HIGH ALTITUDE REVEGETATION COMMITTEE & SOCIETY FOR ECOLOGICAL RESTORATION-ROCKY MOUNTAINS CHAPTER

2022 CONFERENCE

APRIL 12-14, 2022

FORT COLLINS, CO

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Keynote Speakers 2022

James Rattling Leaf Sr.

Building relational and effective partnerships with Indigenous Communities
Wednesday, April 13th, 2022
8:30 am, Room A&B

TREES, WATER & PEOPLE
Helping people and the planet

John Bradford

Climate change, ecological drought, and revegetation challenges in western drylands
Wednesday, April 13th, 2022
3:20 pm, Room A&B

HAR SER-RM Conference

Elise Gornish

Making restoration better (Nothing in this presentation is true but it's exactly how things are)
Wednesday, April 13th, 2022
3:20 pm, Room A&B

FOREST AND RANGELAND STEWARDSHIP
COLORADO STATE UNIVERSITY

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Schedule
Wednesday, April 13th

	Time	Room A&B *Working with Tribes for Successful Restoration on Indigenous lands* **Moderated by Arielle Quintana**
Early Morning	8:15am	**Opening remarks** - Jeremy Sueltenfuss
	8:20am	**Keynote Introduction** – James Calabaza
	8:30am	**KEYNOTE: James Rattling Leaf, Sr. #K1** Building relational and effective partnerships with Indigenous Communities
	9:00am	**Cynthia Naha #O1** Building capacity for Tribal restoration of reservation lands
	9:20am	**Henry Red Cloud #O2** Forest restoration on Pine Ridge Reservation
	9:40am	**James Calabaza #O3** Restoration on Ute Mountain Tribal lands
	10:00am	**Panel Discussion**
BREAK (10:20am - 10:50am)		

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	Time	Room A *Seed Mixes* Moderated by Danielle Neumann	Room B *Tools, Techniques, and Organizations* Moderate by Caroline Havrilla
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	11:05am	**Bryce Richardson #O5** Bet-hedging and proactive strategies to create climate-smart seed mixes	
	11:10am		**Drew Rayburn #O10** SER's CERP Program: Is Restoration Practitioner Certification Right for You?
	11:20am	**Rob Massatti #O6** Knowing your seeds: the importance of within-species variability for promoting restoration success	
	11:30am		**Jesse Dillon #O11** Table Top Conservation Bank – Providing Habitat Uplift for Preble's Meadow Jumping Mouse
	11:35am	**Tara Tafi #O7** Colorado Division of Reclamation, Mining and Safety seed mix map	
	11:50pm	**Rob Cook #O8** Seed-Spec: A native seed blend development tool	**Jeff Ravage #O12** The fungal degradation of the woody by-products of forest management activities
LUNCH: (12:10pm – 1:30pm) SER-RM Annual Chapter Meeting: Ballroom A			

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Schedule
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	Time	Room A *Post-fire Assessment and Recovery* Moderated by Mark Paschke	Room B *Native Plant Materials* Moderated by Rebecca Hufft
Early Afternoon	1:30pm	Laura Marshall **#O13** Climate and topographic drivers of post-fire planting success	Maggie Gaddis **#O17** The Colorado Native Plant Society: Applied approaches for native plant conservation
	1:50pm	Shayna Jones **#O14** Cameron Peak fire restoration: Techniques and collaboration for fire recovery	Jayne Jonas **#O18** Methods for translocating two threatened Physaria species endemic to the Piceance Basin
	2:10pm	Chris Sturm **#O15** Wildfire ready watersheds	Anthony Massaro **#O19** Starting small: growing a native plant materials program at Jefferson County Open Space
	2:30pm	Blake Osborn **#O16** WAVE: A novel, post-wildfire rapid watershed assessment program	Jesse Dillon **#O20** Effects of the timing of precipitation on revegetation growth and vigor
BREAK 2: (2:50pm – 3:20pm)			

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Schedule
Wednesday, April 13th

	Time	Room A&B *Climate Change* **Moderated by Drew Rayburn**
BREAK 2: 2:50 pm – 3:20 pm		
Late Afternoon	3:20pm	**KEYNOTE: John Bradford #K2** Climate change, ecological drought, and revegetation challenges in western drylands
	3:50pm	**Drew Rayburn #O21** The resilient and connected network: Informing landscape-scale, climate-resilient restoration in Colorado
	4:10pm	**Tipton Hudson #O22** Building resilience to climate change through ecological resiliency on grazed rangelands
	4:30pm	**Jennie DeMarco #O23** Evaluating the carbon sequestration potential and drought resilience with wet meadow restoration under a changing climate
	5:00pm-7:30pm	**Poster Social**

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James Rattling Leaf Sr.
Keynote 1 Wednesday, April, 13th

Building relational and effective partnerships with Indigenous Communities

Coordinator, Climate Partnerships for the Great Plains Tribal Water Alliance and Principal, Rattling Leaf Consulting LLC, Black Hawk, South Dakota

Wednesday April 13th, 2022
8:30 am, Room A&B

The presentation will outline recommendations for working with Indigenous communities based on the knowledge that long-term relationship building with these communities is the foundation upon which educational programs, research collaborations, and other initiatives must be co-created. This presentation will define best practices in building relationships and clarify a process for establishing and maintaining effective collaborations with Indigenous communities that respect sovereignty and self-determination.

James Rattling Leaf, Sr. is coordinator of Climate Partnerships for the Great Plains Tribal Water Alliance and Principal, Rattling Leaf Consulting LLC. A member of South Dakota's Rosebud Sioux tribe, James has served as a Visiting Collaborator, South Dakota School of Mines and Technology; Director, Geo-Spatial Applications Center, Sinte Gleska University; Board Member, Education Committee, American Geophysical Union (AGU); Fellow, International Indigenous Resource Management Institute, Denver; Cultural Advisory Board Member, Deep Underground Science and Engineering Lab; Board of Directors, South Dakota National Science Foundation EpSCOR; Member, NASA Space Grant Consortium EpSCOR Technical Advisory Committee; and Cultural Advisor, NOAA National Integrated Drought Information Systems (NIDIS). James received his B.A. in Lakota Studies from Sinte Gleska University (Rosebud Reservation, Mission, South Dakota).

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Abstracts

Wednesday, April 13th

Working with Tribes for successful restoration (Room A&B)

Cynthia Naha - *Hopi* — 9:00 am
Building capacity for Tribal restoration of reservation lands — Room A&B

Over the past 4 years, I've had the opportunity to work with and for the Santo Domingo Pueblo as the Director of the Natural Resources Department, which is a 100% federally funded. I've been able to build capacity for forestry related work and to assist in bring opportunities of restoration to the Pueblo, and it's forest lands. Through federally funding from the Bureau of Indian Affairs, the Pueblo and it's NRD Crew have been able to utilize dollars to conduct assessments of timberlands and woodland areas to determine the appropriate specifications to use in removal of dead and diseased trees, understanding the importance of species types, especially those culturally significant, and ensure they were helping the forest in her efforts to restore itself from the impacts of climate change, this includes the opportunity to leverage and work with other organizations to establish projects for restoration. As a director working in the Tribal Natural Resources field, building partnerships, and working relationships are integral to the work that we do. With federal dollars being limited and the ability to leverage a challenge, establishing these partnerships help increase the Pueblo's ability to enable additional projects that are aimed at restoration and regeneration to ensure that we are being reciprocal to Mother Earth's needs and not just being over-consuming of her resources.

Henry Red Cloud - *Oglala Sioux Tribe/Red Cloud Renewable* — 9:20 am
Forest Restoration on Pine Ridge Reservation — Room A&B

The Pine Ridge Indian Reservation encompasses over 2.1 million acres of prairie, forest and wetland ecosystems that the Oglala Lakota have been stewarding for generations. My presentation will cover the importance of how the Oglala Lakota people are working together through reforestation efforts to combat climate change and preserve our watersheds and ecosystems for future generations. I will highlight how tree planting on the reservation has been a successful way to strengthen community awareness and engagement around land management and protection of our cultural lifeways. Lastly, I will briefly discuss the importance of collaboration with Tribes by creating healthy, reciprocal relationships that serve the best interest of the Tribe and local peoples.

Abstracts

Wednesday, April 13th

Working with Tribes for successful restoration (Room A&B)

James Calabaza - *Ute Mountain Ute Tribe*
Hannah Ertl, Farley Sr. Ketchum, Dorsey Dick
Restoration on Ute Mountain Tribal lands

9:40 am
Room A&B

Conservation on Tribal lands is historically undervalued by the broader community and inherently underfunded. This situation has created severely degraded natural areas important to Tribal communities for subsistence, livelihood, culture, and sovereignty. When restoring Tribal lands, it is important to take all of these values into consideration – not just the ecological importance of restoration. In this way, we are restoring important habitats with Indigenous communities in mind as part of the landscape – harmonizing with the "land ethic" that Aldo Leopold famously characterized in 1949, and a sentiment that Indigenous people have known well for millennia. A willingness to work cross-culturally and build a foundation of trust with Tribal communities is vital to working on Indigenous lands – this may mean stretching beyond your normal comfort zone in planning, design, or implementation of your restoration project. We share an example from Ute Mountain Ute Tribal lands where riparian areas have been restored with wildlife habitat, tribal livelihoods, traditional harvest, and water sovereignty in mind.

Abstracts

Wednesday, April 13th

Seed Mixes (Room A)

Elise Gornish - *University of Arizona*
Creating a restoration species palette
10:50 am
Room A

Creating a species palette for a restoration project is one of the most daunting tasks of the management process. I have developed a free online tool that allows users to create candidate species lists for restoration projects based on user-entered habitat information and management priorities. In this talk, I will walk the audience through the tool for use and also describe how the tool was made.

Bryce Richardson - *USDA Forest Service, Rocky Mountain Research Station*
Bet-hedging and proactive strategies to create climate-smart seed mixes
11:05 am
Room A

Climate change is destabilizing plant adaptation to local environments, and this trend is expected to increase by mid-century. Proactive restoration is needed to maintain plant adaptation and ecosystem function. Proactive restoration strategies may include: seed banking at risk populations, transferring seed from warmer to cooler climates (i.e., assisted gene flow), and strategically mixing seed sources. These restoration strategies can help maintain adaptation to the appropriate environment and genetic diversity, which in turn increases the restoration success and long-term resilience. We demonstrate how the Climate Smart Restoration Tool (CSRT) can be used to formulate these strategies with big sagebrush (*Artemisia tridentata*) and other species. The CSRT is a web tool that can use three techniques to map seed transfer limits, depending on the information available on the species of interest. These techniques include: climate-based provisional seed zones, trait functions, the relationship between trait variation and the environment and species distribution models. We will explore examples of how the CSRT can be applied to inform proactive restoration.

Abstracts
Wednesday, April 13th
Seed Mixes (Room A)

Rob Massatti - *U.S. Geological Survey*
Daniel Winkler, Ella Samuel, Rachel Mitchell, Sarah Sterner
Knowing your seeds: the importance of within-species variability for promoting restoration success

11:20 am
Room A

Restoration is an inherently difficult task as a result of weather conditions, variability of site characteristics, and invasive species, to name a few. Restoration complexities are further compounded by having to choose native plant materials for a site, including from the pool available within a species as well as from what is available among species. Typical guidance suggests that native plant materials should be “genetically appropriate” for restoration sites, which most often means that they are locally adapted to similar environmental conditions. However, other types of intraspecific variability, such as the relative magnitude of trait variation represented within a seed source, may also influence the degree to which restoration is successful. First, we will discuss patterns of intraspecific variability that have been uncovered within restoration species and how they may influence restoration success. We will then illustrate how this knowledge may be used when choosing plant materials for restoration projects and developing new materials to meet future restoration demands. By illuminating a few components of the plant materials selection and development processes, our goal is to inform decision-making and thereby increase the probability that practitioners’ efforts are successful.

Tara Tafi - *Colorado Division of Reclamation, Mining, and Safety*
Andy Herb
Colorado Division of Reclamation, Mining and Safety seed mix map

11:35 am
Room A

The Colorado Division of Reclamation, Mining, and Safety Inactive Mine Reclamation Program has been doing revegetation in the state of CO for over 30 years. In 2014, DRMS contracted with Alpine Eco to evaluate our existing seed mixes and develop new, native seed mixes for use on reclamation projects. Six mixes were developed for use statewide, based on Colorado land type and elevation. Alpine Eco also developed a clickable map tool, which DRMS project managers can easily use to identify which mix to use on their projects based on latitude/ longitude. DRMS does more than 30 reclamation projects per year. Having an easy to use tool for determining which standard mix to use is essential for assisting project managers complete their reclamation projects.

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Abstracts
Wednesday, April 13th
Seed Mixes (Room A)

Rob Cook - *Bamert Seed Company*
George Peacock
Seed-spec: A Native Seed Blend Development Tool

11:50 am
Room A

Establishing native vegetation in any reclamation project can be a challenging task. The species and varieties that match the site must be identified and used to help ensure adequate establishment and persistence. Data exists to help project managers identify what species are native to a given area and commercially available but can be cumbersome and time consuming. Bamert Seed Company has worked with Colorado State University to develop a web application to easily identify a project area of interest (AOI) and provide information on native species composition for the AOI. The tool will provide a list of commercially available species that correspond to the plants that grow natively in the AOI and intuitively walk the user through developing a site-specific native seed blend. Users will have the ability to adjust the seeding rate based on their establishment objectives and seeding method they will be using. Having this tool will allow the reclamation specialist a timely way to determine the best blend for their AOI and get the seed blend to a vendor/seed dealer with knowledge that the species selected will work for their specific site. Rob will discuss and present version 1 of the tool and ask attends to provide input on what other functionality/data would be useful on their operations for version 2.

Abstracts

Wednesday, April 13th

Tools, Techniques and Organization (Room B)

Alexandra Seglias - *Denver Botanic Gardens* 10:50 am
Can alpine species "bank" on conservation? Room B

Plant biodiversity is being lost at an accelerated rate. To conserve native plants, many institutions are turning towards ex situ conservation methods, such as storage in seed banks. However, not all seeds are able to survive in seed bank conditions or they may be short-lived. Alpine species in Italy and Australia have been shown to lose viability at a quicker rate in seed banks compared to low-elevation species. To understand if alpine species from the Rocky Mountains of Colorado exhibit this same pattern, I used accelerated ageing experiments to simulate storage in a seed bank and expedite loss of viability. Ten samples of 50 seeds for four species (*Castilleja puberula, Heterotheca pumila, Physaria alpina*, and *Saussurea weberi*) were rehydrated in a dark incubator for two weeks. Following rehydration, the seeds were placed in a drying oven to age the seeds at various intervals of time. Following the ageing process, the seeds were placed into previously determined germination conditions. All species had P50 (time to 50% germination) values of <13.7 days, which is the threshold to consider a species short-lived in seed banks. These results suggest that we can't haphazardly store seeds and assume that all species will survive for decades in seed banks. Rather, we need to assess what environmental and evolutionary conditions might preclude a species from being long-lived in storage and determine measures to mitigate loss of viability over time.

Drew Rayburn - *The Nature Conservancy in Colorado* 11:10 am
SER's CERP Program: Is Restoration Practitioner Certificate Right for you? Room B

Founded in 2017, SER's Certified Ecological Restoration Practitioner (CERP) program is the only international certification program for ecological restoration practitioners, offering both early-career and senior-level credentials to established practitioners (CERP) and practitioners-in-training (CERPIT). Through certification, the CERP program encourages a high professional standard for those who design, implement, oversee, and monitor ecological restoration projects throughout the world. Certification guarantees that practitioners meet a set of minimum requirements for restoration and ecological knowledge, on-the-ground practical experience, and an understanding of SER's restoration principles and standards. To date, the program has certified a diverse group of over 600 individuals from a range of professional backgrounds and disciplines, including those who work as ecologists, biologists, conservation managers, landscape architects, environmental scientists, and academic researchers. The program is also geographically diverse, with practitioners from 16 countries across five continents operating in a wide variety of ecosystems. As a certified restoration practitioner and member of the CERP Certification Committee since 2017, I will provide an overview of the certification process, as well as share my experiences with the program and perspectives on the value of certification as an applied ecologist, program supervisor, and hiring manager.

Abstracts

Wednesday, April 13th

Tools, Techniques and Organization (Room B)

Jesse Dillon - *Cedar Creek Associates, Inc.*
Tom McIntyre, Ben Guillon, Tim DeGraff
Table Top Conservation Bank – Providing Habitat Uplift for Preble's Meadow Jumping Mouse

11:30 am
Room B

Preble's meadow jumping mouse (PMJM) is a threatened species along the front range of Colorado and Wyoming, whose habitat has shrunk as development, livestock grazing, and mining have expanded. The Table Top Conservation Bank aims to protect and preserve PMJM by enhancing and preserving about 200 acres of the mouse's habitat in Larimer County, Colorado. The conservation bank is situated on important property for habitat connectivity where populations of the mouse are known to occur. The baseline habitat assessment determined that a variety of riparian and upland vegetation communities within the conservation bank provide a mosaic of PMJM habitat functions at lower quality than their optimal state. Therefore, the Table Top Conservation Company, under the purview of the US Fish and Wildlife Service, will implement innovative approaches and land management techniques to restore habitat parameters and function that may be needed to improve habitat to near 100% optimal rating for the PMJM. Management strategies include mixed cattle exclusion and regenerative grazing, potential riparian plantings, installation of PMJM cover structures, and invasive / noxious weed management. Monitoring and adaptive management in perpetuity provided by the bank's fully funded endowment will provide the framework and feedback to ensure the goals of the conservation bank are met.

Jeff Ravage - *Coalition for the Upper South Platte*
Lauren Czaplicki
The fungal degradation of the woody by-products of forest management

11:50 am
Room B

Native, wood-rotting mushrooms were used to accelerate the decay of forest by-products on a remote logging site. The mushrooms were locally collected and conditioned in vitro to recognize wood chips as nourishment. The mushrooms were inoculated into wood chip beds and monitored for five seasons. The mushrooms consumed the wild material, and by the end of the investigation, had converted ~84% of the wood chips into a compost-like material. The control plots lost ~30% of their mass during the same period with no conversion to compost and little loss of structure or resilience. A mild increase in nutrients was detectable in the post-fungal decay product, as was a higher C:N ratio than encountered in natural forest compost (duff). The plausibility of using native wood-rotting mushrooms to decompose logging waste is demonstrated, with reliable starting points for further investigation.

Abstracts

Wednesday, April 13th

Post-fire assessment and Recovery (Room A)

Laura Marshall - *Colorado State University*
Paula Fornwalt, Camille Stevens-Rumann
Climate and topographic drivers of post-fire planting success
1:30 pm
Room A

Across the western US, millions of acres have burned in recent years, with numerous patches burning at high severity due to extreme fire weather combined with fuel buildup from fire suppression, in what has historically been frequent low-severity fire regime forests. As a result, large areas of National Forest land have been left treeless and without the conifer seed source needed for recovery of wind-dispersed species like ponderosa pine (*Pinus ponderosa Douglas ex C. Lawson*). Extensive planting has been undertaken in severely burned areas to maintain forest stocking and enable resilience. Along with extreme fire, drought and climate change limit forest recovery in both natural regeneration and planted areas, by decreasing suitable conditions for establishment. To avoid loss of forested area, it is important to identify common factors leading to success in plantings. Without successful plantings, fire-driven conversion from forest to nonforest in severely burned montane forest is likely. We have compiled post-fire planting records from Colorado, New Mexico, and Arizona and joined them with spatially derived climate and topographic factors to model seedling survival regionally. We will discuss model development and initial findings, in support of improving seedling survival in future plantings and thus forest resilience.

Shayna Jones - *Coalition for the Poudre River Watershed*
Daniel Bowker
Cameron Peak fire restoration: Techniques and collaboration for fire recovery
1:50 pm
Room A

At over 208,000 acres, the 2020 Cameron Peak Fire is the largest wildfire in Colorado history. The fire burned areas of the Cache la Poudre River, Big Thompson River, and Laramie River watersheds. Over 80% of the burned area is on U.S. Forest Service land, with about two-thirds of the fire area falling within the Poudre River watershed. Thirty-six percent of the burn area was classified as high to moderate severity burn according to the Burned Area Emergency Response (BAER) report. The Coalition for the Poudre River Watershed (CPRW) is leading long-term recovery and restoration from the fire, in partnership with multiple agencies and groups. CPRW will briefly summarize the various risk assessments used to prioritize areas for post-fire treatments. The bulk of this presentation will provide details of the multiple techniques being used in the restoration and recovery program, including aerial mulching and point mitigation techniques intended to catch debris, reduce flow velocities, encourage deposition and sediment storage, and promote the establishment of vegetation. We will close with an overview of CPRW's efforts, in collaboration with several local nonprofits and agencies, to prioritize, scope, fund, and implement reforestation on private properties burned in both the High Park Fire (2012) and the Cameron Peak Fire. CPRW welcomes feedback from conference participants on the treatments and techniques being used, as post-fire restoration work will continue in 2022 and beyond.

Abstracts

Wednesday, April 13th

Post-fire assessment and Recovery (Room A)

Chris Sturm - *Colorado Water Conservation Board* 2:10 pm
Wildfire Ready Watersheds Room A

Wildfire Ready Watersheds (WRW) is a strategy and program developed by the Colorado Water Conservation Board that provides a proactive approach to address post wildfire impacts. The mission is to assess the susceptibility of Colorado's water resources, communities, and critical infrastructure to post-wildfire impacts and advance a framework for communities to plan and implement mitigation strategies to minimize these impacts – before wildfires occur. WRW has a two-part focus: (1) a statewide post-fire susceptibility analysis and (2) a framework that communities can use to perform watershed scale planning to address post fire hazards. The susceptibility analysis intersects post fire hazards with known values at risk to determine impacts to life & safety, water supplies, infrastructure, and property. The framework will serve as a guide for best planning practices in advance of a wildfire and will also support post-fire mitigation strategies. Mitigation projects constructed before fire improve watershed resiliency by addressing multiple objectives in watershed health and water supply protection. These project types are designed to protect and enhance ecosystems. Most implementation strategies will involve a mosaic of different project types employed within a watershed.

Blake Osborn - *Colorado Water Center at Colorado State University* 2:30 pm
WAVE: A novel, post-wildfire rapid watershed assessment program Room A

It is well understood that wildfire season in the western United States is lengthening, and fires are increasing in size and frequency. Many local, state, and federal agencies struggle to address the scale and magnitude of pre-fire mitigation and post-fire restoration. Few programs exist to provide multi-jurisdictional post-wildfire technical assistance, and even fewer programs address post-fire recovery at multiple spatial and temporal scales. Funding and technical assistance is often a fraction of the total needed to mitigate post-fire flooding, erosion, and ecological restoration. It is imperative that post-fire technical teams conduct robust assessments to ensure all technical and financial resources are used to maximum benefit. The Watershed Assessment and Vulnerability Evaluations (WAVE) program was developed to help fill a gap in post-fire technical assistance, specifically for private landowners and local agencies. The WAVE program uses a unique assessment protocol administered by trained WAVE ambassadors throughout Colorado. This program works with other major state and federal programs and agencies like the Colorado Water Conservation Board and the Natural Resources Conservation Services but offers flexibility and assistance through a customizable assessment format. Practitioners, particularly government agencies and non-profit watershed groups, provide strong support for the WAVE program as we have built the trust of both private landowners and technical agencies.

Abstracts

Wednesday, April 13th

Native Plant Materials (Room B)

Maggie Gaddis - *Colorado Native Plant Society*
The Colorado Native Plant Society: Applied approaches for native plant conservation
1:30 pm
Room B

The Colorado Native Plant Society (CoNPS) is a statewide non-profit organization dedicated to furthering the knowledge, appreciation and conservation of native plants and habitats of Colorado through education, stewardship and advocacy. CoNPS exhibited resilience in COVID times by expanding our offerings through virtual engagements. These proved to be more inclusive, reaching record numbers for participation. Our traditional programming includes botany walks, special speaker events, native plant sales, native plant garden tours, and education engagements including our annual conference. We also publish Aquilegia, the magazine of the Colorado Native Plant Society.

In this session, we will present our programming with an eye towards engaging students in our civic activities, social and educational gatherings, legislative work, and research initiatives. We have opportunities for native plant restoration and research engagements. Native plant gardening is a huge topic in our modern world, especially as we seek to conserve and protect our native pollinators and habitats in this changing climate. We will present our program expansions for 2022 and beyond, including increased native plant gardening education, K-12 standards-based curricula, ecological restoration, and Aquilegia publication. We hope this session will inspire more student engagement.

Jayne Jonas - *University of Nebraska – Kearney*
Mark Paschke
Methods for translocating two threatened Physaria species endemic to the Piceance Basin
1:50 pm
Room B

Unique habitats of *Physaria obcordata* and *P. congesta*, threatened species endemic to Colorado's Piceance Basin, are situated in areas of intense energy development. While most conservation efforts focus on protecting critical habitat, we initiated a field study to examine approaches for establishing new populations in suitable but unoccupied habitats. Six sites were identified for each species; 3 near (<600 m) and 3 far (>600 m) from natural populations of that species. From 2015 to 2021, we monitored establishment and survival of seeds planted in fall 2014 and seedlings planted in fall 2014 or spring 2015. Despite similar initial responses, success of planting methods diverged over 6 years. While seeding was as successful as transplanting for *P. congesta* by 2021, establishment from seed was exceptionally low for *P. obcordata*. Our results also indicate that *P. obcordata* performed better in sites far from natural populations and *P. congesta* was more likely to survive in near sites. Transplants of both species first flowered after 1 year and successfully recruited after 3 years. All initial *P. congesta* recruits survived to at least age 3. Additional recruitment occurred in both species from 2018 to 2021. Different factors affect establishment and survival of these species despite overlap in their life history traits. To support their long-term viability, more work is needed to understand how habitat, reproductive biology, and weather drive population dynamics of these species.

Abstracts

Wednesday, April 13th

Native Plant Materials (Room B)

Anthony Massaro - *Jefferson County Open Space*
Starting small: growing a native plant materials program at Jefferson County Open Space
2:10 pm
Room B

Native plant material programs have been shown to be extremely beneficial to land managers for a variety of ecological and economic reasons. Research has demonstrated how native ecotypic plant materials can increase restoration success, combat noxious weeds, and enhance plant community resiliency to a changing climate. Additionally, native plant materials and seed reserves have shown to be cost effective and of utmost importance after large disturbance events such as wildfire. As Colorado Front Range communities continue to grow and public lands are increasingly stressed by climate change, disturbance, invasive species, and increasing recreation pressure; private landowners, land managers, and conservation organizations should actively utilize native plant materials that are locally adapted to combat future disturbances. Because of these reasons, Jefferson County Open Space (JCOS) initiated a native plant materials program in 2017 with the goal of building strategic seed reserves for land management projects and unforeseen circumstances such as natural disasters. This presentation will summarize the process JCOS undertook to create and expand a native plant materials program, as well as the benefits the program is already providing to Jefferson County residents and visitors to the park system. I will provide an overview of the steps we took to start a small, but essential program for a large land management organization.

Jesse Dillon - *Cedar Creek Associates, Inc.*
Effects of the timing of precipitation on revegetation growth and vigor
2:30 pm
Room B

In arid environments, quantity and timing of precipitation are vital to revegetation establishment and persistence. This case study pairs quantitative vegetation survey data with site-specific precipitation from a high-elevation desert reclamation site in Utah. The typical precipitation pattern is bi-modal with most rain coming in April-May and August-September. Vegetation cover surveys have been implemented through the first 5 years of revegetation immediately following the spring and monsoonal rains events. This study will show how sporadic precipitation and drastic drought periods have affected the vegetation establishment and persistence throughout the monitoring period.

John Bradford
Keynote 2 Wednesday, April 13th

Climate change, ecological drought, and revegetation challenges in western drylands

Research Ecologist, and Chief, Terrestrial Ecosystems Drylands Branch, USGS Southwest Biological Science Center, Flagstaff, AZ

Wednesday, April 13th, 2022
3:20 pm, Room A&B

Climate change is altering ecosystems and challenging natural resource managers and policymakers. Water-limited dryland ecosystems, which are prevalent across western North America and comprise a large proportion of public land, may be especially vulnerable to anticipated increases in temperature and aridity because these drylands are tightly controlled by patterns of moisture availability. This talk will review some of the key characteristics of expected changes in climate and ecological drought in western drylands, assess how those changes may alter dryland ecosystem structure and function, and evaluate the potential implications for resource management. We will consider the impact of climate change and altered drought patterns on revegetation in dry environments and explore potential tools and decision frameworks that may be useful for managing drylands in the dynamic climate of the 21st century.

John Bradford is a Research Ecologist with the USGS Southwest Biological Science Center. John studies dryland ecosystems in the context of global change and works with resource managers to identify adaptive strategies for sustaining these ecosystems in a changing world. He is currently engaged in the broad topics of ecohydrology and dryland sustainability in the western U.S. and has projects examining a) the potential influence of changing climatic conditions on the distribution and regeneration potential of trees and shrubs in the intermountain western U.S., b) strategies for understanding and enhancing dryland ecosystem resilience to changing climate and drought, and c) ecosystem water balance and patterns of plant-available soil water in dryland regions.

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Abstracts
Wednesday, April 13th
Climate Change (Room A&B)

Drew Rayburn - *The Nature Conservancy in Colorado*
The Resilient and Connected Network: Informing Landscape-Scale, Climate-Resilient Restoration in Colorado

3:50 pm
Room A&B

The Resilient and Connected Network (RCN) is a proposed national conservation network of representative climate-resilient sites designed to sustain biodiversity and ecological functions under a changing climate. Developed over 10 years by a team of scientists led by TNC, the RCN has been described as a paradigm shift for large landscape conservation. Representing 33% of the U.S. and >50% of Colorado, the RCN is already serving as a foundation for accelerating the pace and scale of collaborative, climate-resilient conservation of lands and waters across the U.S. The RCN is now freely available to Colorado land management agencies, land trusts, conservation funding programs, and stakeholders seeking a science-based climate resiliency foundation for land protection, restoration, and management efforts. This presentation will provide an overview of the RCN and its potential as a planning tool for climate-resilient restoration and enhancement of landscape-scale connectivity in Colorado.

Tipton Hudson - *Washington State University Extension*
Sonia Hall, Georgine Yorgey
Building resilience to climate change through ecological resiliency on grazed lands

4:10 pm
Room A&B

Rangelands occupy over a third of the ice-free land on Earth. Livestock operations are a primary user of this land type and will have to adapt to climate change effects on rangelands. Management directed toward ecological stresses which may be amplified under a changing climate is beneficial under every future scenario. Our experience suggests that U.S. ranchers support management strategies and practices that provide ecological and economic benefits in addition to benefits relating to climate change. Our goal is to foster adoption of these “no-regrets strategies” by sharing individual success stories of ecological restoration and sustainable management.

Successful ranchers, through considering economic, ecological, and social risks in decision-making, can identify and implement practices that increase resilience to climate change and support wildland restoration while balancing other risks. Farmer-to-farmer communication is known to be more successful than “expert” outreach; ranchers sharing their resilience practices enable others to join them. Our multi-media case studies are designed to encourage other ranchers to manage toward promoting rangeland restoration, resilience, and economic sustainability. Each case study consists of a short documentary film highlighting an innovative rancher and a peer-reviewed publication with descriptions of the rancher’s ecological context, innovative practices, a discussion of challenges and benefits of adopting restorative practices.

Abstracts

Wednesday, April 13th

Climate Change (Room A&B)

Jennie DeMarco - *Southwestern University*
Jace Cussins, Yetunde Rotimi — 4:30 pm
Evaluating the carbon sequestration potential and drought resilience with wet meadow restoration under climate change — Room A&B

Restoration of degraded ecosystems can provide a mitigation pathway that sequesters atmospheric carbon (C) into the biosphere and make ecosystems more resilient to a changing climate. However, restoration projects efforts primarily focus on the restoration process itself with less focus on quantifying the impacts of restoration and rarely include accounting for C storage and resilience of the ecosystem to future environmental change. In 2020, we begin monitoring soil moisture at two watersheds in the Gunnison Basin of Colorado where wet meadows had been restored to assess the impact of restoration on ecosystem resilience. Wet meadows are a critical brood-rearing habitat for the threatened Gunnison sage-grouse (*Centrocercus minimus*) but have been severely degraded by human activities. Soil moisture was higher in restored compared to unrestored areas, but only for one of the two watersheds. This suggests that restoration impact is site specific and necessitates the need to monitor soil moisture across multiple watersheds. Previous research has shown that restoration of these wet meadows has led to an increase in plant productivity which is highly correlated with soil C. However, little is known about whether restoration in these watersheds has led to increases in soil C storage limiting our understanding of the C mitigation potential of these ecosystems. We will discuss approaches to evaluating soil C sequestration with wet meadow restoration.

Schedule
Thursday, April 14th

	Time	Room A *Mined Land Restoration* Moderated by Denise Arthur	Room B *Riparian & Wetland Restoration* Moderated by Magda Garbowski
Early Morning	8:30am	**Opening Remarks** – Sarah Williams	**Opening Remarks** – Cynthia Brown
	8:40am	**Chandan Shilpakar #O25** Regenerative grazing effects on vegetation diversity, biomass production, and soil carbon restoration	**Amy Gilboy #O29** River Bluffs Open Space: Restoration successes, challenges, and the path forward
	9:00am	**Randy Mandel #O26** Restoration of the USFS Pike San Isabel Peekaboo AML Mine Site	**Tamara Keefe #O30** St Vrain State Park mitigation site restoration
	9:20am	**Tara Tafi #O27** "That's a lot of yarrow": Common problems, pitfalls, and lessons learned from revegetation of high elevation inactive and abandoned mines in Gunnison County	**John Giordanengo #O31** “PRE-storing” floodplain structure and function in anticipation of future changes in urban hydrologic regimes
	9:40am	**Steve Perkins #O28** Effects of organic amendments on vegetation establishment in overburden soil covers at a high-altitude metal mine in New Mexico	**Taryn Contento #O32** Assessment of restoration approaches in the Kawuneeche Valley
BREAK (10:00am – 10:30am)			

Next page: Mid-Morning

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Schedule
Thursday, April 14th

	Time	Room A *Rangeland Restoration* Moderated by Cynthia Brown	Room B *Watching from Above: Drones in Restoration Monitoring* Moderated by Wade Tinkham
Mid-Morning	10:30am	**Shabana Hoosein #O33** Influence of plant community diversity and field-conditioned inoculum on AM fungal and bacterial community diversity and interactions	**Jill Handwerk #O37** Applications of sUAS for mapping and monitoring Parachute penstemon (*Penstemon debilis*)
	10:50am	**Claire Karban #O34** Plant and soil responses to restoration and grazing in a highly degraded semiarid rangeland on the Colorado Plateau	**Laura Hanna #O38** Monitoring forest spatial patterns from UAS remote sensing
	11:10am	**Christina Alba #O35** Incorporation of indaziflam (Rejuvra®) into weed management regimens in natural areas: A post-fire assessment	**Lauren Lad #O39** Preliminary evaluation of tree-level prescribed fire effects monitoring from UAS
	11:30am	**Withdrawn**	**Panel Discussion**
	LUNCH (11:50am – 1:00pm) High Altitude Revegetation Committee meeting: Room 322		

Next page: Early Afternoon

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Schedule
Thursday, April 14th

	Time	Room A *Forest Restoration* Moderated by Paula Fornwalt	Room B *Invasive Annual Grass Management Successes: A Wildlife, Pollinator, & Wildfire Perspective* Moderated by Jake Courkamp
Early Afternoon	1:00pm	**Cora Davies #O40** Forest restoration treatments enhance plant-pollinator networks via floral- and temperature- mediated resource cascades	**Jake Courkamp #O44** Proactive invasive annual grass management and fine fuel reduction with indaziflam
	1:20pm	**Edward Hill #O41** Effects of forest microclimates on juvenile tree survival vary with climate and life-stage	**Noe Marymor #O45** Invasive annual grass restoration partnerships
	1:40pm	**Jesse Dodge #O42** Landscape variation effects on bee health	**Joe Swanson #O46** Rejuvra/ indaziflam a land manager's restoration tool
	2:00pm	**Andrew Slack #O43** Forest restoration and ecological monitoring at Beaver Ranch Park: A case study of collaborative adaptive management in the Upper South Platte Watershed	**Panel Discussion**
	BREAK (2:20pm-2:50pm)		

Next page: Late Afternoon

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Schedule
Thursday, April 14th

	Time	Room A&B *Closing Keynote* **Moderated by Tim Hoelzle**
	BREAK (2:20pm-2:50pm)	
Late Afternoon	2:50pm	**KEYNOTE: Elish Gornish #K3** Making restoration better (Nothing in this presentation is true but it's exactly how things are)
	3:20pm	**Student Awards** - Cynthia Brown & Mark Paschke
	3:30pm	**Raffle** - Jesse Dillon
	3:40pm	**Closing Comments** - Tim Hoelzle

Next page: Day 2 Abstracts

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Elise Gornish

Keynote Thursday, April 14th

Making restoration better (Nothing in this presentation is true but it's exactly how things are)

Cooperative Extension Specialist in Ecological Restoration, University of Arizona, Flagstaff, AZ

Thursday, April 14th, 2022
2:50pm, Room A&B

Dr. Elise Gornish is a Cooperative Extension Specialist in Ecological Restoration at the University of Arizona. Her work largely focuses on identifying strategies for successful restoration in arid land systems and integration of restoration approaches into weed management. Originally from New York, Dr. Gornish received her MS and PhD from Florida State University in 2013. She then completed two years of a post doc at the University of California, Davis. In addition to vegetation management, Dr. Gornish is passionate about STEM inclusion and is also the Director of GALS (Girls on outdoor Adventure for Leadership and Science). GALS focuses on providing science learning and leadership opportunities to traditionally underserved female high school students through backcountry programming.

Ecological restoration has now been a formalized field of research and application for long enough to be characterized by individuals who call themselves experts. Whether we are researchers or practitioners, many of us have been doing restoration 'for a long time.' But, has our perceived expertise and experience hampered our efforts? Do we think we know what's best? Do we forget to spend time with the projects that fail? Do we hide our failures from others? This talk will be an exploration into how we can make restoration better, by continuing to do what we are doing – but changing everything. With examples largely from my own work, this talk will be the gentle reminder we all need that not only do we not know everything, but we know more than we think.

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COLORADO STATE UNIVERSITY

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Abstracts
Thursday, April 14th
Mined Land Restoration (Room A)

Chandan Shilpakar - *University of Wyoming*
David Holbrook, Maichel Baidoo, Mohammed Munkaila, M. Anowarul Islam
Regenerative grazing effects on vegetation diversity, biomass production, and soil carbon restoration

8:30 am
Day 2, Room A

Reestablishing vegetation is an integral part of a reclamation process. Regenerative grazing has been used to reduce the ecological footprints. The objective of the study was to determine the effects of regenerative grazing on vegetation diversity, biomass production, and soil health. Soil and vegetation samples were collected in 2021 from three reclaimed uranium mine sites and two natural grasslands under no, short-term, and long-term grazing scenarios near Shirley Basin, Wyoming. Results showed that the vegetation biodiversity index was not different between natural and reclaimed sites in all grazing scenarios indicating quantitative biodiversity was similar. Vegetation composition was alike in natural grasslands but varied among the reclaimed sites indicating qualitative difference among the sites. Reclaimed sites had higher dry matter productivity (1370 kg ha-1) compared to natural grasslands (537 kg ha-1). Natural grasslands had the highest total soil carbon (19.6 g kg-1) at 0-15 cm depth while no difference among sites was observed at 15-30 cm (15.3 g kg-1) and 30-45 cm (21.9 g kg-1) depths. Site history in combination with grazing scenarios affected vegetation composition, biomass production, and soil carbon content. Overall, the preliminary results showed that reclaimed sites could provide enough forage for livestock grazing, however it will require a longer time to attain an ecosystem similar to natural grasslands.

Randy Mandel - *Ramboll - Technical Lead Restoration/ Biodiversity*
Amy Titterington, Sara Copp Franz, Miller Mandi
Restoration of the USFS Pike San Isabel Peekaboo AML Mine Site

9:00 am
Day 2, Room A

Ramboll is working with USFS Pike - San Isabel National Forest Abandoned Mine Land personnel to restore the Peekaboo Mine in Chaffee County, Colorado. Peekaboo Mine is located approximately 30 miles Northwest of Buena Vista near Independence Pass. The mine was active from the late 1800's until the 1990's and has a long history, ending in tragedy. This work is in support of USFS reclamation efforts to reduce ecological risk, facilitate site stabilization, and improve water quality. Restoration consists of debris removal, cabin deconstruction, and ecotypic seed collection, propagation, and planting. Seed propagation involves the determination and refinement of innovative propagation protocols, many of which require prolonged seed stratification. Species prioritization is based on 22 predominant native grasses, forbs, and woody species that typify the site, and is organized by hydrologic planting suites. Seed collection has been carried out in partnership with USFS personnel, whereas plant propagation is being accomplished by the Colorado State Forest Service. Plant installation began in 2020 and is intended to continue in 2022 using Colorado Correctional Industries State Wildland Inmate Fire Team with USFS and Ramboll oversight. This talk will focus on seed collection, plant propagation, and installation challenges encountered on 11,000 ft msl restoration site, as well as lessons learned from the adjacent USFS White River National Forest Lincoln Creek Restoration.

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Abstracts
Thursday, April 14th
Mined Land Restoration (Room A)

Tara Tafi - *Colorado Division of Reclamation, Mining, and Safety*
"That's a lot of yarrow": Common problems, pitfalls, and lessons learned from revegetation of high elevation inactive and abandoned mines in Gunnison County

9:20 am
Day 2, Room A

Historic coal and hardrock mining have left large areas of mine waste and mine waste impacted lands throughout the State of Colorado. The Colorado Division of Reclamation, Mining, and Safety works to reclaim and revegetate many of these drastically disturbed landscapes. Four inactive mine sites, three hardrock and one coal, near Crested Butte, Colorado, with elevation between 8,950 feet to 11,550 feet were reclaimed and revegetated between 2011 and 2021. Revegetation was accomplished by soil amendment and fertilizer applications, compost applications, live plantings, hand broadcast seeding, and hydro-seeding. All four of these reclaimed mine sites are considered successful projects, however, important lessons were learned at each site. Common problems and pitfalls associated with the reclamation and revegetation methods/techniques implemented at these sites include but are not limited to: noxious weeds and undesirable species, over-seeding, using too much or too little compost and/or mulch, failing to establish appropriate, uniform soil chemistry, undersized erosion controls, over compaction of soils, poor species diversity, and others. Managing expectations, patience, adaptive management, and applying lessons learned have been critical to the eventual success of these projects.

Steve Perkins - *Chevron Technical Center (a Chevron U.S.A. division)*
Doug Romig, Cynthia Gulde
Effects of organic amendments on vegetation establishment in overburden soil covers at a high-altitude metal mine in New Mexico

9:40 am
Day 2, Room A

In 2015, a 15-acre field trial was initiated at a closed hard rock mine in northern New Mexico to investigate the potential for organic soil amendments to enhance vegetation establishment on waste rock piles. Cover material consisted of waste rock with characteristics suitable for plant growth, although nutrient poor. Slope treatments included nearly level plots and plots with 2H:1V and 3H:1V slopes. Soil amendment treatments included composted biosolids (CB), dry mycelium, and control. CB were applied to the top foot of cover using surface and co-loading methods at target rates of 20 and 45 tons/acre. Dry mycelium was applied at the rate of 1 ton/acre. Plots were seeded with a diverse mix of grasses, forbs, and shrubs. Study plots have been monitored annually in the Fall using permanent quadrats. Vegetation cover, diversity, and density were consistently greater in the CB amended plots than in the dry mycelium or control plots. CB application method influenced vegetation performance on sloped plots, and plant diversity and density tended to be higher on plots with co-loaded CB than on plots with surface applied CB. Generally, there was not a significant difference in vegetation cover or density between the 20 and 45 tons/acre application rates for CB. Overall, results of the study indicate that application of CB can promote vegetation establishment on high-altitude waste rock piles and that co-loading is an effective application method.

Abstracts
Thursday, April 14th
Riparian & Wetland Restoration (Room B)

Amy Gilboy - *Larimer County Dept. of Natural Resources*
River Bluffs Open Space: Restoration successes, challenges, and the path forward

8:30 am
Day 2, Room B

River Bluffs Open Space, owned by the Larimer County Department of Natural Resources, is located along the Cache la Poudre River, west of Windsor, CO. This section of river was channelized in the 1950s and constrained by large earthen berms, creating ditch-like conditions which destroyed the functionality of the river. River Bluffs Open Space was impacted by the floods of 2013, when the river overtopped the berms and flooded the area. Larimer County received grants from the Dept. of Local Affairs, Colorado Parks and Wildlife, and Great Outdoors Colorado to restore this ¾ mile stretch of the Poudre River, both the uplands and riparian area. The County used creative and innovative techniques to re-connect the river to its floodplain and original channel, create wetland and riparian habitat, improve flood resiliency, and promote natural river function. Although the project was successful, there have been some challenging results, especially managing vegetation and battling kochia. This presentation will highlight the results of the restoration methods used at River Bluffs Open Space, both our successes and challenges, as well as the path forward.

Tamara Keefe - *Felsburg, Holt, & Ullevig (FHU)*
St Vrain State Park mitigation site restoration

9:00 am
Day 2, Room B

The St Vrain State Park (SVSP) mitigation site was for the 2013 North I-25 EIS Project. The intent of the mitigation plan was to re-establish floodplain wetlands and native riparian habitat to mitigate for the impacts associated with the proposed 35-year build out of the North I-25 EIS Preferred Alternative. A site consisted of a total of 23.9 acres of enhancement to upland, riparian, and wetlands and 6 acres of created wetlands. The plan was to begin work in the fall of 2013, however, due to the floods, it was delayed until Spring of 2014. This presentation would consist of presenting the restoration journey from the time of the floods to present day. A variety of methods were used to bring the site into compliance with the USACE requirements, including grading, planting, seeding, herbicide treatments and goats! The final year of monitoring is expected to be this year.

Abstracts
Thursday, April 14th
Riparian & Wetland Restoration (Room B)

John Giordanengo - *AloTerra Restoration Services*
David Bidelspach
"PRE-storing" Floodplain Structure and Function in Anticipation of Future Changes in Urban Hydrologic Regimes

9:20 am
Day 2, Room B

The distribution of plant communities across floodplains is influenced by flood frequency, groundwater hydrology, soils, shade, landform, and other variables. The consistency of these variables over space and time often leads to the development of predictable hydroseres (i.e., vegetation zones) across floodplains. Residential and commercial developments can cause significant changes in the baseflows and peak flows (flashiness) of urban streams, and can alter the distribution of hydroseres across impacted floodplains. Impacted streams can also experience incision or endure other geomorphic changes, contributing to sedimentation, degradation of plant communities, threats to infrastructure, and cause other undesirable economic and environmental impacts. Increasingly, local and regional agencies are requiring developers to "pre-store" floodplains: to design and construct streams and riparian areas to meet future (not existing) conditions. This provides an opportunity to restore riparian and wetland communities in these systems. However, restoration treatments must be implemented when funds are available, often years before the anticipated hydrologic changes occur. This talk summarizes recent strategies employed in several streams to address these challenges, including a variety of bioengineering methods and a systematic approach to designing riparian and wetland restoration hydroseres on Colorado's urban Front Range.

Taryn Contento - *Colorado State University*
Jeremy Sueltenfuss
Assessment of restoration approaches in the Kawuneeche Valley

9:40 am
Day 2, Room B

Disturbance regimes in riparian areas have been modified, and, as a result, riparian systems and their associated vegetation have been in decline across the United States. The west side of Rocky Mountain National Park (RMNP) in the Kawuneeche Valley has a history of human use and landscape level modification ranging from altered elk and moose populations, hydrological modification from trans basin diversions, and vegetation removal from hay production. These alterations have led to a documented decline in riparian vegetation and raise questions of appropriate adaptive management to address decreased vegetation. This study evaluated willow growth (height, cover, and annual growth) response to these overlapping altered disturbances in the Kawuneeche Valley. We found that the largest influence on willow growth was a high level of herbivory, with exclosures providing potential relief from these impacts. Depth to water level did not significantly relate to willow growth, but a possible -100 cm water level threshold could explain conditions below which water levels would influence growth. Lastly, historic hay production decreased cover and the overall presence of willow, indicating areas of critical need for restoration. Future research is needed to explain mechanisms behind these trends but the next steps in restoring this area are to address the heavy toll of herbivory, investigate the conflicting influence of water table depth, and prioritize sites with the greatest vegetation loss.

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Abstracts
Thursday, April 14th
Rangeland Restoration (Room A)

Shabana Hoosein - *Colorado State University*
Pankaj Trivedi, Mark Paschke
Influence of plant community diversity and field-conditioned inoculum on AM fungal and bacterial community diversity and interactions
10:30 am
Day 2, Room A

The integral role of soil biological relationships in ecological restoration is widely acknowledged as critical for vegetation establishment and primary ecosystem functions. Using conditioned soils from established field plots of high and low plant diversity, I created mesocosm plant communities across a plant diversity gradient using greenhouse-established transplants commonly found in prairies. Pots were inoculated with the high and low diversity field-conditioned soils. Soil samples were collected from mesocosm plant communities and were processed using amplicon-based sequencing methods, diversity metrics and network analyses to evaluate how the relationship between AM fungi and bacteria change with shifts in plant diversity. Overall, we found that AM fungi dominated in contributions to network interactions in all field inoculum treatments. Furthermore, AM fungi also dominated as the hub taxa for most treatments. Positive interactions outweighed negative interactions in the high greenhouse-established plant diversity, high field-conditioned inoculum treatment. Along with the high alpha diversity of AM fungal and bacterial communities in these treatments, the data inferred that these networks are self-maintaining and stable. Overall, this research explored some controversial assumptions often made in plant-soil feedback studies and addresses the diverse use of methodologies to better understand linkages between plant community diversity and soil microbial community dynamics.

Claire Karban - *Department of Ecology and Evolutionary Biology, University of Colorado*
Michael Duniway, Akasha Faist, Dave Hoover, Rebecca Mann, Nichole Barger
Plant and soil responses to restoration and grazing in a highly degraded semiarid rangeland on the Colorado Plateau
10:50 am
Day 2, Room A

Domestic livestock grazing provides critical ecosystem services around the globe. However, overgrazing, both historic and current, has long been recognized as a major degradation pathway in dry rangeland ecosystems, often resulting in the loss of native vegetation, increased invasive vegetation, and accelerated soil erosion. In this study we evaluate restoration strategies to reduce soil loss and increase native vegetation while maintaining cattle grazing. This study was conducted over four years at a highly degraded semiarid grassland in SE Utah. We applied three restoration treatments: 1) restoration of the seedbank by drill seeding native seed mix, 2) stabilization of soils with artificial barriers (“ConMods”) plus hand seeding, 3) drill seeding treatment plus application of an organic soil stabilizer (psyllium) in combination with inoculation of biological soil crusts and compared them to 4) untreated controls. Half of the restoration treatment plots were rested from grazing for the entire experiment. Cattle were reintroduced to half of the restoration treatment plots after a two-year rest period. Grazing reduced plant density and increased total cover in an extremely dry year, driven by non-seeded, weedy or invasive species. Soil stability declined modestly over time but was not dramatically reduced by grazing. Restoration of native vegetation proved extremely challenging across treatments but maintaining cattle grazing on highly invaded vegetation maximized germination.

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Abstracts
Thursday, April 14th
Rangeland Restoration (Room A)

Christina Alba - *Denver Botanic Gardens*
Michelle Deprenger-Levin
Incorporation of indaziflam (Rejuvra®) into weed management regimens in natural areas: A post-fire assessment

11:10 am
Day 2, Room A

We sampled plant communities following the 2020 Calwood Fire in Boulder County, CO, to explore how pre-fire herbicide treatments including Rejuvra® shaped plant community response to fire. Given Rejuvra®'s pre-emergence control of short-lived grasses and forbs, we assessed post-fire response of target (*Bromus tectorum, Bromus japonicus*, and short-lived non-native forbs) and potential non-target (short-lived native grasses and forbs) species in sprayed and unsprayed areas that were burned or not. *Bromus tectorum* and *B. japonicus* were well controlled in burned (96% lower cover of both species where sprayed) and unburned (93% lower cover of *B. tectorum;* 83% lower cover of *B. japonicus*) areas. Non-native short-lived forbs were also well controlled in both burned (richness, 55% lower in sprayed areas; cover, 63% lower in sprayed areas) and unburned (richness, 43% lower; cover, 58% lower) areas. Two native annual grasses, *Vulpia octoflora* and *Hordeum pusillum*, were too uncommon to assess. For short-lived native forbs, richness was 75% lower in burned areas that had been sprayed than those that had not. However, in the absence of fire, spraying had little effect on short-lived native forb richness, and the non-target effect on richness did not emerge for percent cover. In line with previous work, long-lived native forbs and grasses had higher percent cover in sprayed than unsprayed areas, and we show that this holds regardless of burn status.

Abstracts

Thursday, April 14th

Watching from Above: Drones in Restoration Monitoring (Room B)

Jill Handwerk - *Colorado Natural Heritage Program*
Neal Swayze
Applications of sUAS for mapping and monitoring Parachute penstemon (*Penstemon debilis*)
10:30 am
Day 2, Room B

Jill Handwerk, Senior Botanist at the Colorado Natural Heritage Program and Neal Swayze Research Associate at the Natural Resource Ecology Laboratory will provide an overview of three years of research into the use of small Unmanned Aerial Systems (sUAS or drones) to conduct surveys for Parachute penstemon (*Penstemon debilis*) on the steep cliff faces of the Roan Plateau. Parachute penstemon, is a narrow Colorado endemic known only from Garfield County. It is currently a federally listed (threatened) plant species and ranked as a G1 S1 by NatureServe. Parachute penstemon is restricted to the Mahogany Zone of the Parachute Creek Member of the Green River Formation on habitat characterized by sparsely vegetated, steep south-facing slopes of white shale talus. On-the-ground survey and monitoring efforts for Parachute penstemon are hindered by the extremely steep and fragile shale habitat, many areas of which are remote and inaccessible. These conditions are not only dangerous for surveyors, but the movement of scree underfoot makes it nearly impossible to meet USFWS's recovery goals of range-wide surveys and consistent population monitoring while maintaining habitat integrity. Therefore, to address these issues a project was initiated to test the utility of an emerging technology, sUAS, for the surveys and monitoring of Parachute penstemon. The novel methods developed to conduct this work and the resulting discoveries will be discussed.

Laura Hanna - *Colorado State University*
Wade Tinkham, Mike Battaglia
Monitoring forest spatial patterns from UAS remote sensing
10:50 am
Day 2, Room B

Unmanned aerial systems (UAS) have become versatile tools for characterizing forest structures. Concurrently, forest restoration approaches have shifted towards promoting and reestablishing vertical and horizontal heterogeneity in many forest systems. However, few UAS studies have focused on capturing or describing local vertical and horizontal forest complexity. The development of methods for describing the spatial arrangement of all tree size classes in a stand would fully enable the monitoring of spatial restoration objectives.

This presentation evaluates the use of UAS in monitoring and describing forest structural complexity using the individuals, clumps, and openings framework. We assess the accuracy of UAS estimates of vertical and horizontal forest structural heterogeneity across stand density gradients in ponderosa pine-dominated systems by comparing UAS single tree detection estimates of forest horizontal and vertical heterogeneity against 11 unique 1-hectare stem maps. This study also compares larger spatial patterns and structures (e.g., individuals, clusters, and openings) for the UAS and stem map data. Results indicate an underestimation of tree density by the UAS monitoring strategy that worsens as small tree density increases. However, the UAS method saw no statistical differences when assessing the distribution of individuals, clumps, opening, and stand basal area compared to the stem maps.

Abstracts

Thursday, April 14th

Watching from Above: Drones in Restoration Monitoring (Room B)

Lauren Lad - *Colorado State University-Forest and Rangeland Stewardship*
Wade Tinkham

Preliminary evaluation of tree-level prescribed fire effects monitoring from UAS

11:10 am
Day 2, Room B

Prescribed fires are a useful management tool that can reduce forest density, remove fuels, and increase a forest's resilience to subsequent disturbances. Beyond achieving management objectives, prescribed fires offer a unique opportunity to examine the interactions between fuels, burning conditions, and trees' physiological status to explain both short- and long-term fire effects. Unmanned aerial systems (UAS) have potential to improve prescribed fire monitoring by providing ultra-high resolution multispectral data that can be collected before, during, and after the fire. By conducting pre- and post-fire UAS surveys on prescribed burn sites, we can examine pre-fire site conditions and post-fire physiological changes to characterize tree-level fire effects that can be summarized at the stem, group, and stand scales This presentation will discuss existing research, ongoing projects, and future directions for UAS monitoring of prescribed fires and describe the ways in which UASs can be used to improve management of fire-dependent forest systems.

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Abstracts
Thursday, April 14th
Forest Restoration (Room A)

Cora Davies - *Colorado State University*
Thomas Davis
Forest restoration treatments enhance plant-pollinator networks via floral- and temperature-mediated resource cascades

1:00 pm
Day 2, Room A

Many forest restoration projects create canopy gaps of varying sizes to mimic historical forest structures and improve ecosystem function. Canopy gaps promote high floral diversity and may be a valuable resource for native bees with consequences for bee-flower interactions and community structure. Here, we recorded bee-flower interactions in canopy gaps of varying sizes to test how variation in floral availability, pollen nutritional value, and bee and floral traits impact bee-flower networks. We observed ~6,500 bee-flower interactions throughout the growing season to model bee and pollen protein phenology and relate floral visitation to visual traits. Three important findings emerged: (1) although gap size was not strongly associated with phenological matching of bee abundances and protein density, bee body size predicted activity periods and foraging activity of small-to-medium sized bees was mismatched with periods of peak protein density; (2) across all sites, protein density (µg/m2) and floral species richness were the only predictors of interaction abundance and richness, respectively; and (3) floral visual traits predicted visitation, with more interactions recorded for tall species with large floral displays. Our results suggest that canopy gap creation is likely to have similar impacts on bee-flower interaction networks regardless of gap size, but phenological mismatch between bees and pollen protein is more likely for small-bodied bees with short foraging ranges.

Edward Hill - *Department of Forest and Rangeland Stewardship, Colorado State University*
Miranda Redmond, Jeffery Cannon, Seth Ex
Effects of forest microclimates on juvenile tree survival vary with climate and life-stage

1:20 pm
Day 2, Room A

Forest canopies can buffer climate conditions, providing microclimate refugia for tree regeneration otherwise limited by macroclimate conditions, especially in dry forest types. However, the relative importance of microclimates for juveniles may vary with forest structure, life-stage, species, and yearly weather variation. We used a structurally heterogeneous forest restoration treatment to assess how ponderosa pine and Douglas-fir seedling survival varies in relation to structure and microclimates across multiple life-stages and years. Results showed survival responses were dependent on life-stage and yearly weather differences; species responses were overall similar, but Douglas-fir survival was only half that of ponderosa pine. Germinant survival was greatest at <40% canopy cover, corresponding to warmer and drier microclimates, during the coolest weather year with a wet spring, but this pattern reversed to high survival at >50% canopy cover in a warmer, drier year. Survival of older, larger seedlings was greatest at <50% canopy cover, but this pattern was not significant within or across years. Microclimate variation strongly influenced survival of germinants through 2-yr old seedlings, but had minimal effect on older juveniles over time. These results demonstrate the importance of fine-scale, heterogenous forest structure and resulting microclimates in these dry forests for supporting regeneration potential and young seedling establishment of different species over time.

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Abstracts
Thursday, April 14th
Forest Restoration (Room A)

Jesse Dodge - *Department of Forest & Rangeland Stewardship, Colorado State University*
Thomas Davis
1:40 pm
Day 2, Room A

Landscape variation effects on bee health

Bee pollinators play a crucial role in maintaining plant communities, but there has been a recorded decline of bees globally. Land-use changes have led to an increase in fire suppression efforts, leading to overgrown forests with reduced biodiversity and increased wildfire risk. Land managers often implement forest restoration treatments to reduce wildfire risk and promote biodiversity. However, the effects of forest restoration treatments on bee health remains unclear. We sought to determine how high severity wildfire and forest restoration treatments affected bee health and how they changed over time. We released and monitored *Osmia lignaria* within forests of Boulder County, CO at sites treated for ecological restoration (Treated), sites that burned at high severity (Burned) at least 10-years ago, and unburned and untreated sites (Control) during the summers of 2020 and 2021. We found that *O. lignaria* development differed among habitat types for each year, with burned sites having the highest pupae:larvae ratio in 2020 but the lowest pupae:larvae ratio in 2021. Pupae weights were highest in treated sites in 2020 whereas burned sites had the highest weights in 2021. *Tribolium* spp., a pollen predator, presence in 2020, also differed among sites, with burned sites having the highest *O. lignaria:Tribolium spp*. ratio. Although these results were not consistent over time, bee reproduction and development did tend to be higher in disturbed areas with less tree canopy cover.

Andrew Slack - *Colorado Forest Restoration Institute at Colorado State University*
Tori Hunter, Camille Stevens-Rumann
2:00 pm
Day 2, Room A

Forest restoration and ecological monitoring at Beaver Ranch Park: A case study in collaborative adaptive management in the Upper South Platte Watershed

Mechanical thinning treatments are an essential tool many managers use to restore various forest ecosystems. Thinning the forest to reduce tree density and cover is often implemented to mitigate the effects of fire suppression and restore a more open forest structure that sustains ecosystem services in the future. The Upper South Platte Partnership is a cross boundary partnership that brings together numerous stakeholders and land managers to collaboratively plan and implement forest restoration projects designed to reduce wildfire risk and promote ecological resilience. Forest thinning at Beaver Ranch Park was one of the first projects the USPP planned in 2016, and the Colorado Forest Restoration Institute led monitoring efforts to collect field-based data, evaluate treatment outcomes, and advance adaptive management in the partnership. The original goals of the project were to increase the ratio of ponderosa pine, reduce canopy cover, and create conditions that support the future use of prescribed fire. These three goals provided the basis evaluating treatment outcomes, and during the five years since implementation additional information on spatial heterogeneity and understory plant communities have continued to provide insight for managers on treatment effectiveness. The forest restoration project at Beaver Ranch was split into two phases that had different treatment outcomes and provide the USPP with a case study to learn from and adapt future management decisions.

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Abstracts

Thursday, April 14th

Invasive Annual Grass Management Successes: A Wildlife, Pollinator, & Wildfire Perspective (Room B)

Jake Courkamp - *Department of Forest and Rangeland Stewardship, Colorado State University*

1:00 pm
Day 2, Room B

Proactive invasive annual grass management and fine fuel reduction with indaziflam

Indaziflam (Esplanade®, Bayer) has demonstrated the potential to selectively deplete downy brome seed banks and achieve long-term control. This is likely to reduce the amount and continuity of fine fuels in invaded ecosystems. We assessed the ability of indaziflam treatment at three different rates (51, 73 and 102g ai/ha), and imazapic treatment (Plateau®, BASF) at 123g ai/ha to selectively manage downy brome at two high-elevation sagebrush-grassland sites near Pinedale, Wyoming. At each site, we measured canopy cover by species and downy brome seedling density in four replicates of small plots that include each treatment and an untreated control. All treatments were applied in September 2016 and sampled each summer (late June) for the next five years. Comparable reductions in downy brome cover and density between indaziflam- and imazapic-treated plots were observed up to two years after treatment (YAT), and in some cases imazapic outperformed indaziflam one YAT. After two YAT, significant reductions were only observed in indaziflam-treated plots and these reductions remained evident at one site nearly 5 YAT. In August 2019, a wildfire occurred at our study site and left the majority of a larger demonstration plot unburned, likely as a result downy brome reductions after indaziflam treatment. Along with our study results, this suggests that indaziflam is likely to be a useful management tool for mitigating the wildfire threats posed by downy brome invasion.

Noe Marymor - *USDA Natural Resources Conservation Service*

1:20 pm
Day 2, Room B

Invasive annual grass restoration partnerships

Tackling a landscape level problem like that of winter annual invasive grasses can appear to be anything from daunting to futile. However, recent research is shining a spotlight on the enormous impact cheatgrass has on rangelands everywhere it occurs. From changing fire regimes and severity in the intermountain west and low elevation ponderosa pine forests, reducing native plant biomass by orders of magnitude through competition, limiting available browse for native ungulates, impacting floral resources and pollinating insect communities, and the list continues on. The severity of the problem is really only now beginning to be understood, but fortunately this renewed interested in cheatgrass ecology and management comes as a new tool has been added to the land manager's toolbox to effectively fight back. Indaziflam herbicide offers a new invasive annual grass strategy that appears highly effective as a restoration tool in cheatgrass invaded rangelands. Creating local or regional partnerships across conservation and land management interests can leverage funding, education and outreach resources to begin to treat cheatgrass on meaningful scales. In Colorado, an informal coalition of county weed managers, wildlife biologists, foresters, and private business interests has formed and is leading the state's efforts to restore cheatgrass invaded rangelands in eastern Colorado, with much success.

Abstracts

Thursday, April 14th

Invasive Annual Grass Management Successes: A Wildlife, Pollinator, & Wildfire Perspective (Room B)

Joe Swanson - *Boulder County Open Space* 1:40 pm
Rejuvra/ indaziflam a land manager's restoration tool Day 2, Room B

Boulder County Open Space (BCPOS) manages properties in the lowland, foothills and mountains of Colorado that provide critical wildlife and pollinator habitat with highly diverse ecosystems. A major concern of BCPOS ecologists is the loss of critical wildlife habitat, ecosystems, and dynamic diversity of native plant species due to cheatgrass and cheatgrass-fueled wildfires. Invasive winter annual grasses, such as cheatgrass (*Bromus tectorum L.*) are considered serious threats to regional biodiversity. Indaziflam (Rejuvra®, Bayer) has been adopted by many land managers throughout Colorado with an open space, natural areas, and grazing labels. Field studies at Colorado State University and other Universities throughout the west have demonstrated that Rejuvra provides superior long-term invasive annual grass control (3 plus years) with no documented injury to native perennial species. Rejuvra is a root inhibiting herbicide that allows for increased safety of desirable perennial plants that have roots below the layer where the herbicide is active. The remnant native plants that exist in these sites take full advantage of the additional moisture and nutrients suddenly available where cheatgrass is controlled. This response has been thoroughly documented in the county in regard to critical overwintering habitat for mule deer, elk, and other wildlife. Permanent random transects (3 X 200') were created inside cheatgrass-treated, and immediately adjacent, non-treated plots. Data collection included line intercept canopy cover for cheatgrass and all desirable perennial vegetation. In addition, biomass was collected for all species including cheatgrass litter to determine fine-fuel weights in treated vs. non-treated plots. This provided an indication of how quickly cheatgrass fine-fuel litter degrades after Rejuvra treatments. Shrub measurements including longest leader growth, leader counts per plant, and leader biomass. Data were collected over two consecutive summers, at approximately 8 to 42 months after treatment (MAT). Our research has shown that mule deer browse and forb forage dramatically increased where cheatgrass is controlled. Our findings reinforce the idea that cheatgrass and other invasive annual grasses pose a significant threat to native species diversity. For land managers, Rejuvra provides a long-term control option to begin the restoration process on the millions of cheatgrass infested acres.

Poster Titles & Presenters

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Susan Baden #P1	Assessment of Biodiversity, Aboveground Biomass, and Plant Cover Following Sub Alpine Mine Reclamation
Kathryn Bickley #P2	Stream and Wetland Restoration on the Coldharbour Ranch
Haley Burrill #P3	Microbial community differentiation in response to plant community composition and precipitation manipulation in a prairie field experiment
Susan Campbell #P4	Identifying Restoration Projects for Carbon Sequestration and Emissions Reductions
Marin Chambers #P5	2020 Colorado wildfires: tree germination 1-year post-fire
Isabel de Silva #P6	Plant community responses to experimental planting techniques in a stage 0, beaver dam analog riparian restoration setting
Ariel Demarest #P7	Effects of ecological restoration treatments on understory plant community diversity and productivity in Colorado dry conifer forests
Amy Gill #P8	Role of Functionally Diverse Seed Mixes in Mediating Restoration in Semi-arid Rangelands
April Goebl #P9	Experimental assessment of local adaptation and evolutionary potential in multiple common grassland species to inform seed selection for restoration
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Louisa Kimmell #P12	Improving our understanding of abiotic and biotic treatment success in dryland soil restoration: A meta-analysis
Amanda Miller #P13	Herbicides and seed treatments impact pollinator habitat in restoration of abandoned rangelands
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Melinda Stueber #P18	The Role of Microsite Characteristics in Determining the Success of Seedling Recruitment in Grassland Restoration
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Poster Abstracts

Located in Room C&D

Assessment of Biodiversity, Aboveground Biomass, and Plant Cover Following Sub Alpine Mine Reclamation, **Susan Baden**, Mark Paschke, Jayne Jonas

Poster #P1

The Summitville Mine, located in the San Juan Mountain Range of southwest Colorado, was regularly used to extract precious metals beginning around 1870. The site was re-opened in 1984, when open pit heap-leach gold mining was operational until 1992. Mining activity disturbed 200 ha of land consisting primarily of an open pit, a cyanide heap lead pad, and two waste rock piles. Reclamation began when the site was listed as a Superfund Site in 1994. Revegetation test plots were established in 1995 on the northwest section of the mine at the mine's northwest dump. Four replicate blocks consisting of eight different waste-rock amendment treatments were installed to assess the effect of organic and topsoil amendments on biological diversity, aboveground biomass, and spatial cover of plant species introduced to the site. These revegetation plots provided valuable information that was initially used to prescribe amendments for site-wide reclamation. In summer of 2021, we returned to the revegetation test plots to sample plant cover, biomass, and diversity to assess long-term effects of amendment treatments. Results from 2021 suggest that amending waste rock with limestone and compost and capping with topsoil provided the best long-term revegetation success at the site. Summitville Mine revegetation test plots have demonstrated that on-site experimental restoration treatments can be an effective way to test various restoration approaches before embarking on site-wide restoration.

Stream and Wetland Restoration on the Coldharbour Ranch, **Kathryn Bickley**

Poster #P2

This master's project includes design and preparation of a scoping package for stream and wetland restoration on a non-profit ranch in Gunnison, CO. The Coldharbour Institute is a learning laboratory for regenerative living practices located eight miles East of Gunnison. The 334-acre property is comprised primarily of wetlands, 234 of these acres are under an NRCS wetland easement agreement, which requires Coldharbour to maintain or enhance its wetland ecosystem. Human caused topographical changes such as two historic railroad grades throughout the Coldharbour property impede the ability of water to flow across the land as it previously may have. The construction of Highway 50 further distributed natural flow patterns by rerouting Tomichi creek. This project seeks to restore and create wetlands throughout the property as well as restore stream bank stability, increase in stream habitat diversity, and revegetate and strengthen riparian zones. Increasing functionality of the Tomichi creek, and adjacent wetlands, will help ensure that the Coldharbour Institute can continue to sustainably grow and become a more resilient organization. Restoration efforts will also support regenerative grazing on the ranch by increasing the abundance and diversity of available forage. In addition to supporting operations on the ranch, restoration will increase available habitat for aquatic species, migrating waterfowl and ungulates.

Poster Abstracts

Located in Room C&D

Microbial community differentiation in response to plant community composition and precipitation manipulation in a prairie field experiment, **Haley Burrill**, Guangzhou Wang, James Bever

Poster #P3

Research suggests that microbiome dynamics play a major role plant community structure through plant-soil feedbacks. In 2018, we planted 18 prairie species in 1, 2, 3, or 6 species richness, within multiple families or 1. The full-factorial design had 2 replicates, receiving 50% or 150% ambient precip beginning in 2019. We collected soil in 2018 & 2020, extracted DNA, and used amplicon sequencing techniques & bioinformatics pipelines specific to fungi, AMF, bacteria, & oomycetes. We tested whether 1) microbial diversity increases with plant species richness 2) fungal pathogen abundance is higher when plants are closely related 3) differences in microbial composition 4) changes from 2018 to 2020 with precip. In 2018 soil fungal pathogen & bacteria diversity increased with planted species richness, but root oomycete, AMF, & bacteria diversity decreased. All microbial groups differentiated between plant family composition. Fungal pathogen abundance changed in response to plant family composition, suggesting the major role of pathogens in plant community composition & how quickly they can respond to plant community changes. In 2020 oomycete & bacteria diversity increased with 150% precip, but AMF & fungal diversities were higher in 50%. Community composition diverged between plant family & precipitation treatments. These findings provide insights on mechanisms of biodiversity maintenance in plant communities, which we inform restoration and conservation efforts.

Identifying Restoration Projects for Carbon Sequestration and Emissions Reductions, **Susan Campbell**

Poster #P4

The proposed Growing Climate Solutions Act (GCSA), a bipartisan bill that passed the Senate in 2021 on a 92-8 vote, is now before the House Agriculture Committee. It has the potential, if enacted, to transform and accelerate private agricultural landowner restoration in high altitude landscapes. The GCSA proposes to create a system of U.S. Department of Agriculture (USDA) standards for agricultural restoration projects aimed at carbon sequestration and greenhouse gas emissions reductions that will qualify for carbon offset credits in the voluntary carbon markets. The poster includes an overview of the proposed GCSA and carbon market basics and examines the attributes of several restoration approaches that may have high potential for carbon sequestration and/or emissions reduction, along with compatibility with other land uses, such as native grass and forb restoration and plantings, replacement of annual crops with perennial crops (with reduced tillage), and forest and woodland plantings. The poster argues that attributes of restoration approaches that increase such potential include multiple carbon sequestration or emissions reduction mechanisms, landowner flexibility to introduce change in land use and management approach, and landscape scale and variation in vegetation.

Poster Abstracts

Located in Room C&D

2020 Colorado wildfires: tree germination 1-year post-fire, **Marin Chambers**, Kevin Barrett, Camille Stevens-Rumann, Kate Weimer

Poster #P5

The 2020 Colorado wildfire season resulted in nearly 600,000 ac of burned forest across multiple forest types. We measured tree germination 1 year following fire in four of the 2020 Colorado wildfires across four forest types to gain an initial understanding of immediate post-fire forest recovery. Our preliminary findings indicate that high severity post-fire ponderosa pine burned areas had little to no tree germination 1-year post-fire, with higher rates of tree germination in low-moderate severity burn areas. Tree germination is dominated by lodgepole and ponderosa pine in mixed conifer and lodgepole pine forest types, although densities were highly variable 1 year following the fire. Post-fire lodgepole pine dominated areas had 4 times the germinants per acre in high severity burn areas as in low-moderate severity burn areas. High severity burn areas in post-fire subalpine forest also had little tree germination, where there was tree regeneration, but in low-moderate burn areas, germination was dominated by subalpine fir. Information on early post-fire germination is useful for managers as they strategically plan reforestation efforts.

Plant community responses to experimental planting techniques in a stage 0, beaver dam analog riparian restoration setting, **Isabel de Silva**, Jessie Olson, Deb Hummel, Sorokin Yana, Katharine Suding

Poster #P6

Restoration revegetation efforts are often constrained to traditional native species assemblages that are assumed to be suited to local environmental conditions. In 2019, we experimentally manipulated classically upland riparian (presumed to be more xeric adapted) and lowland riparian (presumed to be mesic-adapted) species assemblages, planting ~1,400 individuals and seeding across a 3,500ft^2 area with water availability treatments (elevation) in a stage 0 river restoration project in Lefthand Canyon (Front Range, Colorado). Woody planting survivorship was moderate, with an approximate survivorship of 45% in 2021 with an 8% loss from 2020. Most notably, lower riparian shrubs in the lowest, wettest elevation treatments had the best survivorship, while lower riparian trees in the uppermost, driest elevation treatments had the worst survivorship. Pairing these survivorship responses with plant community composition through time, functional traits, and measures of biomass (NDVI, LAI) will ultimately allow for predicting winning and losing species assemblages for reassembling native, resilient plant communities in the face of invasion, environmental change, and disturbance.

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Located in Room C&D

Effects of ecological restoration treatments on understory plant community diversity and productivity in Colorado dry conifer forests, **Ariel Demarest**, Paula Fornwalt, Miranda Redmond, Brett Wolk

Poster #P7

Dry conifer forests of the western United States have experienced considerable alterations in structure and composition since Euro-American settlement. Ecological restoration treatments aim to restore resilience to wildfire and other disturbances by creating more open, heterogeneous overstory conditions that emulate those of historical forests. While treatments appear to be effective at meeting this primary objective, it is less clear whether they also meet secondary objectives, such as enhancing the diversity and productivity of understory plant communities. We assessed the effects of restoration thinning treatments on understory plants in dry conifer forests of the Colorado Front Range. We collected data pre-treatment and 1-2 years and 4-6 years post-treatment, at 222 plots in treated and untreated areas. Preliminary results show increases in richness and percent cover of understory plants at 4-6 years post-treatment. Richness increased post-treatment in treated plots by an average of 7 species, and increased by an average of 2 species in control plots. Understory plant cover increased in treated plots by 11% on average and decreased in control plots by 1%. These preliminary results suggest that ecological restoration treatments may meet the goal of increasing understory richness and productivity. Further analysis to determine how environmental gradients interact with treatment to affect understory plant communities may help land managers refine treatment prescriptions.

Role of Functionally Diverse Seed Mixes in Mediating Restoration in Semi-arid Rangelands, **Amy Gill**, Hunter Geist-Sanchez, Caroline Havrilla

Poster #P8

Widespread exotic grass invasion in semi arid rangelands can primarily limit successful native revegetation efforts in the United States, such as in Western Colorado. Recovery via native seeding is common to shift these systems to a high diversity, native-dominated state. However, little is known of how native grassland species combat exotic plant invasion. In a greenhouse study, we examined the role of functionally diverse seed mixes in manipulating competition in native versus exotic grass species in southwestern Colorado (SWCO) grasslands-shrublands co-dominated systems. We incorporated SWCO adapted native seed mix—16 native perennial and annual grass and forb species. We determined whether our seed mix effectively controls exotic pressures by a locally invasive grass, *Bromus tectorum* (Cheatgrass). We tested 1) native versus exotic plant recruitment 2) does increasing seed mix diversity affect the native plant biotic resistance to exotic invasion? 3) which native species acquire traits which enhance their performance against Cheatgrass invasion? We expected 1) increasing native plant diversity by species and number will improve native seedling recruitment and survival. 2) Increasing native functional diversity will enhance the competitive resistance of the native species against exotic invasion. 3) Species with the highest competitive traits could outcompete Cheatgrass. Our study could help stakeholders improve their rangeland productivity by restoring plant invaded systems.

Poster Abstracts

Located in Room C&D

Experimental assessment of local adaptation and evolutionary potential in multiple common grassland species to inform seed selection for restoration, **April Goebl**, Megan Clark, Rebecca Hufft

Poster #P9

Grasslands, a dominant biome in the western U.S.A, are increasingly impacted by human disturbance and the effects of climate change. Following grassland disturbance, a key management goal for restoring biodiversity and ecological function includes actively planting native species. A major challenge, however, is identifying source populations that are both suited to current conditions of a given site and that harbor sufficient genetic diversity to adapt as conditions change. To address this challenge, we are initiating a multi-year set of experiments comparing multiple populations of 6 common grassland species across 3 distinct sites. We selected sites that represent 3 different combinations of seed zone and ecoregion in the Front Range of Colorado. Starting in 2022, we will collect data on fitness related traits for all species, and genomic sequence data from two of our focal species. Here we will present early results including germination and seedling growth rates. Our experiments will address 1) variation in performance across sites for all focal species, 2) local adaptation in 2 of our focal species using a genecological common garden approach, and 3) evolutionary potential in 2 of our focal species by combining genomic with fitness data and using quantitative genetic methods. Together this work will help inform seed selection for grassland restoration projects by addressing the importance of matching seed zone, and the tradeoff between genetic diversity and local adaptation.

Restoring Heterogeneity: The Impact of Mounds and Slash Piles on Species Diversity at a Disturbed Sagebrush Parkland, **Rebecca Harris**, Ryan Schroeder, Jayne Jonas, Mark Paschke

Poster #P10

Efforts by resource managers to increase native plant diversity in California Park, a high elevation sagebrush parkland in northern Colorado designated as a Forest Service Special Interest Area, have largely been ineffective. Our study investigates if restoration treatments that create resource heterogeneity and generate niches for plant establishment, can increase native plant diversity and improve restoration success. In 2018, replicated test plots containing four treatments (unseeded control, seeded only, seeded plus soil pits and mounds, and seeded plus slash) were established at degraded sites in California Park. In July 2019-2021, seeded species density and unseeded and seeded plant species cover were sampled. We analyzed treatment effects on seeded species Shannon-Wiener diversity (H), species richness, and plant abundance with linear mixed-effects modelling. Preliminary findings demonstrate that, while all treatments increased species diversity and richness compared to control plots in 2019, by 2021 this trend diminished. In 2021, pit and mound plots still contained higher species richness than control plots, but results were no longer significant. This may be attributed to hotter and drier conditions in 2021 compared to 2019. These findings provide insight into whether increasing soil resource heterogeneity and adding a high-rate, diverse seed mix may set these degraded sites on desirable plant community trajectories.

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Soil Seed Bank Composition of an Urban Canal Undergoing Hydrologic Disturbance, **Alissa Iverson**, Christina Alba

Poster #P11

Soil seed banks in part determine how plant communities respond to disturbance and, by extension, shape post-disturbance ecological function. Our understanding of urban seed banks, especially in irrigation canals, is severely limited. Irrigation canals are common in semi-arid landscapes and have been shown to fulfill ecological functions similar to urban streams yet are not often considered as an important habitat. A section of an urban canal in Denver is being repurposed to serve as green stormwater infrastructure (GSI). This change will increase the amount of water the canal receives annually. The response of the plant community to this hydrologic disturbance will depend on the composition of both the above-ground vegetation and the propagules in the soil. Seeds from canal soil samples were germinated in a greenhouse and emerging seedlings were identified to uncover the species composition of the seed bank. We will compare seed bank composition to that of the aboveground vegetation using the Sørenson's similarity index to evaluate community response. We will also examine the composition of the seed bank through the lens of ecologically meaningful indicators, such as Wetland Indicator Status, to understand what that community response will mean in terms of ecological function. This information will help assess the system's capacity to respond to disturbance from increased flooding and thereby inform management and restoration practices of the canal.

Improving our understanding of abiotic and biotic treatment success in dryland soil restoration: A meta-analysis, **Louisa Kimmell**

Poster #P12

Soil degradation is one of the greatest environmental issues our planet faces today, with over 33% of Earth's soils currently degraded. Drylands are especially vulnerable to soil degradation given their history of intensive land use and desertification. Active soil restoration has been identified as a leading strategy to combat soil degradation and promote ecosystem recovery. However, soil-based dryland restoration techniques have shown varying success, potentially due to a lack of understanding of the ecological contexts in which soil-based treatments are most beneficial. To improve our understanding of how to best use active soil restoration to restore degraded drylands, we conducted a global meta-analysis of soil treatment effectiveness across varying environmental gradients. We created a database using 265 publications, yielding 1,797 unique records. We found that overall, soil restoration had a beneficial effect on all measures of soil health. We also found that for certain variables, such as soil organic carbon (SOC), bacteria and nutrient addition were most effective at increasing SOC. We also found that treatment effectiveness was highest in more arid and highly disturbed environments. These findings can help improve decision-making in dryland restoration by allowing for more informed treatment selection based on site characteristics, which will help improve restoration outcomes.

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Herbicides and Seed Treatments Impact Pollinator Habitat in Restoration of Abandoned Rangelands, **Amanda Miller**, Rebecca Hufft, Nancy Shackelford

Poster #P13

Pollinators provide fundamental ecosystem services, notably fertilizing food crops and native plant communities but their populations are in decline driven in large part by habitat loss. Pollinators require diverse and abundant flowering species, yet many forb-diverse prairie ecosystems have been converted to rangelands dominated by agronomic grasses. Restoring these regions after they are no longer active grazing/haying lands is a difficult but necessary in supporting local and regional pollinator populations. Removing existing grasses is an important first step in restoration, but they tend to be persistent and difficult to control. Herbicide application is a common restoration tool to control such species, but there is little evidence that this will lead to desired recruitment of native forb species unless they are either in the seed bank or seeded into the site. Working in a deeply degraded abandoned pasture dominated by smooth brome (*Bromus inermis*), we tested the impacts of herbicide intensity and seeding on pollinator habitat. On its own, herbicide increased flowering species abundance from 3.1±5.6 per m2 to 5.4±8.9 and reduced total plant cover from 67±21% to 60±28%. However, only the combination of herbicide and seeding consistently increased all measured pollinator habitat metrics, including total flowering plants, flowering plant species richness, diversity, and total floral abundance. Thus, coupling management strategies maximize benefits for pollinator habitats.

Extending the Winterfat Branch, **Haley Monahan**, Nathan Wojcik, Arianna Porter

Poster #P14

The use of winterfat (*Krascheninnikovia lanata*) in restoring arid plant communities and degraded rangeland provides a unique opportunity for collaboration between multiple stakeholders as the characteristics of winterfat confer benefits across a wide variety of land uses. Winterfat has phenological and physiological characteristics that make it a valuable species in restoring highly disturbed landscapes. Winterfat provides erosion control and soil stabilization. Furthermore, the species has a wide distribution and range across the western United States and is found across a broad range of elevations and precipitation zones. When landscapes are highly disturbed, winterfat can establish on poorly developed soils. Winterfat is also considered valuable winter forage for livestock and wildlife, increasing its value in restoration of lands managed for a variety of objectives. The purpose of this presentation is to demonstrate how winterfat serves a variety of functions for different stakeholders and the species' potential to align incentive structures and restoration goals in a shared vision. These characteristics create the potential for deeper and more impactful collaboration between stakeholders and land managers as well as a shared understanding of restoration work.

Poster Abstracts

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Restoration in Front Range Urban Corridors, **Kristin Oles**, Jack Van Vleet, Nick Race, JT Love
Poster #P15

With development and growth in the Front Range showing no signs of slowing down, it is crucial to get all stakeholders (e.g. developers, HOAs, and private homeowners) invested in maintaining short grass prairie ecosystems. Urban restoration initiatives are inherently multidisciplinary, requiring much outreach and education to the general public about native plant communities, the wildlife they support, and the benefits they can provide to the community. Challenges for urban restoration initiatives can include site and soil preparations, heavy invasive species presence in soil seed bank and neighboring project sites, native plant community establishment, and managing human presence and expectations of the site throughout the long restoration process. The High Plains Environmental Center (HPEC) takes a unique approach to addressing these challenges: we work directly with developers, municipalities, landscape architects, and other stakeholders at all stages of the development process to balance development and restoration goals. HPEC manages 651 acres across the northern Front Range with sites ranging from well established native plant communities to highly disturbed lands in new developments. Best management practices and restoration ecology principles coupled with partnerships and outreach programs allow HPEC to directly restore and guide others in creating and maintaining high value native habitat in the midst of rapid development throughout Colorado's Front Range.

Evaluating Gunnison sage-grouse use of restored wet meadow habitat, **Heather Reynolds**
Poster #P16

Understanding Gunnison sage-grouse (*Centrocercus minimus*) critical seasonal habitat requirements is key to their conservation. Improving brood-rearing habitat may aid in chick and juvenile survival into the breeding population. It is unknown if ongoing habitat restoration efforts in Gunnison, CO are benefitting Gunnison sage-grouse (GUSG); a species that was federally listed as threatened in 2014. From 2016-2020 we placed 30 camera traps equally on treated wet meadows that had previously received restoration structures, and nearby control sites that had not, in order to target GUSG. Each year we continuously collected photos during brood-rearing season (July – October) and recorded number of individuals in each photo. Yearly wet meadow vegetation data was compiled from local agencies that monitored similar habitats. The objectives of this study are to assess GUSG use of treated versus control wet meadows over time and determine if there is a relationship with regional drought indices and change in wetland vegetation cover on those types of sites. This study is currently in the analysis phase. Results of the study will be presented along with management recommendations and future studies needed.

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Geospatial Analysis of Soil Moisture Content (SMC) on restored wet meadows using Satellite and Drone images, **Yetunde Rotimi**, Jennie DeMarco, Andrew Breibart

Poster #P17

Soil Moisture Content (SMC) is an important parameter in environmental studies such as the monitoring of drought, and ecosystem response to climate change. Restoration practices may increase ecosystem resilience to drought conditions through improving hydrological function which can increase SMC. To validate the success of restoration initiatives on some these wetlands, particularly wet meadows, there is a need for long-term SMC monitoring. Overtime, conventional means which are labor-intensive, and spatially limited have been adopted to meet this objective. However, the advancement of remote sensing (RS) in estimating SMC has gained a global audience and hence, this study focuses on determining the accuracy and potential of RS techniques in estimating SMC in the Gunnison Basin of Western Colorado. The objective of our study is to determine the accuracy and potential use of the Blackswift drone and Satellite imageries in estimating wet meadows SMC as compared to in-situ generated data. The Blackswift drone has a unique L-Band radiometer that is capable to measure SMC at high spatial resolution for scientific and operational purposes. Flight tests of the drone will be performed at the study sites in spring, summer and fall of 2022. Ground-based data will be collected at the depths of 5cm, 10cm, 20cm and 50cm using TDR 350 Soil moisture meter. Upon the completion of this study, this project will provide land managers information on how effective restoration initiatives have been.

The Role of Microsite Characteristics in Determining the Success of Seedling Recruitment in Grassland Restoration, **Melinda Stueber**, Katharine Suding, Timothy Seastedt, Nancy Shackelford

Poster #P18

Even after many decades, the recovery of agricultural land back to prairie vegetation often stalls. Restoration via seeding is often necessary, yet its highly variable outcomes – ranging from successful establishment of native species to invasion of exotic species. We investigate whether microsite differences across one grassland restoration project at Denver Botanic Gardens Chatfield Farm (Jefferson County, Colorado) are important controls on the success of establishing native seeded species. The restoration site was herbicided in 2018, and in 2019, 52 native species were seeded. In 2021,we measured small-scale variation in soil properties and microtopography as well as in exotic plant cover. We used Poisson general linear regression models to determine how microsite aspects, biotic and abiotic, affected the frequency of seeded native grasses, forbs, and native species richness.

We found that the frequency of seeded forbs were highest in areas with high silt soil content and low soil moisture regardless of exotic presence. In contrast, the successful establishment of native seeded grasses was negatively influenced by exotics but was still high in low soil moisture. Seeded richness was only associated negatively with volumetric water content with no other microsite affinity. These results indicate a strong role of certain microsite characteristics within a restoration project and suggest that attention to microsite may be an important element in restoration success.

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Understory vegetation recovery following wildfire in the Southern Rocky Mountains, **Kate Weimer**, Camille Stevens-Rumann, Marin Chambers

Poster #P19

2020 was a historic fire season with over 600,000 acres burning in Colorado. Because the frequency and size of wildfires in the west is likely to continue to increase, understanding post-fire vegetation dynamics is critical for future management. One year post-fire, we established plots in the Mullen, Cameron Peak, East Troublesome, and Calwood fires across a gradient of burn severity. Plots were placed in four different forest types: subalpine fir and spruce, lodgepole pine, mixed conifer, and ponderosa pine. In each 1/10th acre plot, we identified the species of every vascular plant present. We also measured percent cover, basal area, tree canopy cover, aspect, slope, elevation, fine and coarse woody fuel loads, litter and duff depths, and seedling regeneration.

We found that species richness and percent cover were consistently lower in low/moderate severity burn areas compared to high severity ones. In every forest type, forbs accounted for the majority of percent plant cover in high severity burn areas, but cover was below 4% for every forest type. With more years of data collection, we expect richness and cover in the high severity burn areas to increase rapidly and quite likely surpass the richness of low/moderate severity burn areas. This first year of data collection provides us with an important starting point to monitor change over time, and we plant to revisit plots in 2022 as well as classify vegetative data to better understand trends in community change.

Join the Society for Ecological Restoration – Rocky Mountains Chapter!, **SER-RM Board Members**

Poster #P20

Visit with current SER-RM board members to learn about our chapter and hear about the great benefits provided to chapter members.

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Planning Committees

Committee	Members
Executive	**Jeremy Sueltenfuss – Chair** Mark Paschke, Tim Hoelzle, Jesse Dillon, Cini Brown, Randy Mandel, Brock Bowles, Megan Bowes, Carla DeMasters, Garrett Stephens, Sarah Williams
Program	**Mark Paschke – Chair** Becky Huft, Paula Fornwalt, Cini Brown, Magda Garbowski, Denise Arthur, Steve Roels, Drew Rayburn, Caroline Havrilla, Kristina Hufford
Communications	**Tim Hoelzle – Chair** Marenna Disbro, Taryn Contento, Jayne Jones, Tim Nicosia
Vendors & Sponsorship	**Jesse Dillon – Chair** Paul Griswold, Kate Graves
Logistics	**Randy Mandel – Co-chair**, **Brock Bowles – Co-chair**
Student	**Sarah Williams – Chair** Isabel de Silva
Workshop/Tour	**Carla DeMasters – Co-chair**, **Megan Bowes – Co-chair**
Finance	**Garrett Stephens – Chair** Cini Brown – HAR Treasurer Jeremy Sueltenfuss

A huge thank you to all committee members!

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Workshops

Chatfield Farms: Joint Field Tour with Denver Botanic Gardens and Butterfly Pavilion Staff

April 12th, 2022
8:30 - 11:30 am

Increased native biodiversity is often a measure of success in restoration projects. This joint field tour at Denver Botanic Gardens Chatfield Farms will offer participants an understanding of planning, managing and evaluating habitat restoration projects with a focus on pollinators. Chatfield Farms is a 700-acre native plant refuge and working farm. The tour will include active prairie and riparian restoration projects, specifically focusing on the role of plant diversity and pollinator habitat. Part of the workshop will investigate the components of successful pollinator habitat in natural and developed areas, as well as an overview of pollinator diversity and ecology. Participants will learn pollinator monitoring methods and field identification, as well as discuss restoration planning with pollinators in mind. Other tour elements will include some variety of grassland and riparian restoration efforts.

Boulder County Parks and Open Space Riparian and Grassland Restoration

April 12th, 2022
1:00 - 4:00 pm

Resiliency, biodiversity, and restoration. These three concepts are intimately entwined in the restoration work that Boulder County Parks & Open Space pursues. This field trip will span two different types of restoration; the first, a riparian restoration along St. Vrain Creek that improves in-stream and riparian habitat for a Federally threatened species, provides fish passage for native fish species, all while improving ditch infrastructure and water delivery and overall flood resilience. The second site will look at the use of the herbicide Rejuvra *(Indaziflam*) to control non-native annual grasses, that shows promising results for increasing native vegetation, available pollinator habitat and wildlife browse, and reduces fuel for wildfire.

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Workshops

Tour of Big Thompson River Reclamation between Rossum and Wilson, Loveland Ready-Mix Concrete

April 12th, 2022
8:00 - 11:00 am

The Big Thompson Watershed Coalition used FEMA funding to study, reshape, revegetate along the Big Thompson River between Rossum and Wilson in response to 2012 flood damage. The project was completed several years ago. The property within the Project span is owned by Loveland Ready-Mix Concrete and the City of Loveland. The Loveland Ready-Mix Property was mined for sand and gravel in the late 60's through early 80's and was in various stages of reclamation at the time of the flood.

This field tour will offer participants a chance to see the results of implementation of several techniques to restore wetland, riparian and floodplain habitat, including elements of natural channel design, bioengineering, and revegetation with native species.

Tour at Gutterson Ranch, between Kersey and Keenesburg, Fortress Development Solutions

April 12th, 2022
1:00 - 4:00 pm

Art and Parker Guttersen and Guttersen Ranches, have decades of cattle ranching history coexisting with oil and gas development on a 35,000 acre working cattle ranch south of Kersey, CO. Reclamation activities have been conducted over the years with a focus on maintaining native vegetation and reducing soil erosion in sandy textures, to increase wildlife habitat and conservation, in conjunction with livestock grazing and rangeland stewardship. Projects are developing in soil carbon sequestration and storage through disturbed land reclamation and restoration on the ranch, including cheatgrass control, soil studies and vegetation monitoring. Future educational opportunities are emerging for the community, with plans to get youth involved with agricultural and stewardship activities. Site visit will potentially include demo of nearby reclamation equipment, as well as a variety of revegetation and restoration projects.

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