DRAFT NAC20 topics/sessions

Thursday, October 1, 2020 12:00am - 12:00am

Posters

Burning questions: How severity of wildfire disturbance alters plant growth through disruptions of plant-soil microbiome

Kendall Beals
University of Tennessee, Knoxville

authors: Kendall Beals, Dr. Jennifer Schweitzer
As global change accelerates in the coming decades, disturbance events are predicted to increase rapidly both in rate and intensity. As a result, much ecological research is pivoting to examine how organisms function after environmental disturbance. However, the complexity of the mechanisms of how organisms respond to disturbance is often overlooked. To assess how interactions between soil microbes and plants may influence plant response to disturbance, we a) examined soil microbial diversity of a burn severity gradient of a 2016 wildfire in Great Smoky Mountains National Park (GSMNP) and b) conducted a subsequent greenhouse experiment using soil inoculum from the GSMNP burn gradient to measure growth traits of a widespread understory species (Solidago flexicaulis, Zigzag goldenrod) in response to fire-induced changes to the soil microbiome. As previous research has found that fire generally reduces soil microbial diversity and that microbial diversity can enhance plant growth in response to environmental disturbance, we hypothesized that a) increasing burn severity reduces soil microbial diversity and b) plant growth traits are inhibited in highly disturbed soils because of low microbial diversity.

In support of our first hypothesis, soil bacterial and archaeal diversity and composition greatly differed across the burn severity gradient ($p = 0.007$). On average, unburned soils harbored 20% greater diversity of bacteria and archaea than highly burned soils. Contrary to the second hypothesis, however, the greenhouse experiment found that Solidago flexicaulis exhibited enhanced growth traits when grown in highly burned soil inoculum compared to S. flexicaulis individuals grown in unburned soil inoculum. Individuals grown in microbiomes of high burn grew nearly three times faster on average than individuals grown in microbiomes of unburned soil ($p = 0.01$). Similarly, individuals grown in microbiomes of high burn were 20% more photosynthetically active than those grown in microbiomes of unburned soil and 13% more photosynthetically active than those grown in microbiomes of low-moderately burned soil (p 0.0001). Control treatments in which S. flexicaulis was grown without field soil inoculum revealed that individuals grown without a field microbiome had similar growth rates and photosynthetic activity to individuals grown in microbiomes of high burn. These results suggest that increased severity of wildfire disturbance may enhance some plant growth traits by reducing the presence of pathogenic soil microbes that are common in undisturbed soil. Broadly, this research highlights that fine-scale ecological interactions can in part mediate plant response to environmental disturbance.

Controls on plant-soil feedbacks of herbaceous community following fire in the Ruby Mountains, NV, USA

Katherine Strain
University of Nevada, Reno

Erin J. Hanan, University of Nevada, Reno

As larger and more frequent fires continue to shape landscapes in the Great Basin and across the western United States, it is increasingly important to understand how fire influences ecosystem processes such as carbon and nitrogen retention, streamflow, and water quality. Studies that couple carbon and nitrogen dynamics with vegetation recovery following fire can help us identify when and under what circumstances wildfires are changing the structure and function of Great Basin plant communities, ecosystems and watersheds. To examine how burn severity and soil moisture influences the composition of recovering herbaceous species and soil biogeochemical dynamics, we sampled vegetation and soils from burned and unburned plots following a wildfire that burned a portion of Lamoille Canyon Recreation area outside of Elko, NV, USA. We quantified the cover, presence, and biomass of herbaceous species and analyzed foliar carbon and nitrogen content at the peak of the first postfire growing season and the following year. We also collected mineral soil and forest floor samples (where present) and measured their carbon and nitrogen content, microbial biomass, pH and net mineralization and nitrification rates.

Preliminary data show that in the first year post-fire, herbaceous species composition differs between burned and unburned plots and that soil microbial biomass is negatively associated with burn severity. These results, though preliminary, contribute to our understanding of how fire influences herbaceous community dynamics and soil biogeochemical dynamics in Eastern Nevada. Future work will involve continued sampling of vegetation, soils and forest floor. We will also use our results to inform an ecohydrological model that we will use to examine possible effects of changing climate, plant invasion, and fire regimes on ecosystem processes.

CREEQ: A Public Perceptions of Recreational Water Quality Citizen-Science Initiative

Delaney Demro
SUNY ESF

The application of citizen science in formal research has become increasingly utilized by professionals across disciplines. This approach has the potential to be highly valuable in stream ecosystem conservation in the face of recurring nutrient over-enrichment of surface waters. Achieving accurate monitoring of stream water quality statewide at a sufficient spatial and temporal resolution to maintain protected uses is highly resource-intensive. The NY State Department of Environmental Conservation (DEC) with a research team at the SUNY College of Environmental Science and Forestry (ESF), applied this collaborative approach to conservation to supplement the existing network of stream monitoring efforts performed by the agency. This poster presentation outlines the supporting theory, methods, and preliminary results of the Citizen Recreational Evaluation of Environmental Quality (CREEQ) initiative. Through an online survey, the CREEQ initiative asks citizen-science volunteers to perform a visual evaluation of water quality and recreational usability of publicly-accessible stream locations. In response to volunteer surveys, the research team traveled to evaluated locations to validate submitted reports and collect water column samples. These samples were then analyzed for physical and chemical water quality-indicating parameters to relate volunteer observations to traditional monitoring practices. Validating this relationship and approach is crucial to reliably use public-reported data to inform stream monitoring efforts across New York state and other regions.

Differences in community composition and structure between riparian and non-riparian aspen (Populus tremuloides Michx.)

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The future trajectory of trembling aspen (Populus tremuloides Michx.) health and persistence in the Western United States is uncertain. Many theorize that predicted increasing temperatures and extended periods of drought will have a detrimental effect on the current distribution, composition, and structure of trembling aspen, especially in arid and semi-arid regions of the Intermountain West. Our project is exploring these relationships, and we are interested in whether riparian zones of the Intermountain West can potentially increase aspen stand stability, regeneration and resistance to drought.

We sampled nine riparian aspen stands and nine paired, adjacent non-riparian aspen stands of the Caribou National Forest of southeastern Idaho during the summer months of 2019. Plant community composition, structure, age distribution and regeneration dynamics were assessed within multiple 100-m2 plots established along 2-4 100-m transects oriented along the long axis of each aspen stand. Differences in plant community composition between the riparian and non-riparian stands were determined using multivariate analysis, including non-metric dimensional scaling (NMDS). Additionally, aspen stem size and age distributions were compared between riparian and non-riparian aspen stands with histogram analysis; statistical differences among size class and age group categories were compared with a chi square test for independence.

While both the riparian and non-riparian plant communities are dominated by aspen, the riparian stands were dominated by a mixture of forbs, graminoids and woody shrubs, the non-riparian stands had a lower herbaceous species density, and different woody shrub species. Additionally, we observed higher conifer encroachment in the non-riparian aspen stands. Overall, the stand structure of riparian stands exhibit an even size distribution, while non-riparian aspen stands are dominated by larger, older stems. Additionally, riparian aspen stands have significantly higher seedling and sapling densities than adjacent non-riparian stands (P 0.05).

Our results suggest that riparian aspen stands have a higher variation in aspen stem size and age, and higher aspen regeneration densities relative to adjacent non-riparian stands. The compositional and structural complexity of riparian aspen stands may prove more resistant to future environmental stressors caused by climate change. Furthermore, the higher densities of seedlings within riparian zones show evidence of a higher likelihood of stand stability (i.e. not dependent on disturbance for persistence). We suggest riparian zones could provide refugia for aspen in areas where increasing temperature and drought are expected.

Effects of plant functional groups determine 10-year sagebrush recovery following fuels treatments, A regional study.

David Board
USDA Forest Service, Rocky Mountain Research Station

Many sagebrush ecosystems in western North America are at risk of developing invasive grass-fire cycles prompting management aimed at increasing resilience to wildfire and resistance to invasive annual grasses. Managers implement large-scale fuel treatments to reduce fire risk by decreasing woody fuels and increase recovery potential by promoting native perennial herbaceous species that recover after fire. Responses to these treatments are variable and little is known about long term effects on recovery of keystone sagebrush species. The Sagebrush Treatment Evaluation Project (SageSTEP) was established to evaluate effectiveness of woody fuels treatments (prescribed fire, mechanical, herbicides) in sagebrush ecosystems and now has long-term (10 yr) data on treatment effects. We used path analyses to evaluate effects of community interactions on sagebrush cover and density for sites exhibiting pinyon - juniper expansion and cheatgrass invasion. We included 6 discrete time-steps Ã¢â‚¬' pretreatment and 1, 2, 3, 6 and 10 years after treatment. We asked two questions. (1) How did cover of the dominant plant functional groups influence post-treatment sagebrush population dynamics over time? (2) How did population responses to treatment differ on relatively cool and moist pinyon and juniper expansion sites and warm and dry sagebrush sites exhibiting cheatgrass invasion?
Preliminary results indicate that in controls sagebrush cover and density was consistent over the ten years while annual grass cover increased for both expansion sites and invasion sites. Density and cover of sagebrush in fire treatments at expansion site types increased slowly over the ten years after the initial reduction. Sites with the highest residual sagebrush cover recovered best. Pretreatment sagebrush cover negatively affected perennial native grasses, which negatively affected on cheatgrass, indirectly linking pretreatment sagebrush cover to post-treatment cheatgrass invasion. Mechanical treatment of expansion sites had little impact on sagebrush density and cover. Mowing treatments in the invaded sites reduced sagebrush cover and density neither of which recovered from the treatment over the ten years. Initial analyses of big sagebrush sites exhibiting cheatgrass invasion indicated that tebuthiuron application gradually reduced sagebrush density over time. Competitive interactions among sagebrush, perennial native grasses, and cheatgrass changed following treatment. Effects of sagebrush cover were reduced and effects of perennial native grasses on cheatgrass became apparent. Management implications are that adequate residual

sagebrush cover post-treatment will increase sagebrush recovery, while adequate perennial native grass cover will reduce cheatgrass.

Measuring Local Adaptation in Widespread Common Forbs of the Great Basin

Tessa Bartz
University of Nevada, Reno

Elizabeth Leger
University of Nevada, Reno

Restoration in dryland systems is challenging and prone to failure, but applying evolutionary concepts can improve its efficacy. Locally-sourced native populations may have a greater chance of restoration success because of their adaptations to local conditions. However, the characteristics important for local adaptation can differ drastically between taxa and environments, so it is important to conduct research on a diversity of species and populations to better understand which characteristics influence survival and performance among groups. In the Great Basin, few local adaptation studies have been conducted using forbs, despite their importance in these ecosystems. Here we describe a field-based seed germination and establishment study that compliments a large-scale common garden project designed to examine the variation in traits between populations of 3 widespread forbs of the Great Basin Desert using common gardens and germination experiments. We gathered 113 populations of hoary tansyaster (Machaeranthera canescens), 98 populations of Douglas' dustymaiden (Chaenactis douglasii), and 80 populations of tapertip hawksbeard (Crepis acuminata), and planted them in 6 common gardens; this presentation focuses on the Reno common garden. We transplanted 109 populations of hoary tansyaster, 75 populations of Douglas' dustymaiden and 19 populations of tapertip hawksbeard into an un-watered common garden in fall 2019, and we will measure phenology, neighbor survival, basal rosette diameter, plant height, leaf size, leaf shape, number of seeds per flower, and seed weight. In addition, we planted a seeding trial for a subset of 10 populations of each species randomly selected across the spectrum of local precipitation amounts. Seeds were sown directly into the ground, and will receive 3 watering treatments that encompass the local seasonal precipitation for the majority of our gathered populations. We are monitoring emergence and survival of each seed, and will be able to determine whether these are associated with water availability during early life stages. This work will add to our body of knowledge about the scale of local adaptation in an important guild of plants, native perennial forbs, and provide the opportunity to compare results from transplant and seeding studies.

Modeling Habitat Suitability for Mountain Stewartia and the Implications for Plant Conservation on Public Lands

Clayton Hale
Mississippi State University

Coauthors: Dr. Joshua J. Granger, Dr. Qin Ma, Dr. Jia Yang
Modeling species habitat suitability has become a critical first step in conserving rare or threatened plant species. These models allow conservationists to locate previously undocumented populations and prioritize populations and habitats for conservation. Mountain Stewartia is a rare shrub or small tree endemic to the piedmont and mountains of Georgia, Tennessee, and Alabama with isolated populations occurring in Kentucky, North Carolina, South Carolina, Virginia, and Mississippi. The species often goes misidentified or overlooked by land managers and conservationists. As a result, Stewartia habitat niche descriptions and distribution data are insufficient for restoration and conservation use. Presented is the habitat suitability of the species across its natural range. Herbarium records (25), research-grade INaturalist observations (25), and other author identified locations (15) were used with 10 environmental layers to develop a maximum entropy model (Maxent). A cross-validation Maxent model was run 65 times and was determined to be statistically significant with an AUC of 0.916 and a standard deviation of 0.155. The resulting probability map was classified into bins of 10% of habitat suitability for spatial analysis. A total of 264,210 ha were designated within the top 10% tier of which 30% is nonindustrial protected lands. The presented model will allow plant conservationists to potentially locate new populations of mountain stewartia and identify suitable areas for the establishment of new populations. This approach provides a framework for using citizen science and natural history

records for the modeling of other rare plant species with limited occurrence data.

Novel Use of Passive Acoustic Recorders for Mapping Coyotes on Public Lands

Claudia Pighetti
University of Nevada, Reno

Danielle Miles
University of Nevada, Reno

Claudia Pighetti, University of Nevada - Reno
Danielle C. Miles, University of Nevada - Reno
Dr. Kevin Shoemaker, University of Nevada - Reno

Passive acoustic technologies are changing the way habitat managers track wildlife by providing increasingly low-cost detectors that can be deployed for weeks to months without maintenance. In northern Nevada, a highly understudied region, the use of passive acoustic recording has transformed and simplified long-term species monitoring, bringing forth new opportunities for understanding species presence in lands in northern Nevada experiencing pinyon-juniper removal. To monitor the effects of pinyon-juniper removal on songbirds, we deployed Wildlife Acoustics SM4 passive recording devices for 3 field seasons (2017-2019) in 5 regional project areas distributed widely across the Great Basin in Nevada: Sheldon National Antelope Refuge (USFWS), Ely region (BLM & Mount Grafton Wilderness Area) Elko/Ruby Mountain region (BLM), Vya region (BLM), and Austin region (USFS). In nearly 200 5-minute sound files, we have manually detected howling coyote (Canis latrans) packs using sound visualization software (RavenPro) and anticipate more occurrences in the 2020 summer field season. Coyotes are the most abundant mammalian predator in northern Nevada and their populations affect natural biodiversity and grazing activities alike. This makes efforts to map their habitat use and activities important to land managers, ranchers, and field ecologists. This study explains how we have used passive acoustic technologies and how they can be adapted in future studies across disciplines, specifically by 1) summarizing seasonal coyote habitat use along the sagebrush to pinyon-juniper vegetation gradient , 2) demonstrating the use of triangulation to identify and locate coyote pack vocalizations, and 3) reporting on the costs and benefits of using passive acoustic detectors for monitoring coyotes. Passive acoustic recording has made possible efficient, wide-spread species monitoring on northern Nevada's public lands and will allow more opportunities to gain a better understanding of habitat use in Nevada's understudied regions.

Palaeoecological Studies for Past, Present and Future: A Case Study From Soldier Meadows

Mark Hall
Black Rock Field Office, Bureau of Land Management

Dave Rhode
Earth and Ecosystem Sciences, Desert Research Institute

The purpose of this poster is to illustrate the utility of pollen cores as tools that can provide valuable insights into the past, present and potential future of local vegetation communities. Also illustrated will be the utility of pollen cores in
informing land management decisions.

A pollen core was obtained from the wet meadow surrounding Mud Meadows spring inside the Soldier Meadows Area of Critical Environmental Concern (ACEC) located in the Black Rock-High Rock Emigrant Trails National Conservation Area (NCA) in northern Nevada. It is an unique habitat for threatened plant (basalt cinqefoil) and animal (desert dace) species.

The core was processed to recover pollen and non-pollen palynomorphs. A Bayesian age-depth model was constructed for the core from Pb isotope
and radiocarbon dates. The core extends back 1500 years and its dated resolution ranges from a decade to just

under 200 yrs.
The irregular time series of the proportions of various plant species and taxa are discussed. Through the Medieval Climatic Anomaly (MCA),
the vegetation community is dominated by Chenopodiaceae and Asteracea. In the Little Ice Age (LIA), Artemesia and perennial grasses dominate the vegetation communities and have remained fairly resilient through time, even in the presence of commercial grazing. Analysis of the charcoal grains suggests a decrease in the fire frequency from the MCA through the LIA. The cyanobacteria Rivularia
increases and Glomus decreases circa 350 BP to the present. This is indicative of a change in water chemistry and potentially water level.

The Modern Analogue Technique, in combination with the North American pollen database, is utilized to reconstruct climatic indicators. As expected, the MCA was a warmer and drier period--a climatic condition that is expected to become prevalent in the future. For planned and potential habitat restoration projects in the Soldier Meadows ACEC, the pollen core yields insights on the types of
vegetation and relative quantities of it out there, and its resilience. In accounting for climate change and habitat restoration projects, the pollen core provides evidence of species and taxa that may be better suited for future conditions.

Phenology-based UAV remote sensing for classifying invasive annual grasses to the species level

Alice Ready
University of Nevada, Reno

The spread of invasive plant species severely alters wildfire regimes, degrades critical habitat for native species, and has detrimental impacts upon ecosystem function, rangeland productivity, and dynamics of long-term carbon storage. Remote sensing technology has greatly improved our understanding of invasive plant ecology, and hence our ability to manage invasive species. Imagery obtained from airborne or space-borne platforms can provide spatially explicit estimates of plant population size, extent, and spread. However, it has proved quite challenging to remotely detect and monitor weed invasions at the species level, as detailed satellite imagery is commonly greater than one to four meters in resolution and is too coarse to identify isolated individuals or small patches of invasion. Species-specific weed mapping is essential for early detection of new invasions. Controlling emerging and individual infestations is critical for slowing the rate of invasion and promoting rangeland biodiversity in regions that are potentially at risk.

By capitalizing on species-specific differences in plant phenology and using high resolution Unmanned Aerial Vehicle (UAV) imagery we are able to collect detailed data emphasizing the spectral differences between invasive plants at the species level, even where different species co-occur in a fine-grained mosaic. UAVs can produce images at the centimeter scale, avoiding the 'mixed-pixel problem' where larger pixels encompass multiple cover types and plant species, confounding classification efforts. This study refines a novel methodology to separate invasive annual grasses based on plant phenology, increasing the utility of remote sensing data in invasive species management.

Because areas of invasion vary spatially according to cultural features and environmental influences, predictive species distribution models can improve monitoring by incorporating habitat suitability. By relating occurrence data and likely modes of species dispersal to landscape-explicit data, we can develop predictions of plant invasion over space and time. Using predictive models to explain, approximate, and predict environmental conditions under which invasive species establish and spread will focus monitoring on the most vulnerable locations. This research will use fine-scale UAV imagery to develop a predictive landscape model of future invasion risk. Thus, development of new remote sensing approaches for early detection of medusahead invasions will be timely and advantageous for allowing range managers to control its further spread.

Rapid O'hia Death: A Multi-agency Effort to Detect, Contain and Monitor an Emerging Threat to Native Hawaiian Forests

Christine Flauta
Hawaii Department of Land and Natural Resources

O'hia (Metrosideros polymorpha) is a keystone plant species in Hawai'i's native ecosystems that makes up about 1,000,000 acres of forest across the state. Ranging in altitude 0 - 10,000 ft it can thrive in intense geological conditions and is found growing in dry lava beds to the wettest Hawaiian rain forest. On O'ahu, Hawaii's most populated island, o'hia is essential to forest health but limited to areas with remnant native and intact ecosystems. In 2014, a new fungal disease in the genus Ceratocystis began decimating populations of o'hia on Hawai'i Island. In 2018 the pathogen referred to as Rapid O'hia Death (ROD) was identified as two strains, Ceratocystis lukuohia (destroyer of o'hia) and Ceratocystis huliohia (disrupter of o'hia). ROD quickly spread through 30% of Hawai'i Island's o'hia populations and 90% of the trees sampled were infected with the more aggressive strain, C. lukuohia. The intense spread of this pathogen prompted the creation of the O'ahu ROD working group. This group focused on dividing work loads between private, residential, military and state managed lands. It coordinated multi agency ground and aerial surveying with sampling while developing new methodologies to detect potentially infected trees. Learning from partnerships created on Hawai'i island, O'ahu was able to create an action plan to respond to this ecological disaster. To date over 174,000 acres have been surveyed on O'ahu resulting in 5 detections of C. huliohia. This collaboration between agencies, landowners, and residents made it possible for the early detection and suppression of ROD. The ROD working group will continue to make strides to delineate and manage the growing threat of ROD and will be crucial in planning efforts to secure funding and mitigate the impact on native forests.

Successes and Failures, Ten Years of Managing the First Predator Fence in Hawaii

Jared Char
Hawaii Division of Forestry and Wildlife

Chris Miller
Hawaii Division of Forestry and Wildlife

Kaena Point, located on the westernmost tip of Oahu, is one of the last intact sand dune ecosystems in the main Hawaiian Islands. It is currently managed by the State of Hawaii's Division of Forestry and Wildlife as a part of the Natural Area Reserve System. In 2010, a predator-proof fence was constructed to establish Kaena NAR as the first predator-free reserve in Hawaii. Eliminating predators from the 20-hectare reserve, while challenging, has allowed Laysan albatross and Wedgetail shearwater populations to flourish, as well as a host of native plant species. The reserve is also being used as an introduction site for black-footed albatross, to mitigate effects of sea level rise due to climate change, as well as a recovery site for Hawaiian yellow-faced bees, an endangered species endemic to Hawaii. However, constructing a metal fence with exact specifications in a coastal area with high winds, salt air and high waves has proven difficult and costly to maintain. Additionally, complications with rodenticide labelling and permitting has led to gaps in rodent control efforts. Management strategies had to be developed to mitigate these issues, including improved fence hardware, diversifying trap and bait types, bait deployment, and rodent tracking tools. This presentation will discuss the successes and difficulties met over the last ten years of management at Kaena Point since the construction of the predator-proof fence.

Understanding army cutworms can help restore cheatgrass-invaded areas in the U.S. Intermountain West

Cindy Salo
Sage Ecosystem Science Corp.

Cheatgrass (Bromus tectorum) has invaded many low, dry areas in the U.S. Intermountain West. This exotic annual grass forms near-monocultures across large areas and often dominates sagebrush and salt desert scrub understories. Cheatgrass competes vigorously with species seeded and planted for restoration.

Starting in 2003, widespread cheatgrass die-offs have occurred in some of the lowest, driest areas of the West. Native army cutworm (Euxoa auxiliaris) outbreaks can consume cheatgrass and exotic mustards (Brassicaceae) to produce die-offs. The larvae can also defoliate native shrubs (Artemisia and Atriplex).

Army cutworm eruptions seem to occur when: 1) a year of dry weather ends with heavy late summer rain, 2) numerous adult moths, called miller moths, return from high elevations in fall to lay eggs, and 3) dry weather resumes through winter. Army cutworms overwinter as larvae, feeding at night and resting under objects or in the soil during the day. Larvae pupate in late spring and emerge as miller moths. The moths follow the blooms of flowering plants to high elevations for the summer.

Miller moths travel long distances. Those emerging in the Great Plains fly through Colorado's Front Range on their way to high peaks in the northern Rocky Mountains. Grizzly bears feast on the fat-filled moths. Miller moths emerging in the Intermountain West apparently spend summers in nearby mountain ranges. Large aggregations were found in Great Basin National Park after outbreaks and die-offs in 2014, and black bears were seen feeding on miller moths in the Jemez Mountains of northern New Mexico in the summer of 2003.

I have studied cheatgrass die-offs and army cutworms since 2003 and am developing a network of observers to monitor fall miller moth populations and watch for winter army cutworm outbreaks and cheatgrass die-offs. Understanding Euxoa auxiliaris outbreaks and migrations in the Intermountain West will let us better predict cheatgrass die-offs. Predicting these events will let us take advantage of these times of reduced competition from cheatgrass to seed and plant desirable species in cheatgrass-invaded areas.

Vegetation recovery following forest restoration thinning and pile burning in aspen-conifer stands around the Lake Tahoe

Jennifer Brumbeloe
Humboldt State University

Christa Dagley
Humboldt State University

Land management agencies around the Lake Tahoe Basin have been actively restoring aspen stands at high risk of loss for over a decade. Before these restoration interventions, conifers had been overtopping and shading out the shade-intolerant aspen, and gradually replacing them. Restoration techniques have included mechanically removing conifers from aspen stands, lopping and scattering conifers within aspen stands, and hand thinning, piling, and burning the thinned conifers in and adjacent to aspen stands. The latter technique is commonly used but we know very little about its effects as well as its effectiveness. Through monitoring work we are beginning to understand the effects of pile burning on aspen trees and other components of the aspen ecosystem. In this study we are collecting and analyzing data on tree regeneration inside and adjacent to burn piles, and assessing the changes and recovery of herbaceous vegetation on spots where piles were burned. The earliest restoration thinning treatment that we have regularly monitored was implemented in 2009 followed by pile burning once the cut wood had dried. Additional stands were thinned in 2010 and subsequently burned. Recovery of vegetation has proceeded rapidly, but is variable within and across the range of mesic and xeric study sites. This presentation includes maps and schematic layout of the 2.5-acre permanent monitoring plots surrounding Lake Tahoe, images of actively burning piles and post-fire conditions, and time-series data quantifying rate of vegetation recovery after the forest restoration activities at nine permanent long-term monitoring installations on lands managed by federal and state agencies in California and Nevada.

Monday, October 12, 2020 12:00am - 12:00am

Collaborative approaches to conservation - public/private partnerships

Farm to Forest

Cory Gritzmacher

Mequon Nature Preserve

Farm to Forest

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Mequon Nature Preserve has been doing active land restoration for over 15 years on 438 acres in southeastern Wisconsin. What began as a dream for one man has turned into a nature oasis for over 20,000 people that visit the preserve on an annual basis. MNP took it's first section out of agriculture almost 15years ago. That area today has become an environmental corridor that connects two previously existing woodlots on the property. MNP's 150 year master plan directs the transformation of 400 acres of agriculture fields into a mosaic of hardwood forests, wetlands and prairies.
Over that past 15 years MNP has created with the help of its' partners and funders over 24 acres of wetlands and has 250 acres in active land restoration. MNP recently removed 65 acres from agriculture production in fall of 2016, which was the largest section taken out of agriculture at one time over the past 15 years. Once home to corn and soybeans is now home to over 10,000 native trees and shrubs. The project area has also created a 5 acre wetland systems by simply breaking drain tile that was installed in the early 1900's. The entire 65 acres project area was seeded with native prairie seed from local genotypes. The now thriving prairie will aid in soil health, prevent erosion and create habitat as the trees to continue to grow to become a forest once again.
MNP is now home to 12 species of fish, 5 native crayfish species, 6 frog and 1 toad species and tiger salamanders. Bird diversity has increased from 68 species in 2007 to over 184 species in 2018, which is a great indicator of successful habitat restoration.
MNP will share some of the dramatic before and after photos of restoration from over the past 15 years. Share lessons learned, challenges and success that MNP has encountered while taking on this ambitious goal.

Opportunities for shared stewardship after fire in the Carlton Ridge Research Natural Area, western Montana

Mary Manning
Forest Service

Justin Crotteau
Forest Service

The Research Natural Area (RNA) program is one of the oldest formal programs in the U.S. Forest Service (USFS). Since 1927, RNAs have been systematically established on the national forests and grasslands to represent a wide range of vegetation types in a national network of protected reference sites. These sites are designated in perpetuity for research, education, and the conservation of biological diversity. To date, 533 RNAs have been designated across the nine USFS regions, protecting approximately 600,000 acres. In the USFS Northern Region's Lolo National Forest (LNF), the Carlton Ridge RNA was established in western Montana in 1987 to protect a unique, extensive stand of alpine larch (Larix lyallii). This open, park-like forest community occurs at elevations from 7900 to over 8400 feet, on a subalpine ridge that escaped glaciation and has deep, well-developed soils. Such an extensive deep soil setting has not been documented elsewhere for this tree species. In 2017, the Lolo Peak wildfire burned much of the RNA and surrounding area, creating a complex burn mosaic in which some areas burned severely, killing all alpine larch trees, and others experienced little or no fire. This burn pattern has created opportunities for research and monitoring of post-fire response of this unique vegetation type, which will provide important findings to LNF resource managers and the scientific community. Alpine larch has also been identified as a tree species especially vulnerable to climate change and this burn may create opportunities for monitoring alpine larch populations after fire into the new climate future. The USFS Rocky Mountain Research Station (RMRS), along with the LNF and Northern Regional Office, is collaborating with the non-profit Friends of Lolo Peak (FOLP) to develop a citizen science research and monitoring project that will document fire effects and post-disturbance ecosystem response in this unique plant community. In particular, conifer recruitment will be monitored along biophysical, elevational and fire severity gradients. LNF and RMRS personnel are co-developing the sample design and associated site selection, and FOLP volunteers will work with RMRS on data collection. While many examples of the USFS's policy of shared stewardship preempt wildfire, this is an excellent demonstration of how shared stewardship following fire can foster collaborative conservation and research opportunities in USFS RNAs, and lead to novel methods for management of this high elevation species.

Tuesday, October 13, 2020 12:00am - 12:00am

Aspen conservation

Tuesday, October 13, 2020 12:00am - 12:00am

Development and use of native seed in natural areas management

Biology, ecology, and use of forb species in post-fire restoration

Corey Gucker
University of NV, Reno and Great Basin Fire Science Exchange

Génie MontBlanc
University of NV, Reno and Great Basin Fire Science Exchange

Coauthors: Nancy Shaw, USFS-RMRS; Anne Halford, BLM; Genie Montblanc, University of Nevada, Reno

Larger and more frequent fires fueled by nonnative species in the West, especially large portions of the Great Basin, have depleted native seedbanks. In these areas, active revegetation is necessary to restore native plant communities and historic fire regimes. Native forbs have long been overlooked in revegetation but are important to pollinators, wildlife, and ecosystem functioning. For the past 20 years, an extensive, multi-disciplinary research effort involving various institutions and agencies has improved our understanding of the biology and ecology of western forb species and provided guidance for their use in revegetation. Yet, the information and practical knowledge gathered has yet to be compiled and synthesized.

An online book, Western Forbs: Biology, Ecology, and Use in Restoration, is synthesizing published data and unpublished protocols necessary for seed collectors, growers, practitioners, and land managers to increase the supply and use of appropriate native forb seed sources for restoration of sagebrush steppe and other western ecosystems. The book is made up of chapters focusing on individual forb species including distribution, biological characteristics, ecosystem importance and function, and knowledge gained through seed harvesting, seed production in agricultural fields, and wildland planting.

Implications to the native seed market as we move towards local genetic sources and seed transfer zones

Ed Kleiner
Comstock Seed

The seed industry is going through a radical change adapting to the growing demand for local genetic sources of plant materials and seed. This change is supported by genomic studies that are revealing nuances in our traditional understanding of species distribution. In response, the seed industry is expanding cultivation and local source collections of a wider variety of species within traditional geographic distributions. The BLM is simultaneously supporting this trend with 'Indefinite Delivery Indefinite Quantity (IDIQ)contracts to seed growers. This presentation will walk through a few successful local collection contracts and concludes that these options should be aggressively expanded with urgency due to the long-term process of developing new cultivars in the face of current exponential growth in demand.

Meeting the Need for Ecologically Appropriate Native Plant Materials in the Mojave Desert

Judy Perkins
Bureau of Land Management

Lesley DeFalco
US Geological Survey

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Native plant restoration in the Mojave Desert depends heavily on wildland collection seed. This is partially due to the lack of Mojave appropriate cultivars and partially due to the challenges of commercially growing and harvesting seed for many of the species needed. The Mojave Desert Native Plant Program, working with partners, is improving the availability of appropriate native seed for restoration. The U.S. Geological Survey has completed provisional seed transfer zone development, and their associated Climate Distance Mapper tool, to improve seed sourcing relative to restoration sites, and is working with Rancho Santa Ana Botanic Garden to develop genetic seed transfer zones for select species. Priority restoration species have been identified to guide seed collections and increase grow-outs. Pilot seed increase projects include challenging annual forb species, valuable for Mojave desert tortoise habitat restoration, to develop growing and seed harvest techniques. The overall program goal is to increase ecologically appropriate seed availability for restoration across the Mojave Desert.

Timed Mowing in Combination with Broadcast Seeding Increases Native Plant Coverage in a California Grassland

Esther Cole Adelsheim
Stanford University

California grasslands have been transformed through the introduction and spread of non-native, annual plant species. Restoration efforts typically seek to shift competitive dynamics between native and exotic species by restoring natural forms of disturbance (controlled burns, managed grazing, etc.), targeted control of invasive, non-native species (herbicide application, timed mowing, etc.), or promoting native species (planting, broadcast seeding, etc.). Proximity of developed areas with a high density of people and sympatric species of conservation concern with sensitivities to chemical application, can limit management alternatives. We evaluated the effect of timed mowing in combination with broadcast seeding of native species on the percent cover of native species in an annual Eurasian grassland at Stanford, California. Treatments were applied annually from 2016-2019. Mowing alone did not increase native plant coverage relative to controls. Timed mowing in combination with broadcast seeding significantly increased percent cover of native species. The increases in percent cover were found primarily in seeded, native species, although there was also an increase in the percent cover of non-native, perennial species. Repeated application of timed mowing and broadcast seeding over 4 years increased coverage of native species. We also found a significant effect of year and aspect. Percent cover of native species after the first year of treatment differed by year of application. East facing slopes had a higher percent cover of native species than west facing slopes. The results of our experiment suggest

that timed mowing in combination with broadcast seeding is a viable management tool for increasing coverage of native grassland species, however repeated applications may be required to achieve target levels of native plant coverage.

Using patterns of genetic differentiation as the foundation for seed transfer guidelines

Rob Massatti
U.S. Geological Survey

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Abstract: As restoration needs for natural landscapes increase due to higher frequency and/or intensity disturbances, the establishment of invasive species, and impacts resulting from climate change, considerable time and resources are being invested to guide the development and deployment of native plant materials (NPMs) to improve restoration outcomes. For example, genetic sequence-based approaches are increasingly applied to restoration species to elucidate adaptation to environmental gradients, which can assist the development of seed transfer guidelines. However, the underlying patterns of genetic diversity within such datasets may also provide important knowledge to guide the use and development of NPMs. For example, natural patterns of genetic differentiation (e.g., a species' genetically defined populations), which are increasingly recognized as an inherently valuable resource, would best be protected by explicitly using them to create regional seed transfer boundaries. In turn, such genetic differentiation-informed boundaries may help mitigate other issues that can impact restoration outcomes, such as outbreeding depression or the decay of interactions among species within a community and the subsequent loss of community resilience. Here, we detail a new method that utilizes species distribution models, landscape resistance analyses, and empirical patterns of genetic differentiation to estimate the geographic distribution of genetically defined populations for two species, Pseudoroegneria spicata (bluebunch wheatgrass) and Hilaria jamesii (James' galleta grass). Furthermore, we use these boundaries to regionally constrain estimations of adaptation inferred either from common gardens (in the case of P. spicata) or from genetic sequencing data (in the case of H. jamesii). As such, we develop guidelines that can be used to minimize both genetic and adaptive differentiation during seed transfer or when selecting seed sources from which to generate new NPMs.

Tuesday, October 13, 2020 12:00am - 12:00am

Invasive species management - new and effective approaches

A Comprehensive Method for Detecting and Controlling Angiopteris evecta in Inaccessible Terrain on O'ahu, Hawaii.

Christine Flauta
Hawaii Department of Land and Natural Resources

Jenna Masters
Hawaii Department of Land and Natural Resources

Angiopteris?evecta?is an invasive tropical fern that has negatively impacted O'ahu's??ecosystems by displacing and outcompeting native species. ?Many of O'ahu's intact wet forests are located in remote areas with steep terrain that is often inaccessible to humans. They are diversity rich and being overrun by A. evecta. The State of Hawaii Division of Forestry and Wildlife Native Ecosystem Protection and Management Section (DOFAW-NEPM) is tasked with protecting many of the ecological resources in these areas. In collaboration with public and private partnerships new approaches including aerial imagery, precision helicopter herbicide application, and GIS mapping are being used to combat this highly invasive species. These new approaches have increased safety for ground crews and the efficiency of surveying large inaccessible tracts of land. Precision helicopter spraying has enabled us to control remote and dense patches that act as a reservoir for newly emerging plants. With the continued collaborative effort of our partners, DOFAW-NEPM hopes to bring populations of A. evecta to a manageable threshold and ultimately remove it from areas with high conservation potential. ?

Can mastication and prescribed burning be applied to simultaneously reduce fuels and control invasive plants?

Ryan Tompkins
Univ. of Calif. Cooperative Extension

Michelle Coppoletta
USDA Forest Service Region 5 Ecology Program

Over the past 20 years, managers of public lands in the western United States have witnessed an explosive spread of the highly invasive annual grass medusahead (Elymus caput-medusae). Traditional control methods (e.g. manual removal, herbicide application, prescribed burning) developed for rangeland applications may differ when applied to dry mixed conifer forests where land managers must balance fuel reduction goals with invasive plant control objectives. We implemented a small-scale, replicated field trial to investigate the effect of high intensity prescribed fire and treatment timing on medusahead abundance. We then applied these findings to a larger spatial scale, by designing an experimental fuel reduction treatment that had the dual purpose of lowering fuel loads and reducing medusahead abundance. The specific purpose was to investigate how some of the methods commonly used in landscape-scale fuel management, specifically mastication and prescribed fire, influence the frequency and cover of medusahead over both short (1-year) and long (10-year) time periods. The application of high intensity fire, regardless of timing, reduced the percent cover of medusahead at small scales. At larger scales, mastication and prescribed fire treatments significantly reduced the frequency of medusahead in the first year following treatment. However, in the absence of follow-up treatments medusahead increased over time, and ultimately had higher abundance than prior to treatment. These findings suggest that while some treatments may be effective at small spatial scales and over short timeframes, the variable effects often seen in prescribed fire treatments applied at larger scales can facilitate dispersal of medusahead into newly treated areas over the long term.
(Authors include: Ryan Tompkins, UC Cooperative Extension;
Michelle Coppoletta, USDA Forest Service Region 5 Ecology Program;
Jim Belsher-Howe, USDA Forest Service, Plumas National Forest)

Managing Invasive Annual Grasses

Harry Quicke
Bayer

Corey Ransom
Utah State University

Invasive winter annual grasses, including downy brome, medusahead, and ventenata are causing economic and environmental damage in Utah. These invasive grasses, reduce available forage, impact native and desirable vegetation, and appear to facilitate invasions by other species. Wildfires due to invasive annual grasses consume tens to hundreds of thousands of acres each year costing millions of dollars in losses and management costs. Research conducted at Utah State University the past 20 years has sought to identify strategies for managing invasive annual grasses and protecting desirable plant communities. Studies have evaluated fire, mowing, reseeding, and herbicides. In many instances, a given site has been managed effectively for 1 or 2 years. In the few instances where desirable species plantings have been successful, invasive annual grass resurgence has been delayed even longer. With herbicides alone invasive annual grass control can be improved through proper timing and with different chemical combinations. However, even when properly applied none of the previously investigated treatments could prevent invasive annual grass from becoming dominant again within a few years. More recent research with a newly developed herbicide has shown long term suppression of invasive annual grasses. In these trials, long-term suppression of the annual grasses has allowed native and desirable species to increase in cover and biomass. Some treatments are showing invasive annual grass control almost 5 years after treatment. All of the different herbicides and their unique properties will allow development of effective management and restoration plans for invasive annual grass invaded landscapes.

Nevada Department of Wildlife's Approach to Prevention and Containment of Dreissenid Mussels

Laura Megill
Nevada Department of Wildlife

Nevada has been affected by a number of significant invasive species in recent decades, but none more devastating than the quagga mussel (Dreissena rostriformis bugensis). The 2007 discovery of quagga mussels in Lake Mead catapulted the west and Nevada into action. Watercraft inspection programs have been the primary focus in containing regional mussel populations on the lower Colorado River system and preventing their expansion throughout the State of Nevada. With no viable eradication measures available, containment and prevention are our only options. A brief overview of the watercraft inspection program will show case NDOW's efforts to combat this prolific invader.

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Managing fire regimes in a changing world (good fire/bad fire)

Bandits, Birds, Burning, and Beliefs: The Story of Florida Scrub Jays at Jonathan Dickinson State Park

Rob Rossmanith
Florida Park Service

Jonathan Dickinson State Park (JDSP) is a 4,250 hectare property in south-eastern coastal Florida. JDSP is one of 175 state parks in the Florida Park Service system, which as an agency won its fourth National Gold Medal in 2019. JDSP annually welcomes 300,000 visitors and includes a rare ecosystem, Florida scrub. One of the inhabitants of Florida scrub is the Florida Scrub Jay, a Florida endemic bird that is Federally Threatened. The population of the bird, within JDSP, peaked in the early 1990s due to several wildfires in the 1970s and 1980s and then crashed in the early 2000s. Persistent use of prescribed fire and interpretation of these efforts to the public has created an accepting public outlook which supports the parks' prescribed burning. Due to prescribed fire in the scrub Florida Scrub Jays now thrive and are rebounding in numbers, which we know because of supervised citizen science. The park is a model for using prescribed fire in urban settings and in leveraging community efforts to monitor imperiled species.

Estimating the Impacts of Wildfire on Ecosystem Services in Southern California

Emma Underwood
University of California, Davis

Emma C. Underwood, University of Davis, California, USA and
Hugh D. Safford, USDA Forest Service Pacific Southwest Region, California, USA

Chaparral-type shrublands characterize the world's Mediterranean-type climate regions. In southern California they are the most extensive ecosystem and dominate the four southern USDA Forest Service National Forests. Wildfire is a natural disturbance in California's shrublands and critical for its healthy functioning. However, a rise in anthropogenic ignitions has resulted in increased fire frequency, which is having disastrous effects on property and human lives and incurring millions of dollars in suppression costs. Less obvious, though, are the intangible environmental impacts of wildfires – the consequences on the provision of ecosystem services to the millions of people who live in close proximity. We developed a web mapping tool to quantify fire impacts on six ecosystem services: carbon storage, water runoff and groundwater recharge, sediment erosion, recreation, and biodiversity. The removal of vegetation increases water runoff, recharge and sediment erosion post-fire, and decreases carbon storage immediately after. Moreover, frequent short-interval fire is causing the type-conversion of native shrubs to invasive annual grasses. Quantifying the impacts of wildfire on ecosystem services in addition to routine fire suppression expenses is increasingly recognized as an important component of natural resource management on public lands in southern California. In addition, assessing areas of high ecosystem service provision can help prioritize areas for post-fire management activities, such as stabilizing slopes in areas of high erosion risk, thereby helping to ensure their long-term provision.

Wildfire effects on belowground carbon and nitrogen cycling and microbial biomass in the Sierra Nevada

Mary Brady
University of Nevada, Reno

Coauthors: Erin Hanan, Jessica Miesel, Matthew Dickinson, Jonathan Greenberg, Carol Ewell, Laura Wade
Fire is a key factor regulating carbon (C) and nitrogen (N) retention in soils of the Sierra Nevada. As fire regimes shift in response to climate change and management, it is vital to understand how belowground C and N cycling will respond. However, studying fire is challenging. Fire timing and location are difficult to predict and as a result, researchers must often rely on space-for-time substitutions to evaluate fire effects. Unfortunately, these substitutions make teasing apart fire effects from other drivers challenging. To eliminate such problems, many studies have focused on prescribed fire, which enables researchers to conduct pre- and post-fire measurements at a known location. However, prescribed fires differ from unplanned fires (hereafter called wildfires) in their severity, heterogeneity, and spatial scale. Thus, to understand the effects of wildfire on soils, we need to incorporate location specific pre- and post-fire sampling. Here, we collected soil samples in the path of advancing wildfires in the Sierra Nevada and then resampled the sites immediately post-fire, one month, and six months later. Additionally, because some of our sampling sites did not burn, we were able to examine the role of wildfire alongside seasonal processes that influence soil dynamics. We analyzed the forest floor and mineral soil for N mineralization and nitrification rates, pH, microbial biomass, and total C and N.
Preliminary results show pronounced spikes in pH following fire for both mineral soil and forest floor. The magnitude of these spikes increased with fire severity and were larger in the forest floor than in mineral soil (i.e., 4 and 0.7 pH unit increases, respectively, in the high severity plot). Our results also suggest that microbial responses vary with fire severity: microbial biomass was higher in mineral soils that burned at high severity while plots that burned at low severity had similar mineral soil microbial biomass to unburned plots one month post fire. Forest floor microbial biomass however, was lowest in the high severity fire plots. Preliminary results also indicate different biomass response to spring thawing with larger increases in areas that did not burn. Our current work seeks to link soil temperature measurements from wildfires with belowground biogeochemical fluxes to quantify the effects of fire energy. These measurements are crucial for projecting how carbon and nitrogen retention will respond to future fire and climate conditions.

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Mitigating the impacts of resource extraction on public lands

Wetland mitigation banks are unable to replace many of the native plant species found in natural wetlands

Stephen Tillman
Illinois Department of Natural Resources

The U.S. Army Corps of Engineers regulates development projects that negatively affect natural wetlands by requiring that permittees fund or conduct wetland mitigation to compensate for wetland losses. The Corps' preferred method of compensation is wetland mitigation banking, in which large wetland restoration projects are constructed by third-party bank sponsors to provide mitigation for multiple development projects. To achieve the national goal of no-net-loss of wetland resources, the wetlands produced in banks must adequately compensate for those affected by approved development. Previous studies have used vegetation-based metrics to compare plant communities in mitigation wetlands to those in existing natural wetlands; however, few have examined if mitigation wetlands replace the specific plant species that are lost due to permitted development. To assess banks' ability to replace the native plant species found in natural wetlands, and to examine how regulatory conditions affect species replacement, we compared the plant species present in 13 banks within the Chicago District of the Corps to those in more than 2,000 natural wetlands that may be impacted by permitted development. To do this, we developed a novel modeling approach to simulate the destruction of natural wetlands and the accompanying purchase of mitigation credits from banks as compensation. We found that banks successfully replaced fewer than 40% of the native species present in natural wetlands that were 'destroyed' under typical regulatory conditions in our simulation. While changes to certain policy conditions in our model produced a moderate increase in species replacement by banks, wetlands in banks simply did not contain many of the native species present in the natural wetlands for which they may be used as compensation. Average replacement was greater for species that are highly tolerant of anthropogenic disturbance than for conservative species with high fidelity to undisturbed natural communities. Our results also suggest that there may be differences between the wetland community types present in impacted natural wetlands and those produced in banks. This study documents the limitations of certain wetland mitigation practices and indicates that improving the equivalence between natural and mitigation wetlands should be a greater priority in wetland mitigation policy. Additionally, our simulation model serves as a novel approach to analyzing mitigation outcomes that could be used in other studies wishing to compare the resources present in natural habitats to those in mitigation projects.

Co-author: Jeffrey Matthews, University of Illinois at Urbana-Champaign

Tuesday, October 13, 2020 12:00am - 12:00am

Natural areas management in light of climate change

Application of empirical land-cover changes to construct climate change scenarios in federally-managed lands

Christopher Soulard
Western Geographic Science Center

Matthew Rigge
US Geological Survey

To better understand how climatic factors contribute to sagebrush-dominant ecosystems in the Great Basin, USGS researchers applied NLCD Back in Time fractional vegetation component data to measure the rate of cover change over three decades and quantified the relationship between historical climate and vegetation. Historical rates and causes of land cover change were used to create climate-land change scenarios to project how shrub, herbaceous, and bare cover may be located in the future. Historical data were used to project future rangeland cover in three different federal management areas (Beaty Butte Herd Management Area, Hart Mountain National Antelope Refuge, and Sheldon National Refuge) using a business-as-usual (BAU) scenario and RCP 8.5 climate change scenario spanning 32 years (2018-2050). Summaries of historical changes and gridded spatially-explicit map projections suggest that climate influences may make the landscape more homogeneous in the near future. Across the entire study area, 30m pixels with current high percent bare ground cover are projected to become less bare ground dominant; pixels with current moderate percent herbaceous cover are projected to contain less herbaceous cover, and pixels with current low percent shrub cover are projected to contain more shrub cover by 2050. Although change rates vary between scenarios, general patterns and composition do not differ much between scenarios by the end of

the projected period. This is surprising given that RCP 8.5 climate projections suggest that minimum temperatures will be 17% higher and total precipitation will be 3% higher in the study area by 2050. Different patterns and trends are more apparent by comparing projections between management units. Hart Mountain National Antelope Refuge is projected to undergo the most change over the projected period. BAU and RCP 8.5 models project a larger decline in bare ground, as well as larger upticks in average herbaceous and shrub cover in Hart Mountain compared to the other management areas included in the study. These scenarios present alternate future outcomes that could help guide federal land managers to identify changes in cover that may affect certain species.

Managing small natural areas in light of climate change

Peter Dunwiddie
University of Washington

Considerable efforts have been made in recent decades to enlarge or connect many natural areas to include more complex, heterogeneous landscapes based on the premise that greater size, connectivity, and habitat diversity may allow many species to move to suitable sites as climates change. While protecting key linkages and rewilding natural habitats may be feasible strategies in some areas, in others, these options do not exist. Urban sprawl and development, conversion to farmland and production forestry, and road construction may have irrevocably severed corridors and preclude increasing the size of natural areas and surrounding habitats. This presents enormous challenges and questions regarding the long-term viability of many small, often isolated natural areas that were set aside at a time when conservation paradigms were less aware of the importance of size and connectivity in maintaining ecological functionality. In this talk, I propose an alternative for managing such sites by reconsidering their overall goals. Rather than focusing on trying to maintain unsustainable ecological functionality, I suggest that such sites might be more suitably managed as refugia or 'lifeboats' for maintaining populations of a high diversity of both rare and common species. On the continuum that describes the management of assemblages of native species, with largely untrammeled wilderness at one end and arboretums, gardens, and zoos at the other, this perspective nudges these small natural areas more forcefully towards the latter. Such a shift runs counter to how many such areas have been traditionally managed and is certain to be regarded with skepticism if not outright hostility by many. Yet, I suggest it presents a number of advantages and opportunities both for significant conservation benefits as well as for learning through experimentation. First, many species could be sustained through intensive and proactive management that is often impossible at larger scales on more extensive sites. Such practices could help sustain unique genotypes and add redundancy to populations of rare species that could serve as sources for restoring other sites as needed. Equally important, these sites could ably serve as locations for experiments with assisted migration. It is imperative that conservation practitioners begin to learn how to deliberately transport species that may be threatened in their current habitats due to changing climates and introduce them in a responsible manner to new, more suitable sites that maximizes learning opportunities. This talk will illustrate these ideas with examples from natural areas in the Pacific Northwest.

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Pollinator considerations in natural areas management

Nectar Resources in Oak Savanna Pollinator Habitats

Helen Michaels
Bowling Green State University

Meigan Day
Bowling Green State University

Nectar quality is an important resource to consider for restoring habitats for butterfly conservation. Literature shows that butterflies with diets rich in sugars or amino acids often have improved fecundity, longevity, and increased lifetime fitness, but most habitat assessments only consider host plants and flowering stem counts when evaluating habitats for pollinators. The Karner blue is a bivoltine butterfly listed as federally endangered since 1992 with varying reintroduction success. The aim of this study was to examine nectar quality characteristics of oak savanna forbs in Karner blue butterfly habitats and quantify the variation in nectar sugar resource availability during each flight period. Using existing data on flowering plant density, we measured floral availability, nectar volume, and sugar concentration to estimate nectar resources across 16 sites in Ohio and Michigan. We found that nectar resources per flower were influenced by relative humidity and species present. Nectar sugar availability on the landscape varied with site, season, and species present. Analyses revealed a difference in sugar available per quadrat between seasons among sites with a history of occupation and former release sites no longer occupied. These data on the species-specific characteristics and temporal variation in nectar resources will aid habitat restoration planning and benefit conservation efforts for nectar feeding pollinators of this critically imperiled habitat. Co-author: Ryan Walsh, The Toledo Zoo, Toledo, OH

The nutritional ecology structuring bee-flower communities in the sierra and sagebrush and implications for conservation

Anthony D. Vaudo
University of Nevada Reno

Anne S. Leonard
University of Nevada Reno

Understanding the nutritional drivers of bee-flower interactions is crucial to the conservation of native plants and pollinators. Pollen provides the primary source of protein and lipids necessary for bee development and reproduction. Yet, pollen nutrient composition differs widely among plant species, requiring diverse communities to provide a spectrum of nutrient rewards to support the bee community. Our previous research indicated that pollen protein:lipid ratios (P:L) shape bumble bee host-plant choice. Different bee species may have species-specific P:L nutritional needs driving their own foraging patterns. Therefore, pollen nutrition may shape bee-flower interactions and drive community stability. To understand how nutrition structures communities, we assessed pollen nutrient concentrations among co-flowering plant species in Sierra Nevada meadow and Great Basin sagebrush steppe habitats. We systematically sampled pollen-collecting bee species to create bee-flower visitation networks, and collected bees' pollen loads to analyze their nutritional foraging targets. We determined the relationship between plant species' pollen P:L and diversity of their bee visitors, and whether plants that shared bee visitors offered similar or dissimilar/complementary nutrition. Likewise, we asked if bees differ in P:L targets, and if species collecting similar pollen nutrients share host-plants. In the Sierra Nevada meadow (sagebrush steppe analysis in process), co-flowering plant species varied substantially in pollen nutrition, forming a wide spectrum of P:L values. Specialized plants, with the lowest diversity of visitors, offered the highest (and lowest) P:L values; and bee species diversity was highest on host-plants offering mid-range pollen P:L ratios. Correlating visitor and nutritional similarity, we found that plants with similar P:L ratios did not tend to share visitors, yet bees with similar nutritional targets overlapped in pollen host-plants. This offers new insight into how bees may achieve preferred nutrition by combining visits to plants offering complementary P:L ratios. For example, by collecting pollen from different host-plant species, related bee species within the genera Bombus and Calliopsis collect different pollen P:L ratios. This may indicate that bee species reduce competition by having different nutritional targets, collecting from different host-plant species at different frequencies, and emphasizing the need of diversity for sustainable populations. This study presents a novel approach to understanding fundamental nutritional factors that assemble bee-flower communities across varying environments. Our new framework can be used to identify key host-plants to enhance and complete deficient nutritional landscapes, providing quality forage for bee communities and facilitating their population stability.

Wild bee diversity increases following a bark beetle outbreak in a Douglas-fir forest

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Abstract:

Wild bees (Hymenoptera: Apiformes) provide essential pollination services to the majority of flowering plant species in forest ecosystems. However, knowledge is lacking regarding the effects of disturbances, such as insect outbreaks, on resident bee community assemblages. To assess the early responses of bees to bark beetle disturbance, the bee community of a Douglas-fir, Pseudotsuga menziesii (Mirb.), forest in western Idaho, USA was sampled during a Douglas-fir beetle, Dendroctonus pseudotsugae Hopkins (DFB), outbreak beginning in summer 2016. The area was re-sampled in summer 2018 following reductions in forest canopy cover resulting from mortality of dominant and co-dominant Douglas-fir. Overall, results from repeated measures ANOVA showed a significant increase in bee abundance, richness, and diversity (Shannon's H) in 2018 compared to 2016. Logistic regression analyses revealed percent tree mortality from DFB was positively correlated with increases in total bee abundance and species richness, where community response variables displayed a cubic trend with percent tree mortality. Percent reduction in canopy cover from 2016 to 2018 was also correlated with bee species richness and diversity. These findings suggest that wild bee communities may benefit from changes in forest structure following bark beetle outbreaks.

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Rare species management

Coastal Swamp-Cedar Regeneration 14-Years Post-Hurricane Katrina

Clayton Hale
Mississippi State University

Coauthors: Dr. Joshua J. Granger, Dr. Sandra B. Correa, Dr. Courtney M. Siegert, Dr. Janice L. DuBien
The number and severity of hurricanes in the Gulf Coast are increasing, resulting in intensified disturbance to coastal forest communities. Coastal swamp-cedar (Chamaecyparis thyoides (L.) B.S.P.) grows no further than one hundred miles from the coast, making the species and associated plant communities particularly vulnerable to large-scale disturbances such as hurricanes. Occurring primarily along the Atlantic Coast from Maine to Florida, this species does form isolated communities along the Gulf Coast regions of Florida, Alabama, and Mississippi. Coastal swamp-cedar is imperiled and at risk of extirpation by extreme weather events, altered disturbance regimes, changes in hydrology, and management. The primary objective of this study was to evaluate the recovery of coastal swamp-cedar 14-years post-Hurricane Katrina. Pre and post- Hurricane Katrina data were compared with recent data to determine how Southern Mississippi's coastal swamp-cedar has recovered post-Hurricane Katrina. All coastal swamp-cedar ? 2.5 cm at breast height (1.37 m) were inventoried within a ~4.85 ha study area located within Grand Bay National Wildlife Refuge, Jackson County, Mississippi. This inventory was compared with data obtained after Hurricane Katrina in 2005 to evaluate the long-term impacts of hurricanes on the stand density for this species. Following the 2005 hurricane, coastal swamp-cedar has increased in density across the study site. This increase was spatially correlated with wind damaged and toppled trees previously recorded within this population just after the hurricane. The structural changes caused by the hurricane disturbance supported the regeneration of this imperiled species. Understanding the long-

term recovery of coastal swamp-cedar allows land managers and conservationists to more effectively manage for the species on the landscape.

Oligarchy and Rareness in Large-scale Forest Inventories; Identifying and Managing for Vulnerable Species

James F Rosson Jr
USDA Forest Service

Oligarchy is a common trait of forest stands in the eastern USA. It is evident in forest inventory stand tables of large-scale forest inventories, areas the size of individual states or larger. The degree of forest stand oligarchy is variable and is the result of a complex set of factors arising from competition, disturbance, and species characteristics. In contrast to oligarchy, these types of large-scale forest inventories are also useful in identifying rare tree species. Rare may be defined either spatially or in regard to a proportion of the total population of tree species. A general premise of rareness is that these particular species populations are vulnerable to environmental and/or anthropogenic fluctuations because of their small numbers, thus lessening the probability of survival and prompting the need for possible protective measures. I used data from the USDA Forest Service, Forest Inventory and Analysis (FIA) program to study oligarchy and rareness patterns of tree species in Arkansas. In the 2015 forest inventory 114,872 trees were tallied on 5600 plots representing 109 species. One species, Pinus taeda L., (an oligarch) accounted for 25 percent of all trees tallied. In contrast, 22 species (rare) only occurred 5 times or less in the tally. Because of the low frequency of rare species in a probabilistic sample, statistical parameters are weaker. However, baseline information can be established allowing for stronger follow-up stratified sampling. Establishing and defining specific levels of rareness may be difficult but conservationists might find large-scale forest inventories useful in monitoring changes in rareness. Changes in degrees of rareness in repeated samples over time could be used as alerts in modifying forest management practices in respective states to protect vulnerable tree species.

Quantifying the relationship between soil seed bank and plant community assemblage in Ivesia webberi A. Gray populations

Israel Borokini
University of Nevada Reno

The soil seed bank is an important ecosystem component that can be pivotal for long-term persistence of many plant species. However, many Great Basin Desert perennials invest in clonal regeneration at the expense of seed production, which could limit the importance of their soil seed banks for species persistence. Furthermore, large areas of the Great Basin are currently invaded by alien weeds. Therefore, this study evaluates the relationship between the aboveground flora and the soil seed bank in 10 sites containing populations of the federally-threatened perennial forb Ivesia webberi. We used redundancy analysis, multiple regression on distance matrices, and variation partitioning to quantify the relationship between the aboveground flora and the soil seed bank, accounting for the effects of spatial processes and environmental variables describing the climatic and site conditions in the 10 studied sites. Findings reveal high dissimilarity in species assemblage and abundance between the aboveground plant communities and the soil seed bank. This is largely driven by the abundance of invasive alien weeds that are prevalent in the seed bank. The majority of the dominating native plants sampled in the standing vegetation were absent in the soil seed bank, suggesting high seedling mortality, possibly exacerbated by the competitive effects of invasive weeds. Overall, the plant community structure in the sampled sites is influenced by climatic factors, while floristic dissimilarity between the standing vegetation and the soil seed bank may be due to the abundance of invasive weeds. This indicates low resilience and high risk of native species loss following perturbation. Post-disturbance succession in these plant communities will be largely dominated by invasive annual species, and therefore native plant seeding may be necessary to sustain the ecological legacies of the desert ecosystem.

Reintroduction of American Burying Beetle (Nicrophorus americanus) in Missouri

Steve Buback
Missouri Dept of Conservation

The American Burying Beetle (Coleoptera: Silphidae) was federally-listed in 1989 and was historically known from a wide range of habitat across Missouri. Extensive surveys failed to find any extant populations, and captive rearing was begun by the St Louis Zoo in 2004. Mated pairs have been released with food source on Wah-Kon-T'ah Prairie in St Clair County since 2012. 3 years of mark-recapture study were undertaken to assess reintroduction success. Populations while reintroduction occurred peaked at 144+/- 11 individuals. After moving reintroduction sites, the population in the core area dropped to 45 +/- 7 individuals, though it is unclear the driving factor of this decline. Occupancy of the landscape was concentrated on high ridges throughout the prairie in low years, although the population occupied a much larger portion of the landscape in good year. Dispersal was documented to nearby protected sites over the course of the project, with the farthest site being 7 miles form the reintroduction site. Management for the species may require sustained reintroductions in Missouri, and carrion resources on the landscape may be an impeding factor to long-term establishment.

Tuesday, October 13, 2020 12:00am - 12:00am

Sage-grouse conservation

Greater Sage-grouse habitat and demographic response to grazing by non-native ungulates

Phillip Street
University of Nevada-Reno

Within the Great Basin of the Western United States, management discussions regarding the impacts of grazing by livestock and feral horses on Greater Sage-grouse often focus on the negative habitat impacts, and how the sage-grouse populations will respond in turn. While the linkage between sage-grouse demographics and habitat is well documented, quantifying the direct impacts of non-native grazing on sage-grouse has been fraught with difficulties. These struggles include the logistical constraints and cost associated with monitoring multiple sage grouse populations across large landscapes, an adequate temporal span to detect responses, and grazing manipulations at a large enough spatial scale to affect grouse populations. We investigated the response of sage-grouse demographics, movements, and habitat to grazing of non-native ungulates in Northern Nevada and Southern Oregon. We failed to detect a difference in these metrics when grazing was analyzed at discrete treatment levels, however, we did find evidence for an effect when grazing was treated as a continuous measure of intensity. Grazing intensity during the breeding season of sage-grouse was estimated by integrating records of duration and number of livestock permitted on grazing allotments, and on the ground transect data targeting feces of both horses and livestock. Using Bayesian Hierarchal modeling to account for uncertainty in each component of our data, we found little evidence that sage-grouse are avoiding areas with high intensities of grazing by either horses or livestock. Likewise, there was little support for an effect of grazing on nest survival. We observed lower chick survival rates in areas that had higher grazing intensities of horses, livestock, and combinations both. We also found evidence for a negative effect of grazing on the habitat chicks were using during this time. These results suggest that high intensities of grazing during the breeding season of sage-grouse are negatively impacting populations, and may inform recommendations for issuing grazing permits and managing feral horses within the breeding range of sage-grouse.

Molecular Insights on Greater Sage-grouse Breeding Strategies in the Northwestern Great Basin

Tessa Behnke
University of Nevada, Reno

Co-authors: Phillip Street, Jim Sedinger
For sage-grouse, the annual breeding cycles begin on leks, areas where males produce visual and acoustic displays

for females. Research using visual observations on leks suggests that a few males do most of the breeding. Intraspecific nest parasitism has also been documented in this species. Genetic analysis can reveal true parentage of resulting clutches. Using the vascularized membranes within eggshells, we extracted DNA from each egg. With the addition of adult samples, we verified maternity to determine nest parasitism, and paternity, to test for extra-pair copulations. We sampled the eggshell membranes of 350 eggs from 46 clutches from our study site in Northwestern Nevada. We used feathers collected from the incubating female as a unique genetic sample. We targeted 14 microsatellite loci developed for sage-grouse and one sex determination locus. These highly polymorphic loci are useful for parentage analyses as we can compare the alleles of the putative mother and each offspring. Using the program Cervus, we tested for matches and mismatches among each focal sample and the candidate parent. After matching the mother to her clutch, we compared the offspring genotypes to each other to determine paternity and nest parasitism. We reconstructed possible male genotypes and looked for matches among clutches to evaluate if a dominant male is doing most of the copulations, or if additional copulations are happening off of the lek. Multiple parentages in clutches may help maintain genetic diversity for the population. Females may also mate with multiple males to hedge their bets on male quality, and therefore the quality of offspring. These results provide important insights about sage grouse breeding behavior that observational studies cannot.

Tuesday, October 13, 2020 12:00am - 12:00am

SYMPOSIUM: Linking Research and Management to Improve Native Plant Restoration in the Great Basin

(3) Restoration from seed in the Great Basin: What are we doing well, and is there room for improvement?

Elizabeth Leger
University of Nevada, Reno

Co-authors: Sarah Barga, Alison Agneray, Owen Baughman, Robert Burton, Mark Williams

Restoring dryland ecosystems can be extremely challenging, due in part to environmental constraints that naturally limit recruitment. When highly competitive invasive annuals and modified disturbance regimes are added to the mix, restoration from seed in dryland systems can be very daunting. Despite these challenges, seeding in the Great Basin continues to be one of the world's biggest ongoing restoration efforts, and millions of pounds of seeds are applied to wildlands, especially post-fire, in an attempt to prevent the transition of these ecosystems to invasive annual plants. Some of our practices are at the forefront of restoration best practices, such as clearly identifying seed sources, detecting weed contamination, measuring seed viability, and conducting large-scale agricultural increases for the largest seeding projects. Still, other methods deviate from recommended practices (e.g. current seed sources emphasize only a few functional groups, species, and gene pools). Great Basin case studies and large-scale reviews indicate that there is room for improvement in restoration outcomes, and research suggests that changing seed sourcing could be a way to increase restoration success. In addition to presenting these case studies and reviews, I will highlight an ongoing collaborative effort to implement restoration best practices, in Winnemucca, NV. This collaboration has resulted in the large-scale agricultural increase of locally-collected, source identified, weed-free seeds for use in post-fire restoration projects. While environmental constraints and weed pressure are difficult to control, starting restoration with seeds most likely to survive in semi-arid, invaded sites may be a way to increase overall success in this wild but imperiled region.

Forb common garden research to inform seed transfer guidance for restoration

Sarah Barga
U.S. Forest Service, Rocky Mountain Research Station

Co-authors: Francis Kilkenny, Fred Edwards

As landscape-scale disturbances increase across public lands, understanding how to restore plant communities is of critical importance. Part of incorporating native plants into restoration is understanding the level of flexibility they display when moved away from their location of origin. Some species may be more flexible to novel conditions than others, and many arid-land species display population-level variation in their performance. Common gardens are a tool for examining variation in performance across the range of a species, and the best way to develop seed transfer guidance for restoration. While past common garden work conducted by the Great Basin Native Plant Project (USFS – Rocky Mountain Research Station and BLM – Plant Conservation and Restoration Program) has focused on dominant perennial grasses, their current work focuses on native forbs. We selected three species of forbs common across the Great Basin and known to be of interest for restoration due to their value as forage and cover resources for wildlife. To allow for population genetics work to occur alongside the common garden study, both seeds and plant tissue were collected for some species. In this talk, I will focus on the technical aspects of carrying out a large-scale common garden project, ranging from locating potential sites and site selection to garden installation and trait measurement. I will also present preliminary results for the first year of plant performance. A project of this scale also requires many partners to coordinate resource acquisition, land use, and garden monitoring. The end product will be a spatially-explicit restoration tool for land managers that will inform the appropriate selection of seed for particular restoration projects, as well as multiple research publications. This work is a step toward the larger goal of creating a streamlined approach to seed transfer development for forbs, with the plan of adding three species this year and three more species over the next couple of years.

Getting the right seed: Seed collection collaboration in the Great Basin

Fred Edwards
Bureau of Land Management

Co-authors: Jess Kindred, Sarah Kulpa, Dirk Netz, Russ Wilhelm, Eric Roussel

Wildland seed collections are the starting point for native seed research, development, and restoration. In Nevada, the Nevada Native Seed Partnership (NNSP) is strategically leveraging Seeds of Success collections of target native grasses and forbs across key seed zones, one of the many actions being implemented as part of the Nevada Seed Strategy. Finding common ground among NNSP members is key to our success; target species selected are beneficial to greater sage-grouse and pollinators, and have some cultivation research completed to show how they will perform in an agricultural setting. Our ultimate goal is to increase the availability of genetically, appropriate native seed to improve the health, diversity, and success of restoration efforts and plant communities in the Great Basin. Here, we discuss the steps taken and lessons learned from our coordinated seed collection efforts in Nevada.

Improving our chances: when and where can precision techniques and technology reduce variability in restoration outcomes

Jay Kerby
The Nature Conservancy

Owen Baughman
The Nature Conservancy

Co-authors:Stella Copeland, Owen Baughman, Chad Boyd, Kirk Davies, Tony Svejcar

Dryland ecosystems represent a significant portion of global land area, support billions of people, and suffer high rates of land degradation. Successfully restoring native vegetation to degraded drylands is a global priority and major challenge, and there is a need for more efficient and successful strategies. We introduce the concept of 'precision restoration' as any approach which addresses individual ecological barriers to restoration success with specific tools or actions that target the barrier. Using the Great Basin, USA as a case study, we present a novel dryland restoration strategy that involves: 1) identifying specific and critical barriers to restoration success at a particular site, 2) understanding the spatial and temporal variation of each barrier, and 3) applying the best available restoration strategies, precision or otherwise, based on the specific barriers identified in the first two steps. We summarize common known and emerging critical barriers to the success of seed-based restoration across the Great Basin, discuss methods for defining the spatial and temporal variability of barriers, and give examples of decision processes that utilize our proposed restoration strategy. The proper application of this strategy will rely upon assembling information generated by both research and management. By shifting the initial focus of restoration planning away from tool selection and toward defining barriers to success and their spatiotemporal variability, the eventual choice of tools and techniques to use, and where to use them, will improve restoration outcomes and efficiency.

No really, what is local? – A methodological approach to measuring patterns of local adaptation, evaluating alternativ

Francis Kilkenny
U.S. Forest Service, Rocky Mountain Research Station

As the need for ecological restoration increases, more seed will be required to meet global demands. The geographic source and evolutionary history of seeds used in restoration is important to the long-term success of restoration projects, especially in changing climates, but there is a vigorous international debate over the degree to which local adaptation should be considered in seed-sourcing decisions. While heated opinions exist across the spectrum, few studies have measured patterns of local adaptation with the scale and precision necessary to resolve these debates. This lack is due, in part, to the fact that common garden studies - the only way to directly measure local adaptation - tend to be costly and thus limited in scope. Due to the cost of developing high quality common garden datasets, several shortcut methods have been proposed to develop seed transfer guidelines, including the use of herbarium records and climate data to construct species-specific ecological niche models, and the use of outlier DNA markers to detect potential climate-adapted alleles. While these methods hold promise, their accuracy must be verified with high quality common garden data. Currently, too few integrative studies exist to have a generalized understanding of the effectiveness of these methods. In this talk, I will discuss how to develop common garden datasets that measure patterns of local adaptation at the scale and precision necessary to resolve seed-sourcing debates, and to provide the needed data to verify or discard shortcut methods for seed transfer guideline development, while remaining cost and time efficient. Examples will be used from a methodological approach that is being implemented in the Intermountain West and Great Basin of the United States to develop seed transfer guidelines for important restoration species. This approach uses smart common garden design and close integration with DNA sequencing studies to build high quality datasets, which allow for the evaluation of novel methods of seed transfer guideline development and the support of seed-sourcing decisions in an era of global change.

Strong patterns of intraspecific variation and local adaptation in plants of the Great Basin, USA, revealed through a r

Owen Baughman
The Nature Conservancy

Co-authors: Alison Agneray, Matt Forister, Francis Kilkenny, Erin Espeland, Rob Fiegener, Matt Horning, RC Johnson, Tom Kaye, Jeff Ott, Brad St. Clair, Beth Leger

Variation in natural selection across heterogeneous landscapes often produces 1) among-population differences in phenotypic traits, 2) trait-by-environment associations, and 3) higher fitness of local populations. Using a broad literature review of common garden studies published between 1941 and 2017, we documented the commonness of these three signatures in plants native to North America's Great Basin, an area of extensive restoration and revegetation efforts, and asked which traits and environmental variables were involved. We also asked, independent of geographic distance, whether populations from more similar environments had more similar traits. From 327 experiments testing 121 taxa in 170 studies, we found 95.1% of 305 experiments reported among-population differences, and 81.4% of 161 experiments reported trait-by-environment associations. Locals showed greater survival in 67% of 24 reciprocal experiments that reported survival, and higher fitness in 90% of 10 reciprocal experiments that reported reproductive output. A meta-analysis on a subset of studies found that variation in eight commonly-measured traits was associated with mean annual precipitation and mean annual temperature at the source location, with notably strong relationships for flowering phenology, leaf size, and survival, among others.

Although the Great Basin is sometimes perceived as a region of homogeneous ecosystems, our results demonstrate widespread habitat-related population differentiation and local adaptation. Locally-sourced plants likely harbor adaptations at rates and magnitudes that are immediately relevant to restoration success, and our results suggest that certain key traits and environmental variables should be prioritized in future assessments of plants in this region.

Surviving in the invaded desert: A climate- and trait-based approach to restoration in the Great Basin

Alison Agneray
University of Nevada, Reno

Co-authors: Thomas L. Parchman and Elizabeth A. Leger.

In the Great Basin, there have been enormous efforts from both land managers and scientists to select genetically and environmentally appropriate seed materials for restoration projects. While most of these efforts focus on matching the climates of both seed source and planting site, plants coming from similar abiotic conditions can vary in phenotypic traits. Matching environments is not always sufficient for guaranteeing success, particularly in the most disturbed sites. Here, we asked if we could find excellent seed sources for restoration by describing plant traits that are adaptive in invaded environments. Focusing on three species of grasses, two shrubs, and two forbs common to the region, we collected seeds of each from 16 locations with similar abiotic conditions. We then planted them in four common gardens in highly invaded systems. Using these seven species from the same sites allowed us to ask whether environmental pressures were selecting for favorable traits across multiple species and functional groups at the same locations, which has not been previously studied. We also measured seed and seedling characteristics for each species and population, including seed size, emergence timing, and root length, among others. We asked: 1) whether seed sources differed in survival across gardens; 2) whether any collection locations were highly successful for all species; 3) which potentially adaptive traits were predictive of survival.

Populations differed in survival across the gardens in six of the seven species and differed in nearly every seed and seedling trait. The strength of these effects varied among our seven species. For example, Elymus elymoides showed the most variation in survival, and Poa secunda showed the least. No single source location was superior for all species, but several sites had either above or below average survival for many species. Generally, traits associated with root investment and phenology best predicted survival. In grasses, the populations with earlier emergence and greater root mass ratio were more likely to have increased survival in competitive environments. In the shrubs and forbs, slightly different traits were favored, likely due to their dissimilar growth forms and life-history strategies. These results provide a trait-based approach for selecting seed sources for restoration projects and demonstrated that some locations might contain populations of above-average performance for multiple species. Choosing native plants sources with the most adaptive traits, along with matching climates, will likely be more successful at restoring the most invaded communities.

The sagebrush field of dreams project

Valda Lockie
Bureau of Land Management

Co-author: Amanda Gearhart
Wildfire is a major threat to sage-grouse, a sagebrush-obligate that was considered for listing by the U.S. Fish and Wildlife Service. In 2012, a 315,000-acre wildfire burned approximately one-third of the BLM Eagle Lake Field Office, much in sage-grouse 'Priority Habitat' in northeastern California and northwestern Nevada. Within the burned perimeter, approximately 5,000 acres were drill seeded and 20,000 acres were aerial broadcast seeded with sagebrush (Artemisia tridentata), bitterbrush (Purshia tridentata), and various native perennial grasses. In addition, several areas were hand planted with bare-root and containerized sagebrush and bitterbrush seedlings. Subsequent monitoring revealed that re-seeding efforts were largely unsuccessful, including the hand planted areas which had less than a 3% survival rate. Many factors contributed to low survival rate including drought and non-local seed sources. Due to this seeding failure, in 2015, local sagebrush seed was collected and sent to Northern Nevada Correctional Center for propagation. In the fall of 2016, 2,000 sagebrush seedlings were planted on BLM land in

partnership with the USGS with a goal to create sagebrush islands to improve sage-grouse habitat. In 2017, this process was repeated with more than 50,000 seedlings distributed among five study sites, three sites on BLM Eagle Lake Field Office lands in California and two sites on the BLM Sierra Front Field Office lands in Nevada. Line point intercept and shrub density monitoring began in the fall of 2018 and is planned to continue through the 2020 field season. Preliminary monitoring results suggest that hand planting local sagebrush seedlings may increase mean annual survival rates.

The Sagebrush in Prisons Project: Restoring lands and lives

Shannon Swim
Institute for Applied Ecology

Co-Authors: Stacy Moore, Tom Kaye

The purpose of the 'Sagebrush in Prisons Project' is to improve habitat for greater sage-grouse by engaging state and federal prison systems in the production of sagebrush for habitat restoration. Greater sage-grouse was considered for listing by the U.S. Fish and Wildlife Service, but was not warranted due to extraordinary conservation efforts by many federal, state, and local entities. However, conservation efforts must continue to maintain the integrity of these populations. Loss of sagebrush habitat is the primary driver of the decline of this species in the western United States. Production of sagebrush within state and federal prison systems represents a unique opportunity to provide urgently needed plant materials as well as providing information to incarcerated men and women concerning sagebrush conservation. Institute for Applied Ecology (IAE), a nonprofit organization based in Oregon, runs the 'Sagebrush in Prisons Project,' and works closely with Bureau of Land Management (BLM) and correctional center partners across the country to employ the National Seed Strategy and produce genetically appropriate native plant material for restoration projects. IAE is currently working with nine prisons in five different states. Locally, the program works with three prisons in the state of Nevada; Northern Nevada Correctional Center, Warm Springs Correctional Center and Lovelock Correctional Center, and a Federal Correctional Institution in Herlong, California to propagate hundreds of thousands of sagebrush plugs for restoration projects on BLM lands. IAE staff oversees plant production at the prison facilities, from seed germination through growth and delivery. Since the projects inception in 2014, over 1.5 million genetically appropriate native plant plugs have been produced for habitat restoration, while also allowing this underserved population the chance to be a part of something positive and changing their perspective on the importance of the sagebrush ecosystem.

Using the right seed: Improving native plant restoration in the Great Basin

Sarah Kulpa
U.S. Fish and Wildlife Service

Co-authors: Elizabeth Leger, Owen Baughman, Robert Burton, Fred Edwards
The Great Basin is home to some of the US's largest expanses of wild landscapes, supporting a wide range of plant and animal diversity. However, our native plant communities are threatened by the accelerated invasion of non-native annual grasses, altered fire regimes, drought, and climate change. Slowing and reversing this large-scale conversion will require coordinated efforts between researchers and land managers, working together to identify the most promising seed sources for restoring disturbed and invaded sites. Working with Seeds of Success teams, we collected seeds of native grass species sourced from within an area of Northern Nevada that experiences frequent fire and increased these seeds through a commercial seed producer. These locally-collected and seed-zone matched sources were sown in post-fire locations similar to the original collection locations, in experiments designed to test the long-term performance of locally sourced and increased seeds compared to the partially native seed mixes made from the best available standard cultivars and releases. We will present the experimental design and preliminary data from these seedings, highlighting the successful partnerships working to determine the best ways to restore and preserve our most impacted native plant communities.

Vegetation succession following post-fire seeding with conventional and native seed mixes in the Great Basin

Jeff Ott
U.S. Forest Service, Rocky Mountain Research Station

Co-authors: Francis F. Kilkenny, Daniel D. Summers, Tyler T. Thompson

following vegetation succession at two sites in Tintic Valley, Utah, where a seeding experiment had been installed following wildfire in 1999. Vegetation of seeded treatments and unseeded controls was monitored during post-fire years 1-3 and 16-18. All of the tested seed mixes became established and influenced successional trajectories during this timeframe. Conventional seed mixes with introduced species most effectively suppressed exotic annuals, but did not follow a successional trajectory toward reference conditions from prior to the fire, while native seed mixes generally became more similar to reference vegetation over time. These results underscore the importance of identifying desired long-term outcomes of post-fire seeding and formulating seed mixes accordingly.

Tuesday, October 13, 2020 12:00am - 12:00am

SYMPOSIUM: Fire restoration and consequences for ecosystem management

Applications of fire behavior modeling to strategic land management at project to landscapes in the Sierra Nevada, CA

Edward Smith
The Nature Conservancy

Frequent-fire, dry conifer forests throughout the world are fire-starved and altered in structure, composition, and ecological function due to successful fire suppression activities for over a century in many locations. Re-introduction or restoration of fire regimes to fire-adapted forests is a key process toward improving conditions for wildlife habitat, watershed function and safety for human communities, but re-introducing fire can be difficult due to terrain, accumulated forest fuels, and activity costs, especially in a hotter, drier climate. There are millions of acres throughout the western USA in need of forest fuel removal through mechanical harvest of surface and ladder vegetation or re-introduction of prescribed fire, or both, but the cost of these treatments in both social goodwill as well as operational complexity is prohibitive. Using fire behavior modeling such as FLAMMAP and fire simulation modeler (FSIM) can provide planners and managers with tools to help prioritize areas for restorative treatments by disclosing where fire is more or less likely to occur, and when it does occur, the intensity of its behavior. This analysis can be used at the landscape scale to select which areas are in need of mechanical harvest or prescribed fire or both, to inform where investments are more likely to have a beneficial outcome. We employed fire behavior modeling on the French Meadows Project west of Lake Tahoe in the Sierra Nevada of California both to select areas for treatment, and also to disclose the potential reduction in fire intensity with and without treatment for environmental clearance documentation in the production of an Environmental Assessment for the Tahoe National Forest across 10,000 hectares. The project decision was signed in December 2018 and implementation began in summer of 2019. We also used fire behavior modeling across the 1-million-hectare landscape referred to as the Tahoe Central Sierra Initiative (TCSI) to prioritize large areas that could be restored, and to identify project areas that will be analyzed under subsequent environmental review. We are also using seasonally extracted fire behavior model outputs to identify areas within the Tahoe National Forest that are more suitable for the opportunity to utilize lightning-ignited wildfires for resource benefit. Fire behavior models have proven to be valuable tools for planning ecological restoration treatment projects and strategic plans in the Sierra Nevada. Broad application across large landscapes and project areas can help accelerate the implementation of projects to return fire to ecosystems that have co-evolved with fire.

Ecosystem impacts of managed wildfire in Yosemite National Park

Scott Stephens
UC Berkeley

Since implementing policies to allow wildfires to burn the Illilouette Creek basin over 45 years ago, land managers have allowed fire regimes to return to a near natural state. Over the last 20 years we have done research examining the factors impacting fire severity, the proportions of landscape burned at different severities, how realistic our understanding of fire history is based on fire scar reconstruction, how vegetation states have been changed by a functioning fire regime, and how > 40 fires impacted the mountain hydrology of this 15,000 ha watershed. These questions, and their subsequent answers, are critical to furthering our understanding of how fire historically shaped the landscape and how it could continue to do so today. The Illilouette Creek basin provides hope for how upper montane forests in the Sierra Nevada could be managed into the future.

Fire restoration and consequences for ecosystem management

John Williams
University of California, Davis

In the western United States and in many other fire-adapted landscapes, decades of fire suppression policies have left forests out of equilibrium with natural fire regimes. Reintroducing fire to these landscapes under controlled conditions offers a path to restoring affected ecosystems and to achieving a variety of ecological, conservation, land management and risk abatement objectives. This symposium will specifically address the use of prescribed fire within or bordering public lands and protected areas, and how these and related management actions can be leveraged for multiple benefits. Speakers will describe how they integrate mixed- or limited-severity burn objectives, fuels reduction, timber management, habitat protection and other goals into burn plans. They will also discuss how they control for the vagaries of conditions that add risk and uncertainty to their ability to burn. Additionally, in the panel discussion, speakers and participants will talk about navigating the constraints of weather, smoke, personnel shortages, and narrow burn windows, as well as how to deal with out-of-control burns, damage control and public relations. Finally, participants will be encouraged to share ideas on the use of creative approaches and collaborations with communities, NGOs, the private sector and multiple land management agencies to improve the probability of executing a successful burn.

Following fire with fire: fire as a key restoration tool in areas affected by California's largest wildfire

Gabrielle Bohlman
USDA Forest Service

During the summer of 2018, the Ranch Fire burned over 410,000 acres in the northern California Coast Ranges, about 288,000 of which are on the Mendocino National Forest. The Ranch Fire was the largest fire in California history. The fire burned with varying intensity, leaving a mosaic of burn patterns on the landscape that ranged from unburned islands to large areas where tree canopies were completely consumed. In order to help managers with the task of restoring this post-fire landscape, I used the US Forest Service Region 5 Post-fire Restoration Framework to develop a restoration strategy for yellow pine and mixed conifer forests within the fire perimeter. The resulting strategy identifies the use of prescribed fire and managed wildfire as a key tool for restoring large portions of the Ranch Fire footprint. This talk will provide a brief overview of the development of the Ranch Fire post-fire restoration strategy followed by specific examples for how the Forest plans to use fire in their restoration efforts.

Framework for post-fire restoration in California's national forests

Marc Meyer
USDA Forest Service Pacific Southwest Region

Increasing extent and frequency of high severity wildfires and other large-scale disturbances pose a significant threat to California's ecosystems. This is apparent in forest, chaparral, and sagebrush steppe landscapes, where departure from natural fire regimes may result in large-scale alteration of terrestrial ecosystems and deterioration of the services they provide. Based on these trends and a broader consideration of sustainability, there is a growing need for a comprehensive and science-based approach to post-fire management. We propose a framework to guide the development of post-fire restoration strategies on the national forests in California. The framework is founded on a set of guiding principles and a flexible five-step process that leads to the development of restoration planning and

projects. The restoration framework can inform future post-fire management, monitoring, and research in California's diverse ecosystems.
Coauthors: Jonathan W. Long, Hugh D. Safford, Becky Estes, Kyle Merriam, Nicole Molinari, Shana Gross, Michelle Coppoletta, Sarah Sawyer, Ramona Butz, Amarina Wuenschel, Angela White, Brandon Collins, Malcolm North, Scott Conway, Michele Slaton, Clint Isbell, Dana Walsh, and Emma Underwood

It's now or never: the narrowing window of opportunity for maintaining fire resilience in a restored old-growth stand

Michelle Coppoletta
USDA Forest Service Region 5 Ecology Program

The restoration of forest structure, which was historically created and maintained by frequent fire, has become a central tenet of forest management on public lands. However, information about vegetation and fuel succession in restored stands, as well as the influence of these variables on the longevity of fire resilience, is currently incomplete or lacking. The Beaver Creek Pinery in the Ishi Wilderness of California is frequently cited as a contemporary example of a heterogeneous wildfire-resilient forest with structural attributes that are characteristic of historical frequent-fire ponderosa pine forests. We examined stand-level and landscape-scale changes in forest structure, species composition, and surface fuels in this contemporary reference site by revisiting plots that were established following a 1994 wildfire. We then used this data in forest growth models to project future changes in stand structure over time and evaluate potential fire behavior and fire effects under different fire weather scenarios. In the 22-year absence of fire, the Beaver Creek Pinery experienced substantial infilling of canopy gaps, declines in oak regeneration, and increases in the size and density of tree clusters. Despite these changes, forest conditions are currently considered within the historical range of variability for these forest types and are predicted to be resilient to wildfire in the near-term. However, our modeling of future stand conditions and potential fire risk also suggests that this resilience may be short-lived, with crown fire becoming the predominant behavior in as few as ten years. As vegetation and fuels develop, the effectiveness of prescribed burning at maintaining and restoring desired conditions, will also diminish. Burning in the next 10-20 years, under controlled conditions, will likely be the most effective strategy for reducing surface fuels and small trees, and for maintaining the unique structural heterogeneity of this ecologically significant reference stand.
(Co-authors: Michelle Coppoletta, USDA Forest Service Region 5 Ecology Program; Eric Knapp, USDA Forest Service Pacific Southwest Research Station; Natalie C. Pawlikowski, USDA Forest Service Pacific Northwest Research Station; Alan H. Taylor, The Pennsylvania State University)

Leveraging monitoring, modeling, and messaging to minimize smoke impacts during fire restoration

Leland Tarnay
USDA Forest Service, Pacific Southwest Region (Region 5)

Smoke from wildland fire, if unmanaged, can have substantial impacts on air quality and public health. Historically, the way such impacts have been avoided, especially during prescribed fire, has been to minimize acres burned to a level that nearly assures no impacts to air quality beyond the local area. However, minimizing acres rather than impacts also potentially minimizes the scale at which subsequent fire will be slowed or suppressed, especially for those projects which have the purpose of creating, or building on landscape-scale fire mosaics. We discuss the current smoke management framework and toolbox used in California, and review case studies selected from over two decades of smoke monitoring where that toolbox has been used. We show how wildfires (and Rx fires), proactively managed to moderate spread rates and severity patterns, rarely create the regional-scale impacts we've seen from the latest megafires and likely result in daily emissions rates that the airshed can readily disperse. Thus, a strategy for managing spread rate (actively or passively, as appropriate) such that dispersion and emissions are well-matched, and messaging to warn people where and when any smoke still does occur appears to be one of the most promising ways to increase the pace and scale of the fire effects that reinforce resilient forests. In this way, healthier forests can lead to healthier air.

Linking wildland fuel characteristics to smoke emissions: Development of a compact smoke measurement instrument

Adam Watts
Desert Research Institute

Coauthors: Kellen Nelson, Jayne Boehmler, Vera Samburova, Andrey Khlystov, Hans Moosmüller, Eric Wilcox (Desert Research Institute, Reno, NV).

Smoke emissions from wildland fire can result in poor air quality that threatens human health and therefore requires planning to mitigate effects from prescribed burning and monitoring to inform air resource managers during periods of active burning. To better understand how smoke emissions vary with fuelbed characteristics and environmental conditions, we developed and tested a compact instrument package that integrates direct air sampling with air quality and meteorology sensing, suitable for in situ data collection within burn units and as a payload on multi-rotor small unmanned aircraft systems (sUASs). The instrument employs co-located sensors to collect temporal profiles of carbon dioxide, carbon monoxide, and particulate matter with a microcontroller-based system that includes independent data logging, power systems, radio telemetry, and a global positioning system. Sensor data facilitates precise remote canister collection of air samples suitable for laboratory analysis of volatile organic compounds (VOCs) and other major and trace gases. The sensing system was tested at the Sycan Marsh Preserve, OR during controlled burns in a ponderosa pine/western juniper (Pinus ponderosa/Juniperus occidentalis) forest type with a sagebrush/bitterbrush (Artemisia tridentata/Purshia tridentata) shrub understory. The sensing device was hung at 8-m height to monitor the temporal profile of gas concentrations as a head fire passed under the device. Calibrated carbon monoxide concentrations in the smoke plume rose to 197 ppm and carbon dioxide concentrations rose to 6330 ppm. Modified combustion efficiency estimates ranged from 0.84 to 1.00, similar to other studies that observed flaming combustion in senescent grass and pine litter fuel types. The canister sampling system was tested onboard a sUAS at the Tall Timbers Research Station, FL during controlled burns in a longleaf pine-wiregrass (Pinus palustris/Aristida beyrichiana) forest type. We collected five canister samples for VOC determination by remotely triggering the valve system from outside the burn perimeter. Prefire ambient samples contained total VOC concentrations of 0.8 to 1.8 ppbv, whereas samples collected during active burning contained 7.3 to 24.3 ppbv. Six VOCs (i.e., iso-pentane, benzene, 1-butene + isobutene, 1,3-butadiene, toluene, and styrene) accounted for ~71% and 15 VOCs accounting for ~90% of total VOCs observed in the smoke plume. Understanding how fuel characteristics influence smoke composition and production is critical for fire and fuels management applications used to reduce contemporary heightened fuel loadings and to restore historic ecosystem composition, structure, and function.

Prescribed burn monitoring in California forests ÃƒÆ'Ã†'Ãƒâ€šÃ‚Â¢ÃƒÆ'Ã‚Â¢ÃƒÂ¢Ã¢â€šÂ?

John Williams
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Joe Restaino
CalFIRE

After a century of fire suppression, there is a growing understanding that fire plays a natural and necessary part in many California ecosystems. Even with interest on behalf of government agencies, NGOs and academic researchers, there is a lot to be learned about the art and science of reintroducing fire to fire-adapted landscapes. Given the backlog in forested areas that are long past their historic fire return intervals, how do we prioritize where, when, and how much to burn? How should we apply controlled fire to reduce the risk of catastrophic fire, while managing the inherent risks of conducting prescribed burns and the negative effects of the smoke they create? What are the impacts of prescribed fire on different forest types with respect to tree density, timber productivity, species composition, wildlife habitat and forest heterogeneity? How frequently, how many times, and at what severity do we need to burn before we start seeing a return to pre-suppression forest conditions and the ecosystem service benefits that come with restored fire regimes? These are some of the questions that CalFIRE and researchers from UC Davis are trying to answer in a multi-year prescribed burn monitoring partnership. Working together, these two institutions are leveraging resources and drawing on a broad joint network of land managers to identify sites on private, state and federal forested lands where they are setting up a system of permanent burn monitoring plots. So far, field teams have put in pre- and post-fire plots in multiple sites across the Sierra Nevada, with plans to extend the plot network elsewhere across the State. In this talk, we describe the goals, design and progress of this partnership, and discuss its role in raising awareness about and the application of prescribed fire as a management tool for risk abatement and ecological benefit.

Retrospective analysis of burn windows in the Lake Tahoe Basin

Randy Striplin
USFS R5

Stephanie McAfee
University of Nevada, Reno

Prescribed fire is an essential ecosystem management tool in the Sierra Nevada, but it is relatively underused because of the number of conditions that need to co-occur to burn. Assessing the likelihood of burn windows -- days on which weather is in prescription, air quality regulators permit burning, and sufficient personnel and other resources are available -- is useful for managers planning and implementing a prescribed fire program. To assess burn window patterns in the Lake Tahoe Basin, this study evaluated the daily occurrence and co-occurrence of 1) burn permits granted by the California Air Resources Board, 2) weather within burn plan prescription at local RAWS stations, and 3) local or National Preparedness level less than 3 from 1999-2019. Burn windows were most frequent in the spring and autumn and far less common during the summer or winter. There was considerable interannual variation, even in months when burn windows were relative common. At least part of this interannual variability was due to changes in air quality permitting standards in 2008 that allowed burning under a wider range of conditions. This case study demonstrates how simple planning tools developed from readily available data can be used to identify underutilized burn windows, evaluate regulatory and resource changes that could increase burning opportunities, and provide insight into the research needed to confidently take exploit winter and early spring burn windows that may become more common as temperatures rise.

Springs Fire Case Study: The importance of prescribed burn monitoring for reaching long-term ecological goals.

Ashley Grupenhoff
UC Davis

In late July of 2019, the Inyo National Forest contacted the California prescribed-burning monitoring team (PBMT) about the potential for deployment to the Springs Fire NE of Mammoth Lakes, which was being managed for resource benefit. The PBMT is a joint effort by CalFire and the Safford lab at the University of California-Davis and is intended to produce a database of ecosystem conditions and fire behavior resulting from prescribed burning and to help California tie these findings to climate change adaptation, carbon capture, and environmental sustainability objectives. The PBMT worked on the ground with fire-suppression and burn teams tasked with managing the fire to sample forest and fuels conditions immediately before, and immediately after fire passage. The focus was on areas within the predicted final fire perimeter that had been treated with prescribed fire in previous years. High levels of cooperation between the PBMT and fire management personnel on the ground led to important learning on both sides (e.g., fire crews received informal training in fuels and forest structure measurement, and PBMT staff with red cards received informal training in firing techniques). Plot data were fed to the air quality monitoring team working on the fire which resulted in more accurate and credible air quality predictions. Additionally, a terrestrial LiDAR sampling effort was undertaken by a team from the University of Nevada-Reno to better quantify preburn fuels. Finally, after follow up sampling this season (2020 and continuing for a few years thereafter), the Inyo National Forest will receive a report as to the effectiveness of prescribed fire treatments in reducing fire severity, conserving forest carbon, and outcomes on ecosystem condition due to subsequent fire. The Springs Fire provided an outstanding and, to this point, unique

opportunity to conduct real-time collaboration between scientists and managers. We hope to use lessons-learned from the Springs Fire to make this sort of science-management collaboration more likely in the future. I will present the outcomes of this collaboration, including initial data, to demonstrate the importance of on the ground monitoring before, during, and after burning events.

Tuesday, October 13, 2020 12:00am - 12:00am

SYMPOSIUM: Global change and ecosystem resilience: managing threats to sustainability

Across Time & Space: Species diversity response to fire severity in Sierra Nevada yellow pine and mixed-conifer forests

JonahMaria Weeks
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Clark Richter
UC Davis

Ecological disturbance regimes are changing due to a combination of effects from both direct human influences and climate change. Wildfire regimes in particular are being affected due to interactions between high fuel loads and climate warming, resulting in many regions that historically experienced low to moderate fire severity regimes now seeing increased area burned at high severity. Despite understory taxa comprising the vast majority of forest plant species and playing vital roles in overall ecosystem function, little is known of the effects of changing fire regimes on forest understory plant diversity. Furthermore, the role of time since fire when examining the relationship between fire severity and diversity is understudied, with space for time substitutions often being made. We examined understory plant diversity across gradients of wildfire severity in eight large wildfires in yellow pine and mixed conifer temperate forests of the Sierra Nevada, California, USA. Additionally, we sampled one of those fires at five time-steps across nine years. We found a generally unimodal relationship between local plant diversity and fire severity across fires and through time. High severity burning resulted in lower local diversity as well as some homogenization of the flora at the regional scale. Our research suggests that increases in fire severity in systems historically characterized by low and moderate severity fire may lead to plant diversity losses, which on a global scale may have important implications for biodiversity.

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Estimating loss of carbon stocks in postfire chaparral shrublands in southern California

Mark De Guzman
UC Davis

Carbon sequestration is one of the many ecosystem services provided by chaparral shrublands in Southern California, however chaparral's effectiveness in providing this service is dependent on its resilience to mitigate disturbance. Estimates of carbon stocks pre- and post-fire in chaparral where fire occurrence is within the historical range is directly quantifiable (e.g., aboveground, belowground, litter, soil carbon), but quantification of stocks in areas with short fire return intervals and tailored to the different functional life histories of chaparral species (seeders versus resprouters) has yet to be determined. We estimated carbon stocks through compiling biomass estimates from the literature to build regeneration models for the seeder and resprouter life history types. We then integrated our models with Landsat-derived Enhanced Vegetation Index (EVI) and historical fire perimeter data to estimate changes in carbon stocks in chaparral pre- and post-fire. Carbon stocks were disproportionately affected in areas with the shortest fire return interval which was mainly driven by changes in the vegetation composition. The greatest losses occurred in type-converted landscapes that are heavily dominated by resprouter life history types, which store a higher proportion of biomass belowground compared to seeders. Our methods could be applied to environmental damage assessments to estimate the amount of carbon permanently lost due to fire and changes in fire regime.

Fire severity and productivity influence diversity patterns in California's subalpine forests

Emily Brodie
UC Davis Graduate Group in Ecology

In subalpine forests of the North American Mediterranean climate zone, climate-fueled changes in snowpack and growing season are contributing to larger and more frequent fire events. Changing fire regimes have resulted in biodiversity declines in lower elevation mixed conifer forests, which have low resilience to large patches of high severity fire. However, the risk of high severity fire to diversity in Mediterranean-type subalpine systems is uncertain. The influence of disturbance severity on species diversity is expected to depend in part on ecosystem productivity, but this theory has not been adequately tested in the context of fire and forest ecosystems. This study aims to help elucidate the effect of productivity on the species richness-fire severity relationship as well as to understand the effect of fire severity on species richness in Mediterranean-type subalpine forests. To answer these questions, we sampled understory richness in plots spanning a wide range of fire severity and across 13 fires in California's subalpine forest. In general, post-fire species richness increased with fire severity and decreased with productivity. The interaction between fire severity and productivity was also significant, with species richness increasing more across the fire severity spectrum in high productivity plots than in low productivity plots. Further, high severity plots had 3 times as many unique species as unburned plots and 2 times as many as low severity plots, suggesting that increased richness in high severity plots is driven by flora that can take advantage of the post-fire environment. Accordingly, the number of species with the classic colonizer traits of short lifespan and long-distance dispersal ability increased significantly with fire severity. Our results suggest that ecosystem productivity is an important predictor of the richness-fire severity relationship and that the projection of potentially higher fire severity in high elevation forests may be neutral to positive for species richness.

Fire, carbon, and climate change in California's high elevation forests

Sara Winsemius
University of California, Davis

Recent changes in high elevation forests worldwide indicate that forest structure and long-term ecosystem stability are threatened, with implications for carbon sequestration and ecosystem refugia. Biomass and disturbance models have high uncertainty in high elevation forests, where landscapes are more heterogeneous across short distances and data are more limited than in lower elevations. Anecdotally, subalpine tree mortality after fire is generally low in the first year, with substantial increases in mortality in the five years following. Delayed mortality and compounded disturbances may lead to an underestimation of mortality from disturbances. Given the increasing area and frequency of fires over the last decades, changes in high elevation forest fire regimes and their impacts on biomass are unclear. In this project I analyze temporal patterns of tree mortality using Bayesian machine learning methods with high resolution imagery. I expect the timing of mortality in the several years following fire to vary between drought and non-drought post-fire conditions, and locations, with implications for long-term carbon storage projections and management. California's high elevations are assumed to be stable carbon sinks due to relatively low levels of disturbance, however the severity of disturbances may be underestimated using current methods. Enhanced measurements of post-fire mortality will impact assessment of changing biomass stocks, which is essential for understanding current and projected trends in carbon sequestration.

Global change and ecosystem resilience: managing threats to sustainability

Hugh Safford
USDA-Forest Service

This oral session, jointly sponsored by UC-Davis and the University of Nevada-Reno, centers on global change in western ecosystems and how managers are trying to ensure sustainability in the face of shifting disturbance and stress regimes. Focus is on western forests, chaparral, sagebrush, and meadow ecosystems. Speakers will discuss how interactions among drought, climate warming, fire, grazing, pests and pathogens are affecting ecosystem composition, structure and function, how management is impacted, and how management tactics and strategies may need to change to enhance ecosystem resilience and/or ensure long-term sustainability.

Implications of changing fire regimes for Sierra Nevada bat and bird communities

Zack Steel
UC Berkeley

Managing ecosystems for multiple objectives and multiple taxa is challenging under any circumstance but especially given uncertainties surrounding how biological communities will respond to changing fire regimes. To inform conservation and management efforts we studied the response of bats and birds to fire-induced changes in habitat and landscape pattern. For the bat community we conducted acoustic surveys in and around three wildfire areas during 2014-2017 in conifer forests of California's Sierra Nevada. We tested effects of mean burn severity and its variation, or pyrodiversity, on bat occupancy and diversity using hierarchical models that account for imperfect detection. Of the 17 species that occur in the region, occupancy rates increased with severity for at least 7 and with pyrodiversity for 2. Species richness increased from 8 species in unburned areas to 11 species in moderate- to high-severity burned areas with high pyrodiversity. We contrast these results with studies of avian post-fire habitat relationships in the region. While many bats appear to benefit from wildfire, even high-severity wildfire, bird responses are more mixed. As wildfires continue to grow larger with more area at risk of type conversion from forest to sustained early successional habitat, some species will benefit in the short-term while others lose habitat. Managing for resilience requires understanding how altered disturbance regimes are affecting all components of an ecosystem. For fire-adapted systems, actions that encourage mixed-severity wildfire and pyrodiversity will likely benefit the most species across taxa by limiting habitat extremes such as overly dense, fire-suppressed forests and very large high-severity patches.

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Management to promote the resilience of sagebrush ecosystems: invasive species, altered fire regimes, and climate change

Alexandra Urza
US Forest Service, Rocky Mountain Research Station

In the sagebrush semi-desert of the western United States, the invasion of fire-adapted annual grasses such as cheatgrass (Bromus tectorum) can initiate a grass-fire cycle that results in the progressive loss of native plant communities. Climate change is exacerbating this risk by increasing the size and frequency of wildfires, expanding the climate niche of cheatgrass and other invaders, and reducing the recovery of native perennial species. The resilience of sagebrush ecosystems to fire is highly variable in space and time, and many recent fires have resulted in the conversion of large areas of valuable habitat to annual-grass-dominated ecosystems. There is thus a pressing need to identify management strategies that can promote ecological resilience given the interacting effects of invasive species, altered fire regimes, and warming climate. In this talk, we will discuss post-fire management options for promoting vegetation recovery in heterogeneous landscapes, based on the results of multiple long-term studies. We will show how landscape-scale post-fire recovery potential is related to environmental characteristics and pre-fire biotic conditions, emphasizing the need to target management efforts in those portions of the landscape that will

benefit the most. For example, in the driest portions of the landscape where resilience to fire and resistance to cheatgrass invasion are both low, post-fire management interventions are unlikely to result in the successful restoration of native ecosystems. In contrast, post-fire management interventions are often unnecessary in cool and moist sites at higher elevations, where the rapid recovery of native perennials characterizes a resilient post-fire response. Post-fire management investments often have the greatest benefit in intermediate environmental conditions, including in mosaics of sagebrush shrublands and pinyon-juniper woodlands, where interventions such as seeding have the potential to greatly increase resistance to annual grass invasion. We will share experimental results that demonstrate the effectiveness of post-fire native seeding treatments, and will show how functional diversity can be an effective bet-hedging technique for seeding into heterogeneous landscapes. We will then share research on climate-driven episodic establishment patterns in big sagebrush, discussing how an adaptive management approach that includes repeated seeding can minimize the risk of recovery failure for sagebrush and other key species. Finally, we will discuss how post-fire recovery potential is expected to shift in response to climate change, including increases in the proportion of the landscape characterized by low resilience to fire, and will present management principles for promoting ecosystem adaptation and reorganization in a time of increasing uncertainty.

Prioritizing Post-fire Restoration in Chaparral Shrublands in Southern California

Nicole Molinari
US Forest Service

Emma Underwood
UC Davis

The occurrence and size of wildfires in southern California have increased with human population growth. Chaparral vegetation recovery in post-fire landscapes can be impeded by a number of factors, including drought, excessive fire, and non-native species. Active restoration may be needed to enhance native shrubland recovery in areas affected by these stressors, yet across large fire scars identifying the need for restoration can be challenging. We developed a Post-fire Restoration Prioritization (PReP) tool to aid resource managers with early detection and prioritization of degraded chaparral landscapes in need of restoration. The PReP tool incorporates information on the post-fire regeneration strategy of plant communities and its interaction with fire history, pre- and post-fire drought, and non-native annual species to predict where recovery may be impeded, thereby identifying candidate areas for restoration. The tool also integrates spatial data on erosion risk for recent fires, so that areas in need of restoration can be prioritized for hillslope stabilization. Outputs from the tool can also be integrated with hotspots of ecosystem service provision and accessibility data to further refine restoration decision making. We demonstrate a proof of concept using the Copper and Powerhouse fires on the Angeles National Forest in southern California and find that 1,642 acres (10%) and 3,786 acres (14%) respectively are predicted to have low regeneration capacity and need restoration. Through field monitoring, we verified that areas predicted to have the lowest regeneration capacity indeed had the highest cover of non-native annual grasses and herbs and the lowest cover of native shrubs. The framework of the PReP tool is transferable to chaparral ecosystems across southern California and can guide management decision making to ensure long-term sustainability of chaparral and the ecosystem services it provides.

Recent bark beetle outbreaks influence wildfire severity in mixed-conifer forests of the Sierra Nevada, California, USA

Rebecca Wayman
University of California, Davis

Rebecca B. Wayman and Hugh D. Safford.

In temperate forests, elevated frequency of drought related disturbances will likely increase the incidence of interactions between disturbances such as bark beetle epidemics and wildfires. Ecosystem management relies on sound information from analogous forest types, yet our understanding of the influence of recent drought and insect-induced tree mortality on wildfire severity has largely lacked information from forests historically experiencing frequent fire. A recent unprecedented tree mortality event in California's Sierra Nevada provides an opportunity to examine this disturbance interaction in historically frequent-fire forests, filling an important gap in a body of evidence drawn largely from forests adapted to severe, infrequent fire. Using field data collected within areas of recent tree mortality that subsequently burned in wildfire, we examined whether and under what conditions wildfire severity relates to severity of pre-fire tree mortality in Sierra Nevada mixed-conifer forests. We collected data on 180 plots within the 2015 Rough Fire and 2016 Cedar Fire footprints. Our analyses identified pre-fire tree mortality as influential to all measures of wildfire severity (basal area killed by fire, RdNBR, and canopy torch) on the Cedar Fire and to two of three measures on the Rough Fire. Factors such as fire weather and topographic position also strongly influenced wildfire severity. On the Cedar Fire, the influence of pre-fire mortality on wildfire severity was greater under milder weather conditions. All measures of fire severity increased as pre-fire mortality increased up to pre-fire mortality levels of approximately 30-40%; further increases did not result in greater fire severity. The interacting disturbances shifted a pine dominated system to a cedar/pine/fir dominated system, while the pre-disturbance fir/cedar system retained its species dominance. Managers of historically frequent-fire forests will benefit from utilizing this information when prioritizing fuels reduction treatments in areas of recent tree mortality, as it is the first empirical study to document a relationship between pre-fire mortality and subsequent wildfire severity in these systems. This study contributes to a growing body of evidence that the influence of pre-fire tree mortality on wildfire severity in temperate coniferous forests may depend on other conditions capable of driving extreme wildfire behavior, such as weather.

Regeneration of high-elevation five-needle pines limited by microclimate conditions across disturbance gradients

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Background/Methods
High-elevation forests occupy environments near the physiological tolerances of tree species, and their extreme longevity have allowed for their persistence through significant climatic changes. Unprecedented climate change coupled with threats from mountain pine beetle, white pine blister rust, and changes in fire activity now threaten the resilience of these endemic forests. To improve our understanding of climate and disturbance effects on high-elevation forests dominated by limber pine (Pinus flexilis), bristlecone pine (Pinus longaeva), and whitebark pine (Pinus albicaulis), we asked: a) how does disturbance interact with water availability to influence the regenerating community?, b) to what extent is the regenerating community dominated by surviving advanced regeneration versus post-disturbance recruitment?, and c) what are the implications of species-specific responses to disturbance across climatic gradients? We evaluated natural regeneration in 70 sites varying in climatic and disturbance characteristics across eastern California and the Great Basin. Sites were either undisturbed or affected by one or more disturbance agent. We sampled community composition in addition to quantifying disturbance history and potential seed availability. We used structural equation models to evaluate direct and indirect effects of abiotic and biotic drivers on the regenerating community.
Results/Conclusions
Extensive recent mortality occurred across the study area. Natural regeneration was highly variable, with abundant regeneration of whitebark pine across varying disturbance and climatic conditions but significantly lower limber and bristlecone pine regeneration. All species showed reduced regeneration with increasing understory cover. Coarse acidic soils and decreased water deficit favored whitebark pine regeneration, while limber pine regeneration increased with increasing water deficit and tree density, suggesting potential buffering effects of tree canopy for microclimate. While increased spring snowpack and summer temperature favored bristlecone pine regeneration in undisturbed sites, these drivers had strong negative effects in burned sites.
Our findings highlight the complex drivers of regeneration in arid high-elevation pine forests. Water availability, through increased snowpack, canopy buffering, or soils, is an important driver of regeneration, and water stress is expected to increase under projected future conditions. Bird dispersal may buffer the effects of disturbance by overcoming seed limitations, however forest mortality may exacerbate microclimate conditions, leading to increasingly rare opportunities for establishment. Widespread mortality necessitates continued monitoring of natural regeneration

and implications for forest persistence. This work will help managers target areas for restoration to facilitate persistence of these species under current and future climate scenarios.

Seasonal water availability drives trait variation in isolated Pinus ponderosa populations

Tessa Putz
University of Nevada, Reno

Tessa Putz, Sarah Bisbing, Alexandra Urza

Combined effects of rising temperatures and drought are threatening forests globally. These unprecedented conditions are likely to decrease forest resilience, leading to widespread tree mortality and loss of associated forest ecosystem services. Drought adaptations may, however, confer success under these projected extreme conditions and be key to the perpetuation of long-lived tree species. The timing, amount, and type of moisture strongly influence the degree of drought adaptation in a given population, and local topographic heterogeneity may exacerbate or mitigate these effects, driving variation in trait response both within and among populations. Although drought adaptations are well-studied in widespread tree species, knowledge is limited on the extent of drought-responsive traits in disjunct conifer populations.
In the northern portion of the arid Basin and Range province of the western United States, Pinus ponderosa var. scopulorum is isolated to montane sky islands, making it a model system for testing the effects of climate and topography on conifer species trait variation. We sampled 55 populations across six ranges in Nevada and Utah to quantify trait variation in cone volume, wood density, and needle lifespan. To investigate the relationship between interacting climatic and topographic conditions on drought adaptations we explored the role of seasonal climatic moisture deficit (CMD), monsoonality, and aspect on trait variation using linear mixed models.
Traits varied widely both within and among populations, with seasonal water availability most influential in trait response. Cone volumes increased with increasing summer CMD but decreased in areas with a heavy monsoon influence. The seasonality of moisture similarly influenced wood density, with densities increasing with increasing winter CMD, signaling the importance of winter moisture for tree growth. Needle lifespan was also influenced by monsoonality, indicating that late summer precipitation leads to reduced needle retention. Local topographic variation had a minor influence on trait variation for the populations tested here, mediating climate on northern slopes and acting as a compounding stressor on southern aspects for wood density response alone. These findings suggest the importance of seasonal moisture stress on drought-adapted conifer traits and potential of these conifers to alter traits to conserve growth and alter resources under water limitations, both which have implications under the threat of altered climatic conditions for semi-arid systems.

Tree recruitment and forest expansion following reforestation in the Sierra Nevada, CA

Tara Ursell
University of California, Davis

In post-wildfire landscapes in the western Sierra Nevada, the availability of live, reproductive trees is a strong predictor of conifer regeneration. One proposed management strategy is to reforest small patches as a means of establishing future conifer seed sources in areas where high mortality from wildfire inhibits natural regeneration and where reforestation is difficult at scale. However, certain post-fire successional processes (e.g., the growth of competing vegetation) are also known to inhibit tree establishment and growth, and these processes may become dominant before planted trees become reproductive. Thus, it is unclear whether a small planted stand that produces viable seed could plausibly result in seedling establishment and forest expansion in this system.

In Summer 2019, we conducted an observational field study testing the contribution of now-reproductive planted trees relative to site characteristics in driving conifer seedling recruitment in unplanted areas. We found that regeneration was significantly higher closer to the plantations, suggesting that plantations do contribute to tree establishment outside of the planted area. We did not find a significant effect of shrub cover nor overstory cover on recruitment, leading us to reject the hypothesis that shrub cover limits recruitment even when seeds are present. Though we focused the study on areas that had high post-fire tree mortality, we still found that proximity to surviving trees was a significant predictor of recruitment. Collectively, these results suggest that plantations are a viable option for catalyzing tree recruitment in unplanted areas, but this effect may be most relevant for practitioners in areas where large, surviving trees are not available as seed sources.

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Water stress drives demographic shifts and the potential for type conversions in coastal California pine forests

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Climate change-induced forest dieback is documented as a recent global phenomenon, with pervasive mortality having profound impacts on ecosystem services and natural forest functioning. The prolonged drought and scale of tree die-off in California from 2010-2016 (>145 million trees) was unprecedented in modern history. Morality of this magnitude can transform regional landscapes and have severe effects on forest function and ecosystem services. Ongoing drought and alteration of precipitation due to climate change will likely lead to continued mortality, which is most precarious for endemic species filling narrow yet essential ecosystem roles. Pinus radiata, an endemic to coastal California and Baja Mexico, is susceptible to non-native pine pitch canker and recently experienced widespread mortality following chronic drought stress. We used a 15-year dataset from permanent plot network to evaluate the 1) relative importance of exogenous vs. endogenous factors in shaping forest demography, 2) role of precipitation in the direction and magnitude of change, and 3) predicted impact of climate change on species persistence. Mortality peaked in during the 2014-2015 period of California's extended drought, with the greatest proportional mortality occurring in the small tree size class. Co-occurring Quercus agrifolia experienced negligible mortality over this same timeframe. For P. radiata, climatic water deficit was identified as the primary driver of mortality across all tree size classes (p0.001). Small tree, sapling and seedling mortality were additionally influenced by the length of the frost-free period, with increasing mortality with increasing number of days (p0.001). Pinus radiata recruitment was best explained by antecedent precipitation (p0.001), while Q. agrifolia regeneration was driven by both antecedent and sampling year precipitation levels (p0.05). Forest density was only influential in seedling mortality (p0.05), and pine pitch canker incidence led to higher mortality in seedling and sapling size classes (p0.001). The prevalence of disease significantly influenced demographic patterns over time, but, in all models, climate was the primary determinant of mortality and recruitment. Climate projections predict a decrease in annual precipitation and increase in the frost-free period, indicating a high likelihood for continued mortality and low recruitment for P. radiata into the future. Given the likelihood for ongoing decline of endemic P. radiata, management should focus on ongoing preservation of P. radiata stands in less impacted portions of the species' range as well as conservation of drought-adapted Q. agrifolia to support ongoing promotion and protection of forest ecosystems and associated ecosystem services.

Where and when to plant trees after fire in the face of water limitation and shrub competition.

Quinn Sorenson
University of California—Davis

Wildfires in the mid-elevation forests of California's Sierra Nevada mountain range have massively increased in size and intensity over the past half-century due to a century of fire suppression and possibly climate change. Disturbance on this scale was rarely seen in the Sierra Nevada prior to the initiation of fire suppression. As a result, post-fire forest tree regeneration has become weak in many areas, leading forest managers to invest in tree planting as a strategy to hasten forest recovery after fire. Despite the critical importance of tree planting for forest recovery, it remains unclear how environmental variation in tree stress determines natural regeneration versus planting success. To address this gap, we joined efforts with the U.S. Forest Service to ask how variation in the physical environment (e.g., temperature, precipitation, light intensity, etc.) and competition from shrubs impact natural regeneration and tree planting success after forest fires throughout the Sierra Nevada. We found that natural regeneration is lowest at the hottest, driest sites and that tree planting can provide a moderate boost to forest recovery under these conditions. We also found that the timing of tree planting matters but depends on competition from shrubs. In places where shrub competition is intense, tree planting is much more successful if planting occurs the year immediately following a fire (the soonest that it is practical to plant). Alternatively, in places where shrub competition is weak, waiting a few years to plant trees until some shrubs establish actually facilitates tree survival, perhaps by providing shelter from harsh conditions. Overall, we recommend forest managers prioritize the hottest, driest sites for reforestation projects and plant trees as soon as possible where competition from shrubs will be most intense.

Tuesday, October 13, 2020 12:00am - 12:00am

SYMPOSIUM: Managing for Drought in California Ecosystems

Droughts and Drought Impacts in California: An Overview

Steven Ostoja
USDA California Climate Hub

Chris Fettig
USFS-PSW

Drought is a basic feature to California's climate. Moreover, droughts have been an important influence on California's ecosystems for millennia. Over the past century, the state has experienced several extreme drought events; but in the past 5 decades there has been a notable increase in drought frequency and severity. A notable hallmark of this was the 2012-2016 drought, which based on tree ring records, was the most severe in >1000 years. Droughts like this one can contribute to wide-spread ecological and economic impacts that touch many different industries and sectors. In California the most recent severe drought facilitated wide-spread mortality of trees and shrubs in forests and woodlands, was blamed for poor rangeland condition and leading to agricultural and forestry industry impacts.

In this presentation we will examine how historical drought has differentially shaped California's natural ecosystems. We will also consider what is expected with future climate change especially in regard to extreme climate events like drought and heat waves. Mindful that the future climate change will bring increased frequency and severity of drought; attention will be given to how ecosystem components may be impacted directly and indirectly. We will conceptually introduce how management strategies and approaches can work to prepare forest and associated ecosystems with greater adaptive capacity in the face of future impactful drought events. Such considerations are of value so context-specific management strategies can be considered preemptively with the goal to ameliorate the impacts brought from climate change. Finally, some treatment will be given to what climate mediated impacts could mean for various societal and industry interests if management efforts are not prioritized preemptively.

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Managing Drought-Prone Chaparral Landscapes

Jon Keeley
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Beginning in 2012 California experienced one of the most intense droughts in history. The duration of the drought varied throughout the state. In the Sierra Nevada it lasted three years and was a factor in massive mortality of trees in mid-elevation conifer forests. In southern California the drought continued through most of 2018 and resulted in

massive dieback of chaparral shrublands. There is good reason to believe this dieback was a major factor contributing to the size of the 2017 Thomas Fire and the 2018 Woolsey Fire, the largest fires in the region in recent history. This presents a significant management challenge because dead woody fuels likely contribute to extreme fires, and in this climate these fuels decompose slowly, plus future climate change is predicted to increase the incidence of severe droughts.

Our work has used remote sensing methods (Landsat NDVI) for detecting and verifying vegetation dieback in southern California shrubland landscapes, and then relating these to fire severity patterns in the 2018 Woolsey and 2017 Thomas fires (using Monitoring Trends in Burn Severity, MTBS data). This provides insight into relationships between severe drought, vegetation dieback and subsequent fire severity, and to what extent this information could be used to inform land and fire management activities in the region.

Management options must consider the wildland-urban interface risks associated with prescription burning on this landscape, thus making this obvious management option for dealing with drought an unlikely strategy. Future focus must deal with drought impacts by concentrating on the urban environment and considering the 5 P's of 1) people as the primary problem, 2) prevention of fire ignitions during extreme wind events, 3) planning future developments, 4) p rotection of structures by home-hardening, and 5) predicting capacity for fire trajectories during extreme wind-driven fire events.

Managing Effects of Drought and Facilitating Recovery in California Oak –dominated Forests and Woodlands

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Yana Valachovic
UC Cooperative Extension

Oaks have many adaptations, including drought tolerance and resprouting abilities that afford them increased resilience to drought and associated natural disturbances. Shifts toward increased dominance of oaks are expected in many parts of California based upon projections of increased warming and drought. Such trends have become evident during the recent, widespread drought event that killed many pines and other conifers in the southern Sierra Nevada. Drought and fire-induced mortality are natural regulatory processes that may restore more sustainable forest conditions by reducing densities of oaks and competing conifers, especially if that mortality tends to kill smaller trees and trees in poorer soils, at low elevations, on south-facing slopes. However, mortality events could be degradative where they kill mature trees and inhibit regeneration. For example, in southern California, the combination of drought, wildfire, and expanding insect pests like the goldspotted oak borer may lead to reductions among some oak species. Meanwhile, sudden oak death is a novel stressor in northern California coastal forests. A goal for managing resilience throughout the state is to conserve mature oaks that provide ecosystem services such as acorn production and habitat for wildlife. That goal can be advanced by thinning overly dense oak stands, remove competing conifers, reducing fuels, and supporting use of fire, including cultural burning directed by tribes and informed by traditional knowledge. Treatments also need to create openings for regeneration to ensure sustainable conditions over the long-term. Several recent synthesis reports have proposed and developed these strategies, including the recent General Technical Report on management for drought in the US, a report on restoring California black oak for tribal values, and the 4th California Climate Change Assessment. Reducing competition for water by non-native annual grasses may also be important strategies in grazed woodlands and in urban forests. More active efforts to plant young oaks and water mature trees may be also appropriate in intensively managed areas. Meanwhile, in more remote locations, managing naturally ignited fires and using prescribed burns will be important strategies for resilience. However, managers and the public may want to help inventory and safeguard especially old and large legacy trees that have disproportionate ecological and social value to minimize potential losses from combined stressors.

Managing Effects of Drought and Facilitating Recovery in California: Coast Redwood Forests

Ramona Butz
USDA Forest Service

Within the redwood forests of northern California, annual water use by large redwoods is high, and the greatest demands for water occur during summer months when rain is sparse. Summer fog serves an important role in ameliorating water deficits. During drought, redwood forests continue to tap fog as a water source, and deep, loamy forest soils slowly release the water captured from winter rains. Coast redwoods tend to be poor regulators of water use, making them sensitive to ambient humidity and the presence or absence of cloud cover. During prolonged drought, decreased canopy water content and fog drip can lead to decreased germination and survival rates of seedlings, and reduced radial growth, limited foliar water uptake, and even death in mature trees.
Although mature redwood forests are generally fairly drought tolerant, the effects of drought events of increased intensity and duration can be minimized through a number of management strategies. The loss of redwood trees to natural disturbances (e.g., wildfire, windthrow, floods, severe drought), extensive timber harvest, or other land-use practices converts forests to more open habitats reducing fog capture, thus altering the hydrological balance and creating more drought-prone conditions. Drought mitigation in coast redwood forests includes: (1) reduction of competing vegetation, such as Douglas-fir (Pseudotsuga menziesii), through prescribed burning and mechanical thinning, (2) reduction of practices that create forest structures that are too open, thereby losing their ability to capture moisture from fog, (3) minimization of soil disturbance, (4) reduction of road densities, (5) creation of small gaps for light availability for regenerating seedlings, and (6) protection of old-growth reserves.

Managing for Drought in California Ecosystems

Amarina Wuenschel
US Forest Service, Sierra, Sequoia and Inyo National Forests

Christopher Fettig
US Forest Service, Pacific Southwest Research Station

We propose a symposium related to managing for drought in California that corresponds to a recent chapter in the USDA Forest Service-produced General Technical Report 'Drought Impacts on U.S. Forests and Rangelands: Translating Science into Management Responses'. This symposium will contain an overview of the topic, four additional presentations related to drought management in widespread California ecosystems (montane forests, redwood forests, oak woodlands, chaparral and coastal sage scrub, and grasslands) and conclude with a facilitated discussion. Presentations are germane to the conference topic 'Natural areas management in light of climate change' given that global climate models project severe droughts will become the norm in California.

Drought presents significant challenges for natural resource managers in California, and future droughts will likely exert even greater impacts. Managers can intervene by altering plant structure and composition, increasing annual water yield, and conducting public outreach and education regarding water conservation. Due to strong environmental gradients in California, drought management should be tailored to individual ecosystems. For example, in forests and woodlands, drought management focuses on the use of mechanical thinning and prescribed burning both to decrease stand densities and to promote the growth and vigor of desirable tree species. In chaparral, frequent disturbances are stressors, so soil disturbances need to be limited as much as possible to reduce the spread of nonnative annuals that promote wildfires. Invasive plants are also an important problem in grasslands, where they should be removed and replaced with native grasses and forbs. In grasslands, prescribed fire may be useful to manage nonnative species and increase perennial plant cover to make grasslands more drought-resilient.

By including a diverse group of presenters, experts in their respective ecosystems, this symposium will flesh out the fuller story of drought management across California, and convey specific, actionable, science-driven management options for each ecosystem as well as touch on commonalities across ecosystems. An overview will provide context on the recent 2012-2016 drought relative to historic droughts in California, and serve to convey the need to manage for future drought. Our symposium will act as a much needed forum for delivery of recently-published knowledge to practitioners.

Managing the Effects of Drought and Facilitating Recovery from Drought in California's Montane and Subalpine Forests

Christopher Fettig
Pacific Southwest Research Station

In montane and subalpine forests of California, recent droughts have contributed to widespread bark beetle outbreaks, extensive tree mortality, reduced tree growth, and increased wildfire hazard, all of which in turn affect biogeochemical cycling and hydrologic processes. Reducing forest densities will increase the resilience of montane and subalpine forests to drought and other disturbances exacerbated by drought. The main tools are mechanical thinning and fire, the latter consisting of prescribed fires or wildfires that are allowed to burn under appropriate weather conditions (i.e., managed wildfire). Facilitating recovery and restoration of drought-impacted forests requires a flexible approach. For small patches of tree mortality (e.g., 20 hectares), intervention may be minimal. If green-tree seed sources are not nearby (generally within ~250 m for wind-dispersed conifers), intervention may be limited to planting more drought-tolerant seedlings. In more extensive patches of tree mortality, decisions about salvage harvesting, prescribed burning, planting, and controlling competing vegetation may vary with dead-tree patch size, potential natural seedling recruitment, management goals and fire hazard.

The montane and subalpine forests of California provide immeasurable ecological goods and services, many of which warrant special protection and management considerations. In this presentation, several USDA Forest Service and California Department of Forestry & Fire Protection publications will be reviewed that guide thinking about managing forest structure to emulate the 'natural' heterogeneity of forests, to minimize the undesirable impacts of drought, and to facilitate recovery from drought. Key elements include: (1) increasing the pace and scale of thinning, prescribed burning and managed wildfire, (2) rebuilding the forest products industry in California to facilitate adequate biomass removals, (3) improving forest structure for wildlife habitat, (4) restoring ecologically-sensitive areas (e.g., meadows), (5) facilitating legislative and administrative reforms that act as barriers to project implementation, and (6) implementing monitoring and adaptive management.

Tuesday, October 13, 2020 12:00am - 12:00am

SYMPOSIUM: Modeling social-ecological systems as part of the Lake Tahoe West Restoration Partnership

Collaborative Science for Landscape Management: Lessons Learned from the Lake Tahoe West Restoration Partnership

Sarah Di Vittorio
National Forest Foundation

Shana Gross
Forest Service Pacific Southwest Region

As part of the Lake Tahoe West Restoration Partnership, scientists, land managers, and stakeholders undertook a collaborative modeling effort to inform comprehensive landscape restoration across more than one-third of the Lake Tahoe Basin. This presentation will discuss lessons learned for conducting collaborative, management-relevant science. The goal of the modeling effort was to understand likely outcomes of different management approaches under a changing climate up to 100 years into the future to inform a collaborative landscape restoration strategy. Participants identified several key lessons that may inform future collaborative science, as follows. Collaborative modeling can help diverse interests agree on restoration goals and thresholds, understand possible futures, evaluate tradeoffs between key values, and develop a consensus-based vision and approach for restoring a complex landscape. However, collaborative modeling â€' particularly in a large process with multiple teams and agencies involved â€' requires a large time and resource investment. Participants should clarify expectations regarding goals, timelines, and workloads at the start of the process, and design the project to balance these needs. The need for new science should emerge from the collaborative process as participants identify key questions and uncertainties essential to resolve disagreements and inform management. Collaborative science should focus on addressing these key uncertainties and questions and avoid more peripheral topics. Choice of models should be collaborative and informed by clear understanding of the models' capacities and limitations. Highly technical content and long timelines for collaborative science will pose barriers for some participants, such as stakeholders representing local community interests; process design should factor in level, type, and timing of engagement needed for different participants. Finally, collaborative science efforts would benefit from facilitation by trained facilitators with technical competence and science training in the fields being analyzed.

Authors:
Sarah Di Vittorio, National Forest Foundation;
Shana Gross, Forest Service Pacific Southwest Region;
Kathleen McIntyre, Tahoe Regional Planning Agency

Developing snowpack/forest management support tools for montane forests in the Sierra Nevada

Sebastian Krogh
University of Nevada, Reno

Montane snowpack in the Sierra Nevada provides critical water resources for ecological functions and downstream communities. Understanding the effect of forest removal (e.g. forest thinning) on the snowpack in montane forests is critical to designing effective strategies that account for the co-management of several ecological services such as wildlife habitat, soil erosion, and water quality and quantity. Given the complex and heterogeneous effects that the forest canopy exerts on snow accumulation and melt, and the need to include different climates and forest structures, a multi-site, high-resolution study is required to understand how forest thinning affects snowpack over large areas. Here, we apply a high-resolution (1-m) state-of-the-art snow model to simulate the impact of forest thinning on the snowpack across a variety of sites with lidar-based forest characterization in the northern Sierra Nevada. The snow model is an ideal tool to study the influence of forest thinning on snowpack because it explicitly represents many of the physical processes affecting the snowpack mass and energy balance in the forest, such as tree shading, wind redistribution of snowfall, and canopy interception and sublimation of snowfall. The model is run with the current lidar-based forest structure (height and density), and two virtual thinning scenarios in which trees below 10 and 20-m are removed, during wet and dry years. This multi-site and -year approach allows us to quantify the impact of forest thinning on melt volumes across a gradient of climates and forests conditions, where current dry/warm places may serve as a proxy for future warmer and drier conditions in the Sierra Nevada. The wide range of snowpack conditions and forest structures represented in this study enables us to create a decision support tool that can be extrapolated to sites with different environmental conditions. This tool is expected to help guide ongoing and future forest thinning strategies in the Tahoe Basin that aim to increase melt volumes and mitigate the historically declining snowpacks in the region.

Key planning tools for the Lake Tahoe West Restoration Partnership: Resilience Assessment and Restoration Strategy

Shana Gross
USFS

Sarah Di Vittorio
National Forest Foundation

The Lake Tahoe West Restoration Partnership (LTW) is a multi-agency, collaborative effort to increase the resilience of the forests, watersheds, recreational opportunities, and communities on Lake Tahoe's west shore. Lake Tahoe West's resilience-based approach emphasizes scaling up and accelerating restoration efforts to address a large landscape and all land ownerships, planning for a dynamic and changing future, and addressing a comprehensive set of landscape values. Through an iterative process, with manager, stakeholder and scientist input, ecological and social landscape values and services, and primary disturbances that are important to understand the current state of resilience of the west shore were identified and evaluated in a Landscape Resilience Assessment (LRA). The LRA used quantitative and spatially-explicit data to compare current conditions to historic and/or contemporary reference conditions to determine which portions of the landscape and which landscape values and services are the least resilient to disturbances. The LRA results indicated that much of the Lake Tahoe Basin's west shore is likely not resilient to a variety of disturbances. The LRA, combined with computer modeling and expertise to better understand risks and likely outcomes of different treatment approaches, provided the foundation for development of a science-based Landscape Restoration Strategy (LRS). The LRS guides watershed and forest restoration approaches on the west shore over the next two decades to increase social-ecological resilience. The LRA and LRS are foundational products that support landscape level planning. They reflect an extraordinary amount of collaboration and consensus building among agencies, scientists, and stakeholders. This talk will discuss how the LRA and LRS were developed, focusing on key components of the methods, and how the results were translated into actionable management projects.

Modeling social-ecological systems as part of the Lake Tahoe West Restoration Partnership

Jonathan Long
USDA Forest Service Pacific Southwest Research Station

Patricia Manley
USDA Forest Service Pacific Southwest Research Station

Jonathan W. Long, Patricia Manley, Charles Maxwell, Robert Scheller

Collaborations between scientists and land managers are increasingly important to guide large landscape restoration efforts. Efforts to promote social-ecological system resilience depend upon scientific frameworks for evaluating how different potential management strategies will influence ecological and social indicators across broad spatial and temporal scales. These efforts involve collectively identifying indicators and thresholds that reflect desired future outcomes and then projecting how different management strategies will perform given changes in future climates. As part of the Lake Tahoe West Restoration Partnership, a science team worked with resource managers and stakeholders to model future forest ecosystem dynamics in response to five management scenarios over 100 years across a 60,000 acre landscape in the Lake Tahoe basin of California and Nevada. Forest growth and fire dynamics were modeled using the LANDIS-II landscape platform, on which we based additional modeling to evaluate changes in wildlife habitat, water, and economics. We evaluated how the different management strategies would affect outcomes important to stakeholders, including abundance of old trees, wildlife habitat, fine sediment, water quantity, implementation costs, fire characteristics and threats, air quality, cultural resource quality, and carbon sequestration. The scenarios spanned a wide range of management inputs, from wildfire-suppression only, fuels reduction near communities, moderate and extensive restorative thinning and/or prescribed burning, all under different future climates. The team found that moderate and extensive thinning or burning treatments would promote overall objectives better than no treatment or community protection only, with the exception of carbon sequestration and treatment costs. Over the long-term, more treatment would reduce the wildfire threat to communities, the risk of unnaturally large patches of high intensity burns, and days of extreme emission of smoke into downwind communities. More extensive treatments were projected to increase water yield and promote the growth and occurrence of pine and aspen trees. The modeling considered how increased treatments, especially burning, might promote cultural resources important to the Washoe Tribe, who consider Lake Tahoe the center of their ancestral home. Ramping up the amount of prescribed burning, however, would pose risks to water and air quality, which could be mitigated with careful planning. Managers and stakeholders used the findings of this integrated modeling effort to inform the design of a landscape restoration strategy that balanced risks and benefits based on a robust scientific foundation.

Simulating wildlife habitat dynamics to inform best management strategies under a changing climate

Angela White
USFS Pacific Southwest Research Station

Angela M. White, Timothy Holland, Eric Abelson, Alex Kretchun, Charles Maxwell and Robert Scheller

Many forests of the western United States have undergone over a hundred years of anthropogenic impacts that have led to increased tree density, homogenization in forest structure, and accumulation of woody material, all of which pose threats to valued social and ecological features. Forest conditions in California are particular extreme, as evidenced by recent waves of tree mortality and unprecedented large and destructive fires. Collaborative approaches to finding solutions have been identified by the US Forest Service as key to making restoration progress. In California, the US Forest Service and collaborators recently formed a science-management partnership intended to increase the pace and scale of forest restoration on a 60,000 ac landscape in Lake Tahoe. Using LANDIS-II we modeled how forest management and natural disturbance processes (such as wildfire and bark beetle outbreaks) alter habitat for terrestrial vertebrate species over the next century on the west shore of Lake Tahoe. Although wildlife populations are susceptible to many stressors, we assumed that the probability of a species' persistence over the long-term would in part be determined by the maintenance and configuration of high-quality reproductive habitat patches on the landscape. Suitable reproductive habitat for upland-associated vertebrates was interpreted at each decadal time step. Results suggested that the average number of species with high-quality habitat was expected to increase under all scenarios due to forest growth out-pacing stand replacing disturbances. Scenarios that incorporated more aggressive treatments led to the highest mean performance of biodiversity metrics including species richness, redundancy in ecological function, and diversity supported in early, mid and late seral habitat conditions. This highly collaborative effort has enhanced our understanding the effectiveness of different management actions in achieving desired outcomes, while addressing significant uncertainties, such as the impacts of climate change.

Tuesday, October 13, 2020 12:00am - 12:00am

SYMPOSIUM: Shared Stewardship: working together to make decisions and take actions on the land

Advancing NM's collaborative management- a new comprehensive spatial risk assessment for shared stewardship priorities

Anne Bradley
The Nature Conservancy

Steve Bassett
The Nature Conservancy

The Nature Conservancy worked closely with the New Mexico Division of Forestry to develop a statewide comprehensive risk analysis and associated spatial data to assist the state in completing its update of the Forest Action Plan. The analyses also contributed substantially to the identification of potential joint priorities for the state and the Southwestern Region of the Forest Service. The statewide assessment of values and threats and robust engagement in the Forest Action Plan were made possible by nearly two decades of cross-jurisdictional collaboration between agencies, NGOs, and tribes in New Mexico to work together to restore watersheds and protect communities from large fire impacts. This partnering approach has been especially important for a state with relatively few resources to bring to bear on natural resource problems. The enabling conditions for collaboration and opportunities for cross-jurisdictional resilience-building identified in the Forest Action Plan will be described

Shared Stewardship, Shared Outcomes

Laura Ault

Utah Division of Forestry, Fire and State Lands

Managers and owners of forested land in Utah face many challenges, among them catastrophic fires, drought, insects and disease, invasive species. Of particular concern are longer fire seasons and the increasing size and severity of wildfires, along with the expanding risk to communities, water sources, wildlife habitat, air quality, and the safety of firefighters.
To address these concerns at a landscape scale, the State of Utah (State) and the USDA Forest Service (Forest Service) entered into a Shared Stewardship Agreement. On May 22, 2019, Utah Governor Gary R. Herbert and USDA Secretary Sonny Perdue signed the Agreement for Shared Stewardship between the State and the Forest Service Intermountain Region. Under the agreement, the State and Forest Service will focus on landscape-scale forest restoration activities that protect at-risk communities and watersheds.
The State and Forest Service have worked collaboratively to identify and map priority landscapes that will guide activities across jurisdictional boundaries. Shared Stewardship is about setting priorities together and combining resources to achieve cross-boundary outcomes using every available authority and tool to support partnership efforts to improve forest health and target treatments in the highest priority landscapes, thereby protecting at-risk communities and watersheds from catastrophic fire. The State of Utah and the Forest Service will work in partnership to restore these priority landscapes using all available tools.

Shared Stewardship: Strategies for Engaging Community-Based Partners

Karen Hardigg
Rural Voices for Conservation Coalition

Shared stewardship recognizes that both public land managers and the communities in which they are located, along with other stakeholders, can share responsibility and accountability for being stewards of the land, and can work together across ownership boundaries to accomplish common management objectives. The approach also recognizes that conservation and local community benefits are related and can be mutually supported. At its core, shared stewardship encourages the Forest Service to partner with a diversity of groups and organizations to accomplish its mission.

The Rural Voices for Conservation Coalition (RVCC) has worked closely with the Forest Service on implementing the vision of shared stewardship in the West. We have worked with partners to improve implementation of collaborative restoration projects that cross ownership boundaries by focusing on how agencies, landowners, and organizations can partner to accomplish work on the ground. In this presentation we will share best practices and strategies for including and working with community and collaborative partners. Themes will be drawn from applied research, peer learning exchanges, and case studies.

Shared Stewardship: working together to make decisions and take actions on the land

William Carromero
USDA Forest Service

n/a

Tuesday, October 13, 2020 12:00am - 12:00am

SYMPOSIUM: The Evolution of Forest Restoration Planning in the Central Sierra Nevada

Modeling human and natural disturbances under climate change

Charles Maxwell
North Carolina State University

Kristen Wilson, Robert Scheller, Patricia Manley
Between a history of fire suppression and changing climate, forests are moving outside of their historical range of variation. As fires are becoming more severe, forest managers are searching for strategies that can restore forest health and reduce fire risk. However, management activities are just one part of an integrated suite of disturbance vectors that shape forest conditions. To test this concept of the substitutability of disturbances, a disturbance return interval (DRI) was calculated that represented the average return time for any disturbance, human or natural, for any particular point, specifically to investigate the consequences of changing that interval on the proportion of high severity fire and the net sequestration of carbon on the landscape. In order to explore and quantify trade-offs between human and natural disturbances, we used management scenarios that were developed between forest managers and stakeholders in the Central Sierra Range of California. These scenarios were integrated into a mechanistic forest landscape model that accounted for climate change, harvesting, wildfire, and insect outbreaks. Our results suggest increasing the frequency of all disturbances on the landscape was found to reduce the percentage of high severity fire on landscape but not the total amount of wildfire in general. However, increasing the DRI reduced landscape carbon storage and sequestration, particularly in management strategies that emphasized prescribed fire over hand or mechanical fuel treatments.

North Yuba Project: a spatially explicit condition based management approach

Scott Conway
Conway Conservation Group

Andrew Salmon
South Yuba River Citizens League

The North Yuba Project's planning approach synthesizes ecological, economic, and social data to inform complex forest restoration decision-making across a 275,000-acre landscape. In conjunction with a nine-entity collaborative, a risk assessment and spatially explicit condition-based restoration framework informed by historical, current, and future scenario modeling is being developed to establish a multi-decade treatment design.

Priority-setting for restoration was informed through the quantitative valuation of strategic areas, resources, and assets aggregated with disturbance modeling outputs. With the objective of increasing ecosystem resiliency through improved forest structure and function, a spatially explicit condition-based framework was developed addressing the landscape's dynamic needs over time. Leveraging the modeling outputs from LDsim and Landis, restoration plans and silvicultural treatments were developed based on historical, contemporary, and future conditions. As environmental conditions change, this flexible condition-based approach will provide land managers with an adaptable scientifically-informed suite of options to draw upon in both the present as well as when the future inevitably changes conditions.

Tahoe Central Sierra Initiative: Ecosystem Management Decision Support Tool to guide a Blueprint for Restoration

Patricia Manley
US Forest Service Pacific Southwest Research Station

Nicholas Povak
US Forest Service Pacific Southwest Research Station

The Tahoe Central Sierra Initiative (TCSI) is developing and demonstrating innovative planning, investment, and governance tools across a 1 million hectare landscape, which can also be adapted to forested landscapes throughout the Sierra Nevada region. Specifically, the TCSI will provide information and tools needed for effectively restoring region-wide forest health and resilience by: 1) defining the desired outcomes for the Sierra Nevada in terms of ecosystem resilience from ecological, social, and economic perspectives; 2) assessing current conditions of the TCSI landscape; and 3) identifying the types, locations, and timing of treatments that can transition the landscape toward a more resilient, healthy, and diverse condition. TCSI was structured to address eight pillars of resilience that represent the range of desired landscape outcomes and social benefits that motivate resilience restoration investments: forest resilience, fire dynamics, carbon sequestration, biodiversity conservation, water reliability, air quality, fire-adapted communities, and economic diversity and social well-being. To meet evaluate means by which to achieve desired outcomes, we developed a variety of spatially explicit data on current and future conditions associated with eight pillars. Current conditions were represented by spatially explicit high resolution maps of 25 metrics that spanned the eight pillars of resilience. Future conditions were derived from Landis II model outputs that accounted for climate change, including forest structure and composition, fire dynamics, and beetle mortality, and from secondary models of biodiversity, wood supply, and snow accumulation and melt dynamics based on Landis outputs. Future landscape dynamics were interpreted in terms of the conditions that landscape units tended to support, the stability of conditions in landscape units, and a rating of the ability of landscape units to provide benefits associated with the eight pillars of resilience. These data were integrated into the Ecosystem Management Decision Support (EMDS) Tool synthesize system dynamics and constraints and identify where management activities can have the greatest positive impact on resilience. EMDS is a state-of-the-art modeling framework for decision support of environmental analysis and planning at multiple geographic scales. The system integrates geographic information system data, logic-based reasoning for environmental assessment, and multi-criteria decision analysis for strategic planning to provide explicit, practical decision support for strategic and tactical planning as well as adaptive management. The EMDS model of the TCSI landscape provides a range of management options and opportunities to move the landscape toward achieving desired outcomes that reflect where in the landscape various benefits and outcomes are most readily accomplished and maintained.

Tahoe Central Sierra Initiative: Modeling Historic Range of Variability to inform restoration planning

Becky Estes
USDA Forest Service

Estes, Becky1, McGarigal, Kevin2, Conway, Scott3
1 Pacific Southwest Region
2 LandEco Consulting
3 Conway Conservation

The Tahoe Central Sierra Initiative (TCSI) spans 2.4 million acres covering a range of forest types in the Sierra Nevada in California. The landscape is dynamic, developing as a result of complex natural and human land use history driven largely by disturbance. Fire is the dominant disturbance driving vegetation succession, in which cycles of fire and recovery occur variably over large extents and long periods producing a constantly shifting mosaic of ecosystem conditions. It is generally believed that prior to Euro-American settlement in the mid-1800s, the TCSI landscape was in a dynamic equilibrium with a stable shifting mosaic of vegetation conditions that was highly resilient to permanent change. To understand this dynamism, TCSI felt it was important to develop a quantitative assessment of the historical (ca. 1550–1850) range of variability (HRV) in landscape structure that can be used as a restoration planning tool to: 1) define a reference to evaluate the current landscape 2) develop a framework for deriving desired future conditions and 3) create a monitoring tool to measure restoration success. To simulate disturbance and succession processes representative of the HRV period within the project area, we developed a landscape disturbance-succession model using fine scale LIDAR data in the LDSIM framework and simulated the dynamics in vegetation driven by wildfire during the historical reference period At the landscape scale, the historical reference period was best characterized as a shifting mosaic of vegetation types and conditions that was subject to a remarkably high wildfire disturbance rate. We quantified the range of variability in composition and configuration of the landscape mosaic and compared the results to the current landscape to quantify departure. Current conditions compared to the simulated HRV showed departures in both composition and structure. For example, HRV was characterized by more late seral forests and smaller and more distributed openings than our current conditions. These outputs can define the reason for change and help prioritize where to do treatments. HRV can also be expressed using a biophysical unit framework that defines departure from HRV at a stand scale providing quantitative estimates that can be built into project level silvicultural prescriptions (gap size, seral stage). The HRV departure estimates will ultimately be used to help guide large landscape scale projects in TCSI such as the one underway in

The Evolution of Forest Restoration Planning in the Central Sierra Nevada

Kristen Wilson
The Nature Conservancy

Patricia Manley
Pacific Southwest Research Station

Efforts to restore forests are increasing in pace and scale to improve forest resilience to climate change. Although forest management to achieve desired conditions has been practiced for at least a century, arguably several centuries in the Sierra Nevada, the complexity of the environmental context and the planning processes have increased significantly, creating a need to retool restoration planning approaches. We describe four projects that illustrate recent adaptations in forest restoration planning to broader spatial and temporal scales and to include climate change impacts. An early restoration effort that was designed and implemented over a 15-year period from 2005 to present at the Sagehen Creek Field Station and Experimental Forest, tested a then novel approach to restoration on National Forest System lands. The Sagehen Project created openings or gaps in the forest and thinned out small diameter trees over a 4,000-ha landscape. A more recent project, French Meadows Project, was designed and began implementation over only 3 years. The project tackled multiple land ownerships, and similarly complex silvicultural prescriptions over a 11,000-ha landscape. Both projects took a static view of current fire risk, departure of vegetation from historic conditions, and evaluation of assets at risk from fire. They qualitatively addressed climate change but did not quantify the projected influence of climate change. The Lake Tahoe West Restoration Partnership marked a transition in forest restoration planning. The planning scale increased again to a 24,000-ha landscape ranging from urban to wilderness. The partnership adopted a dynamic view of landscape conditions over 100 years across a large set of ecological and social outcomes modeled under future climates to inform a restoration strategy. The Tahoe Central Sierra Initiative (TCSI) builds on the Lake Tahoe West project by taking another leap to a 1-M ha regional landscape. TCSI also incorporates dynamic modeling over 90 years to inform forest restoration management inputs, and to support planning efforts at all scales within the regional landscape. Broader spatial and temporal scales of analysis along with quantitative evaluation of climate change as a driver of forest health across diverse land ownerships characterize the recent evolution of forest restoration planning.

Tuesday, October 13, 2020 12:00am - 12:00am

SYMPOSIUM: The Quaking Aspen Challenge: Applied Conservation in Keystone Communities

A decade of monitoring aspen restoration in the Lake Tahoe Basin: synthesis of research applicable to management

J.-Pascal Berrill
Humboldt State University

Aspen is a keystone species important to wildlife, water quality, biodiversity, recreation, and aesthetics in the west. In the central Sierra Nevada, the Lake Tahoe Basin is home to scattered small aspen groves that are surrounded, outsized, and being outcompeted by conifer forests. In the absence of natural disturbances such as frequent mixed-severity wildfire, these aspen groves have been undergoing succession to conifer for decades and were being lost. More recently, many groves have been restored by various land management agencies. In collaboration with these agencies, we regularly monitor outcomes of their operational-scale restoration activities in aspen groves. We also monitor untreated groves for comparison. These monitoring collaborations have generated a series of applied research publications in scientific journals. Here we synthesize the key findings of these studies that apply directly to the practice of aspen forest ecosystem restoration. The focus is on restoration thinning treatment responses of aspen regeneration, conifer regeneration (unwanted), and herbaceous vegetation, plus the forecasted future growth of trees and longevity of restoration treatments, and the most recent findings on aspen ecosystem responses to piling and burning of conifer wood from trees cut as part of the aspen restoration activities. The monitoring is ongoing, tracking

trends and generating ever more data and information supporting adaptive management.

Avian-Aspen Relationships in the Sierra Nevada

T. Will Richardson
Tahoe Institute for Natural Science

The importance of quaking aspen to birds and other wildlife in western North America has long been appreciated by biologists. Many studies from this region have demonstrated that aspen habitats typically support much greater diversity, richness, and abundance of birds than adjacent habitats, and several bird species have shown a strong affinity with aspen. This talk will provide an overview of bird-aspen relationships in the Sierra Nevada and highlight research investigating habitat correlates of bird species richness and abundance, aspen as a barrier to nest predators, habitat correlates of nest success, avian nest-site selection within aspen, short-term impacts of mechanical conifer thinning in aspen, and impacts of recent White Satin Moth invasion to the region.

Long-Term Dynamics of Aspen Stands in the Lake Tahoe Basin: a 34-year Analysis of Conifer Encroachment using Landsat

Thomas Dilts
University of Nevada Reno

Co-authors: Tyler Refsland, Hall Cushman, and Jonathan Greenberg
Global climate change, land use legacies, and insect defoliators can have severe implications on forest composition, structure, and regeneration with long-lasting effects on ecosystem services. In the Lake Tahoe Basin (LTB), quaking aspen stands support high levels of biodiversity, provide recreational opportunities, and help maintain water quality. Despite the benefits that aspen provide, aspen stands in the Lake Tahoe Basin have declined in cover due to insect defoliators, fire suppression and conifer encroachment. Recently, managers in the LTB have adopted practices, including fuel reduction and conifer thinning, intended to combat the negative effects of fire suppression and conifer encroachment on aspen regeneration. However, little is known about how aspen canopy cover has changed in the past several decades across the LTB and what areas are most likely to achieve restoration success.
Using the Landsat satellite archive, we performed spectral mixture analysis to identify trends (1984 â?? present) in the fractional cover of healthy aspen, defoliated aspen, and conifers and to map hotspots of defoliation and conifer encroachment within the LTB. To identify Landsat pixels containing aspen we developed the highest resolution and most accurate aspen map in the LTB to-date. This map was created using a combination of leaf-off and leaf-on imagery and LIDAR. To validate our conifer encroachment mapping we hand-digitized 6,186 conifer crown polygons across 138 aspen stands. To identify abiotic conditions most associated with defoliation and conifer encroachment we created predictive models using a wide variety of topographic, soil, climatic, and stand characteristics.
Our high-resolution aspen map identified 553 aspen stands that comprised 1.4% (931 hectares) of the total land area in the LTB. Within the subset of aspen stands where conifer cover was digitized, an average of 11.4% of the present aspen stand area was occupied by conifers. Although our trend analysis is ongoing our preliminary results suggest that there are distinct abiotic conditions that favor conifer encroachment that differ from stands subject to defoliation. Defoliation was most common in many of the largest stands in the basin whereas conifer encroachment tended to occur in smaller stands and along edges. Our 30-meter spatially-explicit maps of conifer encroachment rates and defoliation are being incorporated into a decision support system that enables land managers to identify areas with the greatest benefit-to-cost ratio for habitat restoration. Management criteria include distance to existing roads, slope, distance to riparian areas, stand size, stand connectivity, existing conifer cover and conifer encroachment rate.

Long-term patterns in aspen performance across North America during a period of unprecedented climate change

Hall Cushman
University of Nevada, Reno

Tyler Refsland
University of Nevada, Reno

Forests cover 30% of the Earth's terrestrial surface and have large influences on biogeochemical processes and provide a wide range of ecosystems services. However, throughout the world, an increasing number of tree species are reported to be declining in abundance due to large-scale tree mortality and/or reduced regeneration. Many factors have been implicated as drivers of tree decline, but stress caused by elevated temperatures and drought associated with anthropogenic climate change have emerged as important factors. Understanding the dynamics and spatial extent of tree decline is of great importance given the essential role that trees play in ecological systems.

Quaking aspen (Populus tremuloides) is ideally suited for studying the dynamics of tree decline: 1) it is the most widespread tree species in North America; 2) it inhabits a wide range of environments that are exceptionally variable in topography and climate; and 3) previous research has shown that its performance can be quite variable, exhibiting declines in some parts of its range and no changes in others. Using long-term data from a continent-wide plot network, we have evaluated mortality, growth and recruitment rates of aspen across its range to better understand the vulnerability of this species to global change.

Our data summarize long-term patterns in mortality, growth and recruitment rates of aspen in forest inventory networks established by state, provincial and federal agencies in Canada and the U.S. Mortality rates of adult aspen increased substantially over the past 20-35 years, with patterns persisting in stands of different ages, densities, and compositions. In contrast, recruitment rates of adults decreased through time, with patterns varying with forest composition and age structure. To a lesser extent, growth rates of aspen also decreased through time, although they varied less with composition and stand structure.

The demographic rates of aspen varied greatly among the five biomes that the tree inhabits in North America. For example, recruitment and growth rates were substantially lower in coniferous and boreal forests compared to three other biome types. Within all biomes, we explore the importance of recent climatic anomalies and topographic heterogeneity in predicting demographic rates of aspen.

In summary, our analyses of the long-term dynamics of aspen across its entire geographic range indicate that aspen populations are experiencing region-specific shifts in background demographic rates, with changes most pronounced in regions most affected by recent climate change (i.e., arid and high-latitude environments).

Quaking Aspen Science & Management in Dynamic Times

Paul Rogers
Western Aspen Alliance, Utah State Universtiy

Quaking aspen (Populus tremuloides) science is experiencing a renaissance, of sorts, in terms of multiple advances in related disciplines. Novel findings in genetics, biodiversity and bioindicators monitoring, climate modeling, seedling episodes, chemical defense, herbivore impacts and movement, and fire ecology are all changing the way we think about aspen systems. However, management practices lag behind in their implementation of actions in concert with these discoveries. This presentation will frame recent contributions to aspen ecology that will be detailed in follow-up talks in this Aspen Conservation Special Symposium, as well as describe sound management practices to complement contemporary aspen sciences. Such actions, grounded firmly in adaptive monitoring and ecological restoration, are aimed at preserving ecosystem resilience as we navigate uncertain climate futures. Another aspect of this talk will examine the role land ownership and status (reserved vs. unreserved) plays in often diverging ecologies of aspen forests. Both land and wildlife management practices may promulgate resilience or exacerbate decline. A key tenet of modern land stewardship is emulation of natural processes in practical application. This approach is thought to increase the odds of success or 'â€¦to keep every cog and wheel [as the] first precaution of intelligent tinkering.' as the sage words of Aldo Leopold suggest. Thus, this presentation will provide an overview of advances in aspen ecology, as well as give a functional ecology playbook for implementing management strategies that are knowledgeable and flexible. The expectation is that the work presented here will be of interest to applied scientists and field practitioners interested in aspen conservation.

The Quaking Aspen Challenge: Applied Conservation in Keystone Communities

Paul Rogers
Western Aspen Alliance, Utah State Universtiy

Quaking aspen (Populus tremuloides) occurs across the continent, but displays different functional qualities under widely varying conditions. For instance, Great Basin and Sierra Nevada aspen often have divergent aspen 'ecologies.' Not only do diverse ecologies affect aspen, but a history of human-induced alterations present challenges for the sustainable management of these keystone systems. In order to bridge science-stewardship divides, this session will explore practical, ecologically-based, actions to restore resilience in systems threatened by climate change, herbivory, land conversion, past management, residential development, and other practices. In keeping with NAC 2020's theme, we will recruit presenters with varied geographic and disciplinary foci, meshing science and stewardship with the overall objective of enhancing aspen landscapes. In this region, aspen span a nearly 4,000 ft. (1,020 m) elevation range; thus, we will aim to address aspen functional types co-located with both sagebrush and subalpine forests. Specifically, we will address wildfire, herbivory, climate warming, development pressures, cross-boundary management, and regional monitoring of aspen in the West. A driving paradigm in forest ecology is emulation of natural processes in practical applications. This session will take that approach for aspen ecosystems to the next level: through presentations and a summary discussion we aim to match current ecological understanding with practical application. Our 'gradient' motif will ensure a diversity of western American aspen conditions and practices. Through open and thoughtful information exchange, participants will come away with a trove of new management tools and insights, technical resources, and professional connections for addressing aspen resource issues at local, regional, and continental scales.

The role of climate and fire in shaping aspen forests of the Great Basin: altered dynamics and management challenges

Douglas Shinneman
U.S. Geological Survey

Susan McIlroy
U.S. Geological Survey

Quaking aspen (Populus tremuloides) forests are considered to be in decline across large portions of the western U.S. due to the effects of drought, fire-exclusion, excessive herbivory, insects, and pathogens. However, aspen forests are also considered persistent or even locally expanding in other areas. In the northern Great Basin and surrounding regions, where arid sagebrush-steppe landscapes typically dominate, aspen are found in isolated mountain ranges and often form the only forest ecosystem with substantial areal extent. Loss of aspen forest area in the Great Basin could result in substantial habitat loss for myriad species that disproportionately utilize aspen ecosystems relative to surrounding habitat. Here we discuss some of the key issues affecting aspen in the Great Basin, including interactions between changing climate, altered fire regimes, and herbivory. As the western U.S. becomes increasingly vulnerable to drought, the distribution of aspen forests is likely to contract. This may be especially true in the Great Basin, a region with strongly winter-dominated precipitation regimes and extremely dry summers, in which forests are likely to be particularly affected by declining snowpack. Conversely, because aspen is a fire-adapted species that vegetatively reproduces after disturbance, aspen forests could simultaneously benefit from increasing wildfire activity in the western U.S. We will examine recent research that suggests the relative importance of fire in aspen ecosystems of the Great Basin, including evidence that many aspen forests in the region are stable and don't depend on fire for regeneration and persistence. We will also highlight the importance of adequate precipitation, including during winter, for aspen regeneration in both unburned and recently burned stands in the region. We'll use modeling studies and recent field-based research to discuss how these relationships are likely tenuous in the region, especially given expected and observed changes in climate over time and space. Lastly, we will discuss how interactions among various stressors could occur in novel ways under global change dynamics, making it challenging for land managers to identify, prioritize, and manage at-risk aspen forest habitats. In particular, we will consider how additional factors, such as chronic ungulate herbivory and nonnative species, could interact with changes in climate and fire regimes to contribute to declining aspen populations or shifts in forest-shrubland ecotones.

Authors: Douglas Shinneman and Susan McIlroy

Tuesday, October 13, 2020 12:00am - 12:00am

Technology in natural areas conservation

A study of landscape-level habitat relationships between birds and vegetation on the Modoc Plateau

Jaime Ratchford
California Department of Fish and Wildlife

Occupancy models often provide easy to interpret variables but are difficult to translate into spatially explicit information at a landscape-level. The California Department of Fish and Wildlife Vegetation Classification and Mapping Program is examining the relationship between wildlife communities and how these relationships can be extrapolated across a large geographic area using fine-scale vegetation mapping in the Modoc Plateau. The Modoc Plateau is an area of California with a low human population, yet strongly affected by human-caused disturbances and rapid changes in vegetation patterns. Vegetation classification and mapping of 1.2 million acres of this region began in 2016, providing quantitative spatially explicit vegetation information to be co-analyzed with high-density bird survey data collected in the 2018 and 2019 field seasons.
Field crews collected bird occupancy data using digital recorders at 308 sites during the breeding season in 2018 and 2019. Sites were selected according to a stratified sample allocation covering 15 of the most common terrestrial and wetland vegetation types in the ecoregion. These data are being used to build and test a series of occupancy models for birds of the area, including the declining greater sage-grouse, in order to clarify landscape-level habitat relationships between bird species and regionally important vegetation types. This study is expected to have a significant impact on statewide wildlife habitat assessment and will revise and refine current habitat modeling practices and assumptions state-wide.

Are Talus Sites Important Winter Habitat? A Case Study Monitoring Rare Mammals in Northwestern Nevada

Danielle Miles
University of Nevada, Reno

Claudia Pighetti
University of Nevada, Reno

Talus deposits, the rock formations associated with scree at the base of mountains or cliffs, are important habitats of western North America that provide year-round shelter to a diversity of small mammal species. Rocky habitats such as talus are also long-term refugia against increasing climate variation as organisms can be buffered from the temperature extremes being experienced in more open environments. However, little is known about how rare and threatened mammal species use these buffered habitats for thermoregulation throughout the winter months. The American Pika (Ochotona princeps) is a known rock-dwelling obligate in northwestern Nevada, but previous studies have yet to describe winter activity patterns in pika, in large part to the difficulty of accessing remote areas in snow conditions. In contrast to pika, some bat species that roost in rock crevices during the summer are thought to migrate to warmer locations during the winter, though many bat species are understudied because of their difficulty to capture, tag, and track. Here, we present a novel method of monitoring pika and bat activity through the winter season using passive acoustic detectors. In October 2019, we deployed sets of Wildlife Acoustics SM4 and SM4 Full Spectrum recorders with iButton temperature loggers at 9 talus sites in northwestern Nevada on BLM land and in Sheldon National Wildlife Refuge for 6 months. American Pika vocalizations were identified manually in RavenPro sound visualization software and bats were identified to species using Sonobat. With these new methods, we were able to 1) describe the activity patterns of pika in relationship to available sunlight and temperature fluctuations at sites with known pika presence in the summer and 2) compare bat species richness across seasons for the 15 species we have recorded in the region from 2017-2019. By developing this protocol for assessing presence and activity for rare and hard to track mammals, we are providing land and wildlife managers with the low-cost tools needed for seasonal monitoring in order to understand short- and long-term changes to talus habitats.

Co-producing knowledge on montane forest ecohydrology using very high-resolution observations and models

Adrian Harpold
University of Nevada, Reno

Forest ecohydrology is critical to the prediction of future water supplies and ecosystem services. The spatial arrangement of trees, and other high-resolution information on forest canopy, can have dramatic effects on processes like snow melt with cascading impacts on water availability. Working with forest and water mangers in the Sierra Nevada, California, we have developed new modeling and observational systems to provide information to support decision making around forest treatment type and location. Observational tools include airborne-based lidar, which allows for three-dimensional information on forest structure and 1-meter scale snow depth maps. Unmanned aerial vehicles can collect thermal images at ~10 cm resolution that can information the energy state of the snowpack or fraction of incoming energy used for evaporation. We combine these high-resolution observations with physically-based models to both parameterize and verify their predictions of future hydrology. We will highlight a number of case studies in this talk. First, the sensitivity of snow processes to forest removal using lidar observations and high-resolution snowpack modeling for the Lake Tahoe Basin. This project co-produced information with the U.S. Forest Service and provided a decision support tool for forest managers. A second case study will examine the potential to use high resolution thermal imagery to map tree water stress in very high resolution in Sagehen Creek experimental watershed. The final example will explore the utility of high-resolution modeling to estimate the long-term feedbacks between tree growth and snowpack change, including the role of forest disturbance and climate change. Our central thesis is that high-resolution observations are available and can increase model fidelity in many fields, but that challenges remain in harnessing new datasets into existing models and translating results into management-relevant information.

Detecting change in high elevation forests: disturbance monitoring with the Ecosystem Disturbance and Recovery Tracker

Michele Slaton
US Forest Service Region 5 Remote Sensing Lab

High elevation white pine forests dominate upper treelines of the American West from the Sierra Nevada to the Great Basin and northern Rockies. Whitebark pine (Pinus albicaulis) is a major component of these forests, and is a federal candidate species under the Endangered Species Act, due to threats from climate change and insect and disease outbreaks. The remote and rough terrain and short growing season of these forests make traditional field or airborne monitoring difficult to implement with the frequency required to track rapid changes at broad scales. Operational remote sensing methods that concurrently detect forest anomalies and characterize magnitude of change are in great demand. The Ecosystem Disturbance and Recovery Tracker (eDaRT) is a highly automated, broadly applicable disturbance mapping system that processes all available Landsat imagery, detecting change at 8-16 day timestep, and is operated by the US Forest Service Pacific Southwest Region to generate disturbance map products for science and land management applications. We report on a newly developed method to estimate canopy loss using time series of spectral change associated with eDaRT disturbances. We used training data from high resolution imagery analysis and field plots across California's high elevation forests to develop a regression model for canopy cover loss as a function of eDaRT spectral change. The resulting eDaRT Mortality Magnitude Index (eMMI) combines vegetation indices known to be related to vegetation cover, moisture, and health, including the Normalized Difference Vegetation

Index, Normalized Burn Ratio, and Red-Green Angle. Canopy cover loss was best modeled by including variables representing both proportional and absolute spectral change and their temporal variability, yielding a root mean square error (RMSE) of 13%. We provide an overview of plans for operational implementation of this tool for the Pacific Southwest Region of the Forest Service, and its potential to improve the accuracy and efficiency of delivery of forest change products for researchers and managers.

Developing a Plant Community Targeting Tool for Ecological Restoration in Pennsylvania

Ephraim Zimmerman
Pennsylvania Natural Heritage Program

Understanding what plant species may thrive at a particular site is important in ecological restoration activities and greatly benefits from a solid understanding of a site's ecological characteristics. Identifying a target natural plant community, a group of species occurring together on the landscape driven by ecological site characters, can be a key component of a restoration activity. Since the late 1990s, the Pennsylvania Natural Heritage Program (PNHP) has collected plot-based plant community data, which include species composition and structure information as well as ecological site data. These data, which have been used to drive the development of Pennsylvania's plant community classification and to determine rare natural plant communities in the state (used in the state's environmental review process) are also available to guide restoration planning. This presentation will review a new tool developed by PNHP and NatureServe, which uses the PNHP plot data and geospatial information to determine the plant communities and plant species that may exist at a specific site based on the similarity of each site to classified plots in the Heritage Program's plots database. The tool was designed to be utilized by wetland consultants, regulators, and land managers to provide site specific planting recommendations for restoration activities. We believe that a better understanding of the plant community types that are found at a specific site will benefit native wildlife species, lessen the overall negative ecological impact of development activities, and improve the successes and sustainability of restoration projects.

Estimating biomass of chaparral shrublands in Southern California using Landsat NDVI

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The Mediterranean-type climate region of southern California is dominated by chaparral shrublands. Chaparral regulates essential ecosystem functions and provides critical ecosystem services such as water, air quality, recreation, wildlife habitat, biodiversity, and carbon storage. Today, chaparral shrublands are experiencing wildfires with increasing frequency compared to pre-European settlement and dramatic increases in the area burned. The four National Forests in southern California are dominated by chaparral shrubland, and the USDA Forest Service is interested in understanding the impacts of wildfire disturbance on ecosystem services. Essential to this task, is understanding the initial loss and subsequent recovery of aboveground biomass in chaparral owing to wildfire. To address this issue, we developed a method to estimate chaparral biomass using the deep temporal record of Landsat imagery and precipitation as time-dependent predictors. We used Random Forest, an ensemble machine-learning algorithm, to build an aboveground live biomass model using over 700 field plots from several sources. By using Landsat Normalized Differential Vegetation Index (NDVI) images and precipitation raster layers for each year from 2000 to 2018, we are able to track biomass loss and recovery due to wildfire. Our model estimates compare favorably to field collected data on aboveground live biomass, thereby providing an important contribution to understanding how wildfire disturbance affects the ecosystem service of carbon storage in southern California. These methods rely on

readily available data (i.e., Landsat) and therefore are applicable to assessing biomass in Mediterranean-type climate shrublands worldwide.

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