons Learned Managing Cultural Resources in a Fire-prone Environment: Preservation Issues and Treatments

Historic fire suppression, increased forest densities and recent warm drought conditions have led to more frequent and severe wildfires in the Southwest USA, burning over thousands of archeological sites on public lands in the past decade. With ongoing climate change, predicted increases in fire frequency and intensity, threaten a number of premier archeological zones in this region. Fires often damage archeological sites and significantly alter cultural landscapes. These issues are well-illustrated at Bandelier National Monument, a 13,000 ha national park unit in northern New Mexico that contains over 3,000 archeological sites, which has been effected by four major wildfires in recent years and which therefore has been a locus of research on fire effects on cultural resources. A variety of studies at Bandelier and elsewhere in the southwest have documented numerous effects that fire can have on archeological sites. Post fire treatments to mitigate fire effects have been developed and refined at a number of archeological sites and include placement of excelsior matting, straw mulch, water diversion structures and the emplacement of logs to slow surface runoff. Bandelier archeologists have also been applying a number of techniques to reduce the impacts and threats to wildland fire on archeological sites, starting with intensive field inventory followed by fuel reduction projects that may use prescribe fire to reduce fuels, removal of artifacts susceptible to heat impacts and even pre-construction of fuel breaks and fire lines around at-risk archeological sites.

118 **Gori, Dave** (The Nature Conservancy in New Mexico), dgori@tnc.org

Anne Bradley (The Nature Conservancy in New Mexico), Dave Gori (The Nature Conservancy in New Mexico), Michelle Christman (U.S. Fish and Wildlife Service)

Application of a Climate Change Adaptation Framework to Address Rare Species Management and Fire Risk in a Collaborative Setting: a case study in the Jemez Mountains, New Mexico

In 2009, The Nature Conservancy convened a two-day workshop on climate change adaptation in the Jemez Mountains in northern New Mexico. The workshop introduced a climate change adaptation framework and use of a conceptual model to identify key climate-related threats to target communities, processes or species. In a second iteration of this process, we worked with the New Mexico Endemic Salamander Team and local fire managers to apply the framework to the Jemez Mts Salamander (JMS), a federal candidate species. Workshop participants identified the occurrence of more frequent and extensive crown fires as the primary climate-induced threat to JMS. Fire managers stressed the need to apply fuel treatments (thinning, prescribed burning) over large areas to reduce fire risk while salamander biologists stressed the need to apply treatments cautiously to protect the species' habitat. An outcome of this second workshop was a grant-funded collaborative project designed to identify reference conditions for Jemez Mountain's mixed conifer forests and JMS habitat and characterize current forest and fuel structure in occupied habitat. The proposed outcome of this study is a set of recommendations for fire and forest management compatible with salamander conservation, thereby accelerating the scale and effectiveness of the landscape restoration strategy currently underway in the Jemez Mountains. We will review the adaptation framework, the collaborative process and current status of the on-the-ground project.

215 **Gottfried, Gerald** (US Forest Service), ggottfried@fs.fed.us

Gerald Gottfried (Rocky Mountain Research Station), Peter Ffolliott (University of Arizona), Daniel Neary (Rocky Mountain Research Station)

Fire for Landscape Restoration in the Southwestern Borderlands Region

Fire was an important component of the ecosystems of the Southwestern Borderlands Region of Arizona, New Mexico, and Mexico prior to European settlement. Overgrazing by domestic livestock and aggressive fire control by land management agencies essentially remove fire from the region resulting in increased density of woody species, reduced cover of herbaceous vegetation, and a general decline in ecological diversity. Private and public land managers are attempting to reintroduce fire into the region. Research was initiated on 12 small, gauged watersheds at Cascabel in the Coronado National Forest in southwestern New Mexico in response to this effort. The objective was to evaluate the impacts of cool-season and warm-season prescribed fire treatments and a wildfire on the common oak savannas of the region. The research followed a multi-resource approach to evaluate as many ecological components as possible. Many of the pre-fire attributes of the little studied oak savannas have been reported in the literature. Cascabel was treated with the prescribed fires and an unplanned wildfire in 2008, and post-fire results are being analyzed and reported. All three types of fires resulted in low severity burns. This presentation will summarize information about the impacts of the three fire treatments on soils,

hillslope and channel sedimentation, grasses, herbaceous and shrub species, overstory trees, selected mammals, and bird populations. Fire impacts are compared among treatments and with pre-burn conditions. Some resource attributes were modified by the fires while many remained unchanged.

113 **Graeve, Phil** (Colorado State University), philgraeve@gmail.com

Phil Graeve (Colorado State University), Monique Rocca (Colorado State University)

The impact of drought-induced overstory mortality on seedling establishment in pinyon-juniper communities on the Colorado Plateau

Drought stress in the last decade has led to widespread and well-documented mortality of pinyon and juniper in southwestern Colorado. The consequences of this mortality for pinyon and juniper establishment and possible range shifts are difficult to predict due to uncertainties about the role overstory cover plays in tree seedling establishment. To examine whether pinyon seedlings establish preferentially under specific microhabitat and overstory dynamics, and the impact of overstory mortality on establishment, we sampled the microhabitat preferences and overstory dynamics associated with pinyon and juniper seedling establishment in 75 plots on the east aspect of the Uncompahgre Plateau on the eastern Colorado Plateau. Seedlings were most frequently found under established overstory cover on sites with developed substrate litter. Established seedlings were found in pinyon or juniper litter 1.6 times more frequently than would be predicted for the wider landscape while no overstory was 3.3 times more likely to exclude establishment. Established pinyon and juniper were found in recent dead standing overstory in similar proportions to the dead standing cover found landscape-wide. Over 30 percent of the seedlings found under recent dead standing canopy (mortality since 2004) were less than 3 years old, a proportion similar to that found under live canopy, indicating live overstory canopy alone may not predict short-term success. These findings suggest that overstory mortality may trigger a positive feedback loop by diminishing favorable seedling establishment conditions, though these effects may not be seen in the short-term.

249 **Haffey, Collin** (Bandelier National Monumen), collin.haffey@gmail.com

Collin Haffey (National Park Service), Kay Beeley (National Park Service), Craig D. Allen (U.S. Geological Survey)

Spatial and Temporal Patterning of Pre-1900 Fire Scar Data, and Comparisons with Post -1970 Wildfires, in the Jemez Mountains, New Mexico

Building upon 30+ years of dendrochronological fire history research in the Jemez Mountains of northern New Mexico, we reconstruct pre-1900 spatial and temporal patterns of fire activity, and make comparisons to post-1970 wildfire and prescribed fire activity, across this landscape. We develop the pre-1900 patterns by compiling and analyzing the precise locational and seasonal fire information from >800 individual fire-scarred trees at >40 sites, particularly in the eastern half of the Jemez Mountains. Within-ring positions of individual fire scars are tied to season of paleo-fire occurrence by comparison

with 20+ years of weekly measurement data on local ponderosa pine tree growth across elevational gradients, as well as the relative within-ring positions of scars left by recent fires of known date. We compare these seasonal patterns between century, in and between sites, and across the elevational gradient. Pre-1900 widely spreading surface fires burned at ~ 5 - 20 year intervals, commonly extending broadly across landscape gradients from ponderosa/pinyon-juniper ecotone sites and canyon riparian zones up through open ponderosa forests and into mixed conifer forests and high-elevation montane grasslands. We highlight several years from the fire-scar record that can be considered “large fire years”, when fire scars were present in many sample sites. Local fire regimes have shifted strongly toward broad-scale stand-replacing fires since 1970; e.g., >15 fire-scar sites that documented high-frequency surface fire regimes pre-1900 were largely or completely consumed during recent high-severity fires.

116 **Haire, Sandra** (University of Massachusetts), shaire@eco.umass.edu

Sandra Haire (University of Massachusetts), Carol Miller (US Forest Service), Kevin McGarigal (University of Massachusetts)

Wilderness fire regimes: redefining sustainable ecosystems

Public land management policies now encourage more natural burning, but the implications of these practices for the concept of sustainability are unknown. Some wilderness areas have a history of natural burning practices that spans decades, thus providing the setting for a natural experiment. For three regions of the West, we investigated a continuous gradient of locations from outside to completely within wilderness. We sampled fire size data (1984-2007) across this gradient, generating a scaling parameter to reflect the relative contribution of large fires to structuring the data distribution of each sample. Size distributions differed along the gradient; large fires tended to be more important in structuring distributions within wilderness whereas smaller fires were predominant outside wilderness. This trend held for all three regions, but was strongest in the Northern Rockies and weakest in the Sierra Nevada. In the Southwest, seasonal precipitation, but not seasonal temperature, also influenced scaling of fire regimes; small fires played a greater role where winter precipitation was highest. Our findings suggest that landscapes with natural burning will be shaped in the future by more large fires relative to small ones, at least in the near term. In places where frequent, small fires are considered the norm, an increased frequency of large fires suggests the possibility of qualitative changes in ecosystem properties. As such, conventional definitions of sustainability may not apply to landscapes where fires are allowed to interact with each other and the environment.

235 **Haire, Sandra** (University of Massachusetts), shaire@eco.umass.edu

Sandra Haire (University of Massachusetts)

The importance of spatial heterogeneity in natural restoration: evidence from two southwestern sites

Fire events that include large areas of tree mortality are thought to be uncharacteristic in the Southwest. Indeed, we may be experiencing a shift to a new fire regime with unknown consequences for

plant communities. One aspect of the shift to large fires is the potential for greater heterogeneity in spatial patterns than was common under a fire regime characterized by frequent, low-severity fires. Two study sites that burned decades ago provided an opportunity to investigate the role of spatial patterns of burning in natural restoration of plant communities in general and ponderosa pine in particular: La Mesa (NM; 1977) and Saddle Mountain (AZ; 1960). We collected field data to quantify patterns of succession and forest regeneration in 2005 and modeled their relationship to early post-fire spatial heterogeneity. Life history characteristics were central to understanding distribution of species and communities. Furthermore, spatial patterns of burning played a strong and persistent role in structuring regenerating ponderosa pine forests. These effects were significant even after consideration of subsequent disturbance and other environmental variables. Analysis of tree ages at the two sites revealed similar patterns of slow progress in early post-fire years. On the other hand, successful regeneration occurred after both fires and evidently employed multiple strategies for dispersal. Process centered restoration efforts could utilize our findings in formulating reference dynamics under a changing fire regime.

210 **Hall, Wesley** (USDA Forest Service / Northern Arizona University), wahall@fs.fed.us

Wesley Hall (USDA Forest Service / Northern Arizona University), Andrea Thode (Northern Arizona University)

Using the Forest Vegetation Simulator to Model Crown Fire Potential for Proposed Restoration Treatments: An Analysis of the Four Forest Restoration Initiative

Recent large wildfires in Arizona, such as the Wallow and Rodeo-Chediski fires, have had some negative social and ecological impacts due to high intensity crown fire in ecosystems dependent on frequent surface fires. Large, landscape-scale restoration projects and treatments, such as those proposed under the Four Forest Restoration Initiative, are attempting to restore ponderosa pine ecosystems to more historical condition. Since the effects of these treatments are largely unknown, analyses are often left to computer modeling. This study uses the Forest Vegetation Simulator to determine fuel treatment effectiveness by evaluating torching and crowning indices as measures of crown fire potential. Long term treatment effectiveness was evaluated by creating a maintenance interval in which prescribed fire is repeated over time in order to sustain low crown fire potential. Modeling results for eight different scenarios that consist of combinations of no treatment, uneven aged mechanical treatment only, uneven aged mechanical treatment with prescribed fire, and prescribed fire only will be presented and discussed. Additional research is needed to see how realistic the modeled results are with treatments on the ground.

123 **Halofsky, Jessica** (University of Washington), jhalo@uw.edu

Stephanie Hart (University of Washington), Miles Hemstrom (USDA Forest Service), Morris Johnson (USDA Forest Service), Joshua Halofsky (Washington Department of Natural Resources)

Simulating fire hazard across forested landscapes in Arizona and New Mexico through integration of the Vegetation Dynamics Development Tool (VDDT) and the Fuel Characteristic Classification System (FCCS)

Information on the effects of management activities such as fuel reduction treatments and of processes such as vegetation growth and disturbance on fire hazard can help land managers prioritize treatments across a landscape to best meet management goals. State and transition models (STMs), such as the Vegetation Dynamics Development Tool (VDDT), allow landscape-scale simulations that incorporate effects of succession, management and disturbance on vegetation composition and structure. STMs have been used for many different types of landscape-scale assessments. However, STMs such as VDDT do not currently assess fuels and fire hazard for different vegetation states. We integrated VDDT with a software application called the Fuel Characteristic Classification System (FCCS) to enable assessment of fuel properties and fire hazard with succession, disturbance, and management across landscapes over time. We created FCCS fuelbeds from inventory plots for each vegetation state in VDDT models covering forested ecosystems in Arizona and New Mexico and analyzed their potential fire behavior. Linking the fuelbed analysis for VDDT states with output from VDDT simulations allowed us to address a number of research and management questions, including: 1) How do fuel characteristics vary at the mid-scale (from sub-watershed to regional scales) across forested ecosystems in Arizona and New Mexico?; 2) How do different forest management scenarios affect fuel conditions and fire hazard across a given landscape?; and 3) To what extent can fuel treatment programs reduce fire hazard?

216 **Halofsky, Joshua** (Washington State Department of Natural Resources), joshua.halofsky@dnr.wa.gov

Joshua Halofsky (Washington State Department of Natural Resources), Miles Hemstrom (Pacific Northwest Research Station)

Integrating vegetation growth, natural disturbances, and management in an Arizona landscape

Working with federal, state, and university partners, the Integrated Landscape and Assessment Project is building consistent vegetation maps and models across all lands in Oregon, Washington, Arizona, and New Mexico. The intent of the project is to examine how current and alternative management scenarios interact with natural disturbances and climate change to affect future vegetation, timber volume, fuel potential, and wildlife habitat, among other variables. In this presentation we examine the effects of no management and active management scenarios on wildfire severity and vegetation structure in a 3.6 million hectare area of the Sky Islands spanning forest, woodlands, and arid lands. Early results indicate a decrease in dense forest and a lowering in area burned under high and mixed severity wildfires under the restoration scenario. Perhaps as importantly, the restoration scenario decreased the variation in area burned by wildfires. Additional results, and whether the restoration scenario met the goals of different partners, will be discussed.

264 **Hamilton, Robert** (The Nature Conservancy), bhamilton@tnc.org

Robert Hamilton (The Nature Conservancy)

Application of the fire-grazing interaction model for conservation in the tallgrass prairie of Oklahoma

The 1.5M ha Flint Hills of Kansas and Oklahoma comprise the largest tallgrass prairie landscape in North America. Fire is regularly applied by ranch managers across a sizable portion of this privately-owned landscape. Grazing regimens typically stress uniformity which combined with high fire frequency result in a largely homogeneous landscape with lowered biodiversity potential. Increasing landscape heterogeneity is a goal of The Nature Conservancy (TNC) in the Flint Hills. The first step in addressing the landscape homogeneity concern has been development and demonstration of biodiversity-focused range management tools. At TNC's 16,100 ha Tallgrass Prairie Preserve in northeastern Oklahoma, a free-ranging bison herd has for the past 18 years interacted with randomly selected burn patches that approximate historic seasonality and frequency of fire. Currently, 2,700 bison graze on 9,600 ha of tallgrass prairie and crosstimbers woodlands. The fire-bison interaction produces a vegetative structural and compositional heterogeneity in an ever-shifting landscape patch mosaic. Realizing that a fire-bison regime is not likely to be highly exportable to the private ranching sector, TNC has been working with Oklahoma State University in the development of "patch-burn grazing" regimes that promote heterogeneity using cattle. Over 4,600 ha at the Tallgrass Prairie Preserve is dedicated to cattle patch-burn grazing research and demonstration. Research results have been encouraging: heterogeneity and biodiversity can be enhanced with little or no decrease in livestock production. Strategies will be discussed that are being utilized to promote heterogeneity-focused range management practices on private rangelands in the Flint Hills.

121 **Hoffman, Chad** (Colorado State University), C.Hoffman@colostate.edu

Chad Hoffman (Colorado State University), Carolyn Sieg (USDA Forest Service), Joel McMillin (USDA Forest Service), Pete Fule (Northern Arizona University)

Fuel loadings and predicted fire behavior five years after a bark beetle outbreak in Southwestern ponderosa pine forests

Landscape-level bark beetle outbreaks occurred in Arizona ponderosa pine forests from 2001-2003 in response to severe drought and suitable forest conditions. We quantified surface fuel loadings and depths, and calculated canopy fuels based on forest structure attributes in 60 plots established five years previously on five national forests. Half of the plots we sampled in 2007 had bark beetle-caused pine mortality and half did not have mortality. Adjusting for differences in pre-outbreak stand density, plots with mortality had higher surface fuels but lower canopy fuels five years after the outbreak compared to plots without mortality. Total surface fuels averaged 2.5-times higher and calculated canopy fuels 2-times lower in plots with mortality. Nearly half of the trees killed in the bark beetle outbreak had fallen within five years, resulting in loadings of 1000-hr woody fuels above recommended ranges for dry coniferous forests in 20% of the mortality plots. Fire behavior analyses using NEXUS

suggest that crown fire hazard was not higher in mortality stands despite 2.5 times higher surface fuel loadings 4-5 years after mortality occurred due mainly to increased canopy base heights. Given recent trends of increased tree mortality and projected climate warming, we can expect that bark beetle outbreaks may have increasing impacts on fuel complexes and thus perhaps fire hazard. However, research to date suggests that alterations to fuels complexes are highly variable and depend on local site factors as well as forest type, species of bark beetle involved, and time since outbreak.

126 **Hunter, Molly** (Northern Arizona University), molly.hunter@nau.edu

Molly Hunter (Northern Arizona University)

Effectivness of buffelgrass control treatments in southern Arizona

Buffelgrass (Pennisetum ciliare, syn. Cenchrus cilaris) is an invasive grass species that poses a critical threat to native plant and animal communities in southern Arizona. This species threatens the Sonoran Desert primarily through its potential to serve as a fuel source for wildfires and due to its ability to out-compete native plant species. It poses a major threat to the economy of the area and to personal safety and private property within the growing wildland urban interface. Due to its potential to transform the nearly fire-proof Sonoran Desert into a savanna with a cyclic fire regime, buffelgrass has been the focus of regional and local interagency groups that have been organized to control its spread in southern Arizona. Over the past decade, control efforts have accelerated. Many chemical and manual treatments on public and private lands by employees of the various agencies, roadside management crews, landscape contractors, and volunteers have met varying degrees of success. The purpose of this study was to evaluate effectiveness of treatment techniques for buffelgrass as well as environmental factors that determine success or failure of buffelgrass control efforts. The focus of the project is past treatments in Saguaro National Park and to a lesser degree Organ Pipe Cactus National Monument. Buffelgrass control treatments were less effective on south-facing aspects and on steep slopes. Treatments were more effective in seasons with higher rainfall. Buffelgrass was effectively controlled when multiple treatments occurred in consecutive seasons and when both manual and chemical treatments were used.

244 **Iniguez, Jose** (US Forest Service), jiniguez@fs.fed.us

Jose Iniguez (US Forest Service), Jeff Jenness (Jenness Interprises), Ellis Margolis (University of Arizona)

2011 Fire Season: An overview

The 2011 Southwest wildfire season was unprecedented in the instrumental record in terms of individual fire size, total area burned and single-day high-severity runs. However, like all natural systems it was highly variable. In addition to fire size and severity, the 2011 fires were unique because they burned across a range of vegetation types and recent “treatments,” including mechanical treatments, natural and prescribed fires. Moreover some of these fires re-burning areas for the 4th time in recent decades. To better understand the variability in the ecological impact of these fires we selected the four

largest fires including the Miller (in the Gila NF), Horseshoe 2 (in the Coronado NF), Wallow (in the Apache-Sitgreaves and Gila NF) and Las Conchas fire (in the Santa Fe NF). Within each fire we analyzed fire severity distribution across a number of factors including elevation, slope, aspect, treatment history, recent fire history, and vegetation type. The results suggest there was a burn severity gradient ranging from minimal high burn severity in the Miller fire to more than 30% high severity in the Las Conchas fire.

256 **Iniguez, Jose** (USFS), jiniguez@fs.fed.us

Jose Iniguez (USFS), Ellis Margolis (University of Arizona)

Ponderosa pine spatial patterns in relation to recent burn history in the Gila Wilderness, NM

Historically frequent fire in Southwestern ponderosa pine forests played a role in determining the density and spatial patterns of trees. Fire exclusion over the last century has changed forest density and likely spatial patterns, primarily through infill of young trees. Spatial patterns are increasingly becoming an important variable in forest restoration as it is debated whether fire alone can restore forest structure. Limited studies described the historical spatial structure as clustered ("clumpy-groupy"), but the range of variability of spatial patterns is poorly documented due to limited old-growth reference forests. Our objective was to quantify tree density and spatial patterns in ponderosa pine forests that burned 0-3 times since 1900 and compare them with historical conditions. In an unlogged wilderness area on the Gila National forest we stem mapped all trees and aged a representative sample at 45 plots (40 m^2 plot size) with different recent burn histories. In total we mapped over 5,000 trees and aged over 2,000 trees using standard tree-ring methods. In some plots recent fires have resulted in forest densities similar to historical conditions. Trees were clustered at most plots, however there were differences in the scale and size of clusters depending on recent fire history. These results suggest that ponderosa pine restoration both in terms of tree densities and spatial pattern can be achieved using fire.

136 **Ireland, Kathryn** (Northern Arizona University), kbi3@nau.edu

Kathryn Ireland (Northern Arizona University), Amanda Stan (Northern Arizona University), Peter Fule (Northern Arizona University)

Bottom-up control of a northern Arizona ponderosa pine forest fire regime in a fragmented landscape

Fire regimes often vary at fine spatial scales in response to factors such as topography or fuels while climate usually synchronizes fires across broader scales. We investigated the relative influence of top-down and bottom-up controls on fire occurrence in ponderosa pine (Pinus ponderosa) forests in a highly fragmented landscape at Mount Dellenbaugh, in northwestern Arizona. Our study area of 4,000 ha was characterized by patches of ponderosa pine forest in drainages that were separated by a matrix of pinyon-juniper woodlands, sagebrush shrublands, and perennial grasslands. We reconstructed fire histories from 135 fire-scarred trees in sixteen 25-ha sample sites placed in patches of mature ponderosa forest. We found that, among patches of ponderosa forest, fires were similar in terms of

frequency but highly asynchronous in terms of individual years. Although climate did not synchronize fire across the landscape, it did show a relationship to fire occurrence. Most fires were associated with dry years and La Niña events that were preceded by several wet years and El Niño conditions. The remarkable level of asynchrony suggests that bottom-up factors, such as site productivity and fuel continuity, were more important in regulating fire at Mount Dellenbaugh.

312 **Irwin, Emily** (USDA-Forest Service SW Region), eirwin@fs.fed.us

Josh Hall, Emily Irwin (USDA-Forest Service SW Region)

Fire Season 2011 - Smoke Impacts and Coordination

For several months during 2011, wildfires throughout the Southwest Area and Mexico caused air quality impacts on public health across the region, with significant impacts measured hundreds of miles away from individual wildfires. In order to address the emerging issue, a concerted multi-state interagency air quality coordination effort was initiated. This effort resulted in clear, concise and consistent messages on potential smoke impacts to the public as well as information on the level of current impacts and how the public can protect itself when impacted by wildfire smoke. These levels of coordination and the concerted effort were unprecedented at the time. Experts across a variety of fields and agencies participated in this coordination effort. Modeling support included fire behavior models in Wildland Fire Decision Support System (WFDSS) which was used to inform BlueSky smoke emissions modeling. In combination, these were used to predict and inform the public on potential smoke emissions. Numerous smoke monitors were deployed to supplement the existing network and this data was analyzed to validate the models and inform the public and public health officials of the magnitude of impacts in various communities. Cooperators were briefed daily on modeling results and monitoring data which was used to develop products for the public, Health Departments, Incident Management Teams, media, and Agencies to inform issuance of health alerts, news releases, and communicate smoke impacts. Lessons learned included the importance of early coordination efforts with key partners, consistent messaging, deployment of equipment, and the utilization of decision support tools. In the Southwest Area and Nationally there are multiple opportunities to build from this effort, to increase the capability and capacity on multiple fronts including, communications ,networking, monitoring, decision support, smoke modeling, and public health impacts from acute exposure to smoke.

222 **Jaramillo-Scarborough, Anna** (USDA Forest Service), ajaramillo@fs.fed.us

Anna Jaramillo-Scarborough (USDA Forest Service)

Overview of Fires of 2011 and Implementation of Burned Area Emergency Treatments

The fires of 2011 in Arizona and New Mexico were historic in their size, intensity and burn severity. To date, 3,747 wildland fires have burned and consumed over two million acres between the two states. While many wildfires cause minimal damage and pose few threats to the land or people downstream, some fires require special efforts to prevent additional problems. Loss of vegetation exposes soil to

erosion; water runoff may increase and cause flooding; sediments may move downstream and damage houses or fill reservoirs, putting drinking water supplies or endangered species at risk. Given the large acreage and the post-fire conditions, land managers in these states requested emergency funding for emergency stabilization of these burned areas. The Burned Area Emergency Response (BAER) program is one such program utilized by agencies from the Department of Interior and the Forest Service. The BAER program addresses these situations with the goal of managing the post-fire risk to human life and safety, property, and critical natural or cultural resources. There are a variety of stabilization treatments that may be recommended. Hillslope treatments, such as reseeding with quick-growing or native species or mulching with straw or wood shreds are common. Modifications of road and trail drainage features by enlarging or removing culverts to allow drainage to flow freely and adding additional drainage dips or constructing emergency spillways may keep roads and bridges from washing out during floods. Protection measures such coordinating with other agencies on early warning systems, public closure of unsafe areas, removing specific hazards and posting warning signs are also employed.

311 **Kann, Deirdre** (National Weather Service Albuquerque), deirdre.kann@noaa.gov

Deirdre Kann (NOAA/National Weather Service), J. Brent Wachter (NOAA/National Weather Service)

The Buildup to the New Mexico Wildfire Season of 2011: Climate Variability and Synoptic Regimes supporting Enhanced Fuel Loading and Extreme Fire Growth

The 2011 New Mexico wildfire season was the most active on record. The most extreme event of the 2011 season was the Las Conchas Fire, which grew to 40,000 acres in the first burn period and ultimately became the largest wildfire in New Mexico history. While the growth of this fire and others could be considered unprecedented, in many respects it was months in the making. Several variables ranging from multiseasonal to synoptic time scales contributed. Wide swings in the ENSO cycle, monsoon precipitation and a historic cold air outbreak during the months preceding spring and early summer of 2011 initially contributed to the intensity and duration of the fire season. By early June most of the state was dominated by severe to exceptional drought as New Mexico's driest calendar year on record was underway. Dry conditions were exacerbated by numerous wind events, supported by unstable conditions that contributed to unusually high mixing depths and atmospheric instability that supported extreme fire growth. This paper will first highlight the various climatic factors that led to this historic wildfire season, including the "priming" of the fuels. Next, we describe how the Las Conchas fire and others developed under near perfect atmospheric conditions for extreme fire growth. Climate variability, its subsequent effect on fuels, and extreme atmospheric conditions all combined to produce an historic fire season, in terms of both the number of fires and acres burned.

134 **Kennard, Deborah** (Colorado Mesa University), dkennard@coloradomesa.edu

Deborah Kennard (Colorado Mesa University)

Fire history and spatial structure of a persistent piñon-juniper woodland in the Colorado National Monument, CO

The Colorado National Monument, on the northeastern edge of the Uncompahgre Plateau, supports a persistent piñon (Pinus edulis Engelm.)–juniper (Juniperus osteosperma (Torr.) Little) woodland, which has not been disturbed by large stand-replacing fires since modern fire records began. We examined the fire history of large (> 100 ha) stand-replacing fires, documented tree population structures, and characterized spatial patterns of tree density, quadratic mean diameter (QMD), relative composition, and cumulative mortality using 431–100 m2 plots distributed over 1600 ha of the Monument. We found no evidence of large stand-replacing fires (charred wood or truncated stand structures) in the study area. Based on size–age relationships, stand ages suggest that large stand-replacing fires have been absent for possibly a millenia. Tree population structures show a more stable stand structure for juniper; piñon pine population structures show a more recent and sustained regeneration pulse. Cumulative mortality of piñon pines was 18%, peaking at 47% in trees 20–24.5 cm diameter. Spatial patterns of juniper density, QMD, and mortality were more homogeneous than those of piñon pine. Results suggest temporal dynamics and spatial patterns of the COLM woodland are more influenced by drought than large fires. This study provides important baseline data for changes that may be brought about by climate change in coming decades. It also stresses the importance of controlling cheatgrass and other invasive species to increase resistance of these piñon–juniper woodlands to future fires.

112 **Kitzberger, Thomas** (Universidad Nacional del Comahue), Argentina

Thomas Kitzberger (Universidad Nacional del Comahue), Donald Falk (University of Arizona), Thomas Swetnam (University of Arizona), Anthony Westerling (University of California, Merced)

Climate and snowpack interactions regulate annual area burned across western North America

Warming temperatures have been identified as triggering factors for increased fire activity over certain regions of North America but a more complete geographic assessment of climate-modern fire influences is needed in order to make more informed predictions of future fire activity under climate change scenarios. Snowpack duration can influence fire activity and area burned directly by regulating the provision of water to soils and plants; conversely, earlier snowpack melt may simply manifest drier and warmer springs which desiccate fuels irrespective of snowpack. We analyzed area burned data for the western US and most of Canada for 1972-2004, and compared these with seasonal temperatures, precipitation, and snowpack duration. A strong increasing trend exists in annual area burned over the 34-year period of record. Snow cover duration has declined over most of North America during this period, particularly in the west. Seasonal temperatures are higher in all seasons analyzed (winter, spring, summer) across most of the continent. Trends in seasonal precipitation are more geographically variable. We used Path Analysis to segregate direct and indirect influences of seasonal temperature and precipitation, and snowpack duration on annual area burned in 2.5 degree grid cells. Spring temperature has an important effect on snow cover duration at high latitudes across boreal North America, whereas

winter temperature and precipitation affects snow cover duration at mid latitudes and lower altitudes. We used the IPCC Fourth Assessment SRES Ensemble Scenario A1B to project future values of key drivers of snowpack and annual area burned to AD 2040.

147 **Klinger, Robert** (USGS), rcklinger@usgs.gov

Matt Brooks (USGS), Randy McKinley (USGS)

Long-term effects of burn severity and fire frequency on vegetation and seedbanks in the Mojave Desert

Most published information from the Mojave Desert has focused on short-term effects of fire, but it is the long-term trajectory of plant communities that management plans are designed to influence. In this presentation we compare vegetation structure, species composition, and diversity of aboveground vegetation and the soil seedbank in unburned areas and areas that burned 3 to 35 years ago. We evaluate these patterns across a range of fire frequency (1 – 3 burns), burn severity classes (low to high) and among different vegetation types (low to high elevation zones), and interpret these patterns relative to traditional deterministic succession theory and more recent metacommunity theory. Initial analyses indicate that vegetation structure often returned to levels similar to that in unburned conditions but species composition did not. There was a high degree of heterogeneity in species composition and diversity among areas, primarily along gradients of fire frequency, fire severity, and elevation zone. Areas that burned once but at high fire severity or burned multiple times tended to be characterized by persistent changes in plant community composition and tended to be dominated by non-native annuals with relatively low levels of woody and herbaceous diversity. Non-native annuals occurred in a very high proportion of soil seedbank samples across all elevation zones, including unburned areas. The critical findings in this study are: (1) a grass-fire cycle is not necessary for transitions of previously native dominated woody vegetation communities to non-native herbaceous dominated communities; and, (2) metacommunity processes will frequently result in multiple alternative vegetation states.

241 **Knudson, Gina** (Salmon Valley Stewardship), ginaknudson@salmonvalley.org

Gina Knudson (Salmon Valley Stewardship)

Getting to Possible: Stale Myths and Fresh Realities of Collaborative Conservation on Public Lands

Gina Knudson is the director of Salmon Valley Stewardship, a nonprofit based in Salmon, Idaho, and a partipant in the Rural Voices for Conservation Coalition. Since its inception in 2006, she has coordinated the Lemhi County Forest Restoration Group, a collaborative effort with partners from the Salmon-Challis National Forest and the Salmon Field Office Bureau of Land Management. The group met in the wake of the 2000 Clear Creek fire and an array of appeals halting Forest Service fuels reduction projects that left the community and agency feeling hopeless. The collaborative's first 13,000-acre fuels reduction project went unchallenged and is in its 3rd year of implementation. Meanwhile, the group's second project – a

more ambitious 40,000-acre forest restoration project – is midway through the NEPA process. The Central Idaho collaborative has confronted and occasionally conquered myths about FACA, collaborating throughout the NEPA process, involvement in contracting, and the value of citizen-based monitoring. Gina believes that communities can and should be deeply involved in creating better public lands management projects and will offer insight into how individuals and small NGOs can help large bureaucracies navigate "the possible" of collaboration.

117 **Korb, Julie** (Fort Lewis College), korb_j@fortlewis.edu

Julie Korb (Fort Lewis College), Peter Fule (Northern Arizona University), Rosalind Wu (San Juan National Forest)

High variability of mixed conifer forests in southwestern Colorado, USA: implications for ecological restoration

We established three study sites across a west-east transect of the San Juan National Forest, Colorado to address the following questions: (1) How variable was the historical fire regime and fire-climate relationships in warm/dry mixed conifer across this west-east transect? and (2) how diverse is extant warm/dry mixed conifer forest composition and structure along the same west-east transect? At each study site we collected cross-sections from dead fire-scarred trees to reconstruct fire history. We also established 25 study plots on a 300 m grid per study site to characterize forest structure and vegetation (total N = 3 sites X 25 plots = 75 plots). The three warm/dry mixed conifer sites exhibited markedly different fire histories shaping forests with distinct age structures and species compositions. One site was characterized by numerous smaller fires as well as larger fires that appeared to burn most of the study site with the other two study sites characterized by synchronous, relatively infrequent large fire events. Overall forest composition and structure were statistically different among the three study sites. Age distributions showed that tree establishment was dominated by ponderosa pine prior to 1870 but other conifers and aspen established strongly and consistently through most of the decades after 1870 for all three study sites. Our findings demonstrate the need to develop site-specific reference conditions and for managers to exercise caution when extrapolating fire regimes and forest structure from one geographic locality to another given a projected warmer climate making conditions more favorable to frequent, large wildfires.

332 **Krasilovsky, Eytan** (Forest Guild), eytan@forestguild.org

Eytan Krasilovsky (Forest Guild)

Appropriately Scaled Forest-based Collaboratives Aid in Returning Fire to Landscapes

Collaborative groups and organizations can be powerful partners to assist with mechanical thinning in advance the reintroduction of fire, completing regulatory compliance, and bringing financial resources to bear on the challenge of meeting fire manager's goals. In isolation, agencies may face insufficient financial and personnel capacity to plan and prepare for the reintroduction of fire at a meaningful scale.

In addition agencies may face resistance from citizen groups. Working in partnership with forest-based collaboratives can have many benefits and can even accelerate the reintroduction of fire in a realistic time-frame. However, there are challenges to working with collaborative groups that are often centered on funding, group structure and dynamics, landscape and resource priorities, facilitation, transparency, and attrition over time. This presentation will highlight the benefits and challenges associated with pursuing collaborative forest management by drawing upon three examples from central and northern New Mexico, covering differing scales and jurisdictions.

266 **Limb, Ryan** (Oregon State University), ryan.limb@oregonstate.edu

Ryan Limb (Oregon State University), Samuel Fuhlendorf (Oklahoma State University), David Engle (Oklahoma State University), John Weir (Oklahoma State University)

Attracting Ranchers to Heterogeneity Management with Patch Burning: Livestock Performance with the Fire-grazing Interaction

Achieving economically optimum livestock production on rangelands can conflict with conservation strategies that require lower stocking rate to maintain wildlife habitat. Combining the spatial and temporal interaction of fire and grazing (pyric-herbivory) is a conservation-based approach to management that increases rangeland biodiversity by creating heterogeneous vegetation structure and composition. However, livestock production under pyric-herbivory has not been reported. In both mixed-grass prairie and tallgrass prairie, we compared livestock production in pastures with traditional fire and grazing management (continuous grazing, with periodic fire on tallgrass prairie and without fire on mixed-grass prairie) and conservation-based management (pyric-herbivory applied through patch burning) at a moderate stocking rate. Stocker cattle weight gain, calf weight gain and cow body condition score did not differ ($p > 0.05$) between traditional and conservation-based management at the tallgrass prairie site for the duration of the eight-year study. At the mixed-grass prairie site, stocker cattle gain did not differ in the first four years, but stocker cattle gained more (p ? 0.05) on conservation based management and remained 27% greater for the duration of the eleven-year study. Moreover, variation among years in cattle performance was less on pastures under conservation management. Traditional management in mixed-grass prairie did not include fire, the process that likely was associated with increased stocker cattle performance under conservation management. We conclude that pyric-herbivory is a conservation based rangeland management strategy that returns fire to the landscape without reduced stocking rate, deferment, or rest.

242 **Lindblom, Sam** (The Nature Conservancy), slindblom@tnc.org

Sam Lindblom (The Nature Conservancy)

Collaboration gets fire on the ground faster and better

Sam Lindblom directs the Land and Fire Management programs for The Nature Conservancy in Virginia. Sam has been a leader in a collaborative (Allegheny Highlands Fire Learning Network) that started from

applying fire on a 9,000 ac Conservancy preserve to planning and implementing fire and fire science across a multi-partner landscape of almost 600,000 acres in the Allegeny Highlands. Along the way, he and his state and federal partners created tools and relationships to allow them to put fire on the ground together, sharing resources and expertise to accomplish more than any one individual organization could. Sam will talk about his experience developing partnerships in a political, planning, and operational setting. Additionally, he will describe the barriers that had to be overcome, and what it takes to break through resistance to conducting fire across, not only administrative boundaries, but also across different operational styles, rules and traditions

221 **Luehring, Penny** (U.S.D.A. Forest Service), pluehring@fs.fed.us

Penny Luehring (USDA Forest Service)

Burned-Area Emergency Response Program- Policy and Procedures

Five federal land management agencies (BLM, BIA, NPS, USFWS, and FS) manage similar Burned Area Emergency Response (BAER) programs. The BAER program provides for rapid assessment and immediate response actions to manage risks to life, property and critical natural and cultural resources on federal lands resulting from post-wildfire related threats. Policies and procedures of the BAER program and the differences between BAER and long-term post-fire rehabilitation and restoration programs will be discussed.

135 **Margolis, Ellis** (University of Arizona), ellisqm@ltrr.arizona.edu

Ellis Margolis (University of Arizona)

Fire history to guide restoration at the piñon-juniper/ponderosa pine ecotone

Piñon-juniper (PJ) covers approximately 8 million hectares in Arizona and New Mexico, but there is little data describing the historical role of fire, particularly for PJ savannas. The goal of my research was to reconstruct the history of fire and forest structure on a 30,000 ha mesa landscape at the PJ/ponderosa pine (PIPO)/grassland ecotone. I collected fire scars and quantified forest structure in plots with approximately 7-km spacing. Half of the plots were PIED-dominated and half were PIPO-dominated. From 70 trees (11% PIED and 87% PIPO) I crossdated 401 fire scars that burned during 90 unique fire years (1546-1899). Most fires occurred in the late-spring-early summer. Mean fire interval (MFI) of all fires was 4.35 years. This is similar to the seasonality and frequency of lightning ignitions in the study area in recent decades (87% April – July, MFI = 2.0 years, 1973 -2009). MFI of fires recorded by > 25% of the trees was 24.85 years, which is interpreted as the frequency of widespread fires having an estimated fire area greater than 4,000 ha based on simulated historical fire perimeters. Evidence of high severity fire (e.g., even-aged cohorts coinciding with fire scar dates) was not observed. Instead, variability in PIED and PIPO tree establishment was negatively correlated fire frequency. I conclude that frequent, low-severity fires maintained a relatively open structure in both the PJ and PIPO forest and late 19th century fire cessation resulted in the current structure dominated by young PJ species (< 100 years old).

148 **Matchett, J. R.** (USGS Yosemite Field Station), jmatchett@usgs.gov

J. R. Matchett (USGS), Robert Klinger (USGS), Matthew Brooks (USGS)

Is seeding an effective postfire mitigation tool in the Mojave Desert?

Aerial seeding is one of the oldest tools used by land managers to manage postfire landscapes in western North America. The primary purpose of seedings in forests and mesic shrublands has been to stabilize slopes, but recent studies indicate that they are mostly ineffective for that purpose. In contrast, the primary purpose of seedings in arid and semi-arid shrublands has been to provide livestock forage, and more recently to compete with and suppress invasive annual grasses, but studies evaluating their efficacy in achieving these objectives have yet to be done in the Mojave Desert. Desert ecosystems are water limited, and before questions related to ultimate effects can be addressed, the simple question of whether or not seedings can even establish must be answered. In this presentation, we describe establishment rates of from aerial seedings in the short (1-3 year) and longer term (2-16 year) in the eastern Mojave Desert. Preliminary results indicate that over the past two decades there are extremely low establishment rates of seeded species, both in the short and longer-term following fires in this region.

262 **McGranahan, Devan** (Sewanee: The University of the South), damcgran@sewanee.edu

David Engle (Oklahoma State University), Samuel Fuhlendorf (Oklahoma State University), Stephen Winter (US Fish and Wildlife Service), James Miller (University of Illinois)

Grazing, invasive grasses reduce fire spread and decouple fire and grazing interaction

Many rangelands evolved under an interactive disturbance regime in which grazers respond to the spatial pattern of fire and create a patchy, heterogeneous landscape. Several studies report that spatially-heterogeneous fire and grazing create landscape-level vegetation heterogeneity (patch contrast) and increase rangeland biodiversity versus grazing under spatially-homogeneous fire regimes. In this meta-analysis of five experiments comparing spatially heterogeneous fire treatments to spatially homogeneous fire treatments on grazed rangeland in the North American Great Plains, we compared patch contrast across pastures managed for heterogeneity and pastures managed for homogeneity. We used a linear mixed-effect regression model that partitioned variation in vegetation structure, a measure of patch contrast. We also use a meta-analytical statistic to calculate an effect size for patch contrast at each location. Management for heterogeneity increased spatial heterogeneity in vegetation structure and increased the range of plant functional group composition at three of the five experimental locations. Plant functional group composition varied in proportion to the amount of spatial heterogeneity in vegetation structure on pastures managed for heterogeneity. Management for heterogeneity created landscape-level heterogeneity in vegetation across a broad range of precipitation and plant community types, but management for heterogeneity did not universally create patch contrast. Stocking rate and invasive plant species are key regulators of heterogeneity-based

management, as they determine the influence of fire on the spatial pattern of fuel, vegetation structure and patch selectivity by large herbivores.

142 **McKinley, Randy** (USGS EROS), rmckinley@usgs.gov

Randy McKinley (USGS EROS), Matthew Brooks (USGS WERC), Robert Klinger (USGS WERC)

Recent Fire Trends in the Mojave Desert

The number of fires and area burned since 1990 may be the most in the historic record extending back to the late 1800s. Recent trends (1972-2007) include an increasing number of large fires (>1,000 acres) per year and increased area burned by these large fires per year. Large fires account for approximately 93% of all area burned during this period. Trends were strongly influenced by the extreme fire years of 2005 and 2006 when the amount of area burned eclipsed the cumulative area burned since 1972, peaking in 2005 when area burned was 52 standard deviations above the annual mean. Those two years had a major influence on the fire statistics for number of fires and total area burned in the current 1972-2007 analyses. When 2005 and 2006 were excluded from the current analyses the number of fires and total area burned showed an increase from 1972 to the mid-1990s followed by a downward trend. Percent of burned area that was high severity was generally lower during the 1972 to 1983 period, and higher during the 1984 to 2007 period, although the overall trend was not significant. Approximately 10% of the area burned represented the reburning of lands that had burned earlier in the time period. Most burned and reburned areas occurred in the eastern Mojave Desert, primarily within southern Nevada. These observations are based primarily upon historical fire data for Lincoln and Clark counties in Nevada. Work is in progress to expand analyses to the full Mojave bioregion.

224 **Metzger, Mandy** (Coconino County), mmetzger@coconino.az.gov

Mandy Metzger (Coconino County)

Public Perception During and in the Wake of Forest Fires and Floods

Serving as a Coconino County Supervisor in a time of multiple natural disasters made me keenly aware of the complexities of post-fire rehabilitation when numerous landowners, interested parties and agencies with diverse missions are involved. The 2010 Schultz Fire burned largely on U.S. Forest Service property, but the impacts were acutely felt across intermingled federal, state, and private lands. In the first phase of the devastation, homeowners were shocked by the wildfire. That shock then turned to fear and grief as post-fire floodwaters ravaged the landscape and claimed the life of a young girl. There was confusion on how to get valid, and timely, information and in general, there was a widespread sense of harm. The ensuing rehabilitation efforts involved differing permitting processes, confusion about which agency would take the lead on a given project, and never enough money to complete what needed to be done. Securing funding for private land rehabilitation was especially challenging. Most homeowners did not carry flood insurance and immediate post-flood policy purchases did not take effect for 30 days. How does a local government respond to the multitude of life and ecological

changing challenges that occur after a presidentially declared disaster? How does a community work through anger, gain hope and deal with the long-term changes that rehabilitation demands? The catastrophic event that struck our community continues to serve as a reminder for the importance of agencies and communities working together to shed light on ideas to heal both people and the land.

322 **Meunier, Jed** (Colorado State University), jedmeunier@hotmail.com

Jed Meunier (Colorado State University), William Romme (Colorado State University), Peter Brown (Rocky Mountain Tree-ring Research, Inc.)

Interaction of Fire, Climate, and Forest Structure in Northern Mexico

The 20th century was a period of profound changes in climate, land use, forest structure, and fires throughout most of western North America. While interest in climate-fire and land-use interactions has greatly expanded in the past decade the effects of fire suppression have hindered research progress, which depend in part on documenting fires that would have occurred in the absence of anthropogenic fire exclusion. We investigated fire history in the Sierra San Luis of northern Mexico, an area with a spectrum of 20th century land-use changes from control areas with little or no history of grazing or logging, to sites that were logged (1952-1954) and/or grazed (early 1930's). We analyzed recruitment dates for 589 crossdated tree cores from variable radius plots (n = 31) and collected fire scar samples within plots and opportunistically (n = 173). Weibull median fire intervals composited among sites representing different treatments (control, logged, grazed, logged and grazed) was 3.0 years (all fires) to 8.8 years (fires scaring 25% or more samples). Approximately 86 % of fire-scar intra-ring positions were in the middle earlywood, consistent with fire chronologies in the southwest U.S. with late summer monsoons. Recruitment patterns were bimodal with peaks around 1900 and 1950, possibly indicating influences of both climate (~1900) and changing land uses (mid 1900's). These data contribute to a better understanding of climate, fire, land-use interactions and are of particular value for fire history comparisons with the southwestern U.S due to close proximity of the Sierra San Luis.

333 **Mottek Lucas, Anne** (Greater Flagstaff Forests Partnership), mottekconsulting@infomagic.net

Anne Mottek Lucas (Greater Flagstaff Forests Partnership), Steve Gatewood (Greater Flagstaff Forests Partnership)

Collaborative Success in Project Planning, Implementation, Monitoring and Outreach

The Greater Flagstaff Forests Partnership (GFFP), one of the longest standing collaboratives in the country, formulated in 1996 in response to multiple stand replacing wildfires occurring around the City of Flagstaff. At this juncture, the political and social conditions were heated and the newly formed collaborative's main goal, to work with the Forest Service to restore the ecological integrity of 180,000 acres of forests and to protect the City of Flagstaff, was contested by many groups. Throughout the years, GFFP has initiated various projects and outreach programs to meet these goals and assisted in changing public perceptions that "all trees are good and all fire is bad." This presentation will focus on

events leading up to the formation of a community-based collaborative and key accomplishments that include three main areas: 1) Project planning and implementation, 2) Monitoring, and 3) Public education and outreach. Project planning and implementation will include the Community Wildfire Protection Plan, cost share grants for treating private lands, a gap analysis to locate areas of high priority, training operators to mark for all aspects of ecological restoration and success of treatments in reducing wildfire impacts of the more recent Woody and Hardy fires. Monitoring will encompass social surveys conducted with Flagstaff residents, a Prescribed and Wildfire Smoke and Health Study, and the Mountainaire II Partner Mark, where GFFP Partners demonstrated their vision of marking to meet multiple objectives of forest restoration. Lastly, the education/outreach components will outline successes in media releases as well as youth programs.

114 **Murray, Darrel** (Baylor University), Darrel_Murray@baylor.edu

Darrel Murray (Baylor University), Joseph D. White (Baylor University), Jian Yao (Baylor University), Carl Schwope (Balcones Canyonlands NWR)

Growth Response of a Deciduous Oak Species in Response to Drought and Fire

Drought drives changes in woody communities through direct effects on tree growth, changes in competition and fire, and overall cover changes at the landscape scale. In this study, we assess growth response of a deciduous oak species within a juniper-dominated woodland ecosystem in central Texas to changes in surrounding woody vegetation, climate, fire, and overall woody vegetation cover based on combining tree ring and multi-temporal aerial photographic data. We found no differences between average growth increment index values of tree samples with interpreted surrounding canopy loss and those with no loss. We found significant correlation between average growth increment index values and Palmer Drought Severity Index values for the time interval of 1939-78 and no correlation after 1978. We found significant differences between average growth increment index values for fire-scarred (1.39 ± 0.63) and non-fire-scarred (1.02 ± 0.36) tree samples. The period from 1950 to 1960 showed the highest amount of fire occurrence, coinciding with severe drought. The timing of changes in the mean growth increment index values and frequency of disturbance events indicated by fire scars and tree initiation was also coincident with drought years. Drought appears to be a strong driver of fire and subsequently oak growth and community change in juniper-oak woodlands. Changes in this community type may be linked to extreme climate events such as drought, which is important for predicted future climate variability.

138 **O'Connor, Christopher** (University of Arizona), oconnorc@email.arizona.edu

Christopher O'Connor (University of Arizona), Donald Falk (University of Arizona), Ann Lynch (University of Arizona), Thomas Swetnam (University of Arizona)

Fire, climate and human influences on forest dynamics along an elevational gradient

Studies of fire activity along elevational gradients provide an opportunity to examine how fire spreads among different species assemblages, and how climate, topography, and stand conditions influence fire behavior. We are examining spatial and temporal distributions of fire and dynamics of species assemblages in ponderosa-oak, mixed conifer, and spruce-fir forests of the Pinaleño Mountains in southeastern Arizona. We are conducting dendroecological reconstructions of 55 fixed-radius plots spaced along a one kilometer grid distributed over the mountain range above 2,134 meters elevation. Within and around the plots, we systematically sampled trees with fire scars. Preliminary results from 1,180 plot-trees and 156 fire-scarred trees, suggest distinct differences in fire frequency and severity in adjoining forest types until approximately 1900. Twentieth century fires have been infrequent and severe in all forest types. Prior to 1900, seedling recruitment similarly followed distinct patterns in each forest type, likely related to localized disturbance conditions. Post 1900 seedling recruitment shows synchrony among low and high elevation forest types, suggesting climate or other regional factors are now the major drivers of seedling recruitment, overwhelming stand-level controls. Synchronized seedling recruitment and suppression of fire has resulted in homogenized forest structure that may facilitate fire spread among forest types that maintained very different fire regimes for the past several hundred years. Formation of densely-stocked stands and conversion to a high-severity fire regime across the landscape has implications for drought stress, tree recruitment and longevity, future fire frequency, retention of species adapted to low-severity fire, and resistance to insect outbreaks.

232 **Oertel, Rebecca** (Valles Caldera National Preserve, USDA), rebeccaoertel@vallescaldera.gov

Rebecca Oertel (Valles Caldera National Preserve, USDA), Collin Haffey (Bandelier National Monument, National Park Service, DOI), Kay Beeley (Bandelier National Monument, National Park Service, DOI), Craig Allen (US Geological Survey, DOI)

Rapid Post-Fire Expansion of a Seeded Non-Native Grass (Bromus inermis) into a Ponderosa Pine Burn Mosaic

Historic fire regime changes in southwestern ponderosa pine (Pinus ponderosa) forests have been widely documented but little quantitative information exists regarding long-term vegetative recovery after modern high-severity fires, including the effects of post-fire seeding. Here we document major changes in ponderosa pine forest fire regime, stand structure, and post-fire vegetation composition and succession in the southeastern Jemez Mountains of New Mexico. Methods include dendrochronological fire history reconstructions (1600 A.D. – present), historical records, repeat photography, aerial photography (1935-2011), observations from the 1996 Dome Fire (16,500 acres, 40% stand-replacing fire) and the 2011 Las Conchas Fire, and 14 years of post-fire vegetation transect data including herbaceous and tree seedling responses. Results indicate that post-fire succession is being markedly altered due to expansion of an invasive exotic grass species, smooth brome (Bromus inermis), a

contaminant in the grass seed mix aerially applied after the Dome Fire. By 2008, large portions of the pre-fire ponderosa pine forest became a mixture of shrubland and grassland dominated by smooth brome. Through 2008, ponderosa pine seedling survival and establishment was low and native herbaceous vegetation was being out-competed by the smooth brome. These results demonstrate that the use of seed mixes after fire or logging may contribute to significant alteration of post-disturbance forest succession and ecosystem recovery, including increasing the potential for long-term type-conversion to non-forest vegetation and site dominance by non-native species.

146 **Ostoja, Steven** (USGS - Western Ecological Research Center), sostoja@usgs.gov

Steven Ostoja (USGS - Western Ecological Research Station), Robert Klinger (USGS - Western Ecological Research Station), Matthew Brooks (USGS - Western Ecological Research Station)

Short-term fire effects on vegetation and relationships to burn severity in the Mojave Desert

Land management agencies have Burned Area Emergency Response (BAER) and Emergency Stabilization and Rehabilitation (ES&R) programs designed to mitigate the detrimental effects of wildfires during the first 3 post-fire years. It is during this time that mitigation plans are developed, management actions are implemented, and effectiveness monitoring is begun. Postfire mitigation plans are often based on very limited information from the Mojave Desert, and often rely heavily on burn severity maps derived from satellite imagery. The problem is that vegetation response to fire can be variable, information on soil seedbank responses is almost non-existent, and there have been not attempts to directly link burn severity maps with actual fire effects on soil seedbank and/or vegetation. Unprecedented fires in 2005 and 2006 provided an ideal opportunity to evaluate fire effects across a wide range of environmental conditions which the results will be presented. Additionally our results suggest that burn severity maps derived from satellite-based dNBR values and on the ground-based CBI measurements can be significantly correlated with high severity fires which were associated with reduced cover of non-native annuals during the first post-burn year, and reduced seedbank density of non-native annuals during the second postfire year.

226 **Peppin, Donna** (NPS, Glacier National Park), donna_p3@hotmail.com

Donna Peppin (NPS, Glacier National Park), Peter Fulé (Northern Arizona University), Jan Beyers (USFS, Pacific Southwest Research Station), Carolyn Sieg (USFS, Rocky Mountain Research Station), Molly Hunter (Northern Arizona University)

Post-wildfire seeding in forests in the western US: An evidence-based review

Broadcast seeding is one of the most widely used post-wildfire emergency response treatments intended to reduce soil erosion, increase vegetative ground cover, and minimize establishment and spread of non-native plant species. However, the use of post-fire seeding treatments for achieving specified rehabilitation objectives remains debatable. We conducted an evidence-based review to examine the effectiveness and effects of post-fire seeding treatments on soil stabilization, non-native

species invasion, and plant community recovery in forests in the western U.S. We reviewed 94 scientific papers and agency monitoring reports identified using a systematic search protocol. The majority of studies (64%) evaluating soil erosion in seeded versus unseeded controls showed that seeding did not reduce erosion relative to unseeded controls and that seeded sites rarely supported sufficient plant cover to stabilize soils within the first and second year post-fire. Of the papers evaluating seeding effectiveness for curtailing non-native species invasions, an almost equal percentage found seeding treatments to be effective (54%) or ineffective (45%). However, the majority of the treatments regarded as effective and ineffective (83% and 80% respectively) used non-native species, some of which were annuals that persisted beyond the first year post-fire. A majority of studies (62%) reported that seeding suppressed recovery of native plants, although data on long-term impacts of this reduction are limited. A seeding treatment's ability to reduce soil erosion and/or affect native plant community recovery appears to be strongly driven by amount and timing of precipitation. In addition, long-term studies are needed to assess lasting impacts of seeded species.

345 **Pyne, Steve** (Arizona State University), stephen.pyne@asu.edu

Steve Pyne (Arizona State University)

Smokechased: Fire's American Century

2011 neatly marks an American century of fire. It begins with the Weeks Act of 1911, a response to big burns in the Northwest, which established an institutional infrastructure for American fire management. It ends with the National Cohesive Strategy, the latest iteration of that infrastructure, and with record fires in the Southwest. The dates provide ready-made historical bookends. How might we interpret the span of year between them? One narrative might be termed Patient Progress. It sees, despite setbacks, a century of advance. Another might be labeled Ironic Declension. It sees a century of two doomed enterprises, one of wholesale fire exclusion, followed by one of wholesale fire restoration. A third - my preference - imagines fire history as ever caught, and passing, between two flames. What counts is not a right answer because none exists, but how we deal with the particular fires of our time. The events of 2011 will thus likely be imagined as a test of character since that is finally the lesson of history.

246 **Reid, R. Kent** (NM Forest and Watershed Restoration Institute), rkreid@nmhu.edu

R. Kent Reid (New Mexico Highlands University)

Pre- and post-burn vegetation and fuels on Las Conchas

On Sunday 26 June 2011, the Las Conchas fire stared in the Jemez Mountains of New Mexico. On Tuesday 21 June, a monitoring crew from the NM Forest and Watershed Restoration Institute established three plots on a hillside that burned the first day of that fire. The plots measured the vegetation and fuel loading as part of a project to characterize the habitat of the Jemez Mountain Salamander. The plots were one-quarter acre fixed-radius, with three fuel transects per plot, and

special attention was paid to the down coarse woody debris. Data from the vegetation measurements show a historical transition from ponderosa pine and aspen to large ponderosa pine with a substantial component of mixed conifer. This case study demonstrates that the down coarse woody debris and ladder fuels meant that the old, large-diameter ponderosa pine on the site had no chance of surviving a fire of the intensity of Las Conchas. Pre- and post-fire photographs of the plots illustrate the fire effects.

341 **Reinarz, Joe** (Kaibab National Forest), jreinarz@fs.fed.us

Joe Reinarz (Kaibab National Forest)

Social and Environmental Impacts that Affect Fire Management in the Southwest

How has fire complexity affected our operational capability? How has the increased complexity changed the way we manage fires? What political, social and cultural changes are affecting Incident Management Teams? Do vegetation treatments affect management of large scale fires? Can landscape level treatments affect large fire growth and effects of large wildfires? Looking at historical data and the 2011 fire season, what has changed, and what does the future hold for large fire management?

247 **Ribe, Tom** (FUSEE), tribe@swadventures.com

Ribe Tom (FUSEE)

Cerro Grande, Fire Policy and the Mega Fires of 2011

My book "Inferno by Committee" examines the land use history, land management history and the fire management history of the Cerro Grande (Los Alamos) Fire of 2000. This was a National Park Service prescribed fire that went awry and burned onto US Forest Service lands and then into Los Alamos, New Mexico, home of the nuclear weapons lab at Los Alamos National Laboratory. At the time of the fire, federal agencies were operating under the 1995 National Fire Plan which proved to have serious holes and omissions revealed to receptive policy makers by Cerro Grande. The Cerro Grande Fire was perhaps the most investigated fire in recent history because there was so much controversy in professional circles about exactly what went wrong. Ultimately a Board of Inquiry was convened and that investigation resulted in an honest understanding of the fire's problems. The hasty and self-serving investigations ordered by the USDOI in an election year, and those done by the US Forest Service were then discounted. The Cerro Grande Fire ended up having a major impact on national fire policy and the way prescribed fires are planned and implemented. Though there were no fatalities associated with Cerro Grande, the fire is estimated to have cost $1 billion in property losses and costs to agencies including the US Department of Interior. I propose to offer a review of the prescribed fire and its management and then the suppression efforts that followed its declaration as a wildfire and then the main federal policy changes that came from the lessons learned at Los Alamos. This same area experienced the Las Conchas Fire in July 2011, one of the “mega-fire” that plagued New Mexico and Arizona this year. I will offer a comparison of the two fires in terms of fire effects, weather differences and the effects of drought.

127 **Rideout-Hanzak, Sandra** (Texas A&M University-Kingsville), sandra.rideout-hanzak@tamuk.edu

Sandra Rideout-Hanzak (Texas A&M University-Kingsville)

Heat and Smoke Effects on Germination of Select Grasses and Forbs of the Southern Great Plains

Smoke effects on seed germination were first reported for South African fynbos species in 1990 and have subsequently been reported for many species worldwide. There is relatively little information, however, about smoke or heat effects on grasses and forbs of the southern Great Plains. We exposed seeds of 3 grasses and 2 forbs to smoke produced by dormant-season prescribed fires of native shortgrass-dominated vegetation of the southern Great Plains. Seeds were placed in steel mesh pouches and suspended 1 m from the ground in the downwind portion of the plot before burning. Plots varied in amount and condition of fine fuel as a result of different fire histories: half of the plots had not been burned in recent history while half had been burned the previous year. In addition, some seeds were exposed to smoke from only one fire whereas other seeds were exposed to smoke from 3 fires. Thus, 5 treatments included a control as well as a factorial arrangement of frequency of exposure to smoke and burn history. Response of germination to smoke was species-specific. Increasing exposure to smoke generally reduced germination of big bluestem (Andropogon gerardii) and sideoats grama (Bouteloua curtipendula). Blue grama (B. gracilis) and two forbs (Illinois bundleflower, Desmanthus illinoensis and Maximillian sunflower, Helianthus maximiliana) showed erratic responses to treatments. These results indicate that germination of these species was sometimes reduced by smoke but not generally enhanced. It seems unlikely that smoke acts as a germination cue for these species.

227 **Robichaud, Peter** (USDA Forest Service), probichaud@fs.fed.us

Peter Robichaud (Rocky Mountain Research Station), Robert Brown (Rocky Mountain Research Station), Wayne Robbie (Southwest Regional Office), Sierra Larson (Rocky Mountain Research Station)

Measuring Post-fire Erosion Control Treatment Effectiveness After the 2008 Trigo Fire

Wildfires often make landscapes susceptible to increased runoff and accelerated erosion. To reduce erosion and flooding potential, various postfire rehabilitation treatments are commonly used on highly erodible areas. In the spring of 2008, the Trigo Fire burned 14,000 ac of the Cibola National Forest in central New Mexico. The Burned Area Emergency Response team prescribed hillslope treatments including aerial seeding with a mix of annual ryegrass, mountain brome and slender wheatgrass followed in some areas by aerial mulching with barley straw. Four sediment fences were installed on convergent hillslopes for each treatment: control; seed-only; seed and mulch; and mulch-only within high soil burn severity areas. Tipping bucket rain gauges were installed and ground cover was measured each year. Ground cover increased by the end of the first growing season with the seeded grasses and sprouted barley accounted for 20 percent of the vegetation cover which reduced to 10 percent after the 2nd growing season. The barley straw mulch was 57 percent of the ground cover immediately after application and decreased to 10 percent by the fall of 2008. In the 2008 monsoon season, several rain events with high intensities produced annual erosion rates over 3 tons per acre with little differences between treatments. During 2009 and 2010, annual erosion rates were about 1 ton per acre on the control plots with the treated plots producing less erosion. Reduction in the measured erosion

corresponds to increases in vegetation cover; imply that vegetation recovery was an important factor after the first postfire year.

229 **Roccaforte, John Paul** (Northern Arizona University), John.Roccaforte@nau.edu

John Paul Roccaforte (Northern Arizona University), Peter Z. Fulé (Northern Arizona University), W. Walker Chancellor (Northern Arizona University), Daniel C. Laughlin (University of Waikato)

Woody debris and tree regeneration dynamics following severe wildfires in Arizona ponderosa pine forests

Severe wildfires in southwestern US ponderosa pine forests leave behind large quantities of dead woody debris and regenerating trees which can affect future ecosystem trajectories. We studied a chronosequence of severe fires at 14 sites throughout Arizona spanning 1 to 18 years after burning to investigate post-fire woody debris and regeneration dynamics. All fires were dominated by ponderosa pine prior to burning but included overstory species mixes ranging from pinyon-juniper to oak to mixed-conifer with aspen. Snag densities varied over time with predominantly recent snags in recent fires and broken or fallen snags in older fires. Coarse woody debris peaked over 60 Mg/ha in the time period 6-12 years after fire, a value higher than previously reported in post-fire fuel assessments in this region. However, the peak period was brief and debris loadings rapidly dropped into the range of recommended management values. Overstory and regeneration were most commonly dominated by sprouting deciduous species including aspen, oak, and locust. Ponderosa pine overstory and regeneration was completely lacking in 50 percent and 57 percent of the sites, respectively, indicating that many sites were likely to experience extended periods as shrublands or grasslands rather than returning rapidly to pine forest. More time is needed to see whether these patterns will remain stable, but there are substantial obstacles to pine forest recovery: competition with sprouting species and/or grasses, lack of seed sources, and warmer, drier climatic conditions forecast for coming decades.

276 **Rodriguez, Marie** (Valles Caldera National Preserve), mrodriguez@vallescaldera.gov

Marie Rodriguez (Valles Caldera National Preserve)

The Importance of “Quality Data” and the Role of External Partners in Adaptive Management

Since 2002 the Valles Caldera Trust has invested in the acquisition of “quality” data or, data collected by experts or under the supervision of experts; using specific, repeatable, protocol; and maintained with integrity (established meta-data, limited access). The trust has also engaged citizens, universities, other land managers, and research institutions in the collection and review of our management actions. As a result we have realized benefits in efficiency, reduced costs over time, increased public confidence, and ultimately learning and improved decision making - all considered benefits and rewards of adaptive management.

313 **Rorig, Miriam** (USDA Forest Service), mrorig@fs.fed.us

Miriam Rorig (USDA Forest Service), Robert Solomon (USDA Forest Service), Tara Strand (USDA Forest Service), Sim Larkin (USDA Forest Service)

Real-time Smoke Model Analysis and Evaluation for the 2011 Arizona and New Mexico Fires

The extreme fires that burned in Arizona and New Mexico in late spring and early summer of 2011 produced significant amounts of smoke, resulting in serious health concerns over large populated areas in both states. As part of a larger effort to communicate the potential for health impacts from the wildfire smoke to the public, we conducted several daily customized runs of the BlueSky Smoke Modeling Framework (BlueSky) to estimate the range of possible smoke impacts, based on different estimates of fire growth for the next two to five days. At the same time, several PM2.5 monitors were deployed around and downwind from the fires, supplementing existing state monitoring networks. Each day we were able to compare the model-predicted PM2.5 concentrations with the observation data, allowing for a daily, near-real time evaluation of the model output. We found that, in general, the higher the number of acres burned in the simulation, the higher the predicted PM2.5 concentrations, but the "footprint" of impacts on the ground was not necessarily significantly larger than in the lower-acreage runs. The results showed that BlueSky was fairly successful in predicting where smoke impacts would occur, and also in predicting the strength of the impacts relative to other locations and previous days. As one would think, the models performed less well when the winds were less predictable, such as during periods of thunderstorm activity.

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Victoria Saab (Rocky Mountain Research Station), William Block (Rocky Mountain Research Station), Jeff Hollenbeck (Forest and Rangeland Ecosystem Science Center), Jamie Sanderlin (Rocky Mountain Research Station)

Birds and Burns: Making sense of fire regimes, landscapes, birds and land management

Saab and Powell published a review of fire and avian ecology across North America in 2005. They highlighted future research and management issues that recurred across the continent. Here, we re-examine those pressing issues to determine what we have learned and have yet to learn, focused on forests and grasslands of the western United States. We synthesize recently published work and provide information from unpublished studies that address how avian habitat and population responses vary with severity, season, size and age of burns, and with postfire management activities after prescribed and wildland fires. Landscape-level responses and mechanisms driving population change after fire are also revisited. Our synthesis includes patterns in bird responses to both prescribed and wildland fire in northwestern vs. southwestern dry forests. Our expectations about bird responses to fire restoration often come as logical inferences made from what we know about plant community responses to fire. We acknowledge that some fires burn outside of historical fire regimes; however, even these fires benefit some species. Although controlled comparisons have increased in recent years, we still need designed experiments implemented across large landscapes that test inferences so that management decisions are based on data and not opinion.

231 **Sanderlin, Jamie** (Rocky Mountain Research Station), jlsanderlin@fs.fed.us

Jamie Sanderlin (U.S. Forest Service), William Block (U.S. Forest Service)

Long-term post-wildfire effects on avian diversity in Ponderosa Pine forests

We use a 10 year data set to illustrate the long-term effects of wildfires on avian diversity in the Pondersosa Pine forests of Northern Arizona. This study was conducted in the area where the Horseshoe and Hochderffer wildfires occurred. Using point count data from winter and summer seasons, we describe how avian diversity and community dynamics (e.g., species richness, colonization, extinction) change over time following the wildfires. Of particular interest are the occupancy dynamics and relative abundance of secondary cavity-nesting bird species. We use Bayesian hierarchical models to describe occupancy as a function of variables like burn intensity (severe, moderate, or unburned), season, and/or year, while accounting for variables that may influence detection probability, such as detection method and distance from point center.

269 **Schwope, Carl** (US Fish and Wildlife Service), carl_schwope@fws.gov

Carl Schwope (US Fish and Wildlife Service)

Patch Burning to Enhance Habitat Diversity for Endangered Species;

Overarching patch burning objectives typically are intended to create greater ecological heterogeneity; habitat and landscape diversity. In this case management objectives are also to enable the Endangered Attwater Prairie Chickens better access to a variety of habitat resources to improve survivorship and reproductive success. The temporary attraction and intensive use of improved forage by livestock and large herbivores in newly burned patches also influences these long-term ecological objectives. Known obstacles to patch burning are not insurmountable. Smaller burn patches (?40 acres) require additional fire breaks requiring increased economic input. However, annual disking of fire breaks increases forb production, reducing the need of food plot requirements by the Attwater Prairie Chicken. Intensive livestock grazing in freshly burned patches also have potentially adverse ecological effects. Reduced selective grazing on preferred forage species within freshly burned patches can reduce exotic and invasive species cover. Under higher stocking rates, livestock performance can also potentially be improved through patch burning. Multiple patches per pasture can provide more even livestock dispersal and result in lighter utilization of older burned patches yielding more rapid ecological recovery. The patch-burn-herbivore interaction can also result in greater ecological heterogeneity that is typically commensurate with enhanced landscape biological diversity compared to traditional grazing systems. This presentation will address barriers and advantages to patch burning over traditional systems, along with management activities that have been implemented to help alleviate concerns.

233 **Shive, Kristen** (Northern Arizona University), kls448@nau.edu

Kristen L. Shive (Northern Arizona University), Peter Z. Fule (Northern Arizona University), Carolyn H. Sieg (Rocky Mountain Research Station)

Successional trends in forest recovery on the 2002 Rodeo-Chediski fire of northeastern Arizona

We investigated the interaction of fire severity and pre-fire treatments on vegetation recovery through time by using a series of measurements (2004, 2005, 2010) taken on the 2002 Rodeo-Chediski fire in northeastern Arizona. At 189,650 hectares the fire was one of the largest in the southwest, and it burned through ponderosa pine forests that had been managed for an uneven-aged structure on large landscape scales. We re-measured existing plots stratified by severity (low, high) and pre-fire treatment (untreated, burned only, burned and thinned). In general, the low severity and high severity sites appear to be on distinct trajectories, which we speculate is largely driven by the scarcity of trees in high severity areas. Several lines of evidence show that pre-fire treatments had long-lasting effects on forested ecosystems, even when treated areas burned severely. First, untreated high severity sites have significantly higher plant cover than either treatment, most of which was driven by an increase in shrub cover. Since 2005, mean shrub cover generally increased on all high severity sites, but there were greater increases in cover as treatment intensity decreased. Second, pine regeneration occurred at greater frequency in treated than in untreated sites, even when both burned severely. These differences in community recovery are likely due to in the fact that high severity patches were much smaller in treated areas. The data suggest that these smaller patches of severe burning within a heterogeneous, mixed severity landscape recover differently than severe patches in untreated areas within a more homogeneous landscape.

122 **Sieg, Carolyn** (USDA Forest Service), csieg@fs.fed.us

Carolyn Sieg (USDA Forest Service), Rodman Linn (Los Alamos National Laboratory), Chad Hoffman (Colorado State University), Joel McMillin (USDA Forest Service)

Modeling fire propagation in highly variable pinyon-juniper woodlands following a drought-induced bark beetle outbreak

We used a physics-based model, HIGRAD/FIRETEC, to explore fire propagation relative to time-since-outbreak in pinyon-juniper woodlands following drought-induced bark beetle attacks and subsequent tree mortality. Pinyon-juniper woodlands are highly variable, but trees often are clumped, with sparse patches of herbaceous and shrubby vegetation scattered between clumps. A recent drought-induced bark beetle attack resulted in widespread mortality of pinyon trees across the Southwest. The presence of dead trees intermixed with live junipers raised concerns about increased fire hazard, especially immediately after the trees died and dead needles remained in the trees. We used FIRETEC to explore the coupled fire/vegetation/atmospheric interactions under low and high wind speeds in an attempt to identify thresholds associated with extreme fire behavior in these highly heterogeneous woodlands. We were also interested in how these interactions changed in woodlands without tree mortality (“live”), in the first year when dried needles clung to the dead trees (“dead”), and when the needles dropped to the ground (“dropped”). Our simulations suggest that fire propagation increases three-fold at low wind

speeds (4 m/sec at 10-m height) when dead needles are on the trees compared to live woodlands and simulations with dead needles on the ground. At high wind speeds (7 m/sec), fire propagation in woodlands with dead needles on the trees increased only slightly above that in live woodlands or those with needles on the ground. This study suggests that the fire/vegetation/atmospheric interactions are complex across high spatial and temporal heterogeneity following a drought-induced bark beetle mortality event.

343 **Sisk, Thomas D** (Northern Arizona University), Thomas.Sisk@nau.edu

Thomas D Sisk (Northern Arizona University)

Responding to the Call: Science and Policy Innovations to Expedite Implementation of Landscape Approaches to Forest Planning, Restoration and Fire Management

The past 20 years have exhibited increasingly large and severe stand-replacing forest fires across the Southwest, linked to historic fuel buildups and a warming, drier climate. These trends have transformed discussions of forest and fire management, inspired new levels of public involvement, and engendered collaborative efforts in support of unprecedented management interventions to restore fire-adapted forest ecosystems. Yet on-the-ground practices have changed little outside of wildland-urban interface zones. Despite broad consensus regarding the widespread need for thinning small-diameter trees, increasing use of prescribed fire, and restoring natural fire regimes, public agencies struggle to carry out environmental analyses, navigate complex contracting procedures, and “scale up” thinking and actions to meet the high expectations of a more focused public. Meanwhile, the science of landscape ecology has progressed rapidly. Compelling new data, powerful statistical and modeling tools, and proven approaches for leveraging science to inform public deliberation and decisions currently are significantly underutilized, while public engagement is constrained by traditional approaches to NEPA analysis, developed thirty years ago. I will present four avenues of policy development and management responses where public support is evident, options are clear, and action is urgently needed. We stand in a moment of opportunity, where we can choose to embrace practical new approaches to forest planning and management, incorporate the public in a manner that builds support and defuses conflict, and encourage leaders and decision makers to adopt bold responses that are appropriately scaled to the social, economic, and ecological challenges evident across the region.

205 **Smith, D. Max** (USDA Forest Service Rocky Mountain Research Station), oregonmax@gmail.com

Max Smith (USDA Forest Service Rocky Mountain Research Station), Deborah Finch (USDA Forest Service Rocky Mountain Research Station), David Merritt (USDA Forest Service Rocky Mountain Research Station)

Exotic Plant Invasion and Wildfire along the Middle Rio Grande: Changes in Riparian Forest Structure and Response by Breeding Birds

The cottonwood (Populus deltoides) gallery forests of the Middle Rio Grande are valued for many reasons, including their diverse breeding bird communities. There is concern that, because of increasingly arid conditions, wildfire will accelerate mortality of native trees and promote dominance of exotic species in this and other riparian forests. From 2000 to 2008, we measured vegetation and monitored nests in unburned and post-wildfire sites to relate changes in vegetation structure to success of riparian-nesting birds. Wildfire reduced live cottonwood canopy by 40-80%, but stimulated resprouting by trees and shrubs. Cottonwoods produced the most sprouts among native species (14 % of all stems), indicating that there is potential for post-fire canopy regeneration. Most stems (79%), however, were produced by exotic species, such as saltcedar (Tamarix spp.). Response of birds to changes in vegetation varied among nesting guilds. Following fire, Western Kingbird (Tyrannus verticalus) was the only canopy-nesting species that frequently nested in cottonwood snags. Cavity-nesting birds also constructed nests in post-fire snags, but we found greater numbers in live cottonwoods in unburned sites. Beginning one year after fire, shrub- and subcanopy-nesting birds constructed numerous nests in native and exotic resprouts. Nest survival estimates for two of these species, Mourning Dove (Zenaida macroura) and Black-chinned Hummingbird (Archilochus alexandri), did not differ between post-wildfire and unburned sites. Our results show that (1) understory-nesting birds respond successfully fire-induced change in vegetation structure and (2) regeneration of cottonwood is needed to maintain nesting opportunities for canopy- and cavity-nesting birds in post-wildfire sites.

137 **Stan, Amanda** (Northern Arizona University), Amanda.Stan@nau.edu

Amanda B. Stan (Northern Arizona University), Peter Z. Fulé (Northern Arizona University), Kathryn B. Ireland (Northern Arizona University)

Fire history of a ponderosa pine forest on the Hualapai tribal lands, northwestern Arizona

Forest ecosystems and disturbance regimes on tribal lands in the southwestern U.S. have received limited research attention compared to public lands. In light of historical differences in fire and timber management between tribal and U.S. land management agencies, a better understanding of fire regimes and fire-climate interactions on tribal lands is needed. We reconstructed fire history using 113 fire-scarred trees at five 0.25-hectare sites located in a ponderosa pine dominated forest on the Hualapai tribal lands in northwestern Arizona. Sites were distributed to reflect the gradient of ponderosa pine forest on the landscape, with three sites located in upland forest and two sites located near the ecotone where ponderosa pine forest meets pinyon-juniper woodland. Surface fires were continuous for several centuries up until the late 1800s at each of the five sites. During the pre-1900 period, mean fire interval

ranged from 6.7 years to 8.9 years (fires that scarred 25% or more of recording trees) across all sites. Beginning in the latter half of the 1900s, fires reappeared in the record. This pattern is unlike that typically seen at sites throughout the western U.S. and may reflect a more frequent and broad use of fire on tribal versus public lands. Combined with additional studies of stand structure and fire behavior, our research aims to provide information to assist the Hualapai Tribe in adapting and managing their forest as climate changes.

223 **Steinke, Rory** (Coconino National Forest), rsteinke@fs.fed.us

Rory Steinke (Coconino National Forest)

Perspectives of a BAER (Burned Area Emergency Response) Practitioner

BAER practitioners are responsible for burned area emergency response on wildfires generally larger than 500 acres. The interdisciplinary team makes and an immediate assessment of burn severity, and determines the risk from postfire storm events to life, property, cultural and natural resources. If a determination of emergency watershed conditions exists, the BAER team recommends a series of emergency treatments that are expected to reduce accelerated erosion and runoff that may pose a risk to life, property, culture and natural resource values affected downstream. Most treatments need to be implemented before the first damage producing storm causing extreme urgency and action by Forest Service. Three major categories of treatments are considered including hillslope, channel, road and trail treatments. Treatments types vary by watershed, vegetation type and burn severity. Natural recovery is the preferred treatment method where values are not at significant risk. Wildfires on the Coconino have shown to recover naturally within 3-5 years enough to reduce threats to life, property and resources. Long-term experience and WEPP modeling projections often guide treatment selection on hillslopes, roads, and channels. On the Coconino National forest, mulching (straw and woodshred) has proven to be the most cost effective, safe and technically feasible treatment to slow water down compared to other hillslope treatments. Seeding alone on the Coconino National Forest has shown to be largely ineffective at reducing runoff and erosion before the first damage producing storm especially in pinyon-juniper or drier vegetation types. Seeding accompanied with mulch treatments has shown a little more promise at the end of the first year and into years 2 and 3 as the grass tends to have time to regenerate and holds straw mulch in place and reduce loss of mulch from runoff and wind. Road treatments have shown to be effective at rerouting water runoff and reducing road erosion outside of road prisms. Structural, channel treatments have not been used in large watersheds. Most larger fires have money approved for short-term treatment effectiveness monitoring (1 to 2 years), but the policy does not allow for longer-term BAER funding and monitoring so long-term results of seeding response is lacking. There are high and sometimes unrealistic expectations of treatment effectiveness placed on the forest from outside stakeholders (County, City, and private individuals) and a lack of understanding on the effectiveness of BAER treatments overall.

230 **Stevens-Rumann, Camille** (Northern Arizona University), csrumann@gmail.com

Camille Stevens-Rumann (Northern Arizona University), Carolyn Sieg (Rocky Mountain Research Station), Molly Hunter (Northern Arizona Unviersity)

Ten years after wildfire: how does varying tree mortality impact fire hazard and forest sustainability?

Severe wildfires across the western U.S. have lead to concerns about fuel loading and the potential for high-intensity reburning. Ponderosa pine (Pinus ponderosa) forests, already stressed from a century of fire suppression, now face increasingly large, severe wildfires. We sampled fuel loadings in 2009 and 2010 across a range of tree mortality on the Pumpkin Fire in Arizona. We measured numerous stand structure and surface fuel characteristics across a range of tree mortality and accompanying unburned sites. Ten years post-wildfire, low mortality (0-40%) plots resembled unburned plots in almost every fuels attribute. Basal area in low-mortality plots exceeded reconstructed historical ranges and fire hazard reduction targets by up to 130%. However, coarse woody debris (CWD; woody material >7.62cm) loadings fell below an “optimum” range and herbaceous fuels were sparse. Low mortality and unburned areas should be targeted for reducing stand densities and promoting understory growth, to minimize crown fire hazard and increase site potential. High mortality (81-100%) plots had few trees but CWD loadings exceeded recommended levels by up to 28%, and sufficient herbaceous fuels to carry a surface fire. These areas have the lowest crown fire hazard, but may benefit from some fuel reduction efforts. Mid-mortality (41-80%) plots were characterized by open stands and increased surface fuel loadings, basal area was close to target ranges and CWD loadings were within the recommended ranges. Fuel characteristics in mid-mortality plots most resembled historical targets and met numerous restoration objectives for ponderosa pine-dominated forests, especially in the face of predicted climate changes.

234 **Stropki, Cody** (SWCA Environmental Consultants), cstropki@swca.com

Cody Stropki (SWCA Environmental Consultants), Peter Ffolliott (University of Arizona), Daniel Neary (US Forest Service, Rocky Mountain Research Station), Hui Chen (University of Arizona)

The 2002 Rodeo-Chediski Wildfire’s Impacts on Southwestern Ponderosa Pine Ecosystems, Hydrology, and Fuels

The Rodeo-Chediski Wildfire burned nearly 462,600 acres in north-central Arizona in the summer of 2002. The wildfire damaged or destroyed ecosystem resources and disrupted the hydrologic functioning within the impacted ponderosa pine (Pinus ponderosa) forests in a largely mosaic pattern. Impacts of the wildfire on ecosystem resources, factors important to hydrologic functioning, peak stormflow events and water quality constituents, and loadings of flammable fuels were evaluated on two watersheds in a ponderosa pine forest that was exposed to the burn—one experienced a high severity (stand-replacing) fire (Watershed A), and the other was exposed to only a low severity (stand-modifying) fire (Watershed B). Cumulative impacts of the wildfire on ecosystem resources, hydrologic functioning, and flammable fuels were more pronounced on Watershed A. Recovery of the Stermer Ridge watersheds from the Rodeo-Chediski Wildfire has been related to the respective fire severities that the two watersheds experienced. Watershed A converted from ponderosa pine to grasses, forbs, and a few shrubs. Recovery of the hydrologic functioning on this watershed has begun on a limited scale, but it is anticipated that

the overall hydrologic functioning of Watershed A will not approach pre-fire conditions for many years. Flammable fuels represented by standing trees have been eliminated on Watershed A, but there has been an increase in stem sections, branches, twigs, and herbaceous fuels on the forest floor. While the possibility of a future crown fire has declined, the potential for surface fire remains. Much of Watershed B is slowly recovering from the impacts of the wildfire. Much of the hydrologic functioning of this watershed is also returning slowly to its pre-fire level. The post-fire loadings of flammable fuels were largely unchanged from their pre-fire estimates. Watershed B remains vulnerable to future wildfire events as a consequence.

125 **Swetnam, Thomas** (University of Arizona), tswetnam@ltrr.arizona.edu

Thomas Swetnam (University of Arizona), Michael Crimmins (University of Arizona), Christopher Baisan (University of Arizona), James Swetnam (U.S. Forest Service)

Wind-Driven, Horizontal Roll Vortex Crown Fires in the Southwestern United States: A Preliminary Investigation of Patterns and Causes Over the Past 60 Years

Among the most intense and fastest spreading forest fires are those characterized by a phenomenon known as “horizontal roll vortices” (HRVs). The first well-documented example of an HRV was described by Schaefer (Journal of Forestry 1957) from observations of a 1956 crown fire in a ponderosa pine forest on the Mogollon Plateau of central Arizona. HRVs are wind-driven crown fires that may form a single vortex, or a pair of vortices in a non-vertical, wind-tilted, convective column(s) of smoke. We describe what is now perhaps the best example of a paired HRV captured in still photography and time-lapse video: the Las Conchas Fire in the Jemez Mountains, New Mexico, which burned at least 40,000 acres in a single 24-hour period on June 26-27, 2011. We also evaluate evidence that similar wind-driven crown fire events may have occurred during recent large fire events in Arizona and New Mexico, and in earlier crown fire events since the 1950s. Many of these events (but not all) were associated with plateau and mesa topography and with a distinctive pattern of surface winds from the southwest to the northeast, with increasing wind speeds in the same direction (i.e., wind shear) up to the jet stream level. We discuss the implications of these weather, climate and fire patterns for our understanding of the recent largest wildfires in the past century in Arizona and New Mexico (e.g., Rodeo-Chediski of 2002, Wallow Fire and Las Conchas Fire 2011).

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Thomas Swetnam (University of Arizona)

A Historical-Ecological Perspective on Southwestern Fire regimes in an Age of Consequences

The remarkable physical, ecological, and cultural diversity of the Southwestern United States is reflected in a broad variety of fire regimes and changes that have occurred here during recent and distant centuries. Plant communities and associated fire regimes ranged from the desert basins and pygmy woodlands of lowest elevations, where wildfire rarely if ever spread beyond a single bush or tree, to

open pine savannas with extensive surface fires occurring at intervals as short as one to a few years, to mountain tops and high slopes with spruce-fir forests burning in crown fire conflagrations once or twice in 500 years during the deepest droughts. Climate and weather varied continuously, but within an envelope of variability in recent centuries, and with quasi-periodic events influencing both moisture and fire patterns (e.g., ocean-atmosphere oscillations, such as El Niño/La Niña extremes). Superimposed upon, and interacting with these physical and ecological patterns, humans have profoundly affected fire regimes in certain places and times. Over the past century human influences have become pervasive – including our effects on global and regional climate. The consequences of recent human-caused changes on Southwestern fire regimes are increasingly catastrophic in their effects on native biota, watershed, and other human values. I will review the variations and trajectories I describe above in the context of the extraordinary 2011 fire season, concluding with a personal perspective on the immense challenges facing land management agencies and the public in sustaining ecosystems through this "age of consequences" that we are now within.

143 **Tagestad, Jerry** (Pacific Northwest National Laboratory), Jerry.Tagestad@pnnl.gov

Jerry Tagestad (Pacific Northwest National Laboratory), Valerie Cullinan (Pacific Northwest National Laboratory), Matthew Brooks (U. S. Geological Survey), Randy McKinley (U. S. Geological Survey)

Precipitation Regime Classification for the Mojave Desert – Implications for Fire Occurrence

Precipitation is the lynchpin of ecosystem processes in the Mojave Desert. It controls the foundations of food webs, the evolution of physical landscapes, and the dynamics of nutrient cycles and fire regimes. As such is it an important variable in most predictive ecosystem models, especially those related to fuel bed dynamics and fire regimes. We developed a spatially explicit precipitation pattern analysis based on a 40-year record from the Parameter-elevation Regressions on Independent Slopes Model (PRISM) precipitation database. This analysis classified temporal and spatial patterns across the Mojave Desert to develop precipitation regime boundaries. Because these spatially-continuous precipitation sub-regions are based on precipitation amounts and seasonal distributions, they provide an ecologically relevant and consistent basis for spatial analyses of ecosystem responses and fire regimes. In this presentation we describe how we used the PRISM meteorological database to identify 4 major precipitation regimes defined by their annual amounts and seasonal distributions of precipitation. We then evaluate the degree of concordance these precipitation regimes have with fire occurrence in the period of 1972 to present. We end with a discussion of how changes in precipitation regimes may alter fire regimes in the region.

213 **Thode, Andrea** (Northern Arizona University), andi.thode@nau.edu

Andrea Thode (Northern Arizona University), Marybeth Garmoe (Northern Arizona University), Hondo Brisbin (Northern Arizona University), Karen Weber (Northern Arizona University)

Effects of Post-Fire Restoration Work in Zion National Park

In the summers of 2006 and 2007 two of the largest fires in the history of Zion National Park burned more than 8,000 ha total. Due to the threat of cheatgrass invading the burned areas and causing vegetation type conversions, over 4,800 ha of high severity burned area was treated with Imazapic herbicide and, on one fire, a combination of seeding and herbicide. We monitored the effects of these treatments across 5 sites with over 250 plots. We will present a summary of the results for this effort including the effects on cheatgrass and the native plant community. The use of landscape scale applications of herbicide in protected areas has not been common practice in the National Park Service. However, in changing times with a changing climate and invasive species all the tools for land management need to be understood.

273 **Thomas, Lisa** (Southern Colorado Plateau I&M Network), Lisa_Thomas@nps.gov

Lisa Thomas (National Park Service)

Indicator Selection and Vital Signs for Long-term Monitoring in our National Parks.

The National Park Service has developed a long-term ecological monitoring program for 32 ecoregional networks containing more than 270 parks with significant natural resources. The monitoring program assists park managers in developing a broad-based understanding of the status and trends of park resources as a basis for making decisions and working with other agencies and the public for the long-term protection of park ecosystems. During a 3-year planning process each ecoregional network engaged with park managers and regional experts to define local goals and objectives, identify and prioritize potential indicators, and to select a subset of these indicators for long-term monitoring. The Southern Colorado Plateau Network serves 19 NPS units in Arizona, New Mexico, Colorado and Utah. Among other indicators, we are monitoring vegetation and soils in selected predominant ecological systems ranging from semi-arid grasslands and shrublands, to pinyon-juniper woodlands and mixed conifer forests. We are also exploring the use of Moderate Resolution Spectraradiometer (MODIS) satellite data to monitor productivity and phenology at the scale of ecological systems.

228 **Tillery, Anne** (USGS Albuquerque), atillery@usgs.gov

Anne Tillery (USGS), Kerry Jones (National Weather Service)

Landscape Response to Catastrophic Wildfires in New Mexico Following Short Duration, High Intensity Rainfall Events during Summer 2011

During the summer of 2011, nearly 500,000 acres of forested lands were burned in the State of New Mexico, including the Las Conchas wildfire, the largest in the state's history, which burned portions of

the Santa Clara, Cochiti, San Ildefonso and Santa Domingo Pueblos as well as portions of Bandelier National Monument and the Valles Caldera National Preserve. Some of this area was previously burned by the Cerro Grande Fire in 2000. Freshly burned landscapes are at risk of damage from severe post-fire erosion hazards such as those caused by flash flooding and debris flows. Hydrologic hazards such as flooding and debris flows may persist for years after a fire and can negatively impact water resources, ecology, businesses, homes, reservoirs, roads, and utilities in wildland/urban interface areas. Following the Track and Las Conchas Fires in New Mexico during the summer of 2011, personnel from the USGS and NOAA visited areas that were significantly affected by post-fire effects, conducted debris-flow assessments of the burned areas, and documented severe floods downstream of burn scar areas. Debris-flow hazard assessments and flood-frequency predictions conducted in wildfire threated areas before fires occur could help land and resources managers plan for and mitigate the effects of these hazards in advance of a fire occurrence. This presentation describes the post-fire hydrologic hazards of floods and debris flows, identifies approaches to quantify and in some cases predict them, thus enabling land and resource managers to plan for and mitigate the effects of these hazards.

124 **Towne, Geoffrey** (University of Arizona), gtowne@email.arizona.edu

Geoffrey Towne (University of Arizona), Stephen Yool (University of Arizona), Donald Falk (University of Arizona)

Using Remote Sensing to Model Fuel Moisture Stress for Sky Islands Forests

Wildland fires have become increasingly devastating in the Southwestern United States in the past decade, including the biodiversity rich Sky Islands of southeastern Arizona. Fire risk in this region is increased during drought periods that lead to low fuel moisture conditions. Statistical transformations of spectral indices derived from remote sensing provide a way to identify areas of high fuel moisture stress in vegetation. The Moderate Resolution Imaging Spectroradiometer (MODIS) provides near infrared and visible land cover data of the Sky Islands from 2000 until now. The inverse z scores of the Normalized Difference Vegetation Index (NDVI) and the Enhanced Vegetation Index (EVI) produce a Fuel Moisture Stress Index (FMSI) that can be used to identify when and where vegetation is under moisture stress. The inverse z scores of these indices standardize the pixel values that may be confounded by pixels that may have the same values, but completely different land cover types and topographies. By superimposing FMSI data from regions in years of known high fuel moisture stress, we can establish a procedure to identify areas of high moisture stress to predict years of widespread fire occurrence. FMSI is a spatially-explicit approach to modeling the role of interannual climate variability in modulating time-varying fire risk.

270 **Twidwell, Dirac** (Oklahoma State University), dirac@tamu.edu

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When patch burning will not work: Restoration intervention in juniper woodlands with extreme prescribed fire

Intervention in novel ecosystems requires the creation of novel resource management strategies that push the boundaries associated with conventional management practices. Patch burning is a novel intervention approach that has emerged as a strategy for enhancing the biodiversity and livestock productivity of grasslands, but the overwhelming majority of the world's grasslands have become dominated by woody plants and restoration of grassland-dominated ecosystems is needed before the desired benefits of patch burning are likely to be realized. To determine whether fire can restore grasslands after conversion to woodland, we established experiments in multiple ecological regions of Texas to ignite, control, and study the effects of high intensity prescribed fires conducted during severe drought periods. These extreme prescribed fires produced fire temperatures that were far above conventional applications of prescribed fire in these ecosystems and led to significantly greater levels of mortality in both non-resprouting and resprouting woody plants than mortality from drought alone. Even so, successful restoration of grassland communities is dependent on the degree to which societal constraints limit the occurrence and extent of extreme prescribed fire. We demonstrate how landowner-driven organizations are overcoming dominant social constraints to apply extreme fires for restoration purposes and how such fires can lead to the adoption of patch burning in areas currently dominated by woody plants.

144 **Underwood, Emma** (University of California, Davis), eunderwoodrussell@ucdavis.edu

Robert Klinger (USGS - Western Ecological Research Center)

Modeling invasive annual plant distributions in the Mojave Desert

It is well established that non-native invasive annual grasses in the genera Bromus (B. rubens and B. tectorum) and Schismus (S. arabicus and S. barbatus) can provide supplemental fuels necessary to carry fire in the Mojave Desert, especially at lower elevations. Understanding the biophysical conditions that are conducive to the growth of these species is necessary to help predict where fires are most likely to occur in the future, and where their dominance is most likely to increase following fires. We report the results of environmental niche models for the four Bromus and Schismus species under contemporary and future climate scenarios. Modeling range shifts for these species will allow an evaluation of their potential individual and cumulative contribution to fire patterns in the bioregion. Forecasting range changes for these species will likely provide great insight on potential future changes in fire regimes in the bioregion. The models will also provide land managers with maps of current and potential future distributions for these species that they can use in their planning efforts.

211 **Vaillant, Nicole** (USFS - PNW Research Station), nvaillant@fs.fed.us

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Fuel loading succession following fuel treatments in California

Quantifying the longevity of effectiveness for fuel treatments to reduce potential fire behavior is of great interest to land mangers. To date the majority of research surrounding the effectiveness of fuel treatments only considers the time immediately after treatment. Little is known about how long these treatments last, or how often they will need to be re-treated to maintain desired levels of reduced fire behavior and effects. The duration of treatment effectiveness is likely to vary between forest types and between treatment types such as prescribed fire and mechanical treatments. Quantifying changes in fuel loading over time is necessary to predict potential fire behavior. As part of a long-term fuel treatment effects monitoring project data was collected at 89 permanent plots representing 28 fuel treatment projects on 14 national forests in California from 2001 to 2011. Fuel treatments ranged from prescribed fire only, thinning only, mechanical understory treatments such as mastication, and a combination of thinning plus understory fuel reduction treatments. Forest and fuels inventory data was collected before treatments were applied and up to 10 years after treatment (1, 2, 5, 8, and 10 year post treatment intervals) for each plot. We will present fuel (surface, live understory, and canopy) information over time for distinct forest and treatment types.

206 **Verble, Robin** (University of Arkansas at Little Rock), rmverble@ualr.edu

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Prescribed burning reduces ant diversity in Ozark forests.

Prescribed fire is an increasingly prevalent tool in forest management, but the effects of prescribed fire on insect community structure are largely unknown. Given their conspicuousness and prevalence, ants are an excellent organism through which to study fine-scale ecological effects. For four months post-fire, we surveyed ants in paired replicate burned and unburned Ozark oak forests via Berlese extraction, baiting and hand collecting. Ant abundance, species richness and similarity were lower in burned forests as compared to unburned forests. Species associations were also more fragmented in burned forests. Changes in ant communities post-fire are important, since they may be indicative of fine-scale ecological effects of prescribed burning. Additionally, these data will assist mangers in making decisions about fire reintroduction and seasonal timing in areas with sensitive insect faunas.

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When numbers don't tell the story--a closer look at fire severities on large fires from the Southwest's 2011 fire season

The fire season of 2011 proved to be an historic one, both in number of fires and the number of acres burned. In the state of Arizona alone, over 1,000,000 acres experienced fire. Numbers are often impressive on the nightly news, but do they adequately tell the short and long-term ecological story? This analysis examines several of the largest fires that burned in the Southwest during the 2011 fire season. We investigate fire effects and fire severity by potential natural vegetation type, and qualify the broad range of severities experienced over these landscapes by comparing to historical reference conditions. Utilizing the Rapid Assessment of Vegetation Conditions after Wildfire (RAVG) analysis, fire severity is classified by vegetation type at the broad scale. RAVG uses a change detection process summary of satellite imagery collected before and immediately after a fire to estimate burn severity in the existing vegetation. Fire behavior depends on fuels, weather and terrain. Recognizing the boundless combinations of these factors that make up the fire environment, fire effects are unlimited over such large fires. This translates to multiple fire effects and severities experienced within the perimeter of a wildfire, and within vegetation existing across the landscape. Many thousands of these acres were within the ponderosa pine and dry mixed conifer types, forests that historically experienced frequent, low intensity fires. We examine low severity fire effects and compare to reference condition disturbance impacts, as well as high severity effects that may be well outside the historic range of variation.

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Burn Trends in Conserved Habitat of Spotted Owls: Are There Environmental Factors That Indicate Less Vulnerability to High-severity Burns?

Fire is a natural disturbance of forested habitat used by Spotted Owls. However, for the past 100 years, suppression of fires, changes in weather, and past resource use has promoted greater frequency and extent of high-severity, stand-replacing fires, within many western forests. In trying to reduce the risk or large-scale, intensely burning fires, land managers are faced with limited resources and with making decisions about where and how to focus forest treatments. Conservation of spotted owls and the questions about placements of fire-risk reduction treatments have lead to a conundrum about treating in and adjacent to the owl's roosting and nesting habitat. In this paper, we quantify trends in burn-severity from 1987 to 2008 in 2,652 Protected Activity Centers (PACs), the habitat allocated for conserving roosting, nesting, and proximal foraging habitat of California (Strix occidentalis occidentalis) and Mexican Spotted Owls (S. o. lucida). We then use these data along with spatial data of the physical environment readily available in a geographic information system (GIS) to produce resource selection models that identify key environmental features associated with less high-severity burn in the PACs. We

propose that the identified variables will be of use to land managers in prioritizing and strategically locating future forest treatments to reduce the risk of high-severity, stand replacing fire.

209 **Waring, Kristen** (Northern Arizona University), kristen.waring@nau.edu

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First- and second-entry prescribed fire effects: An analysis of Fire Monitoring Handbook data from Zion National Park

Fire and resource managers at Zion National Park (ZNP) have installed Fire Monitoring Handbook-style (FMH) vegetation and fuels plots since the 1990's to evaluate ecosystem changes in prescribed fire treatment areas over time. We analyzed existing FMH plot data collected at ZNP from 1995 to 2010 to assess the achievement of prescribed fire management objectives in ponderosa pine forests. These included changes in tree densities, understory and substrate cover, and dead and down fuel loading. We analyzed first-entry burn data from pre-fire and 1, 2, 5, 7, and 10 years post-burn and second-entry burn data from pre- to 1 and 2 years post-fire using PerMANOVA. We found that after first-entry prescribed fire no significant changes occurred in overstory or midstory tree density or fuel loading. However, after second-entry fire we found decreasing trends in overstory ponderosa pine density, and significant decreases in ponderosa pine and Gambel oak midstory densities, and fuel loading. We found significant one-year post-first-entry fire decreases in understory shrub, Gambel oak, and total understory cover. Following second-entry fire, we found significant one-year post-fire decreases in litter, shrub, and total understory vegetation cover. Ponderosa pine seedling establishment was low following both first- and second-entry fires. Our results suggest that second-entry prescribed fires achieved more management objectives than first-entry fires; however, several objectives, such as overstory ponderosa pine density, were not achieved with either entry. Implementing fires with either higher or mixed-severity may help ZNP meet more objectives in fewer burn entries.

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The Jemez Mountain Salamander and Fire

The Jemez Mountains salamander (Plethodon neomexicanus) is currently a candidate species for listing under the Endangered Species Act. The species' range is restricted to the Jemez Mountains in northern New Mexico, in Los Alamos, Rio Arriba, and Sandoval Counties, around the rim of the collapsed caldera with some occurrences on topographic features on the interior of the caldera. Identified threats to this narrowly endemic species include historical and current fire management practices, severe wildland fire, forest management practices, fire suppression actions, and post-fire rehabilitation treatments. We have evidence that modification of the salamander's habitat from fire exclusion and severe wildland fire places the species at great risk of extinction. The effects of stand-replacing wildland fire, prescribed fire, fire suppression, and post-fire restoration activities on the recovery of this species will be discussed.

271 **Weir, John** (Oklahoma State University), john.weir@okstate.edu

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Fire Management with Patch Burn Grazing

Patch burn grazing benefits all aspects of a prescribed burning program, with one of the major benefits being added accumulation of fine fuel, which is readily achieved without any deferment of grazing before or after burning. With larger amounts of fine fuel, burns can be conducted under safer weather conditions, including lower air temperature and higher relative humidity. With greater amounts and more continuous fine fuel loads, fires can be more intense, which results in better suppression of woody plants. Patch burn grazing also allows prescribed fires to be conducted at different times of the year, which can spread out the burn season and provide more time to conduct fires. Therefore, a manager who is often is unable to achieve burn objectives with traditional fire management practices because of limited available burn days is better equipped to manage the land. Additional benefits include allowing fires to burn into previously burned areas making prescribed burns safer and easier to conduct. Patch burn grazing also reduces the size of the burn unit requiring more units to be burned which can make the prescribed fire operation a little more costly. But burning these smaller units does have its benefits, such as requiring fewer personnel and less equipment to conduct the burn than when an entire unit is burned. Burning smaller units also produce less smoke, thus minimizing smoke management issues.

253 **Williams, Mark** (University of Wyoming), markalanwilliams@hotmail.com

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Expanding the scale of ponderosa pine historical forest reconstructions in the western US using survey data: results for 925,000 ha

The historical structure and fire regimes in ponderosa pine forests are largely understood through detailed, but scattered plot-based reconstructions or through broader, but qualitative historical records. Thus, spatial variability in the historical structure and fire regimes of large forested landscapes is poorly known, hampering restoration efforts at the landscape level. Here we use new and refined methods to reconstruct forest-structure parameters (tree density, basal area, composition, and diameter distributions) and fire-regime parameters (severity, rotation) using data in the General Land Office (GLO) survey notes from the late-1800s across about 925,000 ha of ponderosa pine forests in two parts of the Mogollon Plateau, Arizona, in the Blue Mountains, Oregon, and in a smaller area in the Colorado Front Range. These reconstructions show that median tree density (trees > 10 cm diameter) was 124 and 136 trees/ha in the two parts of the Mogollon Plateau, 146 trees/ha in the Blue Mountains, and 162 trees/ha in Colorado. About 11% and 15% of these landscapes in Arizona, 23% in Oregon, and 29% in Colorado had tree density exceeding 200 trees/ha, which is more than twice as high as usually reconstructed (i.e., < 100 trees/ha) for ponderosa pine landscapes. Historical fires varied in severity; only 3%, 12%, 40% and 62% of the four landscapes fit the low-severity fire model. Restoration policies should reflect the substantial variability in structure and fire regimes of these historical forests. Policies that seek to

uniformly reduce fuels and fire severity across entire landscapes could have detrimental impacts on biological diversity.

278 **Williamson, Matt** (Grand Canyon Trust), mwilliamson@grandcanyontrust.org

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The Four Forest Restoration Initiative: Opportunities and Challenges for Adaptive Management at Multiple Scales

The Four Forest Restoration Initiative (4FRI) is an effort to restore over 2 million acres of ponderosa pine forests in northern Arizona through the use of prescribed fire and mechanical thinning treatments. Throughout the past decade, substantial resources have been devoted to understanding the ecological effects of forest restoration treatments. Now, through 4FRI, restoration treatments will be implemented at an unprecedented rate across a much larger landscape than previous. As a recipient of funding from the Collaborative Forest Landscape Restoration Act, 4FRI is required to have a collaboratively developed, multi-party monitoring program. The concept of adaptive natural resource management was introduced to deal with uncertainty related to scaling up project-based restoration research to landscape level implications. The combination of 4FRI's broad stakeholder group, university and research partners, and national recognition as a cutting-edge project of extreme importance provide a unique opportunity to leverage substantial resources towards the development of the robust, sustainable monitoring program that is required for adaptive management to succeed. In addition, the rate and scale of 4FRI treatments provide increased opportunities for experimentation and may overcome the time lags typical in natural resources management, thereby allowing monitoring information to feed into the planning process more regularly. We present an overview of the collaborative, multi-stakeholder monitoring plan and focus on the next steps of incorporating the plan into effective adaptive management. Substantial challenges remain; the ability to systematically treat management actions as hypotheses, evaluate monitoring results at the appropriate temporal and spatial scale, and incorporate feedback mechanisms within the framework of the National Environmental Policy Act all represent significant challenges to achieving management that is truly adaptive.

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Climate and land-use drivers of historical fires in northern Mexico

In the United States, regional-scale analyses of climate-fire relationships have been completed for several regions, as well as at the scale of western North America. Most of these studies analyzed climate-fire relationships before the 20th century, because in much of the United States fire regimes were interrupted in the mid- to late-nineteenth century by human influence. To overcome some of the

anthropogenic influence of the twentieth century and extend understanding of the historical relationships between climate and fire in North America, we can look to northern Mexico. Using a network of 52 sites in 5 regions in the Sierra San Pedro Martir, the Sierra Madre Occidental, and the Sierra Madre Oriental, we compared across-region and within-region fire synchrony with climate oscillations including ENSO, PDO, and AMO, as well as combinations of these oscillations. Across-region fires in northern Mexico were more likely to occur during cool phases of ENSO (La Niña) and PDO. AMO was not significantly associated with fire occurrence. Within regions, La Niña phases of ENSO were significantly associated with fire occurrence in four of the five regions, and in three regions fires were also significantly associated with previous-year El Niño conditions. We also compared dates of fire regime disruption across northern Mexico. Dates of fire regime disruption were highly variable. This suggests that human land use change is the strong driver of fire regime interruption, overriding the influence of climate and causing widespread cessation of fire across the region in the nineteenth and twentieth centuries.

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Moving Forward From the 2011 Fire Season

Since its origin as a defined functional activity, wildland fire management has been the natural resource management program having the highest risk, complexity, and greatest potential for serious negative outcomes. This program has developed in an environment characterized by highly dynamic objectives, continuously expanding purpose, evolving strategies and tactics, developing policy, rapid growing scientific and technological information, and often, increasingly inflexible accomplishment expectations. From its earliest stages focused solely on fire control with a principal objective of fire exclusion, the program has developed into a more comprehensive fire management program that today presents a blend of suppression to accomplish protection objectives with the application of prescribed fire and management of naturally ignited wildland fires to accomplish resource benefits. During this time, organizational capability and capacity have grown to the highest levels. Knowledge of the natural role of fire, fire ecology, fire history, fire environment interrelationships, and fire and land use interactions has never been greater. Knowledge of the set of elements comprising risk from wildland fire, science and technological tools to assess this risk, how to apply analytical information to support decision making, and the full range of strategies and tactics available to land managers has never been greater. But, while capability has grown, physical elements such as fuel alterations, vegetation development, land use practices, and expansion of the wildland-urban interface have combined with social-political concerns such as visual impacts, concerns over potential fire outcomes, smoke management and air quality concerns, and economic impacts to expand wildland fire complexity. As a result, wildland fire complexity has never been greater. The changing fire environment is bringing potentially larger numbers of fires and greater areas burned annually. The 2011 fire season in the Southwestern United States typified this situation as large fires became more common and large burned acreages created public, media, and political concerns at the local, regional, and national levels. Culmination of these elements nationally has caused wildfire response to occupy a major part of land management agency workloads and budgets with expectations and costs increasing exponentially. Challenges of the future will continue to become more difficult to address and it is becoming alarmingly clear that past practices, processes, and applications will not effectively support achievement of future program needs and requirements. No longer is fire management facing a fire-vegetation dynamic only; it must now respond equally to

social, political, and ecological concerns and requirements. To move forward from the 2011 fire season and effectively characterize future program requirements, guide management actions, and shape an efficient, mature, and proactive program, a clear understanding of the past, present, and definition of the future are necessary. Social, political, and ecological concerns must be addressed and future program planning and implementation must be dynamic and responsive to these needs. This presentation describes opportunities to influence change, program direction, modernize fire management, and improve land and resource management.