# Proceedings of the 2024 Natural Areas Conference: Where Science Meets Stewardship

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# Proceedings of the 2024 Natural Areas Conference: Where Science Meets Stewardship

Natural Areas Association (NAA) convened the 2024 Natural Areas Conference: Where Science Meets Stewardship in Manhattan, Kansas, October 7–10, 2024. The Natural Areas Conference (NAC) supports the conservation and protection of biodiversity by providing access to quality science, new knowledge, best practices, and emerging methodologies for those who steward natural areas.

For the past 50 years, the NAC has gathered federal, state, regional, tribal, and local natural areas practitioners from nonprofit organizations, private industry, and academic institutions to foster communication and collaboration that can lead to progress in connection to challenges in the management of natural areas. It is the forum for information exchange among natural areas practitioners across North America. Participants have shared countless stories about how information gained from their participation in this conference had a direct impact on the lands they steward.

This year's Natural Areas Conference welcomed 320 natural areas practitioners from 281 nonprofit organizations, agencies, businesses, and academic institutions. The conference program was rich in topics as well as types of sessions, which included field workshops, hands-on identification workshops, symposia, roundtable discussions, poster presentations, and traditional oral presentations of the most progressive and cutting-edge research, methodologies, technologies, and practices available to natural areas management practitioners. The purpose is to foster communication and collaboration that will lead to progress in connection to challenges in the management of natural areas.

Topics covered included:

- Conservation of grassland ecosystems
- Climate adaptation and resilience
- Private lands conservation efforts
- Indigenous perspectives on natural areas management
- Advances in invasive species management
- Native plant materials in restoration
- Fire science and practice
- Technology in natural areas management
- Wildlife habitat management
- Invertebrate/pollinator conservation
- Soil science and considerations in natural areas management
- Restoration of natural areas
- Value of small natural areas
- Wetland and water resource conservation and management
- Tell the story of your work
- Urban ecology

Presenters delivered a total of 103 talks as part of concurrent sessions and 5 symposia. There were 21 posters presented. We are excited to provide you with the titles and abstracts for these presentations in this conference proceedings.

## GIS SYMPOSIUM

**Advancing Land Management with GIS: Unlocking Opportunities for Impact**

GIS technology has evolved well beyond a desktop application, but how can we leverage these tools in our day to day work? This GIS Symposium highlights a cross section of land managing agencies and their partners to highlight their innovative uses of GIS to transform common workflows, what the future holds, and how federal funding and partnerships can help jumpstart your own modernization efforts.

**Using GeoAI to Help Conservationists Gain Deeper Insights for Conservation Planning**

*Christopher Tracey, Director of Spatial Analysis, NatureServe*

For nearly 50 years, NatureServe has been the authoritative source for biodiversity data throughout North America. We work with 60+ network organizations and 1,000+ conservation scientists to collect, analyze, and deliver biodiversity knowledge that informs conservation action. Through our development of a shared spatial database, NatureServe provides analysis and visualization on at-risk species, habitats, and ecosystems. NatureServe has used GIS to support a variety of conservation initiatives, from identifying critical habitats for endangered species to analyzing the impacts of climate change on biodiversity. GIS has also been instrumental in developing tools and resources to aid conservation practitioners, such as the NatureServe Explorer database and the Map of Biodiversity Importance. Now, NatureServe is beginning to explore how GeoAI can help conservationists gain deeper insights for conservation planning.

**Seeing the Forest Through the Trees, & the Patterns Through the Points: GIS as an Agency-Wide Asset at SCDNR**

*Joe Lemeris, GIS & Data Manager, SC Department of Natural Resources*

GIS use at the SC Department of Natural Resources has grown into an enterprise-based model within a relatively short period of time, driven in large part by the demonstrated benefits provided at all levels of the agency, from field technicians to leadership. SCDNR's GIS & Data Manager for the Natural Heritage Program will walk through project examples and lessons learned while garnering the support for GIS modernization to benefit and promote the state's natural resources.

**Using GIS-Based Multicriteria Decision Analysis to Prioritize Invasive Plant Treatment: A Creative Solution for a Pernicious Problem**

*Joshua Cohen, Lead Ecologist, Senior Conservation Scientist, Michigan Natural Features Inventory*

Invasive plant infestations are projected to rapidly increase with continued habitat fragmentation and climate change. The rate of spread often outpaces land managers' ability to effectively detect and control infestations. Land stewards need tools that can match the rapid pace and scale of invasive infestations and help prioritize control efforts in the most ecologically important areas and optimize resource allocation. It is imperative that proposed control be informed by the best available ecological information. We present a spatially explicit modeling framework for prioritizing invasive plant treatment. In our case study from Michigan, we employ a multicriteria decision analysis model that synthesizes four critical factors for prioritizing invasive plant stewardship: integrity, biodiversity, resilience, and ecosystem services. Data for quantifying these factors were compiled from several state, federal, university, and non-governmental data sources. The model uses a geographic information system (GIS) to identify places that are impacted by invasive plant infestations that threaten to degrade ecosystem composition, structure, and function; are characterized by high ecosystem integrity; support high biodiversity; are resilient to disturbance; and provide ecosystem services. While specific to Michigan, our modeling framework is broadly applicable. This type of integrated analysis can help inform decisions about allocation of limited resources for numerous biodiversity stewardship and landscape-level conservation planning needs, regardless of geographic location.

**The Future of Conservation: ECOSphere's Species Workflow**

*Gina Glenne, Adi Sastry, Conservation Innovation Data Analyst, Cartographer - U.S. Fish & Wildlife Service*

The U.S. Fish and Wildlife Service's (FWS) Ecological Services' Division of Data Integration has been developing ECOSphere, our enterprise cloud system. ECOSphere is replacing our Environmental Conservation Online System (ECOS), which has been the services' portal to provide access to USFWS data concerning threatened and endangered species, conservation of habitat and species, refuges, and migratory birds. ECOSphere offers a central point to gather and store information from varying Federal, State, and local partners to administer a national network of lands and waters for the conservation, management, and, where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States. At the heart of ECOSphere is the "Species Workflow," which will be a live repository for storing species and ecosystems information. We discussed our modernization efforts for ECOSphere and Species Workflow which includes visualizing and creating understanding related to taxonomic and regulatory hierarchies, species biogeography, species' status, and trends in a way that was not possible in ECOS. We described our Connecting the Dots tool that will link species' needs to threats or activities that impact and conservation measures that influence these needs. In addition, we will shared our vision for utilizing Artificial Intelligence to help facilitate the modernization and improved functionality of ECOSphere's Species Workflow.

**Improved Statewide Ecological Mapping System Datasets for Arkansas, Kansas, Nebraska, and Texas**

*David D. Diamond, Ph.D., Senior Ecologist, University of Missouri, Columbia & Past Director, Missouri Resource Assessment Partnership (MoRAP)*

We completed statewide 10-m resolution ecological mapping system datasets for Arkansas (123 types), Kansas (47 types), Nebraska (46 types), and Texas (364 types). A total of 68 different types were identified for the adjacent states of Kansas and Nebraska. These maps have nine times better spatial resolution and better thematic resolution and accuracy versus other available maps. The better capture of features such as narrow wooded loess hill canyons, eastern redcedar (*Juniperus virginiana*) versus shortleaf pine (*Pinus echinada*) communities, coastal lomas, Texas live oak (*Quercus fusiformis*) woodlands and shrublands, and both herbaceous and forested wetland communities will aid in conservation planning and management. Key aspects of methods included partnering with state fish and game agencies as project leads, collection of more than 12,000 quantitative virtual ground plots by botanists to support mapping, use of multiple dates of 10-m resolution Sentinel 2a and 2b imagery for landcover classification, and development of fine-resolution geophysical setting information from digital soils maps and processing of digital elevation models. We will summarize key aspects of new technologies used to produce the maps and highlight improved mapping of several ecological systems of conservation concern.

**'Phenobvious' Traits: Integrating Phenology and Community Science to Advance Invasive Species Management**

*Lea Johnson, Associate Director, Land Stewardship and Ecology*
*Co-authors: Kristie Lane Anderson, Evan Horne*

Non-native invasive plants are a major challenge to biodiversity. Protecting and restoring native communities under invasive plant pressure requires species-specific approaches to invasive species management, including attention to timing of plant life cycles. Mapping invasive species populations is essential to adaptive management prioritization but staffing for field observation is often in short supply. Volunteers can provide important support to land management organizations but may lack advanced skill in plant identification necessary to assist with invasive species mapping. To test whether volunteers could produce actionable information if provided with optimal observation times based on highly visible key identifying features, we used community science data from iNaturalist and expert botanical knowledge to develop a calendar of 'phenobvious' traits (seasonally identifying life cycle events, e.g. early spring leaf-out of *Rosa multiflora*) for more than 100 invasive species of the U.S. Mid-Atlantic region (North Carolina to New York), developed a mapping application for use on smart phones, and created and implemented tutorials.

Volunteers were able to rapidly identify focal invasive species using phenological cues. Review of initial mapping revealed a tendency for volunteers to map either broadly (designating a large area as containing a species) or granularly (mapping individual plants). To reduce this variability, we categorized species according to management priority by invasion phase and specified mapping granularity based on priority phase (e.g., mapping all individuals of species with small populations that might be eradicated from the site, versus mapping population boundaries of widespread species). Once creation of the key feature phenology table and tutorials was complete, staff time investment decreased to occasional maintenance of the table and weekly communication with volunteers. Mapped populations are now being integrated with management planning and used in concert with a complementary project identifying optimal treatment phenology to focus invasive species management effort.

**The Geographic Approach to Protecting, Restoring, and Managing Our Environment**

*Sunny Fleming, Director, Environment, Conservation & Natural Resources Solutions, Esri*

As pressures and threats on our natural systems increase, environmental professionals turn to GIS to predict, protect, restore and manage our environment. Organizations are employing a geographic approach to address common challenges across various organization types. This presentation showcases GIS tools are being deployed across land and wildlife management, outdoor recreation, environmental regulation, and climate resilience planning. This talk will kick off our broader GIS Symposium that brings together our peers and showcases the cutting-edge ways in which they are applying the Science of Where to build a more resilient and sustainable future.

## FIRE SYMPOSIUM

**Spark Big Benefits with Prescribed Burning**

Prescribed burning is critical for the maintenance and restoration of natural areas. Beyond recognizing the importance, it's also necessary to understand how to actually apply prescribed burning. Learn with us as we explore how to develop skills and obtain equipment, find cost-share funding to support conservation efforts, and become aware of potential impacts on air quality. The 90-minute mini-symposium will serve to orient participants on prescribed burning and will be followed by a related concurrent session.

**Prescribed Burn Associations - Building Collaborative Burning**

*Mark Howell, Chair, Missouri Prescribed Fire Council*

Missouri has seen an explosion of interest and activity in private lands prescribed fire. Learn what a Prescribed Burn Association is, how it works, and how it helps landowners come together to collaborate for safer, more effective prescribed burning! Visit https://moprescribedfire.org/pba-faqs to learn more!

**Utilizing Prescribed Burning in Conservation Planning**

*Doug Spencer, State Grazing Specialist, USDA-NRCS*

The Natural Resources Conservation Service (NRCS) provides customers with personalized advice and information, based on the latest science and research, to help them make informed decisions. A conservation plan is developed using a nine-step planning process where both planner and customer collaborate to select and implement conservation practices. The conservation plan provides a step-by-step format to help clients achieve their production and conservation goals. Fire is a key driver in Great Plains grasslands and Prescribed Burning (Code 338) is the conservation practice identified by NRCS to assist clients with implementing fire in the landscape. This session will cover details on the role that NRCS plays in assisting clients on their journey to re-introduce or sustain the use of fire to achieve desired outcomes.

**The First Fine Day of Spring: Responding to Smoke Air Quality Concerns in the Kansas Flint Hills**

*Carol Baldwin, Coordinator, Great Plains Fire Science Exchange*

How do you navigate the space between necessary ecological maintenance activities and a distaste for smoke in the air? What do you say to a furious individual 200 miles away impacted by smoke from another state? Who do you involve in creating and delivering appropriate messaging? With more than a decade of experience, Kansas has found ways to engage both the public and ranching communities in discussing the smoke generated by an average of over 2 million acres of rangeland burning each year.

**Fire and Grazing for Conservation on Contemporary Grasslands, Shrublands and Savannas**

*Samuel D. Fuhlendorf, Regents Professor*

Historically, grassland, shrublands and woodlands developed with fire and herbivory. Over the century or more we have suppressed fires and dramatically altered grazing as well as introduced many novel disturbances such as cropland and energy development. Many aspects of conservation are dependent upon understand these from a socio-ecological perspective. The re-introduction of fire on these landscapes has potential to enhance biodiversity and conservation while maintaining agricultural productivity on these system. Understanding the interactive pattern of fire and grazing is critical for conservation in the future.

**Exceptional Events and Prescribed Fire/Smoke Management**

*Gina Grier, EPA Region 7 Ag Air Contact*

EPA recognizes that fire is part of a natural renewal process and essential for sustaining the tall grass prairies, but burning millions of acres during the spring in a compressed time period can send unhealthy levels of smoke emissions into downwind communities. EPA's Exceptional Event Rule can provide Air Agency's with regulatory relief if smoke emissions causing air quality violations are out of the State's (or Tribes) reasonable control.

**Planning for Smoke**

*Joe Carpenter, Co-owner Downey Ranch*

Producer perspective of dealing with smoke management in the tallgrass prairie.

**Weather Impacts on Prescribed Fires and Smoke**

*Nathan Griesemer, Meteorologist at the National Weather Service in Topeka*

Conditions such as inversions, mixing heights, steering and boundary layer winds help dictate smoke issues when performing prescribed burns. In this short presentation, a brief overview of these parameters will be discussed as well as climatology to consider when planning a burn. Additionally, a few resources will be shown for users to visit to help further inform them on the weather when burning.

## NATIVE SEED SYMPOSIUM

**Seeding Successful Prairie Restoration**

Native plants are a foundational element of ecosystems and millions of pounds of seed are used every year to revegetate or enhance disturbed and damaged habitats. As such, native seeds are the currency of ecological restoration, but developing a seed mix with the right species, mix ratios, and seeding rates can be challenging. Decisions made at the seeding stage can have implications for years to come and determine the success of the project. With presenters from academia, non-profit organizations, and agencies, this symposium will look at recent research and share success stories around developing the right species mix for the right habitat restoration project with a focus on midwestern prairie restoration.

**Diversifying Seed Mixes with Culturally Significant Species and the Role of Culturally Significant Species in Seed Mixes**

*Kelly Kindscher, Ph.D., Professor/Senior Scientist, Environmental Studies/Kansas Biological Survey, University of Kansas*

The importance of useful plants, for food, medicine, dye, and other purposes is often overlooked in developing seed mixes for restoration projects. These are important, not just for Native peoples but for all people who might use these plants. If useful plants are incorporated into restorations and if sustainable harvest of the plant materials are required for their use, people will be more engaged in the restoration projects, as management then becomes important for them too. Examples from prairie restoration and prairie ethnobotany will be discussed.

**Factors Influencing Native Seed Price and the Implications for Habitat Biodiversity in Agricultural Landscapes of the Central United States**

*Stephanie Frischie, Agronomist/Native Plant Materials Specialist, The Xerces Society for Invertebrate Conservation*

*Co-authors: Justin Meissen, Andy Olsen, Laura Jackson, Rich Iovanna*

In the intensively managed agricultural regions of the Upper Midwest and Great Plains, the Conservation Reserve Program (CRP) is often the main tool for providing critical support for threatened pollinators and the monarch butterfly across more than 3 million acres. The success of CRP habitat programs relies on diverse, regionally appropriate native seed that is consistently affordable. However, native seed cost and availability is subject to complex supply and demand forces. Through our research under a cooperative agreement with the USDA Farm Services Agency, the Tallgrass Prairie Center at the University of Northern Iowa, and the Xerces Society for Invertebrate Conservation, we are interested to see how a clearer understanding of the factors that affect native seed cost can be applied to build seed mixes and plantings with higher biodiversity and to create sustained, stable demand for native seed suppliers. We will present our preliminary findings on the relationships between native plant and seed traits and seed cost, summary statistics of seed suppliers, and a chronology of the development of the native seed industry in the Upper Midwest and Great Plains from the 1930s to the present.

**Which Species are Missing from Restorations? Insights from the Seed-Based Restoration Pipeline**

*Andrew Kaul, Restoration Scientist, Missouri Botanical Garden*

Plant compositional differences between restored and reference communities are well documented. Multiple anthropogenic, abiotic, and biotic filters act on regional species pools to influence which species occur in a restored location. Appropriate native species are generally missing from restored sites unless they are 1) selected for by seed production areas, 2) included during seed mix design, and 3) establish stable populations. I will describe ongoing research describing which types of species are selected across each of these three transitions.

**A 10-Year Timeline of Tallgrass Prairie Reconstruction Outcomes**

*Jennifer Larson, Invasive Plant Specialist, USDA Forest Service*

Tallgrass prairie is one of the most endangered ecosystems worldwide, with less than 3% of its original extent remaining. Much of the remnant prairie exists as small, isolated fragments in a largely agricultural matrix. Prairie reconstruction, or developing a prairie from a former agricultural field, has the potential to increase connectivity of these remnants and provide essential habitat and forage for pollinators. To gain an understanding of how early restoration practices can influence longer term establishment and success of prairie reconstructions, we established an experimental study across nine locations in Minnesota and Iowa. In 2004–2005 we planted plots using one of three planting methods (dormant broadcast, growing-season broadcast, growing-season drill) fully crossed with one of three species richness categories (10, 20, or 34 species) in a completely randomized design. We measured individual species cover in 2005–2007, 2010, and 2015. Five years post-planting, the optimal planting method with regard to planted cover differed between Minnesota and Iowa; dormant broadcast produced greater planted cover in Minnesota while growing-season drill proved more effective in Iowa. Increasing seed mix richness led

to greater planted species richness but did not improve outcomes with regard to exotic species invasion. Ten years post planting, we saw little variation among treatments with regard to cover of planted, native non-planted, and exotic species, indicating that there is no best planting method in the longer term. Of particular note, cover of the noxious weed *Cirsium arvense* declined over the course of the study, without herbicide. However, the cool-season, invasive grasses *Poa pratensis* and *Bromus inermis* continued to increase, and there was no planting method or seed richness treatment combination that slowed this growth. Management targeting these cool-season grasses will be key to long-term success of tallgrass prairie reconstructions.

**Understanding the Native Seed Supply Chain for Restoration Success**

*Alexis Larsen, Plant Materials Program Director - Institute for Applied Ecology*

Native plant materials development does not happen in a vacuum and requires a high level of communication and coordination to be successful. Enter the native seed supply chain – a system composed of the activities, resources, information, and people that supply native seed for restoration, revegetation, and mitigation projects. At the most basic level the supply chain moves from collection to research and planning to cultivation to harvesting and cleaning to distribution to end users and includes a diverse group of stakeholders along every link. As native seed is the backbone of restoration, but not always the expertise of an ecologist, it is essential to understand parts of this system to improve the success of restoration projects. This may include an understanding of how to procure native seed, develop a site appropriate native seed mix, and write seed transfer zones into restoration planning. Restoration ecologists can play a big or small role in the native seed supply chain, depending on the scale and their interest and expertise. This presentation will describe the native seed supply chain, why there is a growing focus on improving this system, and how restoration ecologists and land managers can engage at different points in the chain.

**Testing the Effect of Provenance on Native Seed Germination to Improve Seed-Based Restoration of Prairies**

*Brandon Clark, Graduate Research Assistant at South Dakota State University*

Grasslands are one of the most endangered ecosystems on the planet and provide essential ecosystem services locally, regionally, and globally. Losses of grasslands can be mitigated through restoration. Seed-based restoration is a widespread option due to its practicality and cost-effectiveness. Planting seeds from non-local sources and may not be adapted for their destination climate can have consequences for germination and restoration success. Using data-informed decision-making when selecting where seed is sourced from is important in restoring grasslands so that germination can occur at the appropriate time and rate. Therefore, we examined the effect of seed source location on seed germination under different temperature regimes. We selected 13 native prairie species each with 3 commercially available county-specific seed source locations. To mimic spring temperatures, the germination chambers were set to 12-hour cycles of the average high and low air temperature for May 15th for Northern Minnesota, central South Dakota, and central Nebraska to encompass variation in temperature from a latitudinal gradient in grasslands of the northern Great Plains of the United States. For each seed source, five replicates of twenty-five seeds each were placed in plastic bags on moist blotter paper. Seeds from each source were placed in germination chambers and germination was recorded three times a week for 6 weeks. Final germination was examined using a relative interaction index (RII) = (Treatment – Control)/(Control + treatment). Control was considered the intermediate temperature and the treatments were the cooler and warmer temperatures. We found significant interactions between source and temperature in final germination percent for 7 of the 13 species tested. Results were species-specific. This shows that more than half of the species tested exhibit some local adaptation for germination characteristics. This study has implications for helping land managers make informed restoration decisions about sourcing seed.

**Building Healthy Communities and Landscapes with Native Seeds**

*Courtney Masterson, Executive Director + Ecologist*

Native seeds have been core to human culture and health for thousands of years, providing opportunity for community building, healthy food systems, creative projects and more. Native Lands Restoration Collaborative and their partners are working with communities to return seed collection as a cultural mainstay, providing opportunities to connect with native plants, landscapes, and each other throughout the year. Learn more about the strength of community in collecting seeds and restoring landscapes through this talk from NLRC's Executive Director and Ecologist, Courtney Masterson.

**Seed-Based Restoration for Great Plains . . . Woodlands?**

*Andrew Klein, Water Quality Forester, Kansas Forest Service*

Usually the words "woody plants seeds" and "Great Plains" do not evoke thoughts of restored ecosystem services. However, there's a new perspective on the horizon. Join Andrew Klein from the Kansas Forest Service to learn about a new approach to riparian woodland restoration in Kansas. This "soils first" approach is rooted in regenerative agriculture practices; incorporating cover crops, no-till, soil inoculants, and high-density, high-diversity, high-precision direct seeding of trees and shrubs, and is proving to be a faster, more cost-effective way to restore riparian soils to their former capacity for water quality and other ecosystem services. Discover how this method diverges from traditional bare-root seedling and direct seeding practices and how it could be applied to your restoration efforts. Bring your questions and ideas to explore this exciting new direction in seed-based restoration!

**Scaling up while Staying Local: Meeting Demand for Local Ecotypes**

*Julia Michaels, Ph.D., Restoration Ecologist, Hedgerow Farms, V.P. of Scientific & Public Affairs, The NativeSeed Group*

There are thousands of native species used in restoration, and for each of these species, there are countless locally adapted ecotypes. As the demand for native seed increases, seed producers must prioritize which local ecotypes to target for wildland collection and amplification. In this presentation, we draw on lessons learned from 30 years of native seed production to show how growers can take a proactive approach to meeting demand for local ecotypes. This approach includes (1) identifying geographic gaps in ecotype availability within our inventory (2) closely tracking state and federal funding to anticipate future demand for ecotypes and (3) working with scientists to develop a list of 'priority' species that have been shown to have especially high genetic variability across ecotypes. Finally, we share how our production-network model has allowed the NativeSeed Group to 'scale up while staying local'—serving our local regions while taking on the financial risks of amplifying new ecotypes. Strategies include sharing inventory across networks of smaller seed companies, planting on farmland across a range of microclimates, and working with the Crop Improvement Associations to increase standards for local ecotypes.

## WOODY ENCROACHMENT SYMPOSIUM

**New Solutions to an Old Problem: Adapting to Grassland Woody Encroachment**

Currently, the greatest conservation threat to grasslands worldwide is woody encroachment—an ecological process whereby native woody plants increase in abundance, displace grasses, and alter normal ecological functioning. For the past half century, land managers, conservationists, and ecologists have been documenting this process and working to identify solutions to stop the spread of woody plants into grasslands. While some of these strategies have slowed woody encroachment, most large landscapes continue to transition from grassland to shrubland or woodland. For these reasons, natural areas managers need additional tools and strategies beyond a 'resist at all costs' approach to woody encroachment. This symposium will focus on woody encroachment in the central Great Plains, and provide information illustrating the drivers and consequences of this phenomenon followed by information identifying potential approaches to maintain biodiversity, range production, and other key ecological services. For the last portion of the symposium, we will facilitate an open discussion between the speakers and the audience regarding this phenomenon and steps to facilitate new management guides that promote acclimation to altered landscapes in the future.

**Holistic Consequences of Woody Plant Encroachment in Great Plains Grasslands**

*Jesse Nippert, University Distinguished Professor, Kansas State University*

Woody plant encroachment is a global phenomenon, and now represents the most widespread threat to grassland conservation after conversion to row-crop agriculture. The consequences of woody plant encroachment on ecosystem structure and function are pervasive. The aboveground consequences of encroachment are well studied. For example, woody plant encroachment typically results in reduced plant and animal biodiversity, loss of suitable habitat for obligate small mammals and birds, and increased threat of diseases carried by ticks. Alterations in aboveground ecosystem structure also reduces forage availability for range management, resulting in billions of dollars of lost revenue for the cattle industry in the United States alone.

The consequences of encroachment on belowground ecosystem dynamics are less well known. Shifts from grass-dominated to shrub- or tree-dominated at the landscape-scale disrupts C, water, and nutrient cycling throughout grasslands. Ecohydrology studies have shown that woody encroachment alters catchment water budgets and recharge rates, runoff generation mechanisms and amounts, the relative contributions of deeper flow paths to streams, and stream discharge and intermittency. Moreover, the replacement of a grassy ecosystem with a woody ecosystem has uncertain impacts on C sequestration due to alterations in soil carbon dioxide fluxes, increased bedrock weathering rates, and changes in labile soil organic carbon accumulation.

In this presentation, I will use examples from the Konza Prairie over the past decade that illustrate linkages between above- and below-ground ecosystem processes following encroachment. In particular, this research shows the mechanisms by which woody vegetation accelerates water cycling and alters the distribution of C within the soil profile. Coarse woody roots appear to create larger soil macropores that speed up rates of infiltration to the groundwater, a process that could shunt C more deeply into the subsurface. Larger macropores also reduce water residence time in surface soils and along with higher ET result in longer-term drying trends in grassland ecosystems. The results from Konza can be extrapolated to other mesic grasslands of the Great Plains, illustrating the significance of belowground ecosystem change on the functional dynamics of our local grassy systems.

**Adapting to a Woodier Great Plains**

*Chris Helzer, Nebraska Director of Science and Stewardship, The Nature Conservancy*

We may not be able to prevent woody plants from becoming a larger component of Great Plains grasslands. An ecological transformation has already happened in many parts of the southern Plains and a similar transition is underway in many other places. Given our inability to control most of the major drivers of this woody transition, it's time to stop putting all our energy into stopping the changes and start thinking about how to guide and adapt to them.

First, we need to understand the full implications of a conversion from grasslands to shrublands or, at least, shrubby grasslands. What species and ecological communities will thrive under these new conditions? How will the changes affect people, economically, emotionally, and otherwise. How will those

people react in a woodier environment and what are the ramifications for land use changes and the resulting impacts on biodiversity?

For some of these questions, we can look to landscapes in places like Texas and Oklahoma, where the transition has already happened, but we also need to invest in research where the conversion is underway or inevitable. What are the land stewardship options available to us? When should we focus on blocking or slowing woody encroachment and when should we try to manage habitat structure and composition? When we can't prevent woody encroachment, how can we manage it to optimize species diversity and ecological resilience?

A woodier landscape still provides a lot of opportunities to manage for biological diversity and ecological resilience. We can manage height, density, cover, and other aspects of woody plant populations, but we need to learn how those habitat attributes affect individual species, species diversity, and ecological processes. Research will be crucial in the coming years, but we also need land managers to experiment, learn, and adapt – and to share what they're learning with each other.

**Can Grazed Tall Grass Prairie Remain Resilient to Woody Encroachment?**

*Zak Ratajczak, Assistant Professor, Kansas State University*

We report on a range of long-term large-scale experiments at Konza Prairie Biological Station and other sites in the Central Great Plains that manipulate fire and grazing. Our observations derive primarily from remote sensing, including airborne lasers. In ungrazed areas, one and two year fire return intervals (FRI) have largely prevented encroachment, but a small shift to a three to four FRI results in extensive encroachment, covering about 40% of the landscape. In areas grazed by bison, a one year FRI results in ~8% landscape encroachment, a two year FRI results in ~18% encroachment, and a three to four year FRI results in ~40% encroachment. Areas grazed by cattle see similar patterns, although average shrub height is potentially lower. Before European colonization, the estimated average FRI in the Central Great Plains was around three to four years, but this rate of burning no longer maintains resilience against encroachment. We have explored more extreme measures to prevent or reverse encroachment, such as reintroducing annual fires to encroached areas, combining annual fires with mechanical shrub removal, combining long-term drought and fire, and extreme fires that combine long-term rest from grazing and hot windy conditions during fires. None of these approaches have fully reversed encroachment. These observations suggest that large-scale factors are decreasing grassland resilience to encroachment. Primary suspects are rising atmospheric CO2 (a stimulant for woody plant growth). Woody vegetation is increasing regionally, which increases woody plant seed rain. For instance, in the northern Flint Hills, around 33% of the landscape is now woody vegetation.

In the 21st century, preventing or reversing encroachment might require new measures, such as reintroducing browsers (e.g., elk or goats), more artificial inputs such as chemical applications, or reduced grazer stocking rates, which would reduce ranching incomes. The fieldtrip associated with this symposium will show the results from most of these experiments. We are keenly interested in hearing approaches other land stewards have taken to prevent or reverse encroachment—this is a difficult problem that will require crowd-sourcing to find viable solutions.

## OAK SAVANNA SYMPOSIUM

**Managing Midwest Oak Savannas for Biodiversity**

Savannas and other grasslands are globally threatened, and Midwestern oak savannas are among the most endangered ecosystems in North America. Characterized by a patchy canopy of scattered oak and other species over a grass- and forb-rich understory, the heterogeneous light and moisture environments of Midwestern oak savannas support exceptionally high plant diversity. Prior to European colonization, these fire-dependent ecosystems covered approximately 13 million hectares from Minnesota and adjacent Canada in the northeast, south to Missouri, and east to Michigan, Ohio, and Ontario, but have been reduced to less than 1% of their historical extent. Following decades of habitat conversion and destruction due to anthropogenic development and fire suppression, remnant savannas support some of the rarest plant and animal species of this region. Managers use prescribed fire in concert with mechanical thinning of shrubs and trees, among other management actions, to overcome woody encroachment and restore structure, diversity, and composition. This symposium will focus on how plant and animal biodiversity respond to restoration management in Midwestern oak savannas, and the tradeoffs in managing diversity among taxonomic groups. We will address which restoration practices are most effective in restoring these dynamic oak savanna ecosystems.

**Connecting the Dots: Restoring Midwestern Oak Savanna Ground Layer Plant Communities, from Toledo to Madison**

*Tyler Bassett, Botanist, Michigan Natural Features Inventory*

Grasslands such as prairies and savannas are threatened globally, and Midwestern oak savannas are among the most endangered ecosystems in North America. Protracted fire suppression is a primary threat. Without fire, key aspects of ecosystem structure that differentiate savannas from forests are lost, including greater light availability associated with low canopy and understory tree and shrub density, and a diverse ground layer dominated by dense herbaceous vegetation rather than leaf litter. Importantly, ground layers are composed largely of species uniquely adapted to savanna conditions, many of which are of high conservation value. Managers and researchers have often found that prescribed fire is slow or insufficient to restore structure, diversity, and composition, and restoration requires fire in concert with mechanical thinning of shrubs and trees to overcome decades of woody encroachment. Despite this progress in understanding, most studies have been geographically limited, spanning one site to a single landscape. A generalizable framework is still needed to describe how variation in fire and thinning affects restored oak savanna structure,

diversity, and composition, and how restoration varies across environmental gradients such as soil productivity. We collected plant community and environmental data in 100 oak savanna restorations across the southern and western Great Lakes basin from Toledo to Madison, including sites in Michigan, Ohio, Indiana, Illinois, and Wisconsin. These restorations represented different management histories (burn-only, thin-only, burn-and-thin, unmanaged controls). We found that the combination of thinning and burning is often associated with more favorable restoration outcomes, including increased native plant species richness and abundance, especially for forbs, woody species, and species of high conservation value. These responses were mediated through increased light availability more often than reduced leaf litter, and occasionally varied across soil productivity gradients. By connecting the dots between management history and plant communities across landscapes that vary in environmental conditions, these results provide a foundation for a generalizable framework for the restoration of Midwestern oak savannas.

**Biodiversity Changes across a Midwest Prairie–Oak Savanna–Forest Gradient**

*Noel B. Pavlovic and Ralph Grundel, Research Ecologist, USGS*

Woody vegetation manipulation is a common approach and goal during oak savanna restoration management along the grassland to forest continuum. We investigated the tradeoffs in plant and animal community composition related to changes in woody vegetation density along this continuum in northwest Indiana and predicted what landscape compositions, related to woody vegetation cover, might maximize diversity of plant and animal communities. We sampled vegetation, birds, reptiles, amphibians, butterflies, and bees across the prairie–savanna–forest gradient among 25 sites at Indiana Dunes National Park, and Tefft and Hoosier Prairie Nature Preserves. Thus, five prairie, oak scrub, oak savanna, oak woodland, and oak forests were sampled. We found that different taxonomic groups responded to different environmental factors (e.g., fire regime, canopy cover, ground cover, plant diversity, composition of plant in flower) across the gradient. In addition, with birds, we showed that we could not maximize species diversity and conservation value of species simultaneously. From this research, we discuss the benefits and drawbacks for oak savanna restoration for the taxonomic groups and what kinds of landscapes would maximize which goals.

**Light, Soil, Fire, and Seeds: Investigating the Environmental Gradients that Drive Restored Oak Woodland Plant Community Diversity**

*Rory Schiafo, PhD Candidate, Northwestern University and Chicago Botanic Garden*

Once widespread across the Midwestern U.S., *Quercus* woodlands have been degraded by land use changes, fire suppression, and invasive species. Previous research shows that gradients of light, soil, and fire structured diversity in predegraded woodlands. However, we know less about the processes structuring diversity in woodlands being restored through native seed addition. This study addresses how the gradients of canopy openness, soil nutrients, and fire frequency influence plant communities being restored with native seeds. We surveyed plant community diversity, canopy openness, soil properties, and determined burn rate and seeding history in seven woodland restorations across Cook County, IL. We found that the seeded status of a plot and canopy openness interacted in their effect on species richness, such that there was a significant relationship between canopy openness and species richness in unseeded plots, but not in the seeded plots ($p = 0.03$*). We also found that the abundance of non-sown species increased with canopy openness ($p = 0.004$*) and decreased with increasing burn rate ($p = 0.02$*). In contrast, there was no relationship between sown species abundance with the gradients of canopy openness or burn rate. These findings suggest that native seed addition can influence the role that canopy openness and burn rate play in driving plant community diversity. Additionally, this work suggests that the differing responses between the sown and non-sown species are important to consider. A better understanding of how plant communities restored through native seed addition respond to environmental gradients will help guide restoration practices in this highly threatened ecosystem.

**Life in the Oak Savanna from a Butterfly's Eye View**

*Ashley Cole-Wick, Conservation Biologist, Michigan Natural Features Inventory*

Oak savannas support a diversity of insects, including the federally endangered Karner blue butterfly (*Plebejus samuelis*). This butterfly is found in oak savannas and oak-pine barrens where its only host plant, sundial lupine (*Lupinus perennis*), grows. The Karner blue is inextricably linked to lupine, a disturbance-dependent perennial legume that thrives on sandy soils. At Michigan Natural Features Inventory, we work to understand how the species responds to habitat management and succession to inform conservation actions.

**The Influence of Canopy Cover and Canopy Heterogeneity on Plant Diversity and Community Composition within Midwest Oak Savannas**

*Sidney Noble, Ecologist USGS*

Midwest oak savannas are among the rarest terrestrial ecosystems globally and contain some of the highest plant diversity in North America. Understanding diversity patterns within these ecosystems is crucial for setting management and restoration goals. This study aimed to understand the role of canopy cover and heterogeneity in canopy cover in influencing plant alpha and beta diversity within oak savanna ecosystems. Conducted in the black oak savannas of the Indiana Dunes along the southern shores of Lake Michigan in NW Indiana, USA, we sampled twenty-nine 1000 $m^2$ plots with gradients in canopy cover and canopy heterogeneity to examine their influence on plant diversity and composition. Woody plant alpha diversity was highest in areas with high canopy cover (>75%). C3 graminoids, C4 graminoids, and sedge alpha diversity were highest in areas with low canopy cover (<25%). Forb and legume alpha diversity were highest with low to intermediate canopy cover (25–50% and 20–35%,

respectively). Overall, plant alpha diversity was highest at intermediate canopy cover. High canopy heterogeneity was associated with high alpha diversity. There was no relationship between canopy cover or canopy heterogeneity and beta diversity. However, beta diversity was exceptionally high within all sites. An average canopy cover of 25–50% is optimal for promoting high plant diversity across many functional groups. Still, both low and high canopy cover sites are important for maximizing the diversity of some functional groups. Therefore, we recommend managing oak savannas for 25–50% canopy cover to maximize diversity. However, where opportunities exist in large remnants of oak savanna/woodlands, maintaining some areas with few trees and other areas with closed canopies can maximize diversity on a landscape scale.

**The Consequences of Burn Pile Scars for Midwest Oak Ecosystem Biodiversity**

*Meghan Midgley, Director of the Center for Tree Science; The Morton Arboretum*

*Co-authors: Antonio Del Vallé, Greta Franke, Ellenore Keller, Jasmine Dwyer, Emma Leavens*

To restore oak savannas in the Midwestern US, ecosystem stewards and managers cut invasive brush and thin trees, creating woody debris brush piles. Brush pile burning is the top strategy for dealing with this debris. Though individual piles are generally small (2–5 m in diameter), burning them can produce extreme soil temperatures that adversely affect soil processes and biota beneath the piles. Brush piles are often produced at high density in small management units undergoing ecological restoration, which may have consequences for ecosystem functioning and regional biodiversity conservation. With approximately 5,000 brush piles being built and burned annually in the Chicago region, there are concerns from the ecological restoration community about the effect of burn scars on regional biodiversity and interest in developing strategies for minimizing these impacts. However, the ecological effects of these "burn scars," which may include long-term changes in plant and fungal communities and soil biogeochemistry, are virtually unexamined. To meet the needs of the restoration community and improve our ecological understanding of burn scar successional dynamics, we established a series of studies to 1) characterize short- and long-term effects of brush pile burns on plant and soil biodiversity; 2) identify the management choices that minimize or maximize these effects; and 3) evaluate post-burn strategies for mitigating brush pile burning effects on biodiversity. In this talk, I will discuss current findings from a large-scale survey, a chronosequence study, and a restoration treatment experiment.

**Rapid Assessment Protocol and Evaluation Metrics for Habitat Delisting**

*Bradford Slaughter, Senior Botanist, Orbis Environmental Consulting*

Indiana Department of Natural Resources (IDNR) contracted with Orbis Environmental Consulting to make modifications to a rapid assessment protocol that assesses progress towards meeting habitat management objectives and delisting of habitat-related beneficial use impairments at 17 sites within the Grand Calumet River Area of Concern. The project involved an iterative process of consultation with IDNR and Nature Conservancy staff, evaluation and selection of habitat quality indicators, and field testing of indicators at project sites. The resulting protocols incorporate a variety of metrics, most of which assess vegetation structure. Important differences from the existing protocols include removal of compositional metrics such as species richness and the presence of indicator species, and the replacement of universal site quality scores with a flexible approach that can be tailored to site-specific or patch-specific habitat management goals.

## INDIVIDUAL PRESENTATIONS

**A Microcosm of Midwestern Native Grassland Communities: A Tour of Missouri's Prairies, Glades, Savannas, and Fens**

*Michael Leahy, Natural Community Ecologist, Missouri Dept of Conservation*

Missouri lies in a transition zone between the dry grasslands of the Great Plains and the humid temperate forests of the eastern U.S. From rocky Ozark glades to bottomland prairies, Missouri has a rich native grassland heritage that supports over 200 species of conservation concern considered critically imperiled, imperiled or vulnerable in our state. This presentation will outline the wide variety of grassland natural communities here, 20 in total, that in turn support 900 vascular plant species. This diversity at the base of the food chain supports thousands of insect species and many vertebrate species. We will explore the interplay between climate, soils, human history and geology in shaping the grassland natural communities of Missouri. These patterns occur not just in Missouri but across neighboring states in the broader Midwest and upper south.

In addition, we will also discuss the threats, current best management practices, and need for further research and monitoring to continue to refine management regimes to adapt to changing ecological conditions. Non-native invasive species such as sericea lespedeza (*Lespedeza cuneata*), invasive native species such as winged sumac (*Rhus copallinum*) and eastern redcedar (*Juniperus virginiana*), hydrologic alterations, changes in agricultural practices, exurban development, fire suppression, and a changing climate and atmospheric chemistry all act as stressors to these natural communities and interact in challenging ways for native grassland managers. Current methods to abate these stressors will be discussed along with the need for further applied research to better address the conservation of these sites.

**Minnesota's Ecological Monitoring Network (EMN) - Status and Trends of Native Plant Communities**

*Nathan Dahlberg, Minnesota Dept. of Natural Resources*

The Ecological Monitoring Network (EMN), established in 2017 by the Minnesota Department of Natural Resources (DNR), is a pioneering effort aimed at tracking ecological change across the state. This comprehensive monitoring

initiative, led by the Minnesota Biological Survey in collaboration with various DNR divisions and partners, including The Nature Conservancy, the University of Minnesota, and the US Fish and Wildlife Service, focuses on assessing how Minnesota's native plant communities are responding to emerging challenges such as climate change, invasive species, and habitat fragmentation.

In this presentation, we will highlight the ways in which the EMN is contributing to biodiversity conservation in Minnesota's native ecosystems. Specifically, we will focus on how the EMN is:

1. Providing essential data on the status and trends of vegetation composition, structure, and condition within native grasslands, wetlands, and forests. This information is crucial for land and water management practitioners to make informed decisions and develop effective strategies for protecting biodiversity in natural areas.
2. Sharing preliminary analyses and data summaries from the EMN's first 10-year resample. These findings will provide valuable insights into long-term ecological trends and help stakeholders understand the importance of sustained monitoring efforts for informed conservation actions.
3. Emphasizing the importance of long-term ecological monitoring for detecting gradual ecological changes, understanding ecosystem resilience, and informing adaptive management strategies. The EMN's approach underscores the value of ongoing monitoring efforts in maintaining ecosystem health and functionality over time.

Overall, the EMN is a valuable tool for improving our understanding of the impacts of external stressors on Minnesota's native ecosystems and for understanding their status and trends in the face of these challenges. The EMN's monitoring approach is designed to provide decision-makers with timely and scientifically rigorous information, aiding in the development of effective strategies for conservation.

**Floristic Quality Assessment of Stout Woods Memorial Woodland State Nature Preserve, Henry County, Indiana**

*John Taylor, Field Station Land Mgr/Restoration Ecologist, Ball State University*

*Co-authors Donald Ruch, Kemuel Badger*

Stout Memorial Woodland State Nature Preserve (Stout Woods), an approximately 14.6 ha (36 ac) woodland acquired in 2013 by Red-tail Land Conservancy (RLC) land trust, is located in Jefferson Township (Henry County), Indiana. The history of Stout Woods revolves around Sam and Stella Stout and their family, whose community spirit and perseverance led to the preservation of this hardwood forest. The site is a flat woodland with a single loop trail. Starting in late April 2023, a floristic quality assessment of the site was conducted, concluding in June 2024. Preliminary analysis through the end of 2023 documented 192 taxa in 139 genera and 72 families; 180 taxa ($\sim$ 90%) were native and 21 taxa ($\sim$ 10%) were non-native. The native floristic quality index (FQI) and average coefficient of conservatism ($\overline{C}$) were 54.2 and 4.0, respectively. The FQI and $\overline{C}$ for all taxa (native and non-native) were 51.3 and 3.6, respectively. Preliminary analysis of the floristic quality matrices indicates that Stout Woods is nature preserve quality from a biological perspective.

**Why I'm Not Panicking About (Some) Invasive Plants Becoming More Abundant in Our Prairie**

*Chris Helzer, Nebraska Director of Science and Stewardship, The Nature Conservancy*

Invasive species are the biggest land stewardship challenge at many sites, but it can be difficult to know how to assess the success of invasive species suppression efforts. At The Nature Conservancy's Platte River Prairies in Nebraska, more than twenty years of plant composition data has shown that smooth brome (*Bromus inermis*) and Kentucky bluegrass (*Poa pratensis*) are increasing in frequency and extent under fire and grazing management. However, mean plant species richness and frequency of individual plants has remained relatively stable throughout that same period. If we're worried about invasive species because of their impacts—for example, their ability to suppress plant diversity—shouldn't we measure the impacts, not the cover or abundance of the invasive species themselves? It's crucial to set clear goals around invasive species management and to evaluate that work based on those specific objectives.

**Tree Species in Peril: The Lingering Hemlock Project**

*Grace Haynes, Extension Aide, New York State Hemlock Initiative*

*Co-author: Caroline Marschner*

The Lingering Hemlock Project, a subset of The Nature Conservancy's "Tree Species in Peril," aims to locate and selectively breed eastern and Carolina hemlocks with genetic resistance to the hemlock woolly adelgid (HWA). This insect is invasive in eastern North America and has already contributed to widespread hemlock mortality in much of the southeastern United States. As it continues to spread through the northeastern US, research into how to save hemlock trees is ramping up. While strategies such as chemical control are effective in the short-term, longer-term hemlock protection depends on biocontrol and selective breeding to promote hemlock woolly adelgid resistance. In this presentation, representatives from the New York State Hemlock Initiative and the Hemlock Restoration Initiative will share more about how natural areas can participate in the Lingering Hemlock Project. In the southeastern US, project partners can locate and record data on hemlocks that remain healthy despite HWA infestations. In the northeastern US, project partners can establish hemlock plots and monitor their health and decline annually. By detecting hemlock trees that are more resistant to the damage caused by HWA, this project aims to identify HWA-resistant genotypes to support resistance breeding in eastern and Carolina hemlocks.

**Project Wingspan: Sowing Success at the Grass Roots**

*Andy Grinstead, Habitat Specialist, Pollinator Partnership*

The monarch is symbolic. It represents a diversity of wildlife and habitat lost due to rapid changes and expansions in land use. Importantly, it serves as a flagship species for the protection and conservation of other imperiled pollinators. In an era of

boundless participation in the outdoors, it is time to rethink how we tackle large-scale conservation issues. By taking advantage of community science and creating structured volunteer networks, Project Wingspan presents a unique flavor of inter-state, cross-sector collaboration between professionals and lay persons, creating quality habitat for pollinators and biodiversity across nine states and 100,000+ acres.

Project Wingspan spearheads a collaborative effort to enhance pollinator habitat across the Midwest and Great Lakes region. Through a coalition of passionate partners, Pollinator Partnership coordinates various initiatives such as volunteer seed collection, technical training and workshops, habitat creation, and more. By engaging public land managers, private land stewards, community groups, non-profit organizations, and other stakeholders, Project Wingspan amplifies grassroots action for the benefit of pollinators and ecosystems.

The program engages volunteers to collect native, ecotypic seed to be cleaned, grown out, and redistributed to qualified projects in the area where the seed was first collected. It cultivates education with technical workshops and webinars, utilizing time-tested training resources and a certification process that is free for everyone. Project Wingspan additionally offers technical support and certification opportunities for agricultural land managers seeking to leverage federal support initiatives.

It is time to empower communities to join forces in grassroots conservation and make a meaningful difference locally, regionally, and nationally.

**Bison Wallows Bolster Biodiversity in Tallgrass Prairie**

*Bess Bookout, Graduate Research Assistant, Kansas State University*

*Co-author: Zak Ratajczak*

Plains bison (*Bison bison*) were an important species that once roamed the Great Plains in the millions but have now largely been replaced by domestic cattle. While cattle and bison share similar ecological roles within grasslands, bison, unlike cattle, create bare-earth depressions (wallows) through dust-bathing. Historically, as bison followed fire across the Plains, wallows would have been abandoned from months to years, likely creating a mosaic of unique plant communities and ephemeral wetlands. This study takes advantage of a long-term bison reintroduction (30 years), which is factorially crossed with fire frequency (1, 2, 4, and 20-year fire intervals) at Konza Prairie Biological Station (KPBS), a native, unplowed tallgrass prairie. I conducted plant surveys in 120 plots (fenced and unfenced wallows and non-wallows; $n = 24$) to determine if wallows contribute to plant diversity in tallgrass prairie, and thus if bison provide distinct services that cattle do not. My results show that wallows support unique plant communities, increase overall plant diversity, and increase phylogenetic diversity, which may contribute to increased functional diversity and resilience. Wallows also house unique soil microsites with greater clay content, and in some wallows (about 20%), long periods of standing water and/or high salt concentrations similar to brackish wetlands. Our results suggest that the removal of bison from Great Plains tallgrass prairie may have reduced the plant biodiversity and the extent of semi-aquatic ecosystems.

**Urban Ecology: A Kansas City Success Story**

*Hunter Moore, Program Manager, Kansas City WildLands*

Kansas City WildLands, a program of Bridging The Gap, Inc., conserves, protects, and restores remnant landscapes that reflect the KC metro's biological heritage. Remnants are among the most biodiverse natural areas, but are often faced with common conservation threats like urbanization and lack of awareness. WildLands is almost 100% volunteer-based, turning effective education and outreach into a unique multifaceted cohort of leaders conducting invasive species removal, native seed efforts, prescribed fire, and citizen science. WildLands, as a coalition driven by resource professionals, government agencies, conservation organizations and citizen scientists, brings partners and volunteers together to overcome barriers and conserve these remnants.

**Using the Rapid Decline of Bird Populations as a Means to Connect Landowners with On-the-Ground Management Techniques**

*Allen Pursell, Director of Forest Programs, Sam Shine Foundation*

Private landowners hold the keys to habitat management in eastern North America, yet many are disinclined to manage their land, or manage it beyond an occasional timber harvest. At the same time the widely publicized disappearance of three billion birds since 1970 garnered a tremendous amount of interest, demonstrating that people are genuinely concerned and looking for solutions. Many of these rapidly declining bird species are disturbance-dependent. To encourage landowners to create the habitat needed for the conservation of declining birds a Forestry for the Birds program was developed for Indiana and the Central Hardwoods Bird Conservation Region. Twelve birds in decline were selected for conservation action. The communications toolbox included: 1) a pocket guide for landowners that identifies these birds and illustrates specific forestry practices they need, 2) a technical guide for professional foresters and wildlife managers, 3) a series of bird management profiles published in a state-wide newsletter for private forest landowners (circulation 30,000), and 4) a short, professionally produced online film for landowners encouraging them to consider managing for birds. As wildlife ranks as increasingly important to landowners as a reason for owning land, the rollout of this program generated interest from consultants, landowners, and bird conservation organizations. Though first developed and tested in Vermont, this program in Indiana demonstrated the versatility of the original ideas and their ease of replication elsewhere.

**Analysis of the City of Ann Arbor's Ecological Survey Data: Translating Community Science to Inform Land Management**

*Troy Tofil, University of Michigan SEAS*

The resilience of natural areas within urbanized ecosystems is increasingly challenged by a nexus of stressors, including

invasive species, habitat loss and fragmentation, and pollution, all intensified under the advancing pressures of climate change. Despite these threats, small and urban natural areas can provide valuable biodiversity refuges and promote an environmental ethic and interest in stewardship in the community. The City of Ann Arbor's Natural Area Preservation (NAP) division in southeast Michigan has amassed three decades worth of ecological survey data through volunteer-based community science initiatives aimed at understanding the diversity of herpetofauna, lepidopterans, and avian species within its natural areas. Along with my team members, Jana Hustedt and Ludo Behrendt, we utilized this extensive dataset to identify long-term biodiversity trends, evaluate the impact of current management practices, and discern the influence of climate variables on the city's natural area fauna. We aim not only to bolster NAP's adaptive management practices but also to inform the value and management of small natural areas management in urbanized settings generally.

Specifically, we analyzed 30 years of bird, herp (frogs, toads, and salamanders), and butterfly occurrence data across more than 550 acres of natural areas distributed throughout the city to: (1) identify spatial and temporal trends in species richness, abundance, and community composition related to habitat characteristics such as size, location, and type; (2) assess the impacts of specific management interventions, including invasive species control and prescribed burns, on wildlife populations over time; and (3) correlate long-term climate data with biodiversity metrics to evaluate the potential resilience of local ecosystems to climate change. By integrating these analyses, we aim to uncover the direct and indirect effects of site characteristics and local management actions within the scope of broader climatic trends.

NAP's dataset serves as a valuable case study of the power of long-term ecological data to inform sustainable peri-urban biodiversity conservation and underscores the critical role community science can play in adaptive management. Our findings are useful for conservation practitioners, city planners, and communities that preserve biodiversity in increasingly urbanized and changing landscapes.

**Seed Collection and Production - A National Park Service Perspective**

*Katie VinZant, Native Plant Materials Coordinator, National Park Service*

The U.S. National Park Service (NPS) currently manages over 60 park units in the Midwest. NPS management policy directs the service to manage in such a way that ecological processes are maintained including the natural abundance, diversity, and genetic integrity of plant populations and species native to the park ecosystems. For restoration activities this includes the use of seeds collected from populations as closely related genetically and ecologically as possible to park populations. With substantial acreages in need of restoration, the NPS has begun to identify priority native species and quantities of seed to collect/produce/clean/store. NPS is currently developing streamlined contracting and agreement mechanisms to enhance the availability and production of native seed to ultimately achieve more restoration acreage on the ground. In addition, NPS is increasing coordination with other agencies and partner organizations to enhance seed availability by participating in the Seeds of Success program, pursuing multi-agency and partner seed collection crews, and identifying shared seed production, cleaning, and storage needs and facilities.

**Managing Excessively Grass-Dominated Prairie to Promote Forbs**

*Andrew Kaul, Restoration Scientist, Missouri Botanical Garden*
*Co-authors: Matthew A. Albrecht, Brad Delfeld, Cal Maginel*

Reconstructed prairies often become excessively dominated by warm-season grasses, leading to decreased forb diversity and abundance. However, few studies have tested whether different combinations of management treatments can favor forb recruitment while also minimizing invasion by non-native species. We initiated an experiment in 2021 to test how three management interventions, including 1) herbicide application, 2) seed additions of 25 forbs, or 3) mowing, affect the plant species diversity, forb abundance, and non-native species abundance in a reconstructed prairie in Missouri. Our herbicide treatments included glyphosate (broad spectrum), fusillade (graminicide), or no herbicide (control). After two years of monitoring our $2 \times 2$ m plots, across herbicide treatments, seed additions were successful in increasing the number of plant species (mean 74% higher; 4.6 species), especially for forbs (mean 53% higher; 4.3 species), and this effect was most pronounced when combined with mowing after seeding. Without seed additions, fusillade slightly decreased the number of species present. Plots that received glyphosate had a similar number of species as control plots, however they were also much more highly invaded by non-native species than plots with fusillade or no herbicide. All treatments were successful in increasing the relative abundance of forbs compared to the plots with no intervention. Overall, our early results indicate that using fusillade in combination with seed additions and mowing increased forb abundance and diversity compared to controls, while also avoiding invasion. Future work will need to identify the optimal application rates and timing of herbicide application for graminicide use as a prairie management strategy over larger spatial scales.

**Giving Wetlands in the Ozarks Their Due: Establishing a Karst Fen Ecological Site Description**

*Frank Nelson, Wetland Systems Manager, Missouri Dept. of Conservation*

*Co-authors: Kyle Steele, Justin Thomas*

Fens are unique wetlands because of their consistently saturated soils fed by diffuse groundwater discharge. While many fens in North America are found in the Northern Peatlands, these small, isolated wetlands can also be found in unglaciated, karst landscapes. In 2020, a collaborative effort between Missouri Department of Conservation, Mark Twain National Forest, and the nonprofit NatureCITE began surveying geology, soils, and plants at 30 different karst fen sites in the

Ozark Highlands of Missouri to collect reference criteria. The combination of this field data and integration from peer-reviewed literature informed the establishment of a new ecological site description (ESD) for these unique habitats.

Karst fens are another byproduct of the highly weathered and fractured geology of the Ozark Highlands of Missouri and Arkansas that is also known for its sinkholes, losing streams, caves, and springs. The diffuse groundwater discharge that feed and keep the soils saturated in fens is just another feature of this karst landscape. These wetlands occur on many different landforms but are commonly found in the upper reaches of the watershed, at the base of steep slopes or the upper portion of abandoned floodplains (terraces). This tendency is why fens are sometimes referred to as 'slope wetlands.' Consequently, due to the variable landscape position the soils of karst fens are also variable. However, all karst fen soils have two distinct characteristics. First, they have a thick, dark-colored surface horizon and, second, the subsurface horizons are iron-depleted and gray-colored. Along with these hydric soil characteristics, a high concentration of calcium from the adjacent geology, and low nutrients from the constant flushing of water shapes the unique flora of high-quality sites. Although the Ozark Highlands are rugged there is a long history of land use, thereby influencing the geochemical processes that control the condition and quality of existing karst fens. Establishing an ESD has outlined the ecological framework in which to evaluate the various ecological states, degrees of degradation, and potential steps to improve karst fens through protection, management, and/or restoration. Despite a long history of being overlooked and undervalued, this collaborative effort has given karst fens in the Ozarks their due and a way forward in conserving these unique wetland habitats into the future.

**Modeling Conservation Opportunity Areas for Species of Greatest Conservation Need and Priority Habitats in Texas**

*Jennifer Marrugo, Ecologist, Texas Parks and Wildlife Department*

Identifying the location of priority habitats is essential for wildlife conservation and management. State Wildlife Action Plans (SWAP) require information on species' distribution, descriptions of locations and conditions of key habitats and community types, and proposed conservation actions of priority habitats for species of greatest conservation need (SGCN). To support the upcoming update to the Texas SWAP, a spatial model depicting conservation opportunity areas based on SGCN habitats is underway. The model is a mix of inductive and deductive modelling efforts, using input from species experts and available distribution models to create an ecological index identifying high value areas on the landscape based on priority SGCN habitats. The ecological index will then be prioritized using Zonation software to add non-terrestrial inputs and threats that can be spatially defined. A connectivity analysis will also be conducted between habitats and to existing public lands and natural areas to support potential land acquisition efforts. Expected to be publicly available in 2025, the model will provide a decision support tool to help conservation practitioners prioritize acquisitions and actions, inform land managers of which SGCN species could benefit from management and provide insight to private landowners to the surrounding priority habitats.

**Analyzing True Bug (Heteroptera)–Plant Interactions**

*Angella Moorehouse, Natural Areas Preservation Specialist, Illinois Nature Preserves Commission*

The use of mutualistic network analysis has largely focused on pollinators, given their important role in facilitating plant reproduction, foundational to sustaining terrestrial biodiversity and crop production. Apart from pollinators, other flower-visiting insects could provide incidental yet overlooked pollination services. The interactions between true bugs (Suborder Heteroptera) and floral resources are rarely studied, despite many species exhibiting a relationship to pollen or nectar of specific flowering plants. These data insufficiencies also hamper long-term population trend assessments for many insect species, hindering the understanding of species-specific habitat requirements and dietary niches. To address these knowledge gaps, the objective of this study was to understand how floral resources support other flower-visiting insects by examining Heteroptera-plant networks across 12 Illinois Nature Preserves in west-central Illinois. In 2023, a long-term project to photo document associations between insects and flowers was revised to utilize voice recording data collection to record each observed interaction. A total of 299 interactions between 30 Heteropteran species and 55 flowering plants were observed at 6 protected natural areas. The project will continue 2024, with a different set of 6 sites. All the sites are protected by the Illinois Nature Preserves System and managed to maintain high-quality vegetative communities. These data will be analyzed using bipartite networks and modularity analyses to predict how resilient the community is to secondary extinctions and rank species' importance within the network through degrees of specialization, evenness, network connectivity and complexity, pollinator importance, and species resiliency. While Heteropterans initially appear to have a much higher number of generalist species and are likely more resilient to landscape-scale changes, network analyses may elucidate complex pollen/nectar usage patterns by Heteropteran species. True bugs often serve many roles within the ecosystem with a varied diet of prey insects, carrion, scat, and plant juices, in addition to pollen. Determining the network properties between Heteropterans and flowering plants may help us to understand the complexity of other flower-visiting insects and their relationship to high-quality vegetative communities.

**Identifying and Prioritizing Plants of One Known Occurrence for Conservation Action**

*Wesley Knapp, Chief Botanist, NatureServe*

Our new geologic era requires modern approaches for preventing extinction events. Previous work on plant extinctions in the United States and Canada discovered that 64% were single-site endemics (Knapp et al. 2021). This agrees with a recent global analysis of plant extinctions that showed taxa from

one area/or with extremely limited geographic ranges is the most common trait shared for all extinct plants (Humphreys et al. 2020). Current methodologies used by the International Union for the Conservation of Nature (IUCN) and NatureServe do not explicitly identify or prioritize taxa of One Known Occurrence (OKO) for conservation action. NatureServe has assessed the entire flora of the United States and Canada. Of these assessments, ca. 1250 taxa are given the highest assessment rank, G1 - Critically Imperiled with Extinction. Given the lack of funding available for plant conservation, it is obvious additional prioritizations are needed to meaningly prevent extinctions. In situ and ex situ conservation methods should be employed for all OKO plants if such actions haven't already occurred. This analysis included the entire United States and Canada, with Laukahi, the Hawai'ian plant conservation network leading the Hawai'i analysis. Our results show the need to prioritize OKO plants for immediate conservation action. We will discuss the two major categories of OKO plants, single-site endemics (SSEs) and plants of One Remaining Occurrence (OROs). Each site supporting an OKO supports an irreplicable component of biodiversity. These locations warrant Key Biodiversity Area and Important Plant Area evaluation.

**Fire and *Carex* Recruitment in Oak-Hickory Woodlands**

*Kevin Tungesvick, Senior Ecologist, Eco Logic LLC*

Oak-hickory woodlands in the eastern Midwest typically have inadequate recruitment of oak and hickory saplings to regenerate these trees in the canopy. Fire suppression and the resulting high density of mesic species in the sapling and mid-canopy layer create insufficient light levels for recruitment of oaks and hickories. To remedy this situation, woodland stewards have introduced prescribed fire to restore the fire tolerant oak-hickory association. While the effects of prescribed fire on tree regeneration in woodlands have been studied in various locations around the Midwest, there has been relatively little monitoring of the herbaceous understory in these woodlands, particularly in complex genera such as *Carex* (sedges).

We monitored the effects of the introduction of prescribed fire on both the woody understory and the herbaceous layer in mature dry mesic oak-hickory woodlands in the Laura Hare Preserve at Blossom Hollow in southern Johnson County Indiana owned by the Central Indiana Land Trust. The study consisted of monitoring six transects including two controls outside the burn unit and four transects inside the burn unit. While the effects of fire on the woody sapling and mid-canopy layer were rather predictable and in line with other studies, the effects on the community of woodland sedges included heavy recruitment from the seedbank and variable effects on established plants.

We collected baseline data in 2018, prior to the treatment of prescribed fire in November 2020. We repeated data collection in 2021, 2022 and 2023. The ten *Carex* species present in the monitoring quadrats represented very conservative taxa with a mean C of 7. Recruitment from the seed bank resulted in the frequency of sedges in the treatment transects increasing from 29 crowns in 2018 to 571 crowns in 2021. Mortality of this generation drove the frequency down to 229 crowns in 2022 and 188 crowns in 2023. However, the baseline percent cover of 4.083% in 2018 briefly fell to 3.5% in 2021 but then steadily increased to 5.833% in 2022 and 7.583% in 2023 as the new generation of sedges matured. The monitoring revealed that a single prescribed fire resulted in a significant cohort of Carex seedlings that matured to nearly double the percent cover that existed prior to the treatment. The effects of the prescribed fire on established *Carex* plants varied by species. While most species showed little change in coverage of existing plants, one common species showed a substantial decline in coverage following treatment. This ongoing study underscores the need for further monitoring of herbaceous communities in oak-hickory woodlands undergoing restoration practices including prescribed fire.

**Saving the Saline River: Watershed-Scale Conservation at the Arkansas Natural Heritage Commission**

*Dustin Lynch, Chief of Research, AR Natural Heritage Commission*

*Co-authors: Katie Morris, Ryan Spotts, Bill Holimon*

The Saline River is an exceptionally biodiverse watershed that is also one of the only undammed rivers of substantial length remaining in the state of Arkansas. Flowing through two of the state's major ecoregions, the Saline and its major tributaries are home to 73 documented species of concern, while the watershed as a whole is home to 215 species of concern. This includes more than a dozen species that are federally listed as endangered or threatened or proposed for federal listing under the Endangered Species Act. Many rare species of mussels, fish, crayfish, amphibians, and other aquatic species depend on protection of the watershed.

The Arkansas Natural Heritage Commission (ANHC) has worked to conserve the Saline River and the rare species that live there through acquisition of natural areas protecting nearly 12 miles of river frontage on the main-stem and along major tributaries, areas that are home to critical habitat for rare species. This includes extensive and highly diverse mussel beds. ANHC Natural Areas within the Saline River watershed include Longview Saline Natural Area (6,028 acres), Goat's Beard Bluff Natural Area (540 acres), Alum Fork Natural Area (520 acres), and Middle Fork Barrens Natural Area (206 acres).

As important as these acquisition and management efforts have been, the conservation of riverine species and ecosystems presents unique challenges due to the interconnected nature and dynamic qualities of rivers. A watershed-scale approach is warranted that may go beyond land acquisition. Watershed-wide partnerships, inter-agency survey efforts, outreach to private landowners, environmental review, and strategic planning of responsible development within the watershed are important strategies that ANHC and its partners employ to protect the incredible natural resource that is the Saline River.

***Microstegium vimineum* Control at Crow's Nest Natural Area Preserve: A Success Story**

*Michael Lott, Northern Region Steward, VA Department of Conservation and Recreation*

*Microstegium vimineum* (Japanese stilt grass) is an invasive annual grass in the eastern half of the United States where it can

form dense monocultures in forest understories, potentially displacing native species. This presentation focuses on control efforts at Crow's Nest Natural Area Preserve in Stafford County, Virginia. This preserve is owned and managed by the Virginia Department of Conservation and Recreation and protects one of the largest contiguous occurrences of mature hardwood forests remaining in the coastal plain of Virginia. In 2012, when invasive species were first mapped at Crow's Nest Natural Area Preserve, *Microstegium* infested over 15 miles of old forest roads and adjacent forested areas. In fact, the percent cover of *Microstegium* exceeded 70% in extensive areas. This extensive spread across the landscape was exacerbated by past land uses activities, including the use of off-road vehicles for hunting and recreation. Treatment of *Microstegium* has largely been accomplished with a low concentration solution of glyphosate (0.5%). Small patches are frequently removed by hand. After 12 years of effort, a dramatic decease in the amount of *Microstegium* is seen across the upland plant communities at Crow's Nest. In many areas a greater than 80% reduction in coverage has been measured. In addition, the amount of herbicide has declined from approximately 200 gallons per linear mile in 2013 to approximately 60 gallons in 2023. It should also be noted that amount used to treat *Microstegium* is even less than the 60 gallons since a greater percentage of the tank mix is now used to treat additional invasive species (e.g., *Perilla frutescens*). Although many land stewards have given up control of *Microstegium* (largely due to limited resources), the results of 12 years of control efforts at Crow's Nest suggest that with the necessary resources the coverage of this aggressive invader can be significantly reduced, thus minimizing the ecological impacts on the local landscape. In support of this, an increase in native vegetation, particularly spring ephemerals, has been observed in areas previously treated for *Microstegium*.

**Intra- and Inter-annual Changes in Soil Health with Native Plant Monocultures**

*Bret Lang, South Dakota State University*

Ecosystems require healthy soil to be productive. Soil provides plants with structural support, water, nutrients, and the microbial relationships needed for biomass production and reproduction. Conventional agriculture practices degrade soil health; however, small plots of native plants grown within agricultural settings have been shown to provide disproportionally large benefits to both ecological and agricultural landscapes (e.g., Prairie STRIPS), meaning even small plots of native plants can greatly impact ecosystem service availability within agricultural landscapes. Although small plots of mixed native plant species improve soil health, they offer little in the way of income benefits for producers. However, native monoculture plots may offer producers an opportunity to harvest and sell seeds, taking advantage of the increasing demands of the native seed market while also improving soil health. The goal of this study is to quantify the effects of small plots of native monocultures on soil health indicators and compare them to soil from conventional crop plots. We investigated abiotic soil health indicators such as nutrient composition as well as biological indicators of soil health such as organic carbon, microbial communities, and microbial enzyme indicators. We hypothesize that, compared to crop plots, native plant monoculture plots will have higher microbial diversity and higher amounts of soil nutrients. We tested our hypothesis by comparing soil health characteristics from plots containing five established native monocultures: *Dalea candida*, *Agastache nepetoides*, *Glycyrrhiza lepidota*, *Liatris ligulistylis*, and *Tradescantia occidentalis*; and one crop plot planted with a corn and soybean rotation. During the third season of growth, monthly soil samples were taken from each plot and sent to a lab for nutrient analysis and a phospholipid fatty acid (PLFA) test. Soil indicator values were compared using Tukey's HSD post hoc tests after performing an analysis of variance (ANOVA).

Our results suggest that native plant species influenced soil health differently than crop rotations after three seasons of growth. Compared to crop plots, soil samples from two species of native plants, *Agastache nepetoides* and *Tradescantia occidentalis*, had higher fungi-to-bacteria ratios ($p = 0.0160$ and $p < 0.0001$, respectively), and higher amounts of saprophyte biomass ($p = 0.0040$ and $p = 0.0484$, respectively). Soils from the *Agastache nepetoides* plots also had higher amounts of Pre18 cyclo fatty acids ($p = 0.0022$) and potassium ($p = 0.0159$). These two species of native plants show potential for improving soil health after three years of establishment. Adding these two native monocultures to marginal, conventional croplands may add soil health benefits during early establishment periods while also providing a marketable crop for producers.

**Assessing Arbuscular Mycorrhizal Fungal Community Diversity in Eastern Washington's Prairie Ecosystems**

*Katherine Cole, Masters Student, Eastern Washington University*

Arbuscular mycorrhizal fungi (AMF), belonging to the phylum Glomeromycota, are key to healthy, functioning terrestrial ecosystems worldwide. Associating with over 80% of all extant land plants, they play a pivotal role in nutrient cycling, contribute to overall plant health, and impact the structure and function of native plant communities. Given their significance to terrestrial ecosystems, AMF have a crucial role to play in the successful restoration of Eastern Washington's native prairies. However, AMF community composition is significantly altered by the commercial agricultural practices used extensively in this region for over 100 years. The Eastern Washington University (EWU) Prairie Restoration Project aims to restore ~120 acres of farmland to native prairie. This study will use high throughput DNA sequencing to compare AMF communities across four distinct prairie land-use types: remnant native prairies (RNP), Conservation Reserve Program (CRP) lands, conventional-till farmland (CTF), and no-till farmland (NTF). We hypothesize that remnant native prairies will have the highest AMF diversity and conventional-till farmland will have the lowest, with CRPs and no-till farmland falling somewhere in the middle. To test this hypothesis, soil samples will be collected from 6–8 sites per each land-use type. Fungal DNA will be extracted from the soil

and amplified using the AMF-specific primer pair NS31-AML2, which targets segments of the small subunit ribosomal RNA (SSU rRNA) that is highly specific to AMF. Amplicons will be sequenced using Illumina MiSeq 250bp paired-end sequencing, and the resulting data will be analyzed using established bioinformatics pipelines and rStudio. This work will support the EWU prairie restoration project by gaining a better understanding of the diversity of native prairie AMF communities and highlighting their importance to healthy prairie ecosystems.

**Role of Plant Diversity and Soil Microbiome in Steering Tallgrass Prairie Ecosystem Services**

*Eric Duell, Postdoctoral Fellow, Kansas Biological Survey & Center for Ecological Research*

*Co-authors: Laura Y. Podzikowski, James D. Bever*

Grasslands are the most widespread, as well as one of the most threatened, terrestrial ecosystems. Grasslands provide a suite of key ecosystem goods and services, many of which are threatened as a result to loss of grassland cover. The loss of grasslands across the globe, coupled with their importance in providing ecosystem goods and services, has fueled a growing interest in the role of grassland biodiversity in maintaining these processes. The overarching goal of this research was to assess the biodiversity–productivity relationship of tallgrass prairie plant communities, and how this relationship is influenced, and if so, to what degree, by the soil microbiome. Additionally, we assessed the relative influence of plant species richness, diversity, and phylogenetic dispersion on soil aggregate stability and carbon storage. Using plots established in 2018 at the University of Kansas Field Research Station, we tested the effects of plant community structure and microbial community assemblages on carbon storage and other soil measurements that are important for soil health, such as soil aggregate stability and microbial abundances. In 2018, plots were planted to one of five species richness treatments (1, 2, 3, 6, or 18), with species assemblages represented by either phylogenetic under- (single taxonomic family) or overdispersion (2 or 3 families). Taxonomic families used in the experiment were Asteraceae, Poaceae, and Fabaceae, representing the three most common families in tallgrass prairie plant communities. Additionally, plots were inoculated with one of three soil inocula: 1) lab-cultured AM fungal propagules, 2) whole prairie soil containing the full suite of soil microbiota, and 3) sterile prairie soil. For the past five years (2018–2022), plots were visited monthly across the growing season (April–October), during which plant cover was assessed visually. Our results indicate that plant phylogenetic dispersion tended to increase productivity, which supports previous research. Productivity, complementarity, and net biodiversity effects were largely driven by various interactions of year, soil inoculation, species richness, and phylogenetic dispersion, highlighting the complexities of drivers of key ecosystem services. Belowground productivity was most strongly influenced by plant family, with plots communities made up of by grasses producing significantly greater belowground biomass compared to composites, legumes, and mixed-family communities. Additionally, AM fungal abundances and soil aggregate stability were significantly greater in plots with greater plant species richness and phylogenetic diversity. These results suggest that plant community dynamics, such as richness and phylogenetic diversity, soil microbial communities, and time interact to facilitate observed biodiversity–productivity relationships, and that these relationship also facilitate key soil-related ecosystem services.

**Effects of Bison and Cattle Grazing on Milkweeds and Monarch Butterflies**

*Grace Thomas, Master's Student, University of Nebraska at Omaha*

Monarch butterflies have experienced massive population declines and are being considered for listing under the US Endangered Species Act. This has inspired conservation efforts to mitigate these declines. One of the primary conservation efforts has been to try to increase milkweed (*Asclepias* spp.) abundance. Milkweeds are the required host plant for monarch caterpillars, and the spread of row-crop agricultural lands has contributed to the deterioration of milkweeds. Previous research by my advisor, Timothy Dickson, indicates that cattle grazing dramatically decreases milkweed abundance, which is important because 34% of the continental USA is grazed by livestock, primarily cattle. However, bison grazing, which occurs on many conservation sites and some beef production sites, may have less adverse effect on milkweed than cattle grazing. In 2023, I compared and quantified the impact of grazing on milkweed densities and juvenile monarch abundances in bison-grazed, cattle-grazed, and ungrazed lands. One interesting finding from my 2023 field data was that monarch oviposition was more common on sand milkweed than eight other milkweed species (2,681 milkweeds surveyed). Even though sand milkweed is the most abundant milkweed species in the Sandhills, these milkweeds have yet to be studied for monarch oviposition in the northern US. Currently, I am studying whether sand milkweed may be crucial for monarch conservation in the Nebraska Sandhills.

**Seven Years After Native Mycorrhizal Fungal Addition in Tallgrass Prairie Restoration; Diversity, Bugs, and Non-natives**

*Elizabeth Koziol, Assistant Research Professor, University of Kansas*

Restoring plant communities to their full diversity and function is challenging. Recent research highlights the crucial role of soil microorganisms, especially in the tallgrass prairies of the Midwestern United States. Microbial products are an emerging technology that land managers can use to meet plant establishment goals, and potentially, limit management effort. Over multiple experiments, we've found that native arbuscular mycorrhizal (AM) fungi applications significantly enhance prairie plant growth and establishment compared to fungi from disturbed soils or commercial sources. However, the methods for distributing native inocula into restoration sites need refinement, and long-term effects are not well understood. To

address these gaps, we revisited two tallgrass prairie restorations to study the persistence of native mycorrhizal amendments seven and eight years after microbial application.

In the first study, plots were inoculated via nurse plants inoculated with whole soil, native AM fungi, or non-inoculated. Both native mycorrhizae and whole soil improved seedling establishment. At the end of the third growing season, AM fungi inoculated plots had the fewest non-native plants and the greatest plant community diversity. In year 8, we assessed these plots for invertebrate diversity and found inoculation affects plant establishment, which in turn affects invertebrate composition.

The second study assessed the response of a restored tallgrass prairie to an inoculation density gradient of native mycorrhizal fungi ranging from 0 to 8192 kg/ha. Positive effects observed in the first year persisted, with increased total and native plant diversity and decreased non-native species abundance. Even low initial densities of mycorrhizal amendments showed benefits by reducing non-native species abundance by the fourth year, indicating a potential for amplification through positive plant–fungal feedback. Moreover, in the 7th year, neighboring non-seeded plots were assessed. Native fungi amendment improved native plants diversity and decreased the presence of non-native species in neighboring unseeded plots. This suggests that native fungal amendment helped native seeds spread more effectively into neighboring areas.

In conclusion, providing restorations with the native microbiome components, particularly AM fungi, can improve restoration success both in the short and long-term.

**Improving Grassland Fire Science - Training Researchers in Methods for Quantifying Weather, Fuels, and Fire Intensity**

*Craig Maier, Coordinator, Tallgrass Prairie and Oak Savanna Fire Science Consortium*

*Co-authors: Devan Allen McGranahan, Ryan Gauger, Chris Woodson, Carissa L. Wonkka*

In the tallgrass prairie region, fire ecology research often lacks critical details about vegetation (fuel load), environmental conditions during prescribed fires, and fire intensity. Treating fire as a categorical variable (for example: burned vs unburned; fire frequency; seasonality) has been important for revealing general patterns, but quantitative methods are needed to improve understanding of the role of fire in these ecosystems and to produce research that can inform the goals of prescribed fire programs and prescribed fire objectives. Despite the documented need for quantitative fire ecology methods, there are an array of challenges to implementing intensive, field-based, fire ecology methods training at colleges and universities to teach these skills at the graduate level. The Hands-On Fire Science Workshop offers a model for collaboration among extension, science, and management entities to meet this need, and to serve practitioners as well as researchers. We report on three iterations of the Hands-On Fire Science Workshop held in the Central Tallgrass Prairie ecoregion. The workshop is based on the Prescribed Fire Training Exchange (TREX) model. Fire science modules incorporated teaching and practice in methods to quantify fuels (fuel moisture and fuel load), environmental conditions (fire weather), and fire behavior and intensity (for example, rate of spread and temperature). Prescribed fire operations training facilitated both hands-on learning and vicarious learning. Participants in the workshop have included graduate students, post-docs, and early career professionals, with land managers representing tribal governments, federal and state agencies, and NGOs. The collaboration has contributed to meeting the host organization's prescribed fire goals, and evaluation data demonstrates that participants are learning methods and skills that can be applied to fire management questions in the region.

**Plant Intraspecific Trait Variation across Environmental Gradients: Identifying Potential Sources of Climate Adaptation**

*Jack Sytsma, Graduate Research Assistant, Kansas State University, Dept. of Biology*

Grasslands were once expansive in the US but today less than 4% remains primarily due to conversion to agriculture. The remaining grasslands are threatened by predicted drought and warming. Understanding grassland species' responses to climate is therefore important for future sustainability of this ecosystem. Within species, plants differ in their ability to respond to changing environmental conditions, and identifying trait variation among populations within their range may be key to mitigating climate change. Here, we characterize climate adaptation using the dominant prairie grass, *Andropogon gerardi* (big bluestem), distributed across BioNorth America. We aimed to measure the performance of *A. gerardi*, quantify trait variation across its range, and assess population-level genetic diversity of *A. gerardi*, especially in dry and wet margins of its range where *A. gerardi* is already experiencing climatic extremes. We sampled 26 populations of *A. gerardi* from Colorado to North Carolina (325–1400 mm/yr rainfall) and Texas to Minnesota (4–21°C mean annual temperature). At each site, we measured morphological (height, blade width, canopy diameter, leaf thickness, and biomass) and physiological traits (photosynthetic rates, midday water potential, and chlorophyl absorbance). We assessed *A. gerardi* abundance and local plant diversity, and sampled tissues for genotyping. We hypothesized 1. that plants from dry sites would demonstrate drought tolerance traits (e.g., more negative water potential and dwarfed morphology) but at wetter sites, we expected higher levels of traits involved in greater competition and light capture (greater height and biomass). 2. We expected *A. gerardi* cover to be the highest in the center of its range and decline towards the margins. Populations in the range core should have lowest trait variation but margin populations should vary more since these sites experience climatic extremes. 3. Genetic diversity should be highest in the range core where *A. gerardi* is most abundant. All traits responded to precipitation but showed weak to no response to temperature. Plant height and diameter, and leaf width increased with rainfall. At drier western and southern ranges, plants had high photosynthetic rates, more favorable water balance, thick leaves, and short stature. Plants outside the

range core showed highest variation and may best adapt to changing environments. This project provides insights into plant function in different climate scenarios and is amongst the most expansive studies of this widespread prairie grass. To mitigate the impacts of future drought, grassland restoration could utilize source populations from arid sites which may be better matched to predicted future climate.

**Long-Term Effects of Prescribed Thinning + Fire, and White-Tailed Deer Exclusion, on Woodland Species Composition**

*Rebecca Carden, PhD student, University of Texas at Austin*

*Co-authors: Christina M. Andruk, Lee Kaplan, Carl Schwope, James M. Mueller, Scott Rowin, Norma L. Fowler*

Oak species are failing to regenerate across much of the United States, including in central Texas. This failure is characterized by a shortage of mid-sized oaks where mature oaks are common, and has been ascribed to (1) widespread fire suppression, which favors more fire-sensitive competitors over oaks, and (2) browsing by over-abundant white-tailed deer. Little is known about which of these two factors is more important, and how their effects may interact.

In central Texas, fire-tolerant Texas red oak saplings are rare, while fire-sensitive Ashe juniper saplings are common. White-tailed deer commonly browse Texas red oaks but rarely browse juniper. Oak regeneration failure is of particular conservation concern in this region because the endangered golden-cheeked warbler requires mature oaks in its habitat.

We compared the long-term effects of two treatments on woodland species composition in these woodlands: selective thinning of Ashe juniper saplings followed by prescribed burning (the 'burn' treatment), imposed factorially with deer exclusion (the 'fence' treatment). We monitored the plots 11 years after treatment implementation. In unburned plots, mature Texas red oak trees that died had been replaced in the canopy by Ashe juniper. In burned plots, Ashe juniper sapling density remained low 11 years after thinning and few had been recruited to the canopy. In the burned–unfenced plots (with deer), hardwood saplings were also rare, presumably due to deer browsing. In contrast, independent Texas red oak saplings, apparently recruited from acorns, were most abundant in the burned–fenced plots (no deer) compared to all other treatments. Saplings of possumhaw, an understory shrub, were also highly abundant in the burned–fenced plots.

We conclude that in the absence of fire, woodland canopies became more dominated by mature Ashe juniper. Within the burned treatments, however, deer access determined woodland trajectories. In particular, recruitment of Texas red oak and other hardwoods required protection from deer in addition to thinning and/or fire. We also note that the combined treatments had the effect of encouraging hardwoods other than oak species, which may compete with oaks. Our results can be used to guide sustainable management of oak-Ashe juniper woodlands for golden-cheeked warbler habitat in central Texas, and may have applications for increasing oak regeneration elsewhere as well.

**Habitat Indicators Allow for Everyone to Participate: Monitoring Natural Areas with Finite Resources**

*Kari Horn, Natural Resource Manager, Great Parks of Hamilton County*

*Co-authors: Daniel Kovar, Jessica Spencer*

A county park district located in the southwest corner of Ohio, Great Parks stewards over 18,000 acres of land, with a policy in place to ensure that 80% of it remains undeveloped. At Great Parks, we rely heavily on volunteers for maintaining the lands we steward and carrying out educational and recreational events. Our team of biologists and specialists are responsible for prioritizing, guiding, and supporting land management activities to preserve biodiversity and conserve natural areas. Citizen science has been built in to how we do this in some ways, such as the annual Winter Bird Count, a long-running bird nest box monitoring program, and presence/absence surveys for multiple taxa. In 2021, our Natural Resource Management Plan was adopted, and we began brainstorming ways to expand our natural areas monitoring program, especially in more 'back-of-house' areas designated as high-quality natural areas. With finite staff and resources, our team began to apply the notion of citizen science to our park managers and their teams of technicians, who have a range of formal training in biology and environmental science. We developed a monitoring program that could be carried out by a person of any background after a field demonstration with the assistance of a printed protocol, species identification sheet, and a mobile app developed in-house. We targeted high-quality forests and asked park teams to collect data on easily observed habitat indicators during the spring season. Our questions were: Do the natural areas ranked highest in our system by aging data still contain characteristics of high-quality natural areas? What land management actions are needed to maintain or improve these natural areas? After three years of monitoring, we found that areas noted as high quality through our data and monitored in the spring using the mobile app were correlated with a higher monitoring score found by our park teams. In other words, we were able to confirm that the high-quality areas we designated with data in our system remained high quality as compared to other locations. In addition, with the capabilities we built into mobile app, our teams were able to note, document, and return to these areas to manage for problems such as invasive plant species and human disturbance. This monitoring approach has allowed us to rapidly assess the state of high-quality natural areas, identify potential problems quickly, and assist with training and engaging our diverse team of park managers and technicians in natural resource management.

**Leveling Up and Leveling Down: How Municipal Planning Addresses Biodiversity**

*Jessica Hardesty Norris, Biohabitats*

In recent years, understanding of the biodiversity crisis has permeated all levels of government, and local municipalities are increasingly asking for support in providing habitat uplift in land-planning decisions. Federal and nationwide datasets provide excellent resources for prioritizing natural areas, but

these often come into conflict with local interests and politics in ways that are difficult to predict. Therefore, although the principles of land use planning for connectivity, diversity, and protection of sensitive areas are relatively simple and universal, the tools available to county and municipal governments are not commonly understood nor widely disseminated, in part because of sensitivities on the part of the public. In support of this effort, the field of ecological restoration sometimes attempts to extrapolate and synthesize results of small, controlled experiments and restoration projects to explain the value of land use planning for biodiversity. While the potential benefits of such shared knowledge are great, translating results available in the scientific literature to local situations and decision-makers can be challenging.

Restoration planning practitioners from Biohabitats will share insights on providing the best data-driven biodiversity planning information for local, small to mid-scale comprehensive, open-space, and land-use planning and implementation projects across the country, including stream, wetland, forest, urban, arid, and prairie systems. We will share lessons learned on model ordinance, peer-to-peer technical exchanges, and trace some examples of how planning ideas were translated to local regulatory language.

**Untangling Biotic and Abiotic Factors that Structure Prairie Pimple Mound Plant Communities**

*Ben Benton, Botanist, Arkansas Natural Heritage Commission*
*Co-authors: Corrie Frank, Brendan J. Kosnik, Grace L. McCartha, Caitlyn M. Sims, Travis D. Marsico, Scott A. Mangan*

Although many studies suggest that plant community composition is a result of competition for soil nutrients, others have shown that root-associated symbionts also regulate plant communities through plant–soil feedbacks. Few studies, however, have been designed to test the relative contribution of these two regulatory mechanisms to plant community assembly. Prairie pimple mounds (relict nebkhas) provide an ideal system to study how below-ground biotic and abiotic factors interact to affect plant communities, in part because they exhibit distinct environmental changes over small spatial scales. In this study, we 1) characterized the variation in plant and soil fungal community composition and soil abiotic properties across twenty paired pimple mound and surrounding prairie matrix sites, and 2) conducted a greenhouse experiment that tested the relative contributions of abiotic and biotic soil factors to the growth of eight plant species common to either pimple mounds or the prairie matrix. We found strong evidence that plant communities, fungal communities, and soil abiotic properties differed between pimple mounds and the surrounding prairie matrix. For example, pimple mounds had six times the available phosphorus than the prairie matrix. Collectively, nutrient compositions of mound soil were more similar to other mounds than they were to adjacent matrix plots ($R = 0.612$, $P = 0.001$). Likewise, communities on the mounds were more similar to other mound communities than they were to adjacent matrix communities for both plants ($R = 0.537$, $P < 0.001$) and fungi ($R = 0.758$, $P = 0.001$). We found strong colorations between the similarity of plant communities, fungal communities, and soil nutrients across both mound and matrix plots. However, mound plant communities were strongly correlated with soil nutrient profiles, but not with fungal communities while matrix plant communities were strongly correlated with fungal communities, but not with soil nutrient profiles. In our greenhouse study, the eight common prairie plant species were planted separately in pots containing either sterilized pimple mound or prairie matrix soil, inoculated with either soil microbial communities from live pimple mound or prairie matrix soil to measure the effect on plant biomass. We found a significant effect of soil type and inoculum type on biomass (soil: F1, 413 = 648.82, $P < 0.001$, inoculum: F2, 213 = 71.92, $P < 0.001$). These results suggest that spatial variation in prairie plant communities is driven by changes in the soil nutrient profile, either directly or indirectly through fungal communities, depending on the habitat.

**Cultivating Inclusive Stewardship: Forest Preserves' Journey with the Latine and Native American Communities**

*Raquel Garcia-Alvarez, Forest Preserves of Cook County*

Join us as we delve into lessons learned by the Forest Preserves of Cook County in their journey to engage and build trust with the Latine and Native American Communities. Through cultivating inclusive programming, the Preserves have created a welcoming space that embraces diverse cultural perspectives on connecting to and caring for the land.

A key aspect of this journey has been the emphasis on co-creating interpretive materials and policies that authentically reflect the cultural richness and ecological wisdom of Native American communities. These collaborative efforts have not only resulted in the development of meaningful partnerships but have also formalized ongoing collaboration and decision-making processes. This process transcends mere Land Acknowledgement, illustrating how it can be put into tangible action and practice.

Furthermore, recognizing the importance of linguistic and cultural inclusivity, the Forest Preserves offers programming in Spanish/Spanglish to engage the Latine community. They provide a consistent stewardship space at Possum Hollow Woods where Latine can practice Spanish, deepen their understanding of nature, and connect with their community while celebrating the outdoors together.

Through prioritizing community voices and values, the Preserves present a dynamic approach to stewardship that honors cultural heritage and promotes environmental conservation for future generations. Join us as we explore the transformative potential of partnership and mutual respect in caring for our shared natural areas.

**Fire and Grazing Management Effects on Soil Nutrient Cycling**

*Elsa Broemmelsiek, Graduate Student, Kansas State University*

The Konza Prairie Biological Station represents a remnant of tallgrass prairie that once stretched across North America from

southern Manitoba to southern Texas. The historical range of tallgrass prairie has been significantly reduced, concomitant with the near extinction of the formerly dominant grazer, the American bison (*Bison bison*), and the suppression of fire with consequent widespread woody encroachment. Today, prescribed burning and grazing are used as management techniques to maintain tallgrass prairie ecosystems, as characterized by nitrogen (N) limitation and high primary production. Generally, frequent fire decreases ecosystem N by volatilizing the N in plant matter before it can return to the soil. Grazing increases plant N availability by digesting forage N and returning it to the soil in more bioavailable forms. Burning increases root growth which, in turn, increases carbon (C) inputs into the soil. Less is known, however, about fire frequency effects, and interactions between fire frequency and grazing, on soil N availability as well as combined implications for C sequestration. Our project compares a variety of soil health metrics to learn which are most responsive to grazing and burning regimes. Specifically, we measure key aspects of C and N cycles in tallgrass prairie soils in a field experiment crossing bison grazing (grazed, ungrazed) with fire frequency (annual, every 2 years, 4 years, or >20 years), at the Konza Prairie Biological Station, embedded in remnant tallgrass prairie in the Flint Hills, Kansas, USA. We assayed bioavailable C and N in multiple ways, and also measured the relative contribution of C3 and C4 plants to certain soil carbon pools, to assess woody plant encroachment effects on soil C. Results to date show that regardless of fire frequency, grazing increased soil potentially mineralizable N ($P = 0.002$). Fire frequency affects fresh soil microbial respiration and 14-day potentially mineralizable C only in ungrazed conditions (Fire*Grazing, $P < 0.005$), such that amounts are lower and C3 (woody) plants contributed more C in infrequently burned areas. This implies that grazing mitigates some of the less desirable effects (i.e., woody encroachment) that fire suppression may have on the C cycle. Continuing work measures soil decomposition enzyme activity and microbial diversity to evaluate connections between C and N cycling function and microbial community structure. These results expand our understanding of the importance of large grazers in the tallgrass prairie ecosystem, and may help contribute to future management decisions.

**Post-Agricultural Prairie Soil Microbial Community Resilience Across the Steep Precipitation Gradient in Kansas, USA**

*Hannah Dea, Kansas State University*

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Soil microbial communities, including bacterial and fungal communities, are ubiquitous and are essential for ecosystem functions such as nitrogen fixation, carbon cycling, and decomposition making them important for assessing ecosystem resilience. The North-American Great Plains present a steep precipitation gradient with Mean Annual Precipitation (MAP) ranging from $<350$ mm $yr^{-1}$ to $>1000$ mm $yr^{-1}$ from west to east, fostering the transition from shortgrass prairies to tallgrass prairies. Precipitation is a limiting resource for plant communities and soil microbial communities, dictating much of the microbial activity. This has significant implications for soil organic carbon and soil microbial carbon, especially in the context of land use. Native, remnant prairies harbor diverse microbial communities; however, the conversion of native prairies to conventional agriculture often results in the decline in this diversity. Once a field is left to establish a prairie plant community post-agricultural use, the ecological memory —the information and materials remaining which shape an ecosystem post-disturbance—is potentially low due to the replacement of microbial taxa with those associated with agricultural and the persistence of agricultural legacies. The re-establishment of soil microbial communities requires diverse microhabitats and may be limited by microbial dispersal and available propagule banks. In this study, we aim to answer the following three questions: (1) how do soil-borne bacterial and fungal communities respond to changing MAP?; (2) does microbial response to MAP differ between land use histories (remnant native prairies, post-agricultural prairies, and fields in current agricultural use)?; and (3) what proportion of taxa are shared between the land uses? We aim to provide insight into the ecological memory, agricultural legacies, and potential dispersal limitation of bacterial and fungal communities in prairie systems post-agriculture. To accomplish this, we sampled soils from six groups of adjacent native prairie remnants, post-agricultural prairies, and agricultural fields across the steep precipitation gradient in Kansas, USA and compared the shared taxa between the land-uses. The data showed that MAP greatly influenced soil community composition, while edaphic variables were more influential than land use history. Further, a large proportion of taxa were unique to each land use, whereas only relatively few were shared among the land uses. We plan to further investigate which taxa are unique to agricultural fields and explore their putative functions.

**Soil History Constrains Grazing Effects on Microbial Diversity and Nutrient Cycling Processes Across the Great Plains**

*Lydia Zeglin, Associate Professor, Kansas State University*

Soils teem with life, most of it too small to see. These microorganisms release plant-available nutrients from soil organic matter (SOM), and can remove and retain soil carbon (C) and nitrogen (N) through their feeding, growth, and death. Like microorganisms, large ungulate grazers are an essential component of grassland ecosystem nutrient cycling, through their digestion of organic N in plant tissues and returning N to the soil in a more bioavailable form. Because many ecological studies on grassland nutrient cycling are conducted in the absence of grazers, there is a need to define the strength of grazing effects on N cycling across diverse grassland ecosystems. We collected soils from eight locations across the Flint Hills of KS and OK, and at five more sites in western KS, NE, and MN, USA, and measured SOM, microbial activity and diversity in actively and minimally grazed (bison and cattle) areas. SOM

level, thus microbial activity, depends on soil mineral chemistry, so we expected soil type to predict C-cycling activities better than grazing status. In contrast, we expected grazing to consistently increase N availability and N-cycling rates. An index of soil chemistry, pH, predicted most of the seven assayed extracellular enzyme activities, except the indicator of microbial N limitation, which was reduced on average by grazing (ANOVA: F, P = 5.7, 0.004), independent of the expected among-site variation (Site = 8.3, < 0.001, Site*Graze = 1.2, 0.28). This result reflects a broad tendency for grazing to increase available N, as expected. SOM varied widely among sites and soil orders and series, but there was no consistent effect, even in direction, of grazing on SOM concentrations (Site*Graze = 6.1, <0.0001). Variation in soil microbial composition was also explained primarily by site and soil type, but there was a small effect of grazing (PERMANOVA: R2 = 0.334, 0.155, 0.105, 0.033 for soil unit, site, site*grazing, and grazing, respectively; all P < 0.01). Beyond the strong and expected soil effect on microbial biodiversity, only a few, but identifiable, microbial taxa respond consistently to grazing. The next challenge, important for both basic and applied understanding of grassland ecosystems, is to define whether these microbial populations are reliable indicators of increased N-cycling rates across a range of locations. Differences in soil chemistry have developed over millennia, but bison have been absent from North American grasslands for only hundreds of years: Studying grasslands, with grazers present, is critical for understanding and conserving grassland biodiversity and ecosystem function globally.

**Improved Statewide Ecological Mapping System Datasets for Arkansas, Kansas, Nebraska, and Texas**

*David Diamond, Senior Ecologist, University of Missouri, Columbia*

We completed statewide 10-m resolution ecological mapping system datasets for Arkansas (123 types), Kansas (47 types), Nebraska (46 types), and Texas (364 types). A total of 68 different types were identified for the adjacent states of Kansas and Nebraska. These maps have nine times better spatial resolution and better thematic resolution and accuracy versus other available maps. The better capture of features such as narrow wooded loess hill canyons, eastern redcedar (*Juniperus virginiana*) versus shortleaf pine (*Pinus echinada*) communities, coastal lomas, Texas live oak (*Quercus fusiformis*) woodlands and shrublands, and both herbaceous and forested wetland communities will aid in conservation planning and management. Key aspects of methods included partnering with state fish and game agencies as project leads, collection of more than 12,000 quantitative virtual ground plots by botanists to support mapping, use of multiple dates of 10-m resolution Sentinel 2a and 2b imagery for landcover classification, and development of fine-resolution geophysical setting information from digital soils maps and processing of digital elevation models. We will summarize key aspects of new technologies used to produce the maps and highlight improved mapping of several ecological systems of conservation concern.

**'Phenobvious' Traits: Integrating Phenology and Community Science to Advance Invasive Species Management**

*Lea Johnson, Associate Director, Land Stewardship and Ecology, Longwood Gardens*

*Co-authors: Kristie Lane Anderson, Evan Horne*

Non-native invasive plants are a major challenge to biodiversity. Protecting and restoring native communities under invasive plant pressure requires species-specific approaches to invasive species management, including attention to timing of plant life cycles. Mapping invasive species populations is essential to adaptive management prioritization but staffing for field observation is often in short supply. Volunteers can provide important support to land management organizations but may lack advanced skill in plant identification necessary to assist with invasive species mapping. To test whether volunteers could produce actionable information if provided with optimal observation times based on highly visible key identifying features, we used community science data from iNaturalist and expert botanical knowledge to develop a calendar of 'phenobvious' traits (seasonally identifying life cycle events, e.g. early spring leaf-out of *Rosa multiflora*) for more than 100 invasive species of the U.S. Mid-Atlantic region (North Carolina to New York), developed a mapping application for use on smart phones, and created and implemented tutorials.

Volunteers were able to rapidly identify focal invasive species using phenological cues. Review of initial mapping revealed a tendency for volunteers to map either broadly (designating a large area as containing a species) or granularly (mapping individual plants). To reduce this variability, we categorized species according to management priority by invasion phase and specified mapping granularity based on priority phase (e.g., mapping all individuals of species with small populations that might be eradicated from the site, versus mapping population boundaries of widespread species). Once creation of the key feature phenology table and tutorials was complete, staff time investment decreased to occasional maintenance of the table and weekly communication with volunteers. Mapped populations are now being integrated with management planning and used in concert with a complementary project identifying optimal treatment phenology to focus invasive species management effort.

**A Potential New Nemesis for Garlic Mustard? Exploring the Range and Impacts of a Newly Arrived Specialist Aphid**

*Rebecah Troutman, Natural Areas Biologist, Holden Forests & Gardens*

Description: During the 2021 field season, the Holden Forests and Gardens (HF&G) Natural Areas Biologist identified an infestation of the novel garlic mustard aphid (*Lipaphis alliariae*) on garlic mustard plants in northeast Ohio. Recognizing its potential impact on garlic mustard control, HF&G initiated a collaborative project in the summer of 2022 involving staff, citizen scientists, and community partners. Using a phone application, participants recorded aphid locations and plant health data across 16 states. Through workshops, grants, and presentations, the project engaged a broad audience, significantly expanding the known range of the aphid and

assessing its potential as a biocontrol agent. This effort highlights the critical role of citizen science and community collaboration in ecological research and management.

During routine garlic mustard (*Alliaria petiolata*) management in the 2021 field season, the Holden Forests and Gardens (HF&G) Natural Areas Biologist discovered garlic mustard plants with twisted seed pods and puckered/wilted leaves, indicating an aphid infestation. This was surprising since garlic mustard typically showed little herbivore damage. The aphid was identified as *Lipaphis alliariae*, a garlic mustard specialist native to Europe and previously unrecorded in the US. Given the need for effective garlic mustard control and the potential impact of this aphid, HF&G launched a collaborative effort to study its distribution and effects.

Beginning in the summer of 2022, HF&G staff, citizen scientists, and community partners used a phone application to record the aphid's location and basic information. Through extensive outreach, including workshops, grants, and presentations, the project engaged citizen scientists across 16 states to identify and report sightings. This collaboration significantly expanded the known range of *Lipaphis alliariae* and provided valuable data on its impact on garlic mustard growth and productivity.

The involvement of citizen scientists was crucial in mapping the regional distribution and studying the aphid's effects on plant health. This collective effort aims to determine whether *Lipaphis alliariae* could serve as a biocontrol agent for garlic mustard, leveraging its existing presence in natural areas. The project underscores the importance of community involvement and interdisciplinary collaboration in addressing ecological challenges.

**Greenhouse Gas Emissions in a Tallgrass Prairie Remnant Under Aquic & Udic Soil Moisture Regimes in the Ozark Highlands**

*Will Dockery, University of Arkansas*

*Co-authors: Kristofor R. Brye, Diego Della Lunga*

The Ozark Highlands ecoregion represents a unique biophysical transition zone between the relatively dry grasslands of western North America and the humid forests of the southeast. Before European settlement, a sizable portion of the region was native tallgrass prairie interspersed with oak (*Quercus* spp.) savannah. However, most of the tallgrass prairies in the region have since been transformed into grazinglands, upland row crops, or urban areas. Quantifying greenhouse gas (GHG) emissions, namely carbon dioxide (CO2), methane (CH4), and nitrous oxide (N2O), by natural, undisturbed ecosystems is critical to understanding atmospheric warming and climate-change implications. To date, most studies on prairie soils and GHG production have been limited to the north and central Great Plains and to measuring CO2 fluxes. The objective of this study is to simultaneously evaluate CO2, CH4, and N2O emissions in an aquic and udic soil moisture regime in the intermound position in a native tallgrass prairie remnant in the Ozark Highlands region of northwest Arkansas. Gas fluxes were measured weekly throughout Summer 2024 (mid-May through September) using a field-portable, GHG analyzer system. Gas emissions varied between udic and aquic soil moisture conditions over time. Greenhouse gas emissions from native tallgrass prairie remnants can provide insight into expected baseline GHG gas emissions and potentially provide a target for prairie restoration activities.

**NEON: Ecological Data and Resources to Understand Changing Ecosystems**

*Rachel Karpiesiuk, Senior Field Ecologist, National Ecological Observatory Network*

The National Ecological Observatory Network (NEON) is a continental-scale observation facility that collects open access, ecological data to better understand how ecosystems are changing across the United States. NEON will provide 30 years of data from 81 terrestrial and aquatic field sites. NEON data cover a range of subject areas within ecology, including organismal observations, biogeochemistry, hyperspectral imagery, and micrometeorology. Collection methods are standardized to ensure long-term comparability of patterns and processes across NEON sites and time. NEON collects data at both terrestrial and aquatic sites through three data collection systems: Airborne Remote Sensing, Automated Instruments, and Observational Sampling. Samples and data collected by NEON are publicly available and can be accessed digitally through the NEON website. NEON data has been used in a little over 1,000 publications and policy documents. This poster will focus on results from two studies that use NEON data to examine land management challenges at local and continental scales to show how NEON science can be an integral co-benefit of protecting and preserving natural communities for generations to come. The first study examines the impacts of riparian and non-riparian woody vegetation on water cycling in a tallgrass prairie watershed. The second study uses lidar data to investigate the effects of vegetation structure on bird richness. By providing free and open standardized data - along with data analysis tools and educational resources - NEON is engaged in a global effort to expand the scope of science and make scientific data access easier for all.

**Testing the Effect of Provenance on Native Seed Germination to Improve Seed-Based Restoration of Prairies**

*Brandon Clark, Graduate Research Assistant, South Dakota State University*

*Co-authors: Maribeth Latvis, Lora Perkins*

Grasslands are one of the most endangered ecosystems on the planet and provide essential ecosystem services locally, regionally, and globally. Losses of grasslands can be mitigated through restoration. Seed-based restoration is a widespread option due to its practicality and cost-effectiveness. Planting seeds from non-local sources and may not be adapted for their destination climate can have consequences for germination and restoration success. Using data-informed decision-making when selecting where seed is sourced from is important in restoring grasslands so that germination can occur at the appropriate time and rate. Therefore, we examined the effect of seed source

location on seed germination under different temperature regimes. We selected 13 native prairie species each with 3 commercially available county-specific seed source locations. To mimic spring temperatures, the germination chambers were set to 12-hour cycles of the average high and low air temperature for May 15th for Northern Minnesota, central South Dakota, and central Nebraska to encompass variation in temperature from a latitudinal gradient in grasslands of the northern Great Plains of the United States. For each seed source, five replicates of twenty-five seeds each were placed in plastic bags on moist blotter paper. Seeds from each source were placed in germination chambers and germination was recorded three times a week for 6 weeks. Final germination was examined using a relative interaction index (RII) = (Treatment − Control)/(Control + treatment). Control was considered the intermediate temperature, and the treatments were the cooler and warmer temperatures. We found significant interactions between source and temperature in final germination percent for 7 of the 13 species tested. Results were species-specific. This shows that more than half of the species tested exhibit some local adaptation for germination characteristics. This study has implications for helping land managers make informed restoration decisions about sourcing seed.

**The Sustainable Rivers Program: A Partnership for Meeting Environmental Flow Needs**

*Heidi Mehl, Director of Water and Agriculture, The Nature Conservancy*

For much of the 20th century, the United States built thousands of large dams and other water projects to meet the nation's growing need for water, food, flood risk reduction, hydropower and navigation. Since their construction, the operations of very few public dams have been fully reviewed and updated to meet environmental needs. Dams and other river infrastructure disrupt natural flow patterns that are critical to the health of rivers and the flora and fauna that depend on them. Seasonal patterns of high and low flows support animal and plant lifecycles, preserve water quality and maintain diverse habitats. By artificially stabilizing river levels across the seasons, dams can set off cascading effects that negatively impact whole freshwater ecosystems and the diverse array of benefits they provide to people. Science has shown that altered rivers systems are a major factor in 40 percent of the nation's fish species and 70 percent of freshwater mussel species being listed as imperiled, and why many commercial fisheries have been decimated. To help address these negative impacts, The Nature Conservancy and the U.S. Army Corps of Engineers—the largest water manager in the nation—launched a collaborative effort to find more sustainable ways to manage river infrastructure to maximize benefits for people and nature. Known as the Sustainable River Program (SRP), the program has grown to include 66 federal dams on 16 rivers in 15 states. This presentation will discuss the science and process for re-operating dams, and highlight some of our successes on rivers across the United States.

**Understanding Wildflower Forage Value: Advocating for Plant Diversity to Ranchers**

*Rae Powers, Pollinator Conservation Biologist, The Xerces Society/NRCS*

Native rangelands are invaluable pollinator habitat, providing vast areas of connected habitat and a diversity of wildflowers. Increasing understanding the value of rangeland wildflowers will help preserve these resources for pollinators and other invertebrates. Wildflowers are often perceived as undesirable by rangeland producers. Wildflowers may be viewed as competitors to grasses, particularly those species that appear after severe disturbances like flooding or drought, are not considered to be valuable forage to livestock, or are seen as noxious weeds or potentially toxic to their livestock. Ranchers spend time and money spraying to remove all forbs, unaware of their value to livestock and wildlife and how to recognize problematic species from others.

Livestock often feed on wildflowers but there is a gap in our current knowledge of forage quality of rangeland forbs. While the forage quality of native grasses has been analyzed extensively, very little information is available about the forage quality and mineral content of our native rangeland forbs.

With the goal of increasing our understanding of how native rangeland forbs contribute to livestock diet and performance, the Xerces Society for Invertebrate Conservation, in collaboration with USDA's Natural Resources Conservation Service and North Dakota State University, have begun collecting much needed data on the nutrient and mineral content of common rangeland wildflowers palatable to cattle in the Northern and Central Great Plains.

We have collected and analyzed 732 samples from 75 wildflower species across 10 states. Results from 2021 and 2022 wildflower collections will be presented. We will also discuss possible strategies for increasing producers' awareness of native forbs and the pollinators that rely on them.

**Conservation Delivery in a Region Dominated by Private Land Ownership**

*Luke Westerman, Supervisory District Conservationist, Natural Resources Conservation Service – USDA*

The Natural Resources Conservation Service (NRCS) stands as a premier agency for private land conservation in the country. It offers both technical and financial support to farmers and ranchers throughout the United States. The NRCS fosters a robust conservation partnership with local Conservation Districts to aid farmers and ranchers in receiving conservation technical and financial assistance. For over eight decades, the application of conservation principles on private lands has enabled landowners to invest in conservation on their working lands, while enhancing the competitiveness of American agriculture. The adoption of conservation practices on private lands has bolstered the quality of air, water, soil, and wildlife habitats nationwide. With over 98% of its land privately owned, Kansas ranks second in the U.S. of privately-owned acres. Conservation on private lands is vital in Kansas to enhance the state's natural resources. The NRCS engages in a distinctive

public/private partnership with private landowners. It employs a nine-step conservation planning process in collaboration with landowners, where an NRCS representative and the landowner jointly create a conservation plan. This plan serves as a roadmap to implement conservation practices that address specific conservation issues on their property. In Kansas, prioritizing conservation implementation on private lands is crucial for achieving conservation on a landscape scale and Kansas NRCS is at the forefront of this conservation delivery.

**The Ecology of Mindfulness**

*Justin Thomas, Science Director, NatureCITE*

Pulling from such sources as Robin Wall Kimmerer's *Braiding Sweetgrass*, Richard Powers' *The Overstory*, and the concepts of rewilding and systems ecology, this presentation will propose that chaotic, disconnected, and distracted minds are less likely to produce, or even functionally interpret, the complex interwovenness, and loss thereof, of the living systems in which we are embedded. It isn't only landscapes that have been traumatized, but our mental landscapes as well and that, to degrees, they are the same phenomenon. A conscious awareness of this real and simple interrelationship can be a wellspring of resolution, growth, inspiration, etc. in the fields of applied ecology and restoration, as well as the burdened psychologies of practitioners. In short, restoring healthful ecosystems likely depends on restoring healthful minds. Mindfulness and meditation offer valuable foundational techniques of processing and improving the work we do, but are rarely discussed, highlighted, or considered.

**Seeds of Change: Volunteer-Powered Restoration in Kansas City's WildLands**

*Sarah Beier, Program Coordinator, Kansas City WildLands*

Kansas City WildLands, a program of Bridging The Gap, Inc., conserves, protects, and restores remnant landscapes that reflect the KC metro's biological heritage. Key to these efforts is a volunteer-powered Seed Team, whose members collect seed from more than 200 species across 17 different and biologically distinct sites. Local ecotype seed blends are then re-distributed for use in public land restoration projects, saving hundreds of thousands of dollars and preserving the genetic integrity of the region's natural areas.

**Small & Mighty: Why Protecting Highly Diverse Original Prairies Matters**

*Carol Davit, Executive Director, Missouri Prairie Foundation*

There is currently much emphasis on native grassland connectivity, but often less consideration is given to species diversity and the ecological function of remnant prairies that are part of that connectivity. In 2018, the Proceedings of the National Academy of Sciences of the United States of America published 'Global synthesis of conservation studies reveals the importance of small habitat patches for biodiversity.' Once deprioritized by many conservation planners, small, isolated patches of original habitat were assumed to be of little ecological value, and attention was focused on conserving large, connected areas. The global analysis presented in this paper, however, illustrates that if small patches of original habitat are not conserved—connected or not—many species could be lost, and biodiversity overall would decline as a result.

In her talk, Missouri Prairie Foundation Executive Director Carol Davit presented the urgent need to protect intensively biodiverse native grasslands—many of which are in the Midwest and Southeast—regardless of size. Benefits of doing so include protection of species and natural communities of conservation concern, protection of seed sources needed for reconstructions to connect remnant habitats, conservation of pollinator reservoirs, and increased opportunities for public enjoyment of remnants, some of which are near population centers. She will share examples of numerous, species-rich prairie communities and the strategies in place to protect them.

**Restoring Biodiversity Through Management in the Grand Prairie Region of Arkansas**

*Ryan Spotts, Chief of Land Acquisition and Stewardship, Arkansas Natural Heritage Commission*

The Grand Prairie region once covered roughly 900,000 acres of Arkansas, about 500,000 of which were tallgrass prairie. Today only around 400 acres of tallgrass prairie remain in the Grand Prairie, which is less than 1% of its historical area. Most of those remaining acres are protected and managed by the Arkansas Natural Heritage Commission (ANHC) at 5 natural areas ranging from 28 acres to 251 acres in size. These natural areas are refuges for unique species such as the prairie mole cricket (*Gryllotalpa major*) as well as declining pollinator species such as the southern plains bumblebee (*Bombus fraternus*). These small remnant prairies have faced many challenges over the years, including a lack of management, mismanagement, overspray of chemicals from neighboring agricultural crops, and the introduction and dominance of non-native invasive plant species. Today, ANHC manages these areas using a combination of prescribed fire, mechanical removal of native and non-native invasive species, and chemical treatment of non-native invasive species. These methods are labor-intensive, but the results can be seen after just a few years. There have been noticeable declines in undesired plant species such as Johnson grass (*Sorghum halepense*) and Chinese privet (*Ligustrum sinense*). In 2023 and 2024, ANHC botanists documented the presence of two plant species not seen in the state of Arkansas in decades: showy evening-primrose (*Oenothera grandis*) and wavy-leaf gaura (*Oenothera sinuosa*).

**Implementing the Kansas Water Plan: Securing Our Water Future**

*Dawn Buehler, Chair of the Kansas Water Authority*

Dawn Buehler, Chair of the Kansas Water Authority, will discuss the implementation planning efforts for the Kansas Water Plan that are underway in Kansas this year.

The heartland of the nation is no different from other places in the world. A changing climate that includes longer periods of droughts, followed by more intense rain events that create more large scale flooding put Kansas at the center of the climate crisis.

The demands of a growing population, a thirst for more and a rapidly changing climate have put our natural resources under stress.

On January 24, 2024, Governor Laura Kelly charged the Kansas Water Authority to develop a strategic plan, including funding, based on the five guiding principles of the Kansas Water Plan. Governor Kelly's request included initial recommendations for a large-scale, long-term investment framework before the 2025 Legislative Session. These recommendations should include policy changes, ways to improve state capacity and water management, measurable goals and timelines, and include input from various state and local stakeholders.

Join Dawn to learn about the process that Kansas is undertaking now to prepare for the future.

**The Importance of Small Natural Areas to Protect Vital Habitat for Globally Imperiled Paleback Darter**

*Katie Morris, Aquatic Ecologist, Arkansas Natural Heritage Commission*

*Co-authors: Dustin Lynch, Maxwell Hartman, Steve Lochmann, Jonathan Spurgeon*

The Ouachita Mountain Ecoregion in Arkansas has 138 native fishes, at least 17 of which are imperiled. The age and complex history of drainage patterns in the ecoregion have allowed for the isolation and continual occupation of fishes, resulting in a diverse assemblage that includes eight endemic species, three of which are darters. One of those, paleback darter *Etheostoma pallididorsum*, is restricted to the upper Caddo and Ouachita river watersheds in west-central Arkansas. It is a species of greatest conservation need and is globally imperiled (G2S2). Paleback darter is considered vulnerable to local scale extirpation from habitat destruction due to habitat fragmentation and a restricted range.

Paleback darter utilizes multiple habitat types to complete specific phases of its life history. Adults occupy the main channel of second through fourth order streams for most of the summer and then in winter they move into off-channel habitat consisting of springs, seeps, and seasonally inundated wetland areas with aquatic vegetation to spawn. After spawning, the adults will move back into main-channel habitat while the juveniles will use the off-channel habitat as a nursery until early June. We used an occupancy modeling approach to quantify broad scale and seasonal habitat characteristics that influence the presence of paleback darter in main-channel and off-channel habitats. Our top five broad-scale models had the distance to springs as an important driver of paleback darter occupancy. Maintenance of connectivity appears necessary to allow paleback darter to utilize both habitat types and maintain genetic diversity.

In Arkansas, almost half of the land in the Ouachita Mountain Ecoregion is owned by small acreage private landowners, approximately one-fourth by timber companies, and the remainder by the United States Forest Service. The Arkansas Natural Heritage Commission protects two small natural areas, Big Fork Creek and Gap Creek (5.5 ha and 4.0 ha, respectively), both of which are highly spring influenced. It is often difficult to protect enough aquatic habitat at a small scale to make a difference, but for paleback darter these small natural areas provide and protect vitally important habitat. Future acquisition and protection of off-channel habitats in the Ouachita Mountain Ecoregion, such as springs, seeps, and seasonally inundated areas are conservation actions that could have lasting benefits for the survival of an Arkansas endemic species.

**Using Drift Fence Camera Arrays to Survey Amphibians, Reptiles, and Small Mammals on City of Boulder Natural Areas**

*Nat Warning, Ecology Technician, City of Boulder Parks and Recreation*

*Co-authors: Joy Master, Erika Carlson, Cooper Lyons*

Traditional herpetofauna surveys using drift fence pitfall traps are effective but are outdated due to the risk of bycatch and extensive staff time required for checking and maintaining trap sites. Camera trapping has emerged as a viable alternative to traditional capture surveys, though their use for small animals has been limited due to insufficient triggering of infrared game cameras and poor image quality. An innovative survey technique known as the Adapted-Hunt Drift Fence Technique (AHDriFT) combines the use of traditional drift fences to divert animal passage, with motion-activated cameras to obtain detectable images, allowing long-term monitoring of smaller taxa with minimal risk of sampling mortality. We deployed two AhDriFT arrays over 330 trap-nights at four Natural Area sites adjacent to wetlands from Apr–Oct 2023–2024. We obtained images of amphibians (4 species), reptiles (8 species), birds (6 species), and mammals (15 species), including federally listed Preble's meadow jumping mouse. We found that AHDriFT deployments provided valuable wildlife inventory data efficiently and cost effectively, requiring minimal staff time compared to alternative survey methods.

**Rethinking Fire Return Intervals Using Qualitative Picture Guides**

*Murray Gheesling, Stewardship Ecologist, Tennessee Division of Natural Areas*

Natural area stewards are tasked with designing prescribed fire regimes to maximize diversity, prevent species loss, and maintain natural community integrity, but are left with a sea of often contradictory recommendations from scientists and experts from a wide range of biological disciplines. This project looked at one community type (limestone outcrop glades) and asked if fire return intervals could be guided by a qualitative assessment of vegetation structure rather than strict temporal return intervals often based on single species studies. Vegetation structure, specifically woody plant encroachment, can be used as analog for the needed return interval of fire in a glade system. Since vegetation in limestone outcrop glades is dictated by substrate (or lack thereof), factors like soil accretion, drought, or other climatic and environmental forces may speed up or slow down encroachment changing the needed fire return interval. We present a pictorial guide to succession and woody

encroachment in glades as a tool for land managers to use when deciding appropriate return intervals. Presented by Murray Gheesling from a paper by Sam King.

**Effects of Ungulate Grazing, Burning, and Cropland on Stream Water Chemistry in Tallgrass Prairie Watersheds**

*MD Abu Raihan, Graduate Research Assistant, K State*

Fire and grazers were historically pivotal for preserving tallgrass prairie, but how they influence stream water quality currently is not understood. We used long-term (1985–2022) water chemistry data for nitrogen and phosphorus from sites within the Kings Creek and Shane Creek watersheds at Konza Prairie Biological Station, KS, with different combinations of grazing (cattle or bison) and fire frequencies. MANCOVA analysis of yearly mean concentrations of NO3-, total P (TP), and soluble reactive P (SRP) across sub-watersheds revealed significant temporal variations only for NO3- ($F = 6.548$, Sig. $= 0.013$) and notable spatial distinctions among watersheds ($F = 27.239$, Sig. $= 0.000$). Years since burning significantly influenced NO3- levels ($F = 5.247$, Sig. $= 0.003$), and the interaction between the watershed and the years since burning was significant ($F = 4.319$, Sig. $= 0.017$). Paired samples over 37 years on bison-grazed and ungrazed watersheds revealed NO3- was 2.03 times, SRP about 1.19 times, and TP approximately 1.41 times greater in bison relative to ungrazed watersheds. In our low grazing density cattle-grazed, patch-burned watershed, concentrations of NO3-, SRP, and TP were substantially higher (1.99 times, 3.34 times, and 2.66 times, respectively) when cattle were present compared to periods of absence. Bison and cattle had similar nutrient concentration effects, but cattle were present only half the year. The water quality impact of controlled burning was comparatively weaker than the effects attributable to grazing activities. Both had less impact than the presence of fertilized cropland.

**Cattle and Bison Regularly Graze Milkweeds, Which Decreases Monarch Egg Laying and Milkweed Survival**

*Timothy Dickson, University of Nebraska, Omaha*
*Co-author: Brittany Poynor*

Most land managers know that the condition, developmental stage, and height of milkweeds affects monarch butterfly egg laying. Most land managers assume cattle and bison avoid milkweeds because milkweeds contain toxic compounds, however, observations show that cattle and bison regularly graze common milkweed (*Asclepias syriaca* L.) and showy milkweed (*Asclepias speciosa* Torr.), which are important summer host plants for monarch butterflies (*Danaus plexippus* L.) east of the Rocky Mountains. We have evidence from comparisons of adjacent prairies that are ungrazed or that are grazed by cattle or bison, showing that milkweeds are grazed significantly more in the prairies containing cattle or bison. We also have trail camera videos showing many instances of cattle and bison grazing milkweeds. In all these prairies we have never observed any evidence of sickness in animals after grazing milkweeds, but we have observed that grazing significantly decreases milkweed abundance relative to ungrazed prairies.

These observations from grazed and ungrazed prairies motivated us to set up an experiment to isolate the effects of clipping (simulated grazing) on milkweed survival and monarch egg laying. We clipped common milkweed stems to half their height on May 16 and again on July 26, and set up a separate treatment where we just clipped off the flowers of milkweeds. We also set up a control treatment where no clipping occurred. We visited the plants twice per week from May 16 to September 16 and examined stem survival and the number of monarch eggs per stems. We did not find any significant differences between the control and floral clipping milkweeds, but found that clipping plants in half significantly decreased stem survival, with July 25 stem survival of 93% in the control / floral clipping stems and 44% in the stems that were previously clipped in half. When examining live plants across the growing season, we found an average of 2 monarch eggs per stem for control / floral clipping, but found only 0.5 eggs per stem for those plants that were clipped in half.

These results suggest that grazing damage to milkweeds likely decreases milkweed survival and monarch egg laying. This directly relates to efforts to add over one billion stems of milkweed to the central USA for monarch butterfly conservation. Future studies should examine effects of delaying spring grazing (defoliating stems later in the growing season) and the effects of grazing the same milkweed plants year after year relative to the effects of grazing milkweed plants just one year.

**Using Prescribed Fire to Control an Old World Bluestem Grass: Opportunities and Challenges**

*Norma Fowler, Professor, University of Texas at Austin*
*Co-authors: Carolyn Whiting, Whitney Behr*

*Bothriochloa ischaemum*, locally called King Ranch bluestem, is a non-native invasive grass species common in central Texas savannas and grasslands, where it often forms near-monocultures. It is a perennial C4 bunchgrass native to central Asia, like other Old World bluestems. *B. ischaemum* is arguably the most challenging non-native invasive plant in central Texas for land managers concerned with native plant diversity, pollinator resources, or grassland birds. It has been widely planted for erosion control, especially along roadsides, and (in the past) for forage improvement, but also spreads readily without deliberate human actions. Previous work by our group and others has confirmed that this species is highly grazing-tolerant and has a wide ecological amplitude.

Prescribed fire is a potential method of managing *B. ischaemum*. Single winter fires are relatively ineffective at reducing the density of this species. We found that August and October fires were most effective in controlling *B. ischaemum*. Other authors have also reported that late summer (August–October) fires were effective in *B. ischaemum* control. It is important that prescribed fires harm *B. ischaemum* more than desirable native species; we found significant positive effects of prescribed fires on native herbaceous species. We also found some evidence that repeated winter fires over a decade may also control of *B. ischaemum*. Prescribed fires in this region can

successfully serve a dual purpose, controlling woody plant encroachment as well as *B. ischaemum*. The factors that determine the effectiveness of a fire in controlling *B. ischaemum* remain unclear, and it remains a topic needing more research, especially on the effects of fire intensity, duration, etc.

**Monitoring and Managing Threatened and Endangered Species on Conservation Lands: Percent Area Occupied (PAO) Approach**

*Milan Mitrovich, Land Resources Manager, San Bernardino Valley Water Conservation District*

*Co-authors: Betsy Miller, Cheryl Brehme, Robert Fisher*

The conservation of wildlife requires the regular collection of monitoring data to inform best practices for the management and recovery of species threatened with extinction. In southern California, we work in the exceptionally rare alluvial fan sage scrub community, where we actively recharge groundwater, but also address the needs of threatened and endangered species largely found here and nowhere else in the world. In our work supporting recovery of the listed species present on the alluvial fan, we employ the Percent Area Occupied (PAO) approach to inform monitoring and management activities. The PAO approach is a powerful tool for land managers and natural resource professionals needing to monitor for threatened and endangered species and assess management actions on conservation lands situated at the wildland–urban interface. Here we present a case study involving development and implementation of a scientifically valid and cost-effective monitoring protocol using the PAO approach for the state and federally listed San Bernardino kangaroo rat (*Dipodomys merriami parvus*; SBKR). The San Bernardino kangaroo rat is one of five species covered under the Upper Santa Ana River Wash Habitat Conservation Plan (Wash Plan), approved by the U.S. Fish and Wildlife Service in July 2020. The 1,660-acre Wash Plan Preserve, distributed across the alluvial fan emanating from the San Bernardino Mountains, is contiguous with mining activities, groundwater recharge, and urban development. The Wash Plan requires status and distribution of SBKR in the Wash Plan Preserve, monitoring of long-term trends, and assessment of the effectiveness of management actions benefitting the species. Using the PAO approach, we quantify occupancy as well as estimate the abundance and density of SBKR. The monitoring protocol and occupancy model allows for combined analyses with existing preserve-level SBKR monitoring and future range-wide SBKR monitoring. Measures of occupancy mute interannual variability in the numbers of SBKR present in the landscape, providing more reliable measure of trends in species status through time. The methodology allows us to identify habitat conditions associated with the presence and absence of the species, as well as the forces driving metapopulation dynamics. Obtained estimates of abundance and density highlight interannual variability associated with the timing and amount of seasonal rainfall and assist in defining habitat restoration goals and the scaling of restoration activities to achieve the desired impact on recovery. Given the potential widespread value for the management and monitoring of threatened wildlife present in the myriad of varied landscapes undergoing rapid environmental change in areas of biodiversity importance in the United States, it is our opinion the PAO methodology should be considered and applied broadly in support of implementation of conservation actions and land management decisions throughout the region.

**Long-Term Impacts of Burning and Mowing on Edaphic Characteristics in a Tall Grass Prairie Ecosystem**

*Charles Antwi, Graduate Student, University of Nebraska, Omaha*

*Co-authors: Paul Ayayee, Timothy Dickson*

North America's Tallgrass Prairie ecosystems are shaped significantly by management practices like prescribed burning and mowing. Although the immediate impacts of these practices are understood, the long-term impacts on overall soil health and the implications for biodiversity need further clarification. This study assessed the impacts of burning and mowing on the edaphic properties and soil microbial community composition of a Tallgrass Prairie ecosystem in the Glacier Creek Preserve in Eastern Nebraska after nearly three decades of management, using both standard soil chemistry variable measurements and next sequence technologies, respectively. Overall, we uncovered comparable pH in mowed and burned plots relative to control plots ($F = 3.76$, $df = 2$, $P = 0.026$) and higher soil moisture content in mowed plots than in burned plots ($F = 3.84$, $df = 2$, $P = 0.024$). These results provide insights for ecosystem preservation by bridging short-term studies with long-term ecological processes and underscore the complexity of management impacts on soil properties, advocating for thoughtful consideration of the types of interventions in ecosystem conservation and restoration efforts. Soil DNA from the treatment plots has been extracted and submitted for sequencing. We anticipated significant impacts of treatments on both bacterial and fungal diversity and community composition, as previously reported in other studies. However, we anticipate adding insights into treatment-specific impacts on microbial metabolic potentials and how this relates to edaphic factors in the plots. We anticipate this data ahead of the meeting.

**Protection and Propagation, Cutting and Burning: What 33 Years of Managing a Globally Rare Plant have Taught us**

*Deborah Landau, Director of Ecological Management, The Nature Conservancy (MD/DC chapter)*

Restoring rare and degraded habitats and their associated species can be a challenging balance between management activities that are aggressive enough to alter the trajectory of a declining population, while maintaining enough of a 'light touch' so as not to negatively impact a sensitive ecosystem. We will discuss strategies we have employed, some with more success than others, to restore the only Maryland population of Canby's dropwort (*Oxypolis canbyi*, G2/S1) in a seasonal depression wetland ('Delmarva bay'). Spoiler: fire was the key to restoring this population, but achieving a burn that would not negatively impact the site (i.e., no firelines) required careful planning, and trust from our partners. The (spectacular) results are discussed.

**Virtual Fence as a Tool for Grassland Bird Conservation in Tallgrass Prairies**

*Theo Michaels, Postdoctoral researcher, Kansas State University*
*Co-authors: Katy Silber, Alice Boyle*

Tallgrass prairie grassland bird populations have seen precipitous declines in recent decades. In addition to habitat loss from human land use change, an under-recognized factor contributing to these declines is the reduction in vegetation structural heterogeneity due to current fire and grazing regimes. Grassland birds are positioned along a gradient of vegetation structural needs. As such, management practices that shape small scale heterogeneity can impact grassland bird reproduction and survival. Working with both private and public partners, we tested the efficacy of Virtual Fence (VF) technology as a tool for grassland bird conservation in tallgrass prairies in the Flint Hills of Kansas. Our objectives were to 1) assess VF as a means to increase heterogeneity and 2) determine the subsequent impacts on grassland bird abundance. To do this we established 11, 4-ha cattle exclusion plots, along with 11, 4-ha control plots, each located in prime nesting habitat for grassland birds. Approximately half of each plot type was burned every other year. During 2022, cattle wore collars but were allowed access to all plots, while in 2023 and 2024 collars restricted access to the 11 exclusion plots. Across all years, we surveyed each plot for vegetation height and structure, and conducted grassland breeding bird point counts during May, June and July. We also conducted greater prairie-chicken lek counts during March and April of each year.

Despite challenges with VF collars, results demonstrate that VF is effective at increasing vegetation heterogeneity which in turn improves conditions for grassland birds. VF increased overall site-level heterogeneity. For instance, vegetation was taller and denser in the exclosures compared to the controls. In burned areas, the proportion of grass in the exclosures mimicked unburned areas, providing structural refugia. In unburned areas, exclosures buffered between year environmental variability by preserving crucial vegetation components, including dead grass, which provides important habitat for key at-risk species. This increase in heterogeneity had subsequent impacts for grassland birds in beneficial and predicted ways. General responses to enclosures and controls show that while some species like grasshopper sparrows favor the fine-scale patchiness associated with the control plots, others like Henslow's sparrow thrive on tall, dense, uniform vegetation created by the exclosures. Importantly, the degree to which species differentiated between exclosures and controls depended on annual environmental conditions. In the drought year (2023), some species like the eastern meadowlark and upland sandpiper, showed no preference between the exclosure or control plots. However, in a more average rainfall year (2024), these species exhibited stark preferences for either the exclosure (upland sandpiper) or control (eastern meadowlark) plots. We also observed strong increases in prairie chicken leks across all years of the study. Taken together, these results show that not only does VF improve heterogeneity, it can mitigate the interannual and spatial homogeneity associated with climate and fire by providing refugia for at-risk species. Reversing bird declines is imperative and VF shows promise as a win-win management tool for both ranchers and grassland birds.

**Indigenous Ecological Knowledge in Australia**

*Skyler Johnson, Undergraduate Student, Franklin College*
*Co-author: Alice Heikens*

Australia supports more than 1 million species, with 82% of its mammals and 93% of its frogs being endemic. Australia's natural habitats range from wetlands to deserts, from forests to plains, from small coral atolls to the Great Barrier Reef. British first colonized Australia in 1788. Colonization brought British culture as well as diseases and invasive species such as foxes, camels, rabbits, and the feral hog. Smallpox killed approximately 70% of the Indigenous population. In addition, Indigenous people and the colonists fought over land. A series of policies allowed the British to remove children from Indigenous families and place them in British homes, resulting in a loss of cultural history. Environmental impacts from European colonization include the reduction in cool burning (prescribed fire) practices, to the introduction of non-native plants and animals. The elimination of cool burning contributed to a catastrophic fire in 2019 that impacted 29 million acres of land, and non-native plants and animals have contributed to the extinction of 100 endemic species. However, recently, groups including the indigenous Yugul-Mangi Rangers, are working to conserve nature by re-discovering and putting into practice indigenous ecological knowledge to help mitigate the ecological harm caused by European colonization.

## POSTER PRESENTATIONS

**Grazing for Pollinators: Plant–Pollinator Networks and Bee Nesting Habitat under Varied Grazing Management**

*Emma Greenlee, Graduate Student, Kansas State University*
*Co-authors: Zak Ratajczak, Ellen Welti*

Native bees are a vital but threatened component of natural and agricultural systems worldwide, including grasslands. In the Great Plains, cattle grazing is a widespread management practice today, and bison and prairie dogs have greatly influenced the region's prairies historically. Grazers like cattle, bison, and prairie dogs shape the ecosystems around them through their effects on plant community composition, vegetation structure, and soil characteristics, but their effects on bee habitat have only been measured in a handful of sites. This study addresses two questions: how do grazers influence 1) plant–pollinator networks and 2) habitat for ground-nesting bees. In summer 2024, I will quantify ground nesting bee diversity and abundance and construct plant–pollinator networks across grazing treatments and grazing intensities at sites spanning tallgrass (Konza Prairie, KS) and shortgrass prairie (American Prairie and Fort Belknap, MT). At Konza, treatments will include bison-grazed, cattle-grazed, and ungrazed sites. At American Prairie, treatments will include bison-grazed (low grazing intensity), cattle-grazed, prairie dog town, and ungrazed sites, along with higher-intensity bison- and cattle-grazed sites at Ft. Belknap. I

will measure bee species abundance via hand-netting surveys and emergence traps, record floral abundance, vegetation structure, and soil characteristics within each treatment, and will complete two to three rounds of sampling in each study region in 2024. This will result in plant–pollinator networks and estimates of nesting habitat across treatments. Our pilot study, carried out in summer 2023, supports the feasibility of these sampling efforts, and my poster will present findings from the 2024 field season. This will be one of the first studies to make comparisons between different grazer species' effects on plant–pollinator network structure and bee nesting habitat, addressing multiple knowledge gaps in the conservation of native bee communities in North American grasslands. Identifying grazing practices that promote healthy, diverse pollinator communities is critical for the conservation and management of Great Plains grasslands.

**Inorganic Fertilizers and the Role of Phosphorus and Potassium in Native Prairie Restoration**

*Kendall Hays, Student, Oklahoma State University*

Phosphorus (P) and potassium (K) are macronutrients required to sustain plant growth and reproduction. They are commonly applied as inorganic fertilizer by farmers across the world for their crops but these nutrients are also important for the development and sustainment of native grassland systems. Much of the Great Plains region has either been used as farmland or grazing land. These practices can disturb natural nutrient cycling by removing nutrients without adequate replacement. Current literature regarding nitrogen (N) application in rangelands has largely focused on the production of biomass and its relation to carbon (C) cycling, but little research exists regarding the application of P and K in rangeland systems. This study evaluates the effects of inorganic fertility application on soil and plant communities in the southern Great Plains region. This experiment was placed on disturbed prairie soils in central Oklahoma. N, P, and K were added as urea, 0-46-0, and 0-0-60 at 67 lbs/ac, 57 lbs/ac, and 57 lbs/ac respectively. Soil sample analysis included macronutrients, micronutrients, texture, pH, and EC. Forage sample analysis looked at nutrient uptake and total N and total C. Currently, ample literature is available for nitrogen application on native grasslands but response to P and K is unclear. This study looks to better understand native prairie responses to immobile nutrients and assist in native prairie restoration in the future.

**How *Andropogon gerardi* Varies Across its Range: Characterizing Potential Climate Adaptations for Prairie Conservation**

*Helen Winters, Kansas State University*

*Co-authors: Jack Sytsma, Ari Jumpponen, Sonny Lee, Adam Smith, Erica Newman, Loretta Johnson*

The majority of tallgrass prairie has been lost and what remains is threatened by increasing temperatures and drought occurrence, potentially shifting species' ranges or productivity. Big bluestem (*Andropogon gerardi*) is a common and widespread prairie grass that is agriculturally, economically, and ecologically important. Our goal is to identify potential climate-adapted *A. gerardi* populations to facilitate more accurate predictions of its responses to future climate. Using these results, current restoration and conservation practices can be designed to minimize the impact of climate change on prairies. During peak growing season 2023, we sampled 26 sites across the U.S.: MN-TX (mean annual temperature [MAT] 4–21°C) and CO-NC (mean annual precipitation [MAP] 325–1400 mm/yr). This included core populations (where plants experience optimal conditions) and non-core populations (where plants experience more extremes). We measured the physiology (photosynthetic rate, stomatal conductance, and water use efficiency), morphology (blade width and plant height), leaf C:N content, and abundance (canopy cover) of *A. gerardi*. We hypothesized that plants within the core would be most abundant due to more favorable environmental conditions. We expected plants to have smaller leaf area (narrower and thicker leaves) at the dry (western) non-core range to reduce evaporative water loss, and lower photosynthetic rates, lower stomatal conductance, and higher water use efficiency to conserve water under water-limited conditions. We expected plants to have greater leaf surface area (wider and thinner leaves) at the wetter (eastern) non-core range to maximize light capture to compensate for increased competition with more abundant shrubs and trees, in addition to higher photosynthetic rates, higher stomatal conductance, and lower water use efficiency. Precipitation and aridity had the greatest effect on plant traits, whereas temperature alone had weak to no effect. *A. gerardi* had highest canopy cover within its range core. Populations from drier sites had higher photosynthetic rates (contrary to what was hypothesized), potentially because of the higher leaf nitrogen content in the plants from drier sites. Additionally, populations from drier sites had lower stomatal conductance and greater water use efficiency. Our results imply that increasing drought and/or aridity may have a larger impact on *A. gerardi* than increasing temperatures alone. To potentially mitigate the impacts of climate change, grasslands could be restored with populations matched to predicted future climate. For example, to improve grassland resilience, more drought tolerant populations of *A. gerardi* could be planted in areas where increasing drought is predicted.

**Remnant Prairie Patches Promote Biodiversity and Succession Across Different Aggregate Sizes and Land Use Histories**

*Reb Bryant, PhD Candidate, University of Kansas*

While many advances have been made by restoration ecologists and practitioners, tallgrass prairie restorations in primarily post-agricultural soils tend to stall in the early stages of succession and often lack the level of biodiversity seen in untilled remnant prairies. Native arbuscular mycorrhizal (AM) fungi often promote the growth of prairie plants, particularly late successional species, and species coexistence in remnant prairies. Given that the AM fungal community in prairie restorations have likely been drastically shifted due to conventional agriculture, these microbes could be key missing components from these soils. In 2017, an experiment was

established with remnant prairie patches (cones 1.5 m in diameter and depth) in an old field and restored field. Six patches were placed in three different arrangements by plot: six individual patches, two three-patch aggregates, or one six-patch aggregate. The patches in these plots serve as sources of native AM fungi and plant species. In each plot, we randomly chose a single patch and added seeds of several plant species in 2023. Over the growing season, we surveyed plant communities in a 1 $m^2$ quadrat in, adjacent to, and 3 m away from the patch. We calculated measures of plant diversity and succession as well as the establishment of new plant species. Interestingly, we found no impact of distance from the patch on new species establishment in the first growing season. In agreement with a previous study of this experiment, we found that measures of succession and native diversity increased in plots closer to the patch across aggregate sizes in both sites. This study highlights the role of native prairie AM fungi in promoting existing plant biodiversity and succession in a variety of landscapes, though data in future growing seasons is needed to determine the impact on species recruitment.

**Grassland & Oak Savanna Conservation in Northeast Wisconsin**

*Andrew LaPlant, Conservation Biologist, UWGB - Cofrin Center for Biodiversity*

*Co-authors: Sam Gerarden, Haillee Fritsch*

Pre-colonial Wisconsin was home to more than 2.1 million acres of tallgrass prairie, but less than 2,000 acres remain today (WDNR 1995). Additionally, Wisconsin was home to more than 5.5 million acres of oak savanna/oak opening (Finley 1976), but less than 1,000 acres of intact habitat remains (WDNR). While northeastern Wisconsin lies north of the range of Wisconsin's native prairie, a small strip of oak savanna was present along the far southeastern shore of Green Bay, where the University of Wisconsin-Green Bay campus resides. Evidence from Dorney and Dorney (1989, American Midland Naturalist 122:103–113) suggests that fires set by indigenous people kept the woodland along the east shore of Green Bay open for hunting and small-scale agriculture. Thus, the Green Bay savanna landscape has both cultural and ecological significance. As we continue to witness the decline of Wisconsin's grassland specialist wildlife, the university has prioritized the conservation of these imperiled ecosystems and the organisms that depend on them. This effort has been spearheaded by the Cofrin Center for Biodiversity, a program on campus that manages all university-owned natural areas and promotes education, scientific research, land protection, and community services that contribute to conservation of western Great Lakes fauna and flora. The Cofrin Center has taken on several unique grassland and oak savanna restoration projects in recent years and has emphasized conservation of Wisconsin's native pollinators at all university natural areas. These projects include conservation of the rusty-patched bumblebee, a federally endangered species with a robust population on the UWGB campus; restoration of two former agricultural fields into oak-savanna; and the creation of several pollinator plantings at a former golf course on campus, turned mixed use recreation space. Our poster presentation will provide insight on the planning, implementation and results of these unique restoration and conservation projects as well as the Cofrin Center for Biodiversity's future plans for conservation in northeast Wisconsin.

**Merging Dendrochronology, Paleoecology and History to Inform Land Stewardship Decisions under Climate Change**

*Calla Ward Olson, University of Wisconsin-Madison*

The tallgrass aspen parkland is a biodiverse but climatically sensitive ecotone biome located in northwest Minnesota. It contains some of the largest and most intact prairie areas left in the Midwest and is considered a conservation priority by multiple stakeholders. The Nature Conservancy's Resilient and Connected Network Landscapes project noted it contains "resilience, flow, and recognized biodiversity" compared to other Midwest ecosystems and designated it a conservation priority. However, little research has been done on what it looked like historically, how it has responded to past climate changes, and its importance to Sovereign Nations prior to colonization. Land stewardship practitioners are currently unsure how to manage the landscape in the face of projected climate changes, particularly with regards to prescribed fire, forestry practices, and assisted migration.

My dissertation research blends methodologies from paleoecology, dendrochronology, and American Indian Studies to explore how past climatic shifts, occupation by Indigenous peoples, and colonization have played out in the tallgrass aspen parkland and how it has changed in response to these forces. By exploring the history of fire, climate, and relationships between land and people in the tallgrass aspen parkland, I hope to develop guidance for how conservation agencies can best protect this ecosystem from future climatic shifts and other challenges, and better respect and honor the sovereignty of the Red Lake Nation and other Sovereign Nations with ties to this landscape.

My research is shaped by the following questions:

1) How is the tallgrass aspen parkland likely to respond to future climate and land use changes?
2) How have human relationships with this landscape changed over time, and how has that impacted the health of the land?
3) [How] can we alter land stewardship techniques, particularly prescribed fire, to better care for this region and help it adapt with minimal loss of biodiversity, ecosystem function, etc.?
4) [How] can western scientific techniques be used to affirm the importance of this landscape to Sovereign Nations and advocate for their Treaty Rights to be honored?

Preliminary results indicate that:

1) The tallgrass aspen parkland landscape was important to multiple Sovereign Nations, and heavily populated.
2) Bison were a key large grazer on this landscape.
3) Thief Lake, the largest lake in the region and a critical wildlife management area for the Minnesota DNR, was much deeper than it is now, supporting abundant fish, wild rice, and other Indigenous lifeways.

4) Fire was regularly used by Sovereign Nations to shape the landscape, and pre and post colonization fire regimes differ.
5) Ratios of various vegetative communities have shifted dramatically since colonization in response to changes in human use, climate, and fire regimes.

**Changes in Population Ecology of Beechdrops (*Epifagus virginiana*) in Central Indiana**

*Grace van Kan, White River Steward, Central Indiana Land Trust*

Beechdrops is a holoparasitic plant that grows exclusively on American Beech tree roots, typically in relatively undisturbed mesic woods. This parasitic plant produces two types of flowers: small, open, and typically sterile (chasmogamous) flowers near the top; and closed, fertile (cleistogamous) flowers lower on the stems. Population metrics collected in 2013, 2021, 2022, 2023 include number of plants, height, number of flowers, and distance to host. Over the 11 years of this study, the population has varied in number of plants from 886 to 547 with extreme changes in one year. Number of flowers (61, 28, 32, and 47 respectively) varied greatly but plant size remained somewhat constant. These changes may be a result of different environmental conditions or natural population fluctuations. The site has experienced disturbances from adjacent development outside of the 12 ha forest as well as storm damage within the forest. However, the decrease in population metric in 2021 is perhaps due to weather because the population in 2022 shows a return to a large population similar to 2013.

**A Sticky Situation: Identifying Drivers of Woody Avoidance in Grasshopper Sparrows (*Ammodramus savannarum*)**

*Logan Anderson, GTA, Kansas State University*
*Co-author: Alice Boyle*

Woody encroachment has been well-documented in grassland systems worldwide. In the Flint Hills of eastern Kansas, woody plant colonization of rangelands and prairies is a major factor in local grassland bird declines. These declines have been largely attributed to increases in nest depredation rates and predator presence around woody plants, but it remains unclear why woody plant avoidance occurs in the first place and whether it is driven directly by shrub avoidance or indirectly via frequent contact with woody-associated predators. To distinguish between shrub and predator avoidance, we tagged and monitored the movement of a common grassland songbird, the grasshopper sparrow (*Ammodramus savannarum*), by triangulating their locations using small arrays of radio receivers surrounding sparrow territories. We experimentally increased woody plant cover and perceived predation risk by placing a model shrike (*Lanius* spp.) on the territories of tracked sparrows. Using the location data, I plotted sparrow movements before and after the introduction of model shrikes and junipers. This novel approach to tracking may prove an effective method for gaining fine-scale movement data across multiple separate home ranges. The results of this project may be crucial in understanding why woody aversion is occurring in areas with pioneering woody plants further informing land managers how small increases in woody plants may affect grassland bird abundance regardless of patch size.

**Black Oak Forest Resilience Concerns and Composition Shifts Associated with Oak Wilt in a Northwestern Ohio Oak Openings**

*Tim Walters, Consultant, Haley & Aldrich*
*Co-authors: Scott R. Abella, LaRae A. Sprow, Karen S. Menard, Timothy A. Schetter*

In the dry sand forests of the Oak Openings Region of Northwest Ohio, the dominant tree species, black oak (*Quercus velutina*), is vulnerable to fungal pathogen attack. We examined the resilience of the black oak forest to the fungal pathogen oak wilt (*Bretziella fagacearum*) and its attempted containment treatment including sanitation cutting of infected oaks and root-severing containment lines in soil. At 28 sites, we compared tree structure and understory plant communities across a gradient of 1- to 10-year-old treatments and reference forest (untreated and without evidence of oak wilt). While oak seedlings were abundant at the sites, oak saplings (1–10 cm in diameter) were absent. Red maple (*Acer rubrum*) was the most common tree species in the sapling layer (over 1 cm DBH) in all sites. Black cherry (*Prunus serotina*) was the most common in the seedling (<50 cm high) and small sapling (>50 cm but less than 1 cm DBH) layers, twice as common as the second-most common sassafras (*Sassafras albidum*). This creates the long-term possibility of a shift from oak to red maple, black cherry, and sassafras in forest canopy trees. Many measures of native understory plant community were highest in oak wilt treatments. Plant species richness doubled in the treatment sites, regardless of age, compared to the reference forest. Plant cover increased with treatment age, with 6-year-old treatments exhibiting 5 times more cover than reference forest. Non-native plants averaged only a small proportion of cover across treatments and reference forest initially in a first sampling in 2020, but increased sharply (particularly Oriental bittersweet, *Celastrus orbiculatus*) by 2024. Variability in understory communities was predictable using treatment age, tree canopy cover, and geographic location. While oak wilt treatments did not facilitate oak regeneration nor many conservation-priority species of open savanna woodland habitats, the treatments did diversify and increase cover of native understory communities, though recent increases in non-native plants is a concern. With the number of oak tree deaths increasing every year, the black oak forest is slowly becoming replaced by the non-fire resistant red maple, black cherry and sassafras.

**Livestock Water Management in Natural Areas**

*Jeff Davidson, retired, KSU*

The most vital resource within natural areas is water. In recent years science has shown that livestock gains are best with high quality water. This has increased interest in protecting water resources so that the best quality water can be provided to livestock. Additionally, the management of prairie streamside riparian areas to provide a buffer for nutrient absorption prior to run-off entering the stream is considered the best way to prevent blue green algae

from forming in streams and livestock ponds. Toxic blue green algae blooms in water sources is a problem that has increased exponentially in the past 25 years in the Flint Hills of Kansas.

Providing water away from streams can reduce time spent by livestock in the riparian area by as much as 96 percent. Existing water resources can be renovated and additional water can be added to modify grazing behavior and protect water resources from livestock concentration around or in the water. Technology now allows remote monitoring of water availability and solar pumping systems allow water to be moved from a stream or pond to a more accessible location. This keeps livestock from being in the prairie stream and keeps them from damaging the streamside shoreline.

Prairie stream riparian areas are ecologically significant comprising only one to two percent of the landscape, yet have the most biodiversity in terms of vegetation and wildlife. It is also the final area where rainfall runoff travels before entering the stream. It is an important area for water quality and deserves protection from excessive use by livestock.

A team of watershed specialists of KCARE (Kansas Center for Agriculture and the Environment) updated and added to the Kansas State Research and Extension publication *Waterers and Watering Systems: A Handbook for Livestock Producers and Landowners*. The handbook was provided to all Kansas Extension, and NRCS offices. Handbook chapters include: wintertime watering; blue green algae; and remote water level monitoring. In addition, chapters have been updated and expanded including: pumps, pipelines, storage, and solar systems. Visit the Kansas State Research & Extension bookstore at https://bookstore.ksre.ksu.edu/pubs/s147.pdf to download the entire handbook.

**Lingering Hemlock Project: We Need Your Help to Restore the Mighty Hemlock**

*Olivia Hall, Lingering Hemlock Project Coordinator, Hemlock Restoration Initiative*

To date, eastern hemlocks have displayed little resistance to hemlock woolly adelgid (HWA) at the population level. The majority of eastern hemlock is susceptible to damage from HWA and therefore likely to decline and eventually die once infested with HWA. Breeding HWA-resistant hemlock populations of hemlock is a critical piece of an overall integrated pest management strategy to save eastern hemlock trees from the plight of HWA. In order for researchers to breed native HWA-resistant hemlocks, surviving, or 'lingering,' trees that may harbor a small amount of genetic resistance need to be found among wild populations. Then, these trees can be tested in a controlled setting and, if found to demonstrate some resistance, bred to increase the level and frequency of resistance. In order for researchers to breed a resistant hemlock, it is important to identify lingering hemlock for additional evaluation and genetic research. This is where tools like the lingering hemlock search protocol (developed as part of the Nature Conservancy's Tree Species in Peril initiative) and the TreeSnap application come in. We are sending out a call to anyone who is in the forest to be a part of this effort by helping us find and record these lingering hemlocks.

**Herpetofauna and Vegetation Response to Wetland Restoration in the Florida Panhandle**

*Caitlin Crocker, Field Biologist, Atlanta Botanical Garden*

The North American Coastal Plain of the southeastern US is an official global biodiversity hotspot. Within this, the Florida panhandle hosts a variety of increasingly rare wetland habitats that are facing immense pressure from coastal development, land conversion, fire suppression, and subsequent shrub encroachment. It is predicted that within the next five decades, more than one million acres of natural habitat in Florida will be lost, resulting in further wetland habitat isolation and degradation. Research related to reliable, efficient restoration strategies to return these systems to their natural state is essential for their continued existence. One challenge faced by restoration practitioners is that in-field solutions are not widely shared. Data obtained from restoration projects often lack consistent or statistically valid experimental designs to substantiate new techniques. Both hinder the widespread implementation of sound restoration.

The Atlanta Botanical Garden and the Florida Park Service formed a partnership to conduct large-scale shrub removal from wet prairies located within Deer Lake State Park in Walton County, Florida in 2015. University of Florida researchers joined the efforts in 2019 to aid in the assessment of novel restoration approaches through evaluating changes in vegetation; streamflow, groundwater, and soil nutrients; and wetland-dependent herpetofauna. This unique collaboration allows for communication of restoration techniques between field crews, field biologists, hydrologists, plant ecologists, and herpetologists, allowing questions across fields to be addressed for a systems approach to restoration. Where efforts are typically focused on monitoring impacts on a single floral or faunal species, it is very rare for a project to focus on a polyphyletic group such as herpetofauna. In addition to monitoring the response of vegetation to restoration efforts, a comparison of the diversity and abundance of herpetofaunal species are also being assessed. Wet prairie reference site comparisons are being utilized to better gauge the response of herpetofauna to restoration treatments. Because of their extreme sensitivity to changes within their environment, herpetofauna species are ideal indicators of ecosystem health and will provide a better understanding of how restoration efforts may be improving wetland habitat on an ecological scale. The goal of this interdisciplinary strategy is to ensure knowledge gained from analysis of the restoration approaches implemented during the project will guide environmental management of this type across the southeastern US. Preliminary findings related to pre- and post-restoration groundcover vegetation and herpetofauna results will be presented.

**Assessing Environmental and Host-Associated Microbiomes Along the Elkhorn River**

*Zachary McMullen, University of Nebraska at Omaha*

Anthropogenic impacts on riverine ecosystems range from acute to diffuse effects that stretch downstream from upstream focal points and may have implications for management and

restoration efforts. This project seeks to study regional differences in the riverine microbiomes of the Nebraska Elkhorn River. The Elkhorn River runs through agricultural and urban areas from North-Central Nebraska Eastward into Douglas County, which connects to the Platte River and is at risk for chemical runoff and urban pollution. This can have important implications for environmental concerns as well as public health as many portions of the Elkhorn River are used for recreation. As the river runs through these spaces, we expect microbiomes to differ in response to environmental changes from pollution. We sampled environmental (water, biofilm, and sediment) factors in four different locations along the Elkhorn River, starting at the headwaters near Stuart, NE, and ending at the Elkhorn Shores Recreation Area just outside of the Omaha metropolitan area. Using DNA extraction techniques, Miseq 16S rRNA high throughput sequencing, and subsequent bioinformatic analyses, we found that microbial communities in both the environmental and host microbiomes change from upstream to downstream locations, and that there are significant differences between host and environmental microbiomes.

**For the Love of Rare Plants: Do Something!**

*Rebecah Troutman, Natural Areas Biologist, Holden Forests & Gardens*

Effective management of rare plants is often hampered by the fear of causing unintended harm, leading to inaction among land managers. This presentation explores the lessons learned from various rare plant management initiatives, emphasizing that proactive efforts, even with inherent risks, are crucial for conservation. Through case studies and field experiences, we demonstrate that well-informed actions, guided by adaptive management principles, can yield positive outcomes for rare plant populations. The presentation aims to encourage land managers to overcome their apprehensions and adopt a more dynamic approach to rare plant conservation. Key insights include the importance of monitoring and adjusting strategies based on real-time data, the value of collaboration with experts and stakeholders, and the necessity of starting with small, manageable interventions. By sharing these lessons, we advocate for a shift from paralysis by analysis to informed action, ensuring that rare plant species receive the active management they need to thrive.

**Small Natural Area with a Large Impact: Opportunities and Challenges at the Pagosa Skyrocket Natural Area**

*Savanna Smith, Botanist, Colorado Natural Areas Program*

The Colorado Natural Areas Program (CNAP) is a small program with a big mission: to identify, evaluate, and protect specific examples of natural features and phenomena as enduring resources for present and future generations. Our humble program was written into Colorado legislation in 1977 and has designated 96 State Natural Areas through voluntary conservation agreements in the nearly 50 years since. Colorado State Natural Areas are designated with all types of landowners and can include high-quality populations of rare plants, plant communities, habitat for rare wildlife and invertebrates, and significant geologic and paleontological features.

The Pagosa Skyrocket Natural Area is an 88 acre site just outside the small town of Pagosa Springs that contains at least half of the world's known population of the federally endangered Pagosa skyrocket (*Ipomopsis polyantha*). The site was slated for development but plans were stalled once it became recognized that a federally listed species occurred there. Utilizing federal Section 6 funding, the state was able to acquire the site and designate it as a State Natural Area for the protection of the federally endangered Pagosa skyrocket.

Since then, CNAP has played an integral role in the protection, monitoring, and ongoing stewardship at this small but significant site. Annual monitoring using innovative techniques has helped elucidate the population dynamics and life history of this charismatic, short-lived species. The population size at this small site has fluctuated from a low of around 550,000 to over 2 million plants. Several questions still remain regarding specific habitat requirements and the long-term trend of the species. In addition to ongoing monitoring, CNAP helps navigate the sometimes competing demands of wildlife, noxious weeds, and water management. The site contains Gunnison's prairie dogs, a species of greatest conservation need, as well as several species of noxious weeds with similar habitat requirements as the Pagosa skyrocket. This site is an excellent case study of both the importance of small natural areas as well as the challenges of managing sites with multiple competing management priorities.

**Not Your Average Watering Hole: Wallows on Tallgrass Prairie**

*Klara Stevermer, Student, Kansas State University Division of Biology*

*Co-authors: Bess Bookout, Zak Ratajczak, Lydia H. Zeglin*

The reintroduction of bison in certain areas has modified the prairie landscape through the establishment of grazing lawns and wallows, and increased forb diversity. Unique wallowing behavior by bison leave depressions on the landscape where soil is compacted, often excluding plants. Bison wallows can fill with and retain rainwater, creating aquatic microhabitats in prairies. Microbial communities (MC) impact biogeochemical cycling, influence plant competition and community structure, and impact climate feedbacks via C and N cycling. However, little is known about MC in wallows and the abiotic factors affecting them. In summer 2023, we sampled MC and abiotic factors from wet and dry wallows and ephemeral streams in bison-grazed areas at Konza Prairie. Soil pH has been shown to have large impacts on MC, whereas aquatic pH and microbial diversity correlations remain less studied. Preliminary results show that wetted wallows and streams have a higher average pH of 8.18 and 7.91, respectively, than that of dry wallows and streams, 6.74 and 7.88, respectively. We sampled DNA from aquatic, benthic, and dry microhabitats, and expect MC in water-filled wallows to be phylogenetically distinct from adjacent microhabitats. We also expect pH, temperature, and nutrient dynamics to be drivers of MC composition in wallows.

**Effect of Prescribed Burning and Deer Exclusion Fencing on Wild Lupine (*Lupinus perennis* L.) and Associated Pollinators**

*Isabella Petitta, Pennsylvania State University*
*Co-authors: Margarita M. López-Uribe, Autumn E. Sabo*

Wild lupine (*Lupinus perennis* L.) is a perennial plant distributed from Minnesota to the east and along the Atlantic coast in the United States and southern Canada. Habitat loss and the alteration of historic disturbance regimes have contributed to population declines throughout its range. Conservation status rank varies between states and provinces but in roughly 60% of its range, wild lupine is of conservation concern. To best conserve existing populations, land managers are in need of recommended management regimes. Here we test the hypothesis that low-intensity prescribed fire and deer exclusion fencing alter wild lupine growth and pollinator visitation. We tested this hypothesis with a factorial field experiment in which we manipulated low-intensity fire (burned/unburned) and deer browsing (fenced/unfenced) across 6 sites in Pennsylvania. Floral traits and pollinator visitation were assessed in the spring before and after treatments were applied. Preliminary analysis shows there is a significant increase in percent cover of lupine in treatments that were burned and fenced. Although, no effect of treatment on population size or pollinator visitation is observed. This suggests that low-intensity prescribed fire and deer exclusion fencing have the potential to increase lupine growth one year after treatments are applied. Treatment effects on habitat and surrounding plant communities are an important consideration for conservation of this species. These effects have been measured but not yet quantified. Management recommendations should consider the use of fire and fencing in wild lupine populations although this should be further investigated.

***Elaeagnus umbellata* Control in the Virginia Northern Piedmont Region**

*Thomas Stogoski, Maintenance Technician I, Loudoun County Government*

*Elaeagnus umbellata* (autumn olive) is listed as a highly invasive species by the Virginia Department of Conservation and Recreation, Division of Natural Heritage (Virginia Department of Conservation and Recreation, 2024). Dense stands of the shrub cause barren understories, crowding out native vegetation and degrading habitat for wildlife. At Banshee Reeks Nature Preserve in Leesburg, VA, autumn olive is estimated to cover fifty-five percent of a 33-acre field referred to as the Raspberry Field. We seek a systematic approach to the control of autumn olive and reestablishment of native vegetation that can be utilized throughout the 695-acre preserve.

The current project goals are to clear two acres of the Raspberry Field of mature invasive vegetation and manage as a woodland plant community composed of vegetation native to the Northern Piedmont region. Contracted personnel use forestry mulchers attached to skid steers to break up vegetation and chip it down to a coarse mulch. Preserve staff then apply a generic glyphosate solution to the cut stumps of autumn olive. The soil is then prepared to be seeded of a mixture of native wildflower and warm season grass seeds.

Subsequent vegetation monitoring showed a desirable emergent plant density but at an inconsistent rate. The species composition showed a majority of native vegetation, mostly coming from the existing seed bank. Continued annual monitoring and invasive management will be needed to determine if the project was a success.

**Predicting Biomass Responses to Grazing with Implications for Regenerative Grassland Management**

*Maggie Anderson, Grassland Science Fellow, The Nature Conservancy*

(1) Background and Context: The Nature Conservancy (TNC) focuses on promoting sustainable grazing practices in the Great Plains region of Minnesota, North Dakota, and South Dakota. Here, the goal of sustainable grazing is to support ranchers, prevent grassland conversion to row crops, and enhance biodiversity and climate adaptability. Accurate measurement of grassland biomass response to grazing activities is crucial for assessing sustainability. Our project aims to determine whether Robel pole, grazing stick, and remote sensing measurements alone can predict biomass across TNC-managed landscapes. These estimates will help us to assess the effectiveness of these measurements across different landscapes and grazing scenarios. By comparing correlations and slopes between standing biomass and measurement techniques, we identify reliable methods and areas where additional data collection is needed to reduce uncertainty.

(2) Methods and Results: Over three years (2021–2023) and across eight sites, field crews collected measurements at nearly 600 stratified points in multiple pastures. These measurements included vegetation height using grazing sticks, visual obstruction readings with Robel poles, and standing biomass (clipped, dried, and weighed). Additionally, we extracted point-level herbaceous biomass estimates for a subset of points using the Rangeland Assessment Platform (RAP), an interactive web app designed to assist rangeland managers. Both Robel poles and grazing sticks strongly predicted biomass across all sites, regardless of pre-grazing or post-grazing status ($P < 0.001$). Robel pole readings were superior predictors of biomass (R2adj = 0.61) compared to grazing sticks (R2adj = 0.52). Furthermore, grazing reduced biomass by nearly two-fold, while resting landscapes exhibited steeper slopes compared to pre-grazing and post-grazing landscapes. Robel pole readings were reliable up to approximately 0.5m (or 30'-tall vegetation) beyond which correlations weakened, suggesting the need for additional data in mature or more productive tallgrass prairies. Preliminary analyses also revealed strong correlations between RAP-derived biomass estimates and Robel pole, grazing stick, and ground-truth biomass measurements.

(3) Conclusions: Alternative biomass approximations, particularly Robel poles, serve as strong predictors of biomass in both grazed and ungrazed landscapes across the MN/ND/SD Great Plains. Managers and ranchers can confidently rely on Robel pole data alone to estimate biomass changes in response

to grazing, although caution is still advised for landscapes with tall vegetation. Furthermore, our preliminary findings demonstrate that RAP-derived estimates of biomass from remote sensing align closely with ground-truth measurements. These findings enhance our ability to predict biomass in the field and assess the sustainability of grazing practices on TNC lands, ultimately promoting ecologically and economically mindful grazing practices in the future.

**Research, Monitoring, and the Importance of Forming Partnerships on Regeneratively Farmed Land in Central California**

*Ann Close, Director of Research, White Buffalo Land Trust*

*Co-authors: Aarushi Jhatro, Darian Rubow, Jesse Smith, Jonah Brees*

Imagine if the food we consume, the fiber that clothes us, and the medicine that heals us, could also nourish, protect, and regenerate our ecosystem and its inhabitants. Our current systems of growing food, fiber, and medicine have contributed to the ongoing crises of climate change and biodiversity loss, which in turn, have greatly impacted our ability to cultivate and grow nutrient dense foods. This perpetuating cycle of agricultural, ecological, and human health degradation has highlighted the need for a change in how we manage our agricultural and natural systems.

White Buffalo Land Trust (WBLT) practices, promotes, and develops systems of regenerative agriculture for local, regional, and global impact. Our goal at WBLT is to restore ecosystems and our relationship with the natural world through agriculture. The Center for Regenerative Agriculture at Jalama Canyon Ranch in Northern Santa Barbara County, CA, serves as our living laboratory to practice, study and develop systems of regenerative agriculture. Our team of land stewards, researchers, educators, and entrepreneurs is committed to re-designing agricultural systems in service of soil health, water, biodiversity, and human health. Our mission moves beyond the goal of 'doing less harm' and aims to generate positive impacts through each action we take.

Monitoring tools and technologies play a vital role in assessing the effectiveness of regenerative agriculture and guiding our management decisions. Monitoring in turn, helps provide the framework for our diverse research agenda. One important aspect of our research agenda is to form bridges between land stewards and the academic community so that rather than be solely adaptors of practices, farmers and ranchers will help guide research questions.

Strategically chosen partnerships are a key component to bringing all these efforts to fruition. We will share how we have leveraged partnerships across academia, non-profits, and private and governmental organizations to study (a) above-and below-ground carbon in relationship to rangeland management, (b) watershed restoration through process based rehydration and revegetation practices, (c) changes in species population and abundance, and (d) beef nutrient density and its relationship to management practices.