High Altitude Revegetation Committee –
Society for Ecological Restoration-Rocky Mountains Chapter
2019 Joint Conference

HAR – SER-RM 2019 Conference Program

Colorado State University
March 12 – 14

HIGH ALTITUDE REVEGETATION

SER ROCKY MOUNTAINS SOCIETY FOR ECOLOGICAL RESTORATION

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REVISED SCHEDULE FOR MARCH 14

Thursday March 14

7:30 AM Registration / Coffee — Outside Ballroom AB

8:30 **Keynote 2** Moderated by Pete Stahl — **Ballroom AB**

Historical reference conditions, species pools, and functional traits: the future of western mixed conifer forests.

Daniel Laughlin

Restoration ecologists have an innate desire to restore what has been lost. Our first instinct is to use historical reference conditions as empirical benchmarks for restoration success. However, historical reference conditions in many regions are undefinable and are increasingly viewed as irrelevant under climate change. The important question to ask is why were species dominant historically? The answer, presumably, is because they exhibited traits that conferred high fitness in those environments. As the environment changes, optimal traits may shift, making historical trait distributions less fit and ill-suited for the task. If this is the case, then we may need a new framework for setting targets to meet desired functional outcomes in ecological restoration in a rapidly changing world. In this talk I will compare and contrast the use of historical reference conditions with those based on functional traits in a fire-adapted mixed conifer forest on the North Rim of Grand Canyon National Park. This forest has increased in tree density since the age of fire suppression, which makes it more susceptible to stand-replacing crown fire. I will show how management actions designed to restore historical conditions work remarkably well to enhance forest resilience, but will also discuss alternative options that might lead to success in a hotter, drier climate.

9:10 – 10:30 AM **Ballroom A**

Organized Session 2: 2013 Flood Recovery Efforts Through the Colorado Emergency Watershed Protection Program

Moderated by Mark Paschke

9:10 Management and oversight of Colorado Emergency Watershed Protection Program for 2013 Colorado flood recovery.

Chris Sturm

In September 2013 massive flooding occurred across Colorado's Front Range communities. The Colorado Water Conservation Board (CWCB) led the effort to repair, re-align, and restore the flood affected rivers, streams, and floodplains. As the Statewide sponsor of the Natural Resources Conservation Service (NRCS) 2013 Phase II Emergency Watershed Protection (EWP) Program, the CWCB was tasked with overseeing and implementing $50 million in stream recovery work. The CWCB also participated in the implementation of another $20 million in stream recovery work funded through other programs including the U.S. Dept of Housing and Urban Development's (HUD) Community Development Block Grant – Disaster Recovery program. The State Department of Local Affairs (DOLA) and the CWCB created a Watershed Resiliency pilot program with the HUD funds, creating capacity in local watershed coalitions, developing resiliency recovery plans, providing stream designs, and constructing projects. Following the 2013 floods, CWCB developed comprehensive watershed and stream master plans that emphasized natural stream function and ecosystem health along with property and infrastructure protection. In total, 117 projects representing nine Front Range Watersheds were restored between March 2015 and May 2018. The purpose of our presentation is to present on the specific restoration and challenges of implementation for 65 miles of streams, rivers, and floodplains.

9:30 The good, the bad, and the ugly of creating and implementing a short time-frame plant materials program for Colorado flood recovery.

Randy Mandel

The 2013 Front Range flooding occurred between September 9 to September 15, 2013 when a slow-moving cold front stalled over Colorado. The resulting heavy rain caused catastrophic damage over an approximately 200 miles range, affecting a total of 17 counties. The Colorado Emergency Watershed Protection Program was created to provide funding to implement emergency recovery measures to address hazards to life and property for the flood affected areas. Phase 2 of the program was funded and administered by the USDA Natural Resources Conservation Service and managed by the Colorado Water Conservation Board with total resources of $63.2 million and a project time-period from Spring 2016 to Spring 2018. To provide the necessary plant materials for revegetation, a portion of this funding was used to create an ecotypic plant materials program. This talk will discuss the specifics of creating a technically sound program on a such short time-period, focusing on successes, challenges, and necessary compromises to meet the needs of approximately 116 recovery projects over a two-year period. Propagule collection and increase of over 70 species, as well as the storage, provision, and implementation of close to 1000 lb of site-specific seed, 227,000 containerized stock, and 61,000 cuttings will be discussed in detail.

9:10 - 10:30 AM **Ballroom B**

Technical Session 4: Wildlife

Moderated by Drew Rayburn

9:10 Insect response and dispersal associated with restoration in a semi-arid natural gas field.
Michael Curran

Insects, the most diverse animal group on Earth, provide a wide-array of ecosystem services. However, 'the little creatures that run the world,' are often underappreciated in restoration and conservation studies. Aside from providing biodiversity, insects are critical pollinators and sources of food for higher trophic levels. Four years of field studies have shown insects respond positively to restoration efforts on well pads in the Jonah Infill and Pinedale Anticline natural gas fields. While the first three years of field work focused on collecting insects on well pads with various vegetation communities and comparing them to insects found in adjacent reference systems clearly showed insects are attracted to reclaimed well pads, determining whether insects disperse from well pads was not an objective. The fourth year of field work involved using immuno-marking techniques to determine whether insects are using revegetated well pads as resource islands or sinks. Here, we demonstrate how insects respond to and disperse from well pads undergoing restoration activity.

9:30 Ponderosa pine forest restoration can benefit avian communities.
Latif Quresh

Fire suppression has increased stand density and risk of severe, stand-replacing wildfire in ponderosa pine forests. The U.S. Forest Service's Collaborative Forest Landscape Restoration Program (CFLRP) aims to restore ecological disturbance processes and improve conditions for biodiversity. We applied the Integrated Monitoring in Bird Conservation Regions program to survey birds in relation to CFLRP treatments along the Colorado Front Range in 2015–2017. We estimated species occupancy and richness at 292 points nested within 54 1km^2 grid cells. The data supported 38 species occupancy relationships with treatment, 22 of which were consistent with hypothesized mechanisms for treatment effects. For example, grid-level occupancy for aerial insectivores increased with percent area treated, which related positively with extent of open forest (10–40% canopy cover), where they forage. In contrast, point-level occupancy for shrub nesting species was lower at treated points, which had less shrub cover. We found both positive and negative point-level relationships with treatment, but only positive grid-level relationships with percent area treated (1km-radius neighborhood). Accordingly, grid-level species richness peaked at ~60% area treated. These results suggest CFLRP treatments can benefit communities by generating habitat for open-forest species without necessarily eliminating habitat for closed-forest species, although we may maximize benefits by maintaining some dense stands.

9:50 Enhancing wildlife habitat through snag recruitment during forest management projects: initial results and future directions.
Steve Murdock

Snags are key structural elements in Front Range forests that provide critical food resources and nesting sites for wildlife. Snags and other coarse woody debris are also important for nutrient cycling, seedling facilitation, stand complexity, and for understanding historical stand dynamics. Snag retention and recruitment are emphasized as elements of forest restoration frameworks in Colorado, with management objectives often including target numbers of snags per acre to be retained and/or recruited. Snag recruitment can result from natural processes such as pathogens, insects, lightning, and fire, as well as from manual treatments such as girdling, topping, prescribed fire, forest pest pheromones additions, and herbicide application. We present the results of a three-year pilot study testing three snag recruitment methods (girdling, topping, and herbicide) begun in 2015 during the implementation of a ponderosa pine enhancement project by Jefferson County Open Space (JCOS) staff at Alderfer / Three Sisters Park in Jefferson County, Colorado. The degree of insect and woodpecker use was recorded annually for each treatment, and both have been generally higher for girdled trees. Study results are guiding snag recruitment efforts in JCOS forest management projects, and staff are planning an expanded study with greater replication to investigate the influence of additional factors such as tree age, height, diameter, and site characteristics on snag recruitment outcomes.

10:10 Considerations for large scale sage grouse habitat improvements.
Jesse Dillon

Projects on federal land must consider compensatory mitigation in situations where potential impacts to the species habitat cannot be avoided or minimized. Two proponent-driven compensatory mitigation projects for Greater Sage Grouse were proposed recently in northern Nevada, for land areas between 20,000 and 230,000 acres. Both projects used a data-driven framework to select focal areas for conservation. GIS-based analysis of breeding, late brood rearing, and winter habitat data along with lek locations and telemetry data; vegetation cover and pinon-juniper encroachment, fire frequency, soil erosion factors, land management and permitted uses, habitat continuity, and topographic data, were used to evaluate the best treatment areas to achieve habitat uplift. Using the best available science, targeted treatments included Pinon Juniper thinning, inter-seeding with desirable grasses and forbs, and weed control. Implementation of treatments required digital tracking technology and real-time data visualization and management. This presentation will demonstrate the screening process to select the treatment areas, discuss the preliminary treatments to be implemented, and introduce habitat improvement goals. Based on our experiences, we present considerations for large scale land restoration data management, technology applications, and project tracking to streamline implementation and reach success factors as they pertain to mitigation programs for the benefit of sage-grouse.

10:30 – 10:50 Break Ballroom CD

10:50 – 12:10 AM **Ballroom A**

Organized Session 3: Can Broad-Scale Wetland Restoration Help Mitigate the Impacts of Climate Change? Results of 10 Years of Implementation.

Moderated by Jeremy Sueltenfuss

10:50 Wetland restoration at the Valles Caldera National Preserve: techniques and vegetation response.

Steven Vrooman

The Valles Caldera National Preserve in the Jemez Mountains of Northern New Mexico is the newest additional to our National Park System. The Preserve has thousands of acres of high altitude valleys that have been heavily impacted by human uses such as grazing, logging and road building. This area has also been impacted by a number of large wildfires that have burned over 2/3rds of the Preserve. For the last 10 years, Los Amigos de VC has worked with funding from the US EPA, New Mexico Environment Department and private foundations to restore the wetlands and streams of the Preserve. A large number of low-cost effective techniques have been developed, tested and monitored to restore wetlands cheaply and effectively. We have also partnered with Los Alamos National Laboratory and Global Conservation Assistance to test the effectiveness of these restoration methods for treating post-fire runoff by the use of stable isotope techniques. We propose that large-scale low tech restoration techniques can be an effective tool to mitigate the impacts of human disturbance and climate change.

11:10 Buffering of hydrological and geochemical impacts of climate change and drought: examples from plug and pond restorations at the Valles Caldera National Preserve.

Brent Newman

Studies of plug and pond type watershed restoration have shown that these kinds of remediation activities drive profound changes in the hydrology and biogeochemistry of treated watersheds. The resulting increases in water storage, groundwater levels, and hydrological residence times as well as changes in redox conditions as a result of plug and pond activities help buffer impacts from climate related affects such as droughts and fires. This presentation will explore the kinds of positive changes that plug and pond restoration imposes using geochemical and stable isotope data from treated watersheds within the Valles Caldera National Preserve in New Mexico, USA.

11:30 Biodiversity accounting for extractive industry net-positive impact goals, can wetland restoration improve biodiversity gains.

Kina Murphy

Mining causes abrupt and extensive forms of land-use change. It not only impacts biodiversity, it destroys ecological processes and causes land degradation that has cascading effects on whole systems. Recently, development banks have adopted performance standards that require the extractive companies they provide with loans to show that they are having a net-positive impact on biodiversity. This has resulted in the creation of core biodiversity monitoring programs that focus on accounting for biodiversity gains and losses. However, these programs often only focus on specific species. We suggest that disturbances to abiotic factors, such as water and soil, should be included in core biodiversity monitoring because they are critical to the survival of all species. Erosion and the subsequent loss of shallow ground water tables are threshold triggers that can be used to identify broad-scale disturbances and climate drivers that affect ecosystem resilience in impacted landscapes. Watershed degradation from erosion, caused by land-use change, is a worldwide issue that impacts the ability of landscapes to support biodiversity. Erosion causes loss of topsoil and diminishes the capacity of landscapes to store water. This reduces primary productivity, baseflow in streams and leads to loss of wildlife habitat, grazing and farming resources. Examples are given that show how restoring ecological processes, such as wetlands, is the most effective mechanism for increasing biodiversity.

11:50 Panel Discussion Moderated by Jeremy Sueltenfuss

10:50 – 12:10 AM **Ballroom B**

Technical Session 2: Case Studies

Moderated by Randy Mandel

10:50 Restoring populations of threatened *Physaria* species endemic to the Piceance Basin

Jayne Jonas

The unique habitats of two threatened mustards (*Physaria obcordata, Physaria congesta*), endemic to the Piceance Basin of Colorado, occur in an area of energy development. Although efforts have focused largely on protecting critical habitat, climate change and continued development pressures may require alternative strategies to ensure their long-term persistence. We initiated a field study to determine the best approach for establishing new populations of each species in suitable but unoccupied habitats within their native range. Three sites <600 m and three sites >600 m from natural populations were established for each species. We examined establishment of seeds planted in fall 2014 and success of greenhouse-grown seedlings planted either in fall 2014 or spring 2015. Through May 2018, establishment from seed has been limited to less than 5% in both species. After three years, survival of transplants of both species is generally higher for individuals planted in the spring than those planted in the fall. Some evidence indicates that distance to natural populations may affect *P. obcordata* establishment. Flowering was first noted in May 2016 for both species; by May 2018, up to ~80% of P. *congesta* survivors flowered. In May 2018, three *P. congesta* and one *P. obcordata* recruits were identified. Although continued monitoring is needed, our observations suggest that it may be possible to establish self-sustaining populations of these rare endemic species in suitable habitat.

11:10 Post-fire restoration of Wyoming big sagebrush within the Douglas Greater Sage-grouse Core Population Area.
Jana White

Natural recolonization and regeneration of Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*) within wildfire-impacted landscapes of eastern Wyoming can take decades or even centuries. For this reason, efforts to preserve and restore the eastern edge of the sagebrush ecosystem are integral to preventing further contraction of this ecosystem and the range of sagebrush-obligate species, such as the Greater Sage-grouse (*Centrocercus urophasianus*). In 2014, the Douglas Core Area (DCA) Restoration Team (Team) began targeting wildfire-impacted areas to investigate strategies for restoring sagebrush to post-wildfire areas within a Greater sage-grouse core population area in eastern Wyoming. Projects have consisted of outplanting 100,000+ greenhouse-grown sagebrush seedlings across 5000+ acres. Annual project monitoring results highlight the importance of using locally collected seed to grow sagebrush seedlings and directly confronting environmental challenges such as competition, soil moisture constraints, and herbivory in project design and implementation. We will present results on seedling survival, growth, and reproduction during the initial years following project implementation. In addition, we will describe ongoing research into the longer-term persistence of sagebrush seedlings after project infrastructure is removed and seedlings are exposed to ambient environmental conditions and land management practices.

11:30 Adoption of simple and effective ecological restoration techniques in a high-altitude floodplain impacted by hard rock mine waste.
Andrew Harley

Minnie Lynch Mine, an abandoned mine site at 10,300 feet, lies within the Bonanza Mining District, CO and contributes flow to Kerber Creek via an intermittent drainage. Environmental impacts include flow from two collapsed adits, heavy metals, unstable mine waste, distressed vegetation, and a geomorphically unstable channel. The work was divided into three phases. This case study focuses on 2016 restoration of the lower portion of the drainage. Over 1,000 cubic yards of mine waste was removed from the channel followed by consolidation and revegetation through amendment incorporation. Channel reconstruction through this section included installation of an EPDM liner to capture channel water while adit water was redirected through a limestone rock trench. Approximately 600 feet of channel below the adit was reshaped to the confluence with Rawley Gulch plus two acres of floodplain reclamation. Channel improvements included increasing sinuosity in the channel, and construction of limestone rip rap check dams and log vanes to manage flow and reduce channel erosion. Floodplain revegetation included lime and organic amendments ripped to maintain a rough and loose surface configuration to reduce surface velocities, trap spring runoff, and provide for a diversity of plant life and productivity. Graded streambanks were protected with biodegradable erosion mats along with large woody debris scattered throughout the site to enhance ecosystem diversity.

11:50 Landscape typology: a case study of data-driven conservation in an urban environment.
Allison Robinson

Understanding the relationship between natural ecosystems in urban environments, or urban ecology, has grown in importance as the world's cities rapidly expand and change. The City of Denver has experienced unprecedented population growth and at the same time, an increasing ambition to preserve native landscapes and enhance Denver's park system. To inform land management decisions, Denver Parks and Recreation (DPR) needed to develop a methodology to quantitatively assess ecosystem function within consistently defined urban ecotypes. The Landscape Typology process establishes spatially defined urban ecotypes found within each individual park and provides tabular data on multiple urban ecosystem parameters for each ecotype. Using this data, DPR is able to optimize urban conservation using adaptive management strategies and maximize efficiency when allocating restoration resources. Furthermore, the Landscape Typology program allows the user to quantitatively measure changes in ecosystem function over time, which provides insight into the success of individual restoration projects, as well as large-scale park design. The Landscape Typology results are formatted as a geodatabase that aims to maximize accessibility of information by decision-makers, parks employees, and the public. A demonstration dataset from DPR Open Space will be presented to show what data is collected and how it can be used to inform conservation and ecological restoration decisions in an urban environment.

12:10 – 1:20	Lunch	Ballroom CD
12:30 – 1:15	High Altitude Revegetation Committee Meeting	LSC 322
12:40 – 1:15	Student-Professional Mixer	LSC 386
12:40 – 1:15	Lory Student Center & CSU Sustainability Tour	Meet at Registration

1:20 **Keynote 3** Moderated by Brett Wolk Ballroom AB

Fire, Climate change and adapting restoration ecology to a changing world
Don Falk

Species have a variety of mechanisms for adapting to climatic variation over a range of time scales, but the current pace of climate change may exceed the adaptive capability of many species as currently distributed. Ecological disturbances, such as wildfires and insect outbreaks, operate at time scales many times faster than even the accelerated climate velocity of the current century. Disturbances are transient processes that can trigger significant and irreversible environmental, demographic and ecosystem change. These interactions of climate change and elevated levels of disturbance constitute the greatest challenge for restoration of terrestrial ecosystems now and many decades into the future. A consensus is emerging within the restoration field that a focus on ecological resilience, rather than strict interpretation of historical reference conditions, may best enhance the adaptive capacity of many ecosystems. Departures from historical references should be undertaken cautiously and incrementally, respecting the importance of ecological legacies, refugia, species interactions, and unexpressed genetic variation. We can decompose ecological responses to disturbance across a spectrum from persistence and recovery to system reorganization, and introduce a theorem of resilience relevant to the formidable challenges in a rapidly changing world.

2:00 – 3:00 PM **Ballroom A**

Keynote Session 3

Moderated by Brett Wolk

2:00 Policies to support forest and fire restoration efforts.
Courtney Schultz

Fire ecologists, policy makers, and managers recognize that we in the Western United States need to promote more fire on forestlands and undertake restoration efforts at more contiguous and larger spatial extents. How can we promote such efforts through policy tools? Research by the CSU Public Lands Policy Group has investigated this question over the last several years. In this talk, I will provide an overview of what we have learned about policy tools to support landscape restoration, and then turn specifically to our recent work on policy barriers and opportunities around the application of prescribed fire. After briefing covering findings from the first phase of our research, looking at trends across the West, I will turn to findings from a local case study—the San Juan National Forest. I will discuss findings from our interviews and document analysis about the factors that are allowing the forest to grow their prescribed fire program. This talk will conclude with some broader observations about policy tools and the role of multi-level governance strategies to support the restoration of fire-adapted forest ecosystems in the Western United States.

2:20 Understory vegetation changes in the decade following the Hayman Fire, Colorado.
Paula Fornwalt

At more than 52,000 ha, the 2002 Hayman Fire remains the largest wildfire known to burn in Colorado, USA. I synthesize results from a group of papers that used pre- and longer-term post-fire data to examine how understory vegetation composition changed in the 10 years after the Hayman Fire, and how changes related to fire severity. Understory composition exhibited longer-term resilience to pre-fire conditions following low-severity burning, despite experiencing some initial changes. Meanwhile, following high-severity burning, understory composition changed initially from pre-fire conditions and continued to move away from them as time passed. Both an initial loss of pre-fire species from the local community, and a continued recruitment of new species, drove compositional changes in areas experiencing high-severity fire. Species that were locally lost following high-severity burning tended to (1) have northern-temperate biogeographic affinities, (2) have long-lived (perennial) life spans, (3) be forbs, and (4) be native to the continental United States. Species that were locally recruited tended to (1) have southern-xeric biogeographic affinities, (2) have either short-lived or long-lived life spans, (3) be either graminoids or forbs, and (4) be either native or exotic to the continental United States.

2:40 Effects of seed source on drought performance and implications for native prairie restoration: a multi-species greenhouse drought experiment.
Katherine Fu

Local provenancing is the most widespread seed sourcing approach in ecological restoration because local seed populations are assumed to possess local adaptation to the environmental conditions of the restoration site. However, contemporary climate change can alter selective pressures such that local populations will no longer be best adapted. Therefore, seed sourcing from populations adapted to predicted future climatic conditions may result in greater restoration success, but these populations must be able to establish in current and future conditions for successful restoration. In Colorado and much of the Southwest US, drought frequency, duration, and severity are expected to increase. To understand how performance of wild-collected and cultivar plant populations in drought conditions relates to the climatic conditions of their collection sites, a greenhouse study with three watering frequencies (control, mild drought, and severe drought) was conducted on seven plant species commonly used in North American native prairie restoration. For each species, plant height, growth rate, and above-ground biomass was compared across 6 wild and 1-2 cultivar populations in the 3 watering treatments. This project informs guidelines for seed sourcing; ideal source populations perform well across all drought treatments, while for populations that do not differ in their performance, any of these populations may potentially be used to achieve reasonably similar restoration outcomes.

2:00 – 3:00 PM **Ballroom B**

Keynote Session 2

Moderated by Pete Stahl

2:00 Intraspecific trait variation of restoration grass seedlings at early developmental stages.
Magda Garbowski

In recent decades, models based on plant functional traits have been used to predict how plant communities will respond to abiotic and biotic perturbations. Species trait values from published literature or large databases that are most often obtained from mature plants are typically used to inform such models. These values may not be appropriate for understanding community processes of restored systems for two reasons: (1) trait values from different populations of the same species may vary and (2) trait values of mature plants may not reflect seedling traits that are important for establishment and survival. To address these concerns, we measured traits of grass species commonly used in arid land restoration (*Elymus trachycaulus*, *Hesperostipa comata*, *Muhlenbergia porteri*, *Vulpia octoflora*) from several populations at different ontogenetic stages and compared them to trait values from the TRY Plant Trait Database or values published in the literature. We found that mean trait values as well as population-level trait variability differed by population, trait measured, and ontogenetic stage. A better understanding of variation in grass seedling traits may inform restoration seed source selection as well as improve the use of models for predicting restoration outcomes.

2:20 Seed ecology of restoration-relevant forb species: phylogeny and climate influence inter- and intraspecific variation in germination.
Alexandra Seglias
Seed dormancy and germination traits can be constrained by phylogenetic history, which can lead to the assumption that related species have similar traits. However, significant intraspecific variation in these traits is also present due to adaptation to local climatic conditions. Understanding sources of both species- and population-level variability can be useful when planning for restoration projects to ensure that seed is sourced from the most appropriate site. We examined the relationships between phylogeny, climate, and seed germination traits for 24 populations of eight native, restoration-relevant forb species from the Southwest United States. The seeds were exposed to eight treatments designed to mimic regional climatic conditions. Phylogenetic relatedness, climatic conditions, and temperature conditions at the source site were all significantly correlated with final germination response, with significant intraspecific variation in germination response for seven of our eight study species. Notably, when analyzing germination during stratification, precipitation seasonality was found to be the only significant predictor of variation in germination, and all eight species showed significant intraspecific variation. Our results suggest that this trait should be considered in germination studies as well as seed sourcing decisions.

2:40 Expanded genetic variation in prairie sunflower inter-population crosses for potential native plant restoration in variable environments.
April Goebl
Restoring native plant communities in degraded habitat is particularly challenging when environmental conditions are highly variable. Revegetation of sites with unpredictable conditions must consider both successful establishment in current conditions & persistence under varying future environments, making selection of source materials non-trivial. Starting with high genetic variation can serve to genetically bet-hedge when variation in inter-annual conditions is high. To investigate the effects of increased genetic variation, we compare performance of inter- & intra-population crosses of *Helianthus petiolaris*. *H. petiolaris* is an annual, native sunflower that typically inhabits prairies & has been proposed for restoration of degraded land on the Colorado Plateau. This species presents a good system to investigate: Does increased genetic variation in inter-population crosses improve average fitness across a range of conditions? To address this question, we crossed 4 *H. petiolaris* ecotypes from locations with varying climates for 2 generations. We planted & tracked a total of 3200 seeds from inter- & intra-population crosses in cleared plots at 2 common garden sites with replicated water treatments. Throughout the annual life cycle we measured fitness components for all plants. I will present data from this experiment to help inform on the importance of genetic variation in the context of restoration in variable environments.

2:50 – 3:20 Break 2:50 – 3:10

3:20 – 4:40 PM **Ballroom A**

Technical Session 5: Invasive species

Moderated by Becky Hufft

3:20 Native annual and biennial species can compete with an aggressive invasive grass.
Carla DeMasters
Bromus tectorum L. (cheatgrass) is the most widespread and problematic annual brome grass in the western United States, dominating more than 40 million hectares of rangeland in the Intermountain West. Areas of *B. tectorum* dominance are extremely difficult to restore via seeding with traditional seed mixes consisting of perennial grasses and forbs. Introduced annual species like *B. tectorum* are better able to germinate early, grow rapidly and allocate resources to aboveground biomass compared to late seral species like perennial grasses and forbs. The theory of limiting similarity postulates that functionally similar native species, those species that rely on the same set of ecological resources, may compete more strongly for resources with non-native annual invasive species than perennials. We tested the ability of native annual and biennial forb species to persist in competition with cheatgrass. Seedling establishment rates show that some of these native annual and biennial species proved themselves capable of coexisting within stands of *B. tectorum* and may be good candidates for inclusion in restoration seed mixes. The results of this experiment will help to inform *B. tectorum* management and current restoration practices.

3:40 Pothole seeding for cheatgrass control in early restoration.
Danielle Johnston
Restoration efforts in arid western ecosystems is often hampered by cheatgrass (*Bromus tectorum* L.). In prior research, we found that soil surface obstructions reduce the dispersal of cheatgrass seeds, and that a roughened, or 'potholed' surface can reduce cheatgrass biomass during early restoration. Here, we explicitly test the impact of a potholed surface on cheatgrass seed dispersal, and report on the development of a new implement to create the pothole surface. Using fluorescently marked cheatgrass seeds, we found that a potholed surface reduces cheatgrass dispersal 2- to 3- fold as compared with a flat surface. The magnitude of potholing's effect far exceeded that of brush mulch, which reduced dispersal by only 20%, and only when combined with potholing. We manufactured a third prototype tool to create the pothole surface efficiently. This tool combines the three seed boxes of a Truax™ Flex II ® rangeland drill with large notched discs, and is capable of creating the pothole surface and seeding in a single pass. We treated 10 ha with the new tool in August 2018 at Escalante State Wildlife Area near Delta, CO. Good germination of seeded species was evident within potholes by November 2018.

4:00 Fungus to the rescue: Canada thistle biocontrol.
John Kaltenbach

A statewide release and monitoring program conducted by the Colorado Department of Agriculture has shown that a highly host-specific rust fungus, *Puccinia punctiformis*, can control Canada thistle. The fungus has been found in North America for well over a century and it is well documented that it can kill Canada thistle. The main barrier to using it as an effective biological control agent is the difficulty in getting it established in a thistle patch. The Colorado Department of Agriculture has now developed effective protocols for establishing the fungus and the next steps will be to refine methods for using the fungus for Canada thistle control, develop management practices to enhance the activity of the fungus and teach end users how best to use the fungus in restoration, conservation and production situations. A description of the rust life cycle and dynamics in a patch of Canada thistle is discussed, as well as methods for detection, monitoring, collection and redistribution. Results of monitoring are presented and future plans for the utilization of this "new" agent will be shared.

4:20 Pile burn scar restoration at Lily Lake: tradeoffs between abundance of non-native and native species.
Ian Sexton

Accumulation of fuels in forests across the Western United States is producing larger, more severe wildfires. To decrease wildfire severity and increase forest resilience, foresters remove excess fuel by burning woody material in piles. This can also cause persistent ecosystem changes that include alteration of soil properties, due to soil heating, which can favor invasive species. Native plant abundance and species richness may remain depressed for years after burning has removed vegetation and diminished propagules. This adds to the vulnerability of burned areas, which can transition to invasive plant dominance. Research on the use of revegetation in forests to suppress invasion is limited. Studies conducted in woodlands that investigated revegetation of pile burn scars have had varying success. To assess pile burn scar restoration in Rocky Mountain National Park, we monitored vegetation in 26 scars in 2014. Later that growing season we selected 14 scars for restoration that included soil scarification, seed addition, and mulch cover. Following restoration, seeded species cover exceeded surrounding unburned areas. This suppressed cover of non-native species and native species that were not seeded in 2014. It also suppressed the growth of a native forb that was planted three years after restoration. We conclude that restoration of scars can be a useful tool that will likely need to be part of an integrated pest management program addressing other infestations near scars.

3:20 – 4:40 PM **Ballroom B**

Technical Session 3: Forest Restoration

Moderated by Magda Grabowski

3:20 Collaborative forest restoration and fire-risk reduction on Colorado's wildland-urban interface: scaling up through interagency cooperation.
Andrew Rayburn

The Colorado Front Range wildlife-urban interface (WUI) is a dynamic managed landscape undergoing rapid changes due population growth, increasing development, wildfire and other disturbances, recreation pressure, expansion of water supplies for large municipal areas, climate change, and land conservation efforts by organizations such as Jefferson County Open Space (JCOS). In Jefferson County, JCOS manages ca. 45,000 ac. Of land spanning 29 open space parks, many of which lie within forested portions of the WUI that are densely populated and at high or extremely high risk of catastrophic wildfire. With the dual goals of restoring forest habitat and reducing wildfire risk, JCOS implements large-scale forest management projects in collaboration with local, state, and national partners to capitalize on funding opportunities and to achieve broader impacts. At Flying J Ranch Park, JCOS is collaborating with Denver Mountain Parks, the Colorado State Forest Service, the Colorado Forest Restoration Institute, contractors, youth groups, and volunteers on a multi-year project to restore ponderosa pine savanna and mixed conifer stands while reducing wildfire risk within the park and creating a landscape-scale fuel break to protect surrounding communities. We will provide a project overview, focusing on the benefits of interagency collaboration at various stages, and describe how this project is serving as a model for JCOS in other forested areas of the park system at risk from wildfire.

3:40 Colorado & New Mexico disasters: utilizing NASA Earth Observations to quantify forest mortality and burn severity to inform management on ranches and open lands.
Sophia Leiker

Both wildfires and forest insect outbreaks have increased in frequency and severity in recent years. Western spruce budworm (*Choristoneura freemani*), a widespread defoliator in western U.S. forests, has affected over 6,000 hectares of forest in south-central Colorado since 1998. Aaron Swallow, an environmental ranch manager in southern Colorado, is concerned that fuel loading from budworm-related tree mortality will increase the risk of catastrophic wildfire on the lands he manages. To address this concern, we selected a study area encompassing the 2018 Spring Creek Fire footprint. Then, we used NASA Earth observations to: 1) analyze and map regional tree mortality prior to the 2018 Spring Creek Fire; 2) quantify and map burn severity for the Spring Creek Fire; and 3) model the relationship between pre-fire tree mortality and burn severity of the fire. We identified key predictor variables with the Variable Selection Using Random Forests (VSURF) R package and modeled pre-fire tree mortality using the randomForest R package. Burn severity was mapped using the Relativized Burn Ratio (RBR). The maps created from this project provided our partners with a comprehensive assessment of tree mortality, facilitating future restoration and management efforts. Additionally, an accompanying methods tutorial will enable our partners to replicate this analysis for other years, locations, and forest disturbances.

4:00 Effects of collaborative restoration and adaptive management on forest structure and composition in the Colorado Front Range.

Kevin Barrett

In response to large, severe wildfires across the western US, federal initiatives have been enacted to increase the pace, scale, and quality of ecological restoration in frequent fire forests. The Collaborative Forest Landscape Restoration Program (CFLRP) supports landscape-scale restoration while emphasizing collaborative and adaptive approaches to forest management. The Colorado Front Range Landscape Restoration Initiative (LRI) was selected as a CFLRP grant recipient in 2010 with the goal of treating 13000 ha of ponderosa pine-dominated forests over a 10-year period across the Pike and San Isabel and the Arapaho and Roosevelt National Forests. Here, we assess stand level desired conditions across 14 projects and a 6-year evaluation period to determine to what extent restoration treatments contribute to desired conditions, and assess whether adaptive management processes contribute to reaching restoration goals regarding forest structure and composition. Results indicate that restoration treatments are moving forests toward desired conditions regarding residual forest structure, however further reductions in the relative abundance of Douglas-fir may be warranted. Adaptive management processes appear to be effective, as more recent projects better match desired conditions compared older projects, including further reductions in Douglas-fir to meet forest composition objectives.

4:20 Modeling the effects of heterogeneous restoration treatments on understory light environment in a mixed-conifer forest.

Jeffery Cannon

Restoration treatments in dry conifer forests often seek to restore the heterogeneous forest structure that historically characterized these stands. Thus, it is crucial to understand how changes in forest spatial structure alter abiotic conditions to improve predictions of how spatially variable treatments impact regeneration response to changes in resource availability. We used hemispherical canopy photography in a stem mapped mixed-conifer forest to model light availability across a forest density gradient using a model selection approach. Using the stem map, we simulated a range of restoration treatment scenarios varying in spatial complexity and applied the model to evaluate how each treatment impacted light availability. We found that light availability was best predicted by forest structure at multiple scales roughly corresponding to crown diameter and vegetation height. Additionally, we found that simulated restoration treatments with the highest aggregation led to 7% higher net light availability relative to random thinning and had the most variability in light availability. Further, spatially aggregated treatments resulted in the most area with high light availability and the least area with low light availability. Thus, we expect that spatially complex restoration treatments may favor light environments conducive to shade-intolerant species such as ponderosa pine over Douglas-fir while maintaining high overstory spatial heterogeneity.

4:40 PM Closing remarks/Awards Randy Mandel Ballroom AB

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