

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 and low abundance of woody vegetation. 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 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. Grassland managers requested help in finding solutions for managing woody encroachment of grasslands (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.

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 species (green ash, aspen, box elder (*Acer negundo*), cottonwood, Siberian elm (*Ulmus pumila*), or willow (*Salix* spp.)) at each site.

Methods

The response to different treatments may vary depending on the dominant woody species at each site. Further, some species may be difficult to manage with certain treatments (e.g., willows are often found in wet sites that are difficult to burn). Thus, 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. Where possible, treatment and control plots will be located side by side on the same property. Otherwise, we will attempt to select sites that appear to be similar, particularly with respect to their distribution of the dominant woody vegetation species. We will require a minimum of two similar sites 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. Treatment plots will be ≥ 4 ha (10 acres) in size to allow head fire in the central portion of the plot.

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 treatment plots. Therefore, 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. 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 m² 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.

Timeline

November-December 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 LCCMR

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

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