Experimental Management of Common Buckthorn on a Dry Bluff Savanna Restoration Site

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Abstract: Common buckthorn *Rhamnus cathartica* was cut and chemically treated in 2004 and 2005 during a dry bluff savanna restoration project in southeastern Minnesota, but continuing buckthorn seedling germination plagued efforts to reintroduce native shrubs, forbs, and grasses. We tested a variety of buckthorn management treatments (wood mulch, chemical application via spraying, pulling, clipping, fire) on small experimental plots to assess the efficacy of larger-scale management. Initial cutting and chemical treatment significantly reduced buckthorn seedling densities on restored (9.4 seedlings/m^2) versus non-restored (13.4 seedlings/m^2) plots after 1 year, but densities increased (to 17.3 seedlings/m^2) on restored sections after two and three growing seasons. Plots where buckthorn seedlings were pulled or clipped and mulched in the fall had lower seedling densities (<2 seedlings/m^2) in spring than control plots (~6 seedlings/m^2). However, pulling, clipping, and mulching had no suppressive effect on buckthorn seedling abundance after the summer growing season. Neither fall nor summer buckthorn treatments had a significant, negative effect on the abundance of forbs and grasses, but pulling buckthorn may pose some problems if forbs and grasses become more abundant. Annual fall cutting and spraying of buckthorn, in conjunction with annual prescribed burns (with more litter added for fuel), may be the optimal buckthorn management strategy for this savanna restoration site during the coming decade.

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Introduction

Nonnative, invasive plant species are a major problem for ecosystem restoration and management (Solecki 1997, Czarapata 2005, Clewell and Aronson 2007). Common buckthorn *Rhamnus cathartica* L. is an invasive shrub that was introduced into North America in the 1800s as an ornamental shrub, for hedgerows, and for wildlife habitat (Moriarty 1998, Czarapata 2005, Wieseler 2005). It spreads easily when birds eat its berries and carry seeds into natural areas, where it can form dense thickets, crowding and shading out native shrubs and forbs (Wieseler 2005). Within the United States, it has invaded woodlands, savannas, and prairies, and now occurs throughout New England and the upper Midwest (Czarapata 2005).

Common buckthorn now poses a serious and long-term threat to ecosystems throughout the upper Midwest (Moriarty 1998, Cochrane and Iltis 2000). Many of the biological traits of buckthorn (e.g., shade tolerance, rapid growth, prolific reproduction, high germination rates) make it a very successful invader (Knight et al. 2007). Aggressive mechanical and chemical control programs have been devised to reduce or eliminate buckthorn from many natural areas (Solecki 1997, Czarapata 2005, Knight et al. 2007), and many public agencies have undertaken large-scale control programs on their properties (Moriarty 1998). Several insects from Europe are being assessed as potential biological control agents for buckthorn in the United States (Czarapata 2005).

Restoring degraded prairies and savannas can be difficult when aggressive exotics such as buckthorn are present. The effectiveness of various management techniques can be highly variable, depending on the degree of infestation, labor and resource availability, and local conditions (Solecki 1997). The present study was designed to examine the efficacy of various techniques (pulling, clipping, burning, spraying, mulching) for controlling common buckthorn on a dry bluff savanna restoration site in southeastern Minnesota.

Study Area

Garvin Heights Park in Winona, MN (N 44° 2' 3.45", W 91° 39' 6.00") comprises 12 hectares of dry bedrock bluff prairie, dry hill oak savanna, and southern dry-mesic oak-hickory woodland. The Mississippi River overlook within the park attracts ~50,000 visitors annually. Beginning in 2001, the City of Winona, Winona State University, and the Minnesota Department of Natural Resources joined partnership for park restoration and upkeep. Since that time, >200 volunteers have assisted in restoration activities in the park (Ayers 2007).

After several decades of no management, the Garvin Heights savanna site, formerly dominated by bur oak *Quercus macrocarpa*, became overgrown with buckthorn, with mature plants, saplings, and seedlings comprising >80% of the sub-canopy and ground cover in 2003 (C.A. Jefferson, personal communication). Buckthorn was first cut on the savanna site in 2004. Cut stems were treated with the herbicides triclopyr and glyphosate, and all brush was burned on site. In late summer 2005, buckthorn seedlings and young saplings on the site were cut again, and cut stems were treated with herbicides. Spot burns of the savanna were attempted in late spring in 2007 and 2008, but their effects were minimal because of lack of fuel. Native shrubs and the seeds of savanna forbs and grasses were purchased locally and applied to the site after buckthorn was removed.

Methods

Field work

In September 2006 and 2008, densities of buckthorn seedlings and young saplings (< 1 m) were assessed in 30, randomly selected small plots

Figure 1. Buckthorn seedlings being clipped on 1 m x 2 m treatment plot in restored savanna at Garvin Heights Park, October 2006. Non-restored savanna choked by mature buckthorn can be seen in the background

Figure 2. Wood mulch being applied to a treatment plot in the restored savanna in Garvin Heights Park, November 2006.

(1 m x 2 m) on the savanna restoration site and in 30 similar plots in an adjacent, non-restored section of the savanna. All buckthorn plants were removed from plots during sampling.

During October 2006, 18 plots (1 m x 2 m) were established within the restored savanna to assess the effectiveness of various treatments on the germination and growth of buckthorn seedlings (Figure 1). Plots were separate from those used previously to assess buckthorn density. Treatments (1-control/buckthorn not disturbed, 2-all buckthorn pulled, 3-all buckthorn clipped at ground level) were applied in triplicate in a nested design, with half of the plots covered with a 10-cm thick layer of wood mulch after the treatment had been applied (Figure 2) and the other half receiving no mulch. Buckthorn, forb, and grass numbers were counted in each plot beginning in late May 2007 (late spring) and continuing on five more dates until early August 2007. On plots where buckthorn had been pulled or clipped, the same treatment was applied during each summer visit to determine the cumulative number of buckthorn seedlings emerging during the growing season. New buckthorn seedlings emerging in control plots were counted and marked, but left undisturbed throughout the summer. Forbs and grasses were counted, but otherwise left undisturbed in all plots throughout the summer.

Eight additional plots (1 m x 2 m) were established on the restored savanna in June 2007 to examine the effects of continuing treatment on buckthorn densities. Two plots served as controls and two plots each were assigned to three buckthorn treatments: pulling, clipping followed by burning with a propane torch, and clipping followed by spraying with glyphosate. New buckthorn seedlings were counted and then subjected to the specific treatment for a given plot every 2 weeks until early August.

Data analyses

Densities of buckthorn seedlings/saplings were compared between restored and non-restored savanna plots with t-tests for each year. Two-factor analysis of variance (ANOVA) tests were used to compare buckthorn seedling densities and forb and grass densities among the three treatments, with

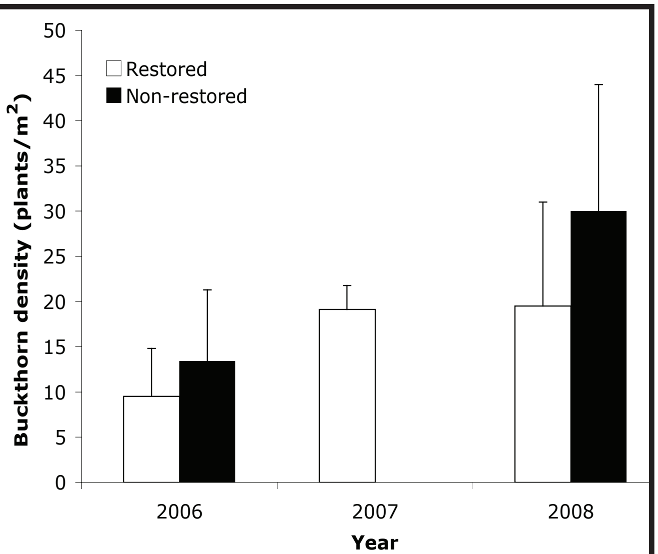

Figure 3. Densities (means ± SD) of buckthorn seedlings and/or young saplings in plots on restored and non-restored savanna in Garvin Heights Park after the 2004 savanna restoration.

Table 1. Results of 2-factor ANOVA tests assessing the effects of mulch application and fall 2006 treatments of clipping and pulling buckthorn on densities of buckthorn and forbs and grasses the following spring and summer.

Comparison/Factor	F	P
Buckthorn – spring		
Mulch	5.64	0.04
Treatment	7.31	0.03
Mulch x Treatment	1.51	0.25
Buckthorn - summer		
Mulch	0.91	0.37
Treatment	0.03	0.86
Mulch x Treatment	0.35	0.57
Forbs & grass - spring		
Mulch	0.01	0.93
Treatment	1.11	0.32
Mulch x Treatment	0.01	0.93
Forbs & grass - summer		
Mulch	1.13	0.32
Treatment	2.07	0.19
Mulch x Treatment	0.01	0.94

mulch as the cofactor. ANOVA tests were applied separately to data collected in May and data gathered from the same plots during the summer. Single-factor ANOVAs were used to compare cumulative buckthorn germinations and season-end forb and grass densities on plots subjected to summer pulling, burning, or spraying.

Results

Buckthorn on restored savanna

Two years after beginning savanna restoration and 1 year after cutting and spraying of buckthorn saplings, densities of buckthorn seedlings and regrown saplings averaged 10 plants/m^2 on the restored savanna (Figure 3), significantly lower ($t=2.28$, $P=0.03$, $df=58$) than densities on the non-restored savanna. In the absence of specific management activities on the restored savanna, buckthorn densities doubled in subsequent years, but still remained significantly lower ($t=3.10$, $P=0.003$, df-58) than densities on non-restored areas (Figure 3).

Effects of mulch and fall buckthorn treatments

Fall clipping and pulling of buckthorn, and application of mulch, had a significant, suppressive effect on spring buckthorn densities in treatment

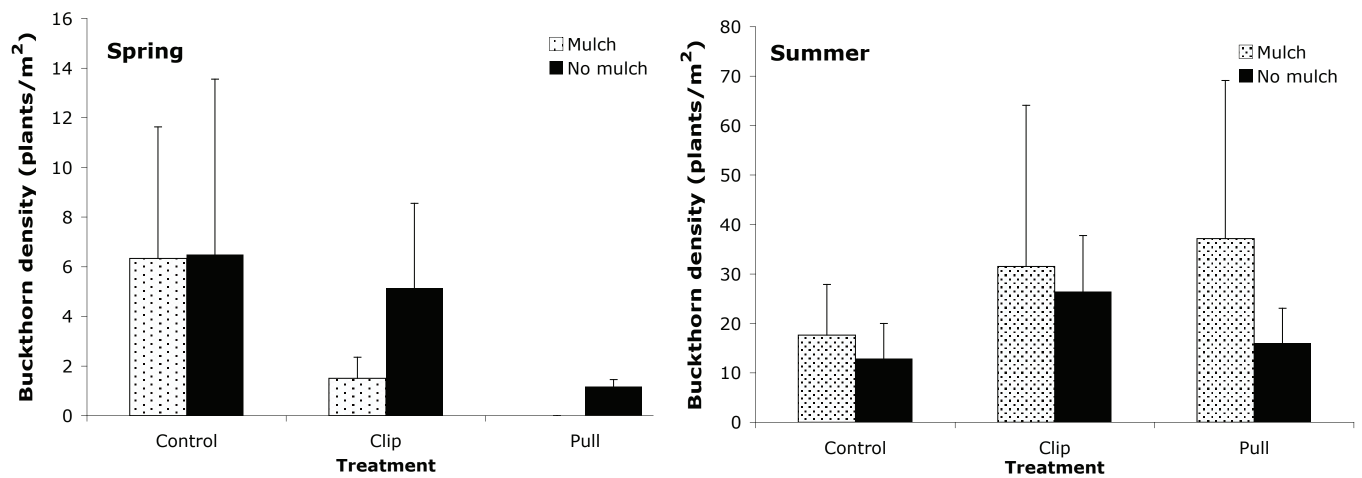

Figure 4. Densities (means ± SD) of buckthorn seedlings in experimental plots the following spring and summer after buckthorn seedlings/saplings were clipped or pulled.

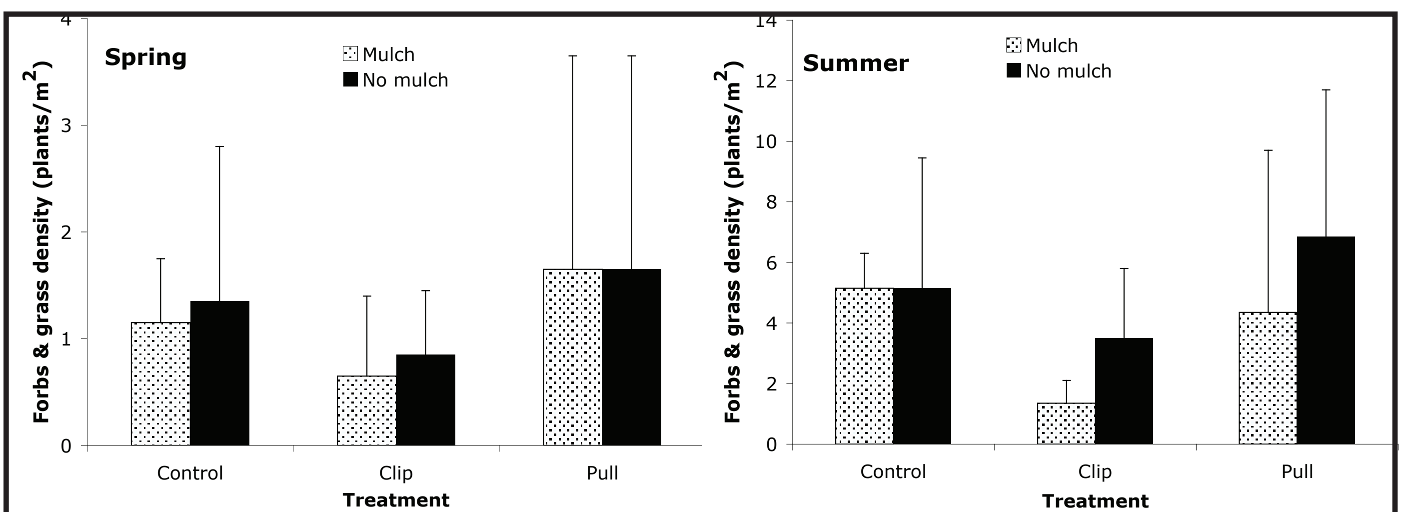

Figure 5. Densities (means ± SD) of forbs and grasses in experimental plots the following spring and summer after buckthorn seedlings/saplings were clipped or pulled.

plots (Figure 4, Table 1). Pulling was the most suppressive treatment, and in combination with mulch, completely prevented spring germination of buckthorn.

In contrast to spring results, buckthorn densities were considerably higher during summer, but were not adversely affected by either mulch or clipping/pulling (Figure 4, Table 1). Clipped or pulled plots lacking mulch had buckthorn densities similar to control plots, whereas treatment plots with mulch had higher and more variable buckthorn densities than did the control plots.

Densities of forbs and grasses in spring and summer were much lower than buckthorn densities in experimental plots (Figure 4, 5). However, unlike with buckthorn, spring densities of forbs and grasses were highly variable and not suppressed by fall mulch application or buckthorn clipping/pulling (Figure 5, Table 1). Forb/grass densities were higher in summer, but continued to display high variability and a lack of significant response to mulch or buckthorn clipping/pulling (Figure 5, Table 1).

Effects of summer buckthorn treatments

During the summer months, emergence of buckthorn seedlings appeared to be more common on experimental plots where buckthorn were burned, sprayed, or pulled regularly than on control plots where buckthorn remained undisturbed (Figure 6). However, small sample size and variability among plots prevented this trend from being significant (single-factor ANOVA F=1.21, P=0.42). Buckthorn treatments also appeared to reduce abundances of forbs and grasses relative to control plots (Figure 6), but these reductions were not significant (F=1.34, P=0.38).

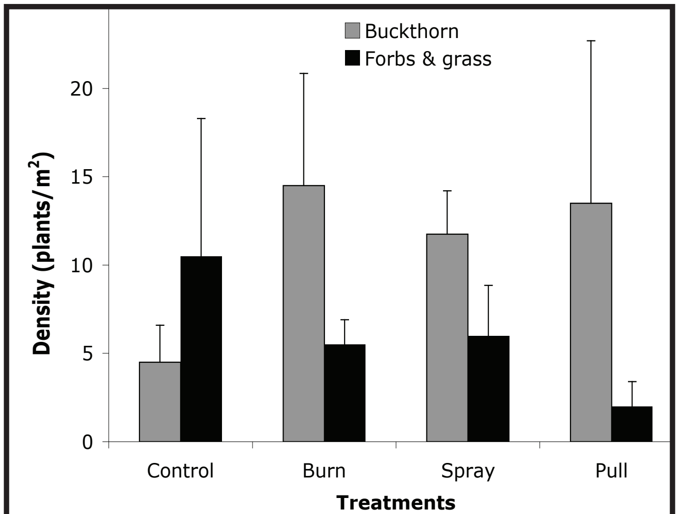

Figure 6. Effects of summer burning, spraying, and pulling buckthorn seedlings on the densities (means ± SD) of buckthorn and grasses/forbs in experimental plots at the end of summer 2007.

Discussion

Buckthorn seedlings rapidly sprouted in the restored savanna immediately after restoration and continued to pose a problem in subsequent years. Spring burns in 2007 and 2008, a recommended approach for dealing with buckthorn seedlings (Czarapata 2005, Bisikwa et al. 2006b), was largely unsuccessful, likely because this area lacked sufficient biomass to burn well (Carapata 2005). More labor-intensive burning of individual buckthorn plants with a propane torch may be required until an adequate native plant community and its associated organic matter can be established.

The traditional cutting and spraying method for controlling buckthorn seedlings and young saplings was modestly successful on this savanna site, significantly reducing seedling and young sapling densities relative to a non-restored site for 3 years. However, buckthorn densities 2 and 3 years after the 2005 cutting and spraying were high enough to greatly suppress the germination and growth of native savanna plants seeded onto this site. From this perspective, the single-year cutting and spraying of buckthorn did not achieve its goal of allowing native plants to become established.

Fall mulching of savanna plots after clipping or pulling buckthorn did little to suppress buckthorn germination or regrowth beyond the spring growing season. Although buckthorn density was initially reduced by these treatments, especially pulling and mulching in combination, this difference disappeared during the summer. A mulch layer up to 5 cm thick has been reported to reduce buckthorn seedling densities, as well as buckthorn shoot height and biomass, in field and greenhouse experiments (Bisikwa et al. 2006a). This suppression apparently results from lower soil temperatures, reduced irradiance, and moister soils produced by the litter

(Bisikwa et al. 2006, Knight et al. 2007). However, longer-term (>1 year) studies of mulch effects on buckthorn germination are lacking, and mulch layers would be susceptible to the prescribed burns also used in buckthorn management (Bisikwa et al. 2006a, b).

None of the buckthorn management techniques used in this study had a significant, negative effect on the abundance of forbs and grasses in the restored savanna. However, densities of forbs and grasses were very low (most <10 plants/m^2) and highly variable, likely the result of the poor seed bank of native plants on this site and spotty reseeding efforts, limiting our ability to detect significant effects of the treatments. It is suspected that, with greater abundance of forbs and grasses, pulling buckthorn may have a negative effect on densities of forbs and grasses (Solecki 1997, Czarapata 2005, Wieseler 2005).

Management Implications

The Garvin Heights restored savanna continues to be plagued by common buckthorn. A regular and consistent program of management needs to be undertaken at this site to bring buckthorn under control and to suppress it as the savanna gradually is restored. Annual spring burns should be continued and the small amount of litter on site should be supplemented by additional biomass (e.g., straw, waste hay, dried brush) brought in from off-site or generated by continuing restoration activities. Propane torches could be used to burn any buckthorn that escaped the spring fire. Annual fall cutting and spraying of buckthorn also should continue, to prevent any saplings from maturing and to provide more dry litter for spring burns. Once buckthorn numbers are brought down to more manageable levels, simple hand-pulling may be sufficient to maintain the savanna.

Acknowledgments

Carol Jefferson, Professor Emeritus at Winona State University, is responsible for initiating and continuing the bluff restoration project. She has worked tirelessly for many years to make this dream a reality and to rally support from public and private agencies and volunteers to keep the project on track.

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