Tallgrass Prairie Restoration—Seeding for Success

Tallgrass prairie is one of the most imperiled ecosystems on Earth. A 2004 estimate indicated that only 2.4 percent of the original northern tallgrass prairie remained in the United States (*http://digitalcommons.unl.edu/usgssta_pub/45*). If tallgrass prairie and the species dependent on it are to survive, management must include restoration of cropland and degraded prairies, in addition to preservation of the few remaining fragments. Despite the importance of restoration and its long history (the first tallgrass prairie restoration was started in 1935 at Curtis Prairie in Wisconsin), few studies have been undertaken with the goal of refining restoration practice (Rowe, 2010). This fact sheet contains the results of one such study, started in 2005, in which we compared three seeding methods (dormant-season broadcast, growing-season broadcast, and growing-season drill) fully crossed with low (10-), medium (20-), and high (34-species) seed mixes replicated 12 times on each of 9 former agricultural fields in Minnesota and Iowa (fig. 1). Plots were 12.2 x 12.2 meters (m) and occupied about 1.6 hectares (ha) (4 acres) of each field. A "successful" restoration is one in which cover and richness of planted species is maximized and cover of exotic and invasive species, especially the noxious weed Canada thistle (*Cirsium arvense*), is minimized. Details of the planting methods can be located in Larson and others (2011).

Do Cover and Richness of Planted and Exotic Species Vary with Planting Method?

Only one species in Minnesota and five species in Iowa failed to establish [see table 1 in Larson and others (2011) for complete species list and percent establishment]. As can be seen in figure 2, broadcasting seed during the growing season was never the best strategy. In Minnesota, broadcasting during the dormant season especially was favorable for forbs and was never detrimental to other planted functional groups. In contrast, drilling seed during the growing season was the best strategy in Iowa, although planted legume cover suffered. Richness of planted species increased with the richness of the seed mix planted in all cases in Minnesota and Iowa.

Bottom line—if using a broadcast method, plant during the dormant season; if planting during the growing season, using a seed drill will produce better results.

Can We Design a Seed Mix to Target a Particular Invasive Species?

Many studies, including some in tallgrass prairies, have shown that plots with higher levels of species richness are more resistant to invasion than are plots with lower species richness (Middleton and others, 2010). The reason is that the presence of a greater number of functional groups (for example, cool-season and warm-season grasses, annual and perennial forbs, legumes) will more effectively use resources, leaving less available for invaders. In addition, it has been shown experimentally that species more functionally similar to a particular invasive species will be more likely to exclude the invader (Fargione and Tilman, 2005). For example, a species that is actively growing and taking up nutrients in the spring may compete better with an invasive species that is trying to secure nutrients at the same time; however, neither of these mechanisms has been demonstrated in an operational prairie restoration setting. We used the restoration experiment described above to do just that (Larson and others, 2013). Only the six fields in Minnesota were used for this study due to lack of Canada thistle establishment in the Iowa fields.

Having previously determined that planted species richness increased with seed mix richness, we asked if seed mix richness was negatively associated with cover of Canada thistle. There was no evidence that seed mix richness had any effect on cover of Canada thistle at our study sites. Not only was there no association with seed mix richness, Canada thistle cover was unrelated to planted species richness measured on plots in 2007 and 2010 (Larson and others, 2013).

Figure 1. Study site location in Minnesota and Iowa.

To evaluate the effects of functional similarity, species were separated into planted and nonplanted functional groups as displayed in figure 3. Species in the same family as Canada thistle (Asteraceae) were expected to be more likely to have negative effects on Canada thistle cover; however, this did not turn out to be the case, at least for the planted asters. Instead, locations that were suitable for planted asters also were suitable for Canada thistle, producing a positive association in the first year after planting. Perennial and annual/biennial asters that arose from the seedbank, however, did tend to have a negative effect on Canada thistle cover in later years (that is, a lag effect). Because of this time lag, we suspect the effects may be related to allelopathy rather than simple space-occupancy. Many of the nonplanted asters are weedy species that are invasive in their non-native range. For example, annual ragweed (*Ambrosia artemisiifolia*) has been shown to have allelopathic effects on Canada thistle in greenhouse trials (Perry and others, 2009).

Planted cool-season grasses (primarily in the genus *Elymus*, wild rye) had consistent negative associations with Canada thistle cover early in the study, but a prescribed fire at all sites in spring 2009 may have weakened these short lived grasses and allowed Canada thistle

	Dormant broadcast		Growing-season broadcast		Growing-season drill	
	Minnesota	Iowa	Minnesota	Iowa	Minnesota	Iowa
Planted species richness	↑	–	↓	–	↓	–
Total planted cover	↑	↓	↓	↓	–	↑
Planted forb cover	↑	–	↓	–	↓	–
Planted legume cover	–	↑	–	↓	–	↓
Planted cool-season grass cover	–	–	–	–	–	–
Planted warm-season grass cover	–	↓	↓	↓	↑	↑
Total exotic cover	↓	↑	↑	↑	↓	↓

Figure 2. Direction of effects of planting methods on planted species richness, total planted cover, cover of planted functional groups, and total exotic cover five years after planting. Green arrows indicate that the method produced the most favorable response of the three, red arrows indicate that the method produced the least favorable response, and blue bars intermediate or no difference in the response variable.

Functional group	Canada thistle cover in 2006	Canada thistle cover in 2007		Canada thistle cover in 2010		
	Functional group measured in 2006	Functional group measured in 2006 (lag)	Functional group measured in 2007	Functional group measured in 2006 (lag)	Functional group measured in 2007 (lag)	Functional group measured in 2010
Planted asters (same family as thistle)	+			+		
Planted non-asters forbs		–				
Planted cool-season grasses	–	–	–		+	+
Planted warm-season grasses				–	–	–
Non-planted asters (same family as thistle)	+	–		–		
Non-planted annual grasses	–/+	+		+		
Non-planted annual/biennial forbs (some in aster family)	–		–	–	–	
Non-planted legumes			–			–

Figure 3. Relationship between functional groups measured in 2006, 2007 and 2010 on cover of Canada thistle in 2006, 2007 and 2010. Note that plants growing in 2006 may have a direct effect on Canada thistle in 2006, but also a "lag" effect on thistle in 2007 and 2010 (see text). Pluses indicate a positive association, minuses a negative association; -/+ indicates that planting methods had different results. Empty cells indicate that there was no relationship between the functional group and Canada thistle cover. The yellow rows distinguish functional groups that are most similar to Canada thistle.

to encroach in 2010. Planted warm-season grasses, however, were beginning to show negative effects on Canada thistle cover in 2010. Yellow sweetclover (*Melilotus officinalis*) invaded some of the study sites and reduced Canada thistle cover in 2007 and 2010.

Bottom line—these results suggest that early, robust establishment of native species, whether they are planted or not, is important for reducing invasion by Canada thistle at the beginning of tallgrass prairie restorations. Functional group similarity, on the other hand, was not a good predictor of effect on Canada thistle cover. Seasonal death of annual grasses and weakening of cool-season grasses by a spring burn appeared to allow encroachment of Canada thistle. Therefore, management actions that reduce cover should be applied with caution when Canada thistle is a concern. Long-lived cool-season native grass species may have a more pronounced long-term suppressive effect on thistles than shorter lived species such as Canada wild rye (*Elymus canadensis*).

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