America's Grasslands: The Future of Grasslands in a Changing Landscape

The 2nd Biennial Conference on the Conservation of America's Grasslands

August 12-14, 2013
Manhattan, Kansas

Conference Proceedings

America's Grasslands: The Future of Grasslands in a Changing Landscape

Proceedings of the 2nd Biennial Conference on the Conservation of America's Grasslands

August 12-14, 2013, Manhattan, Kansas

Edited by

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America's Grasslands Conference participants at Konza Prairie, August 2013. Photo credit: Aviva Glaser.

America's Grasslands Conference Plenary session panelists discuss how ranchers and conservationists can work together. Photo credit: Aviva Glaser.

Introduction to the Proceedings

Lesser Prairie Chicken.
Photo Credit: USDA NRCS.

In August 2013, the National Wildlife Federation joined forces with Kansas State University to host the second ever America's Grasslands Conference - held in Manhattan, Kansas. Only a short drive from the Konza Prairie Biological Station, which just recently celebrated its 40th Birthday, the conference was located in an ideal spot to talk about grassland conservation and the future of grasslands. The conference was attended by around 215 participants from across the country, including a diverse group of researchers, conservationists, ranchers, federal and state policy experts, graduate students, and many others. The conference, which ran from August 12-14, featured over 65 speakers and included a riveting keynote by acclaimed conservation photographer Michael Forsberg, optional field trips to visit local native grasslands, a poster session, a series of roundtable discussions, and a barbeque at the nearby Konza Prairie.

For this year's conference, we chose the theme "The Future of Grasslands in a Changing Landscape." With grasslands disappearing at particularly alarming rates in North America coupled with increasingly volatile weather bringing flooding to some areas and droughts to others, along with a political landscape of uncertainty, the future of grasslands was truly a suitable theme. Grasslands continue to be one of the most threatened ecosystems in the world. Since the publication of the *Proceedings of the 2011 America's Grasslands Conference,* new data has been released showing the additional loss of millions of acres of grasslands. At this year's conference, Dr. Chris Wright, one of our plenary speakers, presented data showing that between 2006 and 2011, U.S. farmers converted more than 1.3 million acres of grassland into corn and soybean fields in the Great Plains region alone.

At the second America's Grasslands Conference, we grappled with this issue of loss of grasslands (especially since USDA does not measure the lost of grasslands in a formal fashion). We also explored and discussed other critical issues including how to raise the profile of grasslands, what federal policy opportunities exist to conserve grasslands, and importantly, how conservationists and private landowners (mostly ranchers) can better work together to conserve grasslands. The focus on working with ranchers was an important one. There was a high level of energy and enthusiasm around this issue, and participants (especially researchers) were particularly excited by the opportunity to have conversations with ranchers and other private landowners about ways to work together to conserve grasslands.

This conference would not have been possible without the help of so many dedicated individuals – including the members of the conference organizing committee, each of the conference moderators, all of the speakers and poster presenters, as well as the many participants who came to the conference. We also want to sincerely thank the conference sponsors for their financial support that was critical for making the conference possible.

Aviva Glaser
National Wildlife Federation
Event Co-Chair

John Briggs
Kansas State University
Event Co-Chair

Organizing Committee

John Briggs
Kansas State University
Sam Fuhlendorf
Oklahoma State University
Aviva Glaser
National Wildlife Federation
Eric Lindstrom
Ducks Unlimited
Ben Larson
National Wildlife Federation
Lisa Long
Kansas State University
Rob Manes
The Nature Conservancy
KC Olson
Kansas State University
Susan Rupp
Enviroscapes Ecological Consulting
Troy Schroeder
Kansas Wildlife Federation
Julie Sibbing
National Wildlife Federation

Keynote and Plenary Speakers

Keynote Address
Michael Forsberg, Conservation photographer,
www.michaelforsberg.com

Plenary Speakers
Dr. Chris Wright
South Dakota State University
Julie Sibbing
National Wildlife Federation
Chuck Kowaleski
Texas Parks and Wildlife Department
Travis Maddock
Maddock ND
Doug Sieck
Selby SD
Mike Kelly, Kelly Ranch
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Landscape Planning and Management for Grassland Conservation

Prairie Potholes and Grassland in North Dakota.
Photo Credit: Ducks Unlimited.

"A paradigm shift is needed to improve the way prairie conservation is done at the landscape level…Connect the science with those working on the land, including farmers, ranchers, and those who have lost the connection to the landscape. Restore a land ethic in America."

–Gwen White, US Fish and Wildlife Service (page 10)

Preserving Our Prairies – Where Great Migrations Begin

Randy W. Renner, Ducks Unlimited, Inc.

In 1997, Ducks Unlimited, Inc. (DU) launched the Grasslands for Tomorrow Program in North Dakota, South Dakota, and Montana. The goal of the program is to protect two million acres of grassland and wetland habitat in the Prairie Pothole Region (PPR) of the U.S.

When the Wisconsin glacier retreated from the Northern Great Plains region 10,000 years ago, it left behind a very unique and diverse landscape containing some of the most numerous, productive and diverse wetland communities in the world. These wetland habitats were intricately linked and provided nesting, brood rearing, loafing and foraging habitats for wetland dependent waterfowl, shorebirds, wading birds, gulls and passerines and also supported many mammals, amphibians and aquatic insects. The surrounding uplands were composed of vast expanses of native prairie, which provided important nesting, brood-rearing and foraging habitats for a wide array of waterfowl, shorebirds, raptors and grassland associated passerines and also supported many mammals, amphibians, reptiles and insects.

Since European settlement, over 60% of the prairie pothole wetlands in the Dakotas have been drained, filled or degraded, largely from agricultural practices. The loss rates in the PPR have been small due to the Swampbuster provisions in the Farm Bill that have been in place since

1985, but that is changing with high commodity prices. Many landowners are opting out of the farm program and relying on Crop Insurance to reduce risk. Crop Insurance is not currently linked to conservation compliance measures, including the Swampbuster provisions. Recently, new technologies and pattern tiling have accelerated the rate of wetland conversion in the PPR. These habitat losses have resulted in declines of many grassland and wetland-dependent birds that depend upon the Prairie Pothole Region for breeding and migratory habitat. Several species of grassland and wetland-dependent birds as well as plants and insects in the area are now listed as federally or state endangered, threatened, proposed, candidate or watch species because of habitat loss.

DU, along with its federal, state, and NGO partners, use conservation easements and a revolving land protection strategy that has protected over one million acres of native grassland and wetland habitat in the three states since the launch of the program.

Easements are a proven conservation tool that is especially popular with ranchers, because their cattle require the same resources as breeding ducks: grass and water. Today, there are over 900 landowners on a two-state waiting list who are eager to participate in the easement program. Although it is extremely successful, the program has had to deal with numerous challenges due to state laws, but by being innovative in numerous ways, the program has protected large tracts of grassland and wetland habitat in perpetuity.

In 2013, DU and Ducks Unlimited Canada launched a cross border initiative called Preserving Our Prairies. This comprehensive conservation plan seeks to provide nesting habitat in farmed landscapes and protect existing wetlands and prairie in the Prairie Pothole Region of the U.S. and Canada. The implementation plan includes: protecting wetlands and grasslands with perpetual easements; providing nesting habitat through Farm Bill conservation programs and promotion of winter wheat in cropland dominated landscapes; working towards effective policies that protect wetlands and grasslands; conducting research for effective and efficient targeting of conservation delivery; and leveraging resources for maximum benefit.

The Implementation and Development of the Minnesota Prairie Plan

Greg Hoch and Marybeth Block, MN Dept of Natural Resources

The coordination of people, science, programs and professionals to implement the *Minnesota Prairie Conservation Plan* has given proponents of the prairie landscape hope. Hope that functioning prairie landscapes can be protected, restored and enhanced, despite the pressures high commodity prices and other threats pose to this endangered ecosystem.

In 2010, several agencies and conservation organizations came together to develop a Prairie Plan to coordinate conservation efforts across the western third of Minnesota in order to be more organized and strategic when competing for funding and to coordinate management across agencies at a landscape scale. The plan goals include permanent protection through fee title or easement of 851,400 acres, restoration of 516,000 acres, and enhancement through burning, tree removal, and conservation grazing of hundreds of thousands of acres annually.

As part of the plan, core areas or clusters of remaining prairies were identified using GIS. Corridors connecting these cores were then modeled in GIS (Figure 1). While the prairie plan covers the entire prairie region of the state, much of the conservation effort will be focused in these core and corridor areas where there are still concentrations of native prairie and where there is still a grass based agricultural economy.

The plan also includes a monitoring component to determine the benefits of these conservation efforts on selected game and nongame wildlife as well as for sustaining plant community diversity and populations of targeted plant populations.

Ten agencies and organizations are working together to implement one plan, providing a unified vision and mutual goals for prairie landscape conservation. A memorandum of understanding commits the partners to carrying out

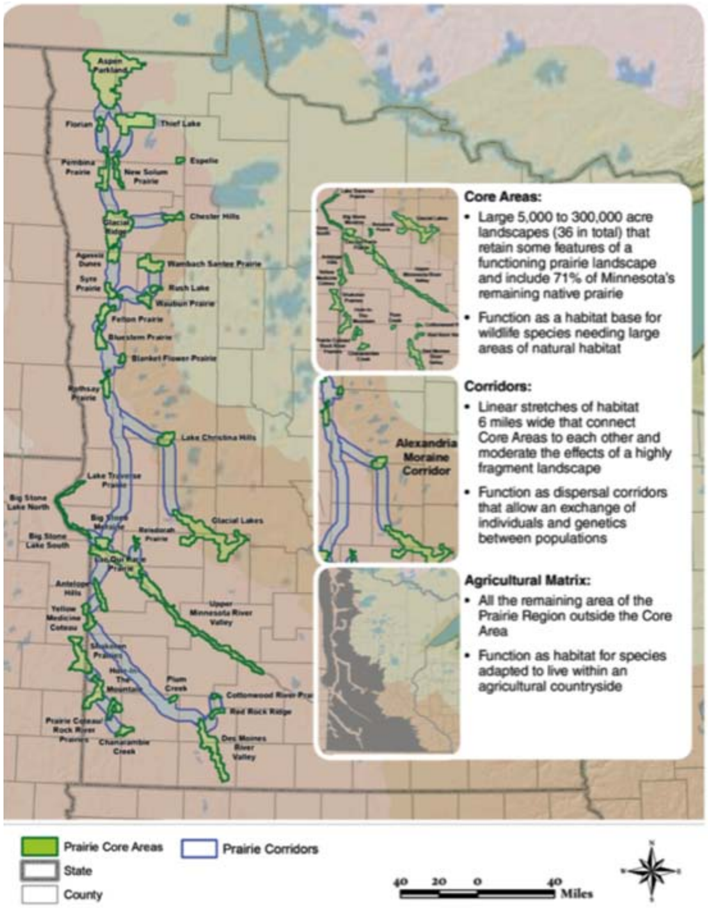

Figure 1: Prairie core areas. Corridors, and agricultural matrix, as identified by the Minnesota Prairie Conservation Plan.

strategic and cohesive actions. The primary strategy is to use the Working Lands Initiative and Farm Bill Assistance models that have shown success in working with private landowners in Minnesota's agricultural regions. These models depend on local teams of resource managers, who are familiar with the local landscapes, targeting and coordinating their efforts. The Prairie Plan has bolstered these local delivery models by providing geographic focus and strong support from regional and state conservation leaders and professionals. Teams have formed around the 10 core focus areas identified in the plan. Members include soil and water conservation district technicians, DNR wildlife managers, USFWS Private Lands Biologists, Pheasants Forever Farm Bill Biologists, The Nature Conservancy Prairie Recovery Specialists, Natural Resource Conservation Service district conservationists and other key field-level resource managers. They are supported by the partner's staff working at the regional and state levels.

All partners have agreed that the first priority is to identify key parcels for conservation action based on the existing native prairie and grassland, and to approach owners of these parcels in a coordinated manner with a consistent menu of conservation options. Other efforts with the prairie plan include developing outreach tools to explain the benefits of grassland conservation to Minnesotans. Partners are also working to demonstrate grass based agriculture can contribute to local economies and strengthen local communities while at the same time providing natural resource and wildlife benefits.

Using focal songbird species to target landscape conservation in the northern Great Plains

Marisa Lipsey, The University of Montana

Other Authors: Dave Naugle and Richard Hutto, The University of Montana; Brian Martin, The Nature Conservancy; John Carlson, Bureau of Land Management

Globally, species extinction rates are accelerating and the pressures of human development on ecosystems are mounting (Vitousek et al. 1997, Winter et al. 2006). We argue that a species-by-species approach to conservation has had only limited success in the past, and, given finite the resources available for conservation, seems unlikely to slow or stop declines into the future (Franklin 1993, Hoffmann et al. 2010, Bottrill et al. 2011, Laycock et al. 2011). Instead, implementation of effective conservation will require a broad-scale approach we refer to as "landscape conservation." Sometimes called "ecosystem management" or another related term, this approach is characterized by a broad scope in space and time, a focus on ecological process instead of individual components, and a deliberate integration of socioeconomic systems with ecosystems (Simberloff 1998, Berkes 2004, Meffe et al. 2006). We outline a four-step process in the scientific implementation of landscape conservation and show how it can be applied to the grassland ecosystem of the northern Great Plains (NGP). The four steps include: (1) selection of conservation targets (focal species), (2) identification of areas of high biological value, (3) identification of threats, and (4) targeting of management action.

Good focal species for conservation have one or more of the following characteristics: strong ecosystem interactions, close ties to ecosystem processes, high data availability, high sensitivity to threats, special conservation status, and the ability to garner public interest or support. In the NGP, grassland songbirds have excellent potential as a focal suite. In particular, our study considers a group of four northern grassland songbird species: Sprague's Pipit *(Anthus spragueii),* Baird's Sparrow *(Ammodramus bairdii),* Chestnut-collared Longspur *(Calcarius ornatus)*, and McCown's Longspur *(Rhynchopanes mccownii).* These species are excellent indicators, responding quickly and predictably to changes in climate and management (Fisher and Davis 2010). They are good trend detectors, with abundant survey data available. Each of these species is particularly sensitive to the loss and degradation of contiguous native grassland, and as a group grassland birds have shown steep and consistent population declines in recent years (Brennan and Kuvlesky 2005, Sauer et al. 2011). Two of the study species *(A. spragueii* and *A. bairdii)* have been or are currently being considered for listing under the Endangered Species Act, and a third is a federal species of conservation concern *(R. mccownii).*

Our science aims to provide tools to help identify areas of high biological value for these bird species as well as threats to their populations. We use a spatially hierarchical occupancy modeling technique to characterize the relationships between focal grassland songbirds and their habitat needs across a set of nested spatial scales including quadrangle (24 x 24 mi), township (6 x 6 mi), and section (1 x 1 mi). We plan to model the entire U.S. and Canadian breeding distribution of the focal species using survey data compiled from a collaborative network of agencies and organizations across the NGP. We use national climate and land cover data in these models to identify and target for conservation the priority landscapes occupied by the study species. Models include analyses that quantify impacts resulting from tillage agriculture and, where data are available, oil and gas well density.

Preliminary hierarchical model results for Montana show that response to the amount of cropland is scale-dependent. All species are positively associated with cropland cover at the quadrangle and township scale, but show strong avoidance at the section scale. All species showed avoidance of areas with high edge density, especially at the two broader scales. All species consistently avoided forest and woodland cover across scales. Selection for grassland productivity (measured with gross primary productivity) was variable across species and scales. Avoidance of oil and gas wells was detected only for *A. spragueii,* and only at the section scale.

Finally, we present a blueprint for how these scientific tools can be used to complete the final step in the landscape conservation process: the targeting of management action. Models create a continuous surface that represents predicted probability of occupancy by a species. Through interaction with managers and relevant stakeholders, the output of a high quality model can be used to delineate core areas of highest biological value, in which the highest proportion of a species' total population can be expected to be contained in the smallest possible area. These regions can then be overlaid with regions identified as important for other focal species and/or with areas of existing or potential future threats. Areas with high value and high threat should be the primary targets for conservation action (Bottrill et al. 2008, 2009; Kiesecker et al. 2011).

This project is currently in progress. The next steps include: finalizing species distribution models for all four species in the entire NGP, using the models to predict the effects of potential future threats from tillage and/or energy development on species distributions, and using an intensive local dataset from northeast Montana to help optimize strategies for songbird management in existing high quality grassland landscapes.

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An integrated acquisition strategy for grassland easements in the Prairie Pothole Region, USA

Johann Walker, Ducks Unlimited

Other Authors: Jay J. Rotella, Charles R. Loesch, Randy W. Renner, James K. Ringelman, Mark S. Lindberg, Randal Dell, and Kevin E. Doherty

Acquisition of perpetual grassland easements is a principal tactic used by the United States Fish and Wildlife Service (FWS) and its partners to protect upland-nesting duck habitat in the Prairie Pothole Region of North and South Dakota, USA. This public-private partnership resulted in the conservation of more than 344,000 ha of grassland during 1998–2012. Past easement acquisition has been targeted to landscapes with high expected abundance of breeding duck pairs without active consideration of probability of conversion or cost of protection. The rising cost of easement acquisition in recent years indicates that re-evaluation and refinement of the easement acquisition strategy could help to improve long-term outcomes of the easement program. We assessed regional patterns of easement acquisition during 1998–2012, evaluated the current targeting strategy, and used a combination of publicly available and proprietary geospatial data to develop a Geographic Information System (GIS) that integrated information about probability of conversion and cost of protection with current targeting criteria. Our assessment of easement acquisitions indicated that overall grassland protection was negatively affected by rising land prices during 1998–2012. In the five years between 2008 and 2012, about 100,000 ha of grassland were protected at a cost of $83 M USD. The 2008–2012 acquisitions represented about one-third (30%) of total protection during the period but composed nearly one-half (47%) of the total expenditure. We observed strong evidence of targeting of easements to priority landscapes both before and after formalization of the FWS conservation strategy in 2004. Easements acquired during 1998–2012 were nearly always located in priority landscapes (99% in ND and 97% in SD). The GIS targeting tool that we developed identified 0.9 M ha of currently unprotected grassland in the region with relatively high expected breeding duck abundance and probability of conversion and relatively low expected cost of protection. We suggest that grassland easement acquisition be refocused on this refined priority area and that an adaptive approach to future easement acquisition, including targeted acquisitions, directed monitoring, and data-based decisions, provides a logical framework for implementation of this new strategy and will facilitate continued conservation success.

Using Applied Topology to Identify Wildlife Corridors in the Northern Great Plains Ecoregion

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Other Authors: Carl A. Olimb, Ph.D., Southwest Minnesota State University

Connecting core areas through corridors is a key adaptation technique that will assist migratory wildlife in dealing with landscape change due to habitat fragmentation and climate change. Various methods for identifying corridors exist, all of which have serious limitations impacting the scale and accuracy of their output. We propose the use of Topological Data Analysis (TDA), a cutting-edge technique used to infer order from complex datasets, to identify connections between suitable habitat areas.

TDA is being used in diverse ¬fields (e.g. cancer therapy, oil and gas extraction, talent scouting in athletics) to analyze data where traditional linear methods are difficult or impossible. TDA works by displaying variables as a point cloud in a Euclidean n-dimensional space where the number of dimensions is determined by the number of (environmental) variables under consideration. Proximity and clustering determines which data points are more closely related. The resulting network can be used to identify suitable habitat areas and the connections between them.

TDA overcomes many of the pitfalls of traditional analysis because it does not rely on indices or queries (which by nature are biased) and has the ability to explore each independent variable simultaneously. TDA studies only properties of geometric objects which do not depend on the chosen coordinates, but rather on intrinsic geometric properties of the objects.

Our TDA approach follows the Mapper algorithm derived in Topology and Data (Carlsson 2009). Specifi¬cally, we will collect data for a suite of raw environmental variables (e.g. land cover, slope, distance to water) spanning the Northern Great Plains Ecoregion (one of World Wildlife Fund's 18 Global Priority Places) that are related to species distribution and connectivity. Data points (representing each environmental variable) will be used to construct an n-dimensional point cloud. Namely, the i-th data point is mapped via the following equation:

$$eccentricity(i) = \left(\frac{1}{N} \sum_{j=0}^{N-1} d(x_i, x_j)^{exponent} \right)^{1/exponent}$$

A cover (or lens) will be used to cluster the maps' level sets into nodes (Figure 2, circles). This gives rise to a topological network by identifying certain edges between pairs of nodes. Effectively, this reduces the high dimensional data set into a combinatorial object with far fewer points which can capture topological and geometric information. The resultant topological network informs similar data structure which is used to isolate wildlife corridors. Parameters are applied post-hoc to customize the results to the species in question.

For example, in our trial project focused on swift fox *(Vulpes velox)* in a subset of the ecoregion, the connectivity layer was guided by the species' preference for or avoidance of landcover, slope, and distance to roads. The network graph in Figure 2 groups the similar data; once we identify the nodes that represent known occupied/corridor habitat (e.g. large blue circles), we can visualize similar habitat (closely positioned nodes) and the degree of similarity (thickness of edge connecting the nodes), thus creating a gradient of potential corridor habitat.

Our next steps are: 1) Identify the species for corridor analysis; 2) Collect the relevant environmental data; 3) Run the ecoregion-wide TDA; and 4) Georeference nodes to source map to pinpoint corridors.

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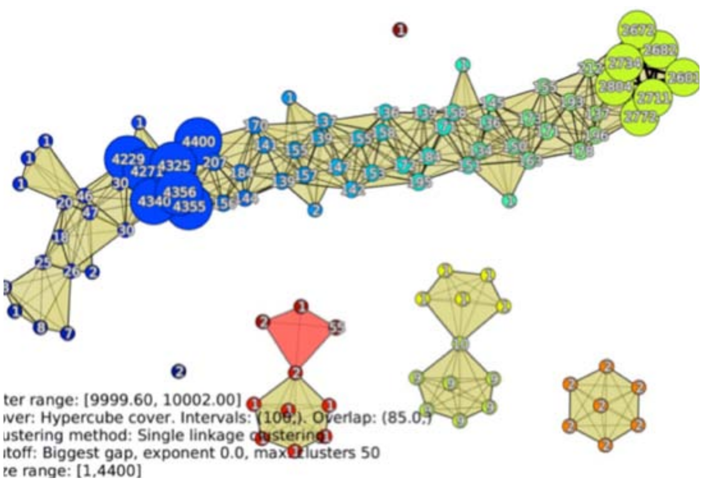

Figure 2. Resultant Topological network graph customized to connectivity of Swift Fox in a subset of the Northern Great Plains Ecoregion.

Collaborative Landscape Conservation in the Southwest Wisconsin Grassland and Stream Conservation Area

Maureen A. Rowe, Wisconsin Department of Natural Resources

Other author: Craig M. Maier, Wisconsin Department of Natural Resources

One of Wisconsin's most important landscapes for conserving large-scale grasslands, biodiversity, and ecosystem processes is also among the state's regions with the highest percentage of farmland. Partners within the 500,000 acre Southwest Wisconsin Grassland and Stream Conservation Area (SWGSCA) recognize that locally-adapted, diversified, and prosperous farm enterprises have contributed to conserving this region's outstanding natural heritage, which includes the state's greatest concentrations of remnant prairie, oak savanna, and grassland bird species, along with significant coldwater stream resources. Managed grasslands, including hayfields and improved pasture, as well as numerous unplowed prairie pastures and grazed oak savannas, have been important sources of forage for the region's numerous dairy and cow-calf beef operations. Managed grazing is maturing as a production system in the Upper Midwest, and growing consumer demand for local, grass-based dairy and meat products can provide market-based opportunities to limit further conversion of grasslands to row crop production. Primary methods for protecting and enhancing this rich natural heritage for the future include: 1) protecting land in several Bird Conservation Areas (BCAs) through easements and purchase from willing sellers; 2) documenting baseline grassland bird populations and identifying additional remnant plant communities; and 3) strengthening relationships with farmers and other agricultural partners through mutually-beneficial partnerships such as the SWGSCA Grazing Broker Project. During development of the SWGSCA master plan, three BCAs were delineated through a rigorous process to identify areas with high concentrations of grassland and to avoid prime agricultural land. Initial bird survey results suggest that populations of five grassland bird species of concern are higher within BCAs than areas sampled outside of BCAs. The Wisconsin Department of Natural Resources, The Nature Conservancy, The Prairie Enthusiasts, Driftless Area Land Conservancy and other partners have begun to protect land within two 2,000-acre BCA cores. The prairie remnant survey incorporated high resolution aerial photography and landowner visits, and ecologists are currently working with willing landowners to restore hotspots of biodiversity located via the surveys. The Grazing Broker project is also poised to help conserve previously-unidentified remnant plant communities as grazing specialists visit private lands to survey grassland resources and develop managed grazing plans.

LCC Prairie Breakout Session: Help us set the 21 Century Science Agenda for Six Landscape Conservation Cooperatives!

Gwen White, Eastern Tallgrass Prairie & Big Rivers LCC, US Fish & Wildlife Service

Other Authors: Glen Salmon, Eastern Tallgrass Prairie & Big Rivers LCC; Rick Nelson, Mike Olson, Plains & Prairie Potholes LCC; James Broska, Great Plains LCC; Greg Wathen, John Tirpak, Gulf Coastal Plains & Ozarks LCC; Genevieve Johnson, Aimee Roberson, Desert LCC; Bill Bartush, Cynthia Edwards, Gulf Coast Prairie LCC

Figure 3: Landscape Conservation Cooperatives.

Landscape Conservation Cooperatives (LCCs) seek to collaboratively identify best practices, connect efforts, identify gaps, and avoid duplication through improved conservation planning and design in a heavily modified and fragmented landscape across the prairie region from Canada to the Gulf Coast.

Staff from six LCCs described how these collaborations are addressing prairie conservation goals by outlining: in what context(s) they are managing prairies; what endpoint(s) they are trying to achieve; objectives for species, water quality, recreational, and other ecosystem services; and what metrics would indicate success at key leverage points leading to desired outcomes.

Examples from LCCs across the region demonstrated how LCCs can support landscape level prairie conservation. The Plains & Prairie Potholes LCC (#1 on Figure 3 map) is supporting projects on projects on important aquatic and terrestrial species, tile drainage, Kentucky bluegrass and smooth brome management, carbon sequestration and expiring CRP, and diversification of the landscape and economic diversity of small towns. The Eastern Tallgrass Prairie & Big Rivers LCC (#2) is focusing on strategic planning to restore and connect wildlife with people on intensive working landscapes from large-scale prairie and river restoration to conservation in agricultural and urban contexts. In response to LCC science needs, the Northeast Climate Science Center funded research on climate impacts on grassland birds. The Great Plains LCC (#3) is identifying resources, threats, management actions and science needs for habitat-species relationships and indicators that evaluate success. The Gulf Coastal Plains and Ozarks LCC (#4) is working on conservation practices, landscape design and conservation targets to define ecological states for prairie habitats. Currently, the LCC will fund $1.75 million in 5 topic areas: integrating conservation goals, evaluating species-habitat relationships, characterizing ecological flow, quantifying ecosystem goods and services, and addressing targeted science needs. The Desert LCC (#5) is developing applied science think tanks and science needs assessments for six critical management questions related to: water management and climate change; monitoring species and processes relative to climate change and related threats; grassland and shrubland management; physiological stress of climate change; changing wildlife regimes and riparian management; and impacts of climate change on amphibians and reptiles. The LCC is identifying the greatest threats to grassland and shrubland across the U.S. and Mexico, as well as areas that are likely to be resilient to climate change and other threats and areas with high potential for restoration. The LCC is currently inventorying ongoing efforts, science projects, and data, and working to fill gaps and strengthen conservation networks and partnerships. The Gulf Coast Prairie LCC (#6) is funding six ongoing projects and finalizing 4-5 more within five science themes: prairie, submersed aquatic vegetation, inventory and monitoring, Gulf Coast vulnerability, and human dimensions. Projects include decision support tools for prairie conservation, identification of focal species and habitats to focus limited resources, and a grassland management inventory tool.

Photo credit: Joseph Smith.

Discussion with session participants

Dialogue between the audience and panel of LCC staff addressed topics ranging from human dimensions to on-the-ground management techniques for native prairie conservation. Participant questions and responses from panel and audience members are summarized below.

How and why were LCCs established?

The concept for Landscape Conservation Cooperatives was initiated by Sam Hamilton, a past U.S. Fish & Wildlife Service director as a new approach to strategic habitat conservation by addressing landscape scale issues through self-directed regional partnerships.

What do LCCs need to address at a landscape scale?

Connect the science with those working on the land, including farmers, ranchers, and those who have lost the connection to the landscape. Restore a land ethic in America. Take a habitat based approach – but measure the results of the action – getting to adaptive management. Do not do research in a vacuum. Conduct research that has immediate utility by reducing uncertainty for managers and which has a direct effect on land management decisions.

What are some examples of how LCCs incorporate social science?

The cultural resources aspect is part of the landscape for LCCs. For example, the Great Plains LCC is hosting outreach meetings to consider landowner attitudes towards playa conservation, including duck hunting. The Plains & Prairie Potholes LCC has completed a study of the role of healthy landscapes in supporting healthy local economies. The Mississippi River Basin LCCs are exploring how social capacity influences adoption of conservation practices that address Gulf hypoxia. Both the Eastern Tallgrass Prairie and Upper Midwest & Great Lakes LCCs are convening urban conservationists to explore the context of metropolitan and small town environments.

How can LCCs reflect a sense of urgency about native prairie conservation?

As a regional initiative, LCCs can identify those configurations among broad landscapes and partners that promote conservation of prairies at large scales. To date conservation has been disjointed; each state has taken a different approach without investing in a strategic collaboration across regional jurisdictions. Conducting "random acts of conservation" with inadequate coordination at the landscape level has been the reality. In some parts of the region, LCCs may facilitate state interaction to link State Wildlife Action Plans (SWAPs) and derive conservation strategies on a grander scale. Identifying common conservation goals, aligning actions, developing region-wide habitat maps and optimizing funding roles for partners at larger scales would help implement prairie conservation more effectively across the landscape.

The landscape scale makes sense, but in terms of research, what is new about this approach?

LCC partners gain insight by using new landscape-level approaches and learning from each other about management at larger scales. Partners are leveraging research and sharing datasets. The LCCs provide a larger forum to connect resources with researchers, connect researchers to each other and to managers, and to connect partners. As an example, getting five states to estimate populations of Lesser Prairie Chicken in the same way was a big step, as was coordinating systems for land cover data among multiple states.

What would participants suggest as next steps for prairie conservation among LCCs?

Participants commented on the following potential roles and approaches for LCCs regarding prairie conservation. LCCs can facilitate connections between researchers and other stakeholders (e.g., urban landscape planners and others). Participants had heard a lot about LCCs but information provided specifically about prairie conservation was new. There are barriers and structural problems to overcome in landscape conservation. In terms of data needs, coordination of broad scale cross-regional sampling and standardization of broad scale data sets with consistent methods through time and space are extremely important. A paradigm shift is needed to improve the way prairie conservation is done at the landscape level. Invasive species issues must be a priority. The grassland habitat monitoring team can collaborate on availability of information, such as synthesizing and interpreting records of what has been done for prairie management, even if it isn't data specifically. Practitioners need to define success and what success means in terms of the ecosystems. Monitoring birds alone may not indicate if the prairie ecosystem is functioning; additional taxa may be needed.

At the conclusion of the session, the LCC staff invited participants and their colleagues to work together to advance landscape-level prairie conservation across the larger region as an effective network of researchers, managers and other partners by participating in LCC activities.

For more information or to provide input on the LCCs, Gwen White can be contacted at gwen_white@fws.gov

Grassland birds. Photo credit: Kent Mason.

2

Innovative Ways to Create Economic and Working land Opportunities for Grasslands and Livestock Producers

Photo credit: Joseph Smith.

"Well managed pastures have multiple benefits, such as improving soil health, reducing soil erosion and nutrient runoff for improved water quality, and providing high quality grassland wildlife habitat."

—Laura Pain, *Contract Grazing in the Upper Mississippi River Basin* (page 21)

Restoring prairie for agricultural production and profit

Cody J. Zilverberg, South Dakota State University

Other authors: W. Carter Johnson, South Dakota State University; David Archer, Agricultural Research Service, United States Dept. of Agriculture

As annual crop prices increase, the remaining tallgrass prairie disappears at an alarming rate despite its rarity and the many ecosystem services it provides. New income streams derived from prairies might increase their economic position relative to annual crops and slow or reverse the land conversion trend. One such approach in eastern South Dakota is the EcoSun Prairie Farm, where a 650-ac corn-soybean farm has been restored to native prairie plants (Zilverberg et al., 2014). Restoration began in 2008 and has included establishment of monocultures for seed production (three ecotypes of switchgrass, prairie cordgrass, and prairie wedgegrass) as well as mixed-species plantings used for grazing and hay. Mixtures range from relatively simple (five species of warm-season grasses) to complex (>100 species of warm-season grasses, cool season grasses, and forbs). Establishment techniques have included transplanting plugs started in a greenhouse, drilling clean seed into the ground, and "snow-seeding" by broadcasting bulk seed during winter. Thirty wetlands have been restored, some virtual monocultures of prairie cordgrass or prairie wedgegrass, and others with a higher diversity of species. Fire, grazing, mowing, manual weed control, and herbicides have all been used to maintain restored fields.

Farm objectives are to identify and demonstrate the productive potential and economic value of native prairie plants. This has been accomplished through farm-scale harvests and small plot experiments. Biomass, cut by hand at ground level each autumn, has been greatest for switchgrass and prairie cordgrass (~5.9 tons/ac), followed by mixed species plantings (~4.2 tons/ac). Two small plot experiments showed 22% less biomass produced by mixed plantings of 13 prairie species, compared to switchgrass monocultures, after three years of data collection. Ongoing research seeks to identify strategic mixtures of native plants that thrive at different landscape positions (shoulderslope, backslope, and footslope), to increase diversity within switchgrass monocultures while maintaining high biomass yields.

Switchgrass and prairie cordgrass monocultures also outyielded more diverse mixtures when harvested with field-scale equipment, despite being harvested for seed with a field combine before being harvested for hay. In 2012, mean autumn-harvested biomass, accomplished by windrower that left a 5-in. residue and a large round baler, was still 2.2 tons/ac across all field types, despite experiencing the driest summer on record.

Grazing by 75 beef stocker heifers was first implemented in 2011 with two objectives: 1) to utilize cattle as "ecosystem engineers" to create targeted disturbances at times and places determined by the farm manager, and 2) to diversify our revenue streams for the biomass produced on the farm. Grazing fees were received from the owner of the cattle. In addition, five heifers were selected for direct marketing of "prairie-raised" beef in 2011. Beef production was increased to 25 heifers in 2012, and EcoSun currently sells to two restaurants, two grocery stores, and many individuals in the local area.

Seed production has been the most important producer of net revenue for the farm since its inception. However, as hay and grazing production increased in recent years, the proportion of gross revenue from the three income streams has converged, so that seed (35%), hay (28%), and grazing/beef (37%) gross revenue were similar in 2012. Preliminary economic analysis indicates that net revenue has increased on the Prairie Farm each of the past 5 years, as establishment costs declined and revenue increased. The farm does not rival corn profitability at the historically high prices of recent years, but net income is sufficient to support a landowner interested in conservation. There are also existing markets not yet exploited on the farm, including the sale of hunting rights and eco-tourism, and potential markets for biofuel feedstock and carbon credits.

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America's Grasslands: Understanding market drivers to increase market opportunity

Anna Bassett, Animal Welfare Approved

Other Author: Andrew Gunther, Animal Welfare Approved

The demand for sustainable products is growing in the US. There is more interest in where food comes from and how it is produced. As consumers learn more they increasingly demand pasture-raised and grass-fed meat and dairy products. In 2012, food industry trend watcher, the Hartman Group, cited grass-fed meat, healthy fats, real butter, cage-free eggs, heirloom marbled pork, and the family dinner as growing trends. In response to this change in consumer demand the market is looking for new suppliers. This demand may be based on food safety concerns, environmental concerns, possible human health benefits or animal welfare concerns.

Studies show that not only are consumers moving towards these product choices, but they are also prepared to pay more for them. Growth in demand has encouraged more retailers to stock grass-fed and pasture-raised products, and although the market share is currently small (for example the "alternative" beef is only estimated to be 3% of the total), it appears to be growing at up to 20% per year.

Consumers want these sustainable and grass-fed products because it fits within one or more of the following matrix of reasons for purchase:

- Good for the environment
- Good for human health
- Support for local and/or family farmers
- Good for animal welfare

Different consumers have different drivers for their purchasing behaviors, but one thing they all have in common is the willingness to pay more for a product that meets their requirements.

This opens a market opportunity for farmers who are either raising livestock in a way that delivers on consumer expectation or for those who are grasping the opportunity to increase margins by appearing to meet consumer expectation. This latter "opportunity" has been behind a proliferation of unregulated claims such as "free range", "green-fed" or "naturally raised" which sound as though they deliver sustainable grass and pasture based products but which may well not. Third party verified claims and programs such as Animal Welfare Approved give the consumer confidence that they are getting the product they are paying for and this confidence is an important part of sustaining and building the market. If consumers become disillusioned

Market demand offers a huge opportunity for farmers to place greater value on their grassland and to achieve a better return from it. Well-managed pasture based production leads to a reduction in the amount and cost of external inputs while maintaining and even improving pasture production. Different grazing techniques such as mob grazing and rotational grazing can be tools to achieve this. Mob grazing is when animals are kept at far higher densities than normal but are also moved to new areas of grazing far more quickly than normal too. The theory is that this grazing pattern mimics the behavior of wild herbivores under the threat of predators. The benefits of mob grazing include reducing the time spent in each grazing area, minimizing damage due to trampling. Longer recovery times between grazing activity also allows for better regrowth. Rotational grazing still requires farmers to move animals round their pastures but at lower stocking densities and generally at slower rates than mob grazing.

Other options for management include maximizing the use of manures from the farm as well as selection and utilization of different forage species. For example forbs tend to be deeper rooting than grasses. Deeper root systems help support healthy soil structures with a resultant reduction in problems such as erosion as well as improvements in drainage and aeration. Using legumes can increase fertility in the pasture through the nitrogen fixing properties of these plants. They can also have a high feed value so increasing livestock live weight gains.

Other benefits of meeting the market demand for sustainable grass based products could be for beef farmers who can start to market finished animals and begin to take control of their production from birth to slaughter rather than shipping stockers to feedlots.

Other species can also be integrated into the pasture based system giving access to additional markets as well as benefiting farm management: for example laying hens following beef cattle provide eggs for sale and help with parasite control. As an alternative option grazing sheep or goats with cattle allows better utilization of grassland due to the different way these species select and utilize different forages.

The techniques for good grassland and livestock management are available; the market increasingly demands the end products – grass based livestock production is the future.

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The techniques for good grassland and livestock management are available; the market increasingly demands the end products – grass based livestock production is the future. Brokering Relationships Between Non-Farming Landowners And Livestock Producers to Increase Grasslands in the Upper Midwest

Brokering Relationships Between Non-Farming Landowners and Livestock Producers to Increase Grasslands in the Upper Midwest

Laura Paine, WI Department of Agriculture, Trade, and Consumer Protection

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The Southwest Wisconsin Grassland and Stream Conservation Area is a 500,000 acre island of grassland-dominated habitat in a sea of annual row crops. Cold water trout streams and relatively high populations of grassland birds dominate the region. Conservation partners have nurtured this grassland using tools such as land and easement purchases, set-aside programs, landowner education, and cost-sharing of conservation practices. Most recently, as commodity prices push landowners toward growing more annual crops, we are exploring market drivers as a tool to preserve grasslands. Pasture raised meat and dairy products are in high demand among consumers, but grassland for grazing livestock is often unavailable to farmers wishing to access this market. This project targets non-farming landowners who control a high proportion of agricultural land in this region. These landowners are diverse, and given a range of possibilities, may choose land management options that balance economic and environmental goals. The goal of the Grazing Broker project is to make those options accessible and at the same time, provide value-added livestock producers access to pasture. The Grazing Broker is modeled after the private consulting forester, brokering relationships between the landowner and the 'resource harvester,' in this case, livestock producers harvesting forage. The broker works to create a mutually beneficial partnership to manage the grassland for its conservation value as well as to produce an income for both parties. The broker shepherds the relationship, developing a grazing plan, connecting both landowner and producer with resources needed to develop fencing and other infrastructure, and providing assistance with lease agreements. As part of this project, we have developed a landowner profile tool for identifying landowner goals, assessing the pasture resource, and calculating a value as a starting point for negotiation with potential renters. This presentation will share the profile tool as well as the successes and challenges of the Grazing Broker project. Our ultimate goal is to replicate the model regionally through partnership with Green Lands Blue Waters, a collaborative effort among agencies, universities and non-profits to promote continuous living cover throughout the Mississippi River Basin.

Canadian Prairie Rangeland – An Environmental Marketing Opportunity?

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The Canadian Prairie provinces account for 83 percent of Canada's agricultural land and encompass over 50 million acres of tame and native rangelands. During the dust bowl of the 1930s, the Canadian federal government took over management responsibilities for many abandoned and fragile lands – some cultivated and some in native grasses. As a result, the government established the Community Pasture Program (CPP) comprised of 85 pastures ranging from 3,000 to 100,000 acres each. These pastures contain some of the largest contiguous tracts of native rangelands in Canada. Seventy-three (73) percent of the CPP lands are native rangeland, 16 percent are seeded pasture, 8 percent are woodlands, and the remainder is water bodies or other mineral lands.

The land, capital improvements, biodiversity, and other environmental assets of the CPP have an estimated value in excess of one billion dollars and have been publicly funded since 1935. The grazing and breeding operations of the program have been privately funded through fees collected from the pasture patrons. In 2012, the Government of Canada committed to transfer management of the CPP lands to the Provinces of Manitoba and Saskatchewan, which in turn are looking to pasture patrons to manage the land. Because pasture patrons are in the ranching business to make money and not to provide public environmental benefits or environmental goods and services (EGS), market instruments are needed to encourage patrons to protect the species at risk that use those pastures and maintain the natural capital that has accrued significant value over the past eight decades.

The private and public benefits provided by federal rangelands and the potential to capture market opportunities are discussed as a means to stimulate dialogues about the questions: (i) should the environmental benefits be part of a discussion on public ownership of CPP lands, and (ii) if so, how and to whom should the economic value of the environmental benefits be distributed?

The original 1937 mandate of the CPP was to reduce soil drifting and stabilize soil conditions and policy makers believe this goal has been met. In 1979, two new objectives were identified: (i) Public – conservation of the resources; and (ii) Private – provision of livestock services. Kulshreshtha et.al. (2008) undertook a comprehensive economic analysis of the public and private benefits of the Community Pasture Program. Given the fee structure that was used at the time, it was determined that the public paid 47 percent of the costs but received 62 percent of the benefits of the federally managed rangelands.

The pasture patrons, or private sector, paid 53 percent of the costs but only received 38 percent of the benefits (Kulshreshtha et.al., 2008). The Canadian public received more in ecological goods and services (or public benefits) than they were paying for, or stated in business terms the public received an excellent return on its investment.

From a policy perspective, this imbalance in public-private costs and benefits has led to continued questioning about whether the fee structure for pasture patrons should be changed. However, from a political perspective pressures from ranchers and other industry group users (i.e. mineral extraction) prevented fees from increasing.

The private benefits from access to grazing, breeding bulls, and water are easier to quantify than the broad range of public benefits (ecosystem function) and quasi-public/private goods and benefits (social functions and other external benefits). Most public benefits, such as: biodiversity, wildlife habitat, endangered species protection, wetlands, flood protection, heritage sites, soil conservation, and other social or environmental goods and services do not have readily identifiable markets and their values are more difficult to calculate.

Despite the difficulty, numerous studies have attempted to determine the market values of ecological goods and services associated with rangelands. The University of Manitoba estimated the total value of the 7.6 million acres of grasslands in Manitoba ranges from $92 to $331 per acre. Heindenreich's 2009 study identified values of global temperate grasslands that range from a low of $77 per ac/yr (Constanza et.al., 2006) to a high of $655 per ac/yr (Wilson, 2008). Other studies have identified economic values arising from specific components of rangeland landscapes. For example, Olewiler (2004) estimated riparian restoration has a value of $27 per acre, while Hill et.al. (2011) suggest that landowners are willing to accept $48 per ac/yr to restore wetlands. Pattison (2009) concluded that taxpayers are willing to pay $360 per household on an annual basis to restore wetlands to 1968 levels or $290 per household annually to retain existing wetlands. If the appropriate market can be established there are willing buyers and sellers for ecological goods and services in Canada.

Kulshreshtha et.al. (2008) derived values for both private and public costs and benefits of the CPP. Private costs are predominantly for breeding and grazing services and amount to approximately 56 percent of the annual costs of operating the CPP; however, the ranchers using the program pay only 53 percent of the total costs. Breeding and grazing benefits only amount to 39 percent of the total benefits of the program. In contrast, the public costs range between 44 and 47 percent and the public benefits are approximately 61 percent of the total benefits of the CPP to the economy and the environment. The economic value of the public benefits derived by is $40.05 million Kulshreshtha et.al. (2008), while the private benefits are estimated to be $24.71 million[1]. The imbalance of who pays the operating costs versus who receives the benefits from the CPP lands has frequently raised policy debates about the investment of taxpayer funds in the CPP.

On April 18, 2012 the Government of Canada announced that *"to ensure long-term prosperity for farmers and the entire agricultural value chain, Agriculture and Agri-Food Canada (AAFC) is refocusing on the changing priorities of the agriculture industry …we will work in collaboration with our provincial partners and with all stakeholders to make sure the transition away from federally operated pastures is as smooth as possible for producers.*" (Gerry Ritz, Minister of Agriculture and Agri-Food). Given the value of the public goods and services and the federal policy change, conservation groups and pasture patrons have been discussing issues and opportunities for the future maintenance of the public and private benefits of the CPP. Conservation groups want to identify means to maintain the ecological goods and services and protect the long-term investments that have been made in the CPP resources over the past 80 years. While the provincial governments have committed in principal to the continued ownership of the land base, pasture patrons are exploring with the federal and provincial governments a number of different models for joint management and operation of the grazing and breeding programs.

Conversion of the CPP rangelands to annual crop production or other uses would not be in the Canadian public interest given their substantial investment over the past 80 years and the potential for ongoing public benefits. As grasslands disappear, so do the associated wetlands and riparian areas that provide many ecological goods and services. The policy debates taking place across North America about the future of grasslands should consider options to retain the remaining grasslands, wetlands, and riparian areas within agricultural landscapes. Similarly, climate change adaptation strategies should include grassland management and retention of wetlands.

Additional investments need to be made in economic valuation studies that specifically aid in the identification of the value of grasslands and more informed land use policy decisions.

Agricultural land managers and landowners can benefit from improved knowledge about the range of public and private benefits that grasslands afford. Conservation organizations are well positioned to provide this information and to help land managers make well informed decisions so they can generate profit *while* providing EGS to the public. Government economists, planners and decision makers have the ability now to develop inventories of grasslands, wetlands, and other natural resources, but they should be better trained in grassland and wetland valuation techniques. Government decision makers need to continually improve their understanding of the wide range of ecological goods and services provided by rangeland ecosystems and the opportunities for investment in these important public natural resources.

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Audubon's Prairie Bird Initiative

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Despite decades of concerted efforts from public and private sector partners, grassland birds continue to show precipitous population declines throughout their ranges. If we are to have better conservation outcomes for Prairie Birds, we need to forge more effective partnerships with the men and women whose land management decisions ultimately determine their fate: ranchers.

Audubon and its partners are now working to develop and deploy market-based support for ranching that is ecologically and economically sustainable. We believe that changes in consumer demand mean new opportunities for conservation-minded ranchers and we are working to help connect those producers with premium markets for their beef. We call this effort, the Prairie Bird Initiative.

Our presentation covered our goals, approach, ecological endpoints and monitoring, market feasibility and early results of our pilot work.

Managing Grassland for Carbon and Cattle

Ashley Rood, Environmental Defense Fund and Randal Dell, Ducks Unlimited

Grasslands cover large parts of the planet, storing significant amounts of carbon while providing important forage for livestock under both public and private working lands. This carbon benefit has new value in developing voluntary carbon markets and the recently implemented California carbon market. Voluntary carbon markets have been operational since the early 2000s in North America, with many producers familiar with the now defunct Chicago Climate Exchange, or CCX. At present there is an international regulatory carbon market that is not directly relevant to producers in North America. This market, the Clean Development Mechanism of the Kyoto Protocol, recorded $6.2 billion in offset sales in 2012, compared to the strictly voluntary market which transacted $523 million in 2012 with North America providing $151 million worth of offsets for the market (Peters-Stanley and Yin 2013).

Approximately 90% of these voluntary buyers are large corporations that are motivated by Corporate Social Responsibility (CSR) initiatives, desire to demonstrate climate leadership, pre-compliance motives and/or Public Relations/branding (Peters-Stanley and Yin 2013). Ranchers and other grassland landowners can potentially produce carbon offsets for this voluntary carbon market but the greatest opportunity for North American Grasslands will be with the newly implemented California compliance market, which went into effect on January 1, 2013. Projections of the market size for the California market forecast a $1.8B market in 2013 which will increase into a $10B market in 2016 (Next 10, 2012). Offsets, or certifiable emission reductions achieved by a non-regulated entity, will be an important cost-containment mechanism for the program. Current projections of the market forecast a shortage of offsets in the coming years as the number of regulated entities covered under the market increase. As of August 2013, only four offset projects are eligible: Ozone Depleting Substances, Forests, Urban Forests and Livestock (manure lagoon management). Projected offset supply under the four approved protocols will not meet expected demand with a 29% shortage projected for the short-term, increasing into a 67% shortage without the recognition of additional offset project categories (Stevenson et al. 2012). This shortage is where agriculture and grasslands can play an important role, with near term projects of potential including nutrient (N_2O) management, rice (CH_4) and soil carbon sequestration and retention in rangelands

Ducks Unlimited and the Environmental Defense Fund have been working with partners to develop the science, accounting methodologies and policy frameworks to include grassland-based carbon offset projects into voluntary and compliance markets. These efforts have focused on protocol and project development for Avoided Grassland Conversion and for Compost Additions to Grazed Grassland.

An Avoided Grassland Conversion project quantifies the carbon benefits of retaining soil organic carbon in grasslands. These projects are potentially viable because of the scale of continued grassland conversion. Annually, between 2007 and 2011, an estimated 75,000 acres of rangeland were converted in North Dakota, South Dakota, Nebraska and Kansas (Claassen et al. 2012). Estimates of conversion for all grasslands have been estimated at 1.0 to 5.4% in the Western Corn Belt from 2006 to 2011 (Wright and Wimberly 2013). With the assistance of USDA Natural Resource Conservation Service Greenhouse Gas Conservation Innovation Grant, DU and partners are working to bring Avoided Grassland Conversion projects into the market space.

Another protocol, Compost Additions to Grazed Grasslands, quantifies both the avoided emissions of diverting compostable materials out of landfills, as well as the increased carbon stored in the soil through compost application. Through the research of Dr. Whendee Silver's lab at UC Berkeley and the Marin Carbon Project, a one-time application of one inch of compost on a ranch in California's north coast resulted in a carbon sequestration rate of 0.6 to 4.1 t CO_2-eq ha^{-1} y^{-1} (Ryals and Silver 2013). In addition to the increased soil carbon sequestration, these sites also saw a 50% increase in forage production for cattle as well as increased water retention in the soil.

Despite the gains made in advancing grassland-based offset projects, challenges still remain. Offset protocol design, and the requirements or burdens they impose on landowners and producers, can determine the success or failure of a project. Further, the economics of project development are challenging under current and historic offset prices. The projected economic payments from offset sales are often not sufficient to incentivize the adoption of practices on their own, requiring additional motivations or payments for practice adoption. An additional challenge encountering most new project types is the need for additional greenhouse gas measurements, which are typically costly and require multiple years of research. Concentrated efforts by the USDA and others to support and concentrate research efforts are ongoing, but it's likely that continuous science support will be needed for robust greenhouse gas measurements and offset markets.

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Photo credit: Joseph Smith.

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Contract Grazing in the Upper Mississippi River Basin

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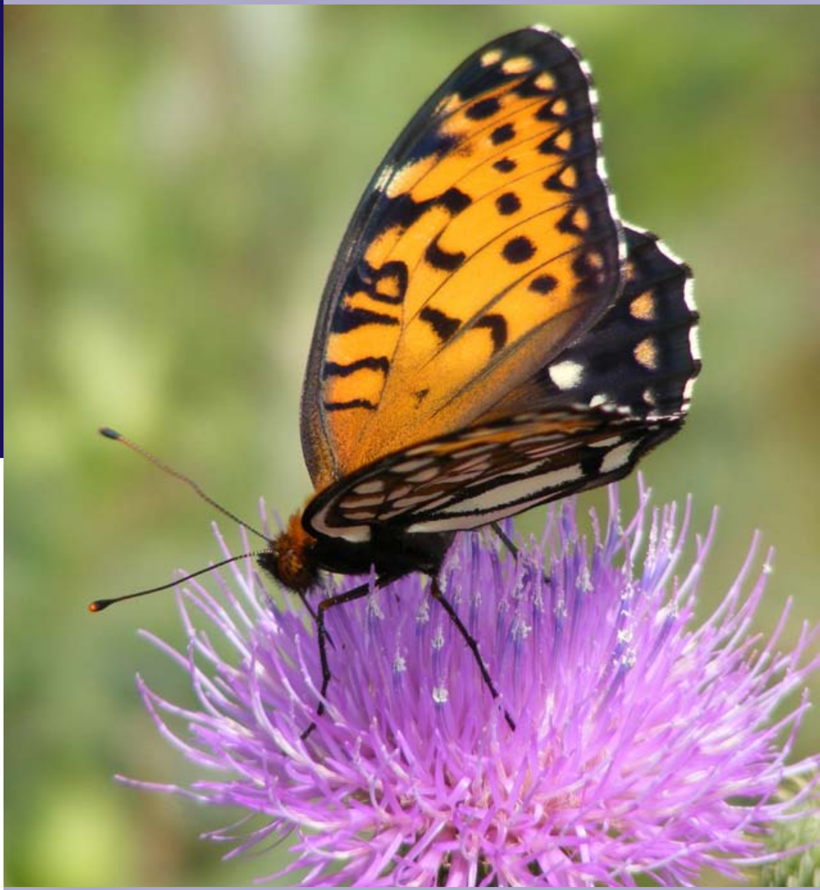
In the Upper Mississippi River Basin, annual row crop agriculture dominates the landscape and has effectively replaced the native tallgrass prairie. Managed grazing represents a potential economically viable way for perennial grassland to be re-established on some acreage in the region. Well-managed pastures have multiple benefits, such as improving soil health, reducing soil erosion and nutrient runoff for improved water quality, and providing high quality grassland wildlife habitat. A main constraint to increasing the number of farms adopting managed grazing is that planning and managing a pasture system and caring for livestock can involve a significant investment of the farmer or landowner's time and resources. The Midwest Perennial Forage and Grazing Working Group (part of the Green Lands Blue Waters collaborative) has identified contract grazing, in which land ownership, livestock ownership, and management of the system are de-coupled, as a means of overcoming this challenge. While fairly common in the more arid Plains states, contract grazing arrangements are rare in the Upper Mississippi River Basin. The Midwest Perennial Forage and Grazing Working Group worked to adapt contract grazing practices specifically for this region, where land rents are higher and dairy and cash grain production are more common. The group has created a series of informational factsheets to be used to provide much needed information about contract grazing to landowners and livestock owners to promote this effective practice.

3

Monitoring and Predicting Grassland Conversion and Implications



Regal fritillary butterfly on a native thistle.
Photo credit: Laura Hubers/ USFWS.

To Plow or Not to Plow: Investigating Grassland to Cropland Conversion in the Northern Great Plains Using Systems Dynamics

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Introduction and Purpose

From 1997 to 2007, 23.7 million acres of grassland were converted to cropland. Fifty seven percent were located in the Northern Great Plains (NGP). Since 2007, another 23.7 million U.S. acres have been converted with the majority located in the NGP (Faber et. al 2012). The short term positive benefits have been increased returns to farmers and food production. However, there could be unintended consequences through loss of ecosystem services like water quality maintenance, wildlife habitat loss/fragmentation, and decreased carbon sequestration. The principal objectives of this work were to: 1) identify structural features influencing land use decisions, 2) quantify implications for land management, and 3) forecast potential unintended consequences from those decisions.

"The disappearance of a major natural unit of vegetation from the face of the earth is an event worthy of causing pause and consideration by any nation. Yet so gradually has the prairie been conquered by the breaking plow, the tractor, and the overcrowded herds of man…that scant attention has been given to the significance of this endless grassland or the course of its destruction. Civilized man is destroying a masterpiece of nature without recording for posterity that which he has destroyed."

—John Ernest Weaver, *North American Prairie* (1954)

Methods

This was achieved through triangulation of qualitative and quantitative data using a systems dynamics approach. Triangulation is defined as a procedure to find convergence among different sources of information to form themes in a study (Creswell and Miller 2000). The three spokes of triangulation are: 1) qualitative information gathering through interviews with system stakeholders (farmers, ranchers, and influencers) to identify relevant factors and themes; 2) using system dynamics modeling to link identifiable themes; and 3) quantitative data incorporation to test themes and identify potential outcomes. System dynamics methodology is a unique set of tools that provides a way to investigate, understand, and interact with complexity in natural and social systems not available within conventional methods (Sterman 2000). Using this methodology, a causal feedback model was developed for future testing.

Results

Factors identified included economic, community, land base, land ethic, ownership, technology, ecology, soil health, and public policy (Table 1).

Using these factors, several themes were constructed.

The first theme, *We are putting all our eggs in one (or a few) baskets,* represents a reinforcing loop comprised of elements from public policy, land base, technological and ecological factors. Public policy in the U.S. Farm Program has continually shifted to support only a few crops (e.g., corn, soybeans and wheat). This support incentivizes producers to plant such crops, and thereby adopt or invest in specialized technology. This locks a producer into future crops to fully utilize the investment and signals to agronomy and equipment companies where to invest (e.g., improving genetics, increasing combine size, etc.). As producers

Table 1. Identified system factors accompanied with a response. Each factor is accompanied with a sample response. Each sample response is followed by the stakeholder identification number. For example, F7 is Farmer #7. R=Rancher, I=Influencer.

Factors:	Sample Response:
Economic	"The drivers are the economics; it's not good. The technology advances have aided it, but the fact is they have to make money- it's sheer economics" (F7)
Community	"I don't think that we can restore the dynamics of the communities in this state any more than we can restore the grasslands." (R6)
Land base	"We're to have more and more pressure put on us as producers to produce more and more [food] on fewer and fewer acres" (R1)
Land ethic	"I would not consider exposing or risking the resources that are entrusted to me, be it erosion or degradation, in the name of profit. It has to be a sustainable (R7)
Ownership	"I'm probably less willing to take some wild risk on something really wild out there than someone who didn't have the roots that we have" (F4)
Technology	"As our farming practices have changed we're seeing more sophisticated agronomy, seeing a lot higher use of fertilizer with guys using variable-rate, using global positioning for tillage." (I4)
Ecology	"If we degrade our ecosystem in an attempt to feed 9 billion people then we will end up starving ourselves...We shouldn't be doing anything to degrade our own ecosystem." (I5)
Soil health	"Healthy land has to have high organic matter, and it has to have residue out there to protect it from wind and water erosion." (F3)
Public policy	"You know the cattle people don't get government payments…But there isn't anything out there that's going to guarantee you $800 an acre whether it rains, hails, whatever. So the livestock industry is at a disadvantage right away." (R6)

scale this technology over more acres, the number of species in the ecosystem decreases as more land is added to production.

The second theme, *Touchdowns are easier running downhill,* expresses a feedback between external stakeholders and policy makers with producers (both farming and ranching) based on their extracted mental models and expressed land ethics. Land (i.e., the playing field) is a finite resource with boundaries. Producers (i.e., the teams) operate on land in an effort to be successful producers. However, farming interacts more opportunistically with other system actors (e.g. stakeholders, policy makers), in effect: working the referees to their advantage. This has tilted the playing field in favor of farming enterprises, giving that land use the advantage. Ranchers, who are much more independent by nature, dig further into their defense. Working the system outside of their immediate control is viewed negatively or greedily in their eyes. This does not help the playing field as the system continues to reward the side that voices their interests. The playing field continues to 'slide the other way' towards farming.

Third, *There isn't enough 'stick' to go with the 'carrots',* expresses a restraint on the corrective forcing functions of the system. A forcing function is an effect or impact being imposed on the system from an exogenous variable. A corrective forcing function would correct or balance the system within some acceptable or sustainable bounds. For example, government subsidies might be considered a positive or reinforcing function to a system whose corrective function is a limit, constraint, or condition under which subsidy benefits can no longer be received. Corrective functions (i.e., the 'sticks') that have traditionally existed such as wetland compliance are no longer in effect to curtail current behavior of decreasing grassland in favor of crop production.

The last theme, *Ignorance (or just looking the other way) is bliss*, deals with the lack of knowledge and responsibility about the complex nature of ecosystem functions, goods, and services, and how these are altered due to major disturbances such as land use changes. Few people are aware of the scale and scope of land use change and even fewer understand the complex nature of the ecosystem and what it provides (e.g., water cycling, nutrient cycling, food production, wildlife habitat, recreation, carbon sequestration) to society. Knowledge of the issue makes one equally responsible for it (i.e. the more you know, the more you are responsible for). Therefore education about the alarming land use changes is essential for informing, challenging and improving mental models about the system and system behavior.

Mental models of system actors were also quite different due to different land use histories, experiences, roles, and values all of which help describe the current system behavior. Farmers thought of connections much more independently and this was observed in the coding process, as farmer interview data revealed that those producers had a more difficult time 'closing the loop'. Ranchers tended to close loops better and valued diversity of the undisturbed landscape. Stakeholders tended to view the system much more objectively than either of the producer groups. However, they usually supported the group in which they had greater associate. They also cherished their role, that of helping producers within the system (Table 2).

Table 2. Brief mental model characteristics identified for each interview group.

Farming	Ranching	Influencers
Efficiency oriented	Synergy oriented	Objective observers
Enterprise accountants	Whole-farm accountants	Supportive of producers
Interactive with external actors	Independent of external actors	Understand system, cherish the role
Land ethic = maintenance of production	*Land ethic = integrity of ecosystem*	*Valued long-term success for all*

These factors and themes led to the creation of a dynamic hypothesis of the grassland conversion issue. The dynamic hypothesis is as follows:

- Conversion of grassland for row-crop production has been driven by an aging agricultural producer, the need to scale farm investment costs, and public support programs (e.g. subsidized insurance, tax incentives) to the exclusion of livestock, which are seen as too time and labor intensive. Row-crop profitability has outpaced historic returns to grassland, which put pressure on cattle grazing opportunities and wildlife habitat, decreasing populations of both. Despite these forces, a different land ethic exists for some producers who consciously make the choice to retain grassland. However, with increasing farm costs, support programs that favor producing certain commodities and few incentives to support bringing young people back to production agriculture- conversion of grassland for farming is likely to continue to the detriment of alternative landscapes and the rural community.

Conclusion

The array of factors identified highlight the enormous complexity underlying land use decisions. Themes constructed describe some of the feedback processes contributing to land use decisions and grassland conversion. Mental models were described that highlight the diverse perspectives of stakeholders who view production and conservation quite differently. Future work includes modeling work incorporating these factors, feedbacks, and preferences to forecast future land use scenarios.

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Risk Management Subsidies, Production System Switching Costs, and Native Grassland Conversion

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Native and unimproved grasslands are critical habitat for many North American duck, shorebird and songbird species, and also for some increasingly rare insects. These habitats coexist with agriculture and the agricultural production environment is changing. A variety of evidence suggests that the rate of native sod conversion to cropland in the United States has increased since the 1990s, and especially in the Dakotas. There may be many reasons for cropland expansion in a historically marginal and yield risky area. Growing demand for commodities in international markets and for fuel has made crop farming more attractive. Innovations in seed technology have reduced non-seed costs, relieved farmers from some environmental compliance constraints, and made crops more drought tolerant. Our concern is with the role of crop insurance subsidies, where subsidy amount varies directly with production riskiness.

A few studies have examined the impacts of Federal risk intervention policies on land-use decisions. Goodwin, Vandeveer, and Deal [Amer. J. Agric. Econ., 86(4), 2004] represent the consensus that while crop insurance subsidies do incentivize cropping, the effect is not large. These works referred to an environment in which lower subsidies were provided than since 2000. More recently Claassen, Cooper, and Carriazo [J. Agric. & Appl. Econ., 43(2), 2011] has sought to provide farm-level analysis of a wide suite of farm programs. Their findings were similar: insurance subsidy impacts occurred, but were not large.

We too seek to understand how risk market subsidies affect incentives to convert native grassland. Unlike all of the current literature, however, we take a dynamic perspective and explore a very different and hitherto unmentioned channel through which risk interventions can affect land-use choices. The Dakotas have seen cropping booms and busts over the past century. Fixed conversion costs can be large and are not recoverable. Land owners will need to be confident that high returns to cropping are not transient before making the conversion decision. Government risk management policies that increase expected future returns to cropping and reduce variability in returns, relative to grazing, will provide assurances to growers, to their bankers, and to input suppliers that production in the area will continue to be viable in the long run.

We developed a real option model of the irreversible native grassland conversion decision. Upon plowing, native grassland can be followed by either a permanent cropping system or a system in which land is put under cropping (respectively, grazing) whenever crop prices are high (respectively, low). Switching costs are incurred upon alternating between cropping and grazing. The effects of risk intervention in the form of crop insurance subsidies are studied, as are the effects of cropping innovations that reduce switching costs. We calibrate the model by using cropping return data for South Central North Dakota over 1989-2012. Simulations show that a risk intervention that offsets 20% of a cropping return shortfall increases the sod-busting cost threshold, below which native sod will be busted, by 41% (or $43.7/acre). Omitting cropping return risk across time underestimates this sod-busting cost threshold by 23% (or $24.35/acre) and hence may substantially underestimate native sod conversion caused by Federal risk management subsidies. This work is preliminary. We expect to publish a clearly explained, more developed paper on the topic at a later date.

Using Predictive Models to Understand the Changing Landscape of the Northern Great Plains and Potential Implications for Wildlife and Human Communities

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The landscape of the Northern Great Plains has changed dramatically over the past decade. The conversion of native grasslands for food and fuel is increasing across the region and with it come potential wide-ranging impacts to wildlife, ecosystem services and human communities. Understanding past trends and being able to predict future ones will assist us in prioritizing conservation actions across the Northern Great Plains Ecoregion.

In this presentation, I described work that World Wildlife Fund (WWF) and partners, including The Nature Conservancy (TNC) and University of Wyoming, have been developing regarding predictive models that describe the potential for converting grassland to cropland and developing oil and gas resources across the Northern Great Plains. I began by presenting historical trends in conversion of grassland to cropland in the U.S. portion of the Northern Great Plains. Based on results from a new study, between 1978 and 2008, the average annual increase in crop acreage within the Northern Great Plains was 0.9%, which is about 1.1 million acres (445,154 ha) over the 30-year period. Growth in acreage of soybeans, corn and wheat accounted for the majority of the increase in crop acreage, with corn and soybeans playing a larger role in the last decade (1998-2008; Rashford, 2012).

Preliminary results from our predictive models suggest that, holding all else steady, an increase in crop prices will lead to an increase in the number of parcels that are converted to cropland on all but those areas with the poorest soil quality. Specifically, an increase in crop prices by 10% will lead to an average increase in probability of converting from grassland to cropland by 0.3%, while a 25% increase in crop prices will lead to a 0.9% increase in the probability of conversion. This 0.9% increase translates to a little over a million acres converted across the US portion of the NGP ecoregion. However, in areas that have high soil quality, an increase in crop prices of 10% leads to an increase in the probability of conversion of 4% to 10% depending on the soil quality (areas with higher soil quality have a higher probability of conversion). These changes largely occur along the eastern edge of the ecoregion in North and South Dakota, while many areas in Montana, Wyoming and Nebraska have poor soils that are not able to support cultivation using current crop types and cropping techniques (Rashford, 2012). Changes in the amount of government payments (e.g., crop insurance, disaster payments) can also substantially change the probability of converting grassland to cropland. Currently, government payments vary across the ecoregion from $0 to $32.47 per acre (0.4 ha), with an average of $8.31 per acre (0.4 ha). Removal of all government payments reduces the probability of converting grassland to cropland by 3% on average, but leads to a reduction of almost 30% in some areas, particularly those that have more marginal soils, specifically in the western portions of North and South Dakota and eastern portions of Montana and Wyoming. In total, the elimination of all government payments translates to an increase and/or reclamation of 5.5 million acres (2.2 million ha) of grassland (Rashford, 2012).

Spatial trends in conversion of grassland to cropland vary across the ecoregion, but generally follow patterns of past conversion. The areas at highest risk of conversion are along the eastern edge of the Northern Great Plains, in the Prairie Pothole Region, as well as the Golden Triangle area in north-central Montana. However, when examining the influence of government payments on conversion to cropland across the ecoregion, a checkerboard pattern emerges, which suggests that in some counties, particularly in western South Dakota and eastern Wyoming, government payments are driving the conversion of grassland to cropland (Rashford, 2012). Thus, the elimination of these payments could lead to lower conversion rates in the future.

A second threat to grasslands in the Northern Great Plains is the development of oil and gas resources. Major oil and gas developments within the U.S. portion of the Northern Great Plains boundary include the Williston Basin in western North Dakota and the Powder River Basin in eastern Wyoming. The Williston Basin covers approximately 201,000 mi2 (520,590 km2) in North Dakota, South Dakota, Montana, Saskatchewan, and Manitoba. The Powder River Basin covers about 24,000 mi2 (62,160 km2) in northeastern Wyoming and southeastern Montana (Schrag and Olimb, 2012). Copeland et al. (2009) produced a spatial data layer that described the relative risk of oil and gas development across the western U.S., based on a variety of geological variables. Copeland and Evans (2012) extended this analysis into the Canadian portion of the Northern Great Plains. Results suggest that additional development is likely in areas that are already developed, and that some development risk extends west of the Bakken Formation into eastern Montana. Over 22 million acres of lands that support high densities of WWF's focal species are at risk for being developed for oil and gas, based on these models.

Together, these studies represent scientifically driven models for incorporating both current and predicted future land uses into conservation planning, and provide insight into how potential changes may impact wildlife and human communities and how the conservation community can better focus its efforts in the Northern Great Plains to combat the impacts of these threats.

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Cropland Conversion and Sage-Grouse: Estimating Historical Impacts and Planning for the Future

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Declines of greater sage-grouse *(Centrocercus urophasianus)* throughout their range are attributed largely to habitat loss and degradation in the sagebrush biome (Connelly et al. 2004, Knick et al 2013). An effective conservation strategy for sage-grouse in the Great Plains, where conversion of native rangelands for food and biofuels crop production is an accelerating agent of land use change, must anticipate impacts of future sod-busting on populations. It remains unclear how large an area is affected by sod-busting and how much fragmentation by cropland can occur before leks are abandoned. Complicating such an analysis, much of the range contraction of sage-grouse had occurred before surveys were established in the middle of the 20th century (Patterson 1952, Schroeder et al. 2004). Locations of extirpated leks (communal breeding grounds on which sage-grouse are counted in the spring) in the periphery of the range—the area most affected by sod-busting—are mostly unknown, ruling out methods of analysis relying on known absences. We use resource selection functions (RSFs; Manly et al. 2002, Johnson et al. 2006), which rely on randomly-generated "pseudo-absences" in available areas, to estimate historical impact of sod-busting on the distribution of sage-grouse leks.

Currently active leks were first used to develop a distribution envelope at an 800 m resolution based only on the presence of sagebrush-dominated landcover, forest landcover, topographic roughness, average annual precipitation, average annual minimum temperature, and average annual maximum temperature. Random points were then sampled from this distribution envelope and used as pseudo-absences in to fit a used-available RSF (Manly et al. 2002). We used the mean of coefficients from 1000 RSF models fit to 1000 random samples to produce parameter estimates. Logistic models using proportion cropland at 0.8, 3.2, 6.4, and 8.5 km were compared using AICc to determine the most supported scale at which cropland influences lek occurrence. Finally, we developed buildout scenarios based on a cropland suitability model (Evans et al., in prep) to estimate potential impacts of future sod-busting on known leks.

Negative effects of cropland on lek occurrence were evident at all scales tested, with the 6.4 km and 8.5 km scales receiving the most support. Impacts were dramatic, with the probability of lek occurrence falling by 50% when about 20% of the landscape within 8.5 km was in cropland (Figure 4). About 13% and 24% of leks currently in the lowest cropland disturbance category are at risk of moving into higher disturbance categories under the moderate and severe buildout thresholds, respectively (Figure 5).

These results indicate that the mechanism through which the presence of cropland affects lek persistence does not merely interfere with breeding activity, but rather operates at a much larger scale consistent with effects on nesting or brood-rearing activity. Like other lekking species, sage-grouse lek locations are thought to represent areas of abundant high-quality nesting habitat where males are likely to encounter receptive females (Gibson 1996, Holloran and Anderson 2005). A number of studies indicate that about 90% of female sage-grouse select nest sites within 8 - 10 km of the lek at which they mated (data from Lyon and Anderson 2003, Holloran and Anderson 2005, Thompson et al. 2005, Tack 2010). The 8.5 km scale is therefore likely to capture ecological processes operating during the nesting and early brood-rearing phases. Future field studies of nest success and/or chick survival in relation to cropland fragmentation may shed light on the mechanism responsible for the strong negative relationship between cropland and lek occurrence observed in this study.

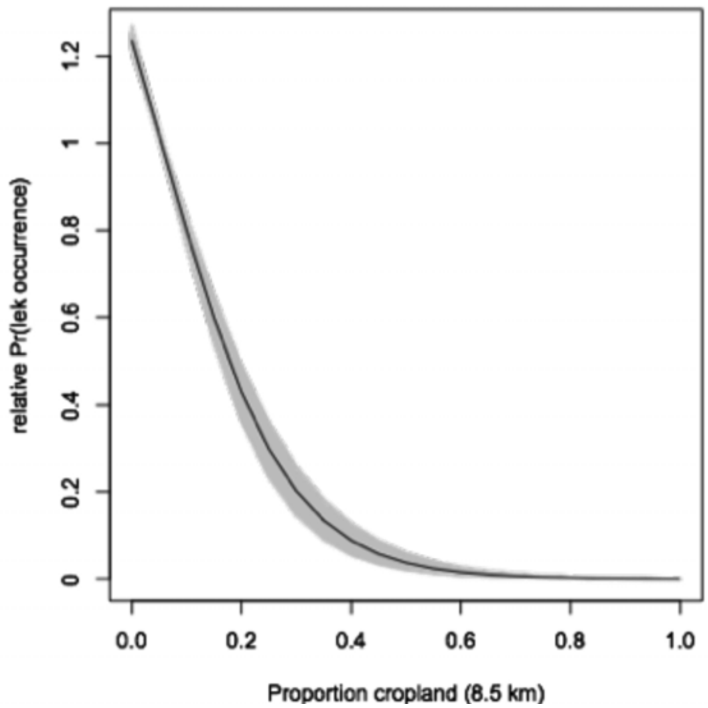

Figure 4

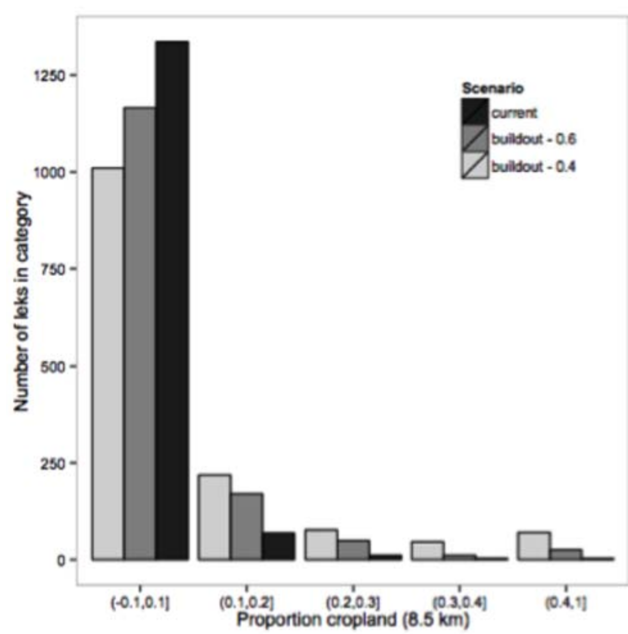

Figure 5

Conservation easements and working lands conservation programs implemented by the USDA Natural Resources Conservation Service (NRCS) represent the few tools available to prevent continued loss of sage-grouse habitat to cropland fragmentation. Implementation of these tools will only be effective when combined with information about where existing populations are threatened by future conversion of habitat. The results of this study, which highlight the large scale and magnitude of impacts of cropland on sage-grouse populations, are needed to evaluate the likely contribution of potential easements and contracts to local and range-wide sage-grouse conservation goals.

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Status, Trends, and Conservation of Grassland-Dependent Birds

Photo Credit: Tanner Gue.

"One of our sweetest, loudest songsters is the meadow-lark...the plains air seems to give it a voice, and it will perch on the top of a bush or tree and sing for hours in rich, bubbling tones."

—Theodore Roosevelt

Brood abundance relative to habitat characteristics in the Prairie Pothole Region

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During the breeding season, grassland landscapes in the Prairie Pothole Region (PPR) of North America provide attractive and productive habitat for millions of upland nesting ducks (*Anas* spp. and *Aythya* spp.). Ongoing cropland expansion and energy development in this region causes loss and fragmentation of grassland habitat with potentially negative consequences for productivity of breeding ducks. Relatively little information exists on how brood abundance is related to environmental characteristics, most likely due to the challenges presented by imperfect detectability of broods. We used data from repeat-visit brood surveys and hierarchical models to test ecological hypotheses about brood abundance. Variables considered in our abundance models included wet basin area, percent upland cover, percent emergent cover, and wetland distance to road. We considered observer experience, presence of previous detections, date, time spent at the basin, and basin wet area in the detection models. Our preliminary results are directly relevant to current conservation efforts and underscore the importance of wetlands and grassland habitat to duck production. Data from future surveys will help elucidate the effect of interactions between grassland cover and precipitation cycles on brood abundance.

Effects of management on grassland-obligate birds on private and public lands

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As part of Audubon's Prairie Bird Initiative, in 2012 we conducted monitoring on 8,000 acres of privately-held ranchlands in Missouri, Kansas, and Nebraska to document breeding bird response to grassland management. We used a unique methodology involving transect-based Distance sampling in conjunction with spot-mapping individual birds' locations on aerial photos. This method provided robust estimates of density, abundance and diversity of grassland obligates, as well as spatial imagery that is illustrative of bird habitat use and response to management. In 2013, we expanded these surveys to all publicly-held grasslands (>50,000 acres) and a sample of private land within the state of Missouri's Conservation Opportunity Areas. This expansion will provide landscape-scale estimates of grassland bird populations as well as further elucidate habitat associations and response to recent management. Our results will provide comprehensive information to both public and private land managers interested in exploring management geared toward increasing populations of grassland birds while maintaining livestock production. In 2012, we documented almost 2,000 grassland birds via survey coverage of over 50% of the sampled properties. Density and abundance estimates were viable for Grasshopper and Henslow's Sparrow, Upland Sandpiper, Dickcissel, Eastern Meadowlark, and Bell's Vireo, all of which are species of conservation concern at state or regional levels. Results from 2012 and 2013 surveys will be presented.

Conservation of a Grassland Species in a Converted Cropland Landscape: Private Landowner Involvement in Mountain Plover Conservation

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Mountain Plover *(Charadrius montanus)* breed primarily in the shortgrass prairies of Colorado, Wyoming, Montana and the southwestern panhandle in Nebraska, however much of the historic grassland in western Nebraska has been converted to cultivated croplands. This conversion often has an adverse effect on grassland obligate species. Mountain Plover depend on disturbed bare ground for nesting, which many croplands provide. The primary conservation threat to nesting plovers is weed management, specifically mechanical tillage operations that use tools such as discs, sweeps, and chisels to move soil. To avoid accidental tillage of nests, landowners give permission for biologists to locate and mark nests on their property, and many landowners locate and mark nests on their own. This successful conservation initiative by Nebraska Prairie Partners (NPP), a collaborative effort between Rocky Mountain Bird Observatory and Nebraska Game and Parks Commission, includes working directly with private landowners to achieve conservation goals. In 2002 NPP began by monitoring 4 nests; 10 years later, more than 100 nests are monitored annually within Kimball County, NE. In addition, the percentage of nests found by landowners increased from 10% in 2002 to more than 42% in 2012. During the past ten years we have engaged with landowners in various research, management and outreach projects. A few examples include; 1). Nest survival study to examine the efficacy of nest-marking as a conservation technique, by comparing unmarked dummy nests to marked active nests. This study revealed hatching success at 79% in marked nests and 30% in unmarked dummy nests, 2).

Chick survival study to examine survival of hatched young to fledgling, preliminary brood survival estimates at 60%, 3). Adaptive management, assess Conservation Reservation Program (CRP) fields for plover habitat to implement habitat management techniques, and 4). Landowner survey to gauge motivations by landowners participating in conservation efforts and evaluate the program's continuing sustainability. We present this long-term conservation effort on private cultivated croplands as a model for conserving grassland birds in an uncertain and changing environment.

Conservation of North America's grassland birds in the Chihuahuan Desert

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Grassland bird populations have declined significantly in recent years, possibly due to decreased survival on their wintering grounds. Fully 90% of migratory grassland bird species breeding in western North America concentrate in Chihuahuan Desert in during winter, yet little is known about their ecology and threats to overwinter survival. We conducted grassland bird monitoring in Grassland Priority Conservation Areas (GPCAs) across six Mexican and three U.S. states from 2007-2013 to identify spatiotemporal patterns of wintering distribution, abundance and habitat use. We also investigated over-winter survival using radio-telemetry and measured habitat loss through remote sensing. Winter bird communities in Chihuahuan Desert grasslands are characterized by dominance of a few species, although species abundance and composition can be highly variable between years. Several of the most steeply declining species (Baird's Sparrow, Sprague's Pipit, and Chestnut-collared Longspur) require grasslands with low amounts of shrub cover (<5%), a condition that is increasingly uncommon to due ongoing shrub encroachment. Daily survival of Vesper Sparrows in January-February in Chihuahua was low (99.1%), suggesting only 25% of birds may survive the 5-month winter. Predation by avian predators was the primary cause of mortality and grass height had a strong positive influence on survival, suggesting taller grass provides important cover from predators. Rapid land use change has destroyed more than 70,000 ha of grasslands in the Central Valleys of Chihuahua since 2006, threatening to eliminate low-slope grasslands within a few decades. The implications of this accelerating habitat loss are exacerbated by the ongoing and widespread effects of poor grazing management and climate change. Increasing the carrying capacity of existing grasslands through habitat restoration and range management could mitigate some of the effects of habitat loss while also improving the economic stability and viability of desert grasslands for livestock production. High concentration, limited and decreasing habitat availability, and low survival suggest a strong possible limiting effect on populations during the winter. Conservation of migratory grassland bird populations will require international cooperation between diverse partners to increase and target resources toward identifying and addressing limiting factors and protect critical habitat for these species throughout their lifecycle.

Shifting population dynamics of the grassland bird community at the Manitoba Tall Grass Prairie Preserve as a result of habitat changes

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Over the past 17 years (1996-2012), there have been changes in the relative abundance of several grassland passerines species at the Manitoba Tall Grass Prairie Preserve. The Monitoring Avian Productivity and Survivorship (MAPS) Program was established in 1996 in the northern block of the Manitoba Tall Grass Prairie Preserve to assess and monitor the population dynamics of prairie passerines. The Preserve's MAPS station follows the constant-effort mist netting protocol established by the Institute for Bird Populations (IBP) and is part of a network of stations located

A newly banded clay-color sparrow is photographed a second before as it escapes the bander's hand at the Manitoba Tall Grass Prairie Preserve. Photo credit: C. Borkowsky, Critical Wildlife Habitat Program.

across North America. This station is located in the largest remnant of tall grass prairie in Canada and the northern extent of this ecosystem in North America. During the 14 seasons of operation 1,703 birds have been captured and 1,374 individuals were banded among 60 species. Over this 17-year period, the species assemblage has shifted with a decrease in the number of captures of savannah sparrow *(Passerculus sandwichensis)* and an increase in clay-colored sparrow *(Spizella pallida)* and common yellowthroat *(Geothlypis trichas).* A change in the habitat structure has also been recorded during this time, with a notable decrease in dry upland prairie and an increase in sedge meadow and greater encroachment by trembling aspen *(Populus tremuloides).* Presently, the Preserve and greater southeastern region of Manitoba are experiencing a drying period which may cause another shift in the vegetation and avian communities.

How Should We Manage Grassland for Lesser Prairie-Chickens North of the Arkansas River in Kansas?

Matthew Bain, The Nature Conservancy

Recent surveys suggest that over half of the rangewide Lesser Prairie-Chicken (LPC) population occurs north of the Arkansas River in Kansas. Populations in this area either did not exist or existed at undetectably low levels prior to the Conservation Reserve Program (CRP). Apparently, CRP reintroduced the critical limiting factor of nesting habitat, while nearby rangeland generally provides lekking and brood-rearing habitat. Given the uncertainty associated with relatively short term CRP contracts, and to efficiently use financial incentives, it is important to identify means of achieving nesting habitat on rangeland in this area.

Various studies have described vegetative structure associated with successful nests. To efficiently incentivize and prescribe management for nesting habitat on rangeland at an adequate scale, the following three questions must be answered: What is the minimum % of an area that needs to be in nesting structure? What is the minimum patch size of that structure? Which rest-rotations should be used with moderate stocking rates to achieve minimum amounts and patches of structure for successful nesting?

Smoky Valley Ranch (SVR) is an approximately 17,000 acre property in western Kansas owned and operated by The Nature Conservancy. Moderate stocking rates and rest rotations are utilized to increase forage production and improve ecosystem health. To expedite this improvement in associated nesting habitat, ecological range sites with species composition capable of producing nesting structure have been identified. SVR is experimenting with season-long deferment, the timing of rest periods during the growing season, flash grazing, and fire on these range sites. Ultimately, we are attempting to identify practices that can increase nesting habitat while maintaining or increasing profitability.

Figure 6 provides an example of a rest-rotation using a moderate stocking rate, where Field 2 has been identified as having the greatest potential to produce nesting structure. Season long deferment of Field 2 over multiple growing seasons would produce a large block of nesting habitat, but would require a high level of financial incentives to offset losses associated with reduced stocking. Adjustment of the timing of use during the growing season would require fewer incentives, and might provide the minimum amounts and patch sizes of structure for successful nesting.

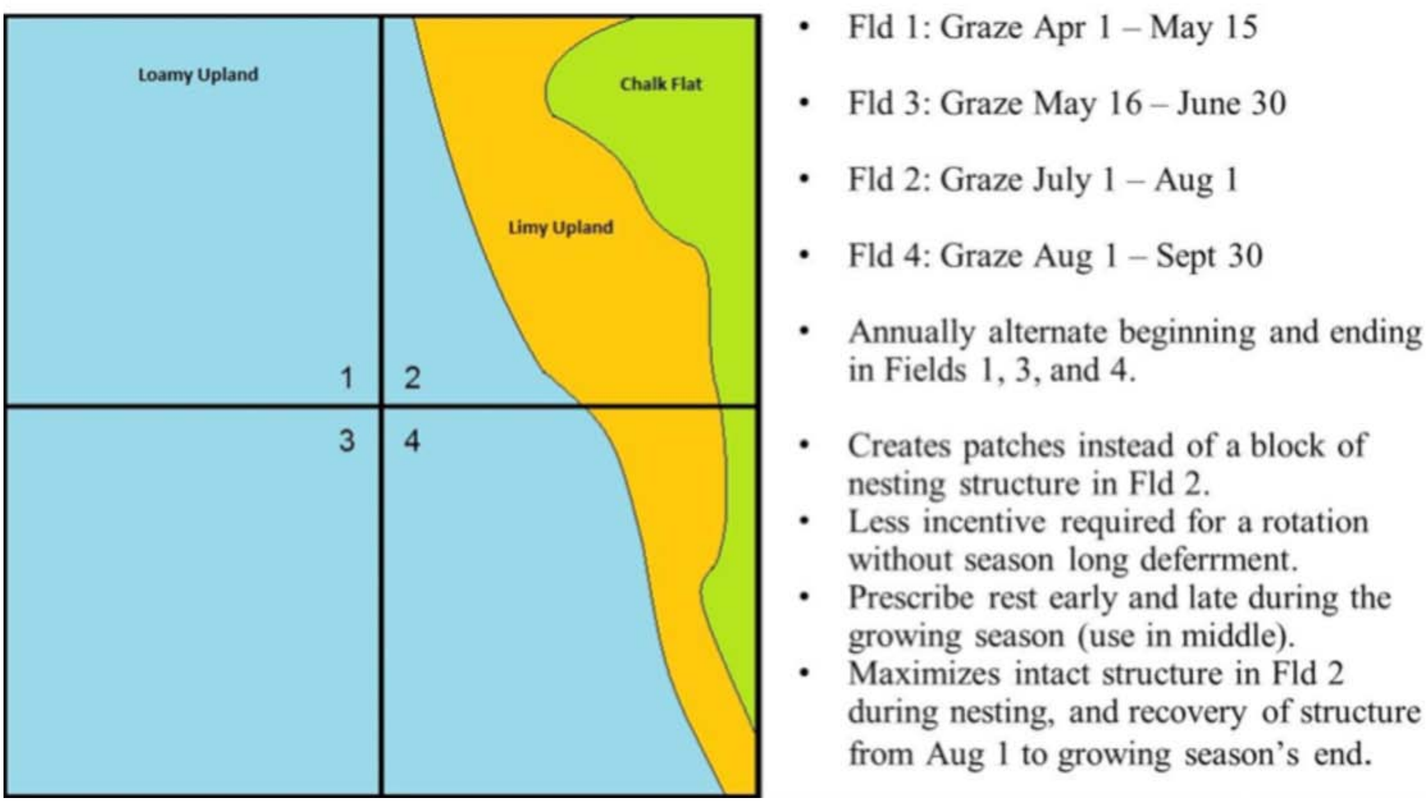

Figure 6

Avian Density and Reproductive Success in Response to Grassland Management on Military Airfields

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Other Authors: Mike Allen, New Jersey Audubon; David Mizrahi, New Jersey Audubon; Kim Peters, Massachusetts Audubon

The primary management objective on airfield grasslands is to reduce the risk of bird/wildlife aircraft strikes, which can be both costly and catastrophic. At the same time, in the Northeastern US, the large grasslands associated with airports have become increasingly important for the conservation of declining grassland birds as alternative habitats (such as agricultural grasslands) have been lost, fragmented or degraded. Management of airfield groundcover to minimize high-risk bird activity is still a controversial subject in North America, with current recommendations based primarily on European studies from the 1960s and 1970s (Cleary and Dolbeer 2005). Although it has been demonstrated that mowing can be successful in restricting shrub encroachment and maintaining grassland habitat, questions remain about the direct and indirect effects of these management practices on avian communities in general (Van Dyke et al. 2004, Zuckerberg and Vickery 2006), and collision-risk species in particular (Fitzpatrick 2003). For example, management on military airfields generally adheres to a strict mowing regime, with vegetation adjacent to runways and taxiways consistently managed to 7-14 inches (USAF 2004). This management practice is based largely on the notion that vegetation between 7 to 14 inches high is least attractive to hazardous birds such as Canada Goose *(Branta canadensis*) and European Starling *(Sturnus vulgaris),* and airfields are maintained at this height through regular mowing. Although this “tall-grass” management approach has been identified as the best practice for deterring problem species, few data are available to support the assumption that such management is preferable to maintaining grass at shorter

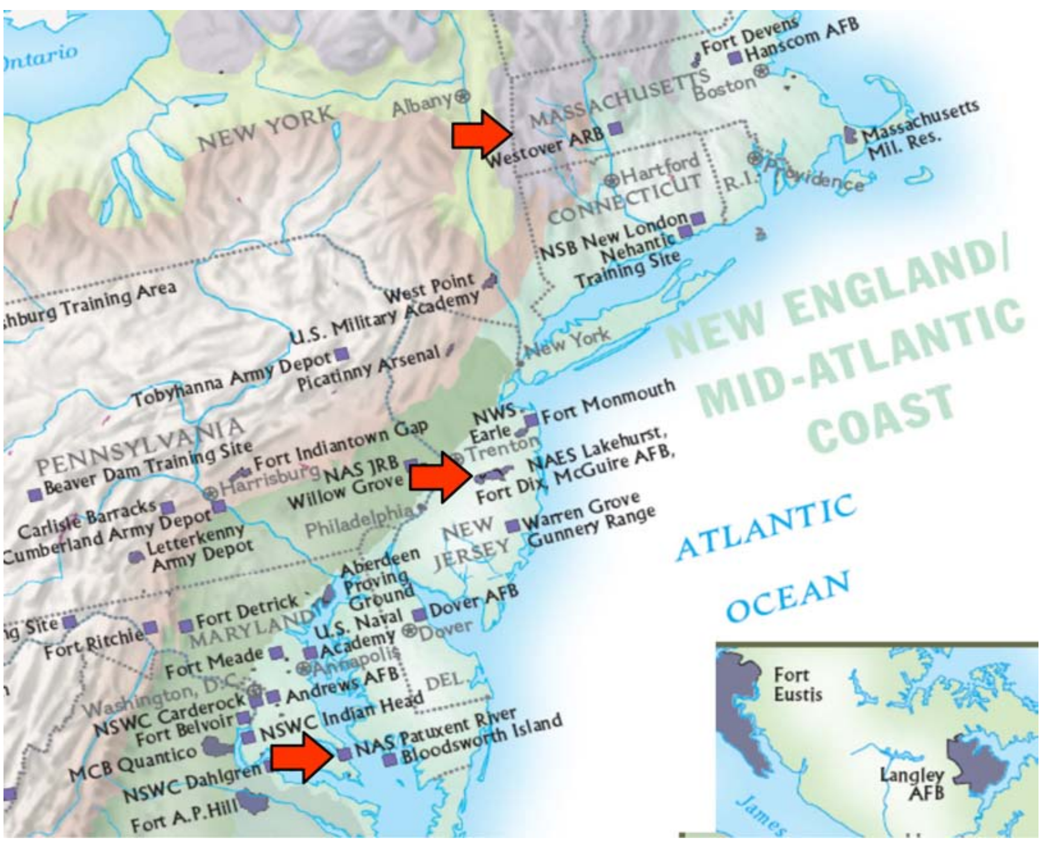

Figure 7: Locations of three eastern U.S. military installations where grassland management studies were performed.

or taller thresholds in the eastern United States or other regions. In fact, some studies have shown either no effect (Milroy 2007) or a negative effect (Fitzpatrick 2003) of these accepted vegetation-height standards on airport safety (e.g., as measured by the presence of strike-risk species).

Furthermore, considering that airfields make up some of the largest areas of contiguous grasslands in the Northeast, there is a serious risk of creating population sinks for grassland birds if habitat management reduces their nesting success (Devault et al. 2012, Blackwell et al. 2013). Airfield mowing may impact the nesting success and productivity of birds using these habitats either through direct mortality (mowers destroying nests) or indirectly through increased nest abandonment, predation, and decreased food availability (Bollinger et al. 1990, Kershner and Bollinger 1996, Zalik and Strong 2008).

Little information is available in the scientific literature regarding 1) the effectiveness of maintaining grassland height at 7-14 inches as a deterrent to hazardous species, and 2) the effects of this management regime on the reproductive success of grassland birds. From 2007-2012, we conducted over 2000 transect bird surveys in (spring, summer, and fall) and monitored over 300 nests in grassland habitats at three eastern U.S. military installations (Figure 7): Westover Air Reserve Base (Massachusetts), Joint Base McGuire-Dix-Lakehurst (Lakehurst section; New Jersey), and Naval Air Station Patuxent River (Maryland). In addition, we conducted vegetation sampling and collected information on grassland management and mowing history at all of our sites.

Using this approach, we found that densities of “hazardous” birds (based on published airplane strike hazard rankings) were lower in longer vegetation, while conservation-value birds (i.e., endangered, threatened and species of concern) were more abundant in taller vegetation, particularly during the summer breeding season. In mowed areas, mowing was the direct cause of failure at an estimated 9-11 % percent of all Grasshopper Sparrow *(Ammodramus savannarum)* nests and 17-20% of all Eastern Meadowlark (*Sturnella magna)* nests. Nest survival (the percent of nests surviving to fledging) of these two species was lower in mowed areas than in non-mowed areas, though this difference was not statistically significant, perhaps due to low sample sizes. Productivity (the number of young fledged per nest) was significantly lower for Eastern Meadowlark nests in mowed vs. non-mowed areas at Westover ARB, the one facility that supports a mix of mowed and unmowed grassland habitats.

Photo Credit: Jeff Hatman.

Results of our work suggest that maintaining vegetation between 7 to 14 inches may not be optimal from an air safety point of view and that it has negative effects on density and nest survival of grassland-obligate birds. More research is needed in both of these areas to determine if these results are applicable to other airfields and in other regions.

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Status, Trends, and Conservation of Grassland-Dependent Wildlife (Non-Birds)

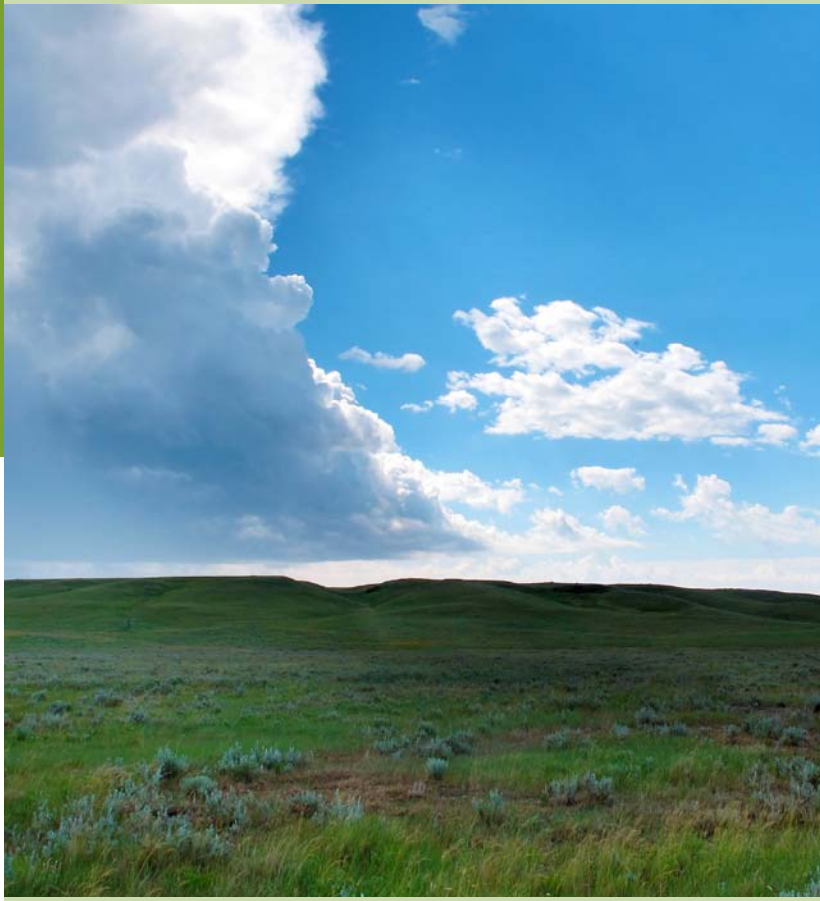

Photo credit: Joseph Smith.

"The landscape of the Northern Great Plains has changed dramatically over the past decade. The conversion of native grasslands for food and fuel is increasing across the reason and with it comes potential wide-ranging impacts to wildlife, ecosystem services, and human communities."

–Anne M. Schrag, *Using predictive models to understand the changing landscape of the Northern Great Plains and potential implications for wildlife and human communities* (page 26)

Swift Fox Distribution and Population Connectivity in Eastern Montana

Jessica Alexander, St. Cloud State University, currently World Wildlife Fund

Other authors: Sarah K. Olimb, World Wildlife Fund; Kristy Bly, World Wildlife Fund, Marco Restani, Ph.D., St. Cloud State University

Historically the swift fox *(Vulpes velox)* occupied a range extending from Alberta, Saskatchewan, and Manitoba to New Mexico and Texas (Moehrenschlager and Sovada, 2004). Once abundant, by the early 1900s this species was rare or extirpated from much of its range due to rodent control programs, conversion of native grassland to agriculture, and predator eradication policies aimed mostly at wolves *(Canis lupus)* and coyotes *(Canis latrans)* (Egoscue, 1979; Sovada et al. 1998; Schauster et al., 2002). Changes in land use and predator control policies in the western United States allowed swift fox populations to recover in portions of their historic range by the mid-1900s (Egoscue, 1979). Reintroduction efforts in the late-1900s also contributed to the species' partial recovery in parts of Alberta, Saskatchewan, Montana, and South Dakota. Today, swift foxes occur in approximately 40 percent of their historical range (Moehrenschlager and Sovada 2004), yet populations in the northern portion remain isolated (Sovada et al. 2009). Swift fox remain a species of conservation concern throughout their range.

Despite reintroduction efforts, swift fox populations in Canada and northern Montana appear disconnected from populations in the central and southern portion of their former range. While swift foxes have the potential to disperse over 100 km from their natal home ranges (Ausband and Foresman 2007, Ausband and Moehrenschlager 2009), fragmentation of native grassland and other factors may limit swift fox re-establishment in much of their historical range, including the region of eastern Montana between the northern and southern populations. Therefore, the overarching goal of this project was to assess swift fox occupancy in southeastern Montana and to determine if the populations are connected.

Camera trap surveys were conducted across southeastern Montana in 2010 and 2011 to evaluate swift fox occupancy between the known northern and southern populations. Surveys were conducted in 70 townships consisting of high quality swift fox habitat identified through a habitat suitability model. A least-cost path analysis was conducted to evaluate the connectivity of swift fox habitat in the study area to existing swift fox populations in the region.

Forty-four vertebrate species were identified at camera stations, including humans and five domesticated species. No swift foxes were detected during any of the surveys. We identified a potential dispersal corridor through southeastern Montana that could facilitate movement between swift fox populations in northern Montana and northern Wyoming (Figure 8). We also identified potential reintroduction sites, rooted in large black-tailed prairie dog *(Cynomys ludovicianus)* complexes, connected to the dispersal corridors. A prairie dog complex consists of several colonies in close proximity (Biggins et al. 1993), and complexes larger than 95 km2 could support at least 9 swift fox pairs (Moehrenschlager and Sovada 2004). Prairie dog complexes represent a reliable source of food and shelter and may be important to swift fox population viability, especially in the northern part of the species' range (Allardyce and Sovada 2003). Four complexes were selected, each encompassing at least 95 km2, in Rosebud, Custer, and Powder River Counties (Figure 8).

While all potential reintroduction sites lay within the dispersal corridor, the Rosebud County site may be most beneficial to swift fox movement. This site is located within an area of highly suitable habitat, but is about 55 km from the nearest existing population and is unlikely to be recolonized without assistance. Once established, however, a population in northern Rosebud County could act a "stepping stone" between current population centers and more distant habitat patches. A secondary release in northern Custer County could further aid in swift fox dispersal into unoccupied habitat. This site is currently over 155 km from existing populations, but would be more accessible after the establishment of a viable swift fox population in Rosebud County. The other potential reintroduction sites may be less beneficial to swift fox movement in the area. The Powder River site is about 10 km from existing populations and is most likely to be recolonized naturally. The site in southern Custer County is isolated among patches of unsuitable habitat and would thus contribute less to improving swift fox presence and connectivity.

We recommend that swift fox reintroductions, beginning with northern Rosebud County, will be highly beneficial to species connectivity in the region. In addition, surveys should continue in areas like southern Powder River County to monitor future range expansion.

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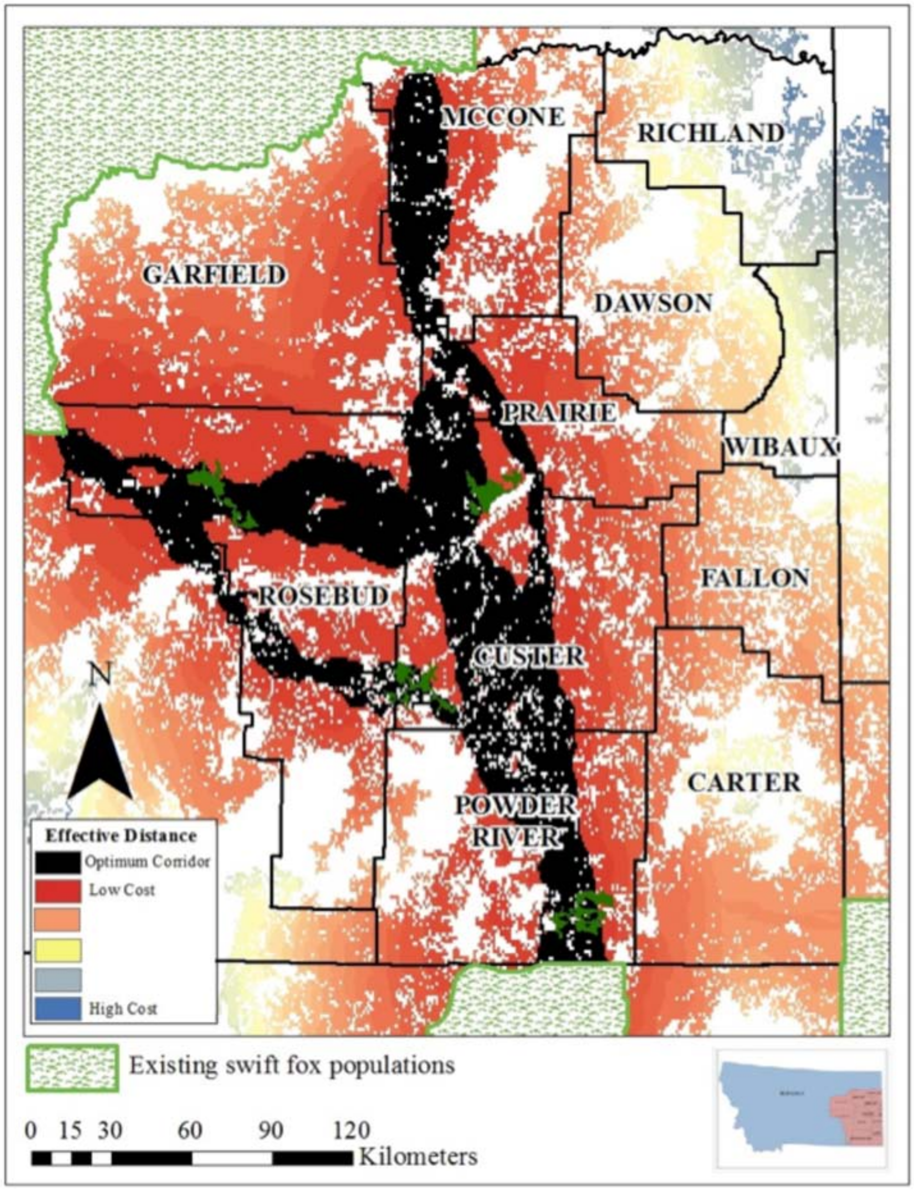

Figure 8: Least-cost corridor through southeastern Montana between existing swift fox (Vulpes velox) populations southeast and northwest of the study area. Unsuitable habitat is in white. The area in black represents the region with lowest travel cost. Potential reintroduction sites are in dark green.

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Ants in the Grassland: Their Importance and Potential as Indicators of Ecosystem Health

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Ants may be useful as bioindicators because they are ubiquitous, abundant, diverse in their ecology, and easily collected. Further, ant species presence, abundance, and activity are hypothesized to respond to changes in ecosystems before more prominent species (e.g. vertebrates) due to their diverse ecological roles, fairly low position in food webs, and their activity on small spatial scales. If true, the assessment of ants may offer a cost and time efficient way to monitor ecosystem function and health. Previous research has shown the possibility for such utility.

I investigated the potential of grassland ant assemblages (communities) as bioindicators in prairies at the Fort Worth Nature Center and Wildlife Refuge in Fort Worth, Texas, including their ability to discern habitat type and respond to disturbance. Ground active ants were collected from 17 sites monthly from March – September 2012 using pitfall traps. Environmental variables important in the choice of nesting areas were measured at the time of trap collection. I conducted ordination analyses on environmental data and ant species presence using the program CANOCO. Ant species were also characterized by functional groups following Andersen (1997).

Principle components analysis (PCA) confirmed that the variables chosen could be used to distinguish sites. Redundancy analysis (RDA) revealed that some of the ant species were aligned with habitat type but disturbance was insignificant (Figure 9). Some species overlapped prairie and woodland habitats but this may be explained by the foraging of those species into habitats other than where they nest. The RDA showed a strong relationship between the ants and the environmental variables. The most significant variables were percent litter cover and soil drainage. However, these factors did not explain more than 20% of the variation in species presence so either there are significant factors not measured or many factors account for the local presence of ants with none being particularly significant. The application of Andersen's functional groups indicated a consistent community structure across these sites (Figure 10). However, Andersen's functional groups are not clearly related to ecological roles and are problematic when applied to systems outside of Australia where his work is focused.

In conclusion, the data indicated weak support for ants as bioindicators and only two genera could be considered indicators of specific habitats: the carpenter ant *(Camponotus americanus* and *Camponotus pennsylvanicus)* for woodland and the Comanche harvester ant *(Pogonomyrmex comanche)* for deep sand prairie (here, the Aquilla formation). I am currently constructing functional groups more appropriate to the ecological roles of the ants in these habitats. These functional groups are expected to provide a better assessment of these sites, the ant assemblages and the utility of ants as bioindicators.

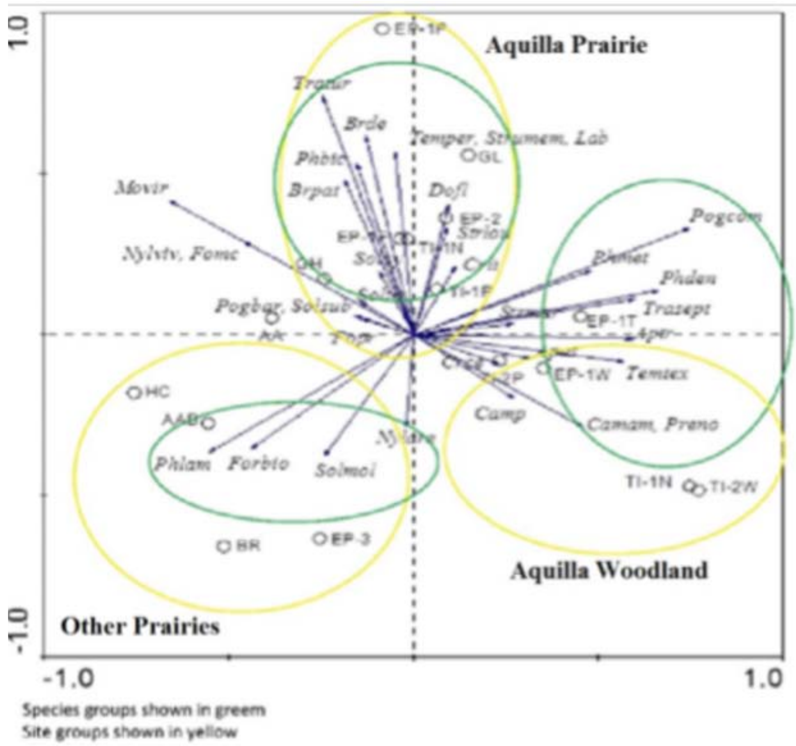

Figure 9: Redundancy analysis (RDA) of species presence and sites by environmental variables. The colored circles indicate groupings only. Sites are indicated with open circles and species with arrows.

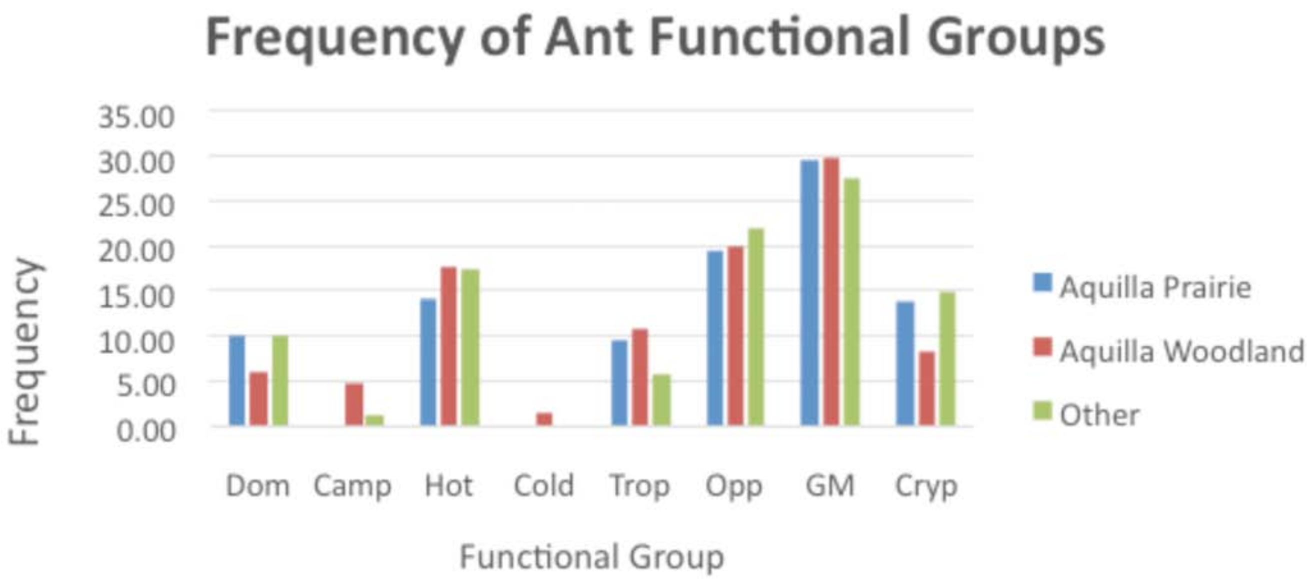

Figure 10: Histogram of functional group richness. Dom = dominant species; Camp = Camponotus species; Hot = hot climate specialist; Cold = cold climate specialists; Trop = tropical climate specialists; Opp = opportunistic species; GM = general myrmicines; Cryp = cryptic species.

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Ecological roles and conservation challenges of prairie dogs in North America's central grasslands

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Other Authors: James K. Detling, Colorado State University and James H. Brown, University of New Mexico

In a nutshell:

- Prairie dogs play important functional roles in North *America's central grasslands*
- *They face many threats, including poisoning, sylvatic plague, shooting, habitat loss, and climate change, and have consequently declined by 98% across their geographic range*
- *To maintain grassland health, biodiversity, and ecosystem services that humans depend on, management must work to maintain the presence of prairie dogs in numbers sufficient to play their functional roles at the landscape scale*

The world's grasslands are fundamentally shaped by an underappreciated key functional group of social, semi-fossorial, herbivorous mammals. Examples include prairie dogs of North America (NA) (*Cynomys* spp.), ground squirrels (*Sciuridae* spp.) of NA, Eurasia, and Africa, and marmots (*Marmota* spp.) of NA and Eurasia, plains vizcachas *(Lagostomus maximus),* Patagonian maras *(Dolichotis patagonum)* and degus *(Octodon degus)* of South America, pikas (*Ochotona* spp.) of Asia, ice rats *(Otomys sloggetti)* and springhares *(Pedetes capensis)* of Africa, and burrowing bettongs *(Bettongia lesueur)* and southern hairy-nosed wombats *(Lasiorhinus latifrons)* of Australia (Davidson et al. 2012). These burrowing mammals often live in colonies ranging from 10s to 1000s of individuals (Davidson et al. 2012). They collectively transform grassland landscapes through their burrowing and herbivory, and by grouping together socially, they create distinctive habitat patches that serve as areas of concentrated prey for many predators (Davidson et al. 2012). Their ecosystem engineering and trophic effects both help maintain grassland biodiversity, and consequently, they often play keystone roles in these ecosystems (Delibes-Mateos et al. 2011, Davidson et al. 2012). Yet, these burrowing mammals are facing myriad threats, which have resulted in dramatic declines in populations of the best-studied species and cascading declines in dependent species and grassland habitat (Delibes-Mateos et al. 2011, Davidson et al. 2012).

In the central grasslands of North America, prairie dogs (*Cynomys* spp.) play keystone and engineering roles by creating islands of unique, open grassland habitat characterized by a low, dense turf of forbs and grazing-tolerant grasses and dotted with mounds and extensive underground burrow systems (Whicker and Detling 1988, Davidson et al. 2012). Consequently, their colonies provide important habitat for numerous plant and animal species, and through their clipping and consumption of vegetation, they enhance the nutritional quality of forage which attracts large herbivores like bison and cattle (Whicker and Detling 1988, Davidson et al. 2012).

Prairie dogs were once ubiquitous features across North America's central grasslands, but have been eliminated from more than 98% of their original geographic range, and they are now subject to frequent epizootics from non-native plague that devastates their populations, in addition to continued lethal "control" programs and a suite of other threats (Delibes-Mateos et al. 2011, Davidson et al. 2012, Bergstrom et al. 2013). Consistent with the loss of keystone species (Power et al. 1996), the impacts of prairie dog, and other burrowing mammal, declines can cascade throughout ecosystems (Davidson et al. 2012). Not only can their loss facilitate woody plant invasion (Weltzin et al. 1997, Ceballos et al. 2010), but animals that rely on their colonies for nesting habitat are at risk, such as burrowing owls, *(Athene cunicularia)* and mountain plovers *(Charadrius montanus)* that have declined with the loss of prairie dogs (Kotliar et al. 2006). Predators dependent on prairie dogs for prey also have shown dramatic declines. Black-footed ferrets *(Mustela nigripes),* for example, rely on prairie dogs for about 90% of their diet, and, largely because of the extensive decline in prairie dogs, they have become one of the most endangered mammals in North America (Kotliar et al. 2006). Interestingly, the United States Fish and Wildlife Service's multi-million dollar breeding program to recover the ferret is running out of suitable reintroduction habitat because ferrets require extensive prairie dog colony complexes to support them; yet, large colony complexes are now extremely rare and declining due to fragmentation, introduced plague, and government-funded extermination programs. Similarly, Ferruginous hawks *(Buteo regalis)* are highly reliant on Gunnison's prairie dogs during their winter migration, and are now threatened largely due to the decline in prairie dogs (Cartron et al. 2004).

Dramatic declines in prairie dogs have effectively eliminated the key ecological roles of prairie dogs throughout much of their range (Davidson et al. 2012). To support the ecosystems associated with prairie dogs, conservation and management must include maintaining or reestablishing their populations and functional roles at the landscape scale. Indeed, grassland management needs to be more holistic, managing not only for livestock production, but also for preserving prairie dog, and other burrowing mammal, populations that are essential for maintaining healthy grasslands over the long-term. Such efforts should include establishing protected areas, engaging local communities, and providing economic incentives whereby landowners receive financial compensation for supporting prairie dogs and their ecosystem services (Hoogland 2006).

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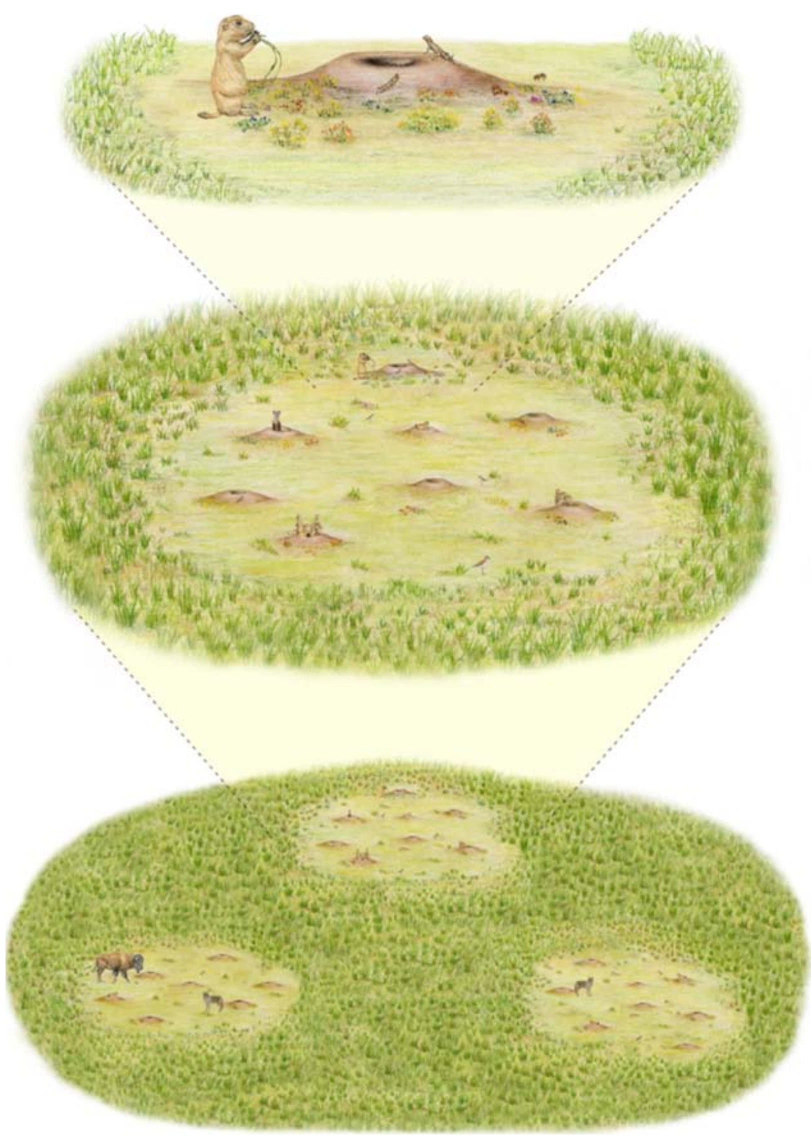

Figure 11. Diagram illustrating the distinctive islands of habitat that prairie dogs create across multiple spatial scales with their mounds (top), individual colonies (middle), and colony complexes (bottom), resulting in increased habitat heterogeneity and biodiversity across the landscape. This illustration is based on black-tailed prairie dogs in the Great Plains grasslands of North America. Drawing is by Sharyn N. Davidson. (Figure taken from Davidson et al. 2012)

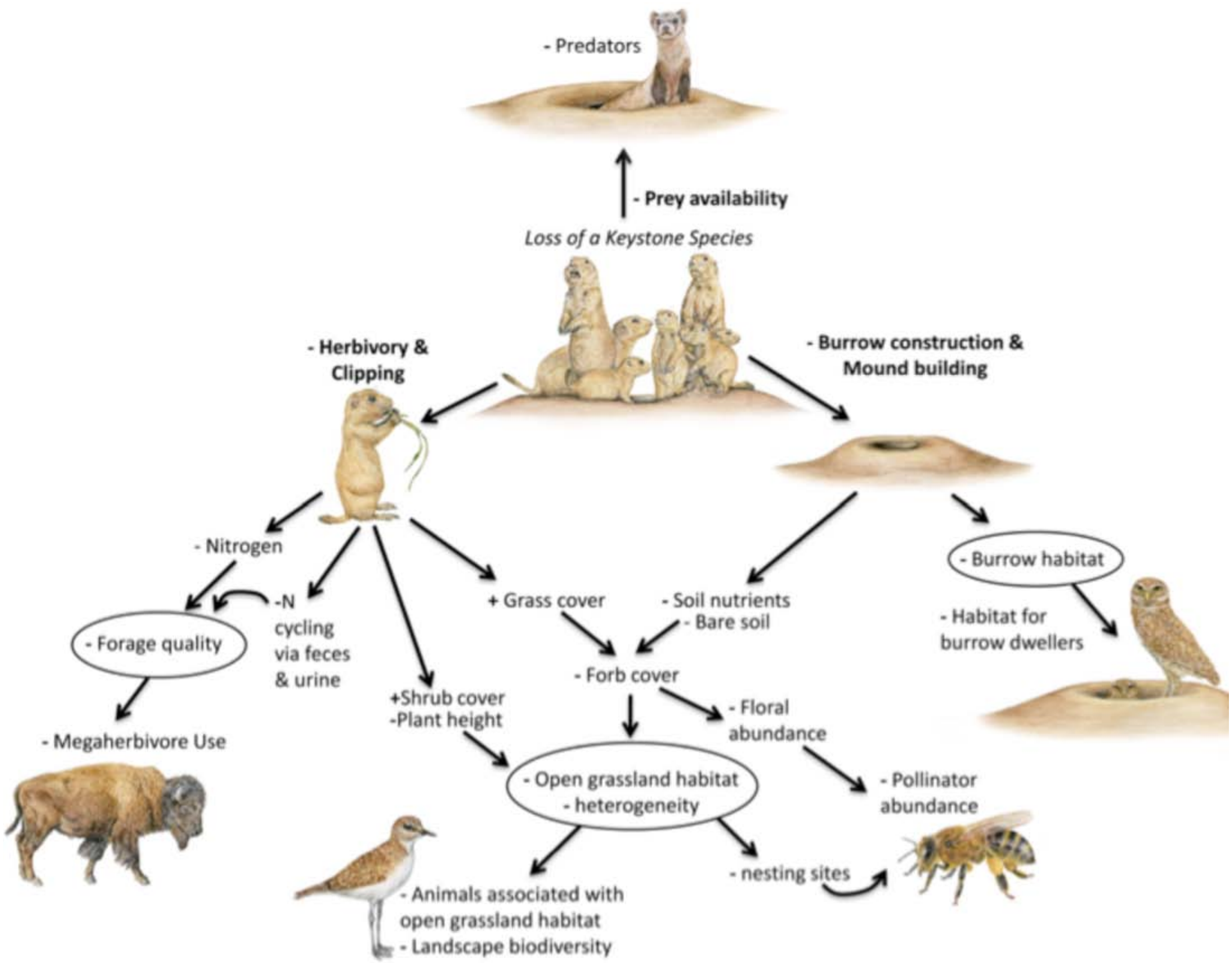

Figure 12. Conceptual diagram illustrating how the loss of a keystone species cascades throughout an ecosystem, using the black-tailed prairie dog *(Cynomys ludovicianus)* in North America's central grasslands as an example. Declines in prairie dogs result in the loss of their trophic (herbivory, prey) and ecosystem engineering (clipping, burrow construction, and mound building) effects on the grassland, with consequent declines in predators [e.g., black-footed ferrets *(Mustela nigripes),* raptors, swift and kit foxes *(Vulpes velox,* V. macrotis), coyotes *(Canis latrans)*, badgers *(Taxidea taxus)*], large activity [e.g., Bison *(Bison bison)*], invertebrate pollinators, and species that associate with the open habitats and burrows that they create [e.g., burrowing owls, *(Athene cunicularia),* mountain plovers *(Charadrius montanus)*, pronghorn *(Antilocapra americana),* swift and kit foxes, cottontail rabbits (*Sylvilagus* spp.), rodents, and many species of herpetofauna and invertebrates]. Black arrows depict the effects of prairie dogs. Plus signs indicate an increase in an ecosystem property as a result of the loss of prairie dogs, minus signs indicate a decrease. Drawings are by Sharyn N. Davidson. (Figure taken from Bergstrom et al. 2013)

Evolving Management Strategies for Shortgrass Prairie, Black-tailed Prairie Dogs, & Black-footed Ferrets: adaptive management in a sea of controversy

Rob Manes, The Nature Conservancy of Kansas

Other Author: Charles Lee, Kansas State University Extension Wildlife Service

From early in its 14-year ownership history at Smoky Valley Ranch (SVR), The Nature Conservancy has struggled to set black-tailed prairie dog management goals and implement supporting strategies that would appropriately support the species' presence on the shortgrass landscape. Efforts to establish a vigorous prairie dog complex on the Logan County property were driven, in part, by Conservancy leaders' desires to reintroduce black-footed ferrets in the region; thus a complex of at least 2,000 acres was needed. Achieving this goal was challenged by a variety of confounding circumstances that included: antagonistic state and local laws; starkly adversarial cultural biases against prairie dogs; lack of management science for the species; a plethora of rumored and untested management options; both real and perceived economic threats of prairie dogs in a livestock grazing context; acrimony from prairie dog and animal rights advocates; the Conservancy's goals of providing lesser prairie chicken habitats on SVR; adverse local and national political attention; costs; and other factors. Over the course of several years, Conservancy staff and its partners tested, proved, modified, and adopted numerous management strategies. Presently, these strategies, including the carefully targeted use of lethal control methods, are successfully protecting a large prairie dog complex that includes wild-reproducing black-footed ferrets.

Assessing the health of commercial honey bees *(Apis mellifera)* across varying agricultural landscapes

Matthew Smart, University of Minnesota

Other Authors: Jeff Pettis, USDA-ARS, Ned Euliss, USGS-Northern Prairie Wildlife Research Center, and Marla Spivak, University of Minnesota

The upper Midwest region possesses some of the richest forage in the U.S. for migratory colonies of honey bees annually. These primarily agricultural landscapes host thousands of colonies each year for the purpose of producing copious amounts of honey throughout the growing season. In the fall, colonies are moved to California where they overwinter and eventually pollinate almonds (February-March).

Successful overwintering and colony survival to almond pollination are therefore integrally connected to the quality of the landscape in those specific apiaries in which colonies are placed during the summer. This relationship underscores the importance of sustainable, quality habitats in the upper Midwest to maintain healthy populations of honey bees, and therefore a diverse and secure supply of food.

Unfortunately, the opposite trend has occurred over the past several years. Lands once considered "bee-friendly" (grasslands, CRP, fallow land, pasture, oil seed crops) have been replaced by non-insect pollinated and/or non- "bee-friendly" crops (i.e. soybeans, corn, wheat) as commodity crop prices have risen. This dramatic shift in land use has had untold consequences for the health and sustainability of honey bees, the beekeeping industry, and therefore agriculture as a whole.

In this experiment, honey bee colonies positioned in varying agricultural landscapes in the Prairie Potholes Region of North Dakota were assessed at 6 week intervals throughout the year, both in North Dakota and California. The landscape within a 2.5 mi. radius of each apiary was surveyed, and land use quantified to determine potential landscape features contributing to success or failure of hives within each apiary. Colony and individual bee health were assessed using a variety of measures of nutritional and immunological status to determine overall suitability of habitats for honey bee colonies.

Preliminary data suggest that ND landscapes differentially affect abdominal fat stores and vitellogenin levels (nutrition), and the cellular and humoral immune responses of honey bees. Apiary mortality (proportion of colonies dead/site/year) was significantly increased at sites surrounded by a greater proportion of non bee-friendly forage. These data highlight the importance of quality and diverse landscapes to support healthy and robust commercial honey bees for honey production and pollination services.

Diminishing Forage – Diminishing Bees

Christi Heintz, Executive Director, Project Apis m.

The Issue

Why should we care about honey bees? Because one mouthful in three, of the food we eat, directly or indirectly benefits from honey bee pollination. While pollinators are responsible for $29 billion in farm income, nearly $20 billion of that is dependent on honey bees, representing one-third of the U.S. food supply, including $6 billion in California specialty crops.

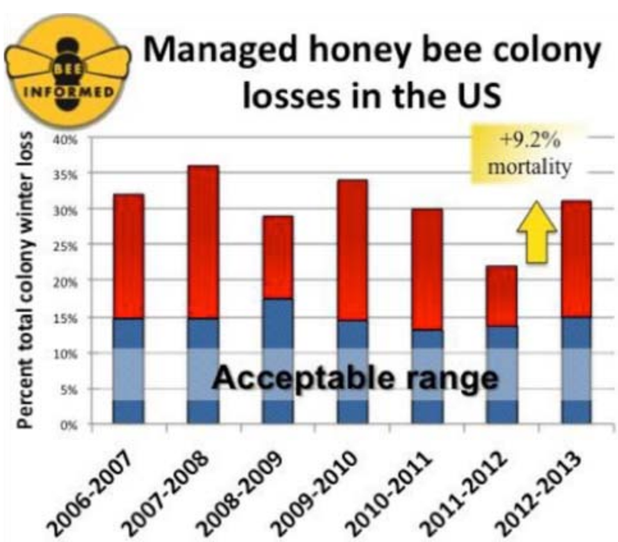

Figure 13.

The Problem

Today's almond bearing acreage in California is approximately 810,000 acres. Successful pollination requires 1.6 million commercial colonies in California in time for almond bloom. Thus, the challenge in honey bee management is providing the supply of colonies for the largest pollination event in the world—the almond bloom each February.

Unfortunately, honey bee colony losses in the U.S. have been in an unsustainable range for the last seven years with an increase of the mortality rate in 2012-2013 alone of more than 9.2 percent. The beekeepers that manage these colonies for California crop pollination must deal with the more than 30% annual losses nationally and must regenerate about 500,000 colonies each year at a value of over $100 million just to cover California almond pollination needs.

After pollination, these honey bees are then available for pollinating other crops and for honey production during the summer months.

The Challenge

The challenge beekeepers face is to keep their honey bees healthy. Improving the health of honey bee colonies involves four components: 1) better nutrition through habitat enhancement, 3) improving management practices to better control pests and diseases, 3) improvements in stock and breeding, and 4) preventing bee losses due to pesticide use.

Honey bees require a diversity of food resources to maintain good health. Increased herbicide use on public and private lands, including herbicides used in farming, on highways and along waterways, has resulted in reduced habitat and biodiversity. Recent drought, wildfires, expansion of single-crop acreage, and urbanization have further combined to seriously affect available food sources for the pollinators.

Project Apis m.

Since its inception in 2006, Project Apis m. (PAm) has infused over $2.6 million into bee research and programs, including over 40 projects involving research institutions in 15 different states. Project Apis m stands for *Apis mellifera,* the scientific name for the honey bee. We have brought new technologies to honey bee health research, discovered

Bee forage. Photo credit: Jody Westfall/Project Aphis m.

new pathogens, and developed comprehensive Best Management Practices programs. We also manage several specialty crop block grants awarded by the California Department of Food and Agriculture (CDFA). PAm is the largest non-governmental, non-profit bee research funding organization in the U.S.

PAm is committed to improving bee health and sustainability. One clear avenue to do that is through increasing honey bee forage. We have identified seed mixes for fall and spring, sourced seed suppliers, initiated forage plots throughout California, and sought use of public lands for bee pastures. PAm promotes the economical and ecological benefits for growers and leverages grant funding along with corporate funding for habitat and forage research. We conducted nutritional analyses of seed mixtures and communicated to the agriculture industry through media coverage on television, print and the internet of the need for available bee forage resources.

Early research taught us that native wildflower seeds are cost prohibitive to do on a large scale. Long-term, clover/vetch and mustards will be important plant species for honey bees. We learned that crop emergence will be highly dependent upon water supply. One hurdle for bee forage will be sustaining the project after the first three-year, cost-assistance expires. Honey bee forage plantings need to occur between mid-September and early December, depending on the location. Planting just prior to the first Fall rains is important, too. In order to accomplish this timing, outreach to landowners and land managers needs to occur by mid-summer.

PAm funding sources are beekeepers, almond growers, corporate grants (Costco and Monsanto), and government/agriculture grants (CA Dept. of Food and Agriculture and ND Dept. of Agriculture). The Monsanto forage project goal for this year is to recruit 10% of all almond growers in California for planting honey bee forage. Seed is sourced through local seed suppliers.

The benefits of planting honey bee forage to the growers include sustaining higher populations of bees to improve crop set, attracting more bees and more beneficial insects, and in some cases, may give growers a negotiating tool for hive rentals. Some other potential benefits to growers are increased water penetration in their fields, organic enrichment of their soils, and nitrogen fixation (essential for all forms of life and all of agriculture). While benefits of getting these seeds to the growers are visual (pretty forage fields), there is also a positive contribution to habitat and building up of the bee population for all crops that require pollination. It is a win-win situation for all.

Presently being planted are mustards, clover-vetch mix (cost-effective and honey bee appropriate), Persian and rose clover, crimson clover and purple vetch, and a wildflower mix. Other possibilities include food grade oil, bio-fuel, and cosmetic oil crops.

PAm also funds bee scientists studying various aspects of honey bee nutrition. Grants help us to enroll large (corporate) landowners in bee forage projects. Our focus thus far has been in California, among the almond orchards and the outlying coastal foothills, and the Sierra Foothills. The first priority for assistance needed is with recruitment of landowners who will plant honey bee forage. We also need assistance with increased awareness by agencies or land management programs with jurisdiction over large U.S. acreage, such as the U.S. Department of the Interior's Bureau of Land Management, USDA Natural Resources Conservation Service, USDA Farm Service Agency, and the USDA Conservation Reserve Program.

Please visit our website at www.ProjectApism.org. Sign up for our monthly PAm eNewsletter by contacting us at ProjectApis@gmail.com. We are also on Facebook (facebook/project apis) and Twitter (twitter/projectapis).

6

Grasslands and Federal Policy

Purple Coneflower. Photo credit: Laura Hubers/USFWS.

"…Current grassland loss rates far exceed habitat protection rates in the U.S. Prairie Pothole Region (PPR) and conservation planning goals will not be met without significant increases in funding or public policy changes."

–Eric Lindstrom, *Sodsaver: Saving America's Last Remaining Native Prairie* (page 51)

Utilizing the Environmental Quality Incentives Program to transition expired Conservation Reserve Program lands into working grasslands, a case study from North Dakota

Randal Dell, Ducks Unlimited

A successful pilot project between Ducks Unlimited and the Natural Resources Conservation Service (NRCS) was conducted in North Dakota to help transition expired Conservation Reserve Program (CRP) acres into working grasslands. Between 2007 and 2013, CRP contracts containing approximately 1.6 million acres will have expired in North Dakota (USDA-Farm Service Agency, 2013). Anecdotally, the conversion of expired CRP to cropland is common and widespread, driven largely by the relative profitability of row crop agriculture. Landowner alternatives under CRP are limited as opportunities for re-enrollment are constrained by a shrinking national acreage cap and changes in the Environmental Benefits Index that rank projects in the northern Great Plains less favorably. Other grassland conservation programs are either unavailable or economically uncompetitive with cropland rental values.

The support of a United States Department of Agriculture-NRCS Greenhouse Gas Conservation Innovation Grant to develop carbon credit opportunities for grassland conservation enabled funding for a special Environmental Quality Incentives Program (EQIP) sign-up. The sign-up provided cost-share assistance for infrastructure investments in grass-based agriculture, namely fencing and water development, on expired- and soon to expire- CRP, and other grasslands in the portion of North Dakota east of the Missouri River. In close collaboration with the North Dakota NRCS, the special EQIP sign-up was promoted as a working lands transition for expired or soon to expire CRP. Local NRCS Field Offices were instrumental in the sign-up outreach by working with their regional Farm Service Agency counterparts to directly contact landowners with expired CRP contracts in an eight county region of South-central North Dakota. Outreach included personalized post-cards, information packets delivered by mail, phone calls, and notifications in local papers and agricultural newsletters.

The targeted outreach led to 201 eligible applications requesting approximately $9.5 Million in EQIP funds during a 30 day sign-up period, greatly exceeding initial expectations of program demand. In total, approximately 25,000 acres of imperiled grasslands enrolled in the program. The sign-up will assist with the installation of over 500,000 linear feet of fencing, 93 watering facilities and prescribed grazing plans developed for 40,596 acres (enrolled acres counted for multiple years of contract). Additional information and opportunities to participate in a grassland easement and a carbon program were also promoted in conjunction with the EQIP sign-up. Development of the carbon program is ongoing, but could potentially provide additional revenue opportunities for participants. Overall, this pilot project demonstrated that there is still substantial interest in maintaining grasslands among North Dakota producers and also the efficacy of targeted conservation outreach.

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Residual CRP- a long-term option to keep CRP in grass

Troy Schroeder, Kansas Wildlife Federation

This presentation will not give results of a scientific study, but rather discuss an idea that may keep Conservation Reserve Program lands in grass after contract expiration.

Initiated in the 1985 Farm Bill, the Conservation Reserve Program (CRP) is widely acknowledged as one of the most popular and successful farmland conservation programs ever devised. The undisputed benefits of CRP include huge reductions in soil erosion, improvements in water quality, carbon sequestration, and significant wildlife population increases.

CRP is a voluntary program that allows eligible landowners to receive annual rental payments and cost-share assistance to establish long-term, resource-conserving covers (mostly grass) on eligible farmland for a 10 to 15 year contract period.

Currently, two overall categories of CRP enrollments exist. General Signup CRP has typically enrolled whole fields or significant blocks of existing fields. Continuous Signup CRP treats specific conservation needs with targeted practices designed to address those needs and usually removes only a small proportion of any given field from crop production. Examples of continuous CRP include filter strips, field borders and waterways. This proposal applies only to general CRP and it is recommended that continuous CRP be continued in its original format.

Peak CRP enrollment occurred in about 2007 when 36.7 million acres were enrolled nationally and 3.2 million acres in Kansas. Now, that figure has been reduced by about a third to 26.9 million acres nationally and 2.3 million acres in Kansas.

The reduction in enrollment has occurred for several reasons. Most significant is the higher grain prices and renewed optimism for being able to make a profit farming highly erodible lands previously enrolled on CRP. In addition, CRP rental rates have not kept pace with cropland rent and crop insurance has been available to reduce farming risk on marginal expired CRP lands.

Threats to CRP in addition to those just mentioned include a reduced national acreage cap, history of irregular signup opportunity, continuing budget problems and a growing public and legislative criticism. Despite the undisputed benefits, concern has grown over the seemingly open-ended nature of the program. The CRP has been criticized for having often more than paid the value of enrolled lands over the life of the program, yet continued payments are required to maintain the conservation and economic benefits. Some land has been re-enrolled 3 times.

A new category or subcategory I will call *"Residual CRP"* is proposed as one means of addressing the future long-term and broader application needs of an evolving Conservation Reserve Program. I have been calling this Residual CRP but perhaps a more descriptive name like "limited-use CRP" would be better.

Residual CRP Basics:

- Allow re-enrollment at a much-reduced annual payment rate (approximating annual grazing rental rates).
- Allow limited (50%) grazing according to an NRCS management plan.
- Require minimum cover criteria to provide environmental benefits, including wildlife.
- Provide cost-share to upgrade cover if needed.
- Provide cost-share for fencing and water supply if needed.
- Enrollment should be long term (20-30 years)
- Make entire rental payment up-front an option to encourage enrollment

Potential pitfalls

- Only attractive on marginal land that will not grow good crops, for example the low rainfall areas of several plains states; TX, OK, KS, NE, CO, ND, SD, WY, MT
- Can't compete with $7/bu corn and may have been more successful 5 years ago
- Many areas will require fencing and water development
- Insuring compliance with reduced grazing requirement

Public benefit

- Benefits of original CRP retained
- Much reduced cost
- Long term benefit
- Limited grazing may be good for grass and wildlife (emergency grazing has often been allowed in general CRP during drought years anyway)

Landowner benefit

- Receive grazing annual rental payment equal to annual grazing rental fee
- Allowed grazing at 50% reduced rate in addition to CRP payment
- Get cost-share for fencing and water development to convert to permanent pasture
- Rental payment paid up-front as an option

Western Kansas cost example

- Cropland rental rate $36/acre/year ($360 for 10 year contract)
- Grazing rental rate $12/acre/year ($360 for 30 year contract)

It is essential to maintain many of the remaining CRP acres in grass cover after expiration to retain benefits. For example, the lesser prairie chicken (a species that is on the verge of being added to the list of those threatened and endangered) has expanded both in range and numbers in Kansas due primarily to CRP. If CRP would be greatly reduced, the LPC population would fall drastically.

This concept is not new. Randy Rodgers, KDWPT and I proposed something similar several years ago. This may not be the exact answer but some new options are needed to insure the continuation of CRP benefits as summarized by Johann Walker, Ducks Unlimited, at the 2011 America's Grasslands Conference: *"If CRP is to remain a viable program and a significant part of the landscape into the future, it is likely the program will need some adjustments to keep it attractive to private landowners. Failure to change and adapt may signal the end of one of the most successful conservation success stories. Program modifications that allow private landowners to retain certain rights (i.e. grazing,) and provide increased management flexibility throughout the year and the contract period will likely keep landowners interested while still maintaining the conservation benefits for our soil, water and wildlife resources. Increased management flexibility also produces the added benefit of reducing program cost; something that speaks volumes as the U.S. looks at significant actions to reduce the national deficit."*

Sodsaver: Saving America's Last Remaining Native Prairie

Eric Lindstrom, Ducks Unlimited, Inc.

Temperate grasslands are one of the most imperiled ecosystems on the planet, yet maintain one of the lowest habitat protection rates of any major terrestrial biome (Hoekstra et al. 2005). Native grasslands that support diverse wildlife populations and grass-based agriculture are being converted to cropland at record rates across many parts of North America. During 2012, nearly 400,000 acres of land with no prior cropping history was broken out for crop production across the United States, including >54,876 acres in Nebraska, >27,128 acres in South Dakota, >26,395 acres in Texas and >24,961 acres in Florida (FSA 2013; See Figure 14). In fact, at current conversion rates, over half of the native prairie remaining in portions of the U.S. Prairie Pothole Region (PPR) will be gone in the next 34 years (Stephens et al. 2008). Agricultural policies, emerging technologies and economic drivers are fueling large-scale conversion of these rare and important habitats. Native grasslands provide critical habitat for wildlife, including a globally-significant breeding range for many waterfowl and shorebird species. These habitats also support numerous grassland-dependent songbirds, which are experiencing a steeper population decline than any other avian guild in North America (Peterjohn and Sauer 1999). Additionally, native rangelands are fundamentally important for livestock production by providing forage and drought mitigation. Ranching, recreational hunting and ecotourism associated with native prairie also provide economic diversity and stability to rural economies.

Today, these last remaining grassland-dominated landscapes are largely confined to areas with poor soils, steep topography and climatic conditions largely unsuitable for consistent crop production. Unfortunately, accelerated grassland conversion is occurring in many of these areas causing significant ecological and societal impacts. Further loss of native rangeland is also an economically costly proposition, bringing additional disaster-prone farmland into production, while creating significant taxpayer liabilities through subsidized risk management. Doherty et al. (2013) report that current grassland loss rates far exceed habitat protection rates in the U.S. PPR and conservation planning goals will not be met without significant increases in funding or public policy changes. A national "Sodsaver" policy would help slow the rate of native prairie conversion, level the economic playing field between ranchers and crop producers and reduce taxpayer liability.

Sodsaver legislation has been proposed in the next U.S. farm bill, which would: 1) limit crop insurance coverage to 65 percent of the applicable transition yield for the first four years until an actual production history is established

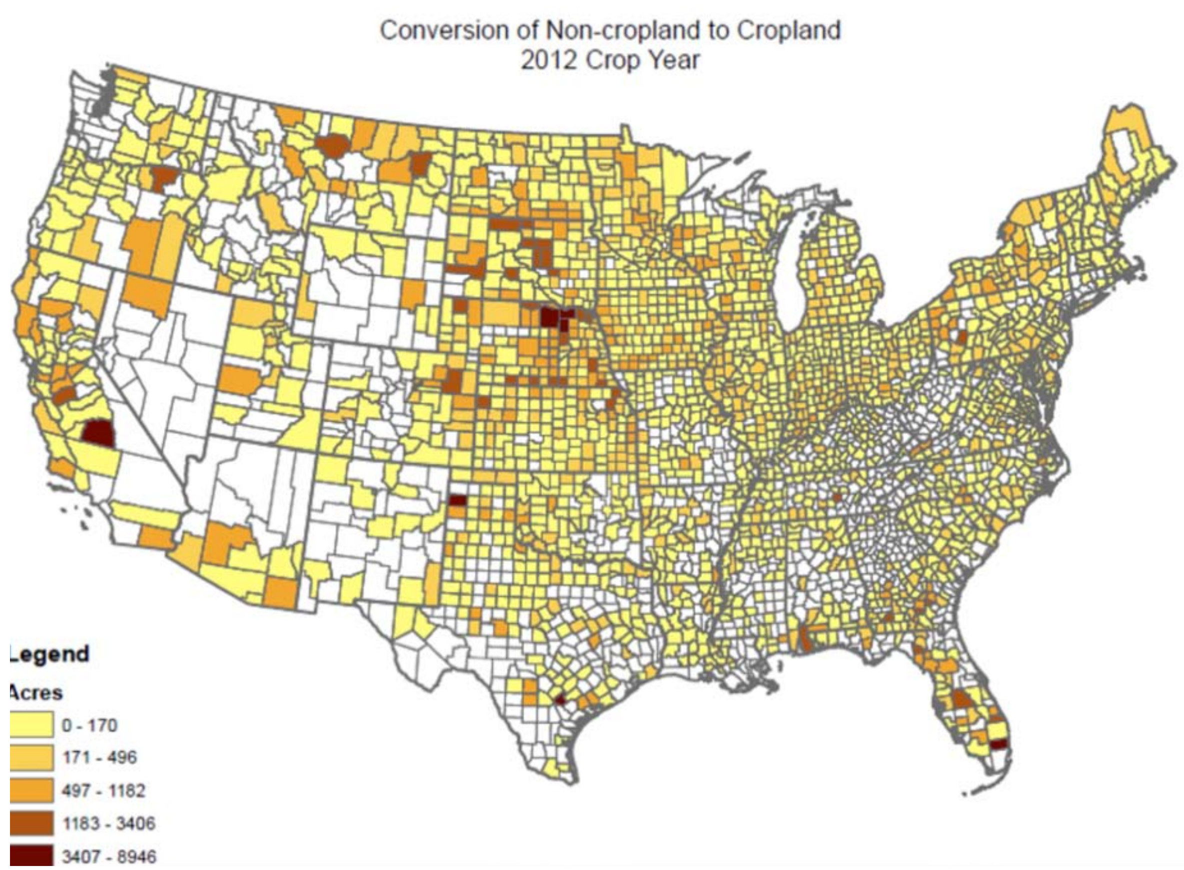

Figure 14: Conversion of non-cropland to cropland during the 2012 crop year (FSA, 2013).

Conversion of native prairie to cropland. Photo Credit: Eric Lindstrom.

on newly broken sod; 2) reduce crop insurance subsidies on newly broken sod by 50 percentage points less than the premium subsidy that would otherwise apply for the first four consecutive years of crop production; and 3) make newly broken acreage ineligible for yield substitution. These provisions were included as a nationwide policy in the 2013 Senate-passed farm bill, but were confined to just the U.S. Prairie Pothole Region in the House-passed farm bill. These proposed policy differences will have to be negotiated in Conference Committee before a new farm bill is passed and signed into law. As evidenced by the 2008 Farm Bill, a regional-only Sodsaver provision will be difficult to administer and create major inequities among agricultural producers in various states. Instead, a national provision would create a more equitable program across the country. Unless Congress enacts a national Sodsaver program and other risk management reforms in the next farm bill, native grassland conversion will likely continue at current or accelerated rates.

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Fueling conversion: How the EPA is letting the RFS drive prairie plowing and forest clearing

Ben Larson, National Wildlife Federation

The environmental community generally supported the Energy Independence and Security Act (EISA) of 2007, largely for the benefits of cellulosic ethanol and advanced biofuels. But numerous groups were concerned that increasing demand for corn and other feedstocks would significantly increase their price and lead farmers to convert grasslands and other untilled lands to cropland. As a result of these concerns, protections against conversion of prairies and forests for feedstock production were included in the RFS. Specifically, in the definition of renewable biomass, croplands used to grow feedstocks had to have been "cleared or cultivated, and non-forested" on the date of enactment (December, 2007). While laudable and important, these protections are not being adequately enforced or implemented by the EPA to counteract the powerful drivers of land conversion.

There are numerous drivers of land conversion, but undoubtedly the main one is the high crop prices since 2007. At its current production of about 13 BG, the ethanol industry is using about 40% of America's corn crop. There is no debate that the RFS is raising the prices of corn and other commodities, and the range in economists' price impact assessments is fairly narrow. At the higher end, a group at UC Davis group estimated that between 2006 and 2011, corn prices were 30% higher because of RFS (Carter et al. no date). At the lower end, Bruce Babcock, a respected agricultural economist from Iowa State, found in 2010 that eliminating the RFS would lower corn prices $.81/bushel or about 21% of its price by 2014 (Babcock et al. 2010). At the farm level, the USDA says average corn income per acre has been over $200/acre. But farmers usually consider their per acre income as being even higher than that because USDA's analysis includes every possible cost.

A secondary driver is subsidized crop insurance, which removes some of the risk, particularly in marginal farmland (Claussen et al. 2011; Decision Innovation Solutions 2013). NWF and many other groups are trying to reform the crop insurance subsidy incentive by including a strong sodsaver provision in the farm bill. In addition to the market and policy drivers, there also are two technical drivers. Glyphosate-resistant crop varieties and no-till equipment have lowered the costs for farmers to convert grasslands to croplands, and more drought-tolerant corn and soy varieties have enabled the Corn Belt to expand westward into the eastern Dakotas and the Prairie Pothole Region.

In its first draft rule, EPA originally proposed enforcing the land-conversion protections by requiring ethanol producers to keep records and report where all agricultural feedstocks were grown. But because of the tremendous outcry by ethanol industry, EPA did away with the record keeping and reporting requirement in its final rule, adopting instead what they called an "aggregate compliance" approach. Under aggregate compliance, EPA doesn't track the source of feedstocks, or even check or assess the risks of land conversion at the level of the plant or county or even state. Instead, aggregate compliance only involves the monitoring national data regarding the amount of cropland in years after passage of the RFS. If subsequent cropland acreage is below the total cropland in 2007, EPA's policy is to assume that no significant amount of land conversion had occurred. EPA set the 'baseline' of cropland in 2007 at 402 million acres, which includes CRP acreage and pastureland. EPA set a threshold for further investigation at 397 million acres; if subsequent cropland reached this level, EPA said it'd assess whether presumptions underlying aggregate compliance are still valid. EPA also said if cropped acreage exceeds 402 million acres, it will implement individual recordkeeping and reporting.

In addition to using aggregate compliance in the US, EPA later allowed Canada to implement an aggregate compliance approach, with a 2010 baseline of 123 million acres, and with a threshold for further investigation of 121 million acres.

In developing aggregate compliance, EPA relied on input from USDA regarding cropland usage trends and economics of land conversion, which formed the presumptions underlying aggregate compliance. Chief among these presumptions was that "Due to the high costs and significant inputs that would be required to make the non-agricultural land suitable for agricultural purposes, it is highly unlikely that farmers will undertake the effort to "shift" land that is currently non-agricultural into agricultural use." As I discuss later, this presumption may have been valid with historic crop prices, but the combination of higher prices and technology that's lowered conversion costs have made this presumption dubious at best. Other presumptions included that there's plenty of land; farmers can switch between crops and use expired CRP acres; and that cropland in US has been declining for decades, so there is unlikely to be pressure to increase cropland. Lastly, EPA asserted that any conversion that does occur will be at minimal, insignificant levels.

NWF has been making the case against aggregate compliance in a number of ways. Originally, we were a party on a suit against EPA (but the suit was dropped for procedural reasons). In our comments to EPA, we have been reiterating that there are compelling reasons to reassess the presumptions underlying aggregate compliance, including farmers' own reporting, recent economic modeling, and remote sensing data. In this paper, I briefly summarize these lines of evidence, and am happy to provide more info on request.

In its 2008 Ag Resource Management Survey, USDA researchers asked farm operators were directly about expanding cropland into previously uncultivated acreage, and one of their finding was that "About 16 percent of 2008 corn and soybean farms brought new acreage into

Photo credit: Aviva Glaser.

production between 2006 and 2008. The uncultivated land brought into production by these farms accounted for approximately 30 percent of the average farm's expansion in total harvested acreage. Most acreage conversion came from uncultivated hay." This uncultivated hay ground was native prairie, which, if converted after enactment, shouldn't have been eligible for feedstock production.

Three new economic models (Claassen et al. 2011; Rashford et al. 2011; Ruiquing et al. 2013), based on current crop prices and accounting for modern technology, strongly suggest that in the era after enactment of the RFS, the combination of high crop prices and crop insurance has created conditions in which farmers are much more likely to convert native prairie, particularly in the Northern Plains. Thus, the models cast doubt on the presumptions EPA used in developing its aggregate compliance approach, particularly the chief presumptions that converting land is too expensive and that farmers won't plow unplowed prairie because it won't be productive enough.

Remote sensing data like the USDA's Cropland Data Layer (CDL) can't distinguish planted grasslands from remnant native prairies, but it can be used for two other very important purposes. First, it can be used to locate concentrations of conversion, such as the 1.3 million acres of grassland conversion that's occurred in the western Corn Belt since the passage of the RFS (Wright et al. 2013). Secondly, CDL data can be used to assess conversion of native prairies if remnant native prairies have been verified and digitally mapped. Beginning in the 1980s, Minnesota County Biological Survey mapped remnant prairies, providing a source of verified remnant native prairies that had been digitally mapped. Furthermore, MN DNR conducted an analysis of landuse change between 1992 and 2007 in about one-third of MN's remnant prairies, which will provide a baseline of conversion before the passage of the RFS and crop prices increased. To assess rates and location of conversion of these prairies since the passage of the RFS, NWF is using MN's mapping of native prairie and the 2008-2012 CDL data for MN (results TBD).

Because Canada's cropland acreage is approaching the threshold for further investigations, Canada may provide the test case for whether and how EPA will revise its aggregate compliance approach. In fact, in 2012 Canada's acreage reached the 121 million acre threshold that EPA established for further investigation, as NWF pointed out in our comments to EPA, but EPA re-reported Canada's 2012 acreage as actually being 120.9 million acres—and therefore just under the threshold for further investigations. If and when Canada does surpass the 121 million acre threshold, EPA will have to decide whether the presumptions are no longer valid, and if so, how to revise aggregate compliance, at least in Canada if not also in the US.

In NWF's comments to EPA, we proposed a revision that we think would strike a compromise between the lax approach of using aggregate compliance on the national level and the stringent requirement of requiring record keeping and reporting all feedstocks, regardless of the actual conversion risk in that region or county. Rather than use national data, we recommended that EPA use county-level cropland acreage data, and investigate and require recordkeeping and reporting if native grassland or forestland conversion rates are likely to be high, such as in counties where increasing cropland acreage (as recorded in FSA field records) exceeds expiring CRP acres. In forested counties, EPA can use annual CDL data to monitor tree and forest conversion; in grassland counties, EPA can use FSA and CRP data can help track conversion, and investigate when expiring CRP acres and FSA acreage records are exceeded by current cropland. We believe that such a moderate reform of EPA's aggregate compliance approach would provide a much greater level of assurance that ineligible lands are not being used for feedstock production.

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7

Cattle Grazing

Photo credit: Joseph Smith.

"Despite decades of concerted efforts from public and private sector partners, grassland birds continue to show precipitous declines throughout their ranges. If we are to have better conservation outcomes for prairie birds, we need to forge more effective partnerships with the men and women whose land management decisions ultimately determine their fate: ranchers."

–Max Alleger, *Audubon's Prairie Initiative* (page 19)

Managing warm-season grasses for pasture-based livestock systems of the northern Prairie Peninsula

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Other Authors: Randall Jackson and Nicole Tautges, University of Wisconsin-Madison; Susan Chamberlain, USDA Farm Service Agency

Native warm-season grasses are rare in pasture systems in Wisconsin. Cool-season grasses dominate pastures for the more than 8000 dairy and livestock producers in the state who utilize managed grazing. As higher temperatures and less dependable rainfall become more common, warm-season grasses could offer greater resilience as well as conservation benefits. In Wisconsin, knowledge and management skills for native grasslands currently reside mostly with natural resource professionals, whose recommendations tend to be based on wildlife habitat objectives. These recommendations may not be the most effective for managing native grasslands for grazing or forage production and may end up discouraging farmers from planting native grasses. The goals of this project were to evaluate alternative grazing management methods for warm-season pastures and to identify practices that may result in improved performance for livestock producers. From 2009 to 2012, we measured the persistence, productivity, and quality of native warm-season grasses under two grazing schedules using rotational stocking of beef cattle. Grazing schedules were designed to reflect either wildlife-based grazing recommendations (i.e., "late graze" initiating grazing after 15 July) or production-based management practices that emphasize livestock nutritional needs (“early grazing” initiating grazing in early June). In addition, we compared the production and persistence of locally sourced ecotype seed versus native grass cultivars selected for vigor and productivity under the two grazing timings. Our results suggest that the two grazing schedules represent a trade-off between forage availability and quality, with the early-graze treatment resulting in lower total yields of higher quality forage. Forage availability for the early graze treatment averaged 7.03 metric tons/ha/yr versus 10.9 metric tons/ha/yr. Relative forage quality values averaged 125 versus 102 and crude protein averaged 10.9% versus 7.8%, for the early and late graze treatments, respectively. Differences between ecotype and cultivar treatments will be shared in addition to trends in species composition over time in response to grazing management. Long term goals of the research are to develop farmer-friendly educational materials that will de-mystify the management of native grass pastures and encourage their use in grazing systems of the northern Prairie Peninsula.

Enhancing Habitat for Ground Nesting Birds in Midwest Grasslands through Soil Disturbance and Initiation of Plant Community Succession by High Density Grazing of Beef Cattle

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Despite grassland programs to preserve wildlife habitat, species such as the bobwhite quail have experienced a 40 year decline in population mainly due to a decline in suitable habitat. However, strategic spring high density grazing may produce appropriate plant community successional stages and vertical structure in perennial grasslands for bobwhite quail habitat while improving habitat for other wildlife species. Two blocks of pastures with cool season grass and legume species without (BL1), and with (BL2) warm season grass species were divided equally into 5 paddocks not grazed (NG), and strip (S; moved once daily with a back fence) or mob (M; moved 4 times daily with a back fence) grazed in spring 2011 (BL1) or 2012 (BL2). Measurements of botanical composition and visual obstruction were used to determine the effects of high density grazing on wildlife habitat for bobwhite quail and other wildlife species. In BL1, the proportions of annual grasses and bare ground were greater, and cool season grasses lower in grazed than NG paddocks in July 2011. In 2012, the proportion of forbs was greater in M in May and in M and S paddocks in July than NG paddocks. In BL2, proportions of annual grasses in M and S paddocks and bare ground in S paddocks were greater than NG paddocks in July 2012. In BL1, there was no difference in visual obstruction in NG and S paddocks below 40 cm in October 2011. In 2012, no differences occurred in visual obstruction throughout the profile in July, in October there was less visual obstruction at 10-20 cm in S compared to M paddocks, however no differences occurred at other height increments. Visual obstruction was greater than 25% in both NG and S pastures to 30 and 40 cm in October 2011 and 2012, respectively. Visual obstruction was greater than 25% in NG, S, and M to 50 cm in July 2012. Strategic spring high density grazing increases annual grasses and forb populations in early succession plant communities, increasing available wildlife feed without impacting the protective canopy for wildlife habitat in following years.

Demographic Responses of grassland songbirds to a patch-burn grazing management in the Flint Hills

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The tallgrass prairie is one of the most threatened ecological communities in North America. Loss of native grasslands and intensification of agricultural practices are thought to be leading factors in the decline of many grassland vertebrates. Grassland songbirds evolved under a shifting mosaic of habitat types shaped by fire and grazing, but much of the Flint Hills is now managed to create a homogenized landscape that is evenly grazed by cattle. Patch-burn grazing aims to restore heterogeneity on rangelands. The purpose of this two-year field study was to determine if grassland songbird species richness, abundance, and nesting success differed between patch-burned sites and traditionally managed sites. Three patch-burned pastures and four traditionally managed pastures were used in this study. During breeding season, birds were surveyed along line transects and nests were located and monitored. Vegetative structural heterogeneity was higher on patch-burn sites. Bird densities and species diversity differed between management types, with some species present only on patch-burned sites. A similar number of nests were found on each management type, with Dickcissel nests having higher nest success on patch-burned sites than on traditionally managed sites. Thus, a patch-burn management may be an effective conservation strategy for grassland songbirds. Additionally, patch-burning may benefit landowners by providing more forage for cattle, particularly in drought years.

The legacy of grazing persists both above- and belowground in tallgrass prairie plant communities

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Background/Question/Methods

Much research has been devoted to understanding immediate responses of tallgrass prairie to disturbance. For example, in tallgrass prairie we have devoted plenty of time to understanding short-term response to three key processes: fire, grazing, and drought. The short-term effects of grazing on tallgrass prairie are well known, and include decreased C4 grass abundance, increased forb abundance, increased species diversity, and increased spatial heterogeneity. However, few studies have determined in these effects persist in the years after disturbance is removed. The research we present here explores the legacy effects of grazing and drought on plant productivity, demography, and diversity, both above- and belowground. To study legacy effects of grazing, we compared recovery areas with grazed and ungrazed areas for 4 years after grazers were removed from the recovery areas. We measured aboveground plant community responses including productivity, stem density, and abundance of species) and the belowground plant community responses including total bud bank density and abundance of species in the bud bank. The bud bank is density of buds on rhizomes and perennating plant organs.

Results/Conclusions

We found that after grazing ceased, the aboveground plant community recovered quickly, becoming more like ungrazed sites, while belowground the plant community in recovering areas continued to look like the plant community in grazed areas. Aboveground plant productivity, stem density, and diversity quickly became more like reference ungrazed areas than grazed areas. Belowground, however, the plant community represented by the bud bank remained more like grazed areas, both in terms of composition and density. Our work demonstrates that lagged effects of drought and grazing are present in tallgrass prairie plant communities, and that the effects of disturbance are mediated through their impact on the demography of belowground bud bank demography.

Effects of pasture size on the efficacy of off-stream water or restricted stream access to alter the spatial/temporal distribution of grazing cows

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For 2 yr, six 12.1-ha cool-season grass pastures were used to determine the effects of grazing management and pasture size on cow distribution. The experimental design was a 3 x 2 switchback with three grazing management treatments: unrestricted stream access without off-stream water (CSU), unrestricted stream access with off-stream water (CSUW), and stream access restricted to stabilized crossings (CSR); and two pasture sizes (small (4.0 ha) and large (12.1 ha)) alternated at 2-wk periods for five 4-wk intervals of each grazing season. In each year, small and large pastures were continuously stocked from mid-May through mid-October with five and fifteen fall-calving cows, respectively. Cow location was recorded at 20-min intervals with GPS collars fitted to 2 to 3 cows in each pasture. Cow location was classified as being in the stream (0-4.6 m from the stream), streamside (4.6-33.5 m from the stream), or upland (greater than 33.5 m from the stream) on aerial maps. In yr 1, the proportion of time cows spent in the stream zone was lower in large than small CSU pastures in periods 4 and 5 and CSUW pastures in periods 2 through 5. In yr 2, cows spent more time in the stream zone of small compared to large CSU and CSUW pastures in periods 1 through 3. In both years, cows in large CSU and CSUW pastures spent less time in the streamside zone than small pastures with these treatments in every period. In yr 1, cows in small CSR pastures spent less time in the streamside zone than small CSU or CSUW pastures in every period. Across all treatments and years, the probability of cows' presence in the stream zone and within 4.6 m of tree driplines increased as the temperature increased; however, the rate of increase was greater in small than large pastures. Off-stream water had little effect on the presence of cattle in or near pasture streams. Pasture size was a major factor affecting congregation of cows in or near pasture streams with unrestricted access at increasing temperatures

A new paradigm for grassland management: landscape heterogeneity management for grassland conservation and livestock production

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Recent research has suggested a paradigm shift in how we manage grasslands. Managing grasslands for conservation while encouraging economically viable production enterprises (primarily livestock production) has become more common. Techniques such as patch-burning grazing and rotational grazing have been suggested as methods to create within-ranch heterogeneity. However, landscapes are created by multiple ranches and multiple owners. On private lands, managers often "manage to the middle", which does not usually enhance heterogeneity but instead promotes homogeneity of vegetation structure and plant communities. Some grassland managers have suggested that private lands can contribute to conservation by managing grasslands at larger spatial scales; however, we lack information about habitat heterogeneity at this "landscape" scale. Our proposed research will address whether a variety of grazing systems on neighboring ranches create large-scale heterogeneity that supports most grassland species. There is a high amount of heterogeneity inherent to mixed-grass prairies, and temporal and spatial variability in management regimes on private lands may result in a heterogeneous landscape that provides habitat for a diversity of prairie species. We will conduct a study to evaluate the level of heterogeneity across multiple contiguous ranches, and how ranch management (e.g., season-long continuous grazing and rotational grazing) affects habitat heterogeneity and bird communities. Our study will take place in the Nebraska Sandhills where we will assess vegetation structural heterogeneity and bird diversity and communities across at least two groups of ranches. Each ranch within one group will have implemented distinctly different management strategies historically, which could be expected to create heterogeneity and increase gamma-scale diversity and greater habitat heterogeneity. All the ranches in the second group will have implemented similar management strategies historically, which would not be expected to increase heterogeneity, but rather result in homogeneity, and not achieve increased levels of gamma-scale diversity. Using these assessments, we will better understand the scale at which management of private lands can contribute to prairie conservation. Further, these data may be used to produce simulated landscapes that can guide management plans for conservation on private lands. Such data is necessary before making recommendations for co-management of privately owned rangelands.

Photo credit: Maggi Sliwinski.

8

Bison Grazing

Bison grazing with a wallow in the foreground at Theodore Roosevelt National Park, near Medora, North Dakota, USA. (Photo by K. Ellison, WCS).

"What a thousand acres of silphiums (compass plants) looked like when they tickled the bellies of the buffalo is a question never again to be answered, and perhaps not even asked."

–Aldo Leopold (1949, *A Sand County Almanac*)

Bison *(Bison bison)* as a force promoting Climate Change Adaptation in grasslands

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Other authors: S. Ewing and K. Noland, Montana State University; M. Cross, E. Rowland, and K. Aune, Wildlife Conservation Society

Currently, grasslands are threatened by conversion for agricultural production and fire suppression, and have been degraded via fragmentation and grazing management that predominately reduces grassland habitat heterogeneity. For millennia, an estimated 10-30 million bison (genus Bison) shaped and maintained North American grasslands. Grazing by bison produced landscape-scale grassland habitat heterogeneity on which endemic grassland birds specialized over thousands of years. In addition, bison are unique as North America's largest terrestrial mammal (adults: 400-900kg) that regularly creates wallows (compacted depressions in dirt or mud). The compaction reduces infiltration, so that wallows serve as local ponds that can retain water for several days following rain or snowmelt.

The number of pre-European contact wallows has been estimated at more than 200 million, comprising over 80,000 ha in the Tallgrass prairie alone, each of which would have displaced 23m3 of sediment (McMillan 1999, Butler 2006). Wallows and grazing by bison can also impact soils and local hydrology by influencing soil compaction, water infiltration, and the temporary storage of water in both abandoned and active wallows. The potential for bison to: create a fine-scale mosaic of soil moisture conditions, improve habitat heterogeneity, and increase productivity

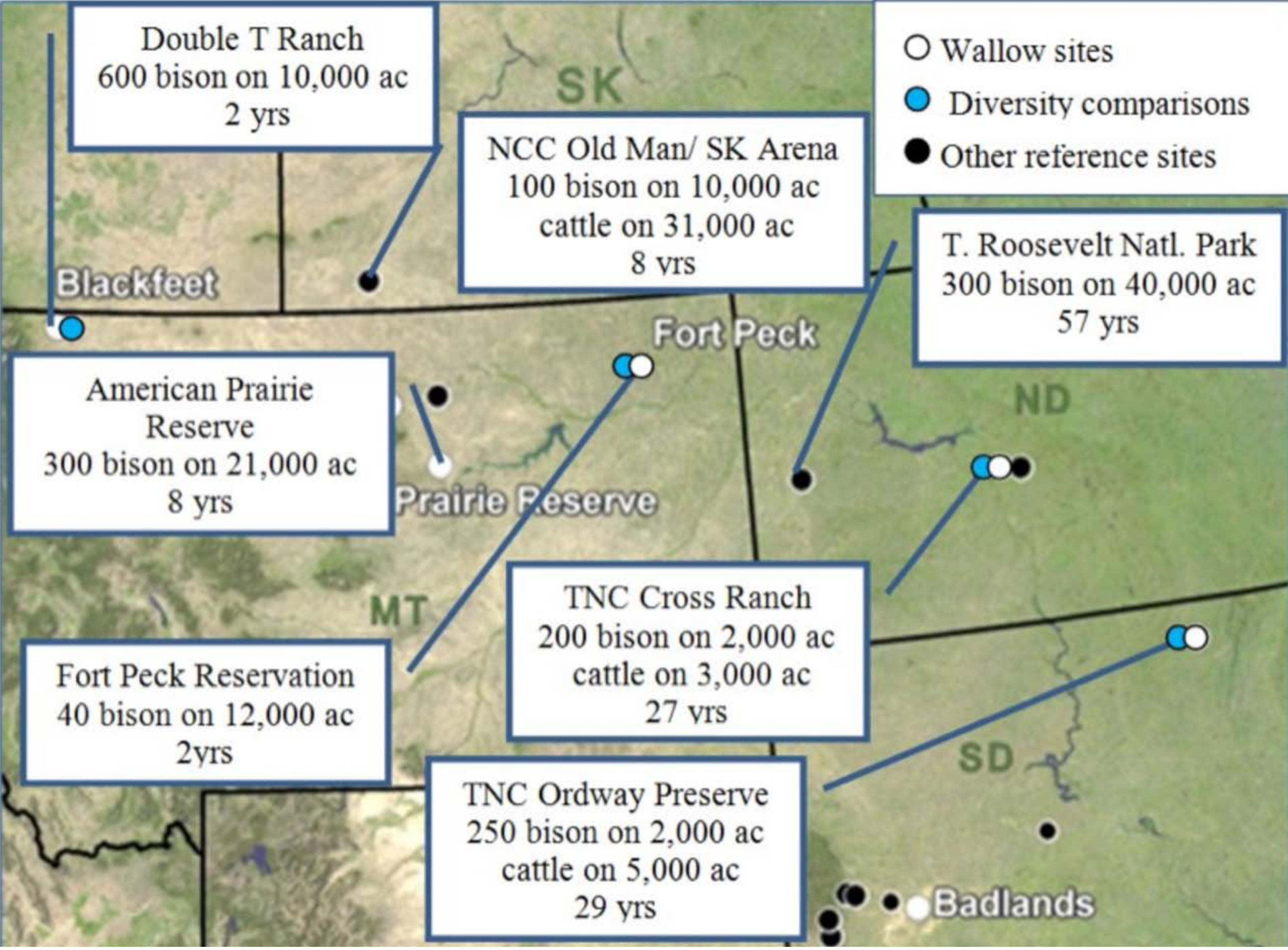

Figure 15. Study sites within the northern Great Plains (Saskatchewan, Canada; Montana, North Dakota and South Dakota, USA). Sites are characterized by the species of grazers, land base and duration of bison presence.

and diversity of birds, amphibians, and other species suggests that they are important for building ecosystem resiliency toward buffering the effects of climate change (likely 4˚C warmer and drier) on grassland ecosystems (see Craine 2013).

To test these hypotheses about the ecological effects of free-ranging bison and their role in building the resiliency of grasslands, we collected baseline bird and vegetation data at bison reintroduction sites in the northern Great Plains that ranged from one year pre-reintroduction to 57 yrs after reintroduction. We also collected more detailed soils data and used an aerial survey for wallows at the American Prairie Reserve near Malta, Montana, where bison were reintroduced in 2005. The wallow portion of our study was designed to compare the dispersion of wallows across sites with varying duration of bison presence and to identify site features associated with wallows. We intend to build upon this pilot project with further research. We anticipate providing outreach on management recommendations for increasing the formation of wallows with a goal of increasing the acreage of grasslands maintained by bison and/or cattle managed in ways that mimic the beneficial effects of historically free-ranging bison.

Methods

Bird and vegetation surveys:

We surveyed vegetation and grassland birds 1,527 points distributed among 17 sites, 2012-2013. The sites surveyed were managed with cattle or bison, and 2 sites were

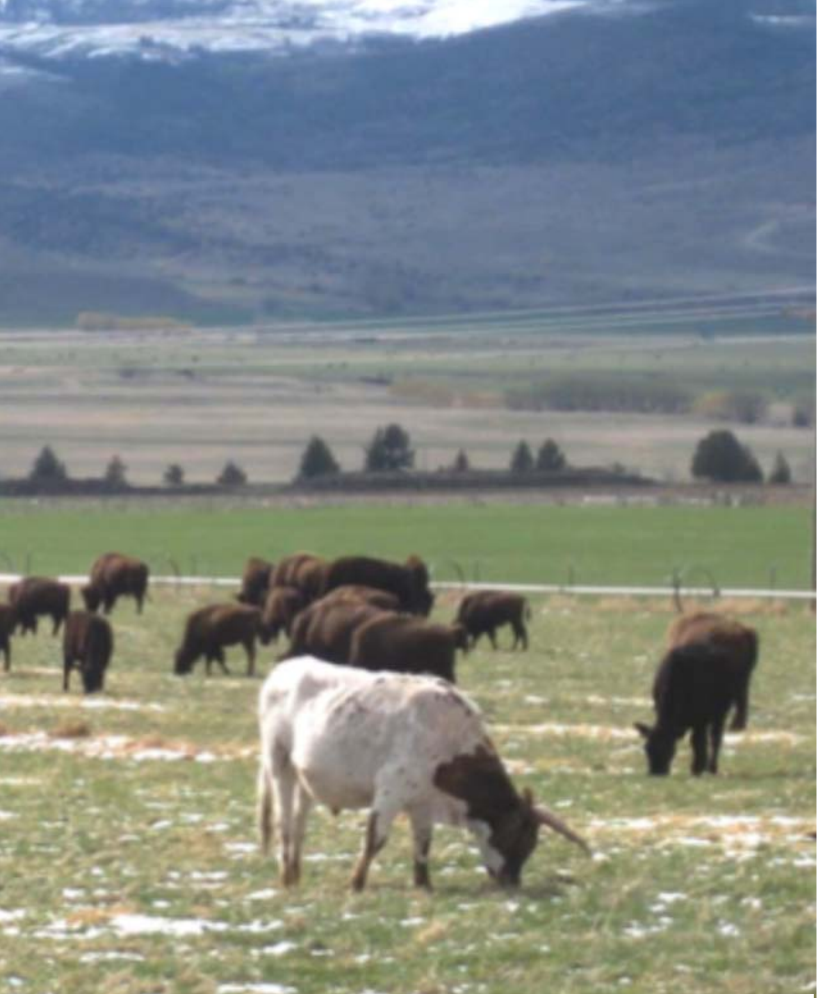

Figure 16. Bison and cattle can be managed together to produce the benefits of complementary grazing and wallows. Bison and cattle shared the open range in the 1800's (Photo by K. Ellison, WCS).

surveyed prior to and after the reintroduction of bison (Figure 15). To test for differences in species richness due to grazing management, we compared vegetation characteristics and species richness between pastures managed at traditional stocking rates typical of production herds and those managed for conservation.

Wallow characterization:
We mapped and measured the dimensions of wallows at Fort Peck Reservation, American Prairie Reserve, Theodore Roosevelt National Park, and Nature Conservancy Canada's Old Man on His Back Reserve.

Soils were surveyed at the American Prairie Reserve. This work included an aerial photographic survey in 2013 of an established 1-km2 grid where soils were sampled (Carbon, Nitrogen, and pH) in 2008. Vegetation plots centered on the same grid-points have been characterized. Soil and vegetation data, plus aerial (at 3 and 6-inch resolution) and ground-based photos, will provide baseline to monitor any future changes as well as facilitate a broad-scale survey of wallows and vegetation.

Results and Discussion

Bird and vegetation surveys:
Among the sites managed for bison, vegetation height was greater (75% of 12 paired sets of pastures [those managed for conservation versus production] at 3 sites) and diversity among the grassland bird species was highest (0-12% greater among 9 grassland species; 0-33% greater among 4 focal grassland species). Thus, we feel the differences are primarily due to management and not the species of grazer per se. We stress that neither management type is better than the other, but that each serves different species to varying degrees and a mixture of practices is needed.

Wallow characterization:
We mapped and measured the dimensions of 116 wallows at 5 sites. Average wallow area was 13.2m2 with an estimated volume of 0.19m3 (soils weigh 600-900kg/m3). Maximum wallow dimensions were 11.6m by 23.8m and 50.8cm deep. Wallow densities and dimensions ere greater at sites where bison had been present longer.

At the American Prairie Reserve, wallow sites were not widely distributed across soil types and were characterized by more undeveloped Entisols (55%) and water gathering/salty Alfisols (45%) soil types than found at points without wallows.

We anticipate conducting further research to better understand how and where wallows are formed and their importance to wildlife species and local hydrology. Next steps beyond this basic research likely include:

1. Consideration for mixed-species grazing strategies (see Figure 16) and/or higher stocking rates/smaller pastures to better achieve ecological benefits via grazing and wallowing

2. Further test relationships of grazing management & bird (& anuran) species richness

3. Collaborate to assess wallow formation through time & across soil types & precipitation regimes which would be useful for assessing climatic scenarios.

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Bison loafing around a windmill at Fort Peck Reservation during a dry April (2013). Photo credit: A. McDonnell, WCS.

Bison *(Bison bison)* mediated seed dispersal in a tallgrass prairie reconstruction

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Other Author: W. Sue Fairbanks, Iowa State University

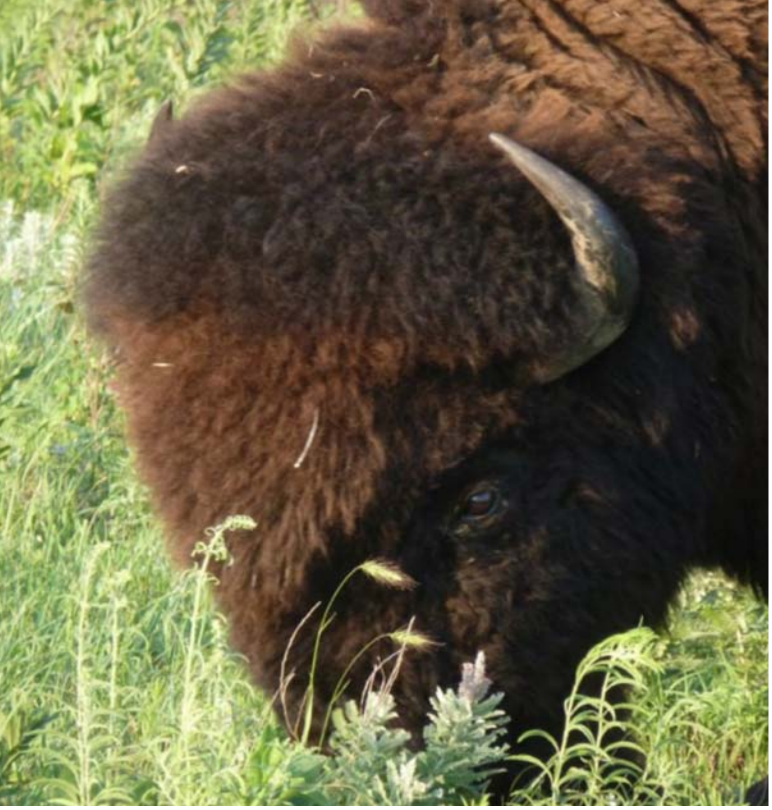
Bison have been considered keystone species in the evolution of tallgrass prairies due to grazing activities, but bison also have great potential to be effective seed dispersers. As part of a larger study, we report the seed composition found in bison dung and shed hair collected from the Neal Smith National Wildlife Refuge in south central Iowa. Our objectives for this study are to determine the potential for dispersal of native and non-native seeds in bison dung and shed hair in a reconstructed tallgrass prairie. We hypothesized that seed species composition in fecal samples would be dominated by graminoid species, based on microhistological diet analysis from previous research at our study site. Shed hair samples were expected to contain a higher proportion of forb species than found in dung. Seeds were extracted and identified from 131 fecal samples collected monthly from May 2011 through April 2012. Seed composition of both shed hair and dung appear to be influenced by forage selection by bison and the phenology of seed dispersal. Bison dung contained a greater percentage of non-native species than native species, while the opposite was true in shed hair. Greater numbers of forb seeds per gram were found in winter dung samples, while dung samples collected during the growing season contained mostly graminoids. Shed hair collected from April through November 2011 contained more grass seeds per gram than forbs. Over the entire year, greater numbers of grass seeds per gram of dung were found, but over half of the grass seeds were damaged by the digestive processes. By contrast, forb, sedge, and rush seeds were less common, but less damaged.

Pyric Herbivory: Landscape-Level Distribution and Movement of Plains Bison *(Bison bison)* at Konza Prairie

Anthony Joern, Kansas State University

Other authors: Adam Skibbe, Mark Sowers, EJ Raynor, Douglas Goodin, and Bohua Ling; Kansas State University

Fire, grazing and climate are major drivers of grassland structure and function, where strong feedbacks exist between fire and grazing (pyric herbivory). Spatially-explicit distributions and movement patterns of bison in such landscapes reflect physical features of the landscape and



Bull bison at Konza Prairie, Photo credit: Edward Raynor.

the availability of quality forage. Our goal was to measure bison habitat preference and movement patterns among watersheds with different burn frequency and burn history. Up to 15 female bison were fitted with GPS collars in each year between 2008 and 2011. These GPS locations were recorded every 2 hours from 2008-2010, and hourly in 2010-2011 and analyzed in a GIS framework. Bison prefer recently burned watersheds during the growing season and unburned watersheds during the rest of the year. As the season progresses, forage quality decreased in recently burned sites, leading to greater homogeneity in plant quality among watersheds, and less site fidelity and increased movement activity by bison. Among recently burned watersheds during the growing season, bison preferred watersheds with longer burn intervals to annually burned watersheds. Bison step-length (straight distance moved between data points) was higher in the growing season compared to the non-growing season. Step length showed an inverse relationship with habitat selection, indicating that bison move quickly through non-preferred watersheds, and are more resident (shorter steps-length) in preferred watersheds. These results showed that herbivory in grasslands is linked to fire frequency, thus illustrating that a strong feedback exists and that a mosaic of habitats is essential to grassland structure and function.

Responses of a grassland spider community to disturbance from fire and bison grazing

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A major overarching hypothesis in community ecology is that habitat spatial and temporal heterogeneity promotes species diversity. In grassland ecosystems, such spatial and temporal heterogeneity at the landscape level results from the interaction of fire, ungulate grazing and climate ecosystem drivers. Ubiquitous arthropod predators like spiders on grassland systems modulate prey community and ecosystem processes. Spiders partition their habitat at a small scale to maximize the effectiveness of a particular hunting strategy and reduce interspecific competition that result in resource diversification. Responses of predators (spider communities) to major disturbances on grassland ecosystems have not been studied in detail. At Konza Prairie Biological Station, unique long-term manipulations (fire frequency and bison grazing) at watershed levels have resulted in a mosaic of habitat types. The **habitat complexity and heterogeneity hypothesis predicts that the overall abundance and species diversity increases with spatial heterogeneity of habitat structure**. To address this hypothesis 23 sites were established along a gradient of habitat types that range from grass dominated habitat to gallery forest areas in bison grazed and ungrazed watersheds at KPBS. At each site, the spider and insect communities were sampled using vacuum and sweep-nets. A series of vegetation characteristics were also measured to characterize the spatial heterogeneity and structural complexity of each site. Results indicate that species richness increases within the growing season. Spider abundance increases on ungrazed sites that may result from an increase in spatial heterogeneity and microhabitat diversity with plant growth over the summer. Species abundance and diversity is influenced by fire frequency. But, spider diversity and abundance increased over time (during the summer) independently from fire frequency. This may be promoted by higher microhabitat availability later in the growing season as result of differential growth among plant species. Spider abundance and species richness increased with increasing spatial heterogeneity in vegetation structure in the early season. Bison grazing influenced habitat heterogeneity maximizing microhabitat availability and use early in the summer. In the late summer and early fall, the effect of spatial heterogeneity in structure was not significant, suggesting a switch to the importance of total structural volume.

Abundance and spatial distribution of bison wallows on a tallgrass prairie

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Wallows are a persistent, landscape feature formed in areas grazed by bison. Wallows increase biodiversity in plant communities, provide breeding grounds for anurans, and act as sources of drinking water for bison. The distribution of wallows in tallgrass prairie has been little studied. This landscape level study looked at the characteristics of existing wallow locations and constructed a model to predict where bison wallowing is most likely to occur. A total of 3561 wallows, classified as either active or inactive, were identified from aerial images of the Konza Prairie Biological Station. These wallows had an average size of 8.6 m2 and accounted for approximately .3% of the total 1000 hectares available to the bison herd. Konza wallows are clustered together spatially, not randomly distributed across the landscape and tended to be located in flat areas associated with mid-elevational limestone benches. An analysis of logistic regression models found that slope and elevation were the primary factors associated with wallow location. Statistically significant comparisons between wallows and random points indicated that bison wallows are located in upland areas with low slopes where aspect and distance to stream did significantly not impact location. With the results of this study we now feel that we can identify the areas where bison are likely to wallow. Knowing the factors involved in wallow distribution furthers our understanding of the role of bison in shaping a tallgrass prairie.

Foraging behavior of plains bison in tallgrass prairie: an investigation of multiple foraging hypotheses

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Other Authors: Anthony Joern and John M. Briggs, Kansas State University

Ungulate foraging behavior can shift in response to differences in forage characteristics and may be a key predictor of patch selection and residence time. Elucidating behavioral mechanisms to understand fine and broad scale spatial distribution of large, ungulate herbivores requires an accounting of the factors driving foraging decisions at multiple scales. To gain fundamental knowledge of behavioral mechanisms and nutritional constraints responsible for foraging behavior by bison, we test multiple foraging hypotheses at Konza Prairie Biological Station with Plains Bison (Bison *bison bison*). We are assessing how bison adjust forage intake in response to shifts in vegetation quality and quantity in aC4 grassland to ask how ecosystem nutrient dynamics determines use of the site across a variety of scales (feeding station to watershed). At the smallest scale, bite rate declined with increasing grass height in biennially burned watersheds during summer (N=26, P=0.04), whereas no significant relationships were observed in other season by burn treatment combinations. In addition, bite rate declined with increasing biomass during spring (N=20, P=0.04) and summer (N=19, P=0.04) in watersheds burned in 2012 but not burned for at least 4 years. At the patch scale, foliar %-N (mean±SE; 1.33±0.03) from areas grazed by bison was 20% higher than nearby areas not grazed by bison during foraging bouts (1.105±0.023). By fitting forage intake rate to available plant biomass using a non-linear Michaelis-Menten function, we observed that intake started to level off at a biomass of around 50 g m-2, and that the maximum intake rate was 32 g min-1 in spring, while forage intake rate started to level at a biomass of around 125 g m-2, and that the maximum intake rate was around 23 g min-1 by late summer. We thus provide evidence that the forage intake rate of the Konza Prairie bison is restricted by ingestion rate. Our findings suggest that bison of the tallgrass prairie adjust foraging behaviors in relation to seasonal variations in vegetation quality and abundance.

Pocket Prairies, Volunteers, and Information Sharing

Grassland Heritage Foundation volunteer Frank Norman conducting a spring prescribed burn at Snyder Prairie in Northeastern Kansas. Photo credit: Wayne Rhodus.

"Even the smallest open space available may possess an immense education potential to reconnect people with nature and landscape. These limited spaces, reconstructions, or restorations are what we call micro-prairies."

–Bruno Borsari, *The Micro-Prairie-Urban Farm Continuum: Sustainable Landscapes within the City Limits* (page 70)

Prairie Management by a Non-Profit Organization: Obstacles and Solutions

Frank J. Norman, GHF Preserve Manager and Norman Ecological Consulting, LLC.

Grassland Heritage Foundation (GHF) is a non-profit membership organization devoted to prairie preservation and education. Since 1994, GHF has been managing its 140-acre tract of land fondly called 'Snyder Prairie', which is composed of restored and native prairie, woodlands, and cool-season grassland. Snyder Prairie is located north of Topeka in Northeastern Kansas, and has approximately 85 acres of tallgrass prairie, of which 15 acres are unplowed, intact prairie. During that time, GHF's volunteer group—Groundhogs—has taken on the management, meeting every third Saturday, January through November annually. Management includes tree removal, brushing of shrubs and other woody growth, herbicide removal of invasive plants such as *sericea lespedeza,* prescribed burns during the spring, and reseeding cleared areas to prairie. Average attendance at Groundhogs from 2006 to 2012 was 4.25 persons per Saturday with 76.6% of volunteer events attended.

As anyone familiar with prairie management knows, prairie is no longer the climax community in the central Midwest; left unmanaged, prairie eventually turns into woodland. This transformation usually is accelerated in fragmented landscapes in which tracts of land surrounding prairies act as reservoirs for seeds and fruits of woody plants. Consequently, GHF is faced with forever fighting woody invasion that includes native species such as rough-leaved dogwood, eastern red cedar, honey locust, and smooth sumac and non-native species such as Osage orange and Siberian elm. Typical methods to control woody invasion—prescribed burning, brushing, and herbicide application—often provide a partial 'kill' or temporary dieback and only delay woody encroachment for several months. In addition, control measures are more time-consuming at Snyder Prairie as GHF uses chainsaws and loppers to keep woody species in check and back sprayers to apply herbicide. Consequently, controlling woody growth in this manner in a prairie environment works well on a small scale where one or two burns can treat an entire prairie tract and a handful of volunteers can effectively control brush over the entire prairie in a year or two. However, it does not work well on a larger scale, such as at Snyder Prairie, where seven more-or-less separate prairie remnants cover over 85 acres distributed across the 140-acre site.

Faced with losing tallgrass prairie habitat at Snyder Prairie, GHF hired subcontractors with mechanized equipment in 2010 to save the prairie on its property for years to come. With the goal to convert all of its prairie to hay meadows, GHF developed a strategy to prep its prairies by 1) removing trees and saplings with a skid loader and tree shearer, 2) knocking back shrubby vegetation with a brush hog, selective herbiciding, and spring burns over multiple years, 3) using an ATV with a water tank to treat sericea lespedeza with herbicide, and 4) incorporating Groundhogs in the control efforts by brushing and burning perimeter areas, treating sericea lespedeza in smaller, harder to reach areas, and picking and piling up woody debris.

By 2011, haying had commenced in two restored prairies and the abundance of sericea lespedeza had been significantly reduced by 2012. GHF will continue with its new management approach with the plan to have all 85 acres prairie habitat in hay meadow in the near future. As haying continues, GHF wants to establish a three-year haying rotation (i.e., burn, hay, and idle) for its future hay meadows to keep woody encroachment at bay and provide a varied wildlife habitat on-site.

Restoring Eden: Oak Savanna Restoration in South Central Iowa

Sibylla Brown, Timberhill Oak Savanna

Before European settlement Oak savanna was the transition zone between the tall grass prairie and the eastern deciduous forest. It extended in a broad arc from Wisconsin and Minnesota south to the Texas hill country. Populated by numerous species of plants and animals it was a unique combination of interrelated organisms.

Whereas most of the pre-settlement virgin prairie has been lost and can only be reconstructed many Midwest unplowed woodlands are highly restorable overstocked oak savanna. They require only timber stand improvement and prescribed fire to restore the habitat. Timberhill is a 200 acre oak savanna restoration in south central Iowa. Management commenced in 1993 with timber stand improvement, specifically crop tree release and selective thinning. Trees with the best potential for crown expansion were saved and all understory trees beneath the crowns of the 'save' trees were removed. Standing dead trees and snags were left for cavity nester birds. Cut dead wood was left on the ground; as the wood breaks down it returns nutrients to the soil.

Oak savanna is a fire dependent system. In 1995 annual dormant season prescribed fire was implemented at Timberhill. Annual dormant season fire results in the highest diversity while doing the least damage. It burns up through the fine fuels of the season and does not heat the ground. Fire also stimulates regeneration of graminoids and forbs. Without any seeding, vascular plants at Timberhill have increased from 100 before restoration began to over 460.

The red-headed woodpecker is the Midwest oak savanna cornerstone species, one that has a disproportionate effect on the environment relative to its biomass. These birds build a new nest each year and abandoned nests are used by other species. It is also a species of conservation concern because of loss of habitat. Red-heads have very specific habitat needs: open woodland, standing dead trees and snags, and open space to feed on insects they catch in flight. The Timberhill restoration has restored habitat for an abundant population of red-heads.

Oak savanna also the habitat of a whole suite of neo-tropical migratory birds. Studies comparing oak savanna and overgrown woodlands have proved that at least 14 species of neotropical migrants have higher nesting success in restored savannas than in overstocked woodlands. (Brawn, Jeffrey D. 1998. "Effects of Oak Savanna Restoration on Avian Populations and Communities in Illinois." Illinois Natural History Survey.)

At Timberhill restoration has also restored springs and seeps, stimulated oak dominance, and increased habitat for habitat sensitive butterflies such as Horace's duskywing, Byssus skipper, and Dion skipper.

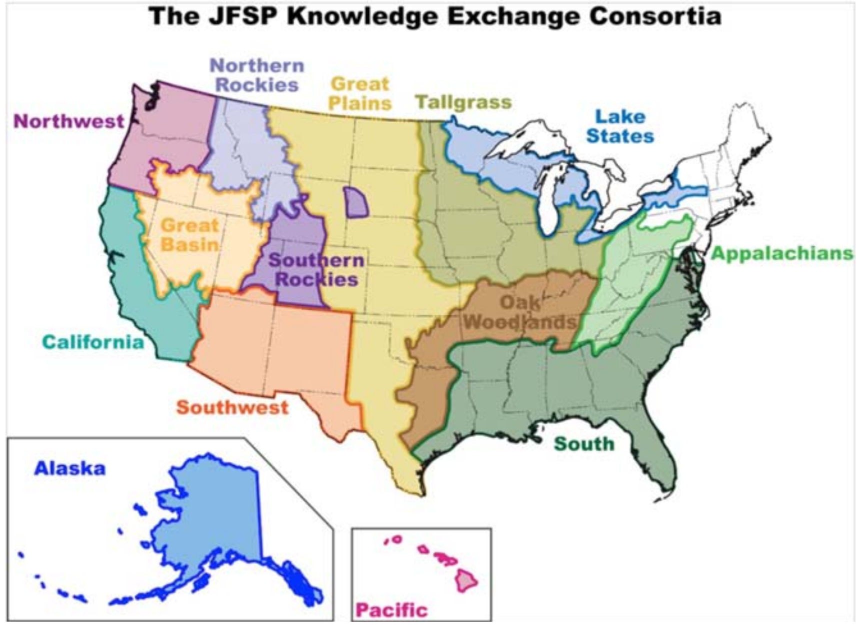

Figure 17

USFWS has made savanna restoration in southern Iowa a high priority. Besides cost share funds for timber stand improvement, a FWS field biologist living in Decatur County, Iowa provides technical support. FWS also sponsors the Southern Iowa Oak Savanna Alliance (SIOSA), an organization of oak savanna landowners. SIOSA conducts oak savanna restoration workshops, a prescribed burn association, and promotes community awareness of the oak savanna landscape.

Moving toward an era of management decisions based on sound science

Carol Blocksome, Great Plains Fire Science Exchange, Kansas State University

Other Authors: Sherry Leis, Great Plains Fire Science Exchange, Missouri State University

Fire is a necessary process for maintaining the integrity of grasslands whether ignition is prescribed or unplanned. Natural resource managers and private landowners working in grasslands have fire management goals that range from enhancing forage production to supporting species diversity, specific species management, or even landscape level goals.

Researchers have worked to provide information relevant to these goals, but managers from all backgrounds struggle with access to the information and how to apply it. The Joint Fire Science Program (JFSP) has responded to these needs with the creation of Knowledge Exchange Consortia (Figure 17). To serve the region encompassing the western tallgrass prairie, midgrass, and shortgrass regions of the United States, the Great Plains Fire Science Exchange (GPFSE) consortium was formed.

The goal of the newly formed Great Plains Fire Science Exchange is to develop ways to transfer information as well as facilitate the interaction between researchers and managers. Results from fire science research will be disseminated to the fire practitioner community. Conversely, the needs of fire practitioners for additional information will be conveyed to science researchers and to JFSP to focus new fire research and to provide grant funding to support this research.

Surveys are conducted biannually, and needs assessments are collected at trainings and other events to determine the most important needs of fire practitioners. The first survey (Figure 18) indicated that fire ecology and fire effects were the most important information needs (25% of respondents), with education as the second most important need (20% of respondents).

Unlike other areas of the United States, the vast majority of land in the Great Plains region in which the GPFSE works, are private lands and also includes numerous Indian tribal lands. These fire users add to the diversity of the fire community, which also includes public safety officers, public land managers, fire practitioners, contractors, researchers, policy makers, the media, and the general public. Analysis of the results indicate that regional needs differ throughout the Great Plains. The GPFSE is committed to meeting these varying needs with appropriate responses, including trainings, science briefs, webinars, and other outreach methods.

During its first year of operation, the GPFSE completed a set of videos entitled “Fire in the Great Plains”, released 1 science brief and 2 factsheets, ; set up an online resource center which includes a website, blog, and Facebook page; published the *Great Plains Fire Communication Kit,* and several editions of the newsletter “The Lek”; hosted two Patch Burn Grazing conferences; identified and began work to capture knowledge from demonstration sites; hosted a webinar “Prescribed Fire Smoke and Air Quality- A Case Study from the Flint Hills of Kansas”; presented a workshop on fire science at the Society for Range Management annual meeting; and provided scholarships for land owners to attend trainings.

The Great Plains Fire Science Exchange will continue to work with many partners, including the Prescribed Fire Associations and Councils in the region, as well as the Fire Learning Network, universities, and others to develop new partnerships. Encroachment of woody species into grasslands will be the focus of research and outreach for the coming year.

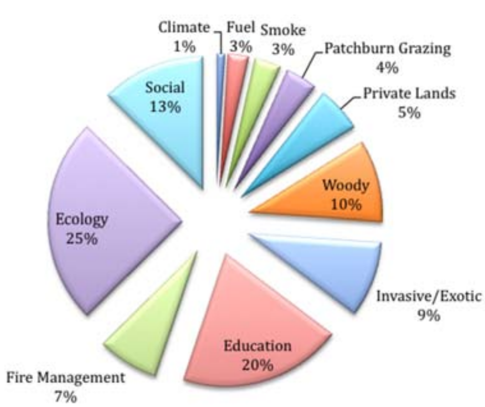

Figure 18: Management Needs Information

The Micro-prairie-Urban Farm Continuum: Sustainable Landscapes within the City Limits

Bruno Borsari, Winona State University

Other Authors: Neal Mundahl, Winona State University and Malcolm F. Vidrine, LSU-Eunice

The ecological integrity and resilience of American grasslands is being challenged by fragmentation, habitat destruction, and a rapid expansion of anthroposcapes. Restoration and reconstruction initiatives often appear as feeble efforts when these are compared to expansions of urban areas and infrastructure. Also, an insatiable hunger for energy, non-renewable resources, and further developments of intrusive, extractive economies (e.g., hydraulic fracturing) are exacerbating the situation and often affecting the grasslands of national parks and other protected lands. We believe that anthropocentrism and affluence are simply the symptoms of a malaise that most people suffer due to an education about nature that is often minimal or nonexistent during the early, formative years of most children (Louv 2005). Consequently, most individuals remain indifferent to habitat extirpation and apathetic to an appreciation for ecological processes and services that are vital to global homeostasis and quality of life. A culture of conservation and stewardship may become established only if the broadest spectrum of modern society becomes better informed about the reasons and benefits of doing so. Therefore, a compelling need to veer education toward curricula that are more eco-driven becomes the mandate for education reform in the 21st century (Borsari 2012). To this end, the urban environment has potential to emerge as the most viable context to make prairie reconstruction successful in achieving the educational effort mentioned here. Even the smallest open space available may possess an immense education potential to reconnect people with nature and landscape. These limited spaces, reconstructions, or restorations are what we call micro-prairies.

The purpose of this work is to present a vision of the environmental and educational value of micro-prairies. These small restorations within the urban environment can be biologically productive and ecologically viable, reducing cities’ carbon footprints, fostering environmental education, and improving the quality of life for city dwellers (Diboll 2004). For several years, prairie gardens and urban farms have been appearing in various municipalities across the Midwest of the United States, demonstrating the potential for and benefits of habitat restoration and reconstruction at the micro scale (Borsari et al. 2013). Often inspired by a permaculture design (Mollison 1999) and with emphasis on soil rehabilitation (Kefeli et al. 2007), micro-prairies are pivotal for establishing an education-for-place paradigm, which includes also the value for pollinators in cities of notable prairie states of the United States.

Micro-prairie gardens that are reconstructed in urban settings have several advantageous attributes that can make them extremely valuable in enhancing an education for stewardship and conservation (Vidrine 2010). Most remarkably, they easily can be accessible to all and they can be managed in ways that are conducive to people's involvement. They are visible and offer great opportunities to bring the community together, making any prairie restoration effort educationally viable and participatory, even when this is done on the smallest vacant lot or space. They can be done in association with community vegetable/flower gardens. These and similar pocket prairie (or postage stamp prairie) demonstrations rely more on people's imagination and creativity to be constructed (Borsari et al. 2013). They may include art and accommodate various forms of visual art works aimed at enhancing views about the landscape that often are inhibited from emerging by most people's links to vestiges of a Puritan heritage (Borsari and DeGrazia 2013). Micro-prairies can spark a new, distinctive culture of landscape design and habitat restoration for the city. The micro-scale approach to prairie restoration or reconstruction can become an instrumental vehicle to supersede anthropocentric world views, improve quality of life in the urban environment and also inspire peoples' reflections to reconsider the role of humans in nature (Hynes and Howe 2004). All of this becomes possible because more and more citizens are being re-educated about conservation when prairie patches are grown in the city. Through this and similar efforts, sustainability education can be pursued as well, especially when prairie restoration at the micro-level merges with large-scale restoration endeavors. The micro-prairie restoration model is connected to the restoration issues, which are typical of large-scale restorations and aware of its advantages and also its flaws. The two prairie models are not antagonistic and despite their similarities, they remain solidly distinctive (Table 3).

Thus, design, management, and more limited resource needs to reestablish micro-prairies should inspire macro-prairie restorationists to research ever more-sustainable methods to achieve and maintain the self-sustenance and productivity of these systems. Vast remnant grasslands may not attract large multitudes of visitors due to their geographic distance from urban centers, whereas micro-prairies may. The flow of knowledge between the two prairie restoration models is centripetal, transparent, holistic, and leads eventually to a unified paradigm for prairie appreciation, preservation, and sustainable landscape design (Figure 19).

Table 3. Selected attributes of reconstructed prairies and main characteristics at the macro and micro scale.

Attribute	Macro-prairie	Micro-prairie
Technology	High	Appropriate
Energy needs	High	Limited
Biodiversity	Very High	Limited
Resource needs	High	Limited
Visibility	Limited	Very High
Accessibility	Variable	High
Education potential	Variable	High
Space/land resource	High	Limited

We envision the cityscape of the future interspersed by micro-prairie islands that blend and connect to larger prairie preserves, farms, and more natural landscape units. The paradoxical vision of Aldo Leopold and Lorrie Otto are in place to become universal visions, lest our planet will undergo so much change that it may become hostile to a majority of living beings, not just those deemed unimportant or noxious by humans.

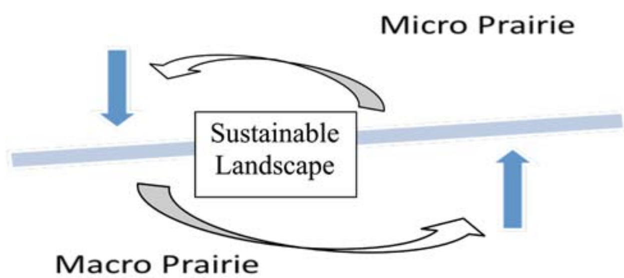

Figure 19. Interconnectedness between large-scale and small-scale prairie restorations.

It is hoped that our vision for micro-prairie design and reconstruction will be adopted, with appropriate adaptations, by many schools, colleges, and universities, as these remain and will continue to be the temples of knowledge and inspiration for future generations to become the best possible stewards of the land.

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Design Process and Reconstruction of a Prairie Garden at Winona State University: A Case Study

Bruno Borsari, Winona State University

Other Authors: Kaitlyn O'Connor and Neal Mundahl, Winona State University

The design and establishment of a prairie garden can become a powerful vehicle for place-based education. It also can counteract Nature Deficit Disorder (NDD) that currently is affecting most school-age children and young adults in the United States (Louw 2005). In addition, an ecology-based curriculum, which includes emphases in outdoor education, demonstrations, and engagement in restoration projects, may further amplify the transformative learning effects of place based-instruction and sustainability (Borsari 2012). We attempted to embrace this pedagogy at Winona State University in early 2013, through the design and construction of a prairie garden on campus. In order to maintain the LEED Gold Certification of its new Integrated Wellness Complex (IWC), Winona State University had to install a landscape in the vicinity of this building that would not require irrigation water. Unfortunately, prolonged, hot and dry weather conditions in 2012 decimated the turf and traditional, inconspicuous landscape plantings that were installed immediately after building construction. To remedy this situation, this project was initiated to design and establish a prairie garden as a demonstration of sustainable landscape on the south side of the IWC, on an area of approximately 750 m2. This work also aimed to demonstrate the efficacy and power of a student-faculty team project capable of initiating successful collaborations between Facilities Services and the WSU Land Stewardship and Arboretum Committee, to use as a model when landscaping projects are undertaken on a college campus, or in similar, public institutions. As predicated by Diboll (2004), prairie gardens should accommodate diverse plant communities of drought-tolerant native prairie forbs and grasses, in an effort to showcase the ecological benefits of more sustainable, landscape alternatives to the typical lawn. Our garden design included an accurate site analysis of walking route patterns by campus users with the aim of detecting also areas of significant soil erosion and compaction. An emphasis on assessing soil characteristics and conditions is always valued in any kind of prairie reconstruction to determine the need for amendment applications prior to establishing any plant community or natural landscape (Kefeli et al. 2007). This preliminary work guided the design process of the prairie garden and also the selection of native plant species and theme areas.

Our garden comprises walking paths, benches, signage, a sample of native Minnesota rocks, and all these features aim at embodying the environmental component of integrated wellness at Winona State University. The paved paths connect the garden to the adjacent building without physical barriers that could impede garden access to wheelchair-bound visitors. These sinuous paths converge to a circular stage or observation area approximately 10 m in diameter, which is located in the center of the prairie garden. On Arbor Day 2013, the garden design was officially presented on-site to a small audience, representative of the whole campus community (Figure 20).

Figure 20. Presentation of the garden design by WSU student Kaitlyn O'Connor. Photo credit: Tom Grier.

The landscape reconstruction took place between May and July 2013. Forty perennial forb species and six grass species were transplanted in the seven thematic areas of the garden. These themes included species of major botanical families *(Fabaceae, Poaceae, Asteraceae)*, in addition to native perennials that typically are attractive to birds and/or butterflies, or that simply possess edible and/or medicinal properties (Table 4).

Table 4. Species diversity per theme area at the WSU prairie garden.

Theme area	No. of Spp.	Selected spp. names	Common name
Bluff Prairie spp.	11	Aster (4 spp.), B. alba, O. humifusa, A. canescens	asters, white indigo, prickly pear, lead plant
Edible spp.	9	R. missouriensis, M. fistulosa, S. canadensis	gooseberry, wild bergamot, elderberry
Medicinal spp.	5	V. virginicum, E. yuccifolium, A. feniculum	Culver's root, rattlesnake master, hyssop
Butterfly spp.	8	A. tuberosa, L. aspera, P. pilosa	butterfly weed, button blazing star, phlox
Birds spp.	7	K. cristata, P. grandiflorum, G. Maculatum	June grass, beardtongue, wild geranium

Xeric species *(Opuntia spp.)* also were planted in the driest and most elevated corner of the garden to educate visitors about the diversity of local prairie habitats that persist within the bluff region of southeastern Minnesota.

The prairie garden at Winona State University has become a key feature of our campus and an integral component of the University's distinctive collection of trees, as WSU continues the work to achieve the notable recognition of soon becoming a Tree Campus USA Arboretum. Signage will soon inform and educate users about the project, while providing more opportunities to the campus community to learn about ecological landscape design, biological diversity, and sustainability. Besides possible opportunities to engage increasing numbers of Winona State University students to restoration ecology, the environmental sciences, and sustainability, the IWC garden hopefully will give to our campus the distinctive image of an open space that is educational and that can be managed adaptively, with minimum off-campus inputs to remain biologically productive, resilient, and esthetically pleasing. This idea of pocket prairies or micro-prairie gardens is beginning to have traction in the culture of natural landscapes within cities and towns across the U.S. (Borsari et al. 2013). It is solidly framed by permaculture theory and approaches (Mollison 1999) and hopefully, it will expand further at Winona State University as soon as its ecological and environmental benefits can be more tangibly substantiated. Possible endeavors and projects to be accomplished at the garden in the near future may be geared toward an assessment of students' learning while studying the distribution and survival of the plants and the diversity of the whole prairie garden.

Acknowledgements

The authors are grateful to Dr. Jim Reynolds and the Land Stewardship and Arboretum Committee of Winona State University for the support given to this project. Generous funds were donated by the Winona State University foundation, through the assistance of Dr. Jim Schmidt and Mr. Scott Ellinghuysen. Mr. Richard Lande, Director of Facilities Services and his crew assisted enthusiastically, with the establishment of the garden.

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Prairie restoration - up close and personal - at a University campus

W. Daniel Svedarsky, Center for Sustainability, U of Minnesota, Crookston

Restoring a prairie of some size or simply using prairie plants in a traditional planting can be extremely variable in success and acceptance; however that is defined. This paper outlines the highlights of over 44 years of working with prairie restoration and native plantings at the Crookston campus of the University of Minnesota. The campus contains a branch research station of the University of Minnesota, known as the Northwest Research and Outreach Center (NWROC). Other regional research outposts are located in other parts of the state and conduct research and demonstrations on agricultural and resource management topics appropriate to that area. Also on campus is a college with an on-campus enrollment of around 1,200 students, predominantly majors in agriculture and natural resources. I have a joint appointment with each unit, commencing first with establishing a natural resources program at the college in 1969 and developing a natural history demonstration area in an 85-acre sheep pasture/abandoned gravel pit site commencing in 1971 on land owned by the NWROC.

The setting of the Crookston campus is the Red River Valley of the North, located in northwest Minnesota in one of the most intensively farmed areas of the United States. The landscape is a lakebed of Glacial Lake Agassiz and has deep, fertile soils developed under tall grass prairie vegetation. Commencing some 8-9 miles to the east is the beach ridge country comprised of rocky and generally sandy soils deposited along the shorelines of the glacial lake. In the late 1960's, this area was a mosaic of remnant prairies, brushland, wetlands, tame grasslands used for haying and grazing, and cropland. A number of state-owned wildlife management areas (WMA), federal waterfowl production areas, and natural sanctuaries of The Nature

Conservancy have been recently acquired in the area. While a few livestock grazing operations have existed over the years to the east, the **predominant culture of the region is cropland** and this has fostered a generally prosperous agricultural economy of sugar beets, small grains, sunflowers, and more recently corn and soybeans. Although prairie vegetation was responsible for the rich soils, most was turned over in the late 1800's and little connection to the original vegetation by the current landowners remains. Against this cultural backdrop, promotion of prairies and prairie plants has encountered more resistance and has required more justification than had the setting been in the Flint Hills of Kansas or the Sand Hills of Nebraska where a **grassland grazing culture** is more predominant. In 2000, the Glacial Ridge Project of The Nature Conservancy was initiated as the largest prairie and wetland restoration effort in the United States and has demonstrated the value of nature, specifically prairie and wetlands, as a regional resource that people will travel to experience. What is now the *Glacial Ridge National Wildlife Refuge* is about 30,000 acres and commences about 10 miles from campus.

Beginnings at the Natural History Area

The Research and Outreach Center is comprised of some 1,500 acres of mostly agricultural land used for agricultural research and crop production, except for the 85-acre sheep pasture/gravel pit area. This area was actually on the docket to be bull-dozed and converted to cropland when I arrived on the scene in 1969. Fortunately, there was an effort building across the state to establish "environmental education areas" and a case was built to set aside this area for that purpose to be used by the college and citizens of the region (Svedarsky 1982). This was acceptable to Bernie Youngquist, the Superintendent of the Experiment Station (now, NW ROC) at that time and he became an advocate. The site is only 1 mile from campus. To say the area was closely grazed by sheep would be a gross understatement; but in a fenced off area, some remnant prairie vegetation was evident in the fall when pinkish leaves of bluestem became evident amid the predominant cover of Smooth Brome and Kentucky bluegrass. Adjacent to the area was an active railroad and a right-of-way of remnant prairie. We commenced spring prescribed burning in 1972 to retard the predominant exotic cool-season grasses and stimulate warm season prairie species. Also, about a third of the area was covered by trembling aspen and their encroachment into the open areas was suppressed by fire. Results of the prairie restoration work at the area which came to be known as the Red River Valley Natural History Area was reported at 2 North American Prairie Conference (Svedarsky and Buckley 1975, Svedarsky et al. 1986). In 1972, I was alerted by the area wildlife manager of the MN Department of Natural Resources that a native prairie WMA was going to be impacted by a road-widening project. About mid-June, my assistant and I rescued a number of prairie clumps, notably Tall Blazing Star and Small White Ladyslippers, as well as strips of prairie sod, cut about 2" thick. While it was not the ideal time of year for transplanting, the time window was short before the dozers began work. For the sod transplants, we simply cut out the blue grass sod at the Natural History Area and rolled in the prairie sod, thereby minimizing exposure time for drying. No less than 30 prairie species survived the transplant with some supplemental watering (Svedarsky 1981). The clump transplants were also successful and within 8-9 years, Small White Ladyslippers had begun to reproduce and spread; perhaps aided by an early spring burning regime (Svedarsky 1996. Tall blazing stars have also flourished (Figure 21). The RRVNHA has functioned as an important field site for natural resources classes from the college over the year as well as a spectrum of other natural history groups. Timing, receptive administrators, creative planning, and proximity along with the usual required persistence were key in the development of the RRVNHA as a regional natural history education and demonstration resource.

Prairie and other natives come to campus

Around 2004, we had the concept of developing a micro-cosm display of Minnesota's 4 biomes in a campus site surrounded on 3 sides by buildings, including the natural resources building. The Director of Facilities at that time was not receptive to the idea since it was a new departure and not a neatly manicured area like the rest of the campus. The University of Minnesota as a system had launched a "Beautiful U" campaign which was a broadly based initiative to promote a "pride-in-place" mentality. In conjunction with the UMC Horticulture and Natural Resources clubs, a small grant was obtained to support the micro-cosm idea. About that time, I had attended an Audubon sponsored conference in Green Bay, Wisconsin and was intrigued by a paper title on butterfly gardens. I heard the paper, was inspired, and got out the sod cutter immediately on returning to campus. We lifted a triangle of bluegrass sod, got on the internet to see what butterflies liked, installed plants, and the butterfly garden was born. About year 2, a local nature and sports enthusiast walked by the garden and asked if I had a sponsor for the garden, to which I replied, "No, not yet." The prospective donor liked the concept of establishing an endowment to fund a summer intern to earn while they learned; the garden became the "Shaver Butterfly Garden" and is prominently identified with a nice sign. The general site, since it was a little out of the way, was dubbed the "Nature Nook" and the micro-cosm project was launched, somewhat in phases; smaller trees from a former campus demonstration nursery were brought in with a Vermeer tree spade, paver stones for a walkway were donated by an alum and installed for ease of access and planting delineation, and about 4,000 square feet of native prairie sod was lifted from a remnant prairie on my farm near Crookston by setting the depth gauge to 3 inches. This site is highly visible as it is immediately outside the Admissions and Financial Aid office, thus sodding provided instant success and avoided the awkward, "juvenile" phase resulting from establishing a prairie from seed and fighting the inevitable weeds (Figure 22). The Nature Nook Prairie is also near where the Chancellor and Vice-Chancellor of Academic Affairs park! The prairie plot is typically spring-burned and its proximity to buildings provides a dramatic "learning moment." In addition to spring burning to suppress Smooth Brome, Kentucky Bluegrass, and Quackgrass, Roundup herbicide has occasionally been spring applied to selectively avoid damage to warm season plants. A steam tunnel runs under the prairie plot and unfortunately had to be accessed to service a heating pipe. This resulted in a deep excavation but the availability of the native prairie sod saved the day. The Landscape Construction class designed and constructed a beautiful courtyard and seating area with a section of a walkway containing permeable pavers as a sustainability demonstration. Some $ 5,000 in paver stones were donated by the Borgert Company with additional funds raised by faculty-mentored, student-authored grants (Figure 23).

A pond and waterfall feature was installed in the "Boreal Forest" corner, with locally collected rocks and rubber liner material salvaged from a flat roof renovation project on campus. An excavation of ~ 3 feet was made near Tamarack trees to see if a small bog could be developed. After filling with water-logged Sphagnum peat, sections of frozen spruce-tamarack bog were chain-sawed and transported from the eastern edge of the county while still frozen in early May. The bog project was partially successful but some species have progressively declined, probably due to alkaline runoff water from the adjacent building which contains about 30% limestone rock in the roof aggregate.

A raised bed of sorts was part of the courtyard with the intent of establishing a dry prairie. After filling with what was understood to be stripped topsoil from a gravel pit excavation, a $ 1,000 worth of dry prairie sod flats were installed. Apparently the soil had been generously fertilized since exotic cool-season weedy grasses (Quackgrass, Crabgrass) quickly swamped the dry prairie species. After one season, the dry prairie project was abandoned and we reverted to landscaping fabric and mulch to have a specimen planting of a variety of prairie species. The effects of the high fertility are still evident with plants showing enhanced vigor and are generally double their normal height. A new site nearby was chosen for the dry prairie where we excavated the clay soil, installed 10-12 " of 1 " rock, 3 " of sand, and installed donated Blue Grama sod from a local native seed producer. We are currently adding dry prairie clump transplants to the grama grass sod and it is reasonably successful although the site is not as xeric as anticipated. Lesson learned: too fertile soil is an enemy of prairie transplants, it favors cool-season exotics.

The Youngquist Prairie Garden

A new student center was dedicated in 2008 and is located in a central campus hub. Near the main entrance door is a nook area that was to be the location of a Golden Eagle sculpture, created by a Native American artist. This nook area is also just outside the "Prairie Lounge" and was an opportune site to develop another display of prairie plants and connect to the culture of the Plains Indians. Three prairie plots were established to accommodate dry, mesic, and wet prairie species. The site was dedicated as the "Youngquist Prairie Garden" in honor of Dr. Bernie Youngquist, a past campus administrator and supporter of the Natural History Area. A signage plaque connects the honoring of an individual with the natural and spiritual heritage of the region. An endowed internship based on the Shaver Butterfly Garden model was established to generate summer maintenance funds. As plants reproduce, not all stay within their designated plots so maintenance "sorting" is required. An interpretative poster is located within the Prairie Lounge that looks out into the Youngquist Garden. Consistent with the prairie theme, striking prairie photos taken by National Geographic photographer, Jim Brandenburg, adorn the walls of the Prairie Lounge.

Campus rain gardens

Tucked into a corner within the Nature Nook is a small, rather symbolic rain garden which receives rain water from 3 downspouts. Native, wet prairie plants were planted in the basin of about 100 square feet. Swamp milkweed is very attractive to butterflies and well as thriving within the occasionally wet basin. When the basin was being installed, there were questions asked about mosquito habitat so it was a learning moment to point out that raingardens are dry most of the time!

The next opportunity for a campus raingarden came with the construction of Evergreen Hall, the first LEED certified residence hall in the U of Minnesota system. Although concept plans were developed, based on installed raingardens at the U of MN, Duluth and other informational resources, opportunities were missed for this sustainability demonstration of stormwater management. Key reasons included the following: raingarden opportunities weren't significant enough to gain substantial LEED credits; appropriate planning was not initiated early enough in the project development process; inexperience in raingarden planning and installation by the general contractor, project architect, and project engineer; and reluctance by campus decision makers and the landscaping contractor to creatively manage storm water. The predominant cultural attitude towards stormwater management in the region is simply to move water to the nearest ditch or storm drain, post haste. There is a challenge in the region, however of high clay soils which limit infiltration rates and require special site modifications. Currently (August 2013) a major raingarden is being installed in front of a newly constructed residence hall which will utilize a predominance of native prairie plants. Due to its strategic location near the entrance to a showplace residence hall and state-of-the-art classroom, it offers a significant opportunity to demonstrate the function of a raingarden in managing stormwater but also how native plants can play a key role in this function. Prairie plants will provide nectaring resources for butterflies and well as Humming Bird feeding sites, thus increasing the aesthetic appeal of the project.

Lessons learned

One learns from experience, talking to others, consultants, from successes and failures, risk-taking, and forging ahead when the time is right. Understanding the attitudinal culture of a region or an institution toward wild plant use and retaining stormwater is key to eventual successes; which may be modest at the outset. Advocating for native prairie plants in a setting where the predominant paradigm is toward using domestic plants and where weed controlling herbicides are purchased by the truck load, can be challenging and requires patience for education to take place. The following are major lessons learned in promoting and installing prairie plants in a campus setting:

- Educational efforts; signage, photos of wildlife sightings and flowers in bloom, articles of class projects, web postings, etc., simply cannot be overdone nor the importance overstated.

- Engagement of students in project planning, installation, and maintenance is key to on-going project success.

- Early successes are important to dampen the critics.

- Be alert to the timing for opportunities.

- Butterflies, Humming birds, and pollinators can be good ambassadors for a prairie planting.

- Prairie plantings can have carbon sequestration offset values for campuses aspiring towards carbon neutrality as well as providing a reduced carbon footprint due to lack of mowing; but this must be communicated. Resistance to unmowed areas can be anticipated from some in the campus community.

- Succession of management personnel needs to be planned in order for projects to be on-going. In some, perhaps all, settings, a prairie champion must move ahead with conviction but with sensitivity to who will carry the torch later.

- Impediments to native prairie plantings include lack of buy-in from facilities management/grounds staff, lack of campus educational efforts and signage, perception of weed and mosquito problems, and biases among decision influencers towards horticultural plants.

• Soil that is too fertile can be an on-going challenge to prairie plants since it favors exotic cool-season grasses.

• Plantings in highly visible places require special considerations. “Neatness” and labeling/signage are important. Sodding avoids the awkward juvenile stage of establishing a prairie plot by seeding.

• Named, endowed management internships are important for project initiation as well as on-going efforts. It addresses the enduring question of, “Who will take care of it?” since “wild” planting do require maintenance, especially in highly visible locations. Good public relations are engendered as well.

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Figure 21. Tall blazing star thriving in a prairie restoration at the Red River Valley Natural History Area at the University of Minnesota, Crookston.

Figure 22. The “Nature Nook Prairie” at the University of Minnesota, Crookston 2 years after a sod transplant.

Figure 23. Development of the Nature Nook using mostly native prairie species at the University of Minnesota, Crookston.

10

Renewable Energy's Role in Fostering Grassland Conservation and Ecosystem Services Protection: The Case of Anaerobic Digestion

Henslow's sparrow. Photo credit: Andy Reago and Chrissy McClarren.

"US agriculture faces major challenges in fulfilling demand for commodities while also providing environmental amenities such as clean water, soil conservation, and wildlife habitat protection. Meeting these challenges will require substantial innovation, and creation of new economic opportunities for farmers, landowners, rural communities, and commercial enterprises…"

–Carol L. Williams, *Bioeconomy Transitions* (page 83)

Expanding the market for grasslands through biogas-to-energy project development

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The use of anaerobic digestion to capture energy from organic material is not a novel concept and the anaerobic digestion process has been utilized in a variety of ways. In the US, anaerobic digestion technology has mostly been used to capture biogas (a mixture of carbon dioxide and methane) from livestock manure, landfills and wastewater treatment facilities. According to the US EPA AgStar Program, there are approximately 220 anaerobic digestion systems utilized at livestock facilities. There are at least 1,054 wastewater treatment facilities collecting biogas and using the gas to help run the facility. Finally, there are 621 landfills capturing biogas from municipal solid waste to help supply renewable electricity to the grid. Although there has been some growth in the number of projects in the landfill, livestock or wastewater treatment sectors, there is a tremendous amount of untapped potential to capture biogas from other types of organic material.

Outside of the US, anaerobic digestion has been used to capture biogas from a variety of different feedstocks, including crop residues, grasses and other cellulose material in addition to manure and waste from a variety of sectors. Expanding the opportunity for biogas development in the US is contingent upon diversifying the feedstock mix used to produce biogas. Diversifying the feedstock mix for biogas production can and should include perennial grasses. The opportunity to combine organic material together, known as co-digestion, is beginning to grow. When manure is combined with a higher carbon source such as fats, oils and greases or food processing waste projects can greatly increase overall biogas production and this can have a positive impact on project economics.

Another opportunity to expand biogas production and use to diversify the energy utilization models for the gas once it is produced. The dominant utilization model in the US is to produce renewable electricity, but this might not always be the highest and best use of biogas and other options. Biogas can be cleaned by using readily available technology to remove the carbon dioxide and other trace gases to a product that is a renewable replacement for natural gas, referred to as renewable natural gas (RNG). RNG be compressed and used in vehicles designed to or converted to run on natural gas, known as compressed natural gas (CNG). Using biogas as a source of transportation fuel, may present a higher value option for potential projects.

Adopting a more coherent strategy for biogas development can help develop a market for perennial grasses. Using perennial grasses in anaerobic digestion projects can help to establish a feedstock supply chain of grasses and the size of projects designed to utilize grasses can increase as the supply chain is developed.

The ability of biogas energy systems to more effectively manage organic waste streams while supplying a reliable and flexible source of renewable energy is a tremendous opportunity. Biogas is truly unique when compared to other traditional renewable energy sources in its ability to meet electricity, thermal or transportation fuel needs. Further biogas can do all this and make a value and necessary contribution towards reducing greenhouse emissions and providing multiple other environmental benefits.

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Anaerobic Digestion of Grasses: System Performance and Environmental Impacts

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Agricultural based anaerobic digestion (AD) systems in the United States (US) are increasing in number with 220 systems operational (USEPA AgSTAR, 2013). These systems are typically operated with manure as the primary feedstock and have traditionally been located in states with a significant dairy industry as the top 4 dairy states have the most operational agricultural digesters (California, Wisconsin, New York, and Pennsylvania). Although manure is a great base for agricultural digesters as it contains the necessary microbial communities for digestion and is readily available at one site, the biogas potential is low as it has already been digested. In order to improve efficiencies of agricultural digester systems, additional high biogas yield feedstocks need to be examined.

There are a variety of different types if digesters available within the United States, with the plug flow and completely mixed systems being the most common. Although there are a number of systems available, all systems operate on the same principles. Digesters are essentially large tanks which are designed to accept organic feedstocks and use microbial populations to degrade the waste in an anaerobic environment. The microbial populations break down organic feedstocks in four general phases (1) hydrolosis, (2) acidogenesis, (3) acetogenesis, and finally (4) methanogenesis. Methane is the target outcome of these processes to be used for a variety of applications (typically used in generators to produce electricity in the US). Of course the feedstocks to the system dictate the amount of biogas produced as well as the quality (or percentage of methane). In addition to feedstocks there are other key parameters to operation that must be adhered to in order to produce methane using anaerobic digestion including temperature, microbial populations, pH, retention time, and loading rate among others. Although there are many factors in producing biogas, the ability to increase the volume of biogas produced lies largely in the feedstock choice making it a key parameter in anaerobic digestion.

In order to increase biogas production additional substrates (or feedstocks) are commonly added to manure in agricultural systems. The increase in biogas production can lead to a more economically sustainable system. A variety of additional substrates have been explored in other countries, particularly grasses. Grasses have been shown to have a greater biogas production potential than manure and are readily available in many areas of the world. The addition of grasses to the digestion system can increase the carbon to nitrogen ratio as compared to manure alone making it more suitable for digestion and increasing biogas production. Manure has been shown to produce 25-35 cubic meters of biogas per ton of feedstock while grasses produce 110 cubic meters of biogas per cubic ton of feedstock (Navickas, 2007), a 4x increase from that of manure. Maintaining and harvesting grasses can also have environmental benefits by supporting animal habitats and serving as filter systems for nutrients improving water quality, particularly when replacing row crops in sensitive areas. However, when using grasses for anaerobic digestion the biogas potential can vary with grass species and rate at which they are added. In addition, it can add costs and logistical problems to collect, pre-treat, and transport grasses to these systems (which is typically the limiting parameter for these substrates). The time of harvest is critical as methane yields decrease with increasing age of vegetation (Amon et al., 2007; Prochnow et al., 2005). This is due in part to the increase in crude fiber with age which decreases the biogas potential (El Bassam, 1998; Shiralipour and Smith, 1984). In addition, collection is typically done at one time in the year making year round additions to the digester difficult or impossible. In order to use the feedstock over time, increased costs must be incurred for storage, and the grasses will lose biogas yield during that storage period. Pretreatment of shredding/chopping is usually required for grasses as generally smaller size particles increase biogas yield. In the end these processes may be cost prohibitive.

Digestion systems around the United States generally face difficulties not in design or engineering issues but with profitability. These systems require a high initial capital expenditure and typically require electricity sales to provide the bulk of the revenue. Although optimizing systems to increase biogas maintaining near maximum energy production of the supporting generator have been shown to increase revenues substantially, the costs associated with collection, pretreatment, and transport to and from the digester may not be economically sustainable. Further work is required to assess if these feedstocks have the potential to be economically viable, and in what scenarios they may be successful (e.g. maximum distance for transport, maximum cost of production, etc.). A better understanding of the financial impacts will greatly improve the understanding and potentially the use of grasses in digesters.

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Harvest of Waterfowl Production Area biomass as an alternative habitat management tool: is it compatible with management goals and are there opportunities for additional benefits?

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The U.S. Fish & Wildlife Service - Leopold Wetland Management District (District) manages more than 13,000 acres of Waterfowl Production Areas (WPAs) in 17 southeastern Wisconsin counties. Fire is the preferred tool for managing grassland habitats, however the District is unable to apply prescribed fire at the scale desired (2,500-3,000 acres per year) to maintain grasslands in an early successional state. The District is in the process of developing a Habitat Management Plan which, in part, will address the habitat maintenance shortfall through an integrated management strategy which will include the supplementation of prescribed burning with haying and grazing. We wondered if our diverse perennial grasslands could not only have the potential to provide suitable habitat for grassland-dependent species and ecosystem services, but also produce clean renewable energy as a co-product of our habitat management activities (i.e. haying). Beginning in 2010 the District, along with researchers and outreach specialists at University of Wisconsin–Madison, began exploring the opportunities for collaborating on a 3-5 year research project to investigate the impacts of late or dormant season haying on biotic and abiotic resources and potential utilization of harvested biomass as a bioenergy source. Our goals are to determine whether and how the production and harvest of diverse perennial herbaceous plant communities within WPAs fulfills habitat management goals; the degree to which harvested materials are technologically and economically feasible for a variety of end-uses (including biopower and biofuel); whether and to what degree harvested materials contribute to formation of local value chains while delivering ecosystem service benefits across geographic and ecological scales; and the nature and extent of social and economic impacts. The presentation will be from the standpoint of a land manager and Biologist discussing the evolution and thought process in developing a collaborative research project.

Nature in Balance: Achieving landscape scale prairie conservation through value innovation

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In every generation there is a window of opportunity to fulfill a role in the industrial revolution of technology. Today there is an opening to provide economy, environmental advantage and energy security and independence. Our ability to produce biomethane (green natural gas) has been advanced through biomass crop and residue anaerobic digestion technology. There is an opportunity to reach significant scale toward shared social-ecological innovation goals. Compressed natural gas (CNG) and liquefied natural gas (LNG) serve as a clean-burning transportation fuel sources while providing economic advantage for our vehicle transport sector and our nation's overall economic competitiveness. Our goal must include a sustainable source of biomass that not only provides financial return for the landowner, entrepreneur, and U.S. taxpayer, but also protects and enhances wildlife conservation, other ecosystem services, and climate. There is mounting scientific evidence that we can use diverse native prairie plantings to anchor our strategic planning and implementation initiatives, and to drive the realization of social-ecological goals.

To that end, we have assembled a high-performing team of leading public and private organizations possessing a wide diversity of perspective, expertise, knowledge, skill, and depth of resource to tackle our challenge of restoration of

15,000+ acres of native prairie grasses on Highly Erodible Lands (HEL) in northern Missouri. Biomass from these lands will be combined in anaerobic digestion with an unprecedented concentration of livestock manure - the largest concentration of its kind in our nation. Anticipated outcomes of these efforts include CNG/LNG production and environmental improvements; and development of science, technology, and financial business models for eco-commerce. The know-how gained from this enterprise provides a model for replication by individual landowner and cooperatives on a decentralized basis throughout the Midwest. Through effective demonstration of our approach, our overarching goal is restoration of 30+ million acres of prairie. This presentation provides an overview of our project motivation, development, and achievements to-date.

For more information on the project, visit www.roesleinae.com

Bioeconomy transitions: cross-sector collaborative development of a perennial grass anaerobic digester in southern Wisconsin

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US agriculture faces major challenges in fulfilling demand for commodities while also providing environmental amenities such as clean water, soil conservation, and wildlife habitat protection. Meeting these challenges will require substantial innovation, and creation of new economic opportunities for

A view of the ecological synergies created at Rudi Roeslein's farm in Northern Missouri through the combining of restored prairie grasses, ponds and row crops. Photo credit: Derick Roeslein.

farmers, landowners, rural communities, and commercial enterprises (Defries et al. 2012, Jordan et al. 2007, Reganold et al. 2011). Bioenergy is frequently evoked as a means for catalyzing agricultural transformation (Rajagopal and Zilberman 2007). Perennial diverse grasslands are promising bioenergy feedstocks that can deliver ecological conservation, environmental protection and agricultural production benefits simultaneously (Tilman et al. 2006). Despite federal policy for encouraging development of cellulosic bioenergy (e.g., EISA 2007), however, there exists a "chicken and egg" dilemma where investors in biomass conversion technologies and infrastructure are reluctant to engage until there is sufficient biomass supply, and biomass producers are unwilling to invest in new crops and production systems until there is sufficient demand. Overcoming this market inertia, and achieving transformation of U.S. agriculture, may require novel intervention for reducing risk and uncertainty in enterprise development and biomass supply (McCormick and Kaberger 2005, Taylor et al. 2013).

A potentially transformative approach to grass-based bioenergy development is collaborative design, implementation, and monitoring of perennial grass supply and value chains anchored to commercial-scale biomass conversion facilities. As a means of introducing strategic change, enabling research, providing feedback for adaptive management, and reducing risk and uncertainty, we have initiated a collaborative pilot project for at-scale anaerobic digestion of perennial grasses and livestock manure in southern Wisconsin. Our cross-sector collaboration includes a bioenergy development corporation; university researchers in grassland ecology, dairy science, engineering, wildlife management, and agricultural policy; government agency personnel; and land management agribusiness.

To accomplish our goal we are leveraging a biomass harvest experiment involving public conservation lands. The U.S. Fish & Wildlife Service Leopold Wetland Management District (District) manages more than 5,250 ha of Waterfowl Production Areas (WPAs) in 17 southern Wisconsin counties. These areas are near wetland basins and are managed as upland habitats, predominantly grasslands for nesting waterfowl. Fire is the preferred tool for managing WPA grassland habitats in early successional states. However, the District is unable to apply prescribed fire at the scale desired (1,100 to 1,200 ha y-1). Therefore, the District is exploring late and dormant season haying as a supplemental tool for maintaining WPAs in diverse and healthy conditions. However, ecological soundness and technical feasibility of WPA harvest is necessary to determine if it meets habitat management goals.

In 2011, the District and personnel of the University of Wisconsin-Madison initiated a multi-year collaborative landscape-scale biomass harvest experiment. The experiment involves a set of 12 WPAs in five southern Wisconsin counties where approximately 1,000 Mg of mixed grass biomass is annually harvested and the ecological and environmental impacts are being evaluated. Farmers, contract harvesters and a value-added biomass agribusiness are our operations partners.

The harvest experiment is located in a region where dairy livestock are abundant and their densities are growing as confined animal feeding operations become more numerous. Here, dairy livestock manure is applied to land to manage farm nutrients. However, applications frequently exceed land capability to sequester phosphorus (P) and nitrogen (N). Excess P and N enter surrounding surface waters via run-off and soil erosion leading to water quality degradation with impacts to human health and economic systems (Ridlington and Kohler 2011). Anaerobic digestion (AD) is a waste management technology that can process livestock manure and deliver a variety of co-products including renewable energy (i.e., biogas). Perennial grasses can be used as secondary substrates in AD processes where they can improve system performance, particularly in the case of cow manure (Lehtomaki et al. 2007). Expansion of warm season perennial grasses in buffers and other configurations is gaining attention as a potential means for mitigating P and N issues (Asbjornsen et al. 2012). Thus, partners in the WPA experiment have with additional partners initiated development of an AD project to improve water quality within the project area, but moreover, to catalyze expansion of perennial grass commerce (i.e., bioeconomic expansion) and in turn, improve overall landscape multifunctionality.

We are currently evaluating a proposed project location near Madison, Wisconsin. The evaluation includes feedstock analysis, technology options, financing and investment opportunities, and site-specific constraints. Our ultimate goal is not only to resolve environmental and bioeconomy

Photo credit: Julie Sibbling.

development challenges, but to understand our own processes of collaboration so that we can extend to others a potential model for application elsewhere.

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Bioenergy Development and Grasslands

Photo credit: Aviva Glaser.

Sustainable Planting and Harvest Guidelines for Non-Forest Perennial Biomass in the Prairie Pothole Region of the Northern Great Plains – Preliminary Findings

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Though the use of biomass for heat and fuel production is not new in the United States, there has been a renewed interest in bioenergy production in response to increasing energy costs, dependence on foreign oil, greenhouse gas emissions and climate change. The 2007 Energy Independence and Security Act (110 P.L. 140) raised the Renewable Fuel Standard (RFS-2) to require biofuels blending (with gasoline) of 36 billion gallons per year by 2022 of which 21 million are to come from non-corn sources such as cellulosic materials. The northern Great Plains holds much potential for the production of cellulosic biomass, but the region is also critical for wildlife producing 50-80% of waterfowl populations and providing breeding habitat for more than half of the bird species that breed in North America.

The Best Management Guidelines (BMGs) presented in this document were developed through a process that involved an advisory group of natural resource professionals with expertise in agronomy, production aspects of energy crops, wildlife (amphibians, birds, insects, mammals, reptiles), and native ecosystems. The following guiding principles helped define the uses and limitations of the BMGs:

"Wildlife sustainability, in the context of bioenergy, necessitates considering (for differing wildlife species) the feedstock selected, the surrounding habitat, the habitat that is replaced, the method of establishment, how intensively the stand will be managed, what inputs (herbicides, fertilizers, etc.) will be used, how much area the feedstock occupies, and how it is to be harvested."

—Bill D. McGuire, *Sustainable Planting and Harvest Guidelines*

- Integrate considerations that address biodiversity as an integral part of bioenergy sustainability

- Incorporate biodiversity when switchgrass or native warm-season grass mixes are established on marginally productive cropland (i.e., no conversion of native sod, wetlands, etc., is assumed)

- Provide a basis for development of site-specific practices that are tailored to local situations

- Balance environmental sustainability and the needs of production economics

- Must be feasible to adopt and include profit potential

- Intended for use by the bioenergy industry and biomass producers

- Although designed for the Prairie Pothole Region, the BMGs should be useful in adjacent geographies within the Northern Great Plains and elsewhere

Switchgrass and a 3-species mix of big bluestem, indiangrass, and sideoats grama were the two feedstocks selected. These feedstocks are currently the focus of collaborative efforts funded by the U.S. Department of Agriculture to create a Midwestern regional system for producing advanced transportation fuels derived from native perennial grasses. Guidelines focus on site selection, planting design, establishment, management, and harvest of these feedstocks on wildlife and their habitats (i.e., food, water, cover, and space). Effects on grassland songbirds, waterfowl, shorebirds, mammals, amphibians, reptiles, insects, and aquatic organisms are examined.

Wildlife sustainability, in the context of bioenergy, necessitates considering (for differing wildlife species) the feedstock selected, the surrounding habitat, the habitat that is replaced, the method of establishment, how intensively the stand will be managed, what inputs (herbicides, fertilizers, etc.) will be used, how much area the feedstock occupies, and how it is to be harvested. The advisory group of natural resource professionals worked together to consider, sort out implications, and identify approaches that integrate a basic level of consideration of wildlife needs. The following BMG's reflect compromise in recognition of energy purposes and economic needs of industry and agricultural producers by focusing on the basic level of wildlife conservation needed to sustain species, not the maximum habitat benefit that is possible:

Landscape and Site Selection Considerations

- Do not convert prairie/sod, wetlands, or other rare native ecosystems.

- Plant biomass crops on existing cropland or other land with a cropping history

- Plant biomass crops, as much as possible, on fields adjacent to native prairie/sod or established stands of native warm-season grasses to increase native ecosystem health (larger tracts of continuous grassland are better than smaller fragments).

- Use native grasses as biomass feedstocks. Locate big bluestem, indiangrass, and sideoats grama mixtures on drier sites and switchgrass on either dry or wet sites (depending on cultivar – upland or lowland) to take advantage of the range of growing conditions native grasses provide.

- Avoid tiling or ditching to drain water from land or in-field low areas that provide important wetland habitat in the early spring.

- Be aware of potential resources (food, water, cover) in the surrounding area and, as feasible, plant feedstocks that complement those resources.

- Consider using biomass plantings as conservation practices for existing cropland; for instance, place plantings along water bodies (streams, ditches, lakes, rivers, wetlands) to reduce erosion and chemical runoff, and on highly erodible soils to reduce erosion.

- In the event hybrid or genetically-modified varieties are considered for use, consult with the state fish and wildlife agency to determine potential risk to nearby native prairie/sod and develop a containment plan.

Planting Design

- Match the native grass feedstock to local/regional soil types and vegetation to enhance yield potential and ecosystem compatibility.

- Consider growing diverse mixture of big bluestem, indiangrass, and sideoats grama as well as switchgrass to create diversity of habitat (structural and spatial) on the landscape and reduce risk to the producer through crop diversification.

- Create a native warm-season grass/forb buffer zone around potholes, wetlands or other bodies of water to provide habitat (pollinators included) and an agrochemical barrier. These buffers should be as wide as possible (100' minimum recommended), seeded at the lowest NRCS rate, and include a 50' unmowed area (closest to the pothole/wetland) with the remainder harvested at a height of 10" or higher.

- Establish native warm-season grass/forb field borders on portions of the field not connected with potholes/wetlands to retain inputs on site and provide additional wildlife habitat. These field borders should be wide enough to address site-specific wildlife needs (consult the state fish and wildlife agency to determine the appropriate width) and managed to create early successional habitat by burning, disking, or haying every 3 to 5 years.

- Consider enrolling field borders and wetland buffers in wildlife-friendly conservation programs, which also provide a constant and dependable source of revenue.

Establishment

- Follow NRCS recommended seeding rates and do not exceed as doing so increases establishment cost and makes stands less desirable for ground-dwelling wildlife.

- Avoid the use of fertilizer during the establishment year to minimize excessive weed growth (which can slow growth of the grasses planted) and potential runoff into streams and wetlands.

- For fields that were planted to a winter cover crop the previous fall, prepare/plant fields as early as practical, but avoid planting during the peak nesting period. Check with the local NRCS office and state wildlife agency for local peak nesting seasons and dates.

- Plant no-till fields as late as practical to leave residual food/cover longer for wildlife

- Plant bare, conventional-tilled fields as soon as possible to reduce erosion and improve quality of water feeding wetlands/potholes.

- Use only the minimum rate of herbicides needed to establish biomass plantings and consider the alternative of mowing when weeds are about 12" tall (leave 6" stubble).

- Avoid the use of herbicide in field borders and wetland buffers.

Management

- Avoid use of fertilizer, herbicide, or mowing in core buffer areas around potholes, wetlands and other bodies of water and in unharvested field borders – manage upland buffers with prescribed fire or shallow disking (to set back plant succession) once every 3 to 5 years, prior to April 15 or after August 1 to avoid peak nesting season. .

- With the technical assistance of NRCS, develop and follow an integrated pest management plan that takes advantage of avian and insect predators and minimizes the use of chemical pesticides.

- In the event chemical pesticides are necessary, consider withholding application in a buffer adjacent to wetlands/ potholes (width determined in consultation with NRCS and the state fish and wildlife agency).

- Monitor fertility and minimize use of fertilizers through stand development and beyond with the aid of an NRCS precision nutrient management program plan designed specifically for perennial grasses, (saves cost, benefits water quality, and is easier on wildlife).

- Consider periodic spring prescribed burns (prior to peak nesting season) on portions of field with enough stubble residual from the previous year to carry a fire (stimulate grasses and benefit wildlife).

Harvest

- Add flushing bars to equipment to minimize bird injuries and deaths.

- Harvest fields from the interior of the field to the exterior to encourage wildlife to flush into surrounding areas.

- Leave at least 4” to 6” stubble after harvest to elevate windrows (aid airflow and speed up drying), and catch/retain snow to boost soil moisture. Higher stubble heights (>10”) are recommended to benefit wildlife.

- Leave wildlife cover in the form of taller stubble (10” or taller) after harvest on unproductive portions of fields (e.g., wet depressions, highly eroded areas) or adjacent to potholes/wetlands. This stubble will provide winter habitat and spring nesting cover – blocks are better than strips (5% of the total field area is recommended).

- Avoid harvest until after the first frost to avoid disturbance of nesting wildlife and improve quality of biomass (i.e., reduce moisture and nutrient content) for bioenergy production.

- Consider incremental harvest after the end of growing season (i.e., store portions of the biomass as a standing crop) versus harvesting all at once – this will leave some cover for wildlife.

- Consider leaving a portion of the field as a standing crop and delaying harvest until the end of the next growing season, at which time another area can be deferred.

We encourage the adoption and adaptation of these high-level guidelines to benefit local conditions while minimizing negative impacts of bioenergy production on wildlife. It is hoped that the BMGs will make it easier for the bioenergy industry, agricultural producers, policymakers, and others to understand and integrate wildlife needs as bioenergy advances in the Prairie Pothole Region of the Northern Great Plains as well as in adjacent geographies.

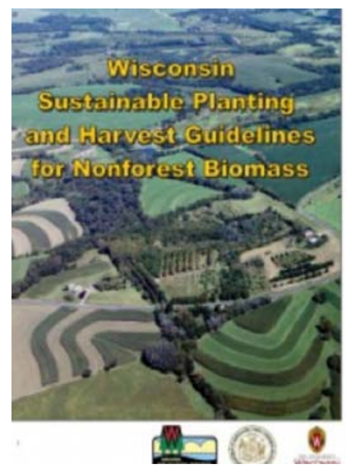
The full report can be found online at: http://www.nwf.org/News-and-Magazines/Media-Center/Reports/Archive/2013/12-19-13-BiomassBMGPPR.aspx

Wisconsin’s Sustainable Planting and Harvest Guidelines for Nonforest Biomass: a Collaborative Effort to Encourage Greater Sustainability of Natural Resource Use and Development

Carol Williams, University of Wisconsin, Madison and Scott Hull, Wisconsin Department of Natural Resources

Other Author: Sara Walling, Wisconsin Department of Agriculture, Trade, and Consumer Protection

If managed sustainably biomass production can contribute to energy needs while enhancing water quality, reducing soil erosion, and promoting healthy wildlife populations. To help ensure bioenergy sustainability and improvement of Wisconsin’s natural resources, in 2009, the Wisconsin Department of Natural Resources, the Department of Agriculture, Trade and Consumer Protection and the University of Wisconsin began a collaborative effort to develop voluntary nonforest biomass harvest and production guidelines. The Guidelines are intended to help decision-makers make informed decisions for bioenergy production on both public and private lands.



The complete guidelines can be viewed online at: http://datcp.wi.gov/uploads/About/pdf/WI-NFBGuidelinesFinalOct2011.pdf.

The *Guidelines*, completed in July 2011 and endorsed by the Wisconsin Bioenergy Council, are science-based and cover four nonforest biomass categories: grasses, nonforest trees and shrubs (including short-rotation woody crops), crop residues, and wetlands. While many field-scale technical guidelines exist for planting and harvesting of biomass few, if any, address broader landscape ramifications. Hence, an innovative framing of the Guidelines is that of ecosystem services, potential impacts at multiple scales (e.g., field, fuel-shed, landscape), and the concept of tradeoffs in ecosystem services when making biomass cropping decisions at multiple scales. Primary challenges in the drafting process included balancing economic interests in an emerging biomass market with wildlife population concerns, particularly at scales beyond the field.

Opportunities for grasslands as biofuel feedstock

Paul Adler, USDA-ARS

Historically, grasslands composed of native species have been of natural origin or established as part of a conservation program such as the Conservation Reserve Program (CRP). CRP grasslands serve the multiple benefits of reducing soil erosion, improving water quality, and providing wildlife habitat. More recently, dedicated grasslands composed of native and nonnative perennial grass species are being established to produce feedstock for bioenergy. We have studied the potential of conservation grasslands, and dedicated grasslands composed of native and nonnative species as bioenergy feedstocks. We have evaluated the yield potential, environmental impacts, life cycle greenhouse gas impacts and abatement costs. We found a large diversity of plant species on CRP lands in the northeastern US planted with warm season grasses, and a large range of biomass yields (Adler et al., 2009). Conservation grasslands with higher numbers of plant species had lower biomass yields and a lower ethanol yield per unit biomass compared with sites with fewer species. We found that, as tall native C4 prairie grass abundance increased from <5% to >80%, the number of plant species decreased and aboveground biomass per unit land area and ethanol yield per unit biomass increased. Low diversity grasslands which include a mixture of the tall native C4 prairie grass could have greater yield stability and productivity. Although early tests in Pennsylvania comparing monocultures and mixtures of switchgrass and big bluestem have resulted in 50% greater monoculture switchgrass yields than big bluestem (PR Adler, unpublished data), there may be more productive big bluestem cultivars in development. While switchgrass yields were greater than big bluestem, in mixtures, big bluestem was more competitive and abundant (PR Adler, unpublished data) resulting in mixture yields between those of switchgrass and big bluestem. Plant species richness and composition are key determinants of biomass and ethanol yields from conservation grasslands and have implications for low-input high-diversity systems. Designing systems to include a large proportion of species with undesirable fermentation characteristics could reduce ethanol yields.

Converting lands from existing uses to biofuel feedstock production involves numerous trade-offs. As a result, consensus exists that sustainable biofuel feedstock production strategies must primarily rely upon abandoned and marginal croplands to minimize competition with food production on higher quality croplands. Despite the rapidly increasing need for energy and the push towards creating renewable sources, the world's growing population demands increasing supplies of food. Furthermore, when food crops are displaced for biofuel crop production, the effect of producing crops elsewhere can significantly increase greenhouse gas emissions associated with biofuel production (Searchinger et al., 2008). To avoid the effect of indirect land use change, there has been interest in identifying marginal and abandoned farmlands (Field et al., 2008). Lands enrolled in the CRP could meet this goal of providing a land resource while maintaining the environmental benefits of the CRP program, however, much of this land is in areas of low precipitation and yields could be below economic viability (Figure 24).

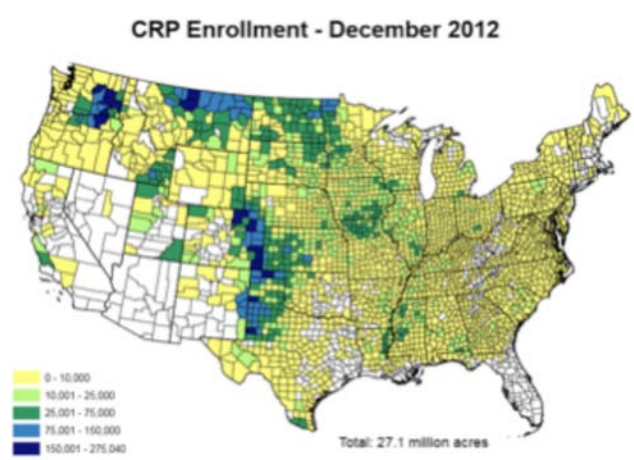


Figure 24. Location of CRP lands in the US.

Much of the work on evaluating switchgrass yields has been conducted on prime agricultural lands, since this is historically where University farms are located. In Pennsylvania, much of the marginal land is poorly drained and we have found that switchgrass yields are similar on prime and poorly drained marginal lands (Figure 26).

Miscanthus has been shown to produce large amounts of biomass without application of N (Maughan et al., 2012). Since N fertilizer is the dominant source of greenhouse gas emissions for feedstock production (Adler et al., 2007; Adler et al., 2012), feedstock N fertilizer requirements could have a large impact on the global warming intensity (GWI) of the biofuel. Wang et al. (2012) determined that the GWI of ethanol produced from switchgrass was about 30% higher than miscanthus (29 compared with 22 g CO2e/MJ ethanol), largely due to the increased N requirement of switchgrass.

In an analysis of abatement costs of biomass feedstock from marginal lands in the NE, we found that densified biomass was a cheaper fuel than fuel oil, potentially saving consumers in NE US $2.3 and $3.9 billion annually, displaces twice as much petroleum as using it to replace gasoline, and is a cheaper GHG mitigation strategy reducing GHGs at a cost savings of $10-11.6 billion dollars annually by targeting the use of biomass to replace fuel oil rather than electricity in the NE US, as promoted in RPS policy (Wilson et al., 2012).

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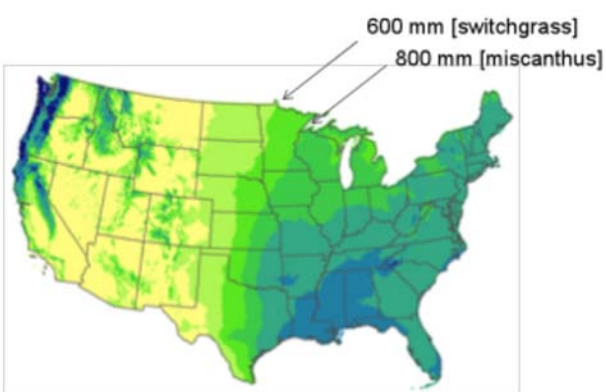

Figure 25. Commercial switchgrass production is targeted on lands with > 600mm precipitation (Mitchell, 2008) while miscanthus has a great precipitation requirement at > 800mm.

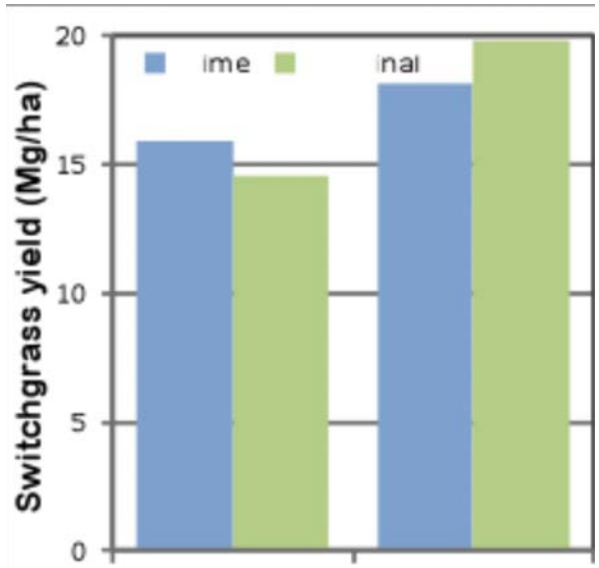

Figure 26. Switchgrass yields on prime v marginal croplands.

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Switchgrass Solution: Enhancing Ecosystem Services and Carbon Sequestration through Low-Input High-Diversity Biofuels

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Low-input high-diversity (LIHD) cultivation includes multiple native grass and forb species that may provide sustainable, low-input biofuel feedstock. Research on restored prairies indicates LIHD sites can produce greater long-term yields than monocultures. Diverse grassland plantings provide multiple benefits such as habitat for invertebrates and wildlife. Low-input cultivation reduces fertilizer input and nutrient leaching, while increasing arbuscular mycorrhizal (AM) fungi, potentially leading to improved soil health and carbon sequestration. Our study assessed mycorrhizal hyphal abundance and soil quality under LIHD cultivation in established plots at Argonne National Laboratory, Illinois. We compared intra-specific diversity with three different switchgrass cultivars and inter-specific diversity with combinations of switchgrass and other native prairie grasses and forb species. Annual productivity of extra-radical AM hyphae was assessed using hyphal in-growth bags, inter-radical colonization was determined using microscopic assessment. Phospholipid and neutral-lipid fatty acid analyses were used to determine soil microbial community composition and AM fungal biomass. Aboveground productivity for each plant species was assessed at harvest. The major goal of this project is to develop LIHD cultivation that will produce high biomass without increased nutrient inputs, which will ultimately sustain wildlife habitat and increase carbon sequestration. Our field data indicates both inter-specific and intra-specific plant species biodiversity produced equal or greater aboveground biomass compared to monocultures of switchgrass, and multiple genotypes of switchgrass had greater annual production of arbuscular mycorrhizal fungi, compared to the switchgrass monocultures. A positive correlation between AM hyphal abundance and soil aggregation and carbon sequestration was observed. Previous studies have shown that invertebrate species richness is positively correlated with plant species richness, and floral species richness and abundance led to greater bee abundance and bee species richness. Therefore, we predict that higher inter- and intra-specific plant species diversity will support greater invertebrate abundance and diversity, and these assessments are currently in progress. Results of our study will inform plant breeders on feedstock management that will decrease fertilizer inputs, improve aboveground ecosystem services, such as wildlife habitat, while also increasing belowgound services such as soil health and soil carbon sequestration, all without a loss in production.

Perennial Grass Miscanthus for Biomass Production and Phytoremediation of Slightly Contaminated Land

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Many soils have suffered degradation from contamination, past practices, flooding or erosion. Recent literature documents the potential for miscanthus for both biomass production and phytoremediation of contaminated and marginal lands. Miscanthus grows well in mildly contaminated soil and where soil quality is poor. It is of interest as an energy crop because of its perennial growth habitat and relatively high yield of biomass with minimal inputs of fertilizers. The advantages and disadvantages of simultaneous production of miscanthus and phytoremediation of contaminated lands will be presented. Research results for soils with metals will be presented, including some new findings of the authors. Laboratory research was conducted by growing Miscanthus x giganteus in Slovakia in soils containing added quantities of cobalt and copper to examine metal uptake. The highest concentration of copper was detected in the roots and smaller concentrations were detected in the above ground plant material. Cobalt was detected only in the roots and only for the highest treated concentration. These results and others in the literature show that metal uptake of miscanthus into the harvested part of the plants is small relative to some other plants, and that miscanthus harvested from some metal contaminated soils may be processed as an energy crop with minimal potential for redistribution of contaminants. Other research results have shown that the biodegradation of petroleum hydrocarbons is stimulated by root exudates from miscanthus. The improvement of soil quality by the addition of soil carbon with simultaneous removal of small amounts of contaminants over many seasons of crop production is envisioned. In other studies, organism diversity is increased over time when miscanthus is grown in contaminated and marginal soils. Miscanthus is being grown as an energy crop in Europe, and it is a subject of current research in the United States. Miscanthus yields have been documented to be intermediate between native, warm-season grasses (switchgrass [Panicum virgatum L.]) big bluestem (Andropogon gerardii Vitman) and annual crops (sorghums, maize) over several years in Kansas. There is a significant amount of metal contaminated land in southeast Kansas and in Missouri that needs to be remediated and used productively. One goal of this work is to find a cost effective way to produce a useful crop while also improving these lands.

Forbs. Photo credit: Aviva Glaser.

12

Climate Change, Drought, and Hydrology

Photo credit: Aviva Glaser.

"The prairie, in all its expressions, is a massive, subtle place, with a long history of contradiction and misunderstanding. But it is worth the effort at comprehension. It is, after all, at the center of our national identity."

—Wayne Fields, *Lost Horizon* (1988)

The Drought in the Southern Plains

Chuck Kowaleski, Texas Parks and Wildlife Department

Large portions of the Southern Great Plains have suffered drought 12 out of the last 15 years. The last 3 years have been the hottest and driest on record for New Mexico and parts of Texas. The peak of severity of the current drought cycle occurred in August of 2011 when most of Texas, Oklahoma and New Mexico were in extreme to exceptional drought (Figure 27). Since that time the drought has decreased in severity but expanded northwestward (Figure 28)

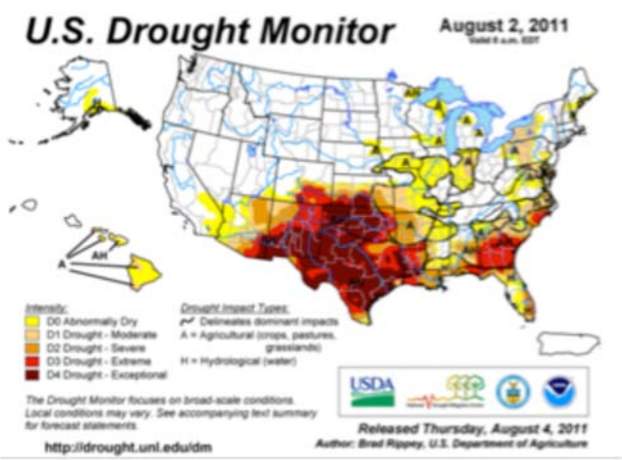

Figure 27. Large area of southern Great Plains in exceptional drought.

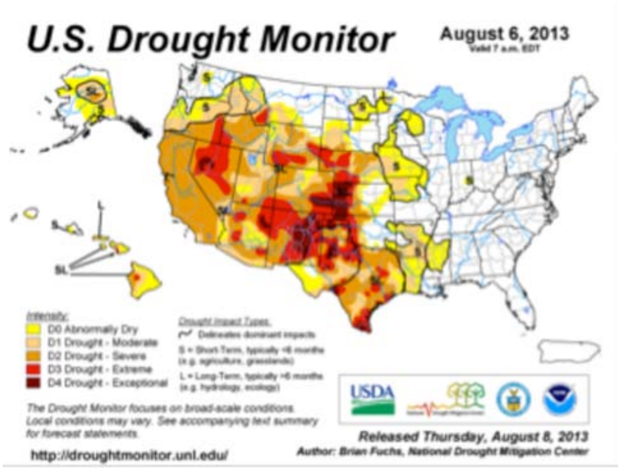

Figure 28. Drought moderates in intensity but increases in size.

This is by no means the longest drought that this region has faced. Tree ring records suggest that a 36 year drought occurred between 1631 and 1667 and numerous multiyear droughts have been recorded over the last 200 years. In each case the rains returned and existing vegetation recovered. But an interesting change in vegetation types has slowly been taking place in the region. Fifty years of photopoints taken at the La Jornada Experimental Range in New Mexico indicates a shift in former blue grama grasslands to a more desert style of vegetation. So, is this latest drought just part of the normal weather cycle or the beginning of a long term climate shift exacerbated by land use issues?

Drought has a number of impacts on grasslands. Early in a drought the production of biomass slows then stops as plants attempt to reduce injury and maintain reserves. If the drought continues long enough the plant expends its reserves and faces injury or death. Lack of green biomass combined with hot and dry conditions also increase the risk of wildfires. In the 5 years from 2006 to 2011 Texas wildfires burned 10 million acres and destroyed nearly 5,000 homes. After such wildfires the large scale loss of vegetation to hold soil in place increases the risk of erosion (Figures 29 -31), reduces soil health and its ability to absorb moisture.

Areas with tighter soils are especially affected due to loss of water infiltration and can experience shifts in vegetation that favor brushy, toxic or more xeric adapted species. The likelihood of this vegetational shift is increased if proper land management practices, such as livestock removal, are not practiced. Figure 32 shows what had been a healthy little bluestem, silver bluestem, Indiangrass pasture after 3 years of continuous grazing during the current drought. This site did not burn but has suffered long term degradation through the elimination of native bunch grasses due to poor land use.

Extended droughts also impact wildlife, with small year-round resident species especially hard hit. Texas Parks and Wildlife annual fish and wildlife population surveys have recorded noticeable declines in reproduction as well as decreased annual survivorship of adults. The current multiyear drought has had a greater impact on wildlife than the oft mentioned droughts of the 1930's and 1950's due to several causes. First, the native grass landscape is has become more highly fragmented due to two main factors. First, the introduction of vast numbers of irrigated crop circles that have sprung up over the last 50 years. Figure 33 shows a Google earth view of an area in the Texas Panhandle that is 25 miles wide and 15 miles tall (~240,000 acres). Today, a similar blanket of crop circles stretch from the center of the Texas Panhandle to Nebraska covering millions of acres of what had been native prairies during the



Figures 29 and 30 show the effect of drought, wildfire and wind erosion. Photos on left by Jeff Bonner, Texas Parks & Wildlife Department. Figure 31. Dust storm. Photo by Dan Jackson.

Figure 32. Native grasses after 3 years of continuous grazing during a drought. Photo by Jeff Bonner, Texas Parks & Wildlife Department.

Figure 33. Google Earth view of anm area in the Texas panhandle with irrigated crop circles.

1930's and 1950's droughts. Second, a lot of highly erodible nonirrigated farmland (3.3 million acres in Texas alone) has been enrolled in the Conservation Reserve Program and planted in introduced grass monocultures that provide limited wildlife benefits.

Droughts also impact farms, ranches and related businesses. The southern Great Plains currently has the lowest cattle numbers since the 1950's drought with some areas in Texas and New Mexico seeing as much as an 80% reduction. In January of 2013 live cattle futures prices collapsed when Cargill announce that it would sharply reduce its meatpacking capacity due to limited cattle supplies. Cargill closed its Plainview, Texas packing plant on February 1, 2013 eliminating 2,000 jobs in a town of 22,000 people and devastating the local economy. As of mid-August of 2013, New Mexico water storage reservoirs have dropped to 17% capacity and many Texas reservoirs are empty or extremely low. Water has become such a precious commodity that Texas has filed lawsuits against New Mexico and Oklahoma over river water rights. The Ogallala aquifer that sustains most of the irrigated farmland mentioned above has also dropped dangerously low with wells drying up or unable to keep up with demand.

The question then arises, "Can the land recover?" The answer is, "It depends!" It depends on timely rains, soil health, surviving plants or seed bank, long term climate influences and the landowner's willingness to adapt their land management practices goals to meet current and future conditions.

Ecotypic variation in drought tolerance and genetic diversity of the ecologically dominant grass big bluestem (Andropogon gerardii) across the Great Plains precipitation gradient: Implications for climate change and restoration

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Big bluestem is a widely distributed dominant C4 grass, whose productivity is dependent upon precipitation. With wide distribution across a sharp precipitation gradient (400-1200mm yr-1 in Kansas to Illinois), we expect ecotypic variation in drought tolerance and potentially, local drought adaptation. A better understanding of ecotypic variation will help predict how a dominant prairie grass may respond to climate change as well as which ecotypes to plant for restoration. We investigate the linkage of ecotypic variation and genetic diversity by using reciprocal common gardens across the precipitation gradient. Sites were planted in

Carbondale, Illinois, Manhattan and Hays KS and a site in Colby, KS (to test ecotype tolerance limit into drier areas). At these four locations, the three ecotypes (each comprised of seed collected from four pristine populations in central KS, eastern KS, and Illinois) were reciprocally planted in replicate blocks with each plant growing singly and in replicated assembled seeded communities (16m2 plots). We measured ecotypic variation in drought tolerance across ecotypes and sites. Because genetic diversity may be critical for predicting a species' ability to adjust/adapt to climate change, we assess genetic diversity and population differentiation using AFLP markers in the 12 source populations also used in the reciprocal gardens. Our data demonstrate a strong ecotypic cline in drought tolerance of the three ecotypes. The westernmost ecotype (central KS) exhibits local adaptation to drought based on the reciprocal garden results. Establishment and cover in the seeded plots showed a significant ecotype ($p<0.0001$), site ($p<0.0001$) and interaction effect ($p<0.0001$). The central KS ecotype had disproportionate cover in western regions relative to the Illinois and eastern KS ecotypes (GXE), indicating local adaptation to drought. Thus, the central KS ecotype had 2x-3x the cover compared to other ecotypes in Hays and Colby sites, respectively. Results (neighbor joining trees, STRUCTURE and PCA) support genetic differentiation of ecotypes. Further, 11 ecotype-specific loci under diversifying selection were identified and related to climatic variables. In spite of the genetic differentiation among ecotypes, greatest genetic variation existed within populations. High within-population genetic diversity may allow populations to better withstand environmental change and has implications for prairie restoration.

The effects of Dust Bowl magnitude heat waves and drought on the tallgrass prairie ecosystem

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Climate extremes, such as heat waves and drought, are expected to increase in their frequency and intensity over the next century. We examined the response of a mesic tallgrass prairie ecosystem to two years of experimentally imposed drought and a short-term heat wave, followed by a recovery year. During 2010 and 2011, we reduced rainfall by 66% (drought) to compare responses to a well-watered treatment (ambient rainfall plus supplemental irrigation). Under these opposing soil moisture regimes we imposed a two-week mid-summer heat wave at four temperature levels, ranging from 0 to +11 degrees C above ambient. In 2012, all plots received ambient rainfall plus supplemental irrigation to ensure that long-term average precipitation inputs were received. The experientially imposed drought and heat waves were well outside the bounds of normal variability and comparable in magnitude to the most severe years of the 1930's Dust Bowl. We examined the individual and combined effects of drought and heat on the tallgrass prairie ecosystem.

While we measured no significant direct or combined effects of the imposed heat waves at the ecosystem or community levels, there were significant effects of drought. Total aboveground productivity was significantly decreased in both drought years, and particularly during the second year of the drought, which was below the 5th percentile of the long-term LTER record for the site. Despite this extreme ecosystem-level response, we observed full recovery in production in the year immediately following drought. This occurred despite significant divergence in community composition during the post-drought year, caused by a reordering in the rank abundances of the dominant species. This reordering was driven by a loss in the dominant forb *(Solidago canadensis)* due to drought, which was replaced by an increase of the dominant grass *(Andropogon gerardii)* in the post-drought year. In summary, two years of extreme drought led to an extreme reduction in productivity, however a full and rapid recovery was possible in just one year due to demographic compensation of the dominant grass. Such changes in community structure could have important consequences for stability in ecosystem function over the long-term.

Influence of grazing treatments and riparian protection on stream geomorphology and sediment concentrations in the Flint Hills and Osage Plains

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Introduction

Despite the decline in stream water quality and ecosystem function concomitant with increasing gazing pressures within grassland ecosystems, there have been no studies to quantitatively assess the relationship between various grazing treatments and sediment production in natural grasslands. Different grazing treatments, such as cattle versus bison grazing, may produce significantly different hillslope-channel responses due to species-specific physiological and behavioral differences (such as wallowing, heat tolerance, vegetation preference, water demand, etc.). We seek to determine the impact of common grazing practices on suspended sediment concentrations within headwater grassland streams of the Tallgrass Prairie ecoregion and channel geomorphology within the Osage Plains.

In this study, we evaluate sediment regimes in ten watersheds, including two seasonally stocked, moderate density cattle grazed watersheds, two seasonally stocked, high density cattle grazed watersheds, three permanently stocked, bison grazed watersheds and three ungrazed watersheds (Figure 34). Impacts of riparian fencing were assessed on five watersheds, two cattle grazed without riparian fencing, two cattle grazed with riparian fencing, and one control watershed without grazing (Figure 35).

Methods

Flow samples were collected by filling a one liter bottle from the thalweg of each stream during baseflow conditions when at least half of the study streams were flowing, and we could sample from at least one stream within each treatment. Water samples were measured for total suspended solids (TSS, mg/L), total inorganic solids (TIS, mg/L), total volatile solids (TVS, mg/L), and percent organic matter (POM, %). ANCOVA analysis tested for correlation with grazing treatment, season (Julian day of year), burn frequency (times burned from 1990-2010), and discharge (m3s-1). Channel geometry was measured by establishing ten permanently monumented cross sections and topographically surveying at 15.24 cm (6 inch) spatial resolution. ANCOVA analysis tested for correlation between changes in channel width and the presence of cattle.

Results and Discussion

Significant relationships were found for TSS ($P<0.01$), TIS ($P<0.001$), TVS ($P<0.01$) and POM ($P<0.001$). Both moderate ($P<0.05$) and high density ($P<0.01$) cattle grazing significantly increase TIS concentrations (Figure 36). Burning frequency, discharge and seasonality are generally less influential relative to grazing treatments. Introduction of unrestricted cattle grazing resulted in significant increases ($P<.05$) in width relative to ungrazed or riparian exclusion grazing treatments (Figure 37).

As expected, cattle grazed watersheds produced the largest baseflow sediment concentrations. However, the magnitude of difference between cattle grazing and other treatments, particularly bison grazing, was surprising. The dramatically lower POM concentrations in high density cattle grazing watersheds were also unexpected. The increased grazing pressure in high density cattle treatments, combined with the physiological demands of cattle, are likely combining to produce these clear distinctions between bison and cattle grazing treatments. Cattle are known to be less heat tolerant than bison and to more readily seek thermal relief in the shade of riparian zones and stream channels at lower temperatures than bison. This would lead to a greater proportion of time spent either adjacent to or in stream channels leading to greater increases in channel width.

From these results, it is clear that modern practices of high density cattle grazing are responsible for significant degradation of baseflow water quality in the Great Plains of North America. Efforts to address this non-point source of baseflow sediment pollution might involve cattle exclusion fencing, shade and water provision outside of the riparian zone, reduction in stocking densities, or replacement of cattle with bison.

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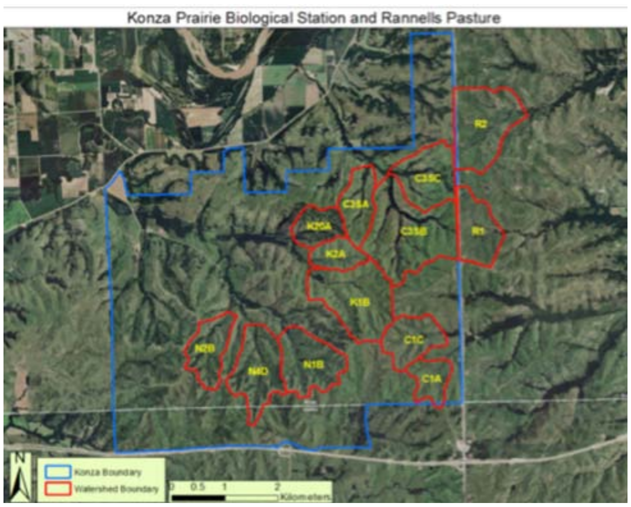

Figure 34. Suspended sediment study watersheds. N watersheds are bison grazed, K are ungrazed, C are moderate density cattle grazed (grazing density is equivalent to bison grazed treatments). R watersheds are high density cattle grazed (grazing density is 3.3 times higher than in C and N watersheds).

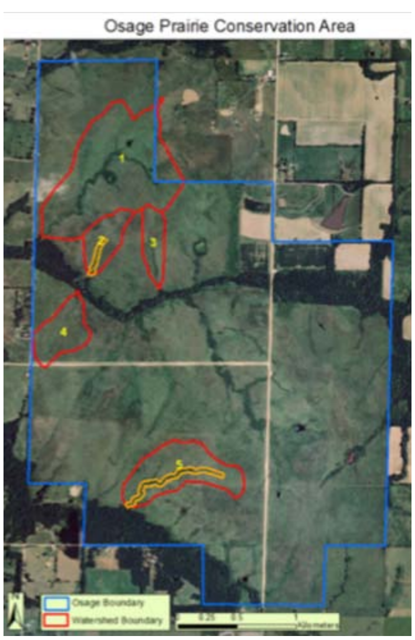

Figure 35. Channel geometry study watersheds. Watersheds 1 & 3 contain cattle with open access to streams, watersheds 2 & 5 contain cattle with riparian stream exclosures, and watershed 4 is ungrazed.

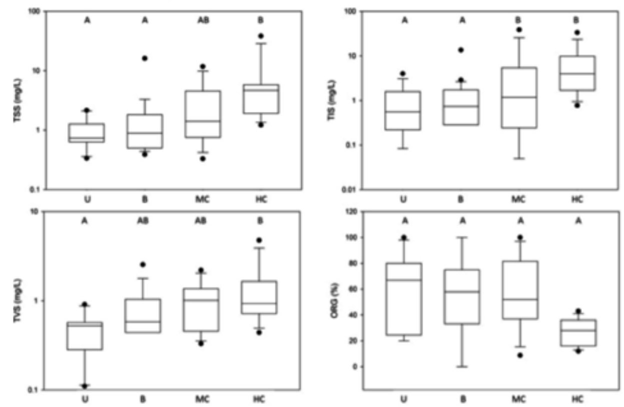

Figure 36. Variability in TSS, TIS, TVS, and POM between grazing treatments.

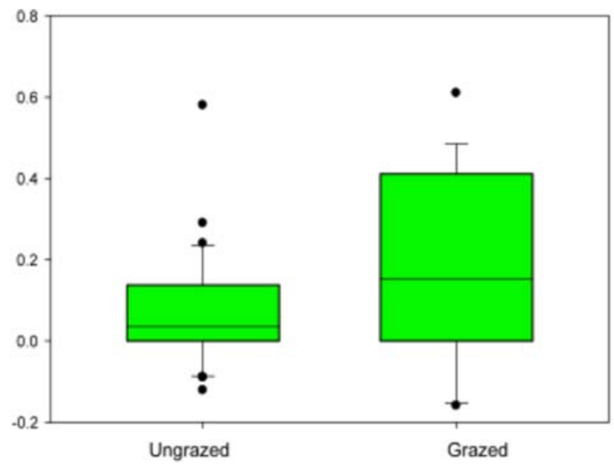

Figure 37. Significant increases in width were found between streams with open access cattle grazing and those that contained riparian exclosures or were ungrazed.

The influence of patch-burn grazing and riparian protection on tallgrass prairie streams

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Fire and cattle grazing are prevailing grassland management tools but how these practices influence stream biology and water quality in most prairie biomes is not studied. We examined the influence of patch-burning grazing (PBG) with and without riparian fencing on tallgrass prairie stream water quality (e.g., nutrients, sediments, and *Escherichia* *coli* bacteria concentrations) and biological structure and function (e.g., algal biomass and whole-stream metabolism). We hypothesized that cattle would increase the concentrations of nutrients, sediments and coliform bacteria, some of which would cascade to influence the biological community. We further predicted that the strongest effects would be observed when cattle were on pasture, but the stream ecosystem would recover to baseline conditions soon after the removal of cattle. Therefore, we tested press and pulse disturbances (Lake 2000) from PBG. A press disturbance is a cumulative pressure on the system through time and has lasting effects following the removal of cattle; this tests the system's ability to resist change following PBG. A pulse disturbance is a response that occurs as a discrete event in time (in this case, when cattle are on pasture), but the response returns to baseline values shortly after the disturbance; this tests the resiliency of the streams to PBG. Further, we tested the exclusion of cattle from the stream by riparian fencing, and predicted that fencing would mitigate stream alterations.

The pretreatment portion of the study was from September 2009-March 2011, in which all watersheds had no fire or grazing in the 5 years. The treatment period followed from April 2011-July 2013. This experiment had three treatments: no PBG ("control"; n=1 watershed), PBG where cattle had free access to the riparian area and streams ("grazed riparian"; n=2 watersheds), and PBG with 10 m, two-tinsel electric riparian fencing on each side of the geomorphically active stream channel ("fenced riparian"; n=2 watersheds). In April 2011, 2012, and 2013 a prescribed patch-burn was carried out in a third of each watershed. The four watersheds with PBG had cow/calf pairs at a density of 0.42 animal units/ha (AU/ha; where one AU=227-363 kg). Cattle were on pasture 1 May – 31 July in each of the three treatment years. We sampled six, first-order streams at Osage Prairie once or twice monthly when flowing at the base of each watershed for total suspended solids, ammonium, total nitrogen, total phosphorus, nitrate, soluble reactive phosphorus, chlorophyll a, Escherichia coli bacterial counts, and whole-stream metabolism (gross primary production, community respiration, and net ecosystem metabolism). Data analysis consisted of a principal components analysis, and the Before-After, Control-Impact (BACIP) design. The BACIP design focuses on the change at the Impact locations relative to the control, after an experimental treatment is applied. The response variable analyzed is the difference value between the control and impact (C-I) for each sampling period, and is used in a Welch's t-test to compare the before and after period. We included data from 13 pretreatment ("before") and 21 treatment ("after") sampling dates in the analyses.

The application of prescribed burning in the after period did not influence any water quality variables as a press response at the control site (alpha > 0.10). Pulse responses to fire and reported in Larson et al. (2013).

After initiation of patch-burn grazing, we detected significant increases in nutrients, total suspended solids, *Escherichia coli,* and chlorophyll a (algal biomass) concentrations in both grazed and fenced riparian watersheds; however, the magnitude of changes were greater in unfenced, grazed watersheds (Figure 38, Figure 39). Total nitrogen values were greatest in grazed riparian (t(29)=-2.56, p=0.016) and fenced riparian (t(33)=-2.35, p=0.025) watersheds in the after period. No significant difference was detected for TSS across sites following PBG treatments in either the grazed riparian nor fenced riparian watersheds (t(22)=-1.65, p=0.114, and t(31)=-0.514, p=0.611). Benthic chlorophyll a (algal biomass) increased in grazed riparian watersheds in the after period (t(26)=-2.65, p=0.014), but not in fenced riparian watersheds (t(12)=-0.16, p=0.874). A stronger signal was detected when we analyzed the pulse hypothesis; when cows were on pasture, chlorophyll a increased in both the fenced and grazed watersheds (t(11)=2.48,p=0.030 and t(10)=4.02, p=0.003, respectively) compared to the control. Escherichia coli bacterial counts were significantly greater in the after period at grazed riparian (t(12)=-2.97, p=0.012) and fenced riparian (t(12)=-1.94, 0.078) watersheds compared to the control. We did not detect changes in gross primary production (GPP), community respiration (CR), or net ecosystem production (NEP) following patch-burn grazing in neither the riparian fenced nor riparian grazed watersheds (alpha > 0.10 for all estimates). The highest water quality values were recorded when cows were on pasture and tended to decline when cattle were removed (Figure 38, Figure 39). Therefore, patch-burn grazing is a measurable disturbance to tallgrass prairie streams; yet, these streams have potential for recovery to baseline values when cattle are off pasture.

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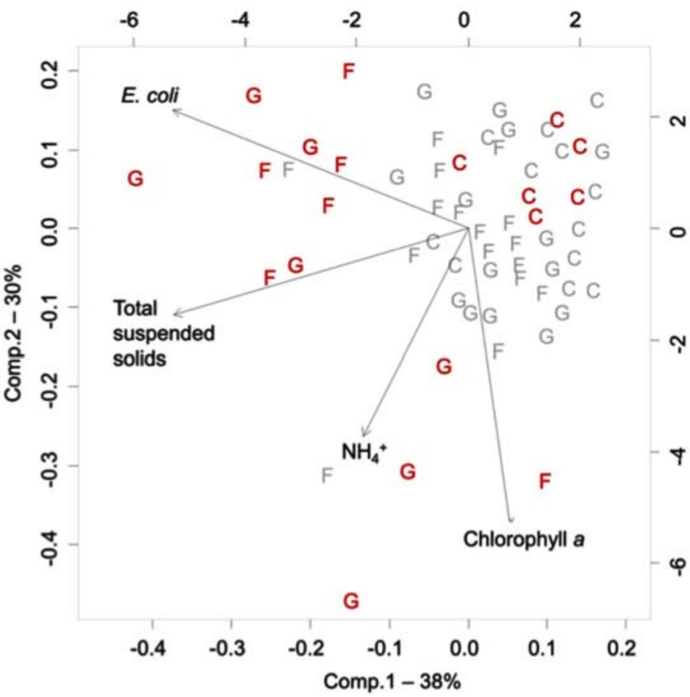

Figure 38. Principal components analysis (PCA) showing the relationship of treatments to gradients of several water quality variables. Data are from Osage Prairie, MO in 2011-2013 and include three treatments: Patch-burn grazing with riparian fencing (F), patch-burn grazing with grazer access to streams (G), and control site without patch-burn grazing (C). The gray symbols are sample dates when cattle were off pasture, and red symbols indicate when cows were on pasture.

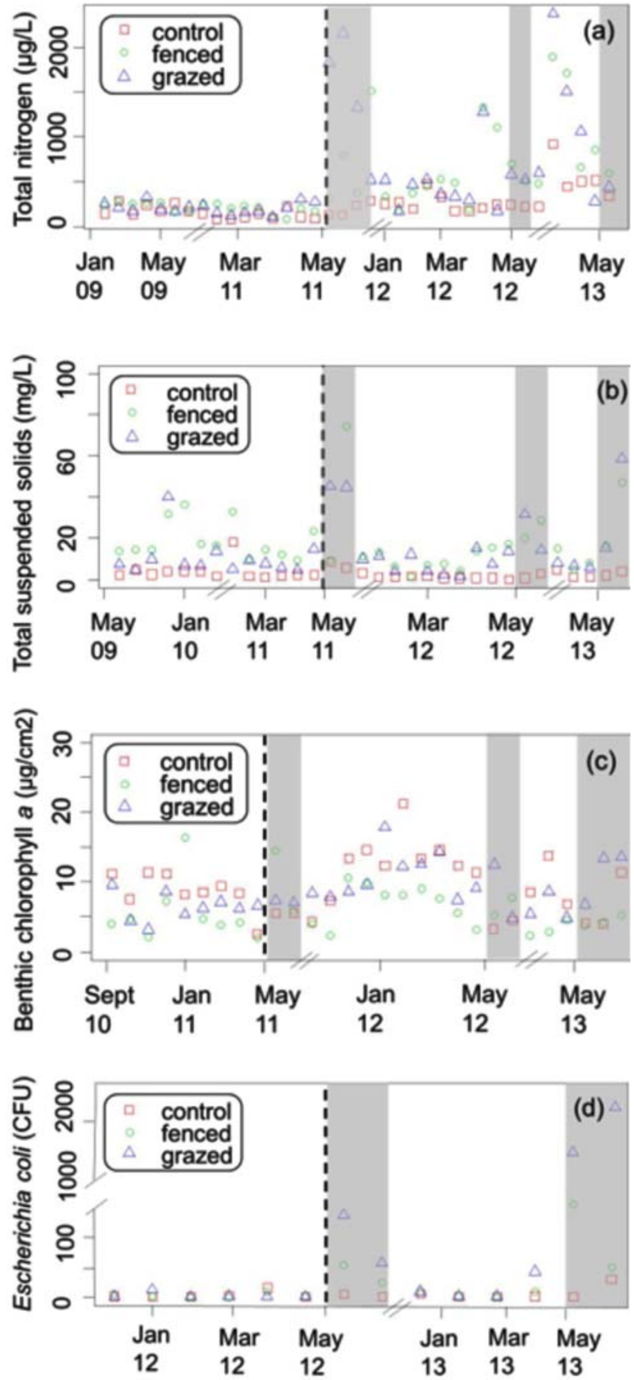

Figure 39. Time series plots for several water quality variables from Osage Prairie, Missouri, USA before and after the implementation of a patch-burn grazing experiment in years 2009-2013. The dashed vertical line shows the separation of the before and after periods of PBG. The gray panels indicate sampling dates when cattle were on pasture from 1 May - 31 July. Hatched marks on the x-axis refer to dry periods with no water sampling, typically in summers. All these parameters were considered statistically significant (alpha <0.10).

The Effect of Precipitation Timing on Flowering in Tallgrass Prairie

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In tallgrass prairie, the dominant C4 grasses *(Andropogon gerardii, Sorghastrum nutans)* reproduce primarily through rhizomes (belowground stems), and thus flowering does not happen every year for a given plant. For these grasses, only about 2- 15% of tillers flower most years. When conditions are right though, mass flowering may occur adding significantly to aboveground primary productivity, with consequences for ecosystem structure and function. Little is known about what factors control flowering of the dominant grasses in tallgrass prairie, beyond a relationship with frequency of fire. Flowering has been shown to be highest with infrequent fire, potentially as a result of increased resource availability. Current year's productivity may influence flowering as there is a significant energy cost to produce the flowering stalks, which can be over 2 meters tall. Previous work has shown that timing of precipitation influences productivity , but is unclear whether precipitation timing affects flowering as well. In order to test whether timing of growing season precipitation is important for flowering, an experiment controlling this factor will be initiated at the beginning of the 2013 growing season at the Konza Prairie Biological Station. Ten study plots (each 6 x 6m) will be divided into four subplots (2.5m x 2.5m) that will each receive a different precipitation treatment. One will have rain excluded beginning on approximately April 15 and lasting 60 days or until 180mm (approximately 30% of the long-term average growing season precipitation) have been excluded; one will have rain excluded beginning on May 15 and lasting 60 days or until 180mm have been excluded; and one will have rain excluded beginning on June 15 lasting until 180mm have been excluded; the fourth plot will be exposed to ambient rainfall. In addition, 10 study plots will receive the long-term average growing season rainfall for the site and an additional 10 plots will receive +30% of the long-term average. All study plots will be burned for the first time in 4 years, and thus there is the potential for significant flowering if water is not limiting. We will assess the effects of precipitation timing on flowering of the dominant grasses by measuring flowering stalk density, height and mass.

Big Bluestem in flower, Konza Prairie Biological Station. Credit: John Dietrich.

Effects of extreme drought on photosynthesis and water potential of Andropogon gerardii (big bluestem) ecotypes in common gardens across Kansas

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Phenotypes of big bluestem *(Andropogon gerardii)* vary throughout the central grasslands of North America, giving rise to genetically-distinct ecotypes within the species. This study sought to distinguish between genetic and environmental variation of big bluestem ecotypes. Photosynthesis and water potential were measured in four ecotypes of big bluestem in common gardens in western, central, and eastern Kansas. Plots contained seeded assemblages to provide interspecific interactions that would occur in natural communities. The role of precipitation was assessed with rainout shelters that reduced ambient rainfall by 50%. Photosynthesis rates and water potential were measured three times during the 2012 growing season. There were differences in photosynthesis among sites that correlated with available soil moisture. The more mesic site in Manhattan, KS had higher photosynthesis and water potentials compared to drier sites in Colby and Hays, KS. Photosynthesis rates decreased in all sites as the growing season progressed. Extreme drought in Colby and Hays reduced photosynthesis rates to near zero by late summer, whereas photosynthesis in Manhattan remained above 6 μmol CO_2 m 2 s 1 in late summer. Big bluestem ecotypes from drier environments had higher photosynthesis compared to mesic ecotypes across sites, particularly evident at the mesic site in Manhattan. Similarly, rainout shelters reduced photosynthesis across sites. Plant water potentials followed soil moisture across sites. Mean water potentials were as low as 7 MPa in Hays and Colby, but were never lower than 1.3 MPa in Manhattan. This study demonstrates ecotypic variation in leaf-level physiology of A. gerardii, potentially related to morphological adaptations or differences in nitrogen assimilation.

Modeling the effects of climate, grazing, and land-cover on the Nebraska Sand Hills

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Other author(s): Dave Wedin, University of Nebraska

Introduction

The Nebraska Sand Hills (58,000 km2) are the largest sand dune system in the Western Hemisphere, and are not only the foundation of the region's cattle industry, but they recharge up to 30% of the groundwater in the High Plains aquifer. Although currently stabilized by vegetation, the Sand Hills have mobilized several times in Pleistocene and Holocene (Mason et al. 2011), yet the mechanism behind this change is poorly understood. Recent modeling suggests that land-cover and moisture status have potentially strong feedbacks on local and regional climate in temperate, semi-arid regions (Koster et al. 2004), and when atmospheric recycling of soil moisture lessens, drought-amplifying feedbacks strengthen (Schubert et al. 2004). This information, coupled with climate change predictions for the Central U.S. indicates widespread dune mobilization is likely to occur again (Schmeisser et al. 2009).

Historical studies conducted through the drought cycle of the 1930's noted changes in the relative abundance of dominant C4 grasses in the Sandhills, but surprisingly little loss of grass cover (Weaver and Albertson 1939). Previous modeling studies showed how biomass in the Sandhills decreased significantly with the combination of fire, grazing, and drought (Mangan et al. 2004), but the ecosystem never lost the grass cover that keeps the dunes stable. Droughts act as a disturbance by reducing plant growth, opening up spaces on the landscape for invasive species (Reece et al. 2004) and allows opportunities for less dominant plant species to grow. Predicted climate change impacts for the Nebraska Sand Hills include more frequent and severe droughts, but how will climate change affect the storage and cycling of Carbon, particularly aboveground biomass?

For this study, we selected the CENTURY model because it is a well validated ecosystem model that can represent management conditions, land-use, plant and soil characteristics, and climate conditions for a variety of sites. We used empirical measurements to calibrate the CENTURY model (v4.6, Parton et al. 1987, 2005), a biogeochemical model designed to simulate the cycling of C, N, and water through an ecosystem. Our goal was to simulate ecosystem processes and give insight into the thresholds, stability, and resiliency of the Sand Hills to changes in management, vegetation cover, and climate. Emphasis was placed on how climate (reduced precipitation) affects the aboveground production of biomass, which in turn affects erosion, or stability of the sand dunes. We expect to find that a drought more severe than the 1930's drought will be required to initiate dune activity (Mangan et al. 2004), and that continual periodic disturbances will eventually push the system into a mobile sand dune state.

Methods

The CENTURY model (v4.6) was used to simulated vegetation responses at the UNL owned Barta Brothers Ranch, located in the eastern portion of the Nebraska Sandhills (Figure 40; Sridhar and Wedin 2009). Model simulations were run using weather data compiled from monthly averages of five nearby towns from 1910-2003, and site specific data from 2004-2012. CENTURY results were validated using on site monthly aboveground biomass measurements from 2005-2012.

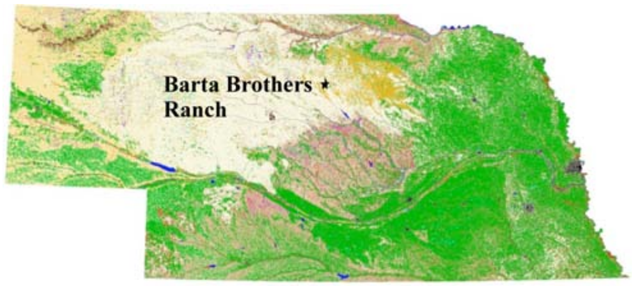

Figure 40. Location of the UNL owned Barta Brothers Ranch in the eastern Nebraska Sandhills.

After model calibration and validation, we use the CENTURY model to simulate the response of the ecosystem to alterations in precipitation over the next 88 years. Model runs were simulated using a control (ungrazed), grazed, and a periodically disturbed ecosystem. Altered climate included unaltered precipitation as a control, -10%, -25%, and -50% precipitation.

Results

Calibration and validation produced a model that explained 60-70% of the variation in observed monthly aboveground biomass. Average peak growing season biomass in control treatment was 179.81 ± 15.60 g/m2 for the on-site observations and 135.76 ± 16.50 g/m2 for model simulations. Simulating the model forward for the next 88 years produced reductions in total system Carbon as precipitation was reduced (Figure 41). Although total system C was decreased under -10% precipitation compared to the

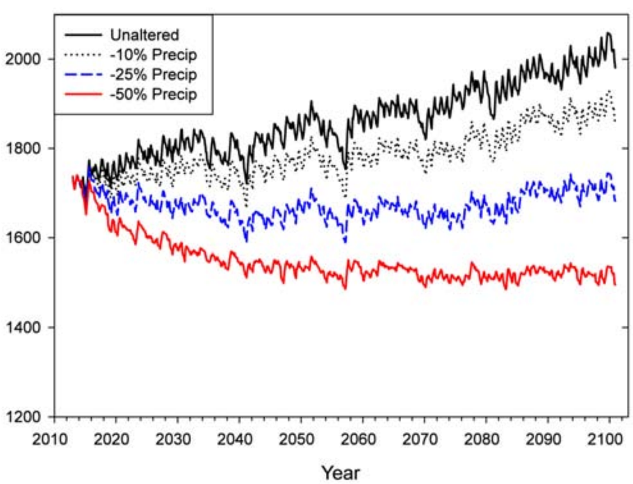

Figure 41. Monthly total system C (g/m2) for the control treatment from 2013-2100.

unaltered precipitation, loss of total system C did not occur until precipitation had been reduced by 50%. Grazed and periodically disturbed treatments showed similar reductions in total system C.

Discussion

The goal of this research was to determine the effects of climate (reduced precipitation) on vegetation dynamics in the Nebraska Sandhills. The CENTURY model was calibrated and validated using empirical measurements, and then run forward to simulate responses to reductions in precipitation. Vegetation responses were simulated in grazed, ungrazed, and periodically disturbed plots.

Although aboveground biomass production was never completely lost, even with 50% reduction of precipitation, all management treatments lost Carbon as precipitation was reduced. The control treatment (released from grazing pressure in 2004) stored carbon in the system until precipitation is 50% less than average. This release from grazing pressure in the control treatment allowed total system C to increase, largely driven by belowground production, until precipitation is decreased by 50%. These results are similar to past studies which concluded that noticeable decreases in Sand Hills vegetation production may require at least a 40% decrease in precipitation from values during the drought of the 1930's (Mangan et al. 2004). The periodic disturbance treatment reduced the aboveground and belowground live biomass, but it never reaches a point with zero vegetation during recovery years. Because of this, severe drought (>50% reduction) over longer time periods (Schmeisser et al. 2009) may be required to reduce aboveground vegetation to near zero.

CENTURY model simulations showed reductions of aboveground live biomass, belowground biomass, and total system C, but the system never lost the grass cover that stabilizes the sand dunes. Although the Nebraska Sand Hills have been mobilized in the past during severe and extended drought, it is still unknown if predicted climate change impacts will have similar effects. The ability to conserve and maintain this economically and ecologically important ecosystem depends on understanding the complex interactions of climate, land cover, and management.

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Influence of precipitation on trichome densities in big bluestem (Andropogon gerardii) ecotypes in Great Plains reciprocal gardens

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Big bluestem *(Andropogon gerardii)* is native to the tallgrass prairie, which is becoming increasingly susceptible to extended drought. The gradient of rainfall across the central United States grassland presumably has given rise to ecotypes of big bluestem adapted to different precipitation regimes. Trichomes (epidermal hairs) are often a water conservation strategy in plants to reduce incoming radiation or increase the boundary layer. This study examined variation in trichome density among five A. gerardii ecotypes (from Central Kansas, Eastern Kansas, Illinois, and two cultivars of Kaw and Sand bluestem) reciprocally grown across a precipitation gradient in common gardens at Colby (505 mm/yr), Hays (582 mm/yr), and Manhattan, KS (872 mm/yr), and Carbondale, IL (1167 mm/yr). Trichome density was calculated on the adaxial surface of leaf blades. Trichome density increased with increasing aridity of sites. The mesic-adapted ecotype from Illinois often responded to decreased precipitation to a greater extent compared to xeric-adapted ecotypes, with increased trichome density in the most arid site in Colby, KS. The most xeric-adapted ecotype from Central Kansas had the greatest number of trichomes at the other dry site in Hays, KS. This indicates a common response to precipitation in genetically different ecotypes. The Eastern Kansas ecotype and the Kaw cultivar exhibited greater trichome density with increasing aridity

Chestnut-Collared Longspur. Photo credit: WCS.

of sites, but to a lesser extent than the Central Kansas or Illinois ecotypes. By contrast, the Sand bluestem cultivar did not form more trichomes with decreased precipitation, likely due to greater amounts of wax on leaves. An ecotype-specific response to precipitation suggests different morphological responses to drought.

A possible mechanism for increased performance of a xeric adapted big bluestem (Andropogon gerardii) ecotype: nitrogen and chlorophyll content of leaves in reciprocal gardens across the Great Plains

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Big bluestem *(Andropogon gerardii)* is a dominant C4 grass in tallgrass prairie. With wide variation in precipitation across the tallgrass prairie (500-1200 mm per year from western Kansas to southern Illinois), it is expected genetic ecotypes might be present within the species, and these ecotypes might be adapted to water availability. To investigate a potential mechanism for drought tolerance, leaf nitrogen concentration (%N) was measured in eight replicate blocks of twelve plants, representing three ecotypes of *A. gerardii* (from Central Kansas, Eastern Kansas, and Illinois) at four reciprocal garden sites (Colby, Hays, and Manhattan, Kansas, and Carbondale, Illinois). Leaf chlorophyll content (based on SPAD measures) and photosynthesis were also measured in these plants. The xeric Central KS ecotype had higher %N and higher chlorophyll content across sites. The Central KS ecotype also had higher photosynthetic rates compared to other ecotypes. Site differences in photosynthesis correlated with available moisture; the highest photosynthesis rates were at the wettest site in Carbondale, IL. When measured across all ecotypes, the garden site in Hays, KS was found to have the highest %N. However, the Carbondale, IL site had plants with the highest chlorophyll content. Increased nitrogen seems to confer an advantage to the xeric Central Kansas ecotype, especially at the drier planting sites. The Central Kansas ecotype maintained higher nitrogen concentration, manifested as increased chlorophyll content and higher photosynthesis rates compared to more mesic ecotypes from Eastern Kansas or Illinois. This research provides a mechanistic understanding of the observed ecotypic variation in physiological performance of big bluestem. Ultimately, this knowledge can help explain plant responses to decreasing precipitation in a dominant prairie species.

Konza Prairie. Photo credit: Aviva Glaser.

"There is no describing [the prairies]… They inspire feelings to unique, so distinct from anything else, so powerful, yet vague and indefinite, as to defy description, while they invite the attempt."

—John C. Van Tramp, *Prairie and Rocky Mountain Adventures* (1860)

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Native Grasslands and Invasion Issues

Spread of Yellow Old World Bluestem in Native Rangeland Pastures

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Introduction

Old world bluestems (OWB) were widely introduced in the central and southern Great Plains as warm-season perennial grasses for soil conservation and forage. Old world bluestems are native to most of temperate and tropical Asia, Australia, Eurasia, and sub-Saharan geographic regions of Africa; therefore, monocultures of OWB are productive in hot, moist environments, yet are capable of persisting in hot, dry environments. Introduced species of OWB are bunch grasses typically without stolons or rhizomes, and they spread primarily by producing and dispersing great quantities of seed. In Kansas, Oklahoma, and Texas, OWB have escaped areas where seeded and have invaded native rangelands. This invasion is undesirable because of competition with native grasses and negative effects on rangeland insect, rodent, and bird communities (Reed et al. 2005; Sammon and Wilkins 2005; Gabbard and Fowler 2006; Hickman et al. 2006). Attempts to control old world bluestems in pasture or natural areas by multiple management strategies, other than tillage, have achieved partial or short-term success. Impacts of OWB invasion on grazing animal behavior in native rangelands is not yet known.

In native rangelands near Hays, KS, we have observed patches of yellow OWB *(Bothriochloa ischaemum)* establishing and appearing to spread over time. The origin of seed for establishment in these native rangelands is presumed to be by natural wind dispersal from nearby plants in ditches and waste areas, by wild animal transport, or by movement of seed incidentally collected on vehicles and transported from the source to native rangelands. The pastures where invading yellow OWB patches were found had never been overseeded nor had any hay fed within the pasture to introduce OWB seed; however, the amount of spread, if any, of the observed patches of OWB was not known or quantified. The objective of this study was to quantify the spread, if any, of invading OWB patches within two native rangeland pastures.

Materials and Methods

Research was conducted on patches of yellow OWB on native rangelands with shortgrass prairie vegetation near Hays, KS. The locations of the patches were considered to be a loamy upland range site and a loamy lowland range site owned by the Kansas State University Agricultural Research Center–Hays and Fort Hays State University.

The perimeter of two yellow OWB patches was flagged in 2003. Yellow OWB plants outside of the patches were also found and flagged by walking a grid outside of the patch. A real-time kinematic (RTK) system was used along with a remote rover GPS system to ensure sub-centimeter corrections and accuracy of the marked coordinate points. In 2011 and 2012, the perimeter of the yellow OWB patches and the individual yellow OWB plants outside of the patches were flagged and recorded again.

Once recorded, the GPS coordinates were translated by ARCGIS software to create a map area of the yellow OWB patches and the individual plants around the patch. Calculations were made within the software to determine patch sizes and the number of individual plants around each patch.

Results

The upland site in 2003 contained two separate patches of yellow OWB that were a total of 2,369 ft2 in size (Figure 42). Additionally, 86 individual plants were found outside the patches. When mapped again in 2011, the two patches had increased to eight patches, and total patch size had increased to 6,389 ft2. Outside the patches, 417 individual yellow OWB plants were found.

The lowland site in 2003 contained a smaller yellow OWB patch than the upland site. The lowland patch was 312 ft2 in 2003, and 24 individual plants were present outside the patch (Figure 43). In 2012, the patch had increased in size to 1,128 ft2, and 106 individual plants were found outside the patch.

Implications

Yellow OWB has excluded almost all native vegetation within the patches. A similar trait to reduce vegetative diversity was found with Caucasian bluestem, a relative of yellow bluestem, in tallgrass prairie (Reed et al. 2005). Yellow bluestem was found to invade multiple habitat types in Texas rangelands, and was only absent in locations with heavy shading (Gabbard and Fowler 2007). Therefore, yellow bluestem would likely be allowed to spread with minimal limitation on the majority of ecological sites in the southern mixed grass and shortgrass steppe regions. Yellow bluestem invasion may have long term consequences by potentially affecting soil nutrient cycling, function and microbial communities in grasslands. Soil alteration may then serve as a means for further invasion. The patches found in these pastures are increasing in size by compounded growth rates of 13–15% each year. At this rate, the upland site will have a yellow OWB patch 1 acre in size within 16 years, 2 acres in size within 21 years, and 3 acres in size within 24 years, and the lowland site will have a yellow OWB patch 1 acre in size within 25 years, 2 acres in size within 31 years, and 3 acres in size within 33 years. For now, we conclude that yellow OWB will continue to increase in native pastures and exclude native grasses in patches if it is not targeted for greater animal use or control.

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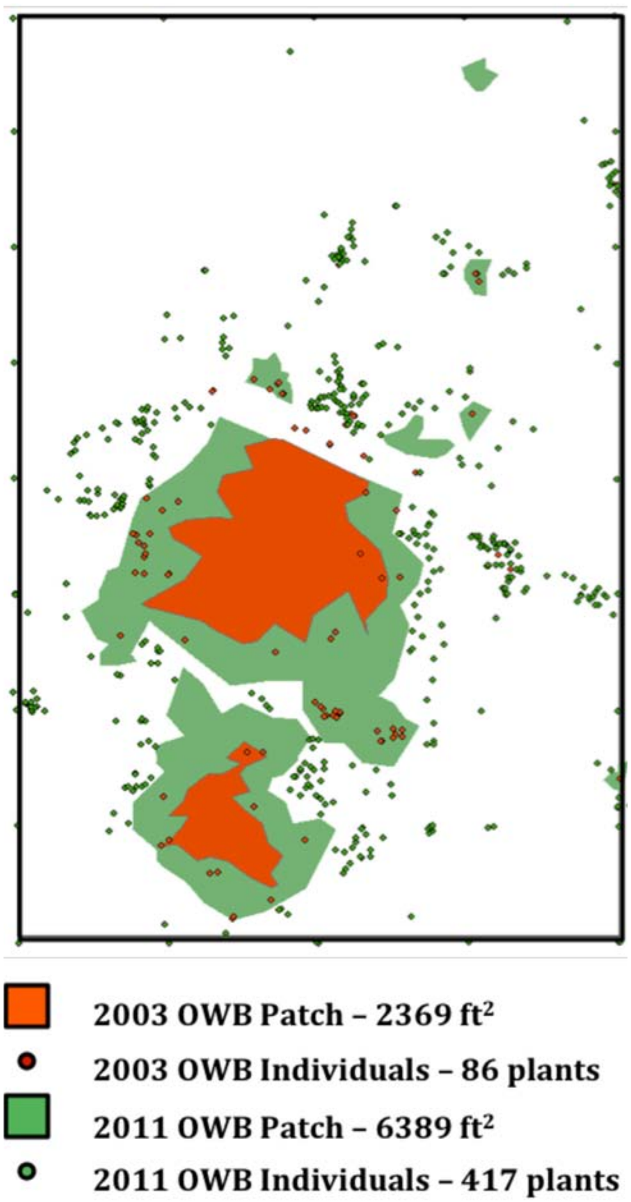

Figure 42. Upland range site with yellow Old World bluestem (OWB) patches and individual plants mapped in 2003 and 2011.

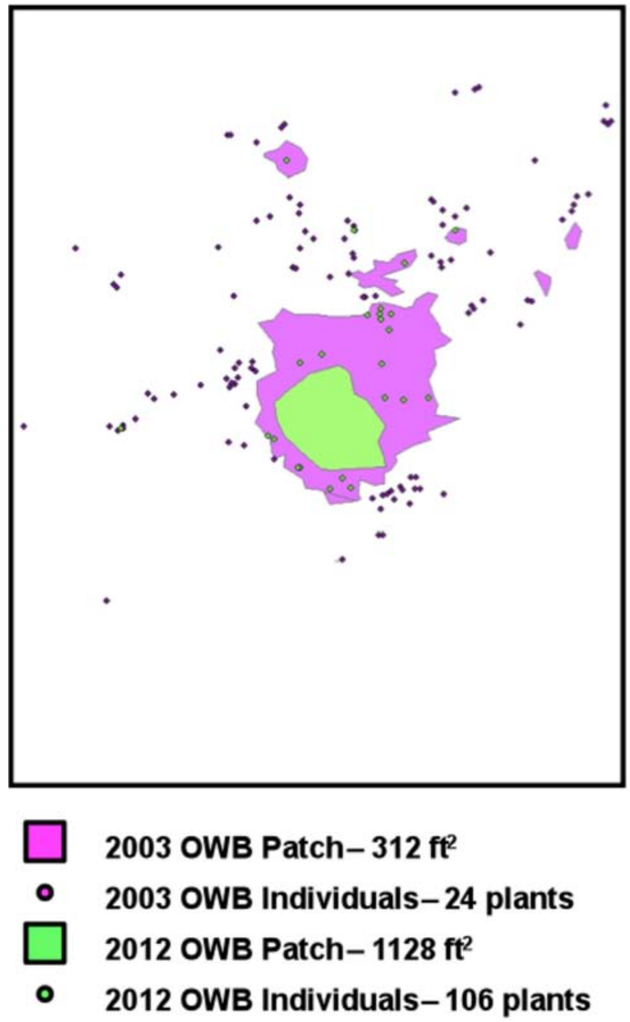

Figure 43. Lowland range site with yellow Old World bluestem (OWB) patches and individual plants mapped in 2003 and 2012.

Old World Bluestem invasion and its effects on the small mammal communities of North Central Oklahoma, USA: An ecological game changer

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Old World Bluestems (OWBs) are invasive warm-season grasses that have been planted onto millions of hectares of marginal farmland and roadside right-of-ways in the southern and central Great Plains to reduce soil erosion and

Monoculture of yellow bluestem, an invasive warm-season grass. Photo credit: Mitchell Greer.

to increase forage production. These grasses are currently of major management concern due to their rapid invasion into native prairies. Invasions of OWBs into native prairies have negative ecological and economical consequences, and may have profound impacts on the small mammal communities of these grasslands. Previous studies have shown that as diverse native plant communities give way to monocultures of exotic species, small mammal diversity, richness, and abundances decline. We hypothesize that as these invasions progress towards monocultures, they will provide fewer microhabitats and resource bases, compared to the highly diverse native rangelands, with a concomitant reduction in abundance and richness of small mammals. We assessed the effects of OWB invasions on small mammal communities in Oklahoma, USA. We conducted small mammal trapping at 4 replicate sites in grasslands with 40-60% OWB cover, and paired native, non-invaded grasslands. Plant species composition, visual obstruction, areial cover, and litter detph were assessed at each trapping site to allow for development of species-specific habitat models. Over the course of our 2 year study, we completed 5,120 trap days (24 hr/day). We captured 191 individuals in the native grasslands and 292 individuals in the OWB invaded grasslands. Our data indicate that invasion of OWB into the native grasslands lowered species richenss and increased the relative abundance of hispid cotton rats (Sigmodon hispidus). However, invasion by this warm-season grass lowered the relative abundance of deer mice (Peromyscus maniculatus), compared to the native grassland controls. Species-specific models show litterdepth, which is positively correlated with OWB coverage, as an important varibale in predicting relative abundances of cotton rats and deer mice. Because small mammals are a vital part of grassland ecosystems, influencing all trophic levels, alterations to these small mammal communities may have profound effects on ecosystem functioning.

Pocket mouse caught during study. Photo credit: Mitchell Greer.

Effects of the Seed Bank and Interseeding in Reconstructed Tallgrass Prairies

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Disturbances such as fire and mowing temporarily increase available resources for plants, opening a window of opportunity for new plants to establish. During the recovery of vegetation after disturbance, new individuals arise from either seeds or vegetative reproduction and can subsequently affect plant diversity. In remnant prairies, seedling establishment is often negligible compared to vegetative regrowth. However, it is unclear if this is true in reconstructed prairies. In two, 25-year-old, low diversity reconstructed prairies, we tested the effect of seedlings by removing seedlings, allowing seedlings (control), and adding seed in 1 m2 plots and comparing their diversity over two growing seasons. To determine whether disturbance frequency affects the contribution of seedlings to vegetation recovery, each treatment was clipped zero, one, or multiple times. To test whether resources affect seedling establishment, photosynthetically active radiation reaching the soil, soil moisture, soil nitrate, the number of seedlings, and the number of mature plants were measured in four 20 cm diameter microsites within each seeded plot. The two field sites were analyzed separately because of their varied management history and abiotic conditions. More frequent clipping increased light availability but did not alter average moisture and nitrate in microsites in either site. In our wetter field site, microsite conditions did not predict seedling numbers. In the drier field site, seedlings were more numerous within the unclipped and once clipped plots which had less light and less exposure than plots clipped twice. In the wetter site, seedling removal plots had the lowest species richness and highest evenness, control plots were intermediate, and plots with added seed had the highest richness and lowest evenness. In the drier site, only adding seed impacted richness (higher) and evenness (lower). In both sites, over 80% of the seeds present in the seed bank were non-native species. Seedling establishment from any source never affected community diversity suggesting that while some seeds establish, reconstructions are primarily maintained by vegetative reproduction. However, given the non-native dominated seed banks, management intended to increase seedling establishment could increase non-native cover.

Kentucky bluegrass in the Northern Great Plains: A turf grass that has invaded our rangelands

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Kentucky bluegrass (*Poa pratensis* L.) has been used as a lawn grass for many years in the temperate regions of the U.S. However, recently Kentucky bluegrass has been invading native grasslands in the northern Great Plains of the US and Canada. Kentucky bluegrass has the ability to tolerate defoliation and go dormant during droughts. While these traits make Kentucky bluegrass and attractive lawn grass, they also provide it with competitive advantages when invading native rangelands. Anecdotal evidence has suggested that Kentucky bluegrass is increasing on northern Great Plains rangelands. Long-term historical data from the Northern Great Plains Research Laboratory (USDA-ARS) has shown increases Kentucky bluegrass on long-term lightly grazed rangelands. Despite its potential impact, little has been done to 1) document the extent of Kentucky bluegrass invasion in the northern Great Plains, 2) identify a potential threshold for Kentucky bluegrass invasion and 3) identify potential impacts of Kentucky bluegrass invasion. Examination of NRI data (USDA-NRCS) has indicated 75% of rangeland sites in North Dakota have either Kentucky bluegrass or smooth bromegrass (*Bromus inermus* L.). Potential impacts of Kentucky bluegrass invasion include alterations in energy flow, hydrologic function, nutrient cycling and community dynamics. These alterations would cause substantial changes in ecological services derived from rangelands. However, more information is needed to determine invasion mechanisms and identify potential thresholds.

Native warm season grasses have a place in Missouri haying and grazing systems

Ryan Diener, Quail Forever and Chris McLeland and Jason Sykes, Missouri Department of Conservation

Native warm-season grasses and forbs were once plentiful across Missouri's landscape. During European settlement, over 15 million acres of lush prairie grew abundantly across the state. Early pioneers realized the benefits of native grasses for hay production and forage for livestock; however, Missouri's native prairies quickly became stressed due to over utilization. They were soon replaced with non-native cool-season grasses, such as tall fescue *(Schedonorus arundinaceus),* thought to provide better forage value and longer grazing seasons. Today, less than 1% of Missouri's native prairies remain, although the value of re-incorporating native warm-season grasses back into livestock operations is gaining momentum. Native grass species such as big bluestem *(Andropogon gerardii),* little bluestem *(Schizachyrium scoparium),* indiangrass *(Surghestrum nutans),* switchgrass *(Panicum virgatum),* and eastern gamagrass *(Tripsacum dactyloides)* are five species commonly selected for warm-season native grass plantings. The drought tolerance of warm-season grass species was very evident during the summer of 2012, when the majority of the state was categorized by the United States Department of Agriculture (USDA) as experiencing extreme drought. During this extreme drought, warm-season grasses were called upon to assist cattle producers in providing additional forage for livestock when stressed cool-season pastures dominated by fescue failed to provide adequate production. Efforts have been made by state and federal agencies to increase education while providing technical assistance and cost share opportunities for producers interested in developing grazing and haying systems that incorporate native grasses. This poster will discuss both monetary and environmental benefits of natives for producers and the landscape.

Cattle in a lush stand of native warm season grasses in mid-July in western Missouri. Photo Credit: Steve Clubine.

Indicators that tallgrass prairie is becoming susceptible to rapid expansion by native shrubs

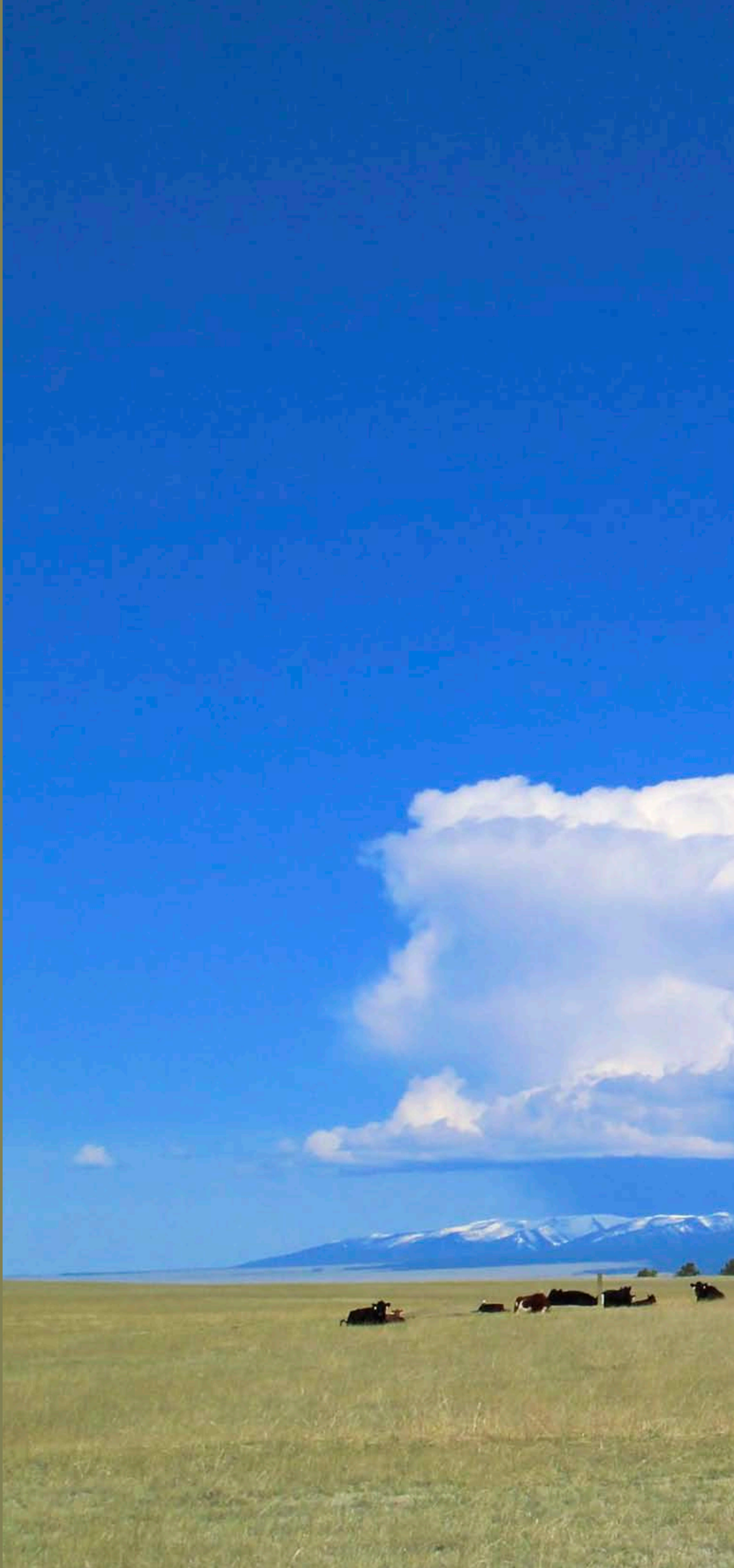
Zak Ratajczak, Kansas State University.

There have been extensive efforts to create theoretically-derived leading indicators (i.e. “warning signs) of declining resilience in physical, biological, and social systems. In grasslands, these tools could be used to avoid management decisions that result a collapse in cattle productivity associated with a loss of grass cover or an increase in shrub cover. These theories have been developed and applied mainly to aquatic, marine, and microbial ecosystems, while little knowledge exists on their applicability to other ecosystems. Due to the relatively long time terrestrial systems take to force a regime shift, more commonly used temporal techniques will seldom be viable in these ecosystems, while spatial methods appear to be more promising. To date spatial indicators have never been applied to “real-world” ecosystems. Here we evaluate spatial leading indicators at multiple scales in a terrestrial system: the regime shift from grassland to shrubland, precipitated by 30 years of fire suppression. At larger scales spatial correlation, a common “leading indicator”, does not consistently anticipate the transition, but instead tends to increase after. Therefore, the success of leading indicators is susceptible to their application at suitable scales. In fact, spatial correlation at the plot scale (<10 m2) is a viable indicator that precedes the transition early enough to engage in resilience-based management. In particular, we find that small scale grass-shrub anti-correlation increases as the system approaches the threshold, which is a manifestation of declining resilience and intensification of feedbacks sustaining the shift to shrubland. The finding that spatial leading indicators provide a viable means of predicting grassland to shrubland transitions opens new doors to managing resilience in terrestrial systems. Our current work is focusing on measurements that are correlated with these leading indicators, in order to facilitate integration with management schemes.

Konza Prairie. Photo credit: Aviva Glaser.

“While I know the standard claim is that Yosemite, Niagara Falls, the upper Yellowstone and the like, afford the greatest natural shows, I am not so sure but the Prairies and Plains, while less stunning at first sight, last longer, fill the esthetic sense fuller, precede all the rest, and make North America’s characteristic landscape.”

–Walt Whitman, *Complete Poetry and Collected Prose* (1982 ed., p. 864, Viking Press, New York, NY)



National Wildlife
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