Field Guide to Research at Neal Smith National Wildlife Refuge

photo by Elizabeth Bach

Produced exclusively for the 22nd North American Prairie Conference field day, August 3, 2010

Research at Neal Smith NWR: The Land Management Research and Demonstration (LMRD) Program

- Neal Smith NWR is one of 8 National Wildlife Refuges designated as LMRD sites in the United States
- The LMRD program provides resources and staff to encourage and undertake scientific research that will enhance wildlife and ecosystem preservation in North America
- The focus of ecological restoration at Neal Smith NWR provides unique opportunities to test scientific theory and deepen our understand of tallgrass prairie ecosystem structure and function
- The LMRD program interprets and demonstrates research and management techniques to land managers and to the public

Research conducted at Neal Smith NWR has resulted in:

- The publication of more than 60 peer-reviewed scientific journal articles
- 25 Masters theses and Ph. D. dissertations
- More than 60 technical research reports
- Conservation and re-introduction of rare and declining grassland species

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Research topics at Neal Smith NWR have included:

- Planting methods for diverse prairie reconstructions testing seed delivery techniques, season of planting, and seed mixes
- Ecological function of prairie planting
- Sedge meadow reconstruction
- Control of invasive species such as Canada thistle and Reed Canary Grass
- Strategic herbicide use in native plantings
- Regal Frittilary butterfly reintroduction
- Grassland birds
- Invertebrates including, moths, butterflies, and many other taxa
- Soil carbon sequestration
- Hydrologic changes as an agricultural landscape returns to prairie
- Groundwater dynamics and surface water quality
- Plant community interactions with large (bison/elk) and small mammals
- Alternative agricultural practices using diverse paririe strips
- Bison and elk diet and habitat selection
- Effectiveness of environmental education programs
- Indiana Bats; federally designated as an endangered species.

Hydrology and water quality in a reconstructed prairie chronosequence

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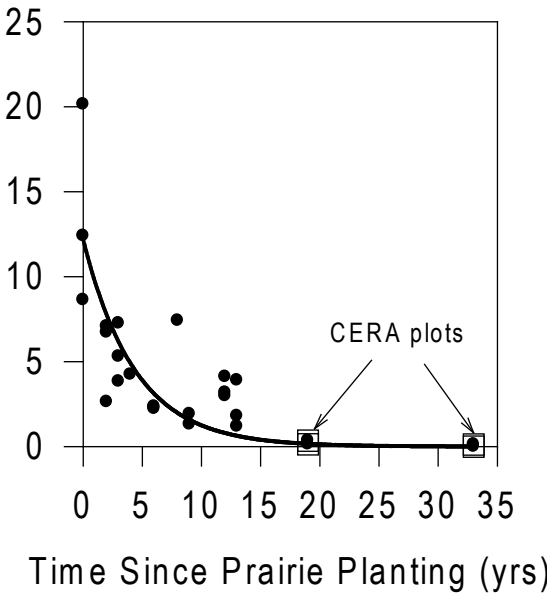

Figure 2. Groundwater nitrate concentrations in the reconstructed prairie chronosequence at NSNWR and CERA. Fitted exponential regression was statistically significant ($p<0.05$).

Chronosequences are time series of sites of varying age with otherwise similar characteristics and they offer an approach useful in evaluating long-term trends in ecosystems. We are using a reconstructed prairie chronosequence at the Neal Smith National Wildlife Refuge (NSNWR) to evaluate changes in hydrology and water quality across a time period of approximately 15 years.

Methods

We installed 19 groundwater wells at upland locations selected to provide similar soil type, landscape position and slope. Prairie planting dates ranged from 1993 to 2004 and our monitoring included a current row crop field for comparison (Fig. 1). In addition, we installed four wells in older prairie reconstructions (1974 and 1987 plantings) at Grinnell College's Conard Environmental Research Area (CERA).

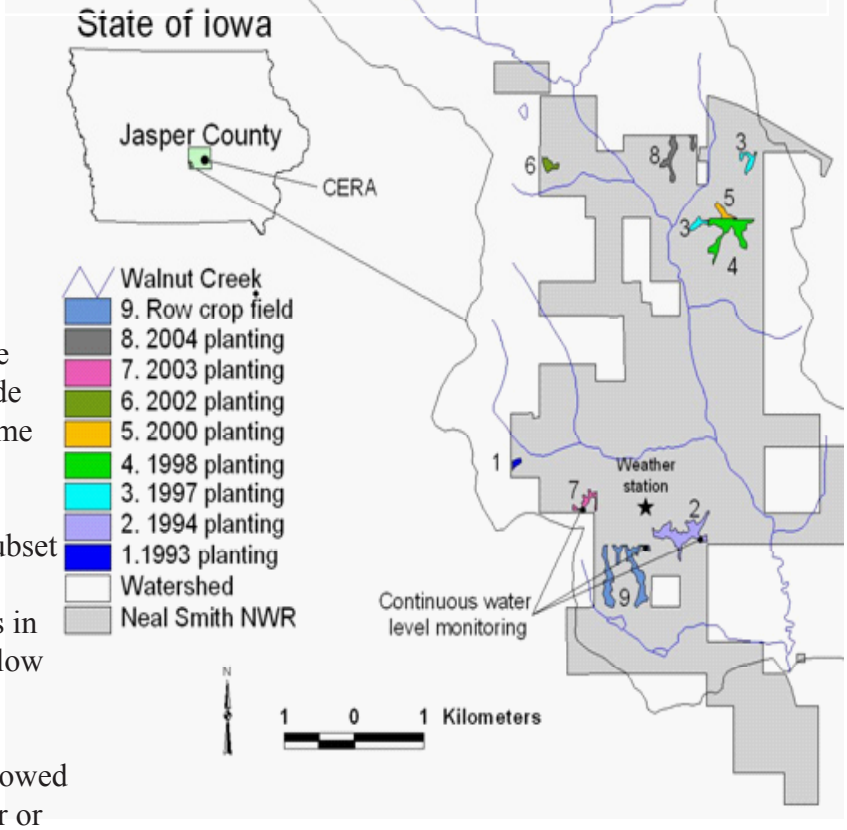

Figure 1 Location of chronosequence monitoring sites at the NSNWR

Initial Results

- Groundwater was deeper under older prairie plantings and groundwater NO_3-N and chloride concentrations significantly decreased with time since planting (Fig. 2).

- Additional soil-water sampling beneath a subset of chronosequence plots suggests that prairie reconstruction may be affecting carbon stocks in soil-water more rapidly than observed in shallow or deep soils.

- Groundwater phosphorus concentrations showed little evidence of temporal trends in soil-water or groundwater and likely reflect the legacy of long-term agriculture.

Watershed Monitoring – How does Prairie Reconstruction affect Water Quality in Walnut Creek Watershed?

Keith Schilling, Iowa Geological and Water Survey

Mark Tomer, National Laboratory for Agriculture and Environment

Nonpoint source pollution is a major problem in Iowa and the Midwest but reintroduction of perennial cover into an agricultural ecosystem for water quality benefits is relatively untested at the watershed scale. We are monitoring surface water conditions in paired 5,000 ha watersheds to evaluate stream response to changing land use patterns at the Neal Smith National Wildlife Refuge. A large portion of the Walnut Creek watershed is being restored from row crop agriculture to native prairie and/or savanna. Between 1993 and 2005, over 3,000 acres of land has been converted from row crop to native prairie, encompassing 25% of the watershed. In neighboring Squaw Creek watershed which serves as the control, land use consists of about 70% row crop. From 1995 to 2005, monitoring was supported by an EPA 319 grant and consisted of four basic monitoring components: 1) tracking of land cover and land management changes within the basins, 2) stream gaging for discharge and suspended sediment at two locations on Walnut Creek and one on Squaw Creek, 3) surface water quality monitoring in the Walnut and Squaw Creek watersheds, and 4) biomonitoring for aquatic macroinvertebrates and fish in Walnut and Squaw Creeks.

Significant water quality changes were observed during the 10-year monitoring project, particularly with respect to nitrate-nitrogen concentrations (nitrate). Nitrate concentrations ranged between <0.5 to 14 mg/l at the Walnut Creek outlet and 2.1 to 15 mg/l at the downstream Squaw Creek outlet (Figure 1). Nitrate concentrations decreased 1.2 mg/l over 10-years in Walnut Creek watershed but increased 1.9 mg/l over 10 years in Squaw Creek. Changes in nitrate were easier to detect and more pronounced in monitored subbasins, decreasing 1.2 to 3.4 mg/l in three Walnut Creek subbasins, but increasing up to 8.0 and 11.6 mg/l in 10 years in two Squaw Creek subbasins. Converting row crop lands to grass reduced stream nitrate levels over time in Walnut Creek, but stream nitrate rapidly increased in Squaw Creek when CRP grasslands were converted back to row crop. Study results highlight the close association of stream nitrate to land use change and emphasize that grasslands or other perennial vegetation placed in agricultural settings should be part of a long-term solution to water quality problems.

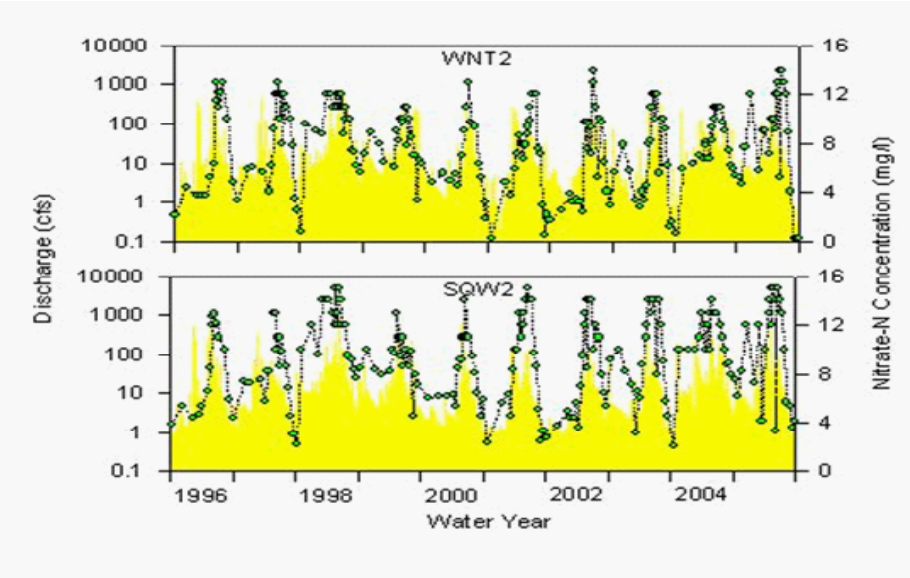

Figure 1. Discharge (yellow) and nitrate concentrations measured during the 10-year Walnut Creek Watershed Monitoring Project at Walnut Creek (WNT2) and Squaw Creek (SQW2) outlets.

Suspended Sediment and Stream Bank Erosion Investigations of Walnut Creek, Neal Smith National Wildlife Refuge

Thomas M. Isenhart[1], Keith E. Schilling[2], Jason A. Palmer[1,3], and Richard C. Schultz[1].

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Suspended sediment is a major water quality problem, yet few monitoring studies have been of sufficient scale and duration to assess the effectiveness of land use change or conservation practice implementation at a watershed scale. As part of this study, daily discharge and suspended sediment export from Walnut and neighboring Squaw Creek watersheds were monitored over a 10-year period (water years 1996 to 2005). In Walnut Creek watershed, a large portion of land was converted from row crop to native prairie, while in Squaw Creek land use remained predominantly row-crop agriculture. Suspended sediment loads were similar in both watersheds, exhibiting flashy behavior typical of incised channels. Modeling results suggested that soil erosion in Walnut Creek should have been reduced 46% relative to Squaw Creek due to changes in land use, yet measured suspended sediment loads showed no significant differences. Stream mapping indicated that Walnut Creek had three times more eroding streambanks than did Squaw Creek suggesting that streambank erosion dominated sediment sources in Walnut Creek and sheet and rill sources dominated sediment sources in Squaw Creek.

Measurement of eroding stream banks.

Face of an eroding stream bank illustrating the depth of eroded soil (post-settlement alluvium) deposited along Walnut Creek in the Neal Smith NWR.

An additional objective of this study is to determine the impact of riparian land use and stream channel modifications on the location and severity of stream bank erosion within Walnut Creek Watershed. The location and length of severe stream bank erosion was mapped along the main channel and eroding lengths were divided into riparian land use categories: cool-season grass, warm-season grass, row-crop agriculture, grazed pasture, riparian forest, and grassland-forest mix. Total stream length, sinuosity, and eroding stream bank lengths were compared among all land use categories. To estimate stream bank recession rates, erosion pins were installed along stream banks in four major riparian land uses along the main stem of Walnut Creek. Areas with high sinuosity located directly downstream of channelized portions of the stream network were found to have more eroding lengths with higher recession rates than locations further up in the watershed. The major riparian land uses most frequently associated with meandered sections of the stream system were riparian forest land and grazed pasture land. Results suggest that past land use and stream modifications have long-lasting effects on stream bank erosion and sediment transport and that there may be a significant lag time between practice implementation and water quality improvement.

Hydrologic Investigations in the Riparian Zone Hydrology of Walnut Creek, Neal Smith National Wildlife Refuge

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- Removal of reed canary grass cover resulted in considerably more groundwater recharge compared to the vegetated soils. Bare soils were dominated by nitrate-nitrogen concentrations and vegetated soils dominated by ammonium concentrations.
- High-resolution water table monitoring under three common riparian land covers (woods, cool season grass, corn) estimated that daily evapotranspiration rates were highest under the woods land cover.
- In 2005, 24 additional water table wells were installed at eight new sites in the Walnut Creek riparian zone under four different land covers types: cool season grass, warm season grass, forest and grazed pasture. Soil N and C content decreased with depth, whereas P concentrations did not vary systematically.
- Mean water table depths near the incised channel were significantly lower than wells located in the floodplain and up to 35% less groundwater recharge occurred in the near-stream wells because of dry riparian soils.

For more information, please refer to one of our project publications:

Schilling et al. 2004. Water Table Fluctuations Near an Incised Stream, Walnut Creek, Iowa. Journal of Hydrology. 286:236-248.

Zhang & Schilling. 2005. Effects of land cover on evapotranspiration, soil moisture and groundwater table and recharge: field observations and assessment. Journal of Hydrology. 319:328-338

Schilling. 2007. Water table fluctuations under three riparian land covers in Iowa, USA. Hydrological Processes. 21:2415-2424.

Schilling et al. 2006. Groundwater-surface water interaction in the riparian zone of an incised channel, Walnut Creek, Iowa. Journal of Hydrology. 327:140-150.

Schilling & Kiniry. 2007. Estimation of evapotranspiration by reed canary grass using field observations and model simulations. Journal of Hydrology. 337:356-363.

Schilling & Jacobson. 2007. Nutrient concentration patterns near an incised stream: effects of floodplain lithology and land management. Biogeochemistry. 87:199-216.

Schilling et al. 2009. Vertical distribution of total carbon, nitrogen and phosphorus in riparian soils of Walnut Creek, southern Iowa (USA). Catena. 77:266-273.

Schilling et al. Water table dynamics and nitrate leaching potential in the riparian zone of an incised Midwestern stream. In preparation.

Left: Riparian zone of Walnut Creek in sedge meadow reconstruction area. Note that Walnut Creek is incised approximately 10 feet into its floodplain.

Prairie establishment success: effects of seed additions and native ungulate activities

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Objectives: Determine if low diversity in prairie plantings is due to seed limitation, lack of disturbance, or both.

Tests: Bison/elk exclosures were established within 8 plantings in the bison enclosure in early spring 2003. Exclosed 'non-grazed' plots were compared to two grazed plots within each planting (24 plots total). Seed additions in the exclosed and grazed plots were done in 2003 and to separate plots in 2004. These were compared to control plots that had no additions. Ten rare plant species were added to plots in 2003, and 25 rare species were added in 2004. Plots were clipped in 2006, and plants were sorted by species, dried, and weighed to determine species composition and diversity.

Results/Conclusions: The highest establishment from seed *ln*(biomass of added species in seed addition plots - biomass of added species in control plots) was found in grazed plots in the second seed addition experiment (Figure 1). This suggests that seed additions may not always lead to greater establishment of rare species, but when seed additions are successful, the disturbance caused by bison/elk will enhance establishment. Seed additions without disturbance had no enhancement effect (Figure 1).

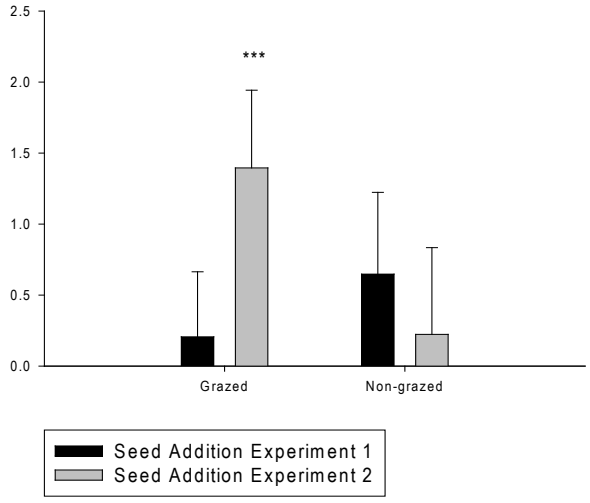

Figure 1. Left panel: Increase in rare prairie plant species with seed additions after four growing season (Experiment 1) and three growing seasons (Experiment 2, asterisks denote significant enhancement $P < 0.01$). Results suggest that low diversity plantings are seed limited and that grazing by bison and elk facilitate rare plant species establishment. Right panel: an example of bison disturbance.

Papers resulting from this project:

Martin, L.M., Moloney, K.A. and B.J. Wilsey. 2005. An assessment of grassland restoration success using species diversity components. *Journal of Applied Ecology* 42:327-336

Martin, L.M. and B.J. Wilsey. 2006. Assessing grassland restoration success: relative roles of seed additions and native ungulate activities. *Journal of Applied Ecology* 43:1098-1109

Interactions between large native grazers and plant communities

W. Sue Fairbanks, Barbara W. Kagima, Pete Eyheralde, Iowa State University (ISU);
Johanna Foster and Kimran Buckholz, Wartburg College, Waverly, Iowa

Diet and habitat selection by bison and elk. [Kagima and Fairbanks, ISU]

Little is known about how native grazers interact with plant communities during the reconstruction process, i.e. selection of plant communities in different stages of reconstruction, representation of exotic plant species in the diet, and the effect of abiotic features on habitat selection. We conducted a two-year (2006-07) diet and habitat selection study on reintroduced populations of elk (*Cervus elaphus*) and bison (*Bos bison*) at the Neal Smith National Wildlife Refuge near Prairie City, Iowa. This observational study included intensive surveys of native ungulate group locations throughout the summer seasons, estimation of percent cover of plant species in habitat patches, and collection of fecal samples for diet analysis. Bison and elk use of the reconstructed tallgrass prairie habitat was spatially nonrandom. Available cover, i.e. trees and reed canary grass (*Phalaris arundinacea*) patches, and farthest distance to fence influenced use of space by elk. Bison segregated into a bull group consisting of older bulls and a mixed sex/age group that included cows, yearlings, calves, and young bulls. The bison bull group appeared to avoid recently burned areas and selected for areas with a high grass:forb ratio and west-facing slopes. The mixed sex/age group was strongly attracted to the most recently burned patches and areas with a higher proportion of native plants. Bison diets consisted of >90% graminoids and elk used mostly forbs, >65%. Species richness of native and exotic plant species did not differ in the bison enclosure, and bison did not consume significantly different proportions of native species compared to exotic species. However, elk diets consisted of > 80% exotic species. Findings from this study illustrate the interactions of reconstruction activities and native grazers during the tallgrass prairie reconstruction process and should aid in future management and reconstruction plans.

Seed dispersal by bison during a tallgrass prairie reconstruction effort. [Eyheralde and Fairbanks, ISU]

Seed dispersal by animals, a critical process in many plant communities, is not well understood in native ecosystems, and is less so in the context of ecosystem restorations with mixtures of native and exotic plant species. Bison (*Bos bison*) may have been particularly important mechanisms for grassland seed dispersal historically, as well as today, by ingesting seeds, by seed attachment/ detachment from their fur, and by shedding winter fur in large clumps post-winter. Bison wallows may be areas of concentrated seed deposition due to fur shed while wallowing, and fecal deposition after resting near wallows. A recently developed simulation model of seed dispersal by animals provides an opportunity to produce predictive models of long-distance seed dispersal by transport in animal hair and by passage through the digestive system (Will and Tackenberg 2008). The goal of this project will be to produce predictive models of native and exotic plant seed dispersal by bison to aid in understanding, restoring, and manipulating this ecosystem process in the restoration of native plant communities.

in an ongoing tallgrass prairie reconstruction effort

Effects of bison wallowing on plant communities as a small-scale disturbance in a restored prairie. [New project initiated in June 2010, Foster and Buckholz, Wartburg College].

Bison (*Bos bison*) constantly re-engineer their environment due to their destructive wallowing behaviors where they roll in soil with such intensity that they destroy vegetation and create bare, shallow depressions. These depressions, i.e. wallows, become permanent landscape features that remain bare with continual use, or eventually become revegetated through plant succession if bison abandon them. As bison enter and leave wallows their activities likely produce gradients of destruction such that plants adjacent to wallows have higher probabilities of trampling compared to those plants occurring in distant areas away from wallows. Each bison disturbance, small-scale compared to the size of the refuge, might differentially affect the success rates of plant species' establishments adjacent to wallows compared to those away from wallows and lead to a more diverse plant community throughout the restoration.

This project will study the impact that wallowing has on plant species distributions adjacent to wallows compared to those in areas without wallows. We will compare cover of plant species at three distances: 0m, i.e. on wallows' edges, ~4m (13ft.) and then ~8m (26ft.) from the wallows' edges to simulate the impact from trampling. Non-wallow areas will be similarly measured by using a virtual wallow as the center point. Plants respond to soil quality too, so additional comparisons include: percent organic matter, pH, nitrates, and phosphates. Both the plant and soil data may help explain plant species distributions in the refuge.

This fresh flop on the right is approximately 25cm (10 in.)

This wallow is ~ 2.5m (8 ft.) wide

Grazing differences between male and female bison: is it an energetics problem? [New pilot study initiated in June 2010, Buckholz and Foster, Wartburg College]

As noted in the ISU study, bison segregate by gender and age and move in different plant patches. For example, male bison prefer to graze in older plant patches, i.e. those not recently burned. These patches contain higher amounts of biomass compared to recently-burned, i.e. younger, patches. Female bison prefer to graze in younger patches - possibly because these grasses have relatively higher protein content compared to older grasses. However, why bison segregate is only partially understood. One hypothesis originates from the different metabolic needs between females, especially pregnant females, and males. Do females and males graze in relation to different metabolic needs associated with reproduction or differences in body size? Females may need the higher protein content found in younger, recently-burned grasses whereas males need more biomass. This gender-needs hypothesis requires food analysis and sex identification to answer the questions.

The goal of this pilot project is to use the relatively safe way to measure food quality and gender by collecting fresh fecal material, using microscope techniques to identify diet, and using DNA extraction to identify gender. Since bison defecate old skin cells it is possible to extract DNA, look for the male-only SRY gene, and determine gender. By combining diet and DNA analyses we can link specific food choice with gender.

The reintroduction of a declining prairie endemic insect: A case study with *Speyeria idalia*, the Regal Fritillary butterfly

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Speyeria idalia, Regal Fritillary
photo by Ron VanNimwegen

The decline of numerous prairie endemic butterfly species in the Midwestern United States has been well documented. In most cases these declines are strongly associated with the destruction and fragmentation of their prairie habitat. One conservation strategy that can be used to compensate for both the loss of prairie and its endemic insect fauna is the reintroduction of rare butterfly species into reconstructed prairie areas. Surveys prior to the refuge establishment reported 51 species of butterflies, but no *Speyeria idalia*. The historic range of *S. idalia* extended from North Dakota south to Colorado and east to Virginia and Maine, but only two populations currently remain east of Illinois. In many of the Midwestern states such as Iowa where they are still present, *S. idalia* occurrence is local and rare. *S. idalia* seems to be restricted in its habitat requirements by the availability of its larval host plants which include a number of prairie–endemic Viola (violet) species. *Viola pedatifida* (Prairie violet) and *V. pedata* (Birdfoot violet), are the most commonly used host plants in Iowa.

Reintroducing *Speyeria idalia*

- We initiated a project to reintroduce *Speyeria idalia*, at Neal Smith National Wildlife Refuge, in 1998. We first established a total of 1,980 local ecotype individuals of S. idalia's host plant, *Viola pedatifida*, in 20 plots across the refuge.

- Gravid *S. idalia* females were moved over a two year period from two abundant source populations in Iowa to the refuge. Butterflies were introduced by placing them in mesh cages over violet plots. Our goal was to have females lay eggs on or near these violet host plants.

- Surveys for larvae and adults were conducted during the summers following reintroduction. In 2002, *S. idalia* butterflies first appeared at the refuge and have been observed each summer since that time.

- We would like to think that our reintroduction efforts were responsible for this population. However, 2002 surveys on several prairies in the vicinity of the refuge indicated that *S. idalia* were experiencing high populations. Thus, long-distance dispersal to the refuge may have also been a factor in helping to establish the refuge population. Regardless, *S. idalia* are now residents of the reconstructed prairie at Neal Smith National Wildlife Refuge.

Viola pedatifida
photo by Cheryl Groom

THE EFFECTS OF VARYING SEEDING RATES OF BOUTELOUA CURTIPENDULA AND MOWING ON NATIVE PLANT ESTABLISHMENT IN A NEW PRAIRIE RECONSTRUCTION

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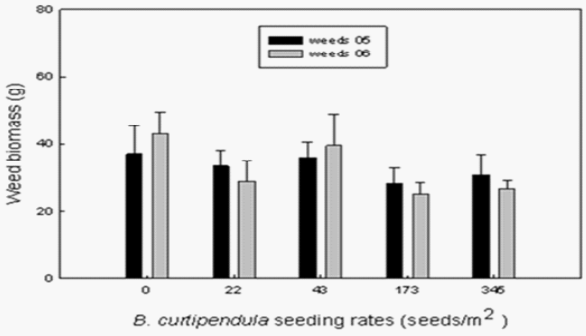
A major problem in prairie reconstruction is weed competition. Research has shown that mowing in the first year can increase establishment and survival of prairie plants. The use of nurse crops (companion crops) has been suggested as an alternative to mowing for weed suppression. The goal of this study was to examine various seeding rates of B. curtipendula, as a nurse crop in mowed and unmowed plots to determine if it suppresses weeds without reducing the establishment of seeded natives. We hypothesized that increasing the seeding rate of B curtipendula will reduce weed growth and promote an increase in native seedling numbers. In addition we hypothesized that number of the native seedlings in mowed plots with no B. curtipendula seed will be similar to unmowed plots seeded with B. curtipendula. Seeds of 25 different species of grasses and forbs were broadcast on June 18th 2005, at Neal Smith Wildlife Refuge at a seeding rate of 22 seeds/ m2. B. curtipendula was also broadcast at seeding rates of 0, 22, 43, 173, and 345 seeds/m2. The site was mowed mid-August of the first growing season and approximately every three weeks of the second growing season. Sampling was done in early September 2005 and in June and mid August 2006. Native seedling counts, biomass clippings, basal cover, and photosynthetic light were measured. Varying seeding rates of Bouteloua curtipendula had no significant effect on native species composition or weed biomass. Mowing had negative effects on native species composition, especially native grasses. Future monitoring will be done to see how the plots change over time, and observe the long term effects of early mowing on native species composition.

Weed biomass in varying *B. curtipendula* seeding rates.



Total Seedlings Sampled in 2005, 2006

	2005	June 2006	August 2006
Grasses	130	506	348
Forbs	379	1136	911
Side-oats	387	204	401

Mean plant numbers and standard errors for mow and no mow treatments sampled in September of 2005 and in August 2006.

Year- Plant Group	Mow	No-Mow	p-value
2005			
Total Natives	10.90 (2.41)	15.35 (3.15)	0.065
Grasses	1.80 (0.63)	4.75 (1.66)	0.077
Forbs	9.10 (2.1)	10.60 (1.95)	0.217
2006			
Total Natives	24.25 (2.34)	38.95 (3.94)	0.002 *
Grasses	2.85 (0.5)	14.60 (3.04)	<0.001 *
Forbs	21.40 (2.20)	24.35 (2.24)	0.172

Response of Desirable Forbs to Herbicides Applied to Control Canada Thistle (*Cirsium arvense*)

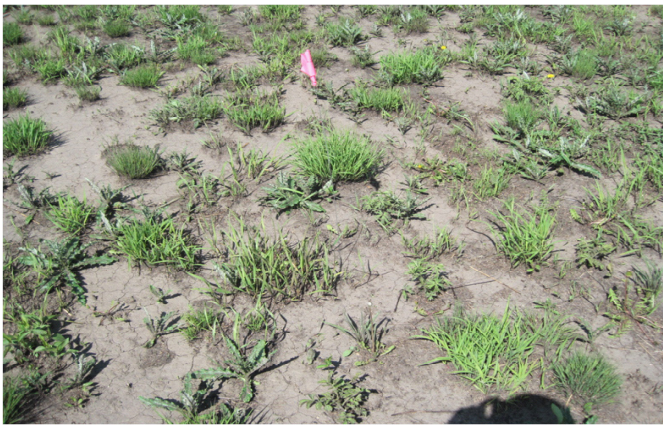
Byron Sleugh

Dow AgroSciences, LLC.

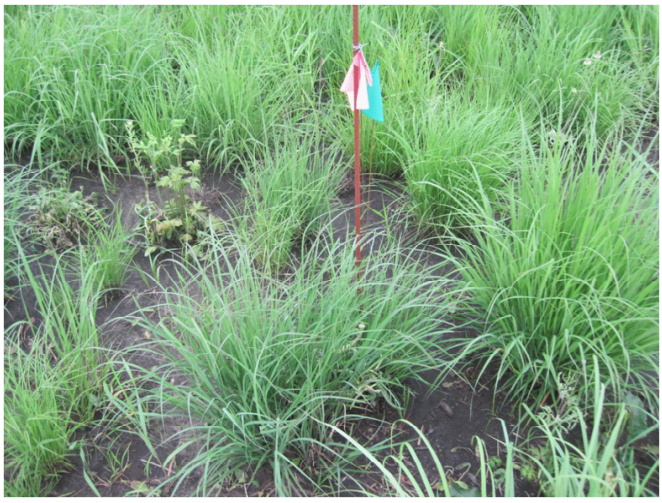
The challenge of restoring prairies or revegetating highly disturbed or cropland sites with native species is faced by many land managers across the country. This challenge is further heightened when management of noxious and invasive weeds is considered, especially when effects of those weed control activities on the desirable plant community are unknown.

Aminopyralid, the active ingredient in Milestone® and Milestone® VM herbicides, is a broadleaf herbicide that has been designated as a reduced risk pesticide by the US EPA when compared to other herbicides. As a result aminopyralid is a desirable alternative for invasive weed control on natural areas, rangeland and wildland sites. The impact of aminopyralid on desirable native forbs and shrubs is a consideration for land managers when making decisions about controlling invasive plants. Clopyralid (active ingredient in Transline® herbicide) has also been extensively used in natural areas because it shows more selectivity on a number of tree, shrub, and herbaceous species.

Research projects initiated at Neal Smith National Wildlife Refuge since 2009 have been focused on addressing revegetation with native grasses, management of noxious and invasive weeds, and evaluating methods of minimizing desirable forb injury after herbicide applications. To reducethe impact on forbs in the plantings, application timing (Spring/summer, early fall, late fall) and rates of herbicides commonly used for Canada thistle management (Milestone® and Transline®) have been evaluated.



Above: plot 15 pre-treatment (5/1/2010)
Below: plot 15 post-treatment (6/7/2010)



Treatments

- 3 fl. oz./acre Milestone®
- 5 fl. oz./acre Milestone®
- 7 fl. oz./acre Milestone®
- 16 fl. oz./acre Transline®
- 3 fl. oz./acre Milestone® + 9 fl. oz./acre Transline®
- Control (no herbicide)

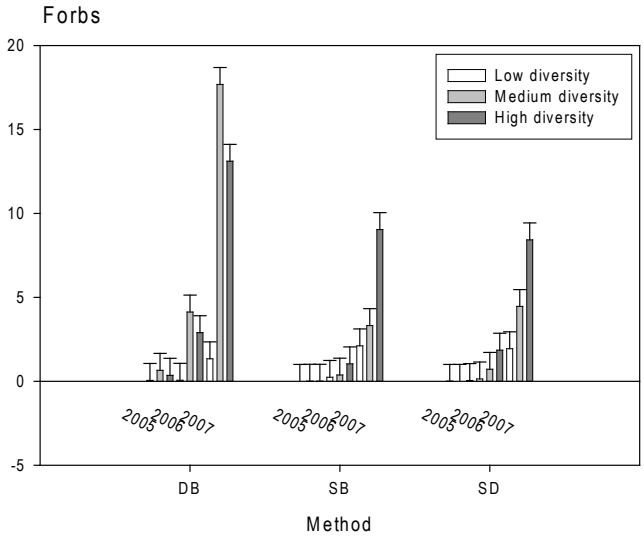
Effects of planting method and seed mix diversity on tallgrass prairie restoration success

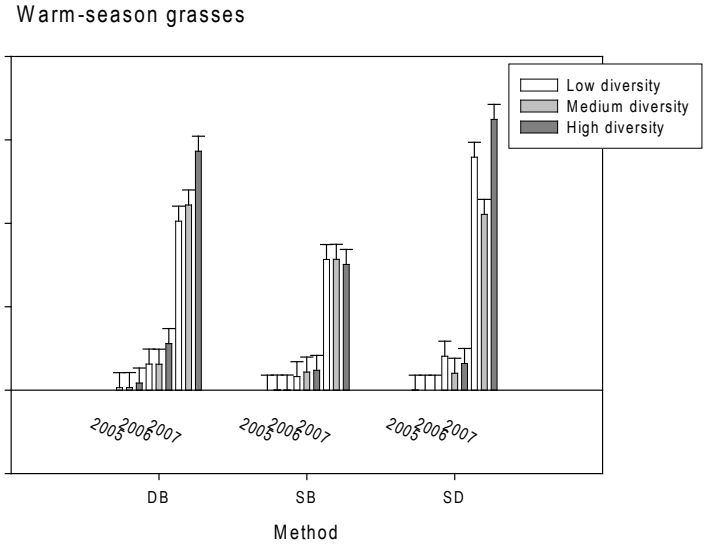
Diane L. Larson (U.S. Geological Survey, Northern Prairie Wildlife Research Center), Pauline Drobney (Neal Smith NWR), Sarah Vacek and JB Bright (Morris Wetland Management District (WMD)), Nick Palaia (Litchfield WMD) ,Doug Wells (Fergus Falls WMD), and Jennifer Larson (University of Minnesota).

The goal of this study is to determine if planting method (dormant broadcast (DB), summer broadcast (SB), or summer drill (SD)) and seed mix diversity (10, 20, or 34 species) can be optimized to both encourage establishment of native tallgrass prairie species and discourage invasion by nonnative species. Seeding occurred in 2005 and here we summarize results as of the 2007 field season. New analyses will be forthcoming.

Guild	Diversity (standardized coefficients of effects of guilds on non-planted cover)		
	Low	Med	High
Warm-season grass	-0.387	-0.311	-0.368
Cool-season grass	-0.584	-0.573	-0.505
Forb	-0.07	-0.213	-0.151

To discourage invasion, we would like to favor the guild that has the largest negative effect on non-planted cover. We used a structural equation model to partition effects of each guild and seed-mix diversity on non-planted cover. By 2007, all three guilds had negative effects, but cool-season grasses had larger effects than did the other two guilds, regardless of seed-mix diversity.





The dormant broadcast method has consistently produced the greatest forb cover of the three planting methods. By 2007, dormant broadcast plots with the medium (20-species) mix had greater forb cover than did those with the high (34-species) mix.

By 2007, cover of warm-season grasses was greatest in high-diversity seed mix, and drilling seemed to have a slight edge over the dormant broadcast. The summer broadcast had the lowest cover of warm-season grasses. Neither planting method nor diversity influenced cool-season grass cover.

Science-based Trials of Rowcrops Integrated with

A collaborative project including Iowa State University, U.S. Fish & Wildlife Service, U.S. Forest Service, USDA-Agriculture Research Service, National Laboratory for Agriculture & the Environment, the Leopold Center for Sustainable Agriculture, Iowa Department of Agriculture and Land Stewardship, USDA National Institute for Food and Agriculture, and the National Science Foundation

Project Objectives:

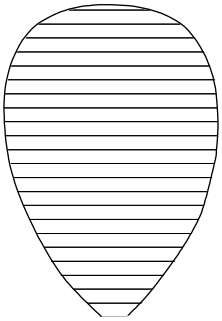
1. Quantify the influence of different proportions and landscape configurations of corn and soybean crop and diverse prairie plant communities on the storage, cycling, and output of nutrients, water, and carbon at the field and catchment scale.
2. Promote greater understanding among diverse groups of people (i.e., the public, policy makers, farmers, environmentalists, etc.) that agroecosystem production and environmental stewardship may be compatible if appropriate combinations and configurations of perennial and annual plants are established.

Hypotheses:

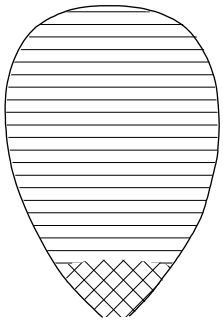
1. The placement of diverse prairie plant communities at strategic locations and of appropriate spatial extent in a watershed will produce disproportionate improvements in ecosystem functioning (e.g., water, nutrient and carbon cycling) without compromising the social and economic viability of agroecosystems.
2. Small increases in perennial plant cover in watersheds dominated by annual crops will result in disproportionately large increases in species richness and diversity of major taxa (plants, animals, insects, microbes).

Prairies at Neal Smith National Wildlife Refuge

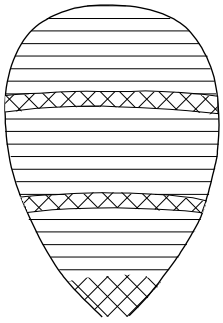
Experimental Design



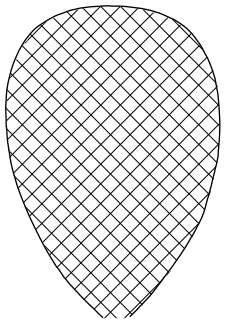
Row-Crop Agricultural System



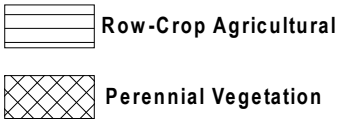
Mixed Agricultural-Perennial System with Toe Position Placement (~5-10%)



Mixed Agricultural-Perennial System with Strategic Placement (~5-10% and ~15-25%)



Complete Perennial System



Watersheds were initially brome grass, and the following treatments were established from Fall 2006 - Spring 2007:

1. Conventional Agriculture (CA): Two-year corn-soybean rotation, without tillage, and with standard herbicide- and fertilizer-based weed and nutrient management practices.
2. Mixed Annual-Perennial system (MAP): Patches and strips of perennial vegetation (native grasses and forbs) are incorporated into the conventional corn-soybean production system, using a combination of modeling and existing knowledge to predict the optimal watershed configuration.
3. Reconstructed Prairie (RP): Native grass and forb seeb (obtained from existing prairie plantings at or near Neal Smith) have been sown. Sites will be maintained by mowing for 2 years, followed by prescribed burning every 2-3 years.

We are measuring the responses of numerous variables, including:

- **Water cycling**
- **Nutrient cycling**
- **Carbon cycling**
- **Biodiversity**

For more information, visit our website at: http://www.nrem.iastate.edu/research/STRIPs/index.php

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