DNR Research Proposal: Phase II November 30, 2010

Controlling encroachment of woody vegetation in grasslands

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Justification

Historically, the dominant threat to grasslands in the U.S. was conversion to agriculture (Samson and Knopf 1994). Although agricultural conversions continue today, expansion of woody vegetation has become one of the greatest threats to grasslands (Heisler et al. 2003, Briggs et al. 2005). The majority of tree species in Minnesota grasslands are native, but they can be considered invasive species due to their detrimental effects on the plant and animal community. Trees change the very character of grassland ecosystems by shading out herbaceous plants and providing habitat for predators of grassland birds. Some bird species simply avoid grasslands with trees present (Bakker et al. 2002, Quamen 2007), whereas survival and nest success of other species is reduced (Snyder 1984, Johnson and Temple 1990).

Prior to European settlement, expansion of woody vegetation was constrained by frequent fire, droughts, and possibly browsing by large mammals (Anderson 2006). During the past 150 years, however, fire suppression and deliberate planting of trees and shrubs for windbreaks and shelterbelts have resulted in a relatively uniform distribution of woody seed sources throughout the prairie-transition zones of Minnesota. Furthermore, human and lightning-caused fires before European settlement occurred during spring, summer, and fall (Bragg 1982, Higgins 1984, McCain and Elzinga 1994), but grassland management today emphasizes spring burning. Thus, proximity to woody vegetation seed sources and season of burning have changed since European settlement.

Heisler et al. (2003) reported that expansion of woody vegetation in a tallgrass prairie of eastern Kansas was constrained by annual spring burning, but not by spring burning on a return interval ≥4 years. Spring burning acted as a pruning mechanism for aboveground shoots of woody vegetation, but post-fire increases in light and nitrogen stimulated vigorous resprouting and growth of woody vegetation (McCarron and Knapp 2003). Thus, spring fire may be required annually to constrain expansion of some woody species once established in grasslands, but spring fire alone may not be sufficient to eliminate co-dominance of woody vegetation (Heisler et al. 2003, McCarron and Knapp 2003, Briggs et al. 2005).

Carbohydrate reserves in plants vary seasonally following a cycle of depletion and restoration related to the growth cycle of the plant (Miller 2000). Mortality rates of woody vegetation can be enhanced by repeated prescribed burning during low carbohydrate periods. Hardwoods in the understory of conifer forests were effectively controlled in Minnesota (Buckman 1964), Colorado (Harrington 1989), and the Southeast (Hodgkins 1958, Waldrop and Lloyd 1991) by repeated prescribed burning during summer when carbohydrate reserves were low. In grassland environments, however, researchers have expended comparatively little effort to investigate effects of growing-season fire on woody and herbaceous plants. Svedarsky et al. (1986) reduced density of aspen (*Populus tremuloides*) suckers by 79% in a degraded prairie in Minnesota with 2 summer burns 3 years apart. Adams et al. (1982) eliminated dogwood (*Cornus drummondii*), green ash (*Fraxinus pennsylvanica*), and cottonwood (*Populus deltoides*) from an

Oklahoma grassland with a summer burn. Growing season fire controlled woody vegetation and enhanced desirable forbs in a Tennessee grassland better than dormant season fire, herbicides, or summer mowing (Gruchy et al. 2006). Howe (1995) found that summer fires in a floodplain grassland in Wisconsin delayed the progression to dominance of large, late-flowering C4 (warm season) grasses (e.g., big bluestem [*Andropogon gerardii*]) and allowed early flowering species, which virtually disappeared in spring-burned or unburned plots, to persist or even prosper. However, 2 cycles of summer fire over 3 years favored a mixture of C3 (cool season) and C4 grasses, including the aggressive C3 reed canary grass (*Phalaris arundinacea*), which was planted in the study plots (Howe 2000).

Currently, an estimated 70% of grassland management units on Minnesota Department of Natural Resources (MDNR) Wildlife Management Areas contain at least one patch of encroaching woody vegetation, despite long-term control efforts. Similar rates of woody encroachment occur on federal (e.g., U.S. Fish & Wildlife Service [USFWS]) and private (e.g., The Nature Conservancy [TNC], Conservation Reserve Program [CRP], Reinvest in Minnesota) grasslands. Opinions of grassland managers on best management practices for woody vegetation control are mixed, and some have requested help in quantitatively assessing the effectiveness of practices intended for controlling woody vegetation (Tranel 2008). The purpose of this study is to compare the effectiveness of various combinations of burning, mechanical, and herbicide treatments for reducing abundance of woody vegetation in grasslands in the prairie-transition zone of Minnesota. Ultimately, our results will help guide state and federal agencies, non-governmental organizations, and private landowners in identifying effective approaches to maintaining high quality grasslands.

Objectives

1) Measure the change in density and cover of woody vegetation in response to treatments.
2) Describe relative responses of C3 versus C4 grasses and forbs to treatments and seasonal timing of treatments.
3) Identify factors that influence the response of woody and herbaceous vegetation to treatments.

Study Sites

This study will be conducted on approximately 15 grassland sites in the prairie-transition zone of Minnesota within the Lake Agassiz Aspen Parklands, Red River Valley, North Central Glaciated Plains, and Minnesota & Northeast Iowa Morainal Ecological Sections (Minnesota Department of Natural Resources 2005). Sites include properties managed as Wildlife Management Areas, Waterfowl Production Areas, National Wildlife Refuges, TNC Preserves, and private lands (CRP lands). All sites are managed as grasslands, but contain patches of undesirable woody vegetation. Woody vegetation was typically dominated by a single taxon (green ash, aspen, box elder (*Acer negundo*), cottonwood, Siberian elm (*Ulmus pumila*), or willow (*Salix* spp.)) at each site. Because effects of treatments may vary among woody vegetation taxa, we will attempt to focus our efforts on 3-4 different dominant woody vegetation species, with site and treatment selection proceeding separately for each of these species. For each woody vegetation species, we will attempt to select 4-5 replicate study sites that are large enough to contain 4 plots (3 treatment and 1 control); have a relatively uniform distribution of vegetation types, soils, and topographies among sites and among plots within sites; and contain similar density and size class of woody vegetation among plots within sites.

Methods

Because woody plants have developed strategies to recover from periodic disturbance (Miller 2000), we will apply repeated burning, mowing, and herbicide treatments over 3 years in an attempt to deplete root reserves and ultimately kill tops and roots of woody plants on treated plots. Each study site will be divided into 3 treatment plots and 1 control plot. Treatment plots will be ≥4 ha (10 acres) in size to allow head fire in the central portion of the plot. Where 4 plots cannot be located on a single study site, we will attempt to locate plots on separate sites that appear similar with respect to vegetation type, soils, topography, and the density, size class, and distribution of the dominant woody vegetation species. We will require a minimum of 2 plots for each woody vegetation species (allowing for a comparison of 2 treatments), but will attempt to select three or more treatment plots and 1 control plot whenever possible.

This study will be conducted over 5 years (2011-2015). Pre-treatment vegetation surveys will be conducted during 2011. Three treatment combinations (Table 1) will be applied to all study sites during 2012-2014. Vegetation surveys will be conducted during each year of treatment, and post-treatment vegetation surveys will be conducted during 2015.

Table 1. Examples of burning, mowing, and herbicide treatments being considered for application during 2012-2014 to control woody vegetation on grasslands in the prairie-transition zone of Minnesota. Selection of treatment combinations that are logistically feasible and of greatest interest to managers of all study sites is not yet completed.

Treatment	2012	2013	2014
1	Spring burn	Rest	Rest
2	Spring burn	Spring burn	Spring burn
3	Spring burn, summer mow	Summer mow	Spring burn, summer mow
4	Summer mow	Summer mow	Summer mow
5	Summer burn	Summer mow	Summer burn
6	Summer mow	Summer herbicide	Summer mow

Mowing and herbicide treatments will be applied only to those portions of plots that contain woody vegetation. Because variability in quality of burns may confound effects of burn season, we will estimate fire conditions associated with each burn. On the day of a burn, we will record weather conditions (e.g., air temperature, wind speed, humidity) and estimate fuel moisture and fire intensity (Johnson 1992). The proportion of above-ground standing vegetation and litter that is consumed by fire will be estimated after each prescribed burn. We will attempt to distinguish portions of plots burned by head fires versus back fires and flank fires.

Vegetation surveys will be conducted twice annually during the growing season (late spring and late summer) during 2011-2015. Changes in density of woody vegetation will be estimated in permanent quadrats distributed systematically through patches of woody vegetation, with transects starting outside the woody vegetation patch, passing through the sparse edge and into the dense center of the patch. Elzinga et al. (1998) demonstrated that long, narrow quadrats oriented along the plant density gradient are most efficient in terms of sampling intensity to achieve a desired level of precision. This sampling design will also allow us to detect changes in the size of the woody vegetation patch. Pilot data suggest the need for variable quadrat dimensions depending on plant density and growth form (e.g., 50 m x 0.5 m quadrats for scattered cottonwood trees versus a series of 1 m x 1 m plots along a 50 m transect for dense willow shrubs).

Cover and frequency of herbaceous and woody plant species will be measured in plots located within the permanent quadrats used for woody vegetation sampling. Each transect will contain rectangular 0.1 m^2 plots distributed at 5-m intervals. During each sampling period, canopy cover of each plant species will be estimated and assigned to one of 6 cover classes (0-5%, 6-25%, 26-50%, 51-75%, 76-95%, 96-100%; Daubenmire 1959). Frequency of plant species will be estimated as the proportion of plots containing a species.

Because initial canopy cover, frequency, and density estimates will vary among sites, we will calculate change in values from 2011. When seasonal estimates differ, we will use comparisons within seasons to detect change across years. We will compare the effects of treatments on changes in vegetation canopy, frequency, and density separately for each dominant species of woody vegetation. Success of treatments in controlling woody vegetation will be apparent if we measure significant reductions in cover and density of woody vegetation compared to pre-treatment and control values.

Timeline

Nov-Dec 2010: complete selection of study areas and treatment options
May-Sep 2011: conduct pre-treatment vegetation surveys
Jan-Oct 2012: apply year 1 treatments
May-Sep 2012: conduct vegetation surveys
Jan-Oct 2013: apply year 2 treatments
May-Sep 2013: conduct vegetation surveys
Oct-Dec 2013: summarize data and report preliminary results to primary funding source
Jan-Oct 2014: apply year 3 treatments
May-Sep 2014: conduct vegetation surveys
May-Sep 2015: conduct post-treatment vegetation surveys
Oct-Dec 2015: summarize data and report comprehensive results to primary funding source
Jan-Jun 2016: complete data analysis and prepare manuscripts for publication

Estimated Budget

Funding for this project will likely come from the Pheasant Habitat Improvement Program (PHIP) and the Legislative-Citizens Commission on Minnesota Resources (LCCMR). The LCCMR has recommended that this project receive $200,000 in funding during FY12-13, although this recommendation is still subject to Legislative approval. I will request a similar level of LCCMR funding for FY14-15 to complete the second half of the study.

	FY11	FY12	FY13	FY14	FY15	FY16
Personnel						
Seasonal workers (4 FTEs)	$17,920	$35,840	$35,840	$35,840	$35,840	$17,920
Graduate student	0	0	0	30,000	30,000	15,000
Contracts						
Plant ecologist	4,500	4,500	4,500	0	0	4,500
Prescribed burns	0	14,000	14,000	14,000	14,000	0
Brush mowing	0	10,500	10,500	10,500	10,500	0
Herbicide application	0	10,500	10,500	10,500	10,500	0
Supplies						
Vegetation sampling	5,000	1,000	1,000	1,000	500	500
Burn intensity equipment	0	5,000	0	0	0	0
Travel (interns + supervisor)						
Lodging	5,530	11,060	11,060	11,060	11,060	5,530
Meals	3,000	6,000	6,000	6,000	6,000	3,000
Fleet	5,400	10,800	10,800	10,800	10,800	5,400
Miscellaneous	4,135	10,920	10,420	12,970	12,920	5,185
Total cost	$45,485	$109,200	$104,200	$129,700	$129,200	$51,850

			Potential Contributions			
DNR - PHIP	$50,000	$10,000	$10,000	$30,000	$30,000	$50,000
LCCMR FY12-13	0	100,000	100,000	0	0	0
LCCMR FY14-15	0	0	0	100,000	100,000	0
Total potential contributions	$50,000	$110,000	$110,000	$130,000	$130,000	$50,000

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