

Past projects

Barger, Nichole, Jeffrey Herrick and Mark Miller: U of CO - Boulder, USDA - Jornada Basin Long Term Ecological Research, and National Park Service

Project: Plant and Soil Responses to Fuels Reduction Treatments in Upland Pinyon-Juniper Woodlands (Shay Mesa)

Research: In 2009, BLM sought to reduce fuel loads and restore sagebrush-grassland ecosystems utilizing three treatments: mastication, lop and scatter with broadcast burning, and hand pile burning. Researchers measured herbaceous vegetation cover, invasive species cover, soil erosion, and soil stability after treatments occurred compared to control sites. Additional monitoring occurred in May 2015.

Bekker, Matthew: Brigham Young University

Project: Tree Ring Analysis of Beef Basin

Research: Chronology was undertaken on two tree cookies provided by Joel Tuhy (TNC-Moab) and cores from over 100 trees in Beef Basin and Dark Canyon Plateau collected in 2012 by Eric Allen. Analysis has not been completed by Dr. Bekker due to time and funding constraints. Eric Allen contacted CRC for potential funding to complete analysis of tree cores in conjunction with Utah State University in fall 2016 with the intent of writing a research paper.

Belnap, Jayne and Natalie Day: U.S. Geological Survey – Moab

Project: Soil Stabilization Using Synthetic and Natural Adhesives

Research: This is a short-term demonstration project prior to a larger field project being implemented in the Mojave Desert. The study will test the effectiveness of different soil stabilization materials on ground that is physically disturbed. Monitoring is scheduled every two months for the latter half of 2016. Treatments include synthetic and natural polymers, rocks, and biocrust organisms.

Bowker, Matthew, Anita Antoninka, and Cristina Rengifo Faiffer: Northern Arizona University

Project: Syntrichia Reciprocal Transplant Experiment

Research: The aim of the research is to understand how moss-dominated biocrust will respond to warming and drying in the Colorado Plateau.

Bowker, Matthew and Anita Antoninka: Northern Arizona University

Project: Biological Soil Crust Restoration and Resiliency

Research: This project is focusing on greenhouse production of both early and late succession biological soil crust species for applicability to landscape-level restoration. Research also consists of common gardens conducted across elevation gradients, with the CRC acting as the mid-elevation zone, Harts Point as the high-elevation zone, and Rio Mesa Center (USU) as the low-elevation location. The experiment is located at the CRC facility north of the pavilion. Goals include improved methods for co-culture of multiple biocrust organisms; field survival rates of greenhouse-grown biocrusts with,

and without, environmental stress mediation; and the degree of local adaptation to climate zones using common gardens along elevation gradients. CRC funded this project at \$5K level in 2016.

Chabot, Eric Hawk Watch International

Project: Indian Creek Raptor Nest Survey

Research: We will evaluate the effectiveness of broadcast surveys to determine territorial occupancy by peregrine falcons in the Indian Creek basin. This low-effort sampling method has been used with variable effectiveness in the state of NV, and with accuracy depending on territorial spacing and habitat factors. Visual surveys will be used to verify results of broadcast surveys, and to determine territorial occupancy for prairie falcons and golden eagles as well. Survey results will be shared as they are collected with BLM research partners, who will use the data to establish and/or modify ‘raptor advisory areas’, where recreation will be discouraged in order to protect these in-use nesting sites from disturbance by climbers and other recreationists. Surveys will be conducted using a speaker that plays a peregrine call, and using spotting scopes and binoculars following standard raptor monitoring procedures. Data will be shared with BLM / Bears Ears NM biologists immediately following surveys being conducted.

Cobb, Neil: Northern Arizona University

Project: Arthropod Research

Research: Pitfall traps were set in upland and riparian systems at the CRC. All specimens are at NAU awaiting identification; awaiting report and/or publication.

Duniway, Mike and Daniel Winkler: USGS-SBSC Moab

Project: Drought Resistance in Sand Dropseed, *Sporobolus Cryptandrus*

Research: *Sporobolus cryptandrus* is a warm season perennial graminoid that is widely distributed in the intermountain west. Decades of research and natural observations suggest that the species is extremely drought tolerant and often able to respond positively to stressors, including severe drought and over grazing. Sand dropseed’s success is likely owed to its prolific seed production and extensive root systems that are able to extend nearly 3 feet laterally and > 8 feet deep. Accordingly, *S. cryptandrus* is a high priority species for potential restoration projects. We plan to sow seeds from multiple populations of *S. cryptandrus* and attempt to germinate individuals under varying precipitation regimes that span what would naturally occur at seed collection sites. Seedling emergence and survival will be monitored and will be followed by harvests of individual plants to measure allocation strategies under the treatments. The study proposed here will place *S. cryptandrus* and its ability to tolerate drought into a restoration context, including an improved understanding of what populations may be best suited for increased climate variability and drought. This improved understanding can directly inform next phase propagation efforts, including seed transfer zone delineations and cultivar development.

de Anguera, Alice: Utah State University

Project: Canyonlands Research Center Communications Plan

Research: Capstone for Masters of Natural Resources at Utah State University seeking to revise the CRC Communications Management Plan; determine what collaborative success, both internal and external, means for the CRC's partners and external stakeholders; analyze mechanisms for success at comparable research organizations and in scientific literature; and develop sample outreach or communication products that makes CRC's collaborative success relevant to stakeholders.

Diamond, Judy and Alan Bond: University of Nebraska-Lincoln

Project: Dimensions of Color Resemblance in Horned Lizards

Research: Conducted a feasibility trip in 2015 for future research in horned lizard color resemblances. Past research has focused on *Corvidae* family of birds. The two researchers have recently published the book, "Concealing Coloration in Animals" (Belknap/Harvard 2013).

Duniway, Mike, Steve Fick, Nichole Barger and John Tatarko: USGS- SBSC Moab, University of Colorado – Boulder, USDA-ARS

Project: Achieving Dryland Restoration Through the Deployment of Enhanced Biocrusts to Improve Soil Stability, Fertility and Native Plant Recruitment.

Research: Evaluate changes to wind and water erosion in artificially induced biocrust communities

Garthwaite, Iris: Northern Arizona University

Project: Characterizing venation trait plasticity of a priority restoration tree species

Research: For my MS thesis research, I am using a landscape-scale common garden approach to examine the magnitude, direction, and consequences of plasticity in *Populus fremontii*. This study characterizes plasticity of leaf venation, a multivariate suite of traits linked to whole plant performance. The common gardens located in Yuma, Agua Fria, and at the Canyonlands Research Center provide a study system to disentangle the effects of environmental and genetic factors to better predict how a foundation tree species will respond to environmental conditions and how responses may vary among genotypes.

Grady, Kevin, Christopher Updike, Gery Allan, Catherine Gehring, Kevin Hultine, and Tom Whitham: Northern Arizona University.

Project: Cottonwood Genetics Experimental Restoration Garden

Research: National Science Foundation Macrosystems Biology grant awarded to study resiliency in genetic variation of cottonwood (*Populus Fremontii*) trees. The five-year study is one of three experimental gardens in a regional-scale research project investigating climate change on riparian ecosystems. Approximately 4,000 tree replications, consisting of 12 genotypes, were planted on four acres of CRC land near "The Island" in the summer of 2015. Irrigation of approximately one acre-foot per year will be obtained from the Dugout Reservoir. Further study is anticipated beyond the initial five-year grant period. CRC funded this project at \$5K level in 2016.

Havrilla, Carrie, Miguel Villareal, and John Vogel: University of Colorado – Boulder and USGS

Project: Exploring biocrust-plant community diversity relationships with unmanned aerial systems (UAS) remote sensing in Canyonlands, Utah

Research: To explore larger-scale relationships between biocrusts and vascular plant community structure, we used UAS's to collect very high-resolution (1 cm) imagery and ground measurements of biocrust and plant communities in six, 5-hectare plots within the Colorado Plateau region of Southeast Utah.

Havrilla, Carrie, Lior Gross, and Nichole Barger: University of Colorado - Boulder

Project: Biocrust Functional Recovery Across Differing Spatial Scales of Disturbance

Research: Examine how different spatial scales of soil disturbance influences biocrust recovery.

Hoover, David, Adrienne Pilmanis and Troy Wood: USGS-BRD-Moab, BLM Colorado Plateau Native Plant Program, USGS-Flagstaff

Project: C4 Grass Monsoon Manipulation

Research: Utilizing transplants of James' galleta grass (*Pleuraphis jamesii*) from four locations (Sevilleta, NM; Chaco Canyon, NM; Moab, UT; and Delta, UT), the CRC acts as a common garden to monitor the plasticity to intra-annual variability in precipitation. After one year of establishment, manipulation of the monsoon to spring precipitation ratio will be implemented using greenhouse shelters. Measurements will analyze a suite of responses including: ecophysiology, morphology, phenology, and productivity. The results of this study will inform strategies to develop seed lines adapted to the diverse environmental settings of the Colorado Plateau in need of ecosystem restoration as well as provide fundamental ecological information about a dominant species of this region.

Karban, Claire: University of Colorado Boulder

Project: Using new technologies to maximize plant recruitment in large-scale dryland restoration.

Research: This project will test two technologies – seed coating and soil pitting – as methods to improve seedling recruitment in largescale dryland restoration. There have been widespread reductions in primary productivity across the southwestern U.S. in recent decades, with up to 44% of semiarid rangelands in southern Utah showing at least some amount of degradation. Common methods to restore degraded rangelands and increase native plant recruitment are difficult or impossible across such large areas of land. In addition to the large spatial extent of degradation, low and highly variable precipitation, low soil holding capacity in soils, and high seed dormancy are challenges to seedling recruitment in dryland restoration. Seed coating is a method that encircles seeds in clay and nutrients to promote moist conditions for germination and provides protection from seed predation. Soil pitting involves creating shallow depressions in the soil that concentrate litter and topsoil, and provided protection from wind and sun. This project will apply a seed mix of native grass and forb species (grasses: *Achnatherum hymenoides*, *Hesperostipa comata*, *Leymus cinereus*, *Pleuraphis jamesii*, *Sporobolus cryptandrus*; forbs: *Oenothera caespitosa*, *Cleome lutea*) in a fully factorial design with seed coating and soil pits, plus controls (uncoated seeds and no soil modifications). Soil moisture and temperature probes will be installed across the study area to capture differences in and out of the soil pits.

Treatment effects on seedling recruitment will be monitored once every two weeks in the spring and early summer by counting and identifying seedlings. In addition to measuring the effect of seed coating and soil pitting on seedling recruitment, we will make these results scalable with the use of high-resolution imagery. We will use a drone to capture images of the study site and create a digital elevation model, comparing differences in elevation (as a result of the soil pitting) with seedling recruitment outcomes. This relationship between soil depressions and seedling outcomes can be used in future studies to map seed microsites and deliver seeds remotely across large areas.

Lewis, Leah: Utah State University

Project: Mexican Spotted Owl Habitat (Master's Thesis)

Research: Focused on identifying habitat features associated with Mexican spotted owl occupancy, nest success, and fledgling success; constructing a predictive model for the owls in Utah; analyzing owl diet and determining the primary prey species. Compared to forested habitat, canyon habitat is poorly defined. A better understanding of this species, such as identifying utilization of structural features and dominant vegetation types, as well as climate variables, helps improve management decisions.

Nehring, Kyle: Utah State University

Project: Interactive Effect of Abiotic and Biotic (Herbivory) factors on *Artemisia tridentata* Stress and Survival

Research: Past research has focused on how soil factors can influence soil water availability on sagebrush establishment. This study is focused on how browsing interacts with these factors to influence sagebrush stress and survival and provide insight on successful establishment on the Colorado Plateau. This study specifically examines the interactions between soil depth, soil texture, and herbivory on sagebrush stress and survival. CRC funded this project at \$2K level in 2016 as part of the Research Fellowships Grant.

Perkins, Dusty and Dana Witwicki: National Park Service, Northern Colorado Plateau Network

Project: Northern Colorado Plateau Network, Uplands Monitoring

Research: The Northern Colorado Plateau Inventory and Monitoring Network (NCPN) of the National Park Service have monitored vegetation and soils within the park boundary of the CRC annually since 2006. When plot establishment is completed, there will be a total of 64 long-term monitoring plots (56 grassland, three blackbrush, and five pinyon-juniper/blackbrush) in the Needles district of Canyonlands National Park. Field crews measure soil stability, hydrologic function, biological soil crusts, and characteristics of plant communities. The network's survey design selects randomized, spatially balanced sampling plots. Each plot is visited for one or two consecutive years, followed by a relatively long interval between revisits (3–6 years), which minimizes the chances of damage by repeated visits and is also a cost-effective way to estimate the health of upland ecosystems across large areas. NCPN uplands monitoring is intended to increase fundamental understanding of these systems and provide managers

with early warning of undesirable change. Initial analysis of monitoring data occurred in 2015 – 2016.

Reed, Sasha, Colin Tucker: USGS-Moab

Project: Climate Adaptive Biocrust Restoration to Restore Ecosystem Function on The Colorado Plateau

Research: To cultivate and restore biological soil crusts (biocrusts) at multiple sites in southeast Utah with the goal of re-establishing ecosystem function and building resilience to a hotter and drier future climate.

Refsnider, Jeanine: University of Toledo

Project: Lizard Community Response to Climate Change

Research: This goal is to understand how lizard communities will respond to climate change. Traits that differ spatially along an elevation gradient are likely to also allow organisms to adjust temporally to a changing climate, either through behavior changes or genetic adaptation. Research is analyzing temperature-sensitive traits in low- and high-elevation populations of four common lizard species to determine which traits differ with elevation. Specifically, behavioral adjustment of basking behavior is thought to be critical in allowing lizards to respond to a changing climate. A method is being developed that uses light-level data recorders to continuously record thermoregulatory behavior in short-horned lizards (*Phrynosoma hernandesi*) in their natural habitat. This will help determine whether the mechanistic basis of thermoregulatory behavior is genetically-driven or behaviorally-plastic and is a critical step in validating models of lizard responses to climate change.

Rushing, Dr. Clark and Kim Savides: Utah State University

Project: Utah Black Rosy-Finch Study

Research: At CRC we propose installation of a single conventional bird feeder to assess Black Rosy-finch occupancy. This feeder will be stocked with black oil sunflower seed during the winter and monitored periodically for use by rosy-finch species. If rosy-finches are using the feeder, a simple count of Black Rosy-finches will be conducted when feeding is observed. If Black Rosy-finches are seen in large numbers, we would propose integrating CRC into our state-wide network of radio frequency identification (RFID)-enabled bird feeders.

Schupp, Eugene: Utah State University

Project: Beef Basin and Dark Canyon Plateau Sagebrush Restoration Monitoring

Research: BLM-Monticello proposed landscape-scale restoration implementation using fire, herbicide, manual cutting, and mechanical reseeding targeting sagebrush-grassland ecosystems in Beef Basin and Dark Canyon Plateau. Pinyon-juniper was targeted to reduce encroachment, fuel loads, invasive species, and to promote native vegetation. The purpose of the study was to provide baseline measurements to measure success of project objectives.

Shue, Jerry: Grand County, Utah Honeybee Inspector

Project: Diversity of Feral Honeybee Populations within the Indian Creek Corridor

Research: Research is designed to provide a baseline of feral honeybee species occurrence within the Indian Creek corridor. Honeybees are not indigenous to North America, but after their arrival they have been found to exist in locations otherwise thought inhabitable. This research will monitor the use of traps, or constructed nest sites, monthly. Species of honeybees will be identified as well as a test for the presence of Varroa mite, the primary factor impacting honeybee health.

Stegner, Allison: University of California – Berkeley

Project: Paleoecology of Small Mammals

Research: Focus is on local pre-industrial and pre-human fluctuations in species diversity, and how they compare to changes resulting from current impacts, like climate change and land-use pressures. Small mammals are important indicators of climate and environment. Pairing plant and animal data in both the fossil and modern record allows for ground truthing assumptions about mammalian habitat fidelity and comparisons of local environmental change recorded in pollen to regional and global environmental change. Field work involves excavation of these fossil deposits, identification of the fossil vertebrates and pollen, modern plant surveys, and catch-and-release surveys of small mammals. Knowing the history of plants and animals in this region over the long term can help land managers prioritize conservation efforts by establishing whether modern ecosystems are significantly altered from pre-industrial baselines, which in turn clarifies the processes underlying ecological shifts through time.

Suski, Kaitlyn, Paul DeMott, Tom Hill, Yutaka Tobo and Jan Uetake: Colorado State University

Project: Analysis of Naturally Occurring Ice-Nucleating Aerosols

Research: Colorado State University's Department of Atmospheric Science, led by Drs. Paul DeMott and Tom Hill helped facilitate Ph.D. candidate Kaitlyn Suski's project analyzing ice-nucleating particles from a wide range of ecological sites across the U.S. The CRC lands were analyzed as an important land-use category – actively grazed rangelands – as part of a larger study across the country. Ice formation in clouds is a poorly understood process that can have large impacts on precipitation processes. A small subset of atmospheric aerosols, known as ice-nucleating particles, which are primarily bacterial in origin, can catalyze the formation of ice in clouds. The development and behavior of thunderstorms is linked to the initial stages of storm cloud development and can set off a series of events that act as a catalyst to intensify these storm events. Perturbation of natural ecosystems, like cattle grazing, can enhance the emission of particles and is critical to understanding changes in climate processes across ecosystems undergoing active anthropogenic use. The immediate results of this sampling period concluded with relatively low levels of ice-nucleating particles; however, seasonality and level of grazing can play a factor in total production of these particles.

Urban, Frank et al.: USGS – Denver

Project: Climate Monitoring and Dust Production Utilizing Total Suspended Particulate Collections

Research: Seeking to improve the measurement and understanding of fugitive dust emissions and deposition effects on snow pack. Dust source areas in American drylands have generated unprecedented amounts of dust since the early 2000's. Driven by climatic variations and land-use changes, dust emission from dryland regions affects many critical issues, including water-resource management of major river basins in the drought-afflicted western United States. Dust emitted from dryland settings has far-reaching effects on water resources as dust is transported hundreds of kilometers and deposited onto mountain snow cover.

Van Scoyoc, Matthew and Eugene Schupp: Utah State University

Project: USFS Ecosystem Assessment (Master's Thesis)

Research: One hundred and forty-eight plots were sampled during the field seasons of 2011 and 2012. Sampling procedures were largely based on the Monitoring Manual for Grassland, Shrubland, and Savanna Ecosystems (Herrick et al. 2009) and the National Park Service's Fire Monitoring Handbook (National Park Service 2003). Data and thesis were given to the USFS-Moab office.

Veblen, Kari et al.: Utah State University

Project: Deer, Elk, and Cattle Effects on Rangeland Plant Communities

Research: Focused on the effects on rangeland plant communities by the use of three dominant herbivores. The study used a multi-site approach to investigate the relationship between herbivory use and related ecological interactions.

Vogel, John and Geoff DeBenedetto: U.S. Geological Survey

Project: High Resolution Imagery Using Unmanned Aircraft Systems (UAS)

Research: In this demonstration project, the U.S. Geological Survey's UAS collaborated with Dr. Duniway of the USGS's Moab field office to provide a demonstration of high-resolution orthoimagery on previously field-monitored plots within the CRC lands led by Duniway and Miller (see Duniway, et al in Continuing Projects section above). The primary goal is to use this technology to characterize vegetation and biological soil crust cover using specific bandwidths of light. Using this technology, analysis of landscape-level changes can be better interpreted by geographers and ecologists.

Weiland, Brooke: California State University – Monterey Bay

Project: Scientific Illustration Internship

Status: The CRC developed a collaborative internship using current research at the CRC as a template for scientific illustration. The six-week internship occurred in August and September 2015 and resulted in the design of three interpretive panels.

Winkler, Daniel, Sasha Reed USGS-SBSC Moab

Project: Germination for Restoration Information and Decision-making (GRID)

Research: The Colorado Plateau Native Plant Program (CPNPP) seeks to identify genetically appropriate seeds for current and future restoration projects. This is evidenced in their mission and their funded studies examining the genetic structure of native plant populations across the Colorado Plateau, as well as experimental studies quantifying trait plasticity of priority graminoids. Yet, there is still much to learn before we can confidently prescribe the right seeds in the right place. Establishing a predictive understanding of how native plant responses to environmental variability scale from individuals to populations, and across populations, will enable much improved projections of which seed sources should be prioritized for seed increase efforts. We plan to examine drought-response strategies in three priority restoration species: *Sphaeralcea parvifolia*, *Cleome lutea*, and *Sporobolus cryptandrus*.

Yokum, Hannah: Brigham Young University

Project: Investigation of *Ephedra viridis* Expansion on the Colorado Plateau

Research: Past research indicates that *Ephedra viridis* is expanding its range in grassland ecosystems. This study is focused on which specific traits – eco-physiological traits such as gas exchange, peak photosynthesis periods, stomatal conductance under water stress, carbon assimilation, respiration and transpiration – may be advantageous for this species' expansion. A portion of this work is in conjunction with the USGS's EDGE experiment (see Duniway and Hoover in Continuing Projects section above) on *Ephedra* adjacent to Canyonlands National Park. CRC funded this project at \$2K level in 2016 as part of the Research Fellowships Grant.