Wet Prairie Restoration Methods Affect Species Richness and Transplant Survival

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Abstract

Urbanization and modification of landscapes has led to a decrease in native wet prairies and caused a decline in species richness due to competitive, invasive plant monotypes. We investigated site preparation and planting diversity treatments on species richness and transplant survival in a small degraded wetland in Menomonie, Wisconsin. We used three site preparations: glyphosate, sod removal, and a control; and two planting diversities: high diversity (14 spp.) and low diversity (3 spp.). Our hypotheses were that native species richness would be highest in high diversity plots with sod removal and that transplant survival would be highest in high diversity, glyphosate plots. Overall species richness was significantly higher in sod removal plots, although with many non-native species. Transplant survival was lower in glyphosate compared to sod removal plots, although this difference was not significant. There was also no significant difference in survival rates between high and low diversity plantings. Our research suggests that sod removal is more effective than glyphosate in fostering native species richness and transplant survival. It may have promoted non-native species richness however. This short-term experiment displays promising solutions for restoring wet prairies, but further research needs to be performed focusing on long-term management.
Keywords: wet prairie restoration, invasive species, site preparation, species richness

Introduction

Wet prairies are an important part of the Wisconsin landscape with many ecological functions such as controlling floods, providing wildlife habitat, and improving water quality (Mitsch & Gosselink, 2007). This valuable ecosystem is steadily declining partly because methods of restoring native wet prairies are poorly understood. Current wet prairie restoration procedures such as harvesting invasive plants, spraying herbicides, and seeding native species need to be redeveloped and new management approaches need to be investigated in order to have long-term impacts (Hall & Zedler, 2010; Healy & Zedler, 2010). The problem is that no method or combination of methods will restore all wet prairies (Fitzpatrick, 2004). Restoration techniques need to be specific to the site. The ability of wet prairies to self-restore is heavily constrained by human interference (Hall & Zedler, 2010). Dams, flood control channels, and urban run-off have changed the timing, duration, and frequency of hydroperiods in wet prairies (Leach & Zedler, 1998). By manipulating these landscapes, the common threat of non-native species invasion is encouraged (Galatowitsch & Perry, 2003). Non-native species have the ability to outcompete native wet prairie species enforcing the need for restoration efforts (Healy & Zedler, 2010).

To investigate the effects of 1) existing non-native vegetation, and 2) planting mix diversity on transplant survival, and resultant native and non-native species richness, we used a combination of six treatments. The restoration methods used in this experiment were chosen based on site characteristics, including past disturbances, existing vegetation, and soil conditions. The three site preparations consisted of glyphosate, sod removal, and control. The herbicide glyphosate was used to decrease competition with the native transplants. Sod removal was chosen because it was suspected that there was a remnant wet prairie seed bank below the existing sod. The control (no manipulation) was used as a basis of comparison and to monitor existing vegetation. The high and low planting diversities were intended to increase native species richness and to determine which native species could compete successfully within the area of study.

We investigated the effects of these different methods on native and non-native richness as well as the survival of high and low diversity transplanted native species in the Outdoor Classroom of the University of Wisconsin-Stout. Our hypotheses were 1) native species richness would be highest in high diversity plots with sod removal due to a potentially remnant seed bank and 2) transplant survival would be highest in high diversity, glyphosate treatments due to facilitative effects of dead existing vegetation on soil moisture.

Experimental Secion

In the Outdoor Classroom of the University of Wisconsin-Stout, an old field dominated by non-native plants, primarily Kentucky bluegrass *(Poa pratensis)* and Canada thistle *(Cirsium arvense)*, is being restored to a diverse wet prairie ecosystem. We used a combination of three site preparation methods and two planting diversities to begin site restoration. Site preparations consisted of Rodeo glyphosate application without thatch removal, mechanical removal of existing sod down to a depth of five centimeters, or control (no preparation). Native species planting consisted of high (14 spp.) and low (3 spp.) diversities. The chosen transplant species were from a variety of functional groups, such as grasses, sedges, rushes, and forbs, and had relatively low coefficient of conservatism ratings to ensure hardiness. Plots with low diversity were planted with plugs of *Carex stricta, Calamagrostis canadensis,* and *Scirpus cyperinus* (ten plugs each for a total of 30 plugs in each plot) while the high diversity plots had the following additional native wet prairie species (2 plugs each for a total of 28 plugs in each plot): *Eupatorium perfoliatum, Iris versicolor, Verbena hastata, Euthamia graminifola, Spartina pectinata, Asclepias incarnata, Aster puniceus, Carex stipata, Eleocharis ovata, Juncus effusus,* and *Aster novae-angliae*. The six combination wet prairie restoration treatments studied were sod removal with no planting (R), sod removal with low diversity (RL), sod removal with high diversity (RH), glyphosate with low diversity (GL), glyphosate with high diversity (GH), and control with no planting (C). Each treatment was replicated six times in randomly located 1.5 x 1.5 m plots with 1 m spacing, producing a total of 36 plots. The plots were enclosed by a deer fence to exclude herbivores and people. The plots were prepared and planted in late May of 2012. During August of 2012 over a two week period, native and non-native species richness was assessed for all plots once using overhead visual percent-cover classes (1: 0-5%, 2: 5-25%, 3: 25-50%, 4: 50-75%, 5: 75-100%). Transplant survival was also assessed once for each plot during this time by simply counting the number of surviving planted individuals for each species. Data was analyzed using analysis of variance (ANOVA) to determine the effects of different treatments on native and non-native species richness, and transplant survival using Minitab (Minitab Inc., 2010). Besides observations and comparisons with control plots, species richness was not assessed prior to manipulating the site. Multiple pair-wise comparisons were conducted using Tukey's HSD to determine which treatments were significantly different from each other.

Results

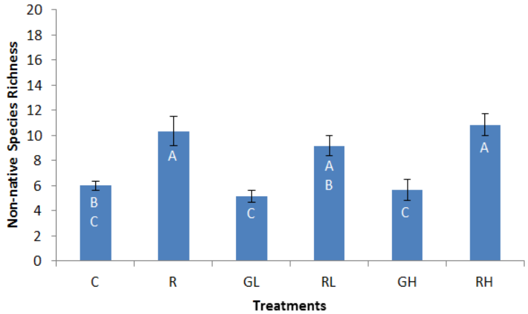
There was a significant difference in non-native species richness among treatments (one-way ANOVA, $F_{5,30} = 10.24$, $P < 0.001$, Fig. 1A), as well as native species richness among treatments (one-way ANOVA, $F_{5,30} = 23.22$, $P < 0.001$, Fig. 1B). There appeared to be more non-native species in sod removal plots and fewer in glyphosate-treated plots compared to the control. Mean native species richness tended to be highest in high diversity transplanted plots and lowest in control plots. However, this difference was not significant. Sod removal alone (R) did result in significantly higher native species richness compared to the control, although non-native species richness was also significantly higher (Fig. 1). Common native volunteers (not transplanted) which added to native species richness in sod removal plots with no planting (R) included *Verbena hastata, Aster puniceus, Stellaria longifolia*, and *Cyperus bipartitus*. Common non-native species in the sod removal (R) plots included *C. arvense, Conyza canadensis, Digitaria ischaemum, Digitaria sanguinalis*, and *Chamaesyce maculata.*

Figure 1: Non-native (A) and native (B) species richness by treatment (C=control; R=removal; GL=glyphosate, low diversity; RL=removal, low diversity; GH=glyphosate, high diversity; and RH=removal, high diversity). Treatments with different letters are significantly different from each other. Error bars are the standard error.

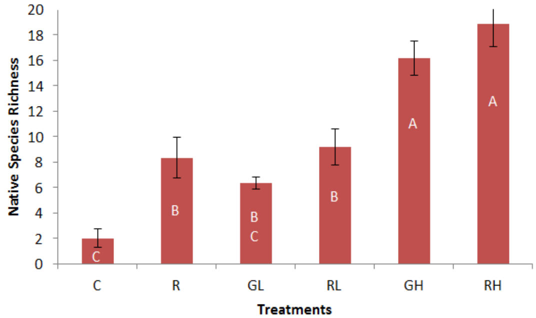
Figure 1

Figure 1

A.



B.



There was no significant effect of site preparation or plant diversities on transplant survival (two-way ANOVA, for site preparation F1,20 = 1.09, P = 0.310; for plant diversities F1,20 = 1.18, P = 0.291; and for interaction F1,20 = 0.21, P = 0.651, Fig. 2). However, low diversity plots did tend to have higher transplant survival compared to high diversity plots. Sod removal plots also had higher survival rates than glyphosate plots. Asclepias incarnata, Aster novae-angliae, Aster puniceus, Euthamia graminifolia, and Eupatorium perfoliatum all had survival rates of less than 50%.

Figure 2

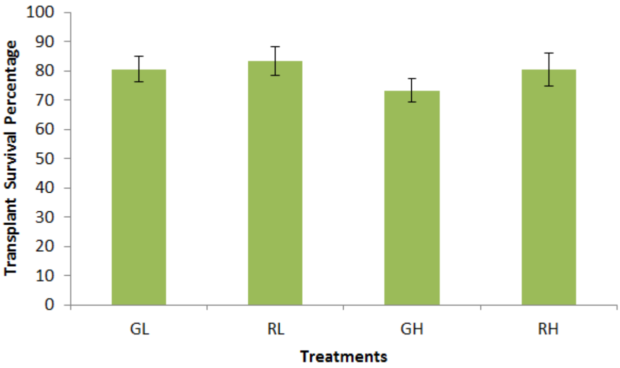


Figure 2: Transplant survival in different treatments (GL=glyphosate, low diversity; RL=removal, low diversity; GH=glyphosate, high diversity; RH=removal, high diversity). Error bars are the standard error.

Discussion

Sod removal plots, in general, had higher native species richness than the control and the glyphosate plots, suggesting that native species may be present in the soil bank, but are outcompeted by existing vegetation. By removing the existing vegetation via sod removal, less competitive native and non-native species were able to germinate and grow, resulting in significantly higher species richness. Since sod removal occurred in the early summer, the native wet prairie volunteers, such as *Verbena hastata* and *Cyperus bipartitus* most likely germinated from the seedbank.

In the glyphosate plots, there were fewer non-native species compared to sod removal and control plots. This is likely a result of the systemic low residual herbicide which killed all existing vegetation, resulting in a thick litter thatch which may have suppressed germination. The application of glyphosate in May of 2012 was effective in this experiment possibly because of the hydrology of the site. Some studies have found that spring application is not as effective as late summer or fall because there is typically standing water (Simpson, 2009;

Adams & Galatowitsch, 2006). However, since this section of the Outdoor Classroom is drained for recreational needs, the wet prairie was relatively dry when the herbicide was sprayed and was successful.

Native species richness in high diversity plots was significantly higher due to transplanting fourteen native species into these plots rather than seeding. Survival of native sedge meadow species is significantly greater for the summer transplant season compared to seeding (DeWald & Steed, 2003). Our hypothesis regarding transplant survival was refuted, both in terms of site preparation and diversity. Although not significantly different, existing vegetation (dead thatch from glyphosate) appeared to decrease transplant survival compared to sod removal. This finding suggests that there was little retention of soil moisture by dead thatch, and perhaps even an inhibiting effect. However, this was not measured. Low diversity plots planted with plugs of *Carex stricta, Calamagrostis canadensis,* and *Scirpus cyperinus* had higher transplant survival rates compared to high diversity plots, although this was not statistically significant. This is likely because these species are hardy plants. Of the fourteen species transplanted in the high diversity plots, there were certain plants that were showing signs of water deprivation due to high sun exposure upon transplant and that were more sensitive than other species, leading to lower transplant survival rates.

Conclusion

Declining native wet prairies, a result of landscape modifications and invasive plants, are in need of restoration efforts. Our research suggests that sod removal is more effective than glyphosate in fostering native species richness and transplant survival. However, it also may have promoted non-native species richness via removal of existing competing vegetation. These findings give insight to possible short-term native wet prairie restoration techniques to increase native species richness and transplant survival, but research still needs to be conducted for long-term solutions. Future research should explore using a complete factorial design including transplanting natives into plots where no site preparation occurred. In addition, monitoring the study site into the future will help determine the long-term success of the restoration methods investigated in this experiment.

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