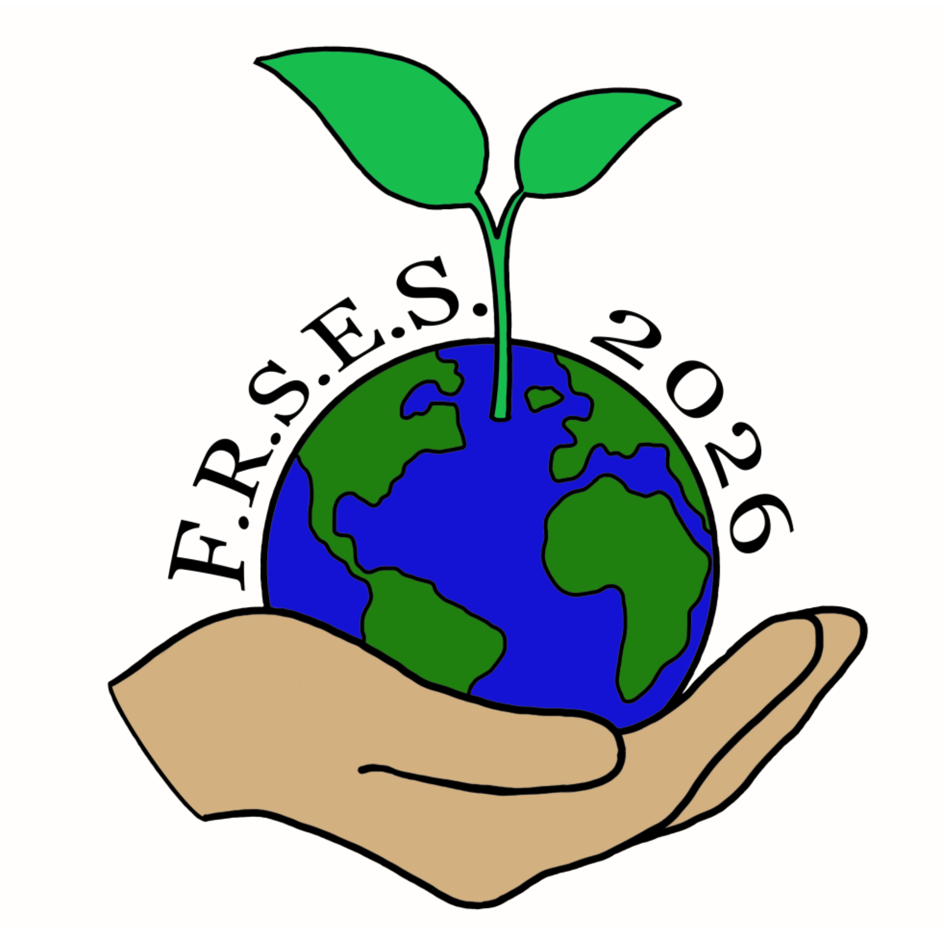
32nd ANNUAL FRONT RANGE STUDENT ECOLOGY SYMPOSIUM



February 26th & 27th, 2026
Colorado State University
Fort Collins, Colorado

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GRADUATE DEGREE PROGRAM IN ECOLOGY COLORADO STATE UNIVERSITY

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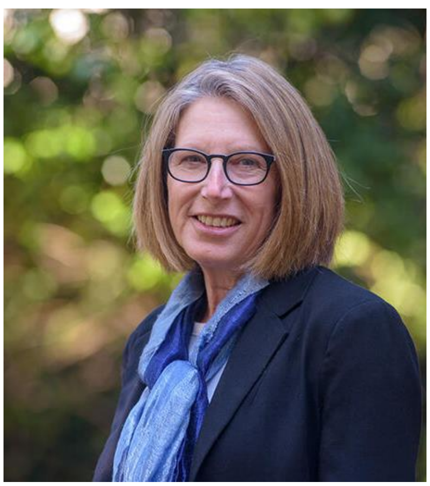
Welcome to FRSES 2026

The FRSES Mission

The Front Range Student Ecology Symposium (FRSES) 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.

Keynote Speaker

Dr. Whendee Silver, University of California, Berkeley



Dr. Whendee Silver is Professor of Ecosystem Ecology and Biogeochemistry in the Department of Environmental Science, Policy, and Management at U.C. Berkeley. She received her PhD in Ecosystem Ecology from Yale University. Her work seeks to determine the biogeochemical effects of climate change and human impacts on the environment, and the potential for mitigating these effects. The Silver Lab is currently working on drought and hurricane impacts on tropical forests, climate change mitigation potential of grasslands, and greenhouse gas dynamics of peatlands and wetlands. Professor Silver is the lead scientist of the Marin Carbon Project, which is determining the potential for land-based climate change mitigation, particularly by composting high-emission organic waste for soil amendments to sequester atmospheric carbon dioxide. The Silver Lab was awarded the Innovation Prize by the American Carbon Registry (2015) for this work. Professor Silver is a fellow of the American Association for the Advancement of Science, American Geophysical Union, the Ecological Society of America, and is a Kavli Frontiers of Science Fellow. She was named a University of California Climate Champion for 2016 for outstanding teaching, research and public service in the areas of climate change solutions, action and broad engagement.

FRSES 2026 Workshops

“Keep your R Code Tidy” with Brooke Anderson

“Ecological Perspectives Across Time: How Past and Present Inform Each Other” with Nicole Archambeau (History) and Lindsay Burnette (Horticulture and Landscape Architecture)

We hope you enjoy the 2026 Front Range Student Ecology Symposium!

Schedule of Events

*All Thursday events will be held in the Lory Student Center Theater - 1101 Center Ave Mall, Fort Collins, CO.
*All Friday events will be held in the Lory Student Center - 1101 Center Ave Mall, Fort Collins, CO.

THURSDAY, FEB. 26		
TIME	**SESSION**	**LOCATION**
1 – 6:00pm	**Check-in**	**LSC Theater**
Meet at 1:45, tours from 2 – 3pm	**University Museum Tours** Insect Museum Biology Collections Herbarium	**Meet at registration table outside LSC Theater**
3:00 – 4pm	**Tea/refreshments**	**LSC Theater**
4 – 5pm	**Keynote Speaker:**	**LSC Theater**
5pm	**Hors d'oeuvres**	**LSC Theater**
5 – 6:30pm	**Poster Session** Even numbers: 5 - 5:45pm; odd: 5:45 – 6:30pm	**LSC Theater**
6:30 – 7:00pm	**Social Hour**	**LSC Theater**

FRIDAY, FEB. 27		
TIME	**SESSION**	**LOCATION**
7am – 2:30pm	**Registration & Check-in**	**Outside LSC Theater**
8am – 3pm	**Coffee, Tea, & Snacks**	**LSC Theater**
8:00 – 9:15am	**Oral Presentations: Session 1** Disease Ecology Invasive Species Disturbance & Restoration Ecology	 **LSC 304-306** **LSC 308-310** **LSC 312**
9:15 – 10:30am	**Break**	
9:30 – 10:45am	**Oral Presentations: Session 2** Behavioral Ecology Urban Ecology Global Change & Conservation	 **LSC 304-306** **LSC 308-310** **LSC 312**
10:45 – 11am	**Break**	
11am – 12pm	**Rocky Mountain Chapter ESA Panel**	**LSC Theater**
12 – 1pm	**Lunch**	**LSC Theater**
1 – 2:30pm	**Oral Presentations: Session 3** Forest & Rangeland Ecology Evolutionary Ecology Ecosystem Ecology	 **LSC 304-306** **LSC 308-310** **LSC 312**
2:30 – 2:45pm	**Break**	
2:45-3:45pm	**Workshops** "Keep your R Code Tidy" with Brooke Anderson	 **LSC 304-306**

	"Ecological Perspectives Across Time: How Past and Present Inform Each Other" with Nicole Archambeau (History) and Lindsay Burnette (Horticulture and Landscape Architecture)	**LSC 308-310**
3:45 – 4pm	**Break**	
4pm – 5pm	**Reception, Awards Ceremony & hors d'oeuvres served**	**LSC Theater**

Participation

This year's symposium includes 44 posters and 42 oral presentations, with exciting work from Colorado State University, Regis University, University of Colorado – Boulder, University of Colorado – Denver, University of Colorado – Colorado Springs, University of Denver, University of Illinois at Urbana-Champaign, Metropolitan State University of Denver, University of Northern Colorado, and University of Wyoming.

Abstracts

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

Judging and Awards

Faculty, post-doctoral scientist, and research scientist judges will be present during the oral and poster sessions. Prizes donated by CSU and local community sponsors will be awarded to winners of both the oral and poster sessions.

Instructions for Presenters

Poster Presentations:
Posters can be set up in the Lory Student Center Theater on Thursday (2/26) from 3:00–4:00 pm. Presenters must attend their posters from 5:00–5:45 pm (even numbers) or 5:45–6:30 pm (odd numbers). Posters must be removed by 7:00 pm. Maximum recommended size is 36″×48″. Judges will attend, and awards will be announced at the Reception & Awards Ceremony. Formatting guide: https://guides.nyu.edu/posters.

Oral Presentations:
Presenters must meet their moderator in the assigned room on Friday (2/27) at least 15 minutes before their session. Talks are limited to 15 minutes total (12–13 minutes presenting, 2–3 minutes for questions). Judges will attend each session, with awards announced at the Reception & Awards Ceremony. Please bring your presentation in widescreen PowerPoint format on a USB drive.

FRSES 2026 Organizing Committee

Executive Board: Joseph Toman (President), Kyle M. Ruszkowski (Vice President), Maricela Alaniz (Treasurer), Nicki Bailey (Secretary)

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Volunteers: Galen Burrell, Levi Burdine, Adam Gillison, Christian Gutierrez, Nora Moss, Kelly Nealon, Erica Patterson, Megan Podolinsky, Izzy Rodelius, Max Schmidtbauer, Maria Schonewise, and Cy Spears.

Judges: Lily Durkee, Liba Pejchar, Tony Vorster, Melinda Smith, Micky Eubanks, Kristen Switzer, Alan Knapp, Carolyn Cornell, Lilian Vallet, Jonathan Tetlie, Anna Hodshire, Kathleen Condon, John Mola, Ian Pearse, Jeremy Brooks, Josie Otto, Trevor Carter, Jill Baron, Ruth Hufbauer, Matt Sturchio, Dan Preston, Cini Brown, Sarah Ortiz, Tessema Kassaw, Edward Hill, Zack Steel, Dennis Ojima, Anping Chen, Sara Bombaci

FRSES Faculty Member: Jennifer Neuwald

Symposium Sponsors

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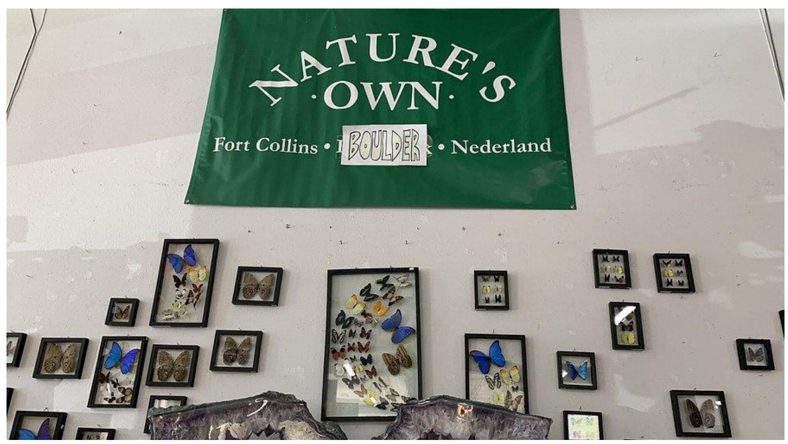

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Thursday, February 26, 2026

Poster Presentations 5 – 6:30 pm

Lory Student Center Theater

Posters with **even numbers** present from 5:00-5:45pm

Posters with **odd numbers** present from 5:45-6:30pm

Poster Number	Title	Lead Author(s)
1	Impacts of Solar Photovoltaics on Bat Foraging Resources	Dani Rosari
2	The functional outcomes of high elevation hummingbird wing morphology	Margaret Hemp
3	Improved methodology enabling population genetic analyses of a complex fungal pathogen	Ada Neupane
4	Urban Oasis: Drivers of Biodiversity in Front Range Urban Ponds	Jackson Bates
5	**--No presenter--**	**--No presenter--**
6	Monarch Development on an Under-Recognized Host Plant	Emma Frederiksen
7	Air We Go Again: Time and Height Effects on the Grassland Aerobiome	Rocio Rodriguez
8	Mapping Genetic Diversity to Inform Conservation Priorities for the Bobolink, a Declining Grassland Bird	George Kinney
9	Project 1 – Winds: The Biodiversity Shadow in Commerce City	Bradley Harz
10	Impact of Winter Heatwaves on Adult Fall Webworm Performance	Audrey Bellows
11	Effects of artificial light at night (ALAN) on insect life history traits and abundance	Kayla Martinez
12	Advanced Parental Reproductive Phenology Can Alter Seed and Seedling Traits	Kyla Knauf
13	Impact of prolonged, extreme drought on seed rain abundance and diversity in a semi-arid grassland	Giselle Gueddiche Izabella Rhomberg
14	Five years of throughfall exclusion reveal divergent soil respiration responses across tropical forests	Hailey Tharp
15	Reseeding success of Bouteloua gracilis following late-season deluges in the Colorado prairie	Carlie Clemmer
16	Teaching Climate Change at the Margins: Assessing Cultural Awareness in Undergraduate Biology Education	Sydney Jackson
17	Spatial and Temporal Shifts in Wood Density in Subalpine Forests	Kyla Wolffe
18	Enhancing the MEMS Model to Incorporate Pyrogenic Organic Matter Dynamics	Emma Hamilton
19	The Pulse Beneath the Prairie: Root Responses to Compound Climate Extremes	Scott Otto
20	GRAZING IN SPITE OF CLIMATE EXTREMES: UNRAVELING THE IMPACTS ON THE SHORT GRASS STEPPE	Anna Hall
21	Predictors of cavity nesting Bee Occupancy in Denvers Urban Gardens	Rene Aronson
22	Do beetle-killed forests burn more brightly? Interactions between bark beetle impacts and fire radiative power (FRP)	Dalton Robberson

	across the southern Rocky Mountains	
23	Age, Not Fungal Pathogen, Influences Phloeosinus punctatus Reproduction in Sequoiadendron giganteum	Jacob Yastrow
24	Life beneath a solar array: Arthropod abundance and diversity in a photovoltaic grassland	Heide Keeble
25	Microplastic Leachates but not Zyrtec Modestly Alter Freshwater Biofilm Metabolism	Connor Lundquist
26	How Arthropod Predators and Herbivores Respond to Urbanization in Community Gardens	Noah Mayer
27	Rejuvra (Indaziflam) Suppresses Invasive Annuals but Produces Site-Specific Changes in Colorado Grassland Communities	Darian Chavez-Matsunaga
28	Exploration of Colorado Forest Management and Wildfire (2000 – 2024)	Elizabeth Buhr
29	Demographic and Temporal Factors Affecting Flea Loads in Black-tailed Prairie Dogs (Cynomys ludovicianus)	Reese Good
30	Microplastics (MP) in Drinking Water Linked with Colorectal Cancer Across Urban-Rural Counties of Maryland	Millen Singh
31	Bee Conservation Using Bee Hotels	Dylan Mitchel
32	The Implications of Introgression on the Behavior of Native Helicoverpa zea Moths.	Cooper Phillips
33	Characterizing bumblebee foraging preferences in urban and natural landscapes to inform floral restoration and pollinator conservation practices	Keirs Manlapas
34	Trailhead tick-check stations are an effective, low-effort approach for tick surveillance	Lawson Dawe
35	Chronic Wasting Disease demonstrated in fawns less than 2 months of age in Arkansas free-ranging white-tailed deer populations	Olivia Kreutzer
36	Reducing Reliance on Wild Queens: Establishing Bumble Bee Microcolonies from Wild-Caught Workers for Lab Research	Allie McQuiston
37	Changes to host-parasite coevolution and community composition in a multi-host assemblage	Carolyn Tett
38	Variation in Pollinator Attraction Among 15 Chili Pepper Cultivars	James Haas
39	Mapping Pathogens with Environmental DNA: Implications for Human and Animal Health in Madagascar	Cristina Blanco
40	Opuntia polycantha flowering in a photovoltaic solar panel array	Daniel Watson
41	Exposure to Novel Song Leads to Developmental Plasticity in Locomotory Behavior of Pacific Field Crickets	Sara Garcia
42	Evolutionary Signatures of Epistasis Explain Asymmetric Transgressive Segregation in Structured Sorghum Populations	Samuel Owusu-Ansah
43	Associational susceptibility shapes aphid-transmitted disease risk in chile peppers	Lara Amiri-Kazaz
44	The unexpected role of ‘hair’ in bumble bee thermal balance	Alex Kurtt

<u>Friday, February 27, 2026</u>

Oral Presentations

All activities held in the Lory Student Center

<u>Oral Presentations Session 1: 8:00 am – 9:15 am</u>

Room 304–306	**Disease Ecology**
8:00 – 8:15 am	<u>Simulating African Swine Fever in the US: Identifying Outbreak Hotspots and Effective Control Strategies</u> Christopher Brandon, Colorado State University
8:15 – 8:30 am	<u>Vegetation preferences and dispersal behaviors of Dermacentor andersoni: a mark-release-recapture study</u> Sabrina Gobran, Colorado State University
8:30 – 8:45 am	<u>Plant–Pollinator Networks as Pathways for Microbial Movement</u> Lincoln Taylor, University of Colorado Boulder
8:45 – 9:00 am	<u>Monsters Inside (Some) of Us: Interactions between parasitic botflies and high-elevation deer mice under climate change</u> Sarah Sense, University of Denver
9:00 – 9:15 am	<u>Quantifying Spatial and Temporal Variation in Direct Contact Rates Among Mule and White-Tailed Deer</u> Maddie Lucas, Colorado State University
Room 308–310	**Invasive Species Ecology**
8:00 – 8:15 am	<u>Leafcutter Bee Movement Through Natural and Residential Areas</u> Kyle Ruszkowski, Colorado State University
8:15 – 8:30 am	<u>Where do honey bees bee-long? Assessing the impacts of experimentally induced honey bee pressure on native bee interactions in Colorado public forests</u> Nicki Bailey, Colorado State University
8:30 – 8:45 am	<u>A trait-based framework for quantifying arthropod invasion potential: a Tropilaelaps mites case study</u> Carmen Black
8:45 – 9:00 am	<u>Brooding over what mite bee: honey bee parasite prevalence patterns with pest management implications</u> Treson Thompson
Room 312	**Disturbance & Restoration Ecology**
8:00 – 8:15 am	<u>Impacts of prolonged, extreme drought and post-drought watering on the soil seed bank of a semi-arid grassland: Implications for post-drought recovery</u> Maddie Amick, Colorado State University
8:15 – 8:30 am	<u>Assessing Native Plant Community Dynamics Under Solar Arrays</u> Adriana Jacobi, Colorado State University
8:30 – 8:45 am	<u>Food stress and pesticide exposure interact to intensify harmful</u>

	reproductive effects in bumblebees Hannah Burke, Colorado State University
8:45 – 9:00 am	Investigating The Impact of Topsoil Transfer on Seeded Plant Development Abigail Ridder, Colorado State University
9:00 – 9:15 am	Targeted seed sowing to maintain function in semi-arid rangelands under a drier future Hunter Geist-Sanchez, University of Colorado Boulder

Oral Presentations Session 2: 9:30 am - 10:45 am

Room 304–306	**Behavioral Ecology**
9:30 – 9:45 am	Do rates of predation vary across host plants for a dietary generalist? Madeline Tepper, University of Denver
9:45 – 10:00 am	A test of the "Mother Knows Best" Hypothesis with a dietary generalist herbivore Max Meyer, University of Denver
10:00 – 10:15 am	Rapid Senescence: How Aging Shapes Bumble Bee Flight Performance Ripken Wellikson, University of Wyoming
10:15 – 10:30 am	Assessment of Swamp Wallaby (Wallabia bicolor) Foraging Activity on the Summerland Peninsula, Phillip Island, Victoria Juliane Wera, Colorado State University
10:30 – 10:45am	Beyond discrete categories: multidimensional movement syndromes reveal a continuum of African elephant ranging behavior Nelson Gathuku, Colorado State University
Room 312	**Urban Ecology**
9:30 – 9:45 am	Bees in the City: Bumble Bee Community Stability Across Urban and Natural Landscapes Laura Lukens, Colorado State University
9:45 – 10:00 am	Seeding Rate Effects on Sown Plant Community Development on Semi-Arid Green Roofs Maria Schonewise, Colorado State University
10:00 – 10:15 am	Synthetic control methods enable stronger causal inference using participatory science data in cities Asia Kaiser, University of Colorado Boulder
10:15 – 10:30 am	Insect Emergence and Riparian Predator Abundance in Urban Ponds Across a Land Cover and Chemical Gradient Jennoa Fleming, Colorado State University
10:30 – 10:45am	A LiDAR-based inventory of forest fuels and structure on the Colorado Front Range Priority Landscape Tanner Gordon, University of Wyoming
Room 308-310	**Global Change & Conservation**

9:30 – 9:45 am	Pollination network response to high severity fire along a gradient of time-since-disturbance Ryleigh Gelles, Colorado State University
9:45 – 10:00 am	Adaptive genomic divergence and implications for Genetic Rescue in the Loggerhead Shrike Holden Fox, Colorado State University
10:00 – 10:15 am	Freezing conditions impact germination success in Colorado alpine seeds Nyika Campbell, University of Colorado Boulder
10:15 – 10:30 am	How does climate shape grassland recovery after a DustBowl-type drought? Greg Tooley, Colorado State University
10:30 – 10:45am	Global political biogeography of country-endemic bird species Margaret Monaghan, Colorado State University

Oral Presentations Session 3: 1:00 pm – 2:30 pm

Room 304–306	**Forest & Rangeland Ecology**
1:00 – 1:15 pm	Developing a plant-driven landscape assessment for climate-smart grazing management in mixed-grass prairies Joseph Toman, Colorado State University
1:15 – 1:30 pm	Driving factors influencing plant distribution of Mixed-grass Prairie pastures in Southeastern Wyoming Lydia Johnsen, Colorado State University
1:30 – 1:45 pm	Novel Solutions to a 100 Year Problem: Larkspur (Delphinium geyeri) Mitigation in Western Rangelands Amber Pelon, Colorado State University
1:45 – 2:00 pm	A Decade-long Economic Comparison of Season-Long and Adaptive Rotational Grazing Systems in the Shortgrass Steppe Rhyse Campion, Colorado State University
Room 308–310	**Evolutionary Ecology**
1:00 – 1:15 pm	Morphological and acoustic divergence in hybridizing field crickets Isaac Hudson Foy, University of Denver
1:15 – 1:30 pm	Immune Function in Hybrid and Parental Gryllus Crickets Hannah Eckert, University of Denver
1:30 – 1:45 pm	At the Right Scale: Using Evolutionary Units to Diagnose Population Decline in Bank Swallows Erica Robertson, Colorado State University
1:45 – 2:00 pm	Morphology, Parasitism, and Adaptation: Phenotypic Plasticity in Ant Social Systems Brendon Davis, University of Colorado Boulder
2:00 – 2:15 pm	Using Genomics to Clarify Migration Phenology of the Common Loon Charlie Dees, Colorado State University
Room 312	**Ecosystem Ecology**

1:00 – 1:15 pm	Temporal Changes in Forest Communities and Understory Vegetation of Rocky Mountain National Park Noah Estrada, University of Northern Colorado
1:15 – 1:30 pm	Reading Leaf Physiology with Light: What Spectroscopy Reveals About Photosynthesis and Water Status in Co-occurring Subalpine Conifers Aylin Barreras, Colorado State University
1:30 – 1:45 pm	Biogeographic variation in lowland tropical forest soil microbial communities and responses to drying Grace McLaughlin, Colorado State University
1:45 – 2:00 pm	Does indaziflam herbicide promote native prairie recovery in Colorado? Amy Gill, Colorado State University

Oral & Poster Presentation Abstracts

Abstracts are listed alphabetically by first name.

Investigating The Impact of Topsoil Transfer on Seeded Plant Development

Abigail Ridder, Colorado State University; Caroline Havrilla, Dept. of Forestry and Rangeland Stewardship Colorado State University; Jaxon Maynor, Dept. of Human Dimensions of Natural Resources, Colorado State University

Cheatgrass (Bromus tectorum) is a predominant invader across the American West and causes landscape wide changes to vegetation, pollinators, and soil communities. Topsoil transfer is a technique used to mitigate invasive species, including B. tectorum, by reintroducing native seeds and soil microbes to invaded areas. Research on topsoil transfer has primarily focused on the influence of reintroducing native seeds, and not on the influence of the transferred soil microbiome on plant development. To better understand how topsoil transfer affects native plant development, we conducted a full factorial greenhouse experiment using two different soils collected from the USDA's Central Plains Experimental Range located near Nunn, Colorado. Soils were collected and sieved in In July 2025. One soil came from an area dominated by B. tectorum, and the other came from an area dominated by native grasses including Hesperostipa comata and Elymus elymoides as well as the cactus Opuntia polyacantha. This soil was taken to Colorado State University's Plant Growth Facility and potted alongside a twice autoclaved control soil that contained an even mix of the invasive and native dominated soils. Six plant species native to the Colorado Shortgrass Steppe were seeded individually into pots, thinned to one individual per pot and allowed to grow for seven and ten weeks at which point we performed a destructive trait harvest. We collected data on the following functional traits and performance measures: specific leaf area, leaf dry matter content, specific root length, canopy volume, aboveground biomass, and percent fungal colonization of roots. Additionally, we collected data on soil nutrients, texture, and DNA. Initial results show developmental differences between soils for some of the species and traits and not for others. These results will help inform management decisions about when soil transfer is a useful restoration intervention.

Improved methodology enabling population genetic analyses of a complex fungal pathogen

Ada J. Neupane, Graduate Degree Program in Ecology Colorado State University; Jorge Ibarra Caballero, Dept. of Agricultural Biology Colorado State University; Jane E. Stewart, Dept. of Agricultural Biology Colorado State University

Understanding the population biology of invasive fungal plant pathogens is critical for developing effective management practices and tracking evolutionary change. The myrtle rust pathogen Austropuccinia psidii has spread throughout culturally, ecologically, and economically important subtropical global ecosystems, infecting over 440 plant hosts. Biological and genomic characteristics of A. psidii have limited detailed population genetic analyses. Individual lesions may have distinct genotypes, yet extractions from single lesions yield little fungal DNA. Further, A. psidii cannot be cultured in vitro, yet inoculations are resource and time intensive. Finally, A. psidii has one of the largest assembled fungal genomes dominated by repetitive regions, complicating whole-genome sequencing. While low-resolution microsatellite markers have been used to identify lineages of A. psidii associated with geographic regions and host species, genetic and phenotypic variation remains that is indistinguishable without improved methodology. To overcome these limitations, we developed a protocol to obtain genome-wide, fine scale genetic data from single-lesion field samples of A. psidii. Our workflow involves DNA extractions with

modified spore lysis and precipitation steps to maximize DNA retention, followed by whole-genome amplification (WGA) of extracted DNA. Restriction-site associated DNA sequencing (RADseq) and associated analyses are then used for genome fragmentation and variant calling. With this protocol, we found that WGA increased the quantity of high molecular weight DNA fragments to sufficient levels for RADseq, even from extractions with no initial quantifiable DNA. Further, whole-genome sequencing of select WGA products showed high read alignment to A. psidii reference genomes, indicating that no preferential extraction or amplification of host plant DNA occurred. Finally, digestion of amplified DNA with RADseq enzymes resulted in desired size fragments. The success of this protocol forms the foundation for future population genetic analyses from field samples, including refining the global population structure and reconstructing the evolutionary history of A. psidii.

Assessing Native Plant Community Dynamics Under Solar Arrays

Adriana Jacobi, Colorado State University; Melinda Smith, Colorado State University; Alan Knapp, Colorado State University; Carrie Havrilla, Colorado State University

Grasslands are among the most threatened ecosystems globally, and the rapid expansion of solar energy infrastructure presents both challenges and opportunities for restoration. This project investigates how shaded environments created by solar panels influence native grassland community composition, diversity, and establishment. Specifically, we aim to evaluate 1) whether solar arrays foster favorable microclimates for restoration and 2) how seed mix diversity shapes outcomes under dynamic shading conditions. During the 2024 field season, we established experimental and control plots at Jack's Solar Garden in Longmont, CO, encompassing 0.6 acres (about the area of a large mansion). Preexisting invasive Smooth Brome (Bromus inermis) was eradicated, and four seed mix treatments (two high-diversity mixes and two low-diversity mixes) were planted. Baseline abiotic data on light availability, soil temperature, and soil moisture were collected, and the early establishment of native grasses has been observed. The experimental design compares shaded (under-panel) and unshaded (open) plots to assess plant community dynamics and the role of seed mix diversity in restoration success.

The unexpected role of 'hair' in bumble bee thermal balance

Alex C. Kurtt, University of Wyoming; Jordan R. Glass, University of Wyoming; Michael E. Dillon, University of Wyoming

Like many pollinators, bumble bees possess a dense array of hair-like structures – often referred to as pile – that helps collect pollen during foraging bouts. Because of pile's close resemblance to mammalian fur, it has long been assumed to serve a similar function, creating a barrier to reduce radiative loss or gain of heat. However, setae (pile) are structurally branched and made of chitin, and thus may exhibit different thermoregulatory properties. In our study, we contrasted the effects of radiative heat loss, radiative gain, and convective cooling between shaved and unshaved dead worker bumble bees. We found that pile does little to insulate thoracic tissue as previously assumed; however, it provides a barrier that reduces the severity of convective cooling. Our findings help underscore the intricate thermal balance that these insects maintain in a drastically changing climate.

Reducing Reliance on Wild Queens: Establishing Bumble Bee Microcolonies from Wild-Caught Workers for Lab Research

Allie McQuiston, Warner College of Natural Resources Colorado State University; Laura Lukens, Forest and Rangeland Stewardship Colorado State University; John Mola, Forest of Rangeland Stewardship Colorado State University

Projects researching native bumble bees in laboratory settings often depend on the removal of many queens from the local environment. Although researchers attempt to minimize ecological impacts, alternative methods could further reduce reliance on wild queen collection. We explored the feasibility of establishing microcolonies - functioning nests of bumble bee workers that raise haploid males in the absence of a queen - from wild-caught workers over the course of the summer. We also evaluated various methods of microcolony establishment to identify ways of increasing success rates. We collected 135 Bombus huntii workers over a one-month period in the summer of 2026, a species with which we have previously achieved successful queen establishment. Workers were sorted into 33 groups of four and monitored for cooperation and brood production. Of these groups, 4/33 displayed signs of cooperation and 2/33 laid eggs in brood cells. Workers caught earlier in the summer had longer individual lifespans and were more likely to cooperate. Although overall success was limited, the establishment of some functional microcolonies and brood production indicates potential for improving survival and productivity through refined methods. With further optimization, this approach may yield consistent, reproducible systems suitable for future laboratory research while reducing dependence on wild queen collection.

<u>Novel Solutions to a 100 Year Problem: Larkspur (Delphinium geyeri) Mitigation in Western Rangelands</u>

Amber Pelon, Colorado State University; Todd Gaines, Colorado State University; Franck Dayan, Colorado State University; Lovreet Shergill, Colorado State University

Foothills larkspur (Delphinium geyeri) is a perennial dicot plant native to the foothills of the Rocky Mountains that is toxic to cattle, causing intestinal stasis, bloat, muscular paralysis, and sudden death due to respiratory paralysis. This high risk of cattle fatalities significantly reduces the usable area of ranchland for cattle production and affects ranchers' annual economic returns. Developing new management tools to control foothills larkspur in rangelands would enable higher stocking rates on cattle ranches, which is a key regional and state issue for cattle producers. Our solution will involve two approaches: mapping and precision removal of above-ground plant mass using drones and robots, and research and testing growth inhibitors that target the terpenoid pathway responsible for producing the toxin in the plants. Both methods will allow this valuable forb to remain in the rangeland while reducing the toxic risk to cattle. Ultimately, we aim to provide innovative larkspur mitigation techniques and develop a tool to help ranchers choose the most effective strategy for their profit, herd health, and rangeland health.

<u>Does indaziflam herbicide promote native prairie recovery in Colorado?</u>

Amy S. Gill, Colorado State University; Caroline A. Havrilla, Department of Forest and Rangeland Stewardship, CSU; Jim Krick, City of Longmont, Longmont, CO

Invasive annual grasses, including Bromus tectorum (cheatgrass), reduce biodiversity and forage quality and increase wildfire risk in rangelands. Indaziflam, a pre-emergent herbicide recently approved for use on rangeland, shows potential for controlling cheatgrass and other annual grasses, yet its effects on non-target native plant and soil communities are poorly understood. We collaborated with land managers along the City of Longmont to investigate indaziflam impacts on a

remnant prairie plant community. Specifically, using a field experiment, we evaluated 1) effects of indaziflam treatment on invasive weed density, native plant biomass, and community composition. Additionally, 2) we tested prairie recovery responses with and without restoration seeding applied two years following indaziflam treatment. Preliminary results indicate that indaziflam effectively reduced invasive weed density and promoted native plant recovery where existing native vegetation was present. However, sites with low native plant density showed limited recovery even with seeding, highlighting challenges for restoration efforts that rely on seeding post-treatment. These findings suggest that indaziflam can be a valuable tool for rangeland weed management but underscore the need for integrated restoration strategies to support native plant establishment. Our work suggests that future work could focus on optimizing seeding approaches and further characterizing soil community responses to ensure sustainable, ecologically informed management.

GRAZING IN SPITE OF CLIMATE EXTREMES: UNRAVELING THE IMPACTS ON THE SHORT GRASS STEPPE

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Climate change is not only affecting global temperatures, but altering the hydrological cycle and increasing precipitation variability across terrestrial ecosystems as well. Although projections of mean annual precipitation remain uncertain, there is broad agreement that climate change will increase the frequency of extreme droughts, intensify rainfall events, and subsequently create compound climate extremes (CCEs), in which severe dry periods are interrupted by large deluges. These CCEs can generate extreme responses, potentially exceeding additive effects and crossing ecological thresholds to a new state. Semi-arid grasslands, like the shortgrass steppe (SGS) of Colorado, are especially vulnerable as productivity within the system is largely constrained by water availability. While drought and deluge events independently influence plant productivity, soil moisture, and biogeochemical cycling, their interactive effects, especially in grazed systems, remain poorly understood. Our two year long project evaluated how extreme drought, a single mid-season deluge, and simulated grazing interact to restructure plant communities and alter ecosystem function in a semi-arid C_4-dominated grassland. Rather than treating drought and deluge as isolated perturbations, we tested whether their sequence generates interactive effects that reorganize community structure and alter the stability of ecosystem processes. We further examined whether grazing, a dominant ecological driver in the shortgrass steppe, modifies these hydrological responses by influencing canopy structure, soil moisture retention, and competitive dynamics among species. Original hypotheses thought an extreme drought would reduce productivity and dominant C_4 grass abundance, increase community diversity, and weaken the structural stability of the overall community. A subsequent deluge following drought could either partially restore canopy structure and function, or generate “hot moments” of activity that cannot fully rescue the grassland communities from the severe drought induced shift in community structure. Finally, we expected grazing to interact with these outcomes, potentially magnifying structural change by reducing canopy cover and soil moisture retention, or buffering competitive shifts among plant functional groups. By uncovering how grazing interacts with compound climate extremes, this study advances understanding of how to sustainably manage our rangelands, critical both environmentally and economically in Colorado.

Synthetic control methods enable stronger causal inference using participatory science data in cities

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As urban populations grow, conserving biodiversity within cities is increasingly vital and of global policy interest. However, urban environments pose unique challenges for understanding drivers of biodiversity change, as fragmented land ownership makes traditional biodiversity monitoring and randomized experiments logistically difficult. While participatory science platforms like iNaturalist offer a promising data source by providing extensive biodiversity data from urban areas, inferring causality remains challenging due to confounding factors in observational data. To leverage these data advances, we offer a framework that combines records from iNaturalist with synthetic control methods, a quasi-experimental approach. We demonstrate this approach in a case study assessing the impact of Hurricane Ida (2021) on the number of research-grade iNaturalist bee observations, used as a proxy for bee abundance, in Philadelphia, USA. The synthetic control estimated a 15.5 - 20.9% decline in bee observations in the two years post-event. In contrast, three conventional ecological analyses—an interrupted time series regression, before-after comparison, and a before-after control impact (BACI) design—failed to detect this decline. Synthetic control methods offer a powerful tool for estimating citywide biodiversity responses to climate events and policy interventions, enhancing the utility of participatory science data for urban ecology.

<u>Impact of Winter Heatwaves on Adult Fall Webworm Performance</u>

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A heatwave is a period of time when temperatures exceed the typical range within a region, and due to anthropogenic global climate change, the prevalence of heatwaves is increasing across all seasons. A recent meta-analysis suggests that winter heatwaves may have greater negative impacts on species than summer heatwaves, but further investigation is necessary. We designed an experiment to test the impact of winter heatwaves on fall webworm (Hyphantria cunea; hereafter FW), a generalist moth native to Colorado. Previous research with FW has shown they are negatively affected by summer heatwaves, but responses depend on diet. We reared FW larvae on six different diets, then exposed pupae to one of four winter heatwave treatments: no heatwave (control), early-, middle-, or late-season heatwaves. We tested if larval diet and the occurrence or timing of winter heatwaves affect FW performance and whether these factors interact. We found no significant effects of any heatwave treatment on FW survival to eclosion, deformity, or adult longevity. Instead, the larval host plant seems to be the primary factor determining overwinter performance. We are conducting further analysis on phenology, fecundity, and fertility measures. Thus far, our results suggest that for FW, winter heatwaves are not as detrimental as summer heatwaves.

<u>Reading Leaf Physiology with Light: What Spectroscopy Reveals About Photosynthesis and Water Status in Co-occurring Subalpine Conifers</u>

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Tracking leaf physiology across co-occurring species is essential for understanding ecosystem functioning, particularly in environments with pronounced seasonal variation in temperature and moisture, such as subalpine forests. In these systems, seasonal climatic shifts drive physiological adjustments that help plants maintain water balance, sustain carbon gain, and support survival under climatic extremes. In subalpine conifers, traditional approaches to monitor photosynthesis and water status, such as remote sensing indices, often perform poorly. These evergreen species exhibit minimal seasonal variation in canopy structure and limited changes in chlorophyll content, making traditional vegetation indices relatively insensitive to physiological changes. Leaf spectroscopy is a promising approach as it provides species-specific spectral reflectance across more than 400 narrow bands (1–5 nm resolution) spanning 400–2500 nm of the reflectance spectrum. This high spectral resolution can capture aspects of leaf physiology with greater sensitivity than conventional multispectral (5–7 bands) approaches. Here we evaluate whether leaf spectroscopy can detect variation in leaf physiology, specifically water status (e.g., equivalent water thickness, relative water content and water potential) and maximum photosynthetic capacity (Amax), in three subalpine conifer species: Engelmann spruce (Picea engelmannii), subalpine fir (Abies lasiocarpa), and lodgepole pine (Pinus contorta). This study was conducted during the 2025 growing season at the Niwot Ridge subalpine forest in the Southern Rocky Mountains, Colorado. Leaf water status, Amax and spectral reflectance were measured in 100 samples collected during the early, mid, and late growing season. Field observations of water status and Amax indicate clear seasonal variation, with distinct patterns among species. Preliminary analyses indicate that random forest models integrating leaf reflectance with field observations of water status and Amax achieve high predictive accuracy ($R^2 \approx$ 0.90–0.98; RMSE ≈ 0.3–2.2). Ongoing analyses will test the accuracy of other predictive models, advancing the use of spectroscopy for monitoring conifer physiology.

Project 1 – Winds: The Biodiversity Shadow in Commerce City

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Industrial corridors on the north side of Denver and Commerce City host a dense cluster of refineries, warehouses, and highways. Communities and urban green spaces downwind of the Suncor refinery live with chronic air-quality alerts, yet we still know little about how these pollution plumes intersect with urban ecology. In this first “Winds” project of the Winds • Waters • Time: The Commerce City Biodiversity Evidence Series, I am building an EcoSphere pilot that links publicly available air-quality data, wind fields, and satellite imagery to future biodiversity surveys in parks and riparian zones along the South Platte River. Using EPA Air Quality System (AQS) monitors, state datasets, and NOAA High-Resolution Rapid Refresh (HRRR) model output, I assembled a recent multi-year record of fine particulate matter (PM2.5) and key gases for the Commerce City area, along with hourly and seasonal wind roses that describe how often plumes travel from the refinery toward surrounding neighborhoods and habitats. I combine these patterns with open satellite imagery and land-cover data to map candidate “biodiversity shadow” zones, or areas that are repeatedly downwind of industrial emissions while also serving as potential habitat fragments. Documented wildfire smoke episodes are used to separate regional smoke impacts from locally generated smog. I will present preliminary pollutant and wind climatologies for Commerce City, examples of smog and smoke events affecting the corridor, and a prototype workflow for adding future field sampling of birds, vegetation, and invertebrates. The goal is to show how a student-built pipeline can connect air-pollution science to questions in urban ecology and environmental justice. I would like to lay practical groundwork for a long-term, community-engaged monitoring effort in this heavily impacted landscape.

Morphology, Parasitism, and Adaptation: Phenotypic Plasticity in Ant Social Systems

Brendon Davis, Department of Ecology & Evolutionary at University of Colorado Boulder

Ants are among the most ecologically successful animals on Earth, owing to the complexity and flexibility of their social systems. We have focused heavily on learning from their success, but their failure is just as rich a source of information. Ant nests are frequently invaded by social parasites, parasitic ant species which infiltrate host colonies and exploit their social systems for reproductive success, substantially lowering the fitness of their host. Given the robust defenses of ants, key questions remain as to how these parasites exploit their hosts. In the genus Formica, which includes free-living ants as well as facultative and obligate social parasites, physical traits such as body size and shape may play an underappreciated role in facilitating parasite-host interactions. The major goal of this project was to determine how morphological variation contributes to social parasitism and host interaction across Formica species and populations. A pilot study conducted at the Mountain Research Station (Nederland, CO) examined seven standard ant measurements across multiple lifestyles. Preliminary work revealed clear morphological patterns associated with lifestyle: free-living species were consistently largest, parasitic species exhibited intermediate body sizes, and host species were the smallest. Parasites demonstrated a mix of host-matching measurements and specialized features that surpassed hosts measurements (e.g. larger mandibles, larger thoraces, same sized eyes) which suggests morphological attunement that may facilitate exploitation. Moreover, within species comparisons showed that facultative social parasites like Formica aserva exhibited significant phenotypic differences between lifestyles. Individuals from parasitic populations were smaller than free-living conspecifics which is consistent with a broader "parasitic syndrome" involving anatomical reduction or specialization. These findings suggest that morphology is not just a byproduct of shared ancestry, but a responsive trait shaped by social context and population specific selection pressures. They motivate a broader, population-level investigation into morphological specialization across parasite–host systems.

Reseeding success of Bouteloua gracilis following late-season deluges in the Colorado prairie

Carlie Clemmer, Warner College of Natural Resources, Colorado State University; Sean Kirkpatrick, Warner College of Natural Resources, College of Liberal Arts, Colorado State University; Maddie Amick, Graduate Degree Program in Ecology, Dept. of Biology, Colorado State University; Dr. Melinda Smith, Graduate Degree Program in Ecology, Dept. of Biology, Colorado State University

Climate change is predicted to change precipitation regimes, resulting in more frequent severe droughts and increasing the probability of deluge events. Despite the prevalence of droughts, we remain unsure as to how grasslands recover from drought and how they interact with deluges. Extreme drought events lead to decreases in dominant plant species and negatively impact the forage quality a grassland can provide. This has been seen in the short grass steppe with the loss of Bouteloua gracilis following extreme drought. Efforts to re-seed dominant plant species following long-term drought may lead to increased recovery, however, little data exists on such methods. Often, re-seeding efforts use cultivars, populations with different traits that are collected and developed. Hachita and Lovington are two B. gracilis cultivars that are utilized for restoration but lack published data regarding their implications for drought recovery. This study examines the impact of late season deluges on the germination of these two cultivars. To do so, a site in Colorado's shortgrass steppe was reseeded with Hachita and Lovington cultivars in April, following a five-year drought that diminished the B. gracilis population. Deluge plots experienced an extreme late-season deluge event in October and were compared to ambient plots for germination and survival. Proximity of surrounding vegetation was measured to determine impacts on germination and survival. Our data show that cultivar type and surrounding vegetation may influence a seed's ability to germinate following extreme drought and deluge events. These findings may alter cultivar selection and timing of seeding for restoration purposes.

A trait-based framework for quantifying arthropod invasion potential: a Tropilaelaps mites case study

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Over the past decade, the global rise in invasive species has accelerated at an unprecedented rate, intensifying threats to ecosystems, human health, and economies worldwide. Newly invasive taxa, such as Tropilaelaps mites, are of particular concern for apiculture and agroecosystems. Despite growing concern about the spread of Tropilaelaps mites and other arthropods, limited resources are available to assess their invasive potential. We characterized 118 invasive arthropod species using available literature to identify key biological and ecological traits associated with invasive potential. We developed predictive generalized linear mixed models (GLMMs) to determine the traits most important for predicting invasive potential (number of invaded regions), and the top-performing models were subsequently applied to Tropilaelaps mercedesae. Several traits were identified as significant predictors of invasiveness, including the degree of human association, resilience at small population sizes, diet breadth, maximum annual number of generations, altitude range, and the interaction between human association and temperature range. Notably, T. mercedesae was predicted to be capable of invading 160 regions, ranking it within the top 10% most invasive species among those evaluated (12th out of 119), ranked just below the cosmopolitan Varroa destructor mite. These findings position T. mercedesae as a high-risk, yet under-recognized, invasive threat. Collectively, this demonstrates the power of predictive trait-based modeling to inform invasion risk prior to widespread establishment and underscores the urgency of reallocating resources toward surveillance, research, and proactive management strategies rather than relying on costly, often ineffective post-establishment eradication.

Changes to host-parasite coevolution and community composition in a multi-host assemblage

Carolyn Tett, Dept. of Biological Sciences University of Denver; Dr. Robin Tinghitella, Dept. of Biological Sciences University of Denver

Parasites and their hosts exert strong selection on one another's traits, but such host-parasite interactions can be more complex when additional, viable hosts co-occur. Despite the potential for species composition and host-parasite coevolution to differ in these systems, there is a startling dearth of empirical work on multi-host assemblages. The recent introduction of the parasitoid fly Ormia ochracea from North America to the Hawaiian islands offers a unique opportunity to fill this gap. To locate the cricket host, Teleogryllus oceanicus, gravid female flies eavesdrop on the mating songs of male crickets. Flies then spray their larvae and the free moving juveniles burrow into the

host's body cavity, later emerging and killing the host. Over the past 40 years, longitudinal field surveys and experiments have captured the rapid evolution of cricket wing morphology and novel song production that avoid fly detection. This rapid evolution is largely the result of the longstanding single host-parasitoid interaction; however, in 2022, my lab discovered that three other introduced cricket species are now found at some sites and can act as hosts for the parasitoid (hereafter alternative hosts). My preliminary data show that some O. ochracea populations even prefer alternative host songs over most novel T.oceanicus songs.

Let's Keep the Common Loon Common: A Genomic Offset Approach to the Conservation of *Gavia immer*

Charlie Dees, Colorado State University; Alec Lindsay, Northern Michigan University; Kristen Ruegg, Colorado State University

Animal populations have three main options when it comes to how they might respond to local environmental changes: they can shift their range, they can go extinct, or they can adapt. When it comes to this third option, populations are differentially limited by the severity of such local change. If the change is too sudden, genetic adaptation is not possible and the likelihood of extirpation increases. One species of historic and recent conservation concern experiencing a broad range of environmental changes in North America is the Common Loon (*Gavia immer*). These iconic migratory water birds are subject to an array of stressors across the annual cycle, including methylmercury toxification, Type E botulism, and anthropic habitat destruction. Perhaps more strikingly, they are projected to lose up to 80% of viable habitat in the United States by 2050 due to climate change. I plan to use a whole-genome sequencing approach to clarify the species' population structure on the breeding grounds. Subsequently, I will investigate gene-environment relationships and generate a genomic offset model to predict where Common Loons will be most susceptible to changes in temperature and precipitation across their entire breeding range. My efforts ultimately aim to inform conservation decisions regarding this much-beloved, culturally significant bird.

Simulating African Swine Fever in the US: Identifying Outbreak Hotspots and Effective Control Strategies

Christopher Brandon, Colorado State University; Colleen Webb, Colorado State University; Lindsay Beck-Johnson, Colorado State University

African Swine Fever (ASF) is a highly transmissible, often deadly virus infecting swine. ASF is closer to the US than ever, having recently been detected in the Caribbean. Given that there are no existing vaccines or treatment options for ASF, an outbreak could cost the US agricultural systems billions of dollars, disrupt the business continuity of the swine industry, and jeopardize the livelihoods of small farmers. To inform preparedness and response to an ASF outbreak in the US, this project utilized two national-scale, premises-level simulation models of livestock shipment networks and ASF-parameterized disease outbreaks. We simulated nearly 1.5 million ASF outbreaks under different control scenarios and assessed which disease control measures were most effective at curbing the spread of ASF. We found that the majority of outbreaks do not escape the premises of origin, but outbreaks that infect more than 1000 premises require extreme control measures to combat ASF transmission. We observed consistency among regions of the US that spark the most consequential ASF outbreaks. We also characterized uncertainty of our model outputs via sensitivity analyses and note that the parameters and characteristics that our model outputs are sensitive to relate to infrastructure and demography. Taken together, these findings suggest that there are certain regions of the US that are more likely to generate large ASF outbreaks, and these findings could be used to inform preparedness and response for ASF.

Microplastic Leachates but not Zyrtec Modestly Alter Freshwater Biofilm Metabolism

Connor Lundquist, Undergraduate of Regis University; Fatimazahra Riadi, Undergraduate of Regis University; Kristofor A. Voss, M.S. Environmental Biology Program Director of Regis University.

Since the 1950s, the breakdown of plastic pollution has introduced micro- and nanoplastic particles (MP/NP) into freshwater systems. While many studies have explored the effects of these particles on freshwater ecosystems, far fewer have explored the effect of chemicals that leach from these plastics in conjunction with other novel pollutants like pharmaceuticals. Together MP leachates and pharmaceuticals may disrupt biofilm algae production (GPP) and ecosystem respiration (R). MP leachates reduce gross primary production (GPP) and induce oxidative stress, while antihistamines such as cetirizine (Zyrtec) may suppress algal growth and microbial respiration (R). We tested the effects of glitter particle leachates and Zyrtec on three metabolism endpoints: GPP, R, and net ecosystem production (NEP) by exposing replicate microcosms to each factor alone and in combination. We hypothesized that these compounds would either suppress metabolism via photosynthetic inhibition or enhance respiration through compositional shifts in the bacterial community or new carbon subsidies. Results from oxygen measurements in light dark incubations after 21 days showed that Zyrtec at environmentally relevant concentrations had no significant effects, whereas glitter leachates marginally increased respiration, likely due to enhanced carbon inputs. No interactive effects were found. These findings suggest MP leachates may only exert modest effects on ecosystem metabolism, though future studies should examine broader impacts of plastic leachates and pharmaceuticals on microbial diversity and functionality as well assess effects on chronic exposure on biofilm metabolism

The Implications of Introgression on the Behavior of Native Helicoverpa zea Moths.

Cooper Phillips, Colorado State University; Frida Zink; Luke Tembrock; Micky Eubanks

In recent years, the genome of the agricultural pest Helicoverpa zea has experienced the introduction of a novel allele via introgression. While this cytochrome P450 allele, known as the B3 allele, is known to regulate the detoxification of insecticides, little is known about other potential fitness advantages the B3 allele or linked genes may confer. In addition, Colorado sweet corn growers believe that H. zea are colonizing Colorado sweet corn fields earlier in the growing season than past years. The early arrival of H. zea into Colorado sweet corn fields may be the result of introgression-related changes in the overall behavior of H. zea. To understand if introgression is impacting H. zea's behavioral biology, we investigated a variety of behavioral components associated with the pest. We conducted cold tolerance experiments, field sampling, and insecticide resistance trials to determine if admixture impacts the behavioral components of H. zea. Our results suggest that H. zea's behavior may have changed in response to admixture, where admixed individuals can survive toxic insecticide thresholds non-admixed individuals cannot. Results also suggest that admixed individuals are attracted to pheromone lure components that differ significantly from non-admixed individuals in bucket trap sampling. If behavioral changes continue to emerge as a consequence of admixture, farmers battling the pest may continue to face challenges in controlling outbreaks of H. zea.

Mapping Pathogens with Environmental DNA: Implications for Human and Animal Health in Madagascar

Cristina M. Blanco, Graduate Degree Program in Ecology, Colorado State University; Georgia Titcomb, Department of Fish, Wildlife, and Conservation Biology, Colorado State University

In today's complex public health landscapes, linking sources of pathogen exposure with land-use and human and animal movements is a crucial first step to developing public health interventions. Land use can alter pathogen presence and infectivity, particularly in developing countries like Madagascar, where diarrheal disease is a leading cause of death. In rural areas, reliance on natural water sources for household and agricultural activities increases exposure to diarrheal disease-causing pathogens. Therefore, it is necessary to understand the relationship between diarrhea causing parasites and water in changing landscapes. This study aims to determine waterborne presence of zoonotic pathogens and map transmission pathways between humans, animals, and the environment. We will utilize genetic metabarcoding to assess endoparasitic assemblages in rural watersheds of northeastern Madagascar using the novel VESPA (Vertebrate Eukaryotic endoSymbiont and Parasite Analysis) protocol. Water samples from rivers in Marojejy National Park and surrounding villages will be sequenced and taxonomically identified to determine parasite presence and abundance. Environmental pathogen presence will be analyzed with human and domestic animal geospatial distribution data to determine risk based on landscape type and water usage. These data will highlight areas where parasites are most prevalent, and where humans and wildlife are at highest risk for contracting or spreading zoonotic disease. There is currently no published literature regarding the use of environmental DNA for parasite risk assessment in Madagascar. Successful use of this technique would allow for monitoring of disease and public health measures that consider environmental impact of disease transmission.

<u>Do beetle-killed forests burn more brightly? Interactions between bark beetle impacts and fire radiative power (FRP) across the southern Rocky Mountains</u>

Dalton Robberson, Western Colorado University; Dr. Jonathan Coop, Western Colorado University; Dr. Jared Balik, Western Colorado University; Dr. Sara Hart, Colorado State University; Dr. Max Cook, Colorado Forest Restoration Institute

Several species of bark beetles native to western North America have in recent decades reached epidemic population levels driven by climate change and altered forest structure. These outbreaks have produced landscape-scale forest mortality in many regions, including within the southern Rocky Mountains. Warming is also increasing wildfire activity, and recent wildfires have burned over beetle-killed forests. However, the combined interactions between these two disturbances are not yet fully understood. Bark beetles have the potential to impact fire behavior through the alteration of forest fuel type, arrangement, moisture, and quantity. Here we propose to investigate the relationship between beetle kill and intensity of wildfires within the Southern Rocky Mountain ecoregion. Utilizing a remotely-sensed metric for fire intensity, fire radiative power (FRP) and satellite-derived maps of beetle tree mortality, we will test the hypothesis that the extent of beetle kill within a forested ecosystem increases fire intensity. These findings will improve ecological understanding of disturbance interactions and may also inform land management decisions and wildland fire incident management.

<u>Impacts of Solar Photovoltaics on Bat Foraging Resources</u>

Dani Rosari, Colorado State University; Heide Keeble, Dept. of Biology Colorado State University; Matt Sturchio, Dept. of Natural Resources and Environment Cornell University

Renewable energy, including ground-mounted solar photovoltaic (PV) installations, is growing rapidly worldwide. These sustainable, enduring renewable energy systems can have unintended consequences for bat foraging behavior and populations. New research indicates bat avoidance of PV sites, with many hypotheses as to why. One hypothesis is that PV sites may affect foraging resources, which is supported by reduced feeding within the PV sites. However, the impacts of PV development on insect communities are understudied, preventing the hypotheses from being supported or rejected. We assessed insect communities, through counts and biomass, among PV sites via pan traps, sticky traps, and night traps from June to August to determine whether PV sites impact the insect communities that local bat species forage on. We hypothesized that there would be a reduced insect richness and abundance within the panel than away from the arrays. Our hypothesis was supported by our data collection, indicating that insect communities that bats are known to rely on as foraging resources are impacted by the PV. This information, and further data collection, can help bridge the gap in knowledge on why bats may avoid solar farms- whether that is behavioral or due to a lack of resources. This information can be used to improve PV impacts on wildlife, especially bats, as installations continue at a rapid pace and bat populations decline.

Opuntia polycantha flowering in a photovoltaic solar panel array

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Photovoltaic (PV) solar panel arrays are land intensive; unpopulated semi-arid grassland of lower economic potential presents an attractive solution for deployment of renewable energy production. The impact of these PV systems on native grassland ecology can be monitored using the keystone species Opuntia polycantha's blooming patterns as indicators of potential environmental impact. PV arrays by design "harvest" available solar energy which otherwise could be utilized by the cacti. Initial results suggest decreased photosynthesis opportunity alters flowering of Opuntia polycantha. Such disruptions may affect pollinator access to critical resources, resulting in cascading effects within the overall semi-arid grassland ecosystem & trophic web.

Rejuvra (Indaziflam) Suppresses Invasive Annuals but Produces Site-Specific Changes in Colorado Grassland Communities

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Invasive annual grasses and shifting fire regimes threaten grassland ecosystems across the Colorado front range. Application of Rejuvra (indaziflam), a pre-emergent herbicide, helps to reduce invasive species such as Bromus tectorum (cheatgrass) and Alyssum simplex, yet its long term ecological effects on plant communities remain under-evaluated. In this study, we assessed the impact of Rejuvra application on plant community composition, species richness, and aboveground biomass across three native shortgrass prairies: Daniels Park, Red Rocks Park, and Backcountry Wilderness Area (Highlands Ranch). To do this, we measured the percent cover of all plant species within thirty-two 1 m2 quadrats and above ground biomass from 20 cm2 sub-quadrats at both a treated and untreated zone at each site. At all three sites, untreated plots exhibited significantly higher Alyssum simplex cover than treated plots, while Bromus cover was significantly lower in treated plots only at Backcountry Wilderness Area and Daniels Park. Contrary to original predictions, the shannon diversity and species richness were significantly

higher in untreated zones at Backcountry Wilderness Area but did not differ between treated and untreated zones at Daniels Park or Red Rocks Park. Rejuvra application partially supports restoration goals in Colorado grasslands by suppressing invasive annuals but fails to support positive changes in species diversity and richness. These results may have been influenced by the expansion of already-present native species (after 2-3 years of re-growth) rather than immigration of new native species to the study areas. These findings provide land managers with evidence that Rejuvra can help minimize invasive species with long-term planning; however, further efforts to reintroduce native species and continued monitoring may still be necessary.

Bee Conservation Using Bee Hotels

Dylan Mitchel, Dept. of Biology Colorado State University; Kyle Ruszkowski, Colorado State University Grad. Degree Program in Ecology; John Mola, Colorado State University Dept. of Forest and Rangeland Stewardship

Native insect populations, including pollinators, have declined due to pesticides, habitat loss, climate change, and competition with invasive species. Pollinators are essential for the proliferation of native plant species, and even crop production, therefore, pollinator population collapse may lead to a far wider, even more devastating ecological impact if work is not done to help rebuild pollinator communities. Bee hotels, designed to provide nesting sites for native cavity-nesting bee species, have become increasingly popular. These hotels aim to assist native pollinator communities in urban settings; however, invasive bees frequently occupy and bee hotels, once again pushing out native species. In this study, we aimed to test how the effect of a roof overhang, that shaded the face of the bee hotel, affected the community composition of bee species in the bee hotels. The shade provided by the overhang helps to cool the cavities, effecting offspring survival, and number of viable generations in a season. We tested this by placing 22 bee hotels with 3 cavity sizes per hotel in semi-urban locations throughout the city of Fort Collins, Colorado, set along the boundary where, historically, the shortgrass prairie meets the montane Rocky Mountains. Though further research is needed, this study suggests a trend correlating higher occupancy of bees to hotels with overhangs.

When Birds Sing: Long-Term Patterns in Avian Vocal Phenology from Passive Acoustic Monitoring

Edder Antunez, Colorado State University; Cathleen Balantic, National Park Service's Natural Sounds and Night Skies Division; Davyd Betchkal, National Park Service's Natural Sounds and Night Skies Division

Understanding shifts in avian vocal phenology is critical for assessing how climate change influences breeding behavior and population dynamics. The timing of vocal onset—the first consistent vocal activity of the breeding season—closely reflects arrival, territory establishment, and reproductive readiness, making it a sensitive indicator of ecological change. Using long-term passive acoustic monitoring data from Denali National Park and Preserve, this study examines how avian vocal onset dates vary across years and environmental gradients. Continuous acoustic recordings from 40-45 monitoring sites spanning a range of elevations and habitat types were analyzed using BirdNET, an automated tool for identifying bird vocalizations. Vocal onset dates were estimated for multiple species using weekly detection histories during the breeding season, allowing for consistent comparison across years. Environmental predictors, including air temperature, precipitation, snow cover, vegetation structure, and elevation, were quantified using GIS-derived layers and historical climate data. Because acoustic detections are influenced by both animal behavior and environmental conditions, occupancy modeling was used to explicitly account for imperfect detection. Single-season and dynamic occupancy models provided a framework to separate true variation in vocal onset timing from changes in detectability driven by habitat or weather. Aggregating detections at a weekly scale improved model stability and aligned with observed pulsed arrival patterns of migratory birds. Preliminary analyses focus on estimating vocal onset dates across years and environmental gradients, with ongoing work evaluating whether the timing of vocal onset has shifted over the study period. We further examine whether habitat characteristics such as elevation and vegetation structure mediate observed variation in vocal onset timing. By integrating bioacoustics, phenology, and occupancy modeling, this research highlights the value of long-term acoustic monitoring for detecting climate-driven changes in avian breeding behavior.

Exploration of Colorado Forest Management and Wildfire (2000 – 2024)

Elizabeth Buhr, Colorado State University; Sarah Hart, Colorado State University

Wildfire activity in the western United States is increasing due to climate change, effective fire suppression policies, and the exclusion of indigenous cultural burning. The ecological legacy of fire suppression is most pronounced in forests adapted to frequent fire, such as Colorado's ponderosa pine (Pinus ponderosa) forests, due to fuel accumulation. In these systems, more fuel increases the risk of high-severity crown fire. To mitigate fire risk and meet other ecological goals, land managers may choose to apply fuel treatments such as thinning or prescribed burning. Key to success in any pursuit is the tracking and consideration of data. Here, I summarize the Colorado Forest Tracker (2000 – 2023) database, created by the Colorado State Forest Service (CSFS) and the Colorado Forest Restoration Institute (CFRI). The database provides novel synthesis of management actions across multiple land ownerships and distinguishes acres managed by human tally versus geographic extent. Using historical fire perimeters from the interagency Monitoring Trends in Burn Severity (MTBS) database, I then add prior wildfire as its own treatment category and identify treatment overlap with subsequent wildfire events. The results reveal basic information about existing forest management and wildfire in Colorado. Fuel treatments have been most commonly applied in ponderosa pine systems using forest thinning (treatments not including burning). While broadcast burning and prior wildfire account for the fewest number of treatments (only 4%), they make up 32% of treated area intersecting with subsequent wildfire. Overlapping all treated areas within wildfire perimeters, we observe a mean treatment extent proportion of 0.09 (n = 73, range = <0.01 – 0.84). Consideration of these data may serve as a starting point for many lines of inquiry. For example, how do ecological effects of wildfire vary by treatment characteristics? What does this tell us about forest stewardship in the future?

Monarch Development on an Under-Recognized Host Plant

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Monarch butterfly (Danaus plexippus) populations have declined in recent years, with one of the predominant contributors being decreased host plant availability. Essential for D. plexippus development, milkweeds in the Asclepias genus have been heavily studied and prioritized in conservation efforts. However, other related taxa, including honeyvine milkweed (Cynanchum laeve), have been largely underappreciated. Cynanchum laeve is an abundant weed and known host plant of D. plexippus in the central and southern U.S., available in mid to late summer after many other milkweeds have senesced. To compare D. plexippus developmental success between different host plants, we reared D. plexippus from egg to pupae on common milkweed (Asclepias syriaca) and C. laeve. Measuring development time from egg to pupae, pupal mass, time as pupae, and adult wing length, we found significant differences between both groups for each trait.

Regarding developmental timing, individuals reared on C. laeve took longer to develop from egg to pupa and spent more time as pupa. Morphologically, pupal mass was lower and wing lengths were shorter for C. laeve individuals. Overall, these differences between treatments were significant, but both host plant species produced viable D. plexippus adults. Our results suggest that A. syriaca may be more efficient as a host plant, but C. laeve can serve as an important host plant, especially in late summer and early fall as A. syriaca senesces. Future D. plexippus conservation efforts should consider C. laeve when alternative host plants are unavailable.

Enhancing the MEMS Model to Incorporate Pyrogenic Organic Matter Dynamics

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Pyrogenic organic matter (PyOM) is a crucial and understudied component of the carbon (C) cycle in terrestrial ecosystems, particularly in fire-affected environments and managed landscapes where biochar application occurs. Its chemical complexity, persistence, and interactions with soil systems make it an important component of long-term C storage and biogeochemical cycles. Despite this, PyOM is often underrepresented in mechanistic models due to the inherent complexity of its chemical diversity and functional behavior. To address this challenge, we developed a PyOM specific submodule for the MEMS model, a process-based biogeochemical ecosystem model designed to simulate soil organic matter (SOM) dynamics across soil depths, including the measurable dynamics of individual soil organic carbon (SOC) fractions. This submodule integrates current understanding of PyOM transformation and stabilization, with pools defined based on a combination of chemical characteristics influenced by both feedstock and pyrolysis temperature. This approach allows the model to represent how PyOM composition influences persistence and its interactions with microbial and other SOM pools. The design accommodates a range of field contexts, including wildfire and biochar application systems in grassland and savannah ecosystems. Field data from a natural fire system and a char-amended experiment will be utilized to evaluate the model's performance and applicability. By explicitly representing PyOM's chemical diversity and transformation processes, this submodule aims to enhance MEMS's ability to simulate SOC dynamics and to improve our understanding of PyOM's role in terrestrial ecosystems.

At the Right Scale: Using Evolutionary Units to Diagnose Population Decline in Bank Swallows

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As climate change accelerates population declines worldwide, effective conservation requires identifying not only the drivers of decline but also the spatial scale at which populations respond. Within species, evolutionary differences among populations can produce heterogeneous responses to shared environmental stressors, meaning that range-wide analyses may obscure biologically meaningful variation. We apply an evolutionarily informed framework to the Bank Swallow (Riparia riparia), a migratory aerial insectivore that has declined by up to 98% across North America. Using range-wide genomic data integrated with migratory behavior information, we delineated six evolutionarily significant units (ESUs) that reflect both genetic and migratory structure. We then used these ESUs as the analytical framework to evaluate environmental

predictors of population decline using generalized additive mixed models. Models incorporating ESU structure outperformed range-wide approaches and revealed distinct ESU-level responses to environmental variables that would have been masked at the species level. By integrating genomics, migration data, and spatial modeling, this work demonstrates how evolutionarily significant units can improve the diagnosis of decline and provide a biologically grounded basis for targeted conservation action in highly mobile species.

Mapping Genetic Diversity to Inform Conservation Priorities for the Bobolink, a Declining Grassland Bird

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North American bird populations have declined drastically since the 1970s, with grassland birds declining faster than any other habitat group. The Bobolink (Dolichonyx oryzivorus) is a particularly imperiled grassland bird, having declined by almost 60% since 1970 and 21% in only the last 10 years. These sharp declines have led scientists and conservation practitioners to designate the Bobolink as one of 112 Tipping Point Species in need of immediate conservation action as part of the Road to Recovery initiative. In addition to identifying Tipping Point Species, the Road to Recovery effort has provided species working groups with an 18-part recovery wheel outlining the recovery process. Two key steps are to assess population structure and identify population vulnerability. Knowledge of population structure enables the identification of genetically distinct breeding populations and delineation of conservation units as a framework for range-wide management. This, in turn, serves as the foundation for understanding local patterns of population vulnerability, including the spatial distribution of genetic variation. Despite the importance of these metrics to inform species recovery, more knowledge is needed regarding the population structure and genetic health of the Bobolink, especially in Colorado and the Mountain West. Previous work has found that Bobolinks breeding in Oregon and British Columbia are genetically distinct from the much larger group spanning the Great Plains and New England, suggesting that other isolated populations of the Mountain West may also be unique and deserving of focused conservation attention. To address these gaps, I propose to construct a map of genetic variation across the Bobolink breeding range which will provide a roadmap for management decisions which can best conserve distinct populations, maintain range-wide genetic diversity, and begin the process of species recovery.

Impact of prolonged, extreme drought on seed rain abundance and diversity in a semi-arid grassland

Giselle Gueddiche & Izabella Rhomberg, Warner College of Natural Resources, Colorado State University; Giselle Gueddiche, Warner College of Natural Resources, Colorado State University; Maddie Amick, Graduate degree Program in Ecology, Colorado State University; Melinda D. Smith, Graduate degree Program in Ecology, Colorado State University

Long term extreme droughts are predicted to increase in frequency and severity in semi-arid regions. Thus, understanding how such ecosystems recover from these climate disturbances is essential. Seed rain plays an integral role in plant community recovery by reintroducing locally extinct individuals and species. We aimed to assess how seed rain responded to extreme drought by examining how the diversity and abundances of species changed over time. At the end of the first growing season, after the cessation of an extreme 4-year experimental drought (October 2018 – May 2023), seed traps were placed in the field (October 2023) in a semi-arid grassland in NE Colorado. Six months later they were replaced (May 2024) and then recollected after another six months (October 2024). Seeds were then collected from the traps in the lab, sorted, and identified to species. We found that plots exposed to extreme drought had significantly more seeds deposited than the control (156.32 vs 28.58). Previously droughted plots contained significantly more species (6.18 vs. 4.35) initially and increased significantly over the course of a year (8.46 vs. 4.49) when compared to controls. This may be attributed to seasonality, as the first sample was placed shortly after the growing season ended. Evenness was significantly lower in previously droughted plots (0.45 vs. 0.69) and continued to decrease with time (0.35 vs. 0.64). Extreme drought, and time after drought significantly alters seed deposition dynamics, potentially altering passive mechanisms of recovery. By monitoring seed deposition, we can understand how species in the seed rain interact with grassland recovery after extreme, prolonged drought.

<u>Biogeographic variation in lowland tropical forest soil microbial communities and responses to drying</u>

Grace McLaughlin, Colorado State University. Kristin Saltonstall, Smithsonian Tropical Research Institution, Nicholas Bouskill, Oregon State University, Stephany Chacon, Oregon State University, Ally Lewis, Colorado State University, Daniela Cusack, Colorado State University and Smithsonian Tropical Research Institute

Soil contains more carbon (C) than terrestrial vegetation and the atmosphere combined, with some of the largest terrestrial C stocks in tropical rainforests. Soil microbes decompose organic matter, playing a vital role in the storage or loss of soil C. Drought conditions are predicted to increase strength and frequency in the tropics with climate change. This project explored effects of chronic and seasonal drying on soil microbial communities across four tropical forests in a long-term drying experiment. We used soils from a drying experiment established in 2018 across four seasonal lowland forests in Panama that vary in rainfall and soil fertility. Soils were collected from 0 – 10 cm during three seasonal periods in the forests across 32 control and drying plots (n = 4 per forest per treatment). The 16S V4 rRNA region was amplified to identify bacteria, and the ITS1 region for fungi. We found significant biogeographic variation in microbial diversity and significant effects of site and drying treatment on different metrics of community composition. These results suggest that increased drought conditions in tropical forests will have a significant long-term impact on soil microbial diversity, with potential downstream effects on soil C storage.

<u>The importance of wet years for initiating grassland recovery after a Dust Bowl-type drought</u>

Greg Tooley, Dept of Biology and GDPE; Kathleen Condon, Dept of Biology and GDPE; Maddie Amick, Dept. of Biology and GDPE; Melinda Smith, Dept. of Biology and GDPE; Alan Knapp, Dept. of Biology and GDPE

Extreme multi-year droughts are projected to become more frequent. Such droughts can dramatically alter ecosystem structure and functioning and lead to prolonged periods of recovery. In the shortgrass steppe, for instance, full recovery following the Dust Bowl drought of the 1930's required nearly two decades. Beyond observational surveys of recovery after the Dust Bowl, it remains unclear how post-drought climate conditions and resource availability influenced grassland recovery. Such understanding is crucial, however, given projections for droughts to increase in severity, frequency, and extent in this region. Here, we imposed a 5-year experimental drought (67% precipitation reduction) in the shortgrass steppe of Northeastern Colorado (USA).

This drought nearly eliminated dominant grasses (Bouteloua sp.) and reduced ANPP by ~99%. We then assessed recovery for three-years post drought under varying rainfall conditions: ambient precipitation, long-term average precipitation (LTA), LTA + 50%, and LTA + 100%. In the first recovery year, ANPP was 300 - 400% greater in droughted plots compared to non-droughted control plots across all precipitation treatments. This positive legacy in ANPP was driven by annual forbs (notably Salsola tragus) and was associated with increased soil nitrogen availability. In subsequent recovery years, ANPP declined in droughted plots, converging with control levels on year three. By contrast, the recovery of dominant C4 grasses, which were nearly eliminated during the drought, was minimal and depended strongly on precipitation treatment. After three years, perennial C4 grass productivity had only recovered by 1–2% in droughted plots under ambient and LTA precipitation conditions. However, recovery reached 15% of control levels in the LTA +100% precipitation treatment. We conclude that post-drought precipitation regulates the recovery of dominant C4 perennial grasses and community structure, yet it has limited influence on the recovery of total ANPP.

<u>Five years of throughfall exclusion reveal divergent soil respiration responses across tropical forests</u>

Hailey Tharp, Graduate Degree Program in Ecology; Daniela Cusack, Dept. of Ecosystem Science and Sustainability

Tropical rainforest soils are poorly understood under the condition of drought. As climate change increases the likelihood of chronic drying in tropical rainforests, studying drought is critical to understanding soil carbon dynamics in the ecosystem representing the largest terrestrial carbon pool. Tropical rainforests represent the largest non-anthropogenic CO_2 flux to the atmosphere and play a vital role in global carbon dynamics. CO_2 flux in tropical rainforests is largely driven through soil microbial heterotrophic respiration of organic matter. Heterotrophic respiration rates are positively correlated with soil moisture, temperature, and soil nutrients. I will examine these relationships using throughfall exclusion structures across four distinct lowland tropical forests that vary in yearly precipitation rates across the Isthmus of Panama. Preliminary results found that across our four lowland tropical forests soil respiration declined for the first five years but then diverged among sites with the most fertile forest showing an increase in soil respiration with drying. Through a combination of historic datasets and new soil sampling and analysis, I will create a 9-year dataset examining the effects of precipitation shifts with chronic drying on soil respiration. Based on differences in baseline soil fertility, I predict that chronic drying will suppress soil respiration in infertile forests while maintaining or enhancing respiration in more fertile sites. With limited knowledge of the effects of global change on tropical rainforests, this research will provide new insights to strengthen conservation efforts for the largest terrestrial carbon sink.

<u>Food stress and pesticide exposure interact to intensify harmful reproductive effects in bumblebees</u>

Hannah Burke, Colorado State University; Jeremy Hemberger, Dept. of Entomology at University of Minnesota; Keirs Manlapas, Dept. of Forest and Rangeland Stewardship at Colorado State University; Laura Lukens, Dept. of Forest and Rangeland Stewardship at Colorado State University; John Mola, Dept. of Forest and Rangeland Stewardship at Colorado State University.

Pollinator populations are declining globally due to multiple interacting stressors, including poor nutrition, pesticide exposure, habitat fragmentation, and emerging pathogens and parasites. These stressors may act synergistically, producing combined effects more harmful than each alone.

Despite growing concern, few studies have examined how poor nutrition and pesticide exposure interact to affect bumblebee survival and colony performance. Understanding how the timing of floral resource abundance shapes resilience to chemical stressors is critical for supporting pollinator populations in increasingly disturbed and agricultural landscapes. We designed an experiment to test the interactive effects of temporal food stress and pesticide exposure in bumblebee systems, focusing on impacts to bee survival, colony growth, and reproduction. In a controlled laboratory experiment, microcolonies of the common eastern bumblebee (Bombus impatiens) were subjected to combinations of dietary and pesticide treatments to test how variation in food abundance and timing modulates vulnerability to sublethal, field-relevant doses of the neonicotinoid pesticide imidacloprid. All microcolonies exposed to imidacloprid displayed decreased microcolony mass growth and produced fewer and smaller males. A harmful synergistic effect on total male production was seen in microcolonies in the late food stress with neonicotinoid exposure treatment group. As well, some evidence of an interaction between late food stress and neonicotinoid exposure was observed for male body size. This study highlights the importance in understanding how nutrition may modulate bee resilience to pesticide exposure. Our work suggests that late-season nutrition may play an important role in aiding bees exposed to neonicotinoids.

Immune Function in Hybrid and Parental Gryllus Crickets

Hannah Eckert, Isaac Hudson Foy, Erica Larson

An organism's immune function can provide insight into physiological differences across species. Two closely-related species of crickets, Gryllus firmus and Gryllus pennsylvanicus, hybridize in the Eastern US, producing F1 hybrids. Previous studies suggest that hybrids may experience evolutionary disadvantages that affect their overall fitness. To investigate this with our study system, we quantified hemocyte counts and measured the melanization of foreign bodies in both parental species and their F1 hybrids as measures of immune response. Our preliminary results indicate no significant differences in immune responses among parental and hybrid crickets.

Life beneath a solar array: Arthropod abundance and diversity in a photovoltaic grassland

Heide Keeble, GDPE, Colorado State University; Alan Knapp, GDPE/Biology, Colorado State University; Matt Sturchio, Cornell University

Ground-mounted photovoltaic solar arrays are growing in number and extent across the US as energy production transitions to renewable forms, and the impacts of this energy infrastructure on arthropods is currently not well understood. As mobile ectotherms, many arthropods may be able to take advantage of the unique microclimates offered within solar arrays, but the effect on abundance and diversity is unknown. We do know that arthropods have been declining in both abundance and species diversity across multiple ecological regions in recent years. In some areas, abundance has not changed, but species turnover has altered communities. Arthropods provide many ecosystem services as pollinators, soil engineers, decomposers, and pest control, so understanding how and why their communities are impacted by human activity is essential to forecasting the functioning of ecosystems in the future. This study aims to assess how solar arrays impact arthropod communities, through collecting both soil surface (via pitfall traps) and canopy arthropods (via sweep netting) within a solar array in a Colorado grassland and comparing these patterns to an adjacent grassland outside the solar array.

Adaptive genomic divergence and implications for Genetic Rescue in the Loggerhead Shrike

Holden Fox, Colorado State University; Amanda Carpenter, Colorado State University; Joan-Ferrer Obiol, Colorado State University; Jim Saracco, The Institute for Bird Populations; Christen Bossu, Colorado State University; Amy Chabot, African Lion Safari; Kristen Ruegg, Colorado State University

Accelerating biodiversity loss has intensified interest in genetic rescue as a tool to counteract declining genetic diversity in imperiled populations. However, successful genetic rescue requires identifying vulnerable populations while minimizing the risks of outbreeding depression and maladaptation. Advances in conservation genomics now allow these decisions to be informed by both neutral and adaptive genetic variation. We used whole-genome sequencing to evaluate genetic rescue potential in the Loggerhead Shrike (Lanius ludovicianus), a partially migratory grassland bird experiencing long-term declines across North America. Using whole-genome sequence data from 324 individuals, we evaluated population structure, genetic diversity, demographic history, and adaptive divergence across the species' range. Genome-wide analyses identified five major genetic groups, including strong isolation of Channel Island populations and clinal isolation by distance across the continental range, indicating historical and ongoing connectivity. Genetic diversity was low throughout the range, with elevated inbreeding in Southeast and Channel Island populations, suggesting heightened vulnerability to inbreeding depression. Demographic reconstruction revealed consistent declines in effective population size across all groups, mirroring long-term census declines shown by Breeding Bird Survey data. Genotype-environment associations identified four adaptive units across the continental range that partially mismatched genome-wide structure and were associated with climate, elevation, and land-cover variation. We found no evidence of large chromosomal inversions that might impede translocation efforts. Together, these results indicate that genetic rescue is feasible for several continental populations, particularly in the Southeast, where low gene flow and elevated inbreeding increase vulnerability. This study demonstrates how integrating neutral and adaptive genomic data can directly inform genetic rescue decisions and provides a practical framework for conservation planning in imperiled species

<u>Targeted seed sowing to maintain function in semi-arid rangelands under a drier future</u>

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Shifts in precipitation across U.S. rangelands may reduce biodiversity, forage productivity, and increase erosion. One indicative sign of degradation is the formation and expansion of bare patches from a loss of vegetation. Warm, dry conditions intensify abiotic stress within these patches, causing erosion and their expansion into persistently denuded areas. Identifying plant species with traits that allow establishment on patch edges and seeding those species could shift degradation to vegetation recovery by facilitating the natural dispersal process and promote the infilling of bare patches. This study aimed to identify plant species that establish on patch edges and how microsite abiotic stress affects seedling emergence and survival. We predicted that all species would have greater recruitment at patch edges due to the tradeoffs between abiotic stress in patch centers and competition within intact vegetation. Species with traits such as earlier

emergence and larger seed mass may perform especially well on edges by tolerating abiotic stress, while earlier emergence could enhance survival under moist conditions. We implemented a seed addition experiment in a xeric tallgrass prairie near Boulder, Colorado. In November 2024, seeds were randomly sown across a gradient from 10 cm into the vegetation and 20 cm into bare patch centers. Soil moisture was measured May-August, and seedling emergence, survival, and mortality were monitored March-August. Generalized linear mixed models assessed the effects of microsite abiotic conditions and recruitment location. Preliminary results show recruitment was highest in the bare patch centers, countering our expectations that edges would have higher recruitment. Species also differed in recruitment across locations. In June, soil moisture was significantly lower and dried faster in the bare patches than in vegetation and edges, but differences disappeared later in the season. Notably, recruitment remained highest in patch centers despite reduced early-season soil moisture.

Morphological and acoustic divergence in hybridizing field crickets

Isaac Hudson Foy, University of Denver; Robin Tinghitella, University of Denver; Ella Mathews, University of Denver; Hannah Eckert, University of Denver; Erica Larson, University of Denver

Behavioral isolation contributes to species boundaries when mating signals diverge and are no longer recognized across species. In the field crickets Gryllus firmus and Gryllus pennsylvanicus, barriers to reproduction are incomplete, allowing hybridization despite differences in morphology, habitat preference, and more cryptically: calling song. To initially attract mates, crickets rub specialized structures on their wings together to produce loud calling songs, directly linking morphology to courting behavior. Here, we analyzed how wing morphology and song characteristics vary across the two species and their hybrids. Using geometric morphometrics of sound-producing wing structures, file tooth counts, and bioacoustic analyses of chirps and pulses, we assess differences between species and whether hybrids show intermediate or novel traits. Together, these results clarify how morphological variation works in tandem with mating signaling to contribute to behavioral isolation in a hybridizing system.

Impact of prolonged, extreme drought on seed rain abundance and diversity in a semi-arid grassland

Izabella Rhomberg & Giselle Gueddiche, Warner College of Natural Resources, Colorado State University; Maddie Amick, Graduate degree Program in Ecology, Colorado State University; Melinda D. Smith, Graduate degree Program in Ecology, Colorado State University

Long term extreme droughts are predicted to increase in frequency and severity in semi-arid regions. Thus, understanding how such ecosystems recover from these climate disturbances is essential. Seed rain plays an integral role in plant community recovery by reintroducing locally extinct individuals and species. We aimed to assess how seed rain responded to extreme drought by examining how the diversity and abundances of species changed over time. At the end of the first growing season, after the cessation of an extreme 4-year experimental drought (October 2018 – May 2023), seed traps were placed in the field (October 2023) in a semi-arid grassland in NE Colorado. Six months later they were replaced (May 2024) and then recollected after another six months (October 2024). Seeds were then collected from the traps in the lab, sorted, and identified to species. We found that plots exposed to extreme drought had significantly more seeds deposited than the control (156.32 vs 28.58). Previously droughted plots contained significantly more species (6.18 vs. 4.35) initially and increased over the course of a year (8.46 vs. 4.49) when compared to controls. This may be attributed to seasonality, as the first sample was placed shortly after the growing season ended. Evenness was significantly lower in previously droughted plots

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Urban Oasis: Drivers of Biodiversity in Front Range Urban Ponds

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Urban ponds are ubiquitous components of municipal infrastructure, yet the factors that distinguish degraded stormwater basins from refuges of unique and conservation-relevant taxa remain poorly understood. We hypothesize that multiple landscape filters, including urbanization, habitat heterogeneity, and human use, influence biodiversity, and that their relative importance can be disentangled to identify the dominant drivers of community homogenization. To test this, we surveyed 48 urban ponds in Fort Collins, Colorado, measuring water quality, fish and amphibian diversity, benthic macroinvertebrate community composition, and surrounding land use and habitat characteristics. Across all sites, we detected 27 fish species, 53 families of benthic macroinvertebrates, two state-listed species, and one species previously undocumented in western North America. Statistical analyses to evaluate the influence of urbanization on pond community composition are currently underway.

Giant sequoia wood properties affect bark beetle reproduction more than exposure to fungal pathogen

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Bark beetles must overcome physical and chemical defenses of trees as well as pathogens. Phloeosinus punctatus (LeConte) is a native bark beetle in Western North America that feeds and reproduces in various species in the cypress family, including giant sequoia (Sequoiadendron giganteum). We isolated and tested two strains of Beauveria bassiana, a known fungal pathogen for P. punctatus, as a biocontrol on S. giganteum. Emergence was counted and compared against treatments and physical branch characteristics (age, growth rate, diameter, bark thickness, and moisture content). There was no difference in emergence between the treatments and control. We found that older branches have lower emergence, moisture content, and growth rate and that there is no relationship between age and bark thickness. These results suggest that younger, smaller branches with higher moisture content are more favorable for P. punctatus reproductive success compared to older, slower growing, dryer and larger branches. This shared herbivore may exhibit similar patterns of reproductive success in other host trees.

Variation in Pollinator Attraction Among 15 Chili Pepper Cultivars

James Haas, Department of Agricultural Biology, Colorado State University; Micky Eubanks, Department of Agricultural Biology, Colorado State University

Insect pollinators play a critical role in sustainable agricultural systems, enhancing crop yield and productivity. Their contributions, however, are commonly overlooked when growers select plant varieties to cultivate. Crop traits such as yield potential, disease resistance, and marketability tend to be prioritized over attractiveness to pollinators. The primary goal of this research is to provide novel insights into the importance of varietal selection in the context of pollination efficiency, encouraging a holistic and eco-friendly approach to farming that increases yield. The specific objectives of this study are to 1) quantify differences in pollinator attraction among chili pepper cultivars, 2) measure floral structures across chili pepper cultivars to identify important plant traits that correlate with pollinator attractiveness, and 3) determine if variation in pollinator visitation affects yield. Fifteen chili pepper (Capsicum annuum L.) varieties were screened. This research implements both open-field and flight cage pollination surveys to assess consistency in results across a range of environments, and to provide evidence that supports relationships found between varietal differences and pollination activity. This study explores crop selection, pollinator optimization, and crop production, all of which are essential components in advancing sustainable agriculture. Findings include an over eightfold difference in pollinator visitation among the chili cultivars, indicating strong variation in cultivar-level pollinator attraction. Approximately 42% of the variation in floral visitation across all cultivars in this study was explained by the number of flowers per chili plant. Additionally, while flower size varied substantially across the cultivars (≈160% range), no association was identified between flower size and floral visitation.

<u>Insect Emergence and Riparian Predator Abundance in Urban Ponds Across a Land Cover and Chemical Gradient</u>

Jennoa E Fleming, Department of Fish, Wildlife, and Conservation Biology, Colorado State University | Jackson A Bates, Department of Fish, Wildlife, and Conservation Biology, Colorado State University | Jeremy M Brooks, Department of Fish, Wildlife, and Conservation Biology, Colorado State University | Michelle L Hladik, California Water Science Center, U.S. Geological Survey | Johanna M Kraus, Columbia Environmental Research Center, U.S. Geological Survey | Daniel L Preston, Department of Fish, Wildlife, and Conservation Biology, Colorado State University

Urbanization affects aquatic and terrestrial biodiversity by fragmenting habitats, introducing pollutants, and shifting species composition. The presence of ponds within urban areas may act as refugia for aquatic species, but it is unclear how ecosystem services shift in relation to surrounding land cover and concomitant changes in water chemistry. A significant ecosystem service provided by urban ponds is the emergence of aquatic insects which transfer energy into terrestrial environments. The aim of this study was to determine how the flux of aquatic insect emergence shifts in relation to urban land cover and water chemistry (including nutrients, pesticides, and trace metals), and how riparian predators may be impacted by these rates. Aquatic emergence traps were deployed at 16 ponds along a gradient of urbanization (measured by percent impermeable land surface) within Fort Collins, Colorado for one month in late summer. Bird and spider surveys were conducted at each site to test if emergence was correlated with riparian predator abundances. Ponds with reduced riparian habitat complexity and increased surrounding areas of impervious surfaces appear to have reduced biomass and reduced species richness of insect emergence. The ponds that were most impacted by urbanization had higher concentrations of pesticides and emergence comprised often exclusively of pollution tolerant midges (Chironomidae). Ponds with more complex riparian habitats, less surrounding areas of impervious surfaces, and lower concentrations of pesticides had more diverse taxa such as Trichoptera, Odonata, Ephemeroptera, and Diptera with higher richness and abundance. Preliminary data also shows that riparian spider and insectivorous bird abundance increase with riparian vegetation complexity. These findings indicate that urban ponds may be an important source for energetic subsidies for riparian environments as riparian predators prepare to overwinter or migrate, but water chemistry and local habitat features may regulate the taxonomic composition of subsidies.

Developing a plant-driven landscape assessment for climate-smart grazing management in mixed-grass prairies

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Accurately predicting plant community composition is essential for adaptive grazing management in the face of shifting climatic conditions. Current grazing management typically defines pasture carrying capacity using Animal Unit Months (AUM) per acre—a measure based on livestock age, class, size, and monthly forage consumption. While useful, this animal-focused metric overlooks plant community heterogeneity and year-to-year variation in forage production driven by climate and topography. Under increasingly variable climates, such oversights can contribute to unsustainable grazing practices through nonoptimal distribution of livestock in relation to plant species' phenological phases at different points in the growing season. Our study addresses this management limitation through introducing a plant-driven landscape assessment that can be used to adjust area and timing of livestock grazing. Our study utilizes the inherent variability of the Mixed-grass prairie, the heterogeneous ecotone between the Tallgrass and Shortgrass prairies, to evaluate trends in cool-season C3 and warm-season C4 species within pastures. To do this, we integrated remote sensing with ground-truth data to assess plant phenology across pastures in southeastern Wyoming in the context of the underlying topography and climate. Through this approach, we accurately identified zones of distinct plant communities with varying proportions of C3, C4, and bare ground cover. Using weather data from 2014–2024, we found that these zones exhibited significantly different growing-season biomass responses within and across years. Our findings underscore the importance of incorporating pasture heterogeneity when predicting plant community responses to climate change.

Assessment of Swamp Wallaby (Wallabia bicolor) Foraging Activity on the Summerland Peninsula, Phillip Island, Victoria

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This study aimed to assess diurnal browsing activity of Swamp Wallabies (Wallabia bicolor) on the Summerland Peninsula by directly observing their feeding patterns and preferences in open habitats. Over one month of data collection (June 26th–August 5th, 2025; Winter 2025), ethogram-based group interval sampling was conducted utilizing ZooMonitor software. This analysis of Wallabia bicolor fieldwork produced activity budgets across the diurnal period from dawn to dusk. Composed across vegetation type and primary behaviours (differentiated between browsing and non-browsing), this offered insight into their interactions with the island's flora. Total sampling was conducted over 200 five-minute sessions across 30-second intervals, amounting to over 16 hours of total data. Preliminary analysis of the Summerland Peninsula swamp wallaby population indicates clear temporal influences on vegetation selection and primary behaviours in open habitats across the diurnal period. With rooting/foraging having the highest display at dusk, more than 50% of the activity budget was composed of browsing behaviours throughout the diurnal period. Selection towards succulent herbage vegetation was observed, with additional weather influence further reinforcing this pattern. This methodology serves as a template to support continuous study of Swamp Wallaby behaviour, providing means for measuring their influence on vegetation across varying seasons, conditions, and years. Contributing to a more comprehensive understanding of Swamp Wallaby ecology, establishing a standardized method for future database expansion, and guiding efforts to balance their population with broader ecosystem health.

Effects of artificial light at night (ALAN) on insect life history traits and abundance

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Anthropogenic pollutants like artificial light at night (ALAN) and noise impact most of the land in the US and have broad negative impacts on biodiversity. ALAN has increased in extent and severity over ~60 years and may be associated with global insect declines. Nocturnal insects may be particularly vulnerable. Here, I test how ALAN impacts behavior and fitness in the nocturnal Pacific field cricket, Teleogryllus oceanicus. I will test how ALAN impacts cricket abundance and distributions (using a field experiment), and fitness through survival and reproduction (in a lab study) using light treatments that mimic common lighting regimes in Hawaii. I hypothesize first that ALAN, particularly white LED, will impact fitness traits of T. oceanicus resulting in decreased survival, delayed development time, and smaller adult size. In turn, I expect that fitness cost will result in avoidance of artificially lit habitats in the field study. In the field, I established "phantom streetlights" by establishing lit areas in a rural field where T. oceanicus naturally occur and there is little, if any, ALAN. There were four treatments: 70 lux yellow-shifted LED, 100 lux yellow-shifted LED, 100 lux white LED, and a control with no added light. I measured how light influenced cricket abundance and distribution over the course of >24 hours of exposure. In the lab, I established the same treatments inside of replicate incubators, randomly assigning the animals to treatments at hatching and rearing them to adulthood. At adulthood, I measured survival, development time, and size. Preliminary results in the field suggest that ALAN does impact cricket abundance and distribution; contrary to expectation, animals tend to remain under ALAN treatments, but leave control sites, perhaps because they are pursuing typical nocturnal mate searching and feeding behaviors. The lab experiment is ongoing.

Characterizing bumblebee foraging preferences in urban and natural landscapes to inform floral restoration and pollinator conservation practices

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Bumble bees are generalists, typically foraging on a wide variety of flowers for nectar and pollen, and are known to make distinct nutritional choices within their diet breadths when foraging. Natural landscapes tend to provide bumble bees with access to native floral communities, while urban landscapes offer a more diverse mix of cultivated and non-native plants that may differ in nutritional quality. However, it remains unclear how bumble bees adapt their foraging behaviors in developed urban settings dominated by ornamental and invasive plant species. Therefore, understanding bumble bee foraging behavior in urban landscapes is essential to gain insight into how urban floral communities can support pollinator populations and better inform effective pollinator conservation efforts in urban settings. We designed a study to examine bumble bee foraging patterns across 12 sites in Fort Collins, Colorado, including residential areas, natural spaces, and managed gardens. To understand how bumble bees utilize urban floral resources relative to their availability, we collected corbicular pollen from 9 Colorado bumble bee species and compared the floral composition of this pollen with floral resource surveys completed at each site. All pollen and flower samples have been mounted on microscope slides for further analysis. We present proposed methodology to analyze pollen collected from bumble bees based on grain size, morphology, and other physical characteristics. Through characterizing floral species composition within bumble bee corbicular loads, we will evaluate plant use relative to resource availability. By comparing foraging patterns with floral availability across different developed land-use types, this study will provide an assessment of how bumble bees interact with urban floral resources and inform pollinator-friendly management and conservation efforts in human-dominated landscapes.

<u>Advanced Parental Reproductive Phenology Can Alter Seed and Seedling Traits</u>

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In temperate environments, climate change is driving earlier snowmelt, often leading to shifts in flowering phenology, particularly in spring wildflowers. While flowering shifts are well-studied, it is unclear whether or not this coincides with shifts in fruiting phenology or affects resultant seed and seedling traits. Understanding how phenological events shift in relation to each other, and how this translates to offspring effects, is critical to more fully understand how climate change may impact plant reproduction. To address these knowledge gaps, we monitored flowering and fruiting phenology (mean and duration of each event) of five subalpine spring wildflower species over three seasons, comparing early snowmelt and control plots at the Rocky Mountain Biological Laboratory in Colorado. Seeds were also collected from these experimental plots to assess seed (total seeds/plant, seeds/fruit, weight, and viability) and seedling traits (emergence phenology, emergence success, growth rate, size. Regarding phenology, results indicate an inconsistent relationship between flowering and fruiting across species and years, with some instances of flowering and fruiting shifting at the same magnitude and other instances where these stages shifted at different magnitudes. Despite these differences, two years of preliminary seed and seedling trait data indicate that many seed traits were consistent between treatments, with a few notable differences that may translate to larger population-level effects. This work highlights the complexity of plant reproductive stages and underscores the need to integrate them to fully understand climate change impacts on plant reproduction.

<u>Temporal Variation in Subalpine Conifer Wood Density in Colorado</u>

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Subalpine forests, high-elevation ecosystems in Colorado, are sensitive to climate-driven stressors such as warming, drought, and disturbance. One way to understand how these stressors impact subalpine forests is to assess changes in functional traits. Wood density is a key trait linked to growth, mechanical support, and resistance to drought, wildfire, and pests. Therefore, tracking wood density over time could elucidate ecosystem responses to climatic conditions. We evaluated spatial and temporal shifts in wood density across four conifer species (Abies lasiocarpa, Pinus contorta, Picea engelmannii, and Pinus flexilis) using forest inventory data at Niwot Ridge, Colorado. Specifically, we examined i) how wood density changes with elevation, ii) whether there

has been an overall shift in wood density over time, and iii) whether species-level wood density has changed. To address these questions, we examined long-term monitored forest plots measured in 2012 and 2025, focusing on dominant species accounting for at least 75% of basal area per plot. Elevation was estimated per plot using high-resolution remote sensing data (1-m LiDAR elevation data). Mean wood density was compared between species and by plot. Across both species and plots, mean wood density generally decreased from 2012-2025. Differences among plots showed that declines were moderate but consistent. Plots located at higher elevations showed a greater decrease, suggesting that environmental gradients may shape wood density change across the site. Species responses varied, indicating that sensitivity to changing conditions may differ, with Picea engelmannii showing the most change and Abies lasiocarpa exhibiting the least. These patterns suggest wood density may be a useful indicator of shifting vulnerability in subalpine forests. Continued long-term monitoring across broader subalpine ecosystems will help clarify whether trait shifts like declining wood density are linked to forest resilience under future climate stress.

Leafcutter Bee Movement Through Natural and Residential Areas

Kyle Ruszkowski, Colorado State University; John Mola, Colorado State University

Urbanization is converting natural landscapes into residential and commercial environments, altering species distributions and movement patterns through an increasingly heterogeneous urban matrix. Cities frequently introduce and favor exotic species whose life-history traits facilitate establishment and spread in human-modified habitats and adjacent landscapes, even as urban conservation initiatives aim to enhance habitat connectivity and conserve native biodiversity. Paradoxically, these interventions may inadvertently support non-native bee species that thrive in urban environments, where advantageous traits such as cavity nesting and high reproductive plasticity combine with human activities that intentionally and unintentionally facilitate their introduction and spread. Species such as Megachile rotundata and Apis mellifera appear frequently in pollinator surveys across urban and non-urban habitats in North America, likely benefiting from conservation initiatives designed for native species. Movement of exotic species within and beyond the urban matrix may therefore complicate native species conservation efforts, yet little is known about how these species move across urban and natural landscapes. We investigated the movement of the exotic cavity-nesting leafcutter bee Megachile rotundata across residential and natural areas using a mark–release–recapture design. We placed trap nests at the interface of residential and natural habitats, released marked bees along transects in both habitat types, and quantified return rates as a proxy for dispersal and landscape resistance. We hypothesized that residential landscapes would impose greater environmental resistance, resulting in lower return rates with increasing distance relative to natural areas. Our results provide insight into how urban landscapes mediate movement in exotic and generalist bees, advancing understanding of the role of urban environments in exotic species establishment and dispersal.

Associational susceptibility shapes aphid-transmitted disease risk in chile peppers

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Detection and vulnerability of a host plant to herbivores may decrease or increase depending on specific plant-plant associations. When the association is positive (associational resistance), the focal species benefits from the association with another species, as detection and vulnerability to herbivores is decreased. However, a plant species can negatively affect a focal species (associational susceptibility), by increasing exposure and vulnerability to herbivores and pathogens associated with them. In this study, we tested whether associational susceptibility explained the prevalence and severity of an aphid-transmitted virus, alfalfa mosaic virus (AMV) recently discovered in chile peppers in Colorado but common to alfalfa. Peppers are often grown in the vicinity of alfalfa in Colorado, and alfalfa is a host to both AMV and several aphid species. This project aimed to test the hypothesis that associational susceptibility to AMV can be explained by proximity to alfalfa. Chile pepper farms in Colorado and California within 1-20 miles of alfalfa were sampled from May to August in 2024 and 2025. Results from this study indicate that the closer the peppers are to alfalfa, the higher the incidence and severity of the virus in peppers.

<u>Bees in the City: Bumble Bee Community Stability Across Urban and Natural Landscapes</u>

Laura Lukens, Graduate Degree Program in Ecology, Colorado State University; Dr. John Mola, Department of Forest & Rangeland Stewardship, Colorado State University

Global land-use change and urbanization are major drivers of biodiversity loss. As natural habitats are converted to human-dominated landscapes, communities are reshaped through fragmentation, altered resource availability, exposure to pollutants, and novel disturbances. Urbanization can also drive ecological homogenization, a process in which communities become increasingly similar due to the loss of specialized or sensitive species and the proliferation of disturbance-tolerant generalists or invasive species. Bumble bees (Bombus spp.) are ecologically and economically important pollinators. Although some species have experienced significant declines, others have remained stable and experienced range expansions. It remains unclear how responses to urbanization vary among species, and whether urban spaces foster diverse, resilient communities or contribute to ecological homogenization. Traits, phenology, and life history likely influence species' vulnerability, highlighting the need to examine both species-level responses and broader community patterns.We investigated how urbanization influences bumble bee community composition, diversity, and temporal stability in Fort Collins, Colorado. Between June-September 2025, we surveyed bumble bees and floral resources at 40 sites: 22 sites city-owned Natural Areas and 18 urban sites with intentional plantings through local conservation programs. We quantified surrounding land cover within 500-2,500 m buffers and applied non-metric multidimensional scaling, mixed-effects models, and indicator species analyses to assess community composition, site- and landscape-level effects, and seasonal turnover. Urban sites supported high overall bumble bee abundance but were dominated by common and range-expanding species, while several rare or sensitive species were largely restricted to natural areas. Bumble bee communities were more similar among urban sites, whereas floral communities showed the opposite pattern. These results underscore the importance of carefully designing conservation plantings to sustain declining or sensitive species and prevent the dominance of common or expanding species.

<u>Trailhead tick-check stations are an effective, low-effort approach for tick surveillance</u>

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Ticks (Family: Ixodidae) are important disease vectors that pose a substantial threat to human and animal health. To evaluate the entomological risk of tick-borne diseases, samples must be collected from wild populations and tested for pathogen presence. While active field sampling is the most common approach for tick surveillance, it can be laborious, particularly in areas where tick abundance is low. This project aims to evaluate the effectiveness of three different tick collection methods: active dragging, trailhead submission stations, and mail-in surveillance. Active tick-dragging is an approach that involves a field ecologist systematically sampling the environment by pulling a drag cloth over the forest understory and collecting any attached ticks. Trailhead tick-check stations are tick submission stations conveniently located at trailheads that allow citizen scientists to submit ticks encountered while recreating. Mail-in surveillance involves community member submission of ticks to the Colorado Department of Public Health and Environment through the mail. All the sites surveyed were located in Northern Colorado and consequently had similar species and life stages of ticks collected. Some variability was observed based on elevation, with Dermacentor andersoni found at higher elevations and D. variabilis at lower elevations. We found that tick-check stations required less effort per tick when the sampling site was located nearby and had low tick density. Sites located further away and with higher tick density required less effort per tick with active surveillance. Many species of ticks are projected to expand their ranges under climate change, making surveillance efforts more important than ever. The information gained from this study is critical for evaluating tick collection methods under different ecological scenarios for reliability/breadth of surveillance, efficiency, and effectiveness and can be used by other researchers to inform tick collection method selection.

Plant–Pollinator Networks as Pathways for Microbial Movement

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The Southern Rocky Mountains of Colorado are a regional hotspot for bumble bee (Bombus) diversity and home to 23 different species. Several of these bumble bee species are experiencing major declines, with parasites and pathogens acting as significant stressors. Bees can acquire parasites by visiting flowers that were previously contaminated by an infected bee, and observing pollinator visits can reveal how pathogens and other microorganisms are moving between bees. However, documenting these visitation patterns can be challenging, as observations are fleeting. These challenges can be overcome by long-term studies with extensive sampling. The University of Colorado Mountain Research Station hosts one of the longest running plant-pollinator network studies in a subalpine meadow. Using a decade of observations, we ask how well floral resource overlap between Bombus species can predict their microbial communities. We propose two hypotheses: 1) bees that share the most resources with each other will also have similar gut microbiota and virus communities, and alternatively, 2) bees more closely related to each other will have similar microbial communities, regardless of their interactions with other bees. Using 16S sequencing and RNAseq, we evaluate how the bacterial and viral communities differ between bumble bees and how microbial transfer may occur, potentially leading to novel management strategies for Bombus conservation.

Driving factors influencing plant distribution of Mixed-grass Prairie pastures in Southeastern Wyoming

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The growing demand for advancements in contemporary management of rangelands across the western US emphasizes the necessity for contextual research regarding the factors influencing ecosystem health and function. Most of the research conducted on plant distribution in rangeland systems primarily has been in Shortgrass and Tallgrass Prairies and utilized generalized and outdated theoretical models, which emphasizes the need for updated context-based management. Therefore, research is increasingly needed in Mixed-grass Prairies to understand how plant distribution interacts with climate, topography, and management to promote resilience and adaptation in a rapidly changing planet. By updating our understanding of Mixed-grass Prairie dynamics, we can improve management strategies related to plant diversity with applications in soil health, cattle grazing, restoration ecology, and more. This research can help inform management decisions on grazing schedules through improving the timing and presence of grazing to promote or reduce species of interest. Our study aims to identify the driving factors of plant distribution in the Southeastern Wyoming Mixed-grass Prairie. To do this, we integrated remote sensing data with field data to compile species richness and abundance, soil characteristics, and topography across six cattle pastures of varying grazing intensities. Through this analysis, we identified the driving factors of plant distribution in these grazing pastures. We will present our findings in the context of the grazing management for these pastures and ecological region our data was sampled and discuss the implications for other regions of the Mixed-grass Prairie based on topography, grazing intensity, and soil characteristics.

Impacts of prolonged, extreme drought and post-drought watering on the soil seed bank of a semi-arid grassland: Implications for post-drought recovery

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Drought is predicted to occur at a higher rate and intensity with forecasted climate change altering the diversity and the community composition of plants during and following these events. The soil seed bank is likely to impact the recovery of plant communities after drought but remains understudied. However, as the seed bank is a living system, it too may be impacted by drought and precipitation availability during recovery. To examine how the seed bank contributes to the recovery of a semi-arid grassland, we investigated the effects of drought on seed bank abundance and diversity and monitored changes over the course of a year. We collected soil samples from the seed bank three times: in May 2023, immediately after the end of a four-year artificial drought; in October 2023, at the end of the first post-drought growing season; and in May of 2024, one year after the end of drought. Watering treatments started in May of 2023 where plots were exposed to either ambient condition, deluge, site-specific long-term average, long-term average plus 50%, or double the long-term average. Collected soils were processed and grown in a greenhouse environment and monitored for seedling emergence. The previously droughted soils initially yielded significantly fewer viable seeds (4.15 vs. 50.3) and species (1.86 vs. 3.53). At the end of the first growing season the previously droughted seed bank recovered in terms of total abundance (40.4 vs. 63.3) and richness (5.5 vs. 5.12) and was maintained in the third sampling period. Watering treatments did not have an impact on the size or diversity of the seed bank, suggesting that the cessation of drought, not the amount of water available after drought, drives recovery. Rapid recovery regardless of precipitation suggests potential usage of the seed bank in ecosystem recovery, but further investigation is required to determine usage.

Quantifying Spatial and Temporal Variation in Direct Contact Rates Among Mule and White-Tailed

Deer

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Access to fine-resolution wildlife movement data provides an opportunity to empirically quantify direct contact rates among individuals in relation to spatial and temporal factors, which is critical for informing wildlife disease management. The identification of dyadic contact patterns is particularly relevant for understanding transmission risk in species such as Mule Deer (Odocoileus hemionus) and White-Tailed Deer (Odocoileus virginianus), where diseases like Chronic Wasting Disease and Bluetongue are prominent on the landscape. We leveraged years of GPS tracking data from over 100 deer to estimate the distribution of dyadic contact rates in relation to home range overlap and spatial proximity. Specifically, we used Bhattacharyya's Affinity (BA) to quantify home range overlap and calculated the average distance between animal centroids for each dyad. We then related each dyad's spatial metrics to their direct contact rates across four seasons (fawning, lactation, rut, and winter). Our analyses found significant temporal variation in contact rates; contact rates increased during the Winter and Fawning seasons in comparison to Lactation and Rut. We then identified the specific distance and BA values where population-level contact rates converge to zero. Our results establish quantitative spatial thresholds that can be used to improve epidemiological models and guide seasonally targeted disease prevention and intervention strategies in cervid populations.

Do rates of predation vary across host plants for a dietary generalist?

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Herbivore populations can be controlled by both bottom-up (e.g., via host plant) and top-down (e.g., via natural enemies) forces and these forces can also interact. For example, natural enemy foraging and attack patterns can depend on the host plant species upon which the herbivore feeds. Some herbivores are able to avoid natural enemy attack by sequestering or retaining plant chemical defenses in their bodies that are deterrents to enemies. Fall Webworms (Hyphantria cunea; hereafter FW) are dietary generalists that feed on >600 plant species worldwide and are fed upon by a wide variety of predators, but whether FW larvae are protected from predation on any of their host plants is unknown. We designed an experiment to test if FW experience decreased predation when feeding on different plant species. We reared FW larvae on 10 host plants that differed in quality and plant chemical defenses, and then we conducted no-choice predator trials using two common predators: assassin bugs (Zelus renardii), and stink bugs (Podisus maculiventris). We recorded if stink bugs and assassin bugs ate FW larvae and measured, the rate of consumption if they ate; with this information, we could determine if the predators were deterred from eating larvae reared on different host plants, and if they were able to consume larvae of different sizes. We found that both assassin bugs and stink bugs ate larvae on all host plants. Assassin bugs were more likely to eat FW reared on the host plant tree of heaven

(Ailanthus altissima) and ate them at a higher rate than larvae reared on other hosts. Stink bugs ate larvae on all hosts equally. We also found that FW larvae appear to be able to escape predation as they age as larger larvae were less likely to be eaten on all hosts. Our results suggest that FW are unable to escape predation on any host plant and thus do not sequester plant chemical defenses; instead, growing larger appears to be their main defense against predators.

The functional outcomes of high elevation hummingbird wing morphology

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Across environmental gradients, trait evolution reflects the balance of multiple selective pressures often acting in opposing directions. For flying species, temperature and partial pressure of oxygen (PO2) along elevational gradients are powerful but contrasting forces that shape morphological evolution. At high elevations, ecogeographic theory predicts larger body masses and shorter wings to conserve heat in colder environments. In contrast, aerodynamic theory predicts smaller body masses and longer wings to maintain lift in thin air. Paradoxically, hummingbirds defy both: their body masses and wing lengths increase with elevation. To compensate for higher wing loading, hummingbirds have evolved differences in wing shape, wingbeat frequency, and stroke amplitude. Yet, how such morphological differences affect physiological function, performance, and ecological outcomes, such as competition, remains unknown.
The giant hummingbirds are ideal for studying the functional consequences of variation in wing morphology. The Northern Giant Hummingbird (Patagona peruviana) is a high elevation resident found from ~2,500-4,300 meters (m) in the central Andes year-round. The Southern Giant Hummingbird (P. gigas) is an extreme elevational migrant that shifts from sea level breeding grounds to >3,500 m during the nonbreeding season. The two breed allopatrically but overlap seasonally at the same high elevation sites, sharing a common environment. Despite equivalent body masses, resident Northerns have significantly longer wings and lower wing loading than migrant Southerns. Southerns show striking plasticity in blood traits, such as hemoglobin concentration ([Hb]) and hematocrit (Hct), including significantly elevated levels relative to Northerns at the same high elevation sites. This suggests that Southerns experience physiological and metabolic performance costs in shared environments. Here, I will examine how divergent wing morphology affects flight efficiency, O2 transport, oxidative stress, behavior, and competition dynamics. Using common garden experiments and competition trials with wild birds, I will link morphological variation to functional outcomes and their underlying mechanisms.

Global political biogeography of country-endemic bird species

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Of all known bird species on Earth, an estimated third occur within single countries. These species are known as country-endemic. Such species are of special conservation concern as they are reliant on the governance context of single countries, which has been dubbed as the doctrine of ultimate national responsibility. These species are of high conservation concern because they are subject to high irreplaceability, conservation capacity deficits, and threat intensity. Against this backdrop, no study has yet assessed the spatial patterns of country-endemic bird species to identify areas of conservation priority to inform resource mobilization internationally. The goal of this study is to develop a baseline of understanding of where these country-endemic bird species are concentrated, what their conservation status is based on the International Union for

Conservation of Nature's Red List of Threatened Species, what governance context they occur in, and the extent to which these species' geographic ranges are covered by protected areas using different spatial analysis tools. Our preliminary results indicate that 3,314 bird species are country-endemic, which corresponds to roughly a third of all known bird species in the world. Of these country-endemic species, a third occur within only five countries: Indonesia, Australia, Brazil, the Philippines, and Peru. Establishing areas of conservation priority for country-endemic bird species can help direct resource allocation, research, policy, and other tools to conserve biodiversity, habitats, and critical evolutionary processes.

Seeding Rate Effects on Sown Plant Community Development on Semi-Arid Green Roofs

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Urban development fragments natural habitats, limiting biodiversity, and therefore critical ecosystem services like pollination. Green roofs can provide habitat and food resources for urban fauna, particularly insect pollinators. However, vegetation quality can often be limited by factors relating to cost, maintenance, plant availability and installation labor. Seeding is rarely utilized on green roofs in semi-arid climates, though recent research has demonstrated viable establishment and pollinator provisioning of perennial communities with Colorado native species. Optimal seeding densities that balance habitat quality, establishment success and economic feasibility for semi-arid green roofs are not yet well understood. This study examines how seeding rate affects the establishment and development of a 36-species seed mix of mostly Colorado native forbs, grasses and shrubs on green roofs. We designed and sowed seed mixes of varied densities (300, 600, 1200, and 2400 pure live seeds/m^2) using a replicated randomized block design across three green roofs in Denver, Colorado. During the 2025 establishment season, we monitored plant communities monthly from June through September. We measured germination rates, plant abundance, species richness, and inflorescence production as indicators of habitat and resource quality for insect pollinators. Additionally, we quantified weed pressure and environmental conditions (substrate temperature, moisture, air temperature, and solar radiation) to assess the influences of other potential stressors affecting establishment. Preliminary data from the first growing season shows site specific differences in plant productivity, suggesting green roof system qualities, microclimatic effects and substrate characteristics of mediate establishment success. Results from this minimum two-year study will inform seeding rate recommendations that optimize vegetation quality for pollinator habitat while minimizing seed input for practitioners. This work addresses gaps in knowledge on horticultural design and installation of sown vegetation in semi-arid environments and supports green roof practitioners in designing and implementing quality habitat to support urban pollinator populations.

A test of the "Mother Knows Best" Hypothesis with a dietary generalist herbivore

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Host choice by herbivorous insects is an important area of research because it can help explain why insects feed upon some plants rather than others. The preference-performance hypothesis, also known as the 'mother knows best' hypothesis, proposes that offspring should perform best on the host plant their mother selected as an oviposition site. We tested this hypothesis using fall webworm (Hyphantria cunea, hereafter FW), which is an extreme dietary generalist moth species.

FW have two morphotypes, black-heads and red-heads, which also vary in diet breadth, with black-heads feeding on more plant species than red-heads. We reared offspring of FW females for both morphotypes that had oviposited on one of four plant species; for each morphotype, the plant species included three host plants and one non-host plant. We found no evidence to support the Mother-knows-best hypothesis for either FW morphotype; FW larvae never did best on the plant their mother preferred. Our results lend further support to the idea that polyphagous insects may not have strong relationships between female preference and larval performance compared to insects with narrower diet breadth.

<u>Microplastics (MP) in Drinking Water Linked with Colorectal Cancer Across Urban-Rural Counties of Maryland</u>

Millen Singh, Landon School

Microplastics, defined as plastic particles less than 5 mm in diameter, are evident in the environment and a growing public health concern because they are found in drinking water systems. Here, we investigate the correlation between microplastic levels in drinking water and colorectal cancer rates in Maryland. Drinking water samples were collected and analyzed. Statistical analyses were conducted to test the relationship between microplastic concentration in drinking water and colorectal cancer incidence. Some rural Maryland counties tended to show significantly higher microplastic concentrations in the drinking water than their urbanized counterparts. Even though one would expect urbanized areas with higher population density and plastic waste generation to show higher microplastic concentrations in their drinking water. Adding to this unexpected pattern, the same rural counties (Allegany, Caroline and Dorchester) that had the highest microplastic contamination in their drinking water were also noted to have the highest incidence of colorectal cancer rates in the state of Maryland. This research highlights the importance of addressing microplastic contamination in drinking water, the pathways through which it enters public systems and its broader implications for public health policies and practices. By identifying potential risks, this study contributes to a growing body of knowledge on environmental toxins and their impact on human health, and to our knowledge, it is the first study that shows a correlation between microplastic-contaminated drinking water in rural counties of Maryland and increased colorectal cancer rates.

<u>Beyond discrete categories: multidimensional movement syndromes reveal a continuum of African elephant ranging behavior</u>

Nelson Gathuku and George Wittemyer, Save the Elephants and Colorado State University

Understanding the ranging behavior of animals is fundamental to movement ecology, yet classifying movement strategies remains challenging, especially for species that exhibit highly flexible behaviors. Here, we developed an integrative framework to characterize ranging behavior by integrating metrics characterizing trajectory, space-use, landscape configuration, and graph-theoretic characteristics of movement. Using 26 years (1999-2025) of movement data from African savanna elephants (Loxodonta africana) in Northern Kenya, we quantified 20 metrics across 113 individuals (348 individual years) and applied unsupervised random forest proximity analysis with partitioning around medoids, complemented by hierarchical clustering, to identify movement syndromes. We identified three primary syndromes characterizing elephant ranging behaviors, fitting with classic range residency, nomadism, and migration classes of movement, with strong agreement across clustering approaches. Five metrics dominated our classification approach: density, diameter, and transitivity (all graph-level metrics), maximum net squared displacement, and use intensity. Sub-clustering revealed six nested strategies, including centralplace foraging and multi-patch residency, local and long-distance migration, and local and dispersed nomadism. Moderate cluster separation in the main clusters and weak separation in sub-clusters indicated that elephant ranging behavior exists along a continuum rather than discrete categories. Elephants exhibited substantial behavioral plasticity, primarily driven by variability in environmental conditions and individual heterogeneity. Temporal variability in temperature and vegetation productivity reduced switching, suggesting constrained flexibility under unpredictable conditions. Our results highlight the complexity and multidimensional nature of ranging behaviors. Our integration of multiple metrics adds resolution to and improves classification of movement syndromes, with implications for understanding animal responses to environmental variability in human-modified landscapes.

Do Honey Bees Bee-long in Colorado Forests? Assessing the impacts of experimentally induced honey bee pressure on native bee interactions in Colorado public forests

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European honey bees (Apis mellifera) are extremely common in the United States for agricultural use, however, their influence on native bees is not well understood. Many commercial beekeepers rotate their hives among different farms, but between these crop cycles, beekeepers require a constant nectar flow so their hives can continue to produce honey. Some beekeepers turn to public lands, permitted by the U.S. Forest Service (USFS), to sustain hives for weeks at a time. Feral honey bee colonies rarely establish in Colorado; therefore, these introductions impose novel pressures on native bees. In this study, we examine how short-term honeybee introductions impact native bee diversity, foraging habits, and reproduction using a Before-After-Control-Impact (BACI) approach. In collaboration with local beekeepers and the USFS in Colorado's Arapaho and Roosevelt National Forest, we surveyed 18 sites during the summers of 2024 and 2025, introducing honeybees to 9 sites during June 2025. To assess shifts in resource use prompted by honeybee introduction, we measured bee-floral interactions before, during, and after honeybee deployment. We present preliminary findings to inform future USFS management and permissions for honeybee grazing on public lands.

Freezing conditions impact germination success in Colorado alpine seeds

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Changing temperature and moisture regimes are causing many plants to migrate upwards in elevation or latitude to track their climatic optima. This tracking is expected to buffer plant communities from the adverse effects of anthropogenic climate change, however, successful migration depends greatly on success at early life stages. While both seed production and adult plant composition have been well documented to change in response to warming temperatures, early life history phases remain understudied. Early-life success in germination, establishment, and survival to adulthood mediates biodiversity patterns observed on the landscape, driving future community composition and affecting the availability of ecosystem services. Therefore it is imperative to understand how early life stage success will change during altered environmental conditions. To do this we ask; Q1: What physiological and microclimatic factors affect plant reproductive success at early life stages; Q2: how do patterns in early life stage success change under future conditions and across latitudinal gradients. To address these questions we are

investigating seed viability, germination, establishment, and survival in alpine plants in Colorado and Ecuador. We collect alpine seed from heterogeneous microclimate sites and conduct both laboratory and field experiments to understand aspects of early life success in plants. In our first year of investigation, we are examining how seed provenance and exposure to freezing conditions affects germination rates in six native forb species from the Colorado Rocky Mountains. Preliminary data has indicated notable decreases in germination success when seeds are exposed to freezing temperatures during cool-wet stratification. Additionally, for some species seed provenance interacts with temperature treatment, influencing germination success. These preliminary results indicate that some species may be vulnerable to detrimental freezing where decreasing snowcover provides less thermal insulation. This could negatively impact germination success, limiting the buffering potential of range shifts even where conditions remain conducive for adult plants.

<u>Temporal Changes in Forest Communities and Understory Vegetation of Rocky Mountain National Park</u>

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Evidence shows a changing climate across the globe and especially in mountain systems. Data indicates a variety of distributional shifts, but mostly an upslope shift in natural vegetation in response to elevated disturbance regimes and climatic variability. Previous studies within Rocky Mountain National Park (RMNP) are consistent with these points and suggest upslope shifts of forest overstory species and an increase in species richness in mesic montane forests. By establishing just over 300 plots within RMNP in the 1970's, Dr. Robert Peet provided a unique opportunity for researchers to quantify climate change's impact on forest vegetation through long-term monitoring. We re-sampled Peet's plots using the Carolina Vegetation Survey (CVS) protocol during the summers of 2025 and will continue in 2026. We have two questions: How have forest communities within RMNP changed since the 1970's? Our second question was a bit more specific, how have understory communities changed in mesic montane forests? We hypothesized an upslope shift across every community type and an increase in understory species' evenness and richness. Our preliminary results support both hypotheses. Our research underscores the importance of long-term data collection in ecological research and validates a growing body of evidence that shows upslope shifts in natural vegetation.

<u>How Arthropod Predators and Herbivores Respond to Urbanization in Community Gardens</u>

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As American cities expand and food deserts continue to be critical issues in urban areas, the importance of productive food forests and community gardens has become abundantly clear. However, differences in landscape characters surrounding each community garden may influence the productivity of the garden, especially with regard to the arthropod community. This study sought to answer how changes in impervious surface at a 200m radius from community garden sites affected the abundance of arthropod predators and herbivores in the gardens. Additionally, I looked at how the relative abundance of these animals would impact the ecosystem services or disservices that they provide humans. I found that as impervious surface around a garden increased, both predator and herbivore abundance significantly decreased. However, the

abundance of predators and herbivores was not a significant predictor for the ecosystem services they each provide.

Chronic Wasting Disease demonstrated in fawns less than 2 months of age in Arkansas free-ranging white-tailed deer populations

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Chronic wasting disease (CWD) is a fatal neurodegenerative disease affecting captive and free-ranging cervids (deer, elk, moose) that has been identified in 36 U.S. states, 5 Canadian Provinces, South Korea, and Scandinavia. We and our collaborators have recently demonstrated CWD in utero mother-to-offspring transmission (i.e. vertical transmission) in free-ranging white-tailed deer populations in the southeastern U.S. states of Arkansas, West Virginia, and Tennessee. Yet, little is known about the CWD status of fawns (less than 1 year of age) in free-ranging herds. This is primarily due to a lack of targeted surveillance within this age demographic. We have capitalized on a 5-year longitudinal CWD surveillance study being conducted in Arkansas to assess multiple tissues (n=41) opportunistically harvested from fawns 1-59 days old (mean=11 days old) (n=13) to determine their CWD status. Tissue samples harvested from the fawns were assessed for the presence of prions using the amyloid amplification assays Protein Misfolding Cyclic Amplification (PMCA) and Real-Time Quaking Induced Conversion (RT-QuIC). While testing is still ongoing, we found that 1 fawn thymus out of 13 thymuses and 3/9 popliteal lymph nodes were positive for CWD. This 2-day old fawn found with a positive thymus was an opportunistic collection with a dam of unknown disease status. Findings from this study will improve our understanding of CWD pathogenesis and transmission dynamics in free-range cervid populations by helping to determine the role vertical transmission plays in the timing of CWD infections in early life, and the ultimate impact of this disease on herd health.

Demographic and Temporal Factors Affecting Flea Loads in Black-tailed Prairie Dogs (Cynomys ludovicianus)

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Sylvatic plague (Yersinia pestis) is an introduced flea-borne pathogen that continues to decimate prairie dog colonies in North America. Flea abundance varies with host demographic traits such as sex, age, and body condition, as well as with seasonal and inter-annual factors. We evaluated how demographic and temporal variables interact to influence flea loads in black-tailed prairie dogs (Cynomys ludovicianus), and how these variables shape the reciprocal relationship between body condition and flea load. We collected fleas from prairie dogs in colonies at the Central Plains Experimental Range in northeastern Colorado during 2024 and 2025. We analyzed flea abundance using negative binomial generalized linear models, considering age, sex, season, and year as potential predictors. We also used linear regression to assess the bidirectional association between body condition and flea load and to identify significant predictors of this relationship across age classes. Adult prairie dogs carried significantly more fleas than juveniles in the spring, while juveniles showed a trend toward higher flea loads in the summer. A marginally non-significant main effect of sex suggested that males may carry more fleas than females. The relationship between body condition and flea load in adults shifted seasonally, with a negative association in the spring (poor condition associated with high flea loads) and a positive association in the summer (good condition associated with high flea loads). Males also had significantly higher body condition than females. These results show temporal context fundamentally alters host–parasite relationships in the prairie dog-plague system where plague outbreaks often coincide with peaks in flea abundance. Understanding how flea loads vary across demographic groups, seasons, and conditions can improve predictions of when and where plague risk is highest within prairie dog colonies, and support more effective management of plague in grassland ecosystems.

Predictors of cavity nesting Bee Occupancy in Denvers Urban Gardens

Rene Aronson, EBIO CU Boulder; Asia Kaiser EBIO CU Boulder; Julian Resasco EBIO CU Boulder; Noah Meyer EBIO CU Boulder.

Cities are growing, and so is the impact they have on the environment. They are complex environments that fragment pollinator habitats and the important services cavity nesting bees (CNBs) in particular provide. Terrestrial environments rely on pollinators such as CNB's. Researchers have understudied urbanization's effect on pollinators more broadly and a mechanistic understanding of their distribution and abundance is lacking, effects remain controversial or region specific; The impacts that global warming will bring are also poorly understood. Understanding how urbanization, experimental increases in temperature to simulate climate change, and local garden characteristics affect these important pollinators will aid advising policies which can conserve pollinators in urban environments. For this study we investigated how gradients in urbanisation, and local factors such as temperature, humidity and nearby habitat availability affected trap nest occupancy in the Denver Metro Area. We placed particular emphasis on understanding the smaller scale (within 100m) variables surrounding our study sites. Additionally, a temperature treatment was applied to approximate conditions predicted under RCP. 3.8. Interestingly we found that within urbanized environments increases in urbanization have weak effects on cavity nesting bee occupancy and it is local garden factors which are better predictors.

A Decade-long Economic Comparison of Season-Long and Adaptive Rotational Grazing Systems in the Shortgrass Steppe

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Rangelands are a critical forage base for the livestock industry and provide ecosystem services such as open space preservation, wildlife habitat, and biodiversity. However, few long-term grazing studies have quantified the economic trade-offs associated with conservation-oriented grazing systems at operational scales. This study evaluated the profitability of traditional range management (TRM; continuous season-long grazing) compared to collaborative adaptive rangeland management (CARM; a stakeholder driven adaptive rotational system) using yearling steers over a 10-year period (2014–2023) at the Central Plains Experimental Range (CPER) in northeastern Colorado. We used steer weight gain data, historical Colorado cattle prices, and system-specific labor and infrastructure costs to determine economic outcomes for TRM and CARM. A Monte Carlo simulation (100,000 iterations) over historical livestock price distributions was used to calculate annual 10-year total net revenue and returns to labor and management for both grazing strategies. TRM was more profitable with an 8.8% higher mean net revenue over the 10 years ($874,573) compared to CARM ($804,020). Further, total forecasted returns to labor and management over the 10 years was 82.5% higher ($232,779) for TRM compared to CARM ($127,596) due to decreased animal performance and higher infrastructure costs with CARM. While CARM improved some ecosystem service outcomes, such as increased vegetation heterogeneity, shrub cover, and maintenance of viable habitats for several native grassland bird species of conservation concern, the grazing strategy reduced livestock production and relative profitability. These findings confirm that intensive rotational systems may carry financial trade-offs under typical market and climate conditions in the semiarid shortgrass steppe. This research is relevant to ranchers because it quantifies the cost of achieving ecologically beneficial outcomes through adaptive rotational grazing. It provides insight for ranchers considering system changes and policymakers aiming to design incentives that reflect both the benefits and costs of conservation oriented grazing management on working rangelands.

Rapid Senescence: How Aging Shapes Bumble Bee Flight Performance

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Aging affects performance and survival across all living organisms, yet its impact on short-lived insects is often overlooked. In social species like bumble bees, workers of different ages live together and perform a variety of tasks. Understanding how intrinsic aging influences individual performance is therefore key to predicting collective colony success. To explore this, we measured flight endurance in Bombus impatiens workers across varing ages. Flight trials were conducted in a controlled chamber and scored on duration and quality. Flight performance declined sharply with age. Young workers (2 to 4 weeks) flew longer and spent most of their time in sustained free flight. While workers aged 6 weeks and older showed reduced endurance and shifted toward assisted or non-flight behaviors. Using bayesian mixed-effects models, we identified age as the strongest predictor of flight duration. Each additional week of age corresponded to a significant drop (~5 minutes) in performance. In contrast, other factors, such as body size, wing wear, and temperature, explained little to none of the variation. This indicates that intrinsic aging drives rapid functional decline in bumble bee workers, largely independent of morphology and environment. These age-dependent patterns reveal that colony performance relies on a narrow window of peak worker capability, underscoring the importance of protecting and supporting effective foragers.

Air We Go Again: Time and Height Effects on the Grassland Aerobiome

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The aerobiome is fundamental to environmental and human health, influencing cloud and ice formation and pathogen transmission processes. Despite significant advancements in understanding other environmental microbiomes, how air microbial communities are composed and structured and what drivers affect these still need to be better understood. Moreover, we need a more comprehensive understanding of the aerobiome in natural environments such as grasslands that are particularly impacted by climate change. In this study, we explored the diurnal and vertical variability of the composition and diversity of the aerobiome from a central midwestern grassland site. We collected air samples from the NEON tower located at the Central Plains Experimental Range (CPER) from two different heights and two 12-hour high-volume filter samples per day (AM and PM) for 33 days in Spring 2023 (May-June). We profiled bacterial and fungal communities by amplicon sequencing using Earth Microbiome Primers (EMP). Our results showed non-significant impacts of sampling height on the diversity and composition of the aerobiome. Ordination analysis showed a clear separation between the daytime and overnight samples for bacteria and fungi, indicating the strong impact of time of day on the aerobiome community composition. The diversity of the overnight samples was significantly ($p = 0.001$) higher than the daytime samples. This research provides valuable insights into the factors shaping air microbial communities in natural areas such as grasslands and exposes the need to further investigate this field.

<u>Pollination network response to high severity fire along a gradient of time-since-disturbance</u>

Ryleigh V. Gelles, Thomas S. Davis, Camille Stevens-Rumann

Increasing frequency and severity of wildfire across western North America are transforming forested landscapes into mosaics of high severity burn scars embedded within a matrix of intact or anthropogenically-altered forest. These stand replacing disturbances create spatially discrete patches that may function as “terrestrial islands” of novel habitat. While post-fire vegetation dynamics are relatively well studied, how species interactions and ecosystem services reassemble following severe natural disturbance remains understudied. Here, we apply island biogeography theory to examine how pollination networks recolonize and reorganize within high severity burn scars in ponderosa pine–dominant landscapes of the Colorado Front Range. Using the lens of the equilibrium framework proposed by E. O. Wilson and Robert MacArthur (1967), we make three predictions: (H1) interaction richness follows expectations of equilibrium dynamics across a chronosequence of time-since-fire; (H2) bee–plant network structure (e.g., nestedness, specialization, connectance) varies with time-since-fire, burn scar characteristics, and climate; and (H3) bee responses differ among genera according to nesting strategy, reflecting trait-mediated colonization processes. We present preliminary analyses from historical burn scars spanning gradients of size, isolation, and successional stage. Ongoing analyses will fully test all proposed hypotheses. This work integrates foundational island biogeography theory with ecological network analysis to inform post-fire land management and pollinator conservation in increasingly disturbance-prone landscapes.

<u>Vegetation preferences and dispersal behaviors of Dermacentor andersoni: a mark-release-recapture study</u>

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Tick-borne diseases (TBDs) constitute a greater threat to human health within the contiguous United States than mosquito or flea-borne viruses, bacteria, and parasites. From 2001-2023, vector-borne disease cases more than doubled in the U.S., with TBDs garnering the highest case reports. In the mountain west, the primary tick vector is Dermacentor andersoni (Rocky Mountain wood tick), which is capable of transmitting Rickettsia rickettsii (Rocky Mountain spotted fever) and Colorado tick fever virus. Geographic distribution of numerous tick species and overall TBD incidence in the U.S. has been increasing, attributed to climate warming, reforestation efforts, and human encroachment into tick habitat. It is thus important to understand how changing landscape and climate conditions will impact tick behavior and TBD risk. Mark-release-recapture (MRR) is a commonly used tool in ecological research to study animal movement, estimate population sizes, and quantify survivorship. We used tick MRR to quantify D. andersoni dispersal distances and vegetation preferences in Northern Colorado. We constructed five continuous 10 m2 study plots in Rustic, Colorado, which were surveyed by active dragging 1-3 times per week for 8 weeks. Ticks were marked with nail polish using a unique 3-color system and released onto predetermined vegetation sites representing the overall diversity of plants in the area. Recaptured ticks were identified based on their unique markings. We recorded the vegetation type each tick was recollected from and the straight-line distance to its prior release site. We found that D. andersoni ticks exhibit directed movement towards preferred vegetation (i.e., grass, leaf litter) and away from non-preferred vegetation (e.g., shrub). The average rate of movement was 0.76 m/day (SD = 1.2), with most ticks moving <2 m/day. Overall, we were able to determine fine scale vegetation preferences and dispersal behaviors of individual D. andersoni ticks.

<u>Evolutionary Signatures of Epistasis Explain Asymmetric Transgressive Segregation in Structured Sorghum Populations</u>

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Directional selection in plant breeding relies heavily on transgressive segregation. Extreme scenarios arise where recombinants consistently exceed one parental extreme more than the other. The mechanism underlying this observation of asymmetric transgressive segregation has not been properly explained in the literature. This work tests the hypothesis that asymmetric transgressive segregation in complex traits is driven by evolutionary signatures of epistasis found within structured populations. Using a representation of global sorghum diversity, the study explores the signatures of magnitude, sign and reciprocal sign epistasis in sorghum nested association mapping (NAM) population. Forward simulations demonstrate that genetic backgrounds enriched for these evolutionary epistatic patterns systematically push progeny beyond one parental extreme, providing a mechanistic explanation for asymmetric transgression. Empirical analyses across the ten NAM families corroborate these predictions, revealing that a cumulation of different epistatic signatures could explain asymmetric transgression. The merit of this work lies in reframing asymmetric transgressive segregation as a predictable consequence of structured evolutionary histories rather than a stochastic breeding outcome. By linking evolutionary ecology with quantitative trait architecture, these findings provide a conceptual and practical framework for anticipating extreme phenotypes in breeding programs.

Exposure to Novel Song Leads to Developmental Plasticity in Locomotory Behavior of Pacific Field Crickets

Sara Garcia, Ryuka Nagamine, Dale Broder, Robin Tinghitella

Acoustic communication plays a vital role in coordinating reproduction across the animal kingdom. Male Pacific field crickets (Teleogryllus oceanicus) rub their wings together to produce songs that attract locomotory females from afar. However, in response to acoustically-orienting parasitoid flies (Ormia ochracea), Hawaiian T. oceanicus males have evolved silent (silent flatwing) or novel attenuated songs (e.g., purring, rattling) to help evade parasitism. Both increased locomotory behavior and behavioral plasticity (environment influencing a single genotype to produce multiple phenotypes) have been hypothesized to increase the ability of females to locate novel males. Additionally, body condition affects the cost-benefit ratio associated with movement behaviors and could thus affect locomotory behaviors. Developmental plasticity in response to the acoustic environment is known to influence adult mating behavior and locomotive behavior in this study system. We ask: how does acoustic rearing experience affect female body condition and locomotory behavior, and what is the relationship between them? We reared female purring crickets in four acoustic treatments (exposed to purring, ancestral, or rattling song, or silence) and, at adulthood, measured their mass and pronotum width to calculate condition, and conducted locomotory experiments (measuring how quickly individuals move after being released and how many lines they cross on a grid on the arena floor). Preliminary results suggest that rearing treatment did not impact body size (pronotum width) or condition. However, both the time to begin moving and the lines crossed depended on the acoustic treatment received. In particular, individuals reared in attenuated song types began moving more quickly, suggesting that plasticity in locomotory behavior may facilitate the success of novel male types.

Monsters Inside (Some) of Us: Interactions between parasitic botflies and high-elevation deer mice under climate change

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With global temperatures rising, species distributions are shifting as they follow temperature optima. Parasitic insects, for example, are moving towards higher latitudes and elevations, primarily due to increased winter temperatures and in turn, survival. These shifts have the potential to alter not only the life-history of these insects, but also the physiology and demography of the hosts they parasitize, though we know little about this. One such host-parasite system is that of deer mice (Peromyscus maniculatus) which are a common host for botflies, an obligate cutaneous endoparasite that, as larvae, infect small mammals and feed on their interstitial fluids, cellular debris, and necrotic tissues. Deer mice have the largest elevational range of any North American mammal and co-occur with botflies throughout much of that range. However, while botflies do not occur above ~2,500m, deer mice are found at the highest elevations in the Rocky Mountains. My research will illuminate the costs of botfly infection; I will investigate if costs are elevation dependent and model how botfly-naïve mice will respond to novel interactions under climate change.

The Pulse Beneath the Prairie: Root Responses to Compound Climate Extremes

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Semi-arid grasslands play a disproportionate role in global carbon cycling due to strong precipitation controls on ecosystem productivity. Climate change is intensifying hydrological variability, increasing the frequency of compound climate extremes (CCE), where prolonged droughts are followed by intense rainfall events (deluges). While drought is widely recognized to suppress grassland productivity, deluge events may generate short-term productivity pulses that partially offset drought legacy effects. However, most research has focused on aboveground responses, such as changes in aboveground net primary productivity (ANPP) or canopy dynamics, leaving belowground net primary productivity (BNPP) and functional root trait dynamics understudied. This aboveground emphasis overlooks that, in semi-arid ecosystems, BNPP often equals or exceeds ANPP, and a substantial proportion of ecosystem carbon is stored belowground in roots and soils. This study examines how CCE influence BNPP and root functional traits in a semi-arid grassland ecosystem. Using a manipulative field experiment at the Central Plains Experimental Range in Northeastern Colorado, drought treatments were applied using rainout shelters followed by controlled deluge events. Root ingrowth cores were installed across treatment plots to quantify BNPP and characterize root morphological responses across soil depths. Root traits were assessed using specific root length (SRL) and root tissue density (RTD), which represent key axes of resource acquisition and play an important role in carbon cycling. I hypothesize that drought will shift root systems toward conservative strategies characterized by increased RTD and reduced SRL, while subsequent deluge events will stimulate pulses in BNPP and favor acquisitive trait expression. By linking BNPP responses with root trait dynamics, this study aims to improve understanding of belowground carbon allocation under increasingly variable precipitation regimes and improve representation of belowground processes in ecosystem and Earth system models under future climate scenarios.

Teaching Climate Change at the Margins: Assessing Cultural Awareness in Undergraduate Biology Education

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Within the natural sciences, topics that approach the intersection between social justice and science have historically been avoided due to concerns of complexity and lack of instructor expertise. Socio-scientific topics such as anthropogenic climate change highlight these areas of overlap, where human communities are impacted by extreme weather events, fluctuations in average temperature, and changes in annual precipitation. To address this topic, we have developed a novel activity to provide university science students with a learning experience to expand their awareness of climate change's impact on marginalized communities. In Spring 2026, we are implementing the finalized activity and collecting pre and post-survey data, both Likert agreement and short answer, from five undergraduate science classes at two institutions. We will analyze the data with descriptive statistics and thematic analysis to assess students' understanding of climate change, determine whether their understanding of climate change's impact on communities is ethnorelative or ethnocentric, and measure students' psychological distance of climate change impacts on their own communities. By cultivating a deeper understanding and evaluation of climate change's impacts on different communities, we aim to empower a cohort of informed and culturally sensitive individuals within science. Furthermore, this activity represents a new lesson that will be broadly available to college science instructors to complement their instruction of climate change.

A LiDAR-based inventory of forest fuels and structure on the Colorado Front Range Priority

Landscape

Tanner James Gordon University of Wyoming; Shelby N. Byerly University of Wyoming; Bradley K. Parry University of Wyoming; Paige E. Copenhaver-Parry University of Wyoming

Across the western United States, wildfires have increased in extent and severity due in large part to the increases in fuel aridity as a consequence of a warming climate. Urban populations within the Wildland Urban Interface (WUI) have increased dramatically within the past 2 decades. In response to intensifying wildfire activity across the western United States, the USDA Forest Service's Wildfire Crisis Strategy prioritizes landscapes like the Colorado Front Range for fuel reduction and community protection. Forest managers face growing pressure to plan and implement landscape-scale treatments that reduce wildfire risk while safeguarding natural resources. To support these efforts, we completed a LiDAR-based forest inventory of ~885,000 ha of conifer-dominated forest on the Colorado Front Range. High-resolution airborne LiDAR (QL1) was combined with field data from 450 stratified plots, including tree inventories and increment cores, to model forest structure and stand age at a 20 m resolution. Regression models trained on LiDAR metrics were used to produce wall-to-wall maps of fuels, stand age, and structural attributes relevant to fire risk reduction. Results show that canopy structure metrics, including canopy fuel metrics, were modeled well from LiDAR whereas models for surface fuels and understory vegetation metrics performed poorly. Canopy fuels were high across the majority of the landscape, although canopy bulk density was relatively low despite high tree densities and basal areas. Overall, LiDAR inventory can be a valuable tool for managers tasked with prioritizing wildfire mitigation at landscape scales.

Brooding over what mite bee: honey bee parasite prevalence patterns with pest management implications

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The European honey bee (Apis mellifera) are the most agriculturally and economically important insects on the Front Range as the source of honey and beeswax for artisanal producers. Yet, they still remain vulnerable to parasitic organisms that do not share recent coevolutionary history, such as invasive brood mites. The Varroa mite (Varroa destructor, Acari: Mesostigmata) has proven a particularly pervasive problem for beekeepers, vectoring disease and contributing to enormous annual colony loss. Varroa mites reproduce inside sealed wax comb cells, feeding on bee larvae and producing offspring that mate with each other before the host emerges. Typically, bee larvae are infested with a single mother mite, but can be infested by multiple females. These multi-infested cells are of interest as they produce fewer mite offspring per mother mite but provide the parasite with the opportunity for genetic recombination. Understandably, multi-infested cell prevalence is positively correlated with overall infestation rate: as the parasite to host ratio increases, parasites share resources more frequently. However, multi-infestations continue to occur even at low parasite prevalence levels, suggesting the benefit of genetic recombination may outweigh the cost of sharing resources at the parasite population level. In this project, I assess beehive infestations at the brood cell level, recording the contents and location of every sealed cell on brood frames collected from managed hives on the Front Range. I address whether multi-infestations occur more frequently than expected, assess if infested hosts are spatially clustered, and compare field methods for quantifying infestation level. These answers provide data and avenues for interrupting mite reproduction, maintaining low parasite prevalence within A. mellifera colonies, and supporting Front Range beekeeping communities and businesses.