28TH ANNUAL FRONT RANGE STUDENT ECOLOGY SYMPOSIUM

February 23rd and 24th, 2022
Colorado State University
Fort Collins, Colorado

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GRADUATE DEGREE PROGRAM IN ECOLOGY
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Welcome To FRSES 2022

The FRSES Mission

The Front Range Student Ecology Symposium is a showcase for outstanding ecological research done by secondary, undergraduate, and graduate students from schools along the Front Range and beyond. Our entirely student-run symposium is organized like a traditional scientific meeting, with an emphasis on creating a supportive atmosphere for discussion and critique and providing a venue for Front Range students to interact. We welcome the participation of any student doing ecological or ecology-related research, whether at the level of organisms, populations, communities, ecosystems, or social-ecological systems. Students may present completed research, research-in-progress, research proposals, senior or class projects, or simply ideas deserving a closer look by ecologists.

Changing Landscapes: Understanding Ecosystems of the Future

This year's theme highlights the challenges associated with studying ecology in the Anthropocene, as landscapes are altered and boundaries are blurred. In particular, we want to feature the wildland-urban interface in ecological studies with our keynote speaker, Dr. Nancy Grimm. Understanding this zone is increasingly relevant as climate change exerts new and intense pressures across landscapes. Overall, as ecosystems interact in new ways, we hope to identify ways to progress our ecological studies to find meaningful insights for the future

2021 Photo Contest Winner: Anna Clare Monlezun

Abstracts

Abstracts for all oral presentations and posters can be found on our website, frses.org, or at the end of this program.

Photo Contest

Photos of study organisms, sites, ecologists at work, and humorous ecology were submitted by FRSES 2022 attendees. Photos are on display all day Thursday in the poster hall of the Lory Student Center, where all attendees may vote for Best Photo. Voting will take place during the Poster Presentation Session.

Participation

This year's symposium includes 23 posters and 43 oral presentations, with exciting work from **Colorado State University, Metropolitan State University of Denver, University of Colorado - Boulder, University of Colorado - Denver, University of Denver, University of Northern Colorado, and the University of Wyoming.**

Judging and Awards

Faculty judges will be present during the oral and poster sessions. Prizes donated by CSU and local community sponsors will be awarded in the following categories: Best Graduate Oral Presentation, Best Undergraduate Oral Presentation, Best Graduate Poster Presentation, and Best Undergraduate Poster Presentation.

Instructions for Presenters

Oral Presentations. Presenters must meet with the moderator in their assigned room to load their presentation at least 15 minutes before the start of the session. Presentations will be limited to 15 minutes, with a recommended presentation length of 12-13 minutes, allowing 2-3 minutes for questions. Judges will be present in each session.

Poster Presentations. Posters may be set up in Room 382 of the Lory Student Center anytime between 8 am - 3 pm on Thursday. Presenters must be at their poster from 3:30 - 5:00 pm on Thursday to speak with judges and attendees. Posters must be taken down following the poster presentation session.

2022 Coordinating Committee

Executive Board: Olivia Hajek, *President*; Caitlin Miller, *Vice-President*; Aaron Prairie, *Treasurer & Financial Officer*; Kathy Condon, *Secretary*

Committee Chairs: Nico Matallana, *Fundraising*; Mary Linabury, *Social and Outreach;* Josie Smith, *Abstracts and Program;* Caitlin Miller, *Day-Of Coordination*

Committee Members: Alex Siggers, Anna Shampain, Paige Hansen, Sam Leuthold, Katie Nigro, Elizabeth Diaz-Clark, Kyle Ruszkowski, Matt Sturchio, Emma Svatos, Cozette Romero, Teia Schweizer, Carina Donne, Mel Morado, Stephen Chang

Keynote Speaker

Dr. Nancy Grimm

NANCY B. GRIMM is an ecologist studying interactions of climate change, human activities, resilience, and biogeochemical processes in urban and stream ecosystems. Grimm was founding director of the Central Arizona–Phoenix LTER and now co-directs the Urban Resilience to Extremes Sustainability Research Network and the NATURA and ESSA networks, all focused on solving problems of the Anthropocene. Grimm was President of the Ecological Society of America (ESA) and is a Fellow of AAAS, AGU, ESA, SFS, and a member of the NAS. She is an editor for *Earth's Future* and has made >200 contributions to the scientific literature with colleagues and students.

Workshop

Transforming Graduate Education to Meet the Challenges of the Anthropocene

Dr. Nancy Grimm will lead a workshop on Wednesday afternoon to discuss how graduate education can address global challenges through a new lens. At Arizona State University, Dr. Grimm directs a new graduate initiative geared at tackling problems at the Anthropocene, including enhanced mentoring and multi-disciplinary training to help students prepare for careers both within and out of academia. This workshop will introduce this new graduate initiative Dr. Grimm is leading as well as provide the opportunity to have a discussion regarding graduate training and education.

IGNITE Talks

What is an IGNITE talk? Presenters prepare 20 slides which automatically advance every 15 seconds, resulting in a fast-paced 5-minute talk. On Thursday, faculty and students will present on subjects ranging from biodiversity to navigating graduate school. The 2022 IGNITE presenters include: Ed Hall, Mary Linabury, and Natalie Buchholz.

28th Annual Front Range Student Ecology Symposium Events

Wednesday, February 23rd, 2022

4:00 - 5:00 pm	Workshop: Dr. Nancy Grimm **Transforming Graduate Education to Meet the Challenges of the Anthropocene**	Biology Building, Room 136

Thursday, February 24th, 2022

8:00 - 2:00 pm	Registration & Coffee	Outside North Ballroom
9:00 - 10:15 am	Oral Presentations - Session 1	
	Ecological Modeling, GIS, and Remote Sensing	Room 372
	Ecosystem Science	Room 374
	Evolutionary and Behavioral Ecology	Room 376
10:15 - 10:45 am	Coffee Break	
10:45 - 12:00 pm	Oral Presentations - Session 2	
	Global Change and Conservation Biology	Room 372
	Disturbance and Restoration Ecology	Room 374
	Microbial and Disease Ecology	Room 376
12:00 - 1:00 pm	IGNITE Talks & Lunch	North Ballroom
1:00 - 2:00 pm	Keynote Address: Dr. Nancy Grimm **Envisioning positive futures and nature-based solutions for the Anthropocene**	Ballroom - Cherokee Park
2:00 - 2:15 pm	Break	Ballroom - Cherokee Park
2:15 - 3:30 pm	Oral Presentations - Session 3	
	Human Dimensions of Ecology	Room 372
	Forest and Rangeland Management	Room 374
	Terrestrial and Aquatic Ecosystems	Room 376
3:30 - 5:00 pm	Poster Presentations	Room 382
5:00 pm	Closing Remarks and Awards Ceremony **Happy Hour and Band to follow**	Ballroom

Oral Presentations - Session 1

Room 372 Ecological Modeling, GIS, and Remote Sensing

9:00-9:15 Comparing bird migration networks generated from band-recovery and telemetry data.
Brooke Berger, Colorado State University

9:15-9:30 Disentangling drivers of climate vulnerability in an alpine sky island specialist
Matthew DeSaix, Colorado State University

9:30-9:45 Spatial network analyses reveal complex plant-mediated interactions between two gall-forming biological control insects
Christine Folks, Colorado State University

9:45-10:00 Developing a Novel Foliar Moisture Content Indicator for Individual Trees
Lauren Lad, Colorado State University

10:00-10:15 Tracking The Shifting Range of a Cryptic Species Using Host Data: Predicting range shifts of Celastrina echo sidara by analyzing host plant collections.
Braden Pate, Colorado State University

Room 374 Ecosystem Science

9:00-9:15 Cities, pests and trees, oh my! A tale of invasive insects in the urban forest
Jacqueline Buenrostro, Colorado State University

9:15-9:30 Soil organic carbon response to global environmental change is informed by mineral-associated and particulate organic matter
Katie Rocci, Colorado State University

9:30-9:45 Exploring Spatial Patterns in Above and Below Ground Carbon in One of the Most Carbon Dense Ecosystems.
Trevor Carter, University of Colorado -Denver

9:45-10:00 Improved restoration of arid lands affected by coal mining by applying natural humate
Ali Alghamdi, University of Denver

10:00-10:15 The effect of diet on head capsule width and number of instars in fall webworm (Hyphantria cunea)
Mykaela Tanino-Springsteen, University of Denver

Room 376 Evolutionary and Behavioral Ecology

9:00-9:15 The repeatability of evolution: conserving diversity through a microgeographic lens
Rebecca Cheek, Colorado State University

9:15-9:30 Does fear of humans drive wildlife interactions in African food webs?
Monica Lasky, Colorado State University

9:30-9:45 Using integrative conservation units to map vulnerability to future climate change in the Canada warbler (Cardellina canadensis)
Caitlin Miller, Colorado State University

9:45-10:00 Metabolic rate shapes differences in foraging efficiency in honeybee foragers
Julian Cassano, Colorado State University

10:00-10:15 Behavioral response of Carolina Wrens (Thryothorus ludovicianus) to songs altered to escape the masking effects of anthropogenic noise
Leah Crenshaw, University of Northern Colorado

Oral Presentations - Session 2

Room 372 Global Change and Conservation Biology

10:45-11:00 Interactive effects of drought and erosion push the thermal limits of grasses on the shortgrass steppe
Scott Bradfield, Colorado State University

11:00-11:15 Differential stress experiences in niche-tracking and niche-switching yellow warblers?
Noelle Mason, Colorado State University

11:15-11:30 Warming and drying winters drive extirpations of the Wyoming ground squirrel, Urocitellus elegans
Austin Nash, University of Colorado - Boulder

11:30-11:45 Effects of fire severity on the floral visitor community, pollination, and reproduction of a dominant flowering sub-alpine shrub
Blyss Bieber, University of Denver

11:45-12:00 The effect of climate change and host plant quality on the performance of a generalist insect
Claire Guzinski, University of Denver

Room 374 Disturbance and Restoration Ecology

10:45-11:00 Grasslands in Glacier National Park: 20 years of change
Nico Matallana, Colorado State University

11:00-11:15 Trees on the move: are disturbances facilitating range shifts in trees of the western US?
Katie Nigro, Colorado State University

11:15-11:30 Response of bats to severe bark beetle outbreaks and ensuing successional changes
Amanda Bevan, University of Northern Colorado

11:30-11:45 Global Evaluation of River Restoration Strategies Using Automated Content Analysis
Aziz Syammach, Colorado State University

11:45-12:00 Tracing Tamarix control and its outcomes in the American Southwest: a systematic review and meta-analysis
Alex Goetz, University of Denver

Room 376 Microbial and Disease Ecology

10:45-11:00 Water deficit affects interkingdom microbial connections in plant rhizosphere
Kate Bazany, Colorado State University

11:00-11:15 No evidence for compensatory recruitment in response to disease in high elevation amphibian populations
Bennett Hardy, Colorado State University

11:15-11:30 Microscopic time travelers: A finely tuned, time-resolved analysis of viral and microbial communities in the Erpe river
Josué Rodríguez-Ramos, Colorado State University

11:30-11:45 Few microbial groups of fine taxonomic resolution drive overall microbial community response to drought in grassland ecosystems.
Alex Siggers, Colorado State University

11:45-12:00 Below-ground soil microbial functioning varies in resistance to drought across a precipitation gradient in the central US grasslands
Leena Vilonen, Colorado State University

Oral Presentations - Session 3

Room 372 Human Dimensions of Ecology

2:15-2:30 What's in a name? The paradox of citizen science and community science
Dani Lin Hunter, Colorado State University

2:30-2:45 The role of Indigenous-led land stewardship in shaping mammal conservation in the tropics of Guatemala
Tamara Layden, Colorado State University

2:45-3:00 Graduate Field Leadership: Challenges, Successes and Suggestions
Kate Hayes, University of Colorado - Denver

Room 374 Forest and Rangeland Management

2:15-2:30 Virtual Fencing Case Study in Colorado: An Emerging Technology in Ranching and Rangeland Management
Giovanni Borsari, Colorado State University

2:30-2:45 The Effects of Drought on Resource Allocation in Pinus ponderosa
Angie Gonzalez, Colorado State University

2:45-3:00 Effects of forest microclimates on juvenile tree survival vary with climate and life-stage
Edward Hill, Colorado State University

3:00-3:15 Overlapping bark beetle outbreaks have unexpected consequences in the southern Rocky Mountains
Niko Tutland, Colorado State University

3:15-3:30 Soil C impacts of cheatgrass remediation and grassland restoration
Ellie Ellis, Colorado State University

Room 376 Terrestrial and Aquatic Ecosystems

2:15-2:30 Burrow sites of Aphonopelma hentzi (Girard, 1854) in Southeastern Colorado.
Jackie Billotte, Colorado State University

2:30-2:45 Seedling functional traits may explain changing dynamics in an everwet neotropical forest
Sam Smith, Colorado State University

2:45-3:00 Grassland plant community response and recovery from extreme drought
Maggie Ross, Colorado State University

3:00-3:15 Centennial to Decadal-Scale Changes in Algal Production and Community Composition in Santa Fe Lake, New Mexico
Anna Shampain, Colorado State University

3:15-3:30 Environmental gradients impact key leaf traits in riparian trees
Mandy Malone, University of Denver

Poster Presentations - Room 382

1. Trade-off between responses to drought and neighborhood cover among grassland communities along a precipitation gradient
   Hailey Mount, University of Wyoming
2. Human-generated noise has larger effects on cricket behavior than life history or reproductive investment
   Sophia Anner, University of Denver
3. What urban features mediate habitat use by Cooper's hawks in Denver, CO?
   Alyssa Davidge, University of Colorado, Denver
4. Sex Ratio Effects on Pair Bond Formation in Convict Cichlids (Amatitlania Nigrofasciata)
   Rory Van Lieu, Metropolitan State University of Denver
5. Examination of Migratory Bird Flight Calls in Relation to Radar Forecasting
   Madison Chudzik, Colorado State University
6. Density-dependence outweighs habitat influences on brook trout condition in the Southeastern US
   George Valentine, Colorado State University
7. Effects of ecological restoration treatments on understory plant diversity and productivity in Colorado dry conifer forests
   Ariel Demarest, Colorado State University
8. Restoring heterogeneity: the impact of creating mounds and slash piles on species diversity at a disturbed sagebrush parkland.
   Becca Harris, Colorado State University
9. Fungal friends and foes: Effects of mycorrhizal inoculation on disease response in hybrid poplars
   Kaydee Barker, Colorado State University
10. Responses of a semi-arid grassland to climate change-induced alterations in the seasonal availability of water
    Olivia Hajek, Colorado State University
11. Plant water use in Front Range wetlands
    Anna Wright, Colorado State University
12. Assessing How Perceived Poaching Risk Alters Forest Elephant (Loxodonta Cyclotis) Distribution and Activity
    Ana Verahrami, Colorado State University

Poster Presentations - Room 382

13 Community composition of trematode parasites along a river continuum
Falke Landon, Colorado State University

14 Disturbance and disease: effects of wildfire on host-parasite interactions
Emma Svatos, Colorado State University

15 Improving soil moisture sensor protocols in agrivoltaics systems
Tillie Pinkowitz, Colorado State University

16 Estimating return on investment from carbon sequestration and other ecosystem services to inform policy decisions
Ben Choat, Colorado State University

17 Ecosystem responses to extreme precipitation events during wetter-than-average conditions in the semi-arid shortgrass steppe
Kathy Condon, Colorado State University

18 Applying the In-N-Out framework to a meta-analysis of hierarchical controls on soil carbon storage and nitrogen recycling across North America and Europe
Paige Hansen, Colorado State University

19 The role of litter chemistry and degree of carbon saturation deficit on soil organic matter formation
Laura Moore, Colorado State University

20 Changes in the soil microbiome
Andie Gonzales, Colorado State University

21 Ecological processes of the dryland soil microbiome shift across a systemic breakdown phase aridity threshold
LeAundra Schopflibn, Colorado State University

22 Soil aggregates - the tiny homes for soil organic matter
Rebecca Even, Colorado State University

23 Exploring shifts in the character and distribution of soil organic matter fractions across a physiochemical soil gradient
Sam Leuthold, Colorado State

Abstracts

Improved restoration of arid lands affected by coal mining by applying natural humate

Ali Alghamdi

The restoration of extremely arid ecosystems depends upon choosing effective techniques to re-establish vegetation after disturbance. To this end, we are investigating the value of using a by-product of mining, in the rehabilitation of degraded land in New Mexico. One such by-product is humate, the salt of humic acid, derived from coal mining. Humic acid can influence plant growth by decreasing pH in soils, and affecting nutrient availability important for plant growth. To determine if humate can be used in reclamation, we measured vegetation in plots established by Habitat Management, inc. that had humate of two depths applied with or without topsoil, plus a control (5 treatments x 4 replicates). Within each plot we counted seedlings and estimated % cover within each plot. We also performed a PCA on %cover by species for a measure of the plant community; PC1 could be interpreted as a measure of weediness. Our first-year results suggest that total vegetation cover and specifically weedy cover are significantly higher with topsoil, regardless of humate depth. Whereas, the total number of seedlings significantly increased with the addition of low humate regardless of topsoil. This study has important implications for developing effective techniques for restoring degraded environments.

Human-generated noise has larger effects on cricket behavior than life history or reproductive investment

Sophia Anner

Human-generated noise pollution is ubiquitous across most communities and can cause changes in stress responses, vocalizations, foraging, anti-predator behavior, and reproductive success. Despite their broad ecological significance, very little noise research in the last 20 years has assessed effects on invertebrates. Previous work in our lab showed that chronic masking traffic noise disrupts cricket reproduction by interrupting mate location and reducing adult lifespan. Here, we expand that work to investigate (1) the effects of traffic noise on reproductive investment, life-history, and immune traits; (2) whether these effects can be mitigated if the noise experience changes; and (3) the extent that impacts of noise affect future generations. We reared crickets in silence or three traffic noise treatments and at adulthood, re-assigned each cricket to one of the four noise treatments, mimicking potential adult dispersion. Preliminary results suggest that, unlike behavior, reproductive traits (reproductive organ mass, sperm live to dead ratio) and number of offspring were not affected by exposure to noise. As this experiment is ongoing, it remains to be seen how survival to adulthood and immune measures are affected, as well as the impacts on the same traits measured in the offspring.

Fungal friends and foes: Effects of mycorrhizal inoculation on disease response in hybrid poplars

Kaydee Barker

Poplars are an ecologically and economically important crop used for biofuels and bio-based products. Poplars are susceptible to cankers and leaf rust-causing pathogens that threaten the survival and quality of the crop. Arbuscular mycorrhizal (AMF) and ectomycorrhizal (EMF) root symbiotic fungi provide poplars with nutrients in exchange for carbon. AMF and EMF may also support inter-plant communication and improved disease resistance. To test disease resistance across mycorrhizal groups, Populus canadensis (hybrid poplar) cuttings were exposed to Phomopsis macrospora canker and Septoria musiva leaf spot and grown for 4 months in a greenhouse: a) un-inoculated, b) inoculated with AMF taxa: Funneliformus mosseae, Rhizophagus irregularis, or Scutellospora calospora, and c) inoculated with EMF taxa: Paxillus involutus, Laccaria bicolor, or Cenococcum geophilum. We found no differences in the rate of infection across treatments. However, the rate of survival was higher for AMF-treated poplars compared with EMF, largely attributed to the success of R. irregularis-inoculated plants. Leaf and root biomass was also highest for R. irregularis, suggesting that it may be the ideal fungal symbiont for supporting disease resilience in P. canadensis. Contrasting low survival rates and biomass production of EMF indicates these taxa may turn from mutualism to antagonism under disease-induced stress. This study provides evidence for the effectiveness of specific mycorrhizal inoculants to increase disease resistance in poplars, while highlighting the need to investigate mycorrhiza-mediated disease responses.

Water deficit affects interkingdom microbial connections in plant rhizosphere

Kate Bazany

We examined the influence of water deficit stress on bacteria, fungi, and protists associated with corn and sugar beet rhizospheres. We found that the impact of water deficit on rhizosphere alpha and beta diversity varied by microbial kingdom. Bacteria and protists were more strongly influenced by water deficit conditions than fungi. Inter-kingdom interactions changed as well. Positive interactions between kingdoms increased in the water deficit condition, which could indicate that external stress was exerting a top-down control that overshadowed the influence of predation and competition in the community. We also identified phyla that were most influenced by the water deficit condition, which would likely indicate drought tolerance or sensitivity. Insights into these complex interactions will advance our understanding of the ecological processes that govern microbiome assembly and will be crucial in the development of targeted and effective microbial amendments that can improve crop fitness and productivity under drought. These findings additionally make a compelling case for including protists in future soil microbiome research to understand multi-kingdom interactions.

Comparing bird migration networks generated from band-recovery and telemetry data.

Brooke Berger

Migratory bird hosts are one of the primary routes by which new strains of avian influenza enter North America from Asia. In order to determine the frequency of these introductions, and to predict when and where they will occur in the future, we need a clear picture of host migration patterns. A network approach allows us to identify migratory communities that move between continents and identify key monitoring locations to detect this movement. The best information on bird movement in North America is from band recovery data where birds are located only twice in their life. In contrast, data on Asian birds comes from telemetry studies where each bird has many locations over time. We want to know if networks made from each data type show significantly different structure. We pruned banding and telemetry networks to the same spatial extent, and compared edge distribution, connectance, and centrality measures. In order to combine each data type into a single network we propose framing this as a missing data problem, where telemetry represents a more complete picture of bird movement, while banding data represents a beginning an end. A Markov process model may be used to infer the middle part of bird movement that is missing in the banding data set while also incorporating sources of bias from different marking methods.

Response of bats to severe bark beetle outbreaks and ensuing successional changes

Amanda Bevan

Climate change has caused increased frequency and severity of disturbance events globally, including widespread bark beetle outbreaks in North America and Europe. Forests recovering from intense outbreaks undergo a series of successional changes that include competitive release of forest-floor vegetation and growth of understory trees. Although bats are known to be impacted by altered habitat structure, how bats are affected by beetle kill and ensuing changes in forest structure remains elusive. Front Range bats in northern Colorado are segregated into foraging guilds including forest, open, edge, and generalist species. I measured overstory and understory vegetative changes and deployed Wildlife Acoustics SM Mini Bat detectors within various successional stages to quantify how disturbance and recovery alters bat assemblage composition and activity (calls/night) from June to August of 2020 and 2021. Results from a Non-metric Multidimensional Scaling ordination on data collected in 2020 indicated there is some cohesion of species-specific responses to forest succession according to bat foraging guilds. Forest structure prior to the outbreak event is driving species response patterns as there was low average nightly detections for all bat species in stands with higher percentage beetle kill and higher volumes of newly fallen trees. Additional sites were surveyed in 2021 and those data will be incorporated in this analysis to compare with results from the 2020 dataset. This study will contribute to our understanding of the impacts of climate change on bats in high elevation ecosystems as these habitats are expected to become important refuges with climate warming at lower elevations.

Effects of fire severity on the floral visitor community, pollination, and reproduction of a dominant flowering sub-alpine shrub

Blyssalyn Bieber

Anthropogenic climate change is driving extreme fire events with lasting effects on biological communities and the ecosystem services they provide. The Rocky Mountains have forests that are recovering from mixed severity wildfires that burned ~20 years ago, which can help us understand how native bees and their pollination services are impacted long-term by fire severity. To determine how fire severity impacted bee visitation and pollination of a dominant flowering shrub, we sampled the community of native bees foraging on wax currants (Ribes cereum) throughout the flowering season in high severity, low severity, and unburned sites in the Pike National Forest. By comparing abundance and diversity of native bees visiting R. cereum, we saw a trend of both lowest diversity and lowest abundance at low severity sites. Notably, we were the first to document the pollinator community for R. cereum with Lasioglossum being the most common pollinator at all fire severities. We simultaneously conducted a pollinator exclusion experiment using R. cereum to compare effects of pollination services across fire severities. Full pollinator exclusion had the lowest mean fruit set indicating native bees are effective pollinators. Additionally, we found that fire severity did not affect fruit set. This study bridges a knowledge gap in our understanding of how climate change will influence ecosystem services within the Rocky Mountain region.

Burrow sites of "Aphonopelma hentzi" (Girard, 1854) in Southeastern Colorado.

Jackie Billotte

Tarantulas are a charismatic arthropod of the short-grass steppe, where a main land use is grazing by cattle. Little is known about nesting sites of even the most common tarantula species, nor how grazing affects nest density. We compared the nesting sites of "Aphonopelma hentzi" living in Southeastern Colorado by examining soil conditions, proximal ground cover, and the density of nests at sites that were grazed and ungrazed by domestic cattle ("Bos taurus"). The density of "A. hentzi" nests were determined using distance sampling at five sites within the Southern Plains Land Trust. We visually estimated the ground cover within a 30 cm^2 area around each burrow as well as at control locations every 200 meters. Initial results showed that burrow density was higher in locations that were more frequently grazed higher amounts of loose soil. Ranching has a strong effect on the lands used for grazing and can drastically alter the ecosystem. Understanding how "A. hentzi" nesting preferences are affected by ranching can help to predict how the populations in Southeastern Colorado may respond allows humans to better co-exist with tarantulas by maintaining habits that encourage tarantulas to nest in areas that will not find them in conflict with humans.

Virtual Fencing Case Study in Colorado: An Emerging Technology in Ranching and Rangeland Management

Giovanni Borsari

Virtual fencing is an emerging technology with many promising applications in agriculture, rangeland management, and conservation. Collars are fitted to cows, and through the use of global positioning systems (GPS), virtual fences are drawn onto maps using a smartphone, tablet, or computer. The collars provide auditory and electrical stimuli when the cow moves too closely to the virtual perimeter. This discourages any further forward movement and guides the animal back into the desired grazing area. In this presentation, we share lessons learned about this new technology that was used at Fitch Ranch, one of the first livestock operations in Colorado to adopt virtual fencing. In this case, virtual fencing provided an economical alternative to rebuilding the barbed wire fences burned in the East Troublesome Fire of 2020. This technology also has the advantage of tracking each cow's movement and allowing for flexible, targeted herding capabilities. We analyzed daily sound and shock stimuli counts for each cow during the training period and the following summer months to better understand their learning and the efficacy of this technology at controlling cattle movement. Findings and lessons learned are discussed in terms of their implications for animal welfare and behavior, operational efficiency, and technological design.

Interactive effects of drought and erosion push the thermal limits of grasses on the shortgrass steppe

Scott Bradfield

The shortgrass steppe (SGS) of Eastern Colorado is dominated by C4 perennial grasses, which heavily rely on below ground meristems for the next year's production. Because these meristems are found in the crown tissue below the soil surface, they are generally protected from aboveground disturbances like fire, grazing, and heat waves. However, erosion can expose the crown tissue and roots to a harsher microclimate than beneath the soil surface. A notable example is that the soil provides insulation around the crown tissue preventing it from reaching the thermal limits of the meristems during fires and heat waves. Although fires have been commonly studied in grasslands, the intense solar radiation received by the SGS can also lead to high temperatures at the soil surface. The surface temperature on the SGS have been recorded at temperatures over 70°C during years with low precipitation. These low precipitation years are also accompanied with limited aboveground production. Meaning that any crown tissue that has been eroded likely lacks the shading effects of the canopy and can also experience temperatures up to 70°C. Exposure to this temperature, even for a limited amount of time, has been shown to be lethal to the meristems, substantially contributing to the lag effect that is observed when grasslands are recovering from droughts.

Cities, pests and trees, oh my! A tale of invasive insects in the urban forest

Jacqueline Buenrostro

Urban ecosystems are gaining international importance as the fastest growing habitat type in the world, with the majority of the global population inhabiting them. Trees within urban areas (urban forests) are critically important for providing ecosystem services to this growing urban populace, but their health is threatened by invasive insects. Insect density and damage vary in different sites across urban landscapes, such that trees in some sites experience outbreaks and are severely damaged while others are relatively unaffected. To protect the urban forest against damage from invasive insects and support future delivery of ecosystem services, we must first understand the factors that promote insect density and damage to their hosts across urban landscapes. This research explores how a variety of environmental factors that vary across urban habitats influence density of invasive insects. Specifically, we evaluate how vegetational complexity, distance to buildings, impervious surface, canopy temperature, host availability, and density of co-occurring herbivores impact three invasive pests of elm trees. We found that insect responses to these factors were species-specific, with the direction and strength of associations influenced by insect biology and life history. Results of this study can be used to inform future pest management and tree care efforts in cities, making urban forests more resilient in an era where globalization and climate change make them particularly vulnerable.

Exploring Spatial Patterns in Above and Below Ground Carbon in One of the Most Carbon Dense Ecosystems.

Trevor Carter

The coast of southeast Alaska and British Columbia is the largest temperate rainforest and one of the most biomass dense ecosystems in the world; biomass carbon frequently exceed 500 Mg/ha and soil organic carbon stocks are of a similar magnitude. Unfortunately, accurate and spatially explicit assessments of carbon in this region are difficult because the area is large and lacks substantial infrastructure, precluding extensive plot-based studies. Additionally, global estimates of this region are coarse and inaccurate. Identifying the contexts in which carbon stocks are either promoted or constrained both aboveground and belowground, and in concert is important to predict future carbon sequestration and to understand relationships with ecosystem functioning, and ecological community dynamics. Here, we explore the landscape contexts that lead to convergence or divergence in above and belowground carbon. Using high resolution, spatially explicit estimates of both above and belowground carbon storage across southeast Alaska and coastal British Columbia, we examine spatially explicit correlations between carbon, climate, topographic, and management covariates to determine what landscape features lead to hotspot convergence and what features lead to divergence. We then examine the history of forest management and ecosystem disturbances to see how carbon hotspots and management are collocated, asking where those hotspots are preserved and where they are impacted. Results here are crucial to understanding the intersection between ecological communities, ecosystem carbon/biomass, and human management.

Metabolic rate shapes differences in foraging efficiency in honeybee foragers

Julian Cassano

Metabolic rate (MR) is the rate at which organisms process energy and is often considered as the fundamental driver of life history processes at all levels of biological organization. The link between MR and life history is primarily mediated via foraging, which shapes the energy acquisition patterns of an individual, leading to the prediction that individuals with different MR likely vary in their foraging strategies. However, such links have rarely been investigated in the context of optimal foraging theory, which is a powerful framework for understanding how animals maximize their foraging returns. Many central place foragers such as honeybees are known to maximize their energetic efficiency rather than the rate of energetic gain. We therefore investigated if individuals of low and high MR differ in terms of these foraging currencies using genetic lines of honeybees with different MR. Our results show that low MR foragers visit more flowers during a single foraging trip and have higher energetic efficiency than high MR foragers in both low and high resource conditions. We discuss the significance of these results in the context of division of labor and the adaptive role of phenotypic diversity in MR in a social insect colony.

The repeatability of evolution: conserving diversity through a microgeographic lens

Rebecca Cheek

Can we predict evolution? We see different species exhibit similar traits in response to similar environmental pressures. Yet there is no guarantee that natural selection, the deterministic process that may drive these similarities, has a singular genetic basis. The Island Scrub-jay offers the opportunity to study how adaptation to ecologically similar environments may reach phenotypic convergence through either the same (parallel) or different (non-parallel) processes within a shared genetic background. In this study, I scrutinize patterns of genomic divergence using tens of thousands of single nucleotide polymorphisms from 180 individual Island Scrub-jays to determine if repeated patterns of bill divergence in different habitats have arisen through similar or differing genomic pathways. Understanding the genomic repeatability in the evolution of traits between individuals allows for a deeper understanding of the processes that generate variation within and between populations and the predictability of evolutionary change in nature. This is critical for the effective management of the Island Scrub-jay and other species that are vulnerable to the rapid environmental fluctuations predicted to occur with global climate change. As species that demonstrate non-parallel evolution to similar habitats may be incompatible and should therefore be managed as genetically and evolutionary distinct.

Estimating return on investment from carbon sequestration and other ecosystem services to inform policy decisions

Benjamin Choat

About 15-20% of the acres of irrigated agriculture in the South Platte River Basin (SPRB) of Colorado are expected to be dried by 2050. Many of the agrarian communities in the SPRB that rely on irrigated agriculture as an economic driver are likely to be heavily impacted. One option to keep financial capital in those communities is to adopt payment-for-ecosystem services policies, but timely assessment of the return on investment from various land uses is needed for good policy decisions. Therefore, this work investigated the ecosystem service of carbon sequestration (CS) and methods that may be used for policy-relevant analysis of CS. Insights about identified methods (e.g., spatially explicit benefit transfer) will be discussed. COMET-Planner (NRCS & CSU) was identified as an appropriate tool and was used to estimate annual carbon sequestration from three scenarios where irrigated agriculture was converted to more natural cover in three areas of interest in the SPRB. Ranges of return on investment (ROI) values were estimated using values identified from literature review for social cost of carbon, discount rate, and time preference and Monte-Carlo simulations. Values of ROI ranged over tens-of-millions of dollars for two of the three areas of interest. An R-Shiny app was created for easy assessment in other areas of the SPRB.

Examination of Migratory Bird Flight Calls in Relation to Radar Forecasting

Madi Chudzik

Billions of migratory birds make their way across the continent each fall and spring season as they move to and from their breeding grounds. Understanding this phenomenon is critical if we are to help protect migratory species and the ecosystems they rely upon. Weather surveillance radar (WSR) is a somewhat recently developed tool used to predict patterns and magnitude of movements on a nightly basis. However, on-the-ground observations that help elucidate the accuracy of these forecasts are somewhat sparse, limiting their effectiveness as a tool. We conducted a descriptive study of migration during the fall and spring seasons from a single site along the Front Range of Colorado. Using nocturnal flight calls (NFCs) of migratory birds, we examined taxonomic composition, timing, and density of birds in relationship to nightly migration forecasts. NFCs were collected using acoustical recording units and identified by a trained observer. Our results reveal patterns and prevalence of migratory bird species at our study site, and that these observations are fairly in line with nightly migratory forecasts. We are currently still investigating the impact of air quality on this relationship, but this largely unaccounted for variable might have negative consequences on migratory ability and thus impact the accuracy of migratory forecasts.

Ecosystem responses to extreme precipitation events during wetter-than-average conditions in the semi-arid shortgrass steppe

Kathy Condon

In water-limited grasslands, ecosystem processes are largely driven by soil moisture pulses caused by discrete rain events, including statistically large rain events (deluges). With climate change, extreme rain events are expected to increase in both size and frequency, and arid and semi-arid systems are expected to be particularly sensitive to these changes. Here, we designed an experiment to assess how a mid-summer deluge during an already wet season affected ecosystem function in the shortgrass steppe (SGS) in Northeastern Colorado. Previous experiments have shown that ecosystem processes in the SGS are responsive to deluges, and some processes (aboveground net primary production (ANPP), soil respiration) show linear increases in both dry years and years with extreme amounts of rainfall. In 2021, April-June precipitation amounts were ~50-140% higher than the monthly long-term averages in the SGS. So, in mid-July, we imposed a 60mm deluge to our treatment plots and monitored several response variables including soil moisture, soil respiration, ANPP, and canopy greenness. We found some evidence that a deluge during an extreme wet season affects ecosystem function as inferred through carbon cycling measurements. These findings will have important implications for understanding ecosystem saturation points and functioning during extreme hydrologic years. Further, our findings can be compared with previous studies to assess differences in responses to deluges when preceding conditions vary.

Behavioral response of Carolina Wrens (Thryothorus ludovicianus) to songs altered to escape the masking effects of anthropogenic noise

Leah Crenshaw

Anthropogenic noise pollution presents animal signalers with novel acoustic environments. Compressor stations associated with shale gas extraction produce 90-100 dB of chronic, low-frequency noise. Previous research by the authors found that Carolina Wrens sang at higher minimum frequencies near active compressor stations compared to quieter well pads in Arkansas. We sought to determine if these altered songs allow signalers to minimize information loss in noisy environments by determining if altered songs elicit different responses from receivers in quiet and noisy conditions. In summer 2018 and 2019, we exposed 16 male wrens to altered and typical songs under quiet and simulated noisy conditions, then analyzed their behavioral response to playback. A playback speaker and noise speaker were placed in each bird's territory for four trials with the following conditions: altered song/noise, altered song/quiet, unaltered song/noise, and unaltered song/quiet. Each 30-minute trial had three phases: pre-, during, and post-playback during which we recorded the number of songs and flights, closest approach to playback speaker, time spent within 5m of the speaker, and latency to sing or approach the speaker. We determined the minimum and maximum frequency, the frequency range, and phrase length for five randomly selected phrases in each phase. Statistical analysis is ongoing. This research moves beyond identifying the effects of noise pollution on signal production by evaluating the impact of altered signals on recipient behavior.

What urban features mediate habitat use by Cooper's hawks in Denver, CO?

Ally Davidge

Urban landscapes have expanded exponentially across the globe within the last century. Urbanization is often discussed as a degenerative force for habitat structureand complexity; however, recent research suggests these environments may also offer benefits to wildlife. Raptor species face increased disturbance from human activity and higher risk of disease, yet thrive on abundant prey and procure nesting habitat earlier in the breeding season. Studies examining Cooper's hawk (Accipiter cooperii) populations over the past 20 years indicate that this species uses human disturbance to maximize foraging outcomes and urban landscape design to increase reproductive success. Denver represents an intersection of different ecological regions because of its location on the foothills of the front range. Habitat partitioning, dictated by food availability and habitat quality, is an important factor that differs between urban and ex-urban Cooper's hawks, but has yet to be effectively modeled for Denver. This research will explore how habitat features such as tree species and size, patch density, and urban landscape composition influence habitat use by finding nesting pairs and identifying which elements of occupied territories occur more than expected due to chance. By measuring the relationship of site occupancy to habitat availability, we can determine what features of the urban environment best predict occupancy by urban pairs and better inform future urban planning as well as wildlife conservation in the city.

Effects of ecological restoration treatments on understory plant diversity and productivity in Colorado dry conifer forests

Ariel Demarest

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

Disentangling drivers of climate vulnerability in an alpine sky island specialist

Matt DeSaix

Characterizing threats to species's persistence in the face of climate change is critical for development of conservation efforts to preserve biodiversity. While forecasting ecological niche shifts and genomic maladaptation are commonly used independently to identify potential climate vulnerability, using the two in combination can reveal novel insights. In this study, we present an integrated framework for understanding where future suitable habitat may exist for an organism to persist, and the magnitude of genetic change required to adapt to those conditions. We demonstrate this approach with the Brown-capped Rosy-Finch (Leucosticte australis), an alpine-obligate species predominantly restricted to the Colorado Rocky Mountains. We show that future forecasted suitable habitat is not predicted to be available in new regions and existing forecasted suitable habitat contracts to higher elevations. The magnitude of genetic changes required to keep pace with climate change vary across the breeding range but measures of climate niche shift show that large portions of the range are shifting to novel climate conditions. Our results highlight the importance of characterizing the prevalence of novel conditions for genomic maladaptation forecasting given the uncertainty in extrapolation and the potential for underestimating vulnerability. Overall, our study demonstrates that integrating ecological niche shifts with predictions of genomic maladaptation can facilitate more nuanced predictions of climate impacts.

Soil C impacts of cheatgrass remediation and grassland restoration

Ellie Ellis

Cheatgrass (Bromus tectorum L. and related species) has become one of the most damaging invasive species in western rangelands and savannas. In addition to reducing the abundance and diversity of native species, cheatgrass invasion may also impact soil carbon storage (e.g. limited C inputs and shallow distribution from annuals compared to perennial species). Herbicide treatments may be used to suppress cheatgrass over several years, resulting in recovery of native perennial species. If the recovery of perennials can be maintained over time, then it is possible that soil carbon stocks could recover, possibly to near pre-disturbance levels. The purpose of the study was to compare soil carbon and nitrogen stocks for treated (herbicided) and untreated grasslands at three sites in the Central Rocky Mountain region. Field work was carried out in spring 2021, with collection of soil, litter and aboveground biomass samples from three field trials treated with Indaziflam and other herbicide mixtures and untreated control sites. Soil organic C and total N concentration data suggest that there is no significant difference in soil C and N stocks between the treated and untreated plots. Absence of treatment difference is likely because of the low productivity and annual C assimilation rates in the study ecosystems and lack of time elapsed since treatment (ca. 4 years).

Soil aggregates - the tiny homes for soil organic matter

Rebecca Even

Loss of soil organic matter (SOM) as CO2 to the atmosphere has accelerated efforts to better manage soils and contribute to climate change mitigation. One way to regain SOM is to enhance soil structure by preserving or stimulating aggregation, a structural property affected by tilling or land use change. The mechanisms by which aggregation protects SOM are unclear however. I aim to understand how aggregation impacts two proposed pathways of SOM formation. One is through decomposing structural plant inputs that form particulate (P) OM. The other forms mineral associated (MA) OM via soluble plant inputs and their microbial transformations. To track SOM dynamics, I designed a yearlong incubation study using 13C labeled structural (SPC) and soluble (HWE) plant material added to a highly aggregated soil (HA) and a soil with low aggregation (LA). Both soil types were left undisturbed (U) or crushed (D) to break aggregates. Two destructive harvests occurred to assess newly formed and persistent SOM. I proposed that efficient MAOM formation would occur most with HWE in HA soil but that MAOM persistence would not be affected by treatment, POM would persist most in the U soils, and that HAD soil would regain aggregation with SPC. Data analysis is ongoing. I will present on CO2 respiration, POM and MAOM formation, and aggregate dynamics.

Spatial network analyses reveal complex plant-mediated interactions between two gall-forming biological control insects

Christine Folks

An important issue for biological control programs is whether to control invasive species by single or multiple releases of biocontrol agents. It is unknown how spatial arrangement on a shared host plant influences the magnitude and direction of indirect interactions between insects. We constructed spatial networks of the galls of two biological control agents on Rhaponticum repens to examine the plant-mediated interspecific and intraspecific interactions of two gall insects (i.e., a midge Jaapiella ivannikovi and wasp Aulacidea acroptilonica), asking how insect identity and spatial arrangement influence the direction (i.e., positive or negative) and magnitude of interactions as well as whether oviposition choices are made according to fitness outcomes. We demonstrate that for the gall midge, facilitation occurs at the stem level, but competition occurs at the plant level. We suggest that within a stem, midge galls intercept plant resources drawn upward through stems by co-occurring galls, while between stems midge galls experience both interspecific and intraspecific competition for plant resources.

Tracing Tamarix control and its outcomes in the American Southwest: a systematic review and meta-analysis

Alex Goetz

Control of invasive Tamarix spp. trees and associated riparian restoration in the American Southwest has been of great interest to scientists and resource managers for decades. Hundreds of studies have reported highly variable outcomes of control efforts. We conducted meta-analyses on papers that quantitatively measured a variety of responses, within different temporal and spatial scales, to removal of Tamarix. Using 54 published sources that resulted in 777 data points, we analyzed responses to control by management approach and ecosystem component (e.g., vegetation, fauna). We found significantly positive responses of vegetation metrics overall to biocontrol, herbicide, and cut-stump treatments. However, while treatments were effective at reducing Tamarix cover, there was no consistent impact on desirable vegetation. Metrics other than vegetation, including fauna, soils, and hydrogeomorphic dynamics were too infrequently measured to draw conclusions. Overall, our results suggest that common removal methods are generally effective at reducing Tamarix cover, but the more indirect effects on other aspects of the ecosystem are variable and remain understudied. Despite calls for increased monitoring, these findings reveal that more work needs to be done to determine general patterns of ecosystem response to this common restoration approach.

Changes in the soil microbiome

Andie Gonzales

The soil microbiome affects the health of the plants and protects them from pest and abiotic conditions, therefore it is important to understands climatic change will affects soil microbes and microbe-plant interactions directly and indirectly. In this research a time series of soil community data from the B4WarmED (Boreal Forest Warming in an Ecotone in Danger) long-term climate research project is studying with the help of 16S ribosomal RNA and ITS. We found that changes of microbial community under elevated temperature.

The Effects of Drought on Resource Allocation in Pinus ponderosa

Angie Gonzalez

Extreme droughts and warming temperatures increase pressure on trees to adequately distribute resources and ultimately make them more susceptible to mortality and regeneration failure. A considerable body of research has focused on life history theory, yet few general conclusions can be made on the physiological, environmental, and genetic mechanisms behind resource allocation. To better gauge how species are able to acclimate to future increases in aridity and drought, we assessed tradeoffs in resource allocation between tree growth, defense, and reproduction across scales (annual, individual, and site-level) among Pinus ponderosa. We found evidence of a defense-reproduction and growth-reproduction tradeoff among individuals (annual-level), where total resin area and growth were lower in years of high cone production. Site drought conditions and individual drought resistance were not associated with resource allocation across individuals but impacted annual growth-reproduction tradeoffs across years. Trees with higher drought resistance showed less of a tradeoff between cone production and growth, yet trees located in sites with higher drought conditions showed stronger tradeoffs between annual reproduction and growth. Our results indicate the impact that drought conditions and drought resistance has on resource allocation patterns and tradeoffs, underscoring the importance of drought adaptation on future forest fecundity and individual fitness.

The effect of climate change and host plant quality on the performance of a generalist insect

Claire Guzinski

Climate variability has increased in recent decades and this trend is predicted to continue, resulting in an increase in extreme temperatures worldwide. In particular, heatwaves are increasing in both intensity and frequency and as ectotherms, insects are especially affected by temperature variation. As the most ubiquitous terrestrial herbivores, insects are key members of most ecosystems; therefore, we must understand how temperature extremes affect insect herbivores and their interactions with their host plants. The fall webworm (Hyphantria cunea) is a generalist herbivore native to North America and feeds on dozens of different hosts. In this study, we evaluated the effects of elevated temperature regimes and heat wave conditions on fall webworm caterpillar performance using fitness proxies of survival, development time, and pupal mass. Additionally, we examined whether caterpillar mortality and development are mediated by different diets while under temperature extremes. Our results suggest that increased temperatures negatively impacted fall webworm performance but that some of these negative effects were mediated by diet. Further, fall webworm performance during a heatwave was dependent on host plant and we found a significant interaction between host plant and heatwave duration. Our work adds to the growing body of evidence that heatwaves have detrimental effects on insect populations but suggests that these effects may vary with diet.

Responses of a semi-arid grassland to climate change-induced alterations in the seasonal availability of water

Olivia Hajek

Seasonal variation in plant available water is a key determinant of the distribution of ecosystem types and their functioning. An unappreciated outcome of climate change is that the seasonality of water availability may be altered for many ecosystems through a variety of mechanisms. Semi-arid grasslands of the North American Great Plains are especially vulnerable to seasonal shifts because this region is water-limited and co-dominated by species with distinct seasons of growth (C3 vs C4 grasses). We designed an experiment to evaluate how shifts in the seasonality of rainfall affects ecosystem structure and function in a northern mixed grass prairie in southeastern Wyoming. Without changing total precipitation amount, we excluded most rainfall during the spring (April - June) in treatment plots and returned the excluded amount of rainfall throughout the summer (July-September). We measured several response variables, including soil moisture, soil respiration, plant water potentials, aboveground net primary production, and shifts in plant phenology and community composition. We found that even during a single, relatively wet year, shifts in the seasonal timing of rainfall altered carbon cycling dynamics and led to shifts among C3 and C4 species. Thus, as seasonal patterns of water availability shift with climate change, a wide range of ecological consequences can be expected in this regionally extensive grassland, with implications for carbon climate feedbacks and key ecosystem services such as forage production.

Applying the In-N-Out framework to a meta-analysis of hierarchical controls on soil carbon storage and nitrogen recycling across North America and Europe

Paige Hansen

The soil carbon (C) and nitrogen (N) cycles are highly intertwined, but their structure of controls has not been entirely elucidated. To define these controls more comprehensively, we proposed the In-N-Out framework (Cotrufo et al., 2021), which identifies hierarchical, interactive controls on C and N cycling including climate, C input vs. output limitations, and soil, plant, and microbial traits. To test this framework, we synthesized climate, vegetation, and soil organic matter (SOM) fraction data from published studies across the United States and Europe. Future work involves using this comprehensive database and structural equation modeling (SEM) to evaluate direct and indirect controls on C and N cycling. This database and SEM plans will be presented. We predict climate is the primary control of C and N cycling in extreme climates, while interactions between plant, microbial, and soil traits are primary controls in mesic climates. We also predict C input vs. output limitations regulate C storage in particulate (POM) vs. mineral-associated (MAOM) organic matter and the openness of the N cycle; we expect C input-limited systems are characterized by MAOM accumulation and N losses, and C output-limited systems are characterized by POM accumulation and N immobilization. Lastly, we predict subsoils are C-input limited and dominated by MAOM, with C and N cycling depending on soil traits. More knowledge of these feedbacks will advance our understanding of C and N cycling across different ecosystems, and aid in developing strategies that support both C sequestration and enhanced plant productivity.

No evidence for compensatory recruitment in response to disease in high elevation amphibian populations

Bennett Hardy

Emerging infectious diseases are important drivers of host population dynamics as documented by recent outbreaks in human, domestic animal, and wildlife systems. Many diseases cause catastrophic harm to host populations, even driving extirpations. However, population-level variation exists, such that some populations persist at lower densities or abundances, or even rebound to pre-disease levels. One such mechanism of population persistence that has gained empirical support in the amphibian-chytridiomycosis host-pathogen system is compensatory recruitment. Increasing recruitment to compensate for reduced survival due to infection, could limiting the negative effects of the disease on population trajectories. We used 20 years of long-term capture-mark-recapture data from five populations of boreal toads (Anaxyrus boreas boreas) in Colorado, before and after pathogen exposure, to assess whether populations can persist with disease via compensatory recruitment. Before disease was detected, survival and recruitment estimates followed predictions based on life history tradeoffs typically expected in populations at different elevations. Specifically, toads at high elevation ponds had high survival but lower recruitment and vice versa at lower elevation ponds. Disease arrival had a strong negative effect on annual apparent survival and recruitment, and led to extremely low population growth rates and host abundances. We did not find support for compensatory recruitment in our system, highlighting the devastating effect of disease in these populations and their vulnerability to disease.

Restoring heterogeneity: the impact of creating mounds and slash piles on species diversity at a disturbed sagebrush parkland.

Becca Harris

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 only marginally significant ($P < 0.08$). 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.

Graduate Field Leadership: Challenges, Successes and Suggestions

Kate Hayes

Ecology and environmental science graduate degrees generally involve fieldwork, often lead by the graduate student. While successfully planning and implementing a data collection field campaign can be fundamental to completing a graduate degree, little formal training and resources exist to support graduate students or their supervisors in preparing for that aspect of the degree. Fieldwork requires leading and managing a team, often in unique circumstances (specialized skillsets, long hours, remote regions, etc.), and thus can be challenging even for those with previous leadership or field experience. Our objectives were to a) collect general advice for graduate students leading fieldwork without prior experience, b) solicit specific suggestions on resources and actions and 3) develop a series of policy recommendations for labs, departments, and universities. We developed a survey to solicit community input and distributed it widely to the ecology community. Here, we present initial results from the survey responses, including a summary of the perceived challenges that face graduate students leading their own fieldwork and suggestions for how to prepare and complete fieldwork successfully.

Effects of forest microclimates on juvenile tree survival vary with climate and life-stage

Edward Hill

Forest canopies can buffer climate conditions, providing microclimate refugia for tree regeneration otherwise limited by macroclimate conditions, especially in dry forests which frequently experience high temperatures and drought. However, the relative importance of microclimates for juveniles may vary with forest structure, life-stage, species life-history strategies, 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 response patterns to microclimates 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 year with drier spring conditions. 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.

Developing a Novel Foliar Moisture Content Indicator for Individual Trees

Lauren Lad

Fire suppression in fire-adapted forests of the Western US has increased fuel loads and forest densities. Prescribed fires are a necessary restoration tool in these fire-adapted forests, especially as drought frequency and intensity are expected to increase. The remote sensing of prescribed fires provides unique opportunities to examine pre- and post-fire effects to understand localized impacts. Unmanned Aerial Vehicles (UAVs) are valuable prescribed fire monitoring tools as they provide reflectance data at < 5cm resolution and user-controlled flight times. Currently, we can quantify fire effects using UAV-derived spectral indices such as the Normalized Difference Vegetation Index. However, we are unable to quantify pre-fire drought-stress, and with that, pre-fire risk. Using laboratory-based combustion experiments, this project will test the impact of drought-stress on sapling mortality of two species, Douglas-fir and western white pine, to develop a novel Foliar Moisture Content Indicator using the spectral channels available on a MicaSense multispectral UAV sensor. This research began in Fall 2021, with saplings burned at two Fire Radiative Energy levels and across a range of moistures from well-watered to ~40% of maximum foliar moisture content. This novel indicator captures foliar moisture content status and will be used to inform development of fire-risk and fire-effect models.

Community composition of trematode parasites along a river continuum

Landon Falke

In lotic ecosystems, the River Continuum Concept (RCC) provides a framework for understanding changes in environmental factors and free-living communities, yet how parasite communities vary along river continua remains less clear. We quantified infections by multi-host trematode parasites, including 11 taxa, by dissecting >15,000 host snails across 137 stream reaches spanning 175 km in the Willamette River Basin in western Oregon, USA. Environmental factors - including flow volume, temperature, benthic algae, canopy cover, woody debris, and land cover - changed predictably with stream order, consistent with the RCC. From first- to eighth-order reaches, overall infection prevalence decreased significantly but taxon-specific patterns were also observed. Certain trematode species dominated infections in headwater reaches while other species dominated infections in larger mainstem rivers. This suggests that parasite life cycle characteristics along with environmental variation and corresponding changes in non-snail hosts drive spatial variation in parasite communities in river continua. Our findings also indicate predictable spatial variation in disease risk to vertebrate hosts from pathogenic trematodes in this study system and indicate that the RCC can help explain shifts in parasite communities in lotic ecosystems.

Does fear of humans drive wildlife interactions in African food webs?

Monica Lasky

Interactions between species can shape ecological communities and their underlying systems through top-down processes, making species interactions potentially vital to ecosystem health. For example, predator presence can induce fear in prey, which can be powerful enough to drive behavioral changes in wildlife. This induced fear that indirectly alters animal behavior and spatial use of habitat through the mere presence of apex predators is known as the landscape of fear. Although much evidence suggests that apex predators can play a strong role in shaping behavior of species in lower trophic levels, the assumption that apex predators maintain ecological roles at the top of food webs is being challenged. As with other apex predators, humans can cause a landscape of fear that has the potential to alter natural apex predator feeding behavior, which can lead to further behavioral alterations in apex predator-mesopredator and apex predator-prey interactions. I will analyze how human-induced fear impacts trophic interactions among apex predators, mesopredators, and prey in South African food webs, and how these alterations correspond with tourism pressure. This study will address 1) how human presence alters spatiotemporal overlaps between species across multiple trophic levels, and 2) how the presence or absence of tourism impacts the human-induced landscape of fear.

The role of Indigenous-led land stewardship in shaping mammal conservation in the tropics of Guatemala

Tamara Layden

Threats to the maintenance and protection of Indigenous knowledge and land stewardship continue to jeopardize our planet's biological diversity, 80% of which is held within Indigenous territories. Local empowerment through community-based (i.e. 'people-centered') conservation provides a promising solution to biodiversity loss. Despite mounting evidence demonstrating the effectiveness of community-based conservation, both socially and environmentally, ecological research remains largely directive (i.e. 'top-down'), while primarily favoring Western knowledge over Indigenous knowledge for conservation. Moreover, empirical studies rarely elevate Indigenous researchers and methodologies - an approach that has shown to improve social, ecological, and economic outcomes. My research employs the complementary integration of Indigenous and Western sciences using a bottom-up (Indigenous-led) approach to identify the role of Indigenous land management in shaping mammal diversity and occupancy in Mesoamerica. This research works to expand knowledge in the understudied region of Southwestern Guatemala, while facilitating community-based conservation of over 2000 hectares of forest. In absence of such knowledge, conservation efforts may continue to perpetuate the separation of Indigenous communities from their ancestral lands and rely too heavily on fragmented government protections in some of the most biodiverse areas of the world.

Exploring shifts in the character and distribution of soil organic matter fractions across a physiochemical soil gradient

Sam Leuthold

Soil organic matter (SOM) is composed heterogeneous organic molecules which differ in origin, structural complexity, and turnover time. These organic molecules can be separated into different fractions depending on the pathways by which they are formed and their associations with soil minerals. Several methods of separating these organic matter fractions have been developed, typically taking advantage of contrasting size and density of various organic matter particles and their mineral associations. However, questions remain concerning how inherent soil properties may influence the efficacy of these methods, and whether the isolated fractions represent the same formation processes and pathways across diverse soils. Here we present results of a study that aims to identify the relationship between soil physiochemical properties and the distribution and character of organic matter fractions. We collected soil in various agricultural systems across a broad geographic range and measured physiochemical parameters (texture, pH, iron and aluminum content, DOC sorption potential, and total SOM). We fractionated soils to isolate discrete pools of SOM and explored the relationships between the fractional distribution of organic matter, the chemical characteristics of SOM, and soil physiochemical properties. Our results will identify the role of soil physical and chemical attributes in regulating SOM accrual and distribution and will further inform future methods of SOM fractionation.

What's in a name? The paradox of citizen science and community science

Dani Lin Hunter

Citizen science has expanded ecological and environmental sciences by making possible studies across greater spatial and temporal scales while incorporating local expertise and interests that might otherwise be overlooked. Broadly, citizen science involves the public in the process of science. However, it continues to struggle to engage diverse participants. Citizen science project coordinators are increasingly trying to promote inclusivity by rebranding as "community science" to avoid the term "citizen." Rebranding efforts, while well-intentioned, are uninformed by research, as we lack an evidenced-based understanding of these terms. We distributed a survey to those who participate in citizen and community science. We found differences in how well known and accepted the terms are, who is perceived as initiating and benefiting from the projects, and associated levels of inclusivity. Our findings have important implications for those involved in citizen and community science seeking to better describe projects in the future.

Environmental gradients impact key leaf traits in riparian trees

Mandy Malone

Intraspecific variability is an important, but often overlooked component of ecosystems. In plants, this variability has widespread impacts on higher trophic levels. Functional traits, or measurable traits tied to fitness and ecological strategies, help us explore this variability. One especially useful functional trait is specific leaf area (SLA equals leaf area/leaf mass), which reflects a plant's carbon investment per unit of light capturing area. SLA has been identified as a key trait to describe overall resource allocation and water use efficiency in arid environments. We explore the role of ecogeomorphic factors on SLA for a native tree (Salix amygdaloides) and an invasive tree (Elaeagnus angustifolia) in riparian ecosystems, using proxies for water availability and urbanization. Preliminary models of these landscape and tree level variables suggest a high degree of intraspecific variability explained by metrics of sun exposure, but a portion was also explained by distance to the closest water channel for both trees. Our research on intraspecific variability will add to the paucity of data on functional traits for these two species as well as our general understanding about how the environment affects SLA and therefore plant growth strategies. Understanding the effects of environment on plant strategies and traits has broader implications in restoration project planning as well as increasing the predictive power of functional traits in community ecology.

Differential stress experiences in niche-tracking and niche-switching yellow warblers

Noelle Mason

Conservation of biological diversity is increasingly challenging as the global climate rapidly changes. Recent work supports the idea that avian populations, which have declined by 2.9 billion birds since the 1970s, are able to persist in the face of changing climate conditions based on the extent of climate specialization across the annual cycle. Climate specialists track their climate niche across the annual cycle, whereas generalists which switch their climate niche between seasons. However, ornithologists' understanding of what happens on North American birds' wintering grounds is often limited. Here we take advantage of a rare opportunity to study the potential implications of climate tracking and climate switching on individuals in the yellow warbler (Setophaga petechia), where the extent of climate tracking across the annual cycle has been extensively quantified. Because niche-trackers and switchers likely experience differential stress, this study aims to understand whether niche-switching and niche-tracking populations differ in telomere length. Telomeres reflect stress throughout an organism's life history and are strongly correlated to an individual's relative lifespan and fitness. Environmental stressors, such as those experienced as a result of niche-tracking or switching, accelerate this attrition. Understanding stress impacts associated with migration to wintering ground niches may help to reveal the selective pressures exerted on yellow warblers outside of their breeding grounds. This knowledge could even illuminate the adaptive capacity of climate specialists compared to generalists. Implications from this study will support conservation efforts of birds and other migratory taxa in the face of rapid climate change.

Grasslands in Glacier National Park: 20 years of change

Nicolas Matallana-Mejia

Native grasslands are experiencing the highest rate of conversion to human-dominated use of all biomes, making them the most endangered biome on the planet. This land conversion coupled with climate change disrupts natural disturbances that shape grasslands. The grasslands in Glacier National Park, Montana, USA (GNP) are considered a pristine ecotone between mixed-grass steppe and montane assemblages, which have largely been ignored in the literature. However, important disturbances like fire and large mammal grazing have been largely removed or altered, and new disturbances such as human development have been introduced. Park managers are interested in how the grasslands are responding to these changes. I assessed status and trends in grassland plant community composition, woody encroachment and exotic invasion in 70 grassland plots surveyed recently and 20 years ago. Initial survey showed large variation in composition across plots in GNP's grasslands, including mixed-grass steppe and montane species. I discovered significant woody encroachment over the 20-yr study period in the form of trees and shrub species either establishing or increasing in cover. Increase in invasive cover was found in certain areas of the park, usually related to proximity to disturbance. Our results provide insights into the roles of fire and human disturbance in GNP's grasslands and have important implications for disturbance reintroduction.

Using integrative conservation units to map vulnerability to future climate change in the Canada warbler (Cardellina canadensis)

Caitlin Miller

The broad geographic ranges of many species of migratory birds often pose challenges for the development of coherent conservation and management strategies in the face of climate change. Species can be subdivided in several ways and each method may have benefits depending on the conservation objective. Evolutionarily significant units (ESU) define broad groups with distinct evolutionary histories, adaptive units (AU) identify groups that share similar adaptive traits, and management units (MU) define natural populations nested within the ESU. While genetic information is often one of the most important sources of data for the designation of ESUs and AUs, methods for defining MUs vary more broadly by species. Here I used the threatened, migratory species the Canada warbler (Cardellina canadensis) to demonstrate how integrative conservation units that use both genomic and demographic data can be used to successfully define each conservation unit and map future climate vulnerability across the range. Using both genomic and demographic data, I found 3 ESUs, 3 AUs and 14 natural populations. With these conservation units, I investigated vulnerability to future climate change across the range to identify conservation priorities.

The role of litter chemistry and degree of carbon saturation deficit on soil organic matter formation

Laura Moore

Soil organic matter (SOM) is the largest store of carbon (C) in terrestrial ecosystems. Therefore, SOM formation dynamics and persistence must be understood to manage soils more effectively for C storage and climate change mitigation. Plant litter chemistry and soil mineral C saturation deficits are recognized as critical controls for SOM formation into mineral-associated organic matter (MAOM) and particulate organic matter (POM); however, comprehensive testing of these mechanisms is needed. Isotopically labeled plant litter was tracked into soils with different soil mineral C saturation deficits over a 3-year incubation. This analysis represents the final 3-year harvest of the experiment, building off previous 1-year incubation results, which show that more labile litters contributed more to MAOM. However, contrary to the initial hypothesis, more MAOM did not form in soils with a higher mineral C saturation deficit. After 3 years of incubation, I hypothesize that we will see more POM formation from recalcitrant plant litters, which will ultimately contribute to more soil C. Additionally, I hypothesize that we will now see increased labile plant litter derived MAOM formation in soils with a higher soil mineral C saturation deficit. This experiment will help to better understand the mechanisms of SOM formation and persistence.

Trade-off between responses to drought and neighborhood cover among grassland communities along a precipitation gradient

Hailey Mount

Plant species exhibit a spectrum of strategies that either confer resistance to limited resources or enhance resource exploitation. We expect a diversity of these strategies to coexist within communities in response to disturbance and climatic variability; however, it is unclear whether more extreme resource limited environments will exhibit a narrower range of successful strategies than more productive environments. We imposed four-year chronic experimental droughts in five grassland types across the west-central US and calculated intrinsic low density population growth rates (LDGR) as an indicator of fitness for each species in each site under ambient and drought conditions. We observed a strong trade-off between species LDGR response to drought and LDGR response to neighbors within each grassland where the spread of strategies was equally broad in arid and humid grasslands. Acquisitive economics traits (nitrogen content and specific leaf area) were associated with response to neighbor cover while conservative traits (tissue densities) were associated with response to drought, but the direction of these relationships varied by grassland. Perhaps most surprisingly, one species could exhibit opposite responses to drought and neighbors at different grasslands with little intraspecific trait variation between populations. Our results suggest that even though there is convergent functional trait selection within grasslands along a precipitation gradient, there are divergent responses to abiotic and biotic stresses within the community and between species populations.

Warming and drying winters drive extirpations of the Wyoming ground squirrel, Urocitellus elegans

Austin Nash

In the current era of accelerated climate change, species are exposed to increasingly novel and potentially stressful climatic conditions. However, there is a high degree of heterogeneity in whether species are impacted by changes in climate and the direction of those impacts. Resurveying locations where a species was collected in the past, often derived from museum specimen locality information, is a commonly employed technique that allows for the investigation of climate impacts across an appropriately large temporal extent. I conducted resurveys to investigate whether the Wyoming ground squirrel, Urocitellus elegans, was responding to climate change. I conducted resurveys in an occupancy modeling framework at 54 historical collection localities where U. elegans specimens were collected prior to 1980. Resurveys occurred between May and August in 2021 and 2022 and were located throughout western Colorado and western Wyoming. Due to an extremely high detection probability, > 0.99, I employed logistic regression in an information theoretic framework to determine if changes in climate variables or modern climate conditions pulled from PRISM datasets were associated with persistence of U. elegans at a site. The top performing model supported that Wyoming ground squirrels are responding to climate change, with warming minimum winter temperatures and increasing winter atmospheric dryness reducing the probability of persistence at a site.

Trees on the move: are disturbances facilitating range shifts in trees of the western US?

Katie Nigro

Climate change is projected to cause shifts in tree species distributions, but the ability of trees to track current changes in climate is uncertain, and significant lags have already been reported. Disturbances may provide catalysts for tree species range shifts by creating new regeneration environments and eliminating species that can no longer persist. In this study, we use US Forest Inventory and Analysis data for 13 widespread tree species across the interior western US to identify how tree species distributions are shifting in response to recent warming, and how disturbances alter these shifts. Across the species studied, larger shifts occurred in disturbed areas, with most species shifting away from sites with hot temperatures and shifts in precipitation space differing by disturbance type. Overall, range contractions were more common than expansions and higher elevation species are experiencing more range contraction and less expansion than lower elevation species, making them more at risk of local extirpation due to climate warming. This study reveals that dominant tree species in the intermountain west are responding to climate warming by reduced regeneration in hotter climate niches and that disturbances are accelerating this response. The increasing frequency and extent of disturbances across the western US may therefore accelerate range contractions for trees, whereas evidence for expansion remains to be seen.

Tracking The Shifting Range of a Cryptic Species Using Host Data: Predicting range shifts of Celastrina echo sidara by analyzing host plant collections.

Braden Pate

Celastrina echo sidara is a subspecies of the echo azure that is native to the front range of Colorado. The genus is continuously undergoing taxonomic revisions and there are vastly differing opinions on how they should be classified. Morphological characteristics have complicated the matter, making identification difficult and limiting observations from online databases. Celastrina echo sidara is a known generalist for rosacea plants, with a preference for Jamesia americana as a host in larval stage (Wright et al, 1998). Given the lack of usable data and for the subspecies, we present the idea of predicting these shifts using host plant collections and citizen science data. The study shows overlapping ranges in Colorado for C. echo sidara and J. americana, both longitudinally and in elevation. Insufficient and possibly biased data for C. echo sidara has likely resulted in an inaccurate representation of true distribution and range shifts for the subspecies. This study presses the urgency for collecting more and accurate observations of the subspecies. However, the ranges of both C. echo sidara and J. americana occur within high threat regions for wildfires, and the 2020 wildfires may influence future range studies. While the range of a cryptic species may be complicated to study, utilizing citizen science data for an easily identified host may provide key information for analysis of potential threats to range shift studies.

Improving soil moisture sensor protocols in agrivoltaics systems

Tillie Pinkowitz

Soil moisture (SM) is a critical factor for predicting productivity in agricultural and natural ecosystems. The introduction of photovoltaic (PV) arrays affects the distribution of precipitation in these systems which may have consequences for distribution of annual net primary productivity (ANPP). Here, we deployed soil moisture sensors at a 20-centimeter interval underneath and between solar panels programmed to record measurements every 15 minutes. The goal of this study was to understand how inputs of precipitation change seasonally, if those inputs are consistent across location (ex. E side of panel vs. W side of panel), and whether there is an interactive effect between season and location. Improved understanding of seasonal dynamics of SM inputs will increase our understanding of the microenvironment underneath ground mounted PV arrays in both agricultural and natural grassland systems of the semi-arid west.

Soil organic carbon response to global environmental change is informed by mineral-associated and particulate organic matter

Katie Rocci

Soil organic matter carbon (SOM-C), as the largest terrestrial carbon pool, plays an important role in global carbon (C) cycling, which may be significantly impacted by global changes such as nutrient fertilization, elevated carbon dioxide (CO2), warming, and increased precipitation. Yet, our ability to accurately detect and predict the impact of these global changes on SOM dynamics is still limited. Investigating SOM responses to global changes separately for mineral-associated and particulate organic matter (MAOM and POM) can aid in the understanding of overall SOM-C responses, because these are formed, protected, and lost through different pathways. To this end, we performed a systematic meta-analysis of the response of SOM, MAOM, and POM-C to global changes and investigated their responses to nutrient fertilization in global grassland sites, in collaboration with the Nutrient Network. In the meta-analysis, POM-C was particularly responsive, confirming that it is a better diagnostic indicator of soil C changes in the short-term, compared to total SOM and MAOM. Nitrogen (N) fertilization, which comprised the majority of the meta-analysis dataset, increased SOC (+5.64%), MAOC (+4.49%), and POC (+13.17%), but addition of low levels of N, phosphorus (P), and potassium (K) had minimal effects on soil C in our grassland study. Instead, adding N increased soil N more so than soil C, indicating the need to investigate both C and N responses to global change. Our meta-analysis and grassland studies show that studying the individual responses of C and N, for POM and MAOM, improves understanding of the underlying dynamics of SOM responses to global change.

Microscopic time travelers: A finely tuned, time-resolved analysis of viral and microbial communities in the Erpe river

Josué Rodríguez-Ramos

Bacteria, archaea, and viruses are known to play key roles in carbon, nitrogen, and other global elemental cycles. These cycles are the underpinning of the world as we know it and have important impacts across all our ecosystems. In the field of microbial ecology, most studies either use data that is not taken across multiple timepoints or use data that is taken at time points that may not reflect the life cycles of these microorganisms. For this work, we sampled the Erpe river in Germany every 3 hours for 48hrs, providing a finely resolved timeseries dataset that can be used to assess questions about these microorganisms' permanence and their changes in this flowing ecosystem. From this data, we reconstructed 354 bacterial and archaeal microorganisms as well as 1178 viruses. We show that a portion of these viruses are present across all of our samples and timepoints and predict their possible hosts for 29 of them using computational techniques. Together, our findings bolster support for the idea that microbial and viral communities can exist as taxonomically, and metabolically stable communities along a flowing river corridor; and raise important questions that could affect ecosystem models attempting to constrain the underpinning dynamics of biogeochemical cycles in rivers.

Grassland plant community response and recovery from extreme drought

Maggie Ross

Extreme drought has the potential to dramatically impact grassland plant communities by reducing function and shifting plant community structure. While shifts in community structure have been documented during drought, it is unclear whether these shifts persist after drought ends. Our study aimed to characterize plant composition during and following drought, and to understand how changes in composition during drought correspond with recovery post-drought. We experimentally imposed extreme drought at four grassland sites in the Great Plains over four growing seasons and then continued to monitor the sites an additional four years under ambient conditions to assess recovery. The sites range across a gradient in mean annual precipitation (MAP) from 375 mm to 892 mm and represent the major grassland types of the region. Preliminary results show an altered plant composition between the treatment and control plots during and following drought at all sites. However, the magnitude of compositional difference varied by site, and was most pronounced at the driest site. These results indicate that grasslands may vary in their response and recovery to an extreme drought. Additional analyses will explore how species richness, evenness, and gains/losses contributed to compositional differences during and following drought across a precipitation gradient.

Ecological processes of the dryland soil microbiome shift across a systemic breakdown phase aridity threshold

LeAundra Schopflibn

Drylands, which comprise 41% of the earth's surface, rank among the most susceptible environments to climate disturbance. Within these dryland systems, crossing of aridity thresholds can instigate rapid change in both plant and microbial communities. Future climate forecasts predict that 22% of emerged lands could cross an aridity threshold in the next 100 years. In a global study of 54 dryland sites spread across six continents, we aimed to understand the effect of a system breakdown phase aridity threshold (AI = 0.8) on soil microbiome and their associated functions. A metagenomic survey recovered 94 significantly correlated gene groups of which 38 groups were correlated with semi-arid plots (below AI 0.8) and 56 groups were correlated with arid plots (above AI 0.8). Within the semi-arid group, steroid hormone biosynthesis and sphingolipid and histidine metabolisms were associated with hyphae formation, cell membrane synthesis and repair, and transcriptional regulation. Within the arid group, ribosome biogenesis, DNA replication proteins, and the calcium signaling pathway were associated with cell regulation, DNA repair, motility, and antibiotic synthesis. Our data reveal a distinct change in soil microbiome processes associated with crossing the 0.8 AI aridity threshold. In the context of ongoing climate change, understanding this aridity thresholds and its long-term effects is vital for mitigating sudden climate change caused ecological disruptions in the soil microbiome.

Centennial to Decadal-Scale Changes in Algal Production and Community Composition in Santa Fe Lake, New Mexico

Anna Shampain

As sentinel ecosystems, mountain environments serve as early warning signals for global change, including impacts of climate change, and airborne pollutants. Anthropogenic activities have led to significant alterations in Earth systems. Imprints of these changes can be determined from sediments that accumulate sequentially over time in lakes. Here we analyzed stable isotopes, elemental composition (C, N), diatoms, and algal pigments in a 40-cm core from Santa Fe Lake, NM, to place anthropogenic activities into a multi-centennial context of environmental change.The core provided a ca. 250-year record of change in phototrophic communities. Lake production was elevated prior to the Little Ice Age. Then increased again during the 20th century. Cryptophytes and chlorophytes increased throughout most of the record. In contrast, cyanobacteria were more abundant early in the sediment record, declined during the Little Ice Age, and maintained a lower abundance for the remainder of the sediment record. Similar declines during the cool interval were recorded for diatoms. Preliminary diatom identification demonstrated the presence of planktonic diatoms throughout the core. Our preliminary findings suggest that trajectories of change within Santa Fe Lake during recent decades occurred in conjunction with accelerated human activities. However, all responses subtle and overall algal and diatom biomass in the lake has remained low throughout its history. Further analyses will focus on features that may have buffered Santa Fe from environmental change.

Few microbial groups of fine taxonomic resolution drive overall microbial community response to drought in grassland ecosystems.

Alex Siggers

Addressed are preliminary findings assessing the potential taxonomic and functional reorganization of soil microbial communities in response to drought conditions in grassland ecosystems. Following a severe four-year experimental drought treatment across an environmental gradient, bulk soil samples were collected and processed. Initial analyses display bacterial phylum-level shifts in response to drought (i.e. increased relative abundance of Actino- and Acidobacteria in drought conditions) are driven by few groups of finer taxonomic resolution (i.e. increased relative abundance of class Acidimicrobiia and Actinobacteria in drought conditions). Alpha and Beta diversity of drought-treated communities differ significantly from controls. Overall fungal response is negligible, though notable shifts occur in classes Basidiobolomycetes, Mortierellomycetes, and Glomeromycetes. Overall functional response displays enhanced ability to assist peripheral plant communities to persist in drought conditions (i.e. increase in genes involved in cell wall biosynthesis, nutrient uptake, and recalcitrant polysaccharide degradation). Current and future efforts are focused on shifts in rhizosphere microbial communities within the same grassland network and the functional differences that arise. We seek to understand the recovery and/or resilience of the communities to drought conditions and if soil microbial communities remain primed for future drought events.

Seedling functional traits may explain changing dynamics in an everwet neotropical forest

Sam Smith

Reports over the last 20 years suggest that long-lived woody vines, called lianas, are taking over tropical forests. There is substantial evidence to demonstrate that tropical forests could shut down as global carbon sinks that if lianas become relatively more abundant than trees. We examined long-term liana and tree seedling dynamics to understand if lianas seedlings are becoming abundant in an Amazonian rainforest. We then investigated whether changing forest dynamics could be explained by seedling performance or functional traits. Our data suggest that liana seedlings became more abundant in Yasuní, Ecuador since 2003. During the 18 year-long study, liana seedlings survived at lower rates than trees across Yasuní despite increasing liana seedling abundance. Although we found no growth-form level differences between liana and tree seedling functional traits, liana and tree seedlings appear to assume different life history strategies in ridge, slope, and valley habitats. Our findings indicate that liana proliferation in tropical forests like Yasuní begins at early ontogenic stages and is likely mediated by habitat-level differences between liana and tree seedling functional traits.

Disturbance and disease: effects of wildfire on host-parasite interactions

Emma Svatos

Wildfires are ravaging the western United States with increasing frequency and intensity, stimulating known drivers of wildlife disease and posing implications for both wildlife conservation and human health. Despite the link between fire and disease, research intersecting these fields remains rare. Understanding how wildfire affects host-parasite interactions is critical as parasites are integrated in every ecosystem, highly abundant, and can shape host communities by altering host behavior, reproduction, and mortality. The objective of this study was to determine the effects of fire on host-parasite dynamics in a freshwater study system, using the stream snail, Juga plicifera, as host to over 20 trematode parasite species. Using a Before-After-Control-Impact (BACI) design, measures of trematode infection prevalence, richness, and community composition were analyzed pre- and post-fire. Snail population demographics were also measured, including relative abundance and mass. Preliminary results suggest that trematode prevalence and richness were not affected by the fire. Snail host demographics were also unaffected. Environmental variables, such as stream basin, may influence impacts of fire on trematode community composition. These findings supplement previous literature accounts of stability in trematode communities over time.

Global Evaluation of River Restoration Strategies Using Automated Content Analysis

Aziz Syammach

Rivers and surrounding riparian plant communities provide ecosystem services that are disrupted by anthropogenic impacts worldwide, however restoration is implemented and evaluated at the local scale. Due to river degradation being a global concern, there is a need to generalize trends in the river restoration literature and synthesize what restoration measures are effective. Current review methods include literature reviews and meta-analysis. These methods are ill equipped to deal with the growing volume of ecological literature as they are prone to under sampling and associated with several biases. Meta-analysis can only be done on literature that meets specific criteria and literature synthesis involves a lengthy process of sorting and classifying papers based on domain expertise and researcher experience. Automated Content Analysis (ACA) is a novel type of literature review method that generates probabilistic text models to automatically quantify topics (synonymous with 'themes' or 'concepts') and trends in large literature datasets. Unlike traditional literature review methods, ACA allows for the discovery of topics beyond a priori assumptions and the ability to analyze 1000's of documents. Additionally, this method is underutilized in ecology with a literature search returning only 6 articles using ACA. I will conduct an ACA of the existing river restoration literature (1,462 articles) to synthesize findings in this growing field by identifying generalizable approaches based on ecosystem type, climate, soil, and other shared river features.

The effect of diet on head capsule width and number of instars in fall webworm (Hyphantria cunea)

Mykaela Tanino-Springsteen

Measurements of caterpillar head capsule width are commonly used to characterize the number of developmental stages (instars) in Lepidoptera. The number and duration of instars is influenced by environmental (season, temperature), top-down (parasitism), and bottom-up (diet) factors. Studies of head capsules and instars are commonly conducted on pest species to improve age-specific pesticide application. However, it is also valuable to understand the progression of instars for ecological studies that use the same developmental stage for different treatments or to identify the instar of an individual caterpillar in the field. Fall webworm (Hyphantria cunea) is a polyphagous herbivore found in Colorado and has recently become a model system for studying the evolution of diet breadth. However, the duration and number of fall webworm instars have not been characterized, which creates challenges for experiments that require using the same developmental stage. Because fall webworm is a dietary generalist, it is also important to understand how instars could vary according to host plant. To examine how diet affects fall webworm head capsule width and number of instars, we measured the head capsules of over 2500 caterpillars, from different matrilines, reared on host plants commonly eaten by wild fall webworms in Colorado. This research will provide a better fundamental understanding of fall webworm larval development, which can be used to advance both lab and field research of this species.

Overlapping bark beetle outbreaks have unexpected consequences in the southern Rocky Mountains

Niko Tutland

Outbreaks of native, tree-killing bark beetles are important disturbances in subalpine forests of the southern Rocky Mountains (SRM), where spruce beetle (SB), mountain pine beetle (MPB), and western balsam bark beetle (WBBB) have caused extensive tree mortality since the late 1990s. Despite their importance, little research has examined the effects of overlapping outbreaks of multiple bark beetle species, which are likely widespread in mixed-species forest systems. To address this uncertainty, we used geospatial data to map forest susceptibility and occurrence for each beetle species and compared outbreak severity in forests affected by overlapping outbreaks in the last 20 years. We found that about 22% of forest stands with susceptible host trees had composition suitable for overlapping outbreaks, and of those stands, only 28% experienced outbreaks of two more bark beetle species. When stand experienced overlap of the more aggressive SB and MPB, we found higher rates of mortality than areas affected by a single species. However, stands with conditions susceptible to both SB and MPB were uncommon (< 2% of sampled stands). These results indicate that host tree distributions and abundance thresholds limit the extent of severe mortality from overlapping bark beetle outbreaks in the SRM. This unexpectedly suggests that, while multiple tree species in the SRM may be simultaneously susceptible to outbreaks, focusing management on individual bark beetle species is appropriate in most cases.

Density-dependence outweighs habitat influences on brook trout condition in the Southeastern US

George Valentine

Brook trout are a charismatic salmonid native to the eastern US. Threatened by streamflow and temperature changes associated with climate change, they occur in high elevation and high latitude habitats, and thrive where they can avoid competition with invasive salmonids. Brook trout have also been found to show strong density-dependent patterns in vital rates such as growth and recruitment. Little research has compared the influences of habitat and density variables on brook trout condition, defined here as body weight at length. We investigate the importance of density-dependent vs. density-independent predictors on brook trout condition using quantile regression. We analyze 1,935 sites from Georgia to Maryland in the Southeastern US, where brook trout populations have declined most significantly. Our analysis reveals that the influence of trout density on predicted brook trout condition at a site was stronger than that of latitude or elevation. Density of larger trout had the strongest negative influence on predicted weight at length, suggesting that density effects are the result of direct competition and size hierarchies. Where they exist in sympatry with non-native rainbow trout and brown trout, brook trout condition is more negatively affected by non-native trout density than their own density, indicating the preeminence of interspecific competition over conspecific competition. Our results add important substance to the debate over the relative importance of density-dependent vs. density-independent drivers of individual brook trout condition.

Sex Ratio Effects on Pair Bond Formation in Convict Cichlids (Amatitlania Nigrofasciata)

Rory Van Lieu

Operational sex ratio may affect the formation of pair bonds. We are testing the effects of sex ratio in the socially monogamous, biparental convict cichlid (Amatitlania nigrofasciatus). In convict cichlids, both females and males are choosy during pair bond formation. If sex ratio affects pair bond formation, we predict that the control (1 male: 1 female) would have fewer pair bond formations than the experimental groups. In addition, the duration to form a pair bond would take longer in the control compared to the experimental groups. Furthermore, the group with 2 females and 2 males will have the most and the quickest pair bond formations, because it allows for both male and female mate choice. This experiment has a control (1 male: female), and 3 experimental treatment groups with different sex ratios: 1) 1 male: 2 females; 2) 1 female: 2 males; 3) 2 males: 2 females. Five observations per day are taken using a webcam to determine when a pair has formed. After a pair bond has formed, videotaping of the pair's behaviors are recorded for 15 minutes. The videos will then be analyzed for courtship and aggression behaviors. Although the number of pair bond formations does not differ between the groups, preliminary data suggests the control group had a longer duration to pair bond formation compared to the experimental groups.

Assessing How Perceived Poaching Risk Alters Forest Elephant (Loxodonta Cyclotis) Distribution and Activity

Ana Verahrami

Anthropogenic disturbances have been documented as key drivers of spatial and temporal heterogeneity across our planet at many scales. However, our knowledge on how anthropogenic disturbance influences populations of cryptic species occupying inaccessible habitats is limited due to difficulty collecting detailed data for such species. The population of one such species, the critically endangered African forest elephant (Loxodonta cyclotis), has declined by over 80% in the last 93 years largely due to ivory poaching. Most of our knowledge on how anthropogenic disturbances such as poaching impact elephants comes from research on African savanna elephants (Loxodonta africana) and Asian elephants (Elephas maximus), limiting our understanding on how forest elephant populations might be responding differently. To address these knowledge gaps, an acoustic detector will be developed to classify recorded poaching events as automatic (associated with elephant poaching) or non-automatic (unassociated with elephant poaching) weapon fire. The detector will be applied to acoustic recordings from an existing monitoring effort in the Republic of Congo to examine how different perceived levels of elephant poaching threat influence forest elephant distribution and acoustic activity in the region. These findings will be used to advance management strategies and inform conservation initiatives such as antipoaching patrols in an area where poaching is having critical, but unknown impacts on forest elephants.

Below-ground soil microbial functioning varies in resistance to drought across a precipitation gradient in the central US grasslands

Leena Vilonen

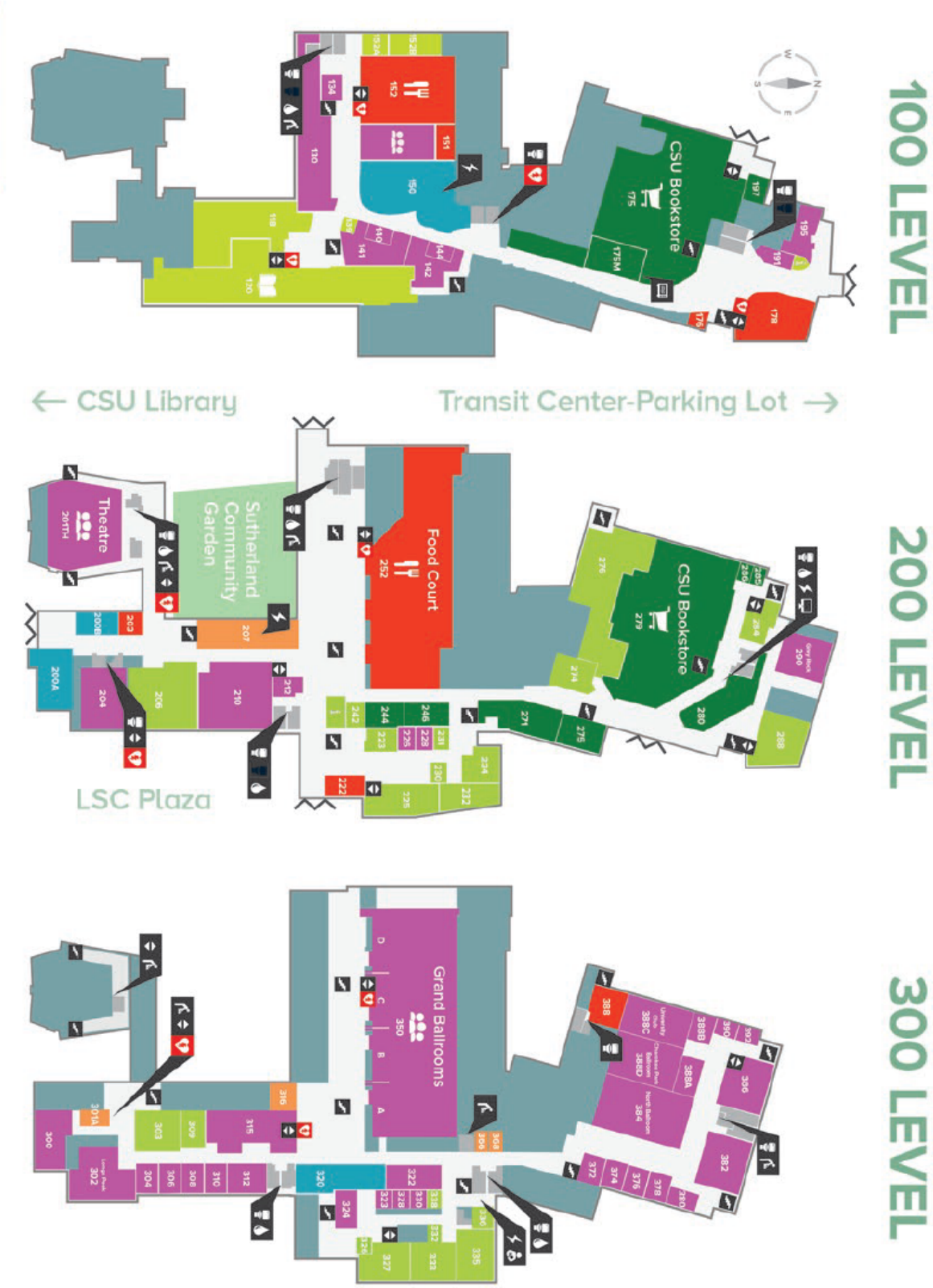
Drought is increasing in intensity and duration throughout the US Great Plains grasslands and has the potential to have large impacts on grassland functioning. Yet, we have a poor understanding of how resistance to drought in the belowground changes across a precipitation gradient. This study aimed to understand how the resistance of belowground functioning varied across four grasslands that ranged in a precipitation gradient ranging in mean annual precipitation (MAP) from 375 mm to 892 mm. To understand belowground response, we collected in-tact soil cores using PVC tubing from each site and split these into the drought and control treatments. We withheld water for 30 days in the drought treatments and maintained the control treatments at a soil moisture specific to their site. We collected soil samples from both treatments after 30 days and analyzed the soils for soil inorganic nitrogen, soil potential enzyme activity, and gene copy number of bacteria and fungi. We found that ammonium was lower in the drought treatment at the highest precipitation site, but higher at the lowest precipitation site compared to the control. We also found that enzyme activity was decreased across all 7 enzymes in the drought treatment of the highest precipitation site and lowest precipitation site. Overall, we did not find that the lower precipitation sites were less resilient to drought, but the highest precipitation site seemed the most sensitive to drought.

Plant water use in Front Range wetlands

Anna Wright

In the arid west, wetlands are a major source of water loss through evaporation and plant transpiration. Understanding water loss patterns in restored wetlands is critical in water-scarce Colorado, because if a restoration project uses more water than before, it must obtain water rights. Previous research shows little difference in water loss between open water, vegetated wetlands, and wetland plant species. However, our preliminary data suggest different wetland plant species exhibit different patterns and amounts of water use throughout the day. To increase our understanding of plant-driven water loss, we will collect water loss data from five restored wetlands on the Front Range. We will estimate the daily amount of water use per plant with an infrared gas analyzer and the daily water loss at site level by measuring fluctuation in groundwater. Combining this data with plant species composition will allow us to understand site-wide patterns in evapotranspiration. We will also explore the physiological plant traits that correspond with different water regulation strategies. This project will help water rights holders along Colorado rivers make better decisions in restoring wetland ecosystem function to meet their desired goals.

Map of Lory Student Center



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