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Species Diversity is a Good Predictor of Prairie Plant Persistence in Restorations

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Abstract
Prairie restoration projects sometimes fail because of heavy invasion by invasive weeds, especially if they are not intensively managed. Few restoration projects are sampled after the first few years post-establishment, and little is known about what predictors are significant in maintaining restored communities over the very long term. Here, we stopped weeding experimental restoration plots to determine if persistence (that is, remaining unchanged after weeds are allowed to invade) of native prairie in western Iowa was related to planted species diversity

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Introduction

Prairie restoration projects sometimes fail because of heavy invasion by invasive weeds, especially if they are not intensively managed. Few restoration projects are sampled after the first few years post-establishment, and little is known about what predictors are significant in maintaining restored communities over the very long term. Here, we stopped weeding experimental restoration plots to determine if persistence (that is, remaining unchanged after weeds are allowed to invade) of native prairie in western Iowa was related to planted species diversity.

Materials and Methods

We established 72 experimental plots with a randomized block design on three slopes in 2003 and 2004. In the experiment, we varied prairie species diversity by planting plots with four species (mixtures) or a single species (monocultures) using transplants (72 per plot). Mixture plots were planted with three levels of species evenness (low, medium, high) crossed with two levels of height dissimilarity (all tall species or having tall and short species combined). Evenness was varied by changing the level of dominance by the tall grass big bluestem *Andropogon gerardii.* All species used were also planted in monoculture. Thus, we varied functional diversity (low in all tall plots, high in plots with dissimilar height), species richness, and species evenness in the experiment. After 2005-2006, these plots were no longer weeded, and natural invasion was allowed to proceed. The prediction that we were testing is that the most diverse plots (mixtures of four species and plots with tall and short species) will persist in the face of invasion better than lower diversity plots (monocultures and mixtures with all tall species) through 2011.

Persistence was estimated with peak aboveground biomass sampled in September 2011. Biomass was sorted by species and was summed to get estimates of originally planted and invader species biomass. Measures of persistence included proportion of planted species in plots and proportion of planted species that went locally extinct by 2011, with lower extinction rates indicating higher persistence. We also estimated peak biomass as a measure of net primary productivity in 2011 to see if relationships have changed across treatments due to species invasion.

Results and Discussion

Persistence was affected by all our treatments, and relationships between diversity and productivity remained strong after allowing weed invasion. The proportion of planted species was higher in four-species mixtures than in monocultures and was higher in plots with all tall species than in plots with dissimilar heights (data not shown for brevity, $P<0.01$). Net primary productivity was higher in four species plots than monocultures (data not shown for brevity), and was linearly related to evenness in plots with all tall species (Figure 1, $P<0.01$). This mirrored the results from studies done pre-invasion, which suggests that relationships have persisted well, and that diverse plots have continued to have higher productivity even in the presence of invaders. Local extinction was greater in monocultures than in mixtures (data not shown for brevity), and was greater in plots

with tall and short species combined (dissimilar) than in plots with all tall species (Figure 2, P<0.01). Short species, especially *Bouteloua gracilis* and *Liatris punctata*, were especially prone to local extinction due to invaders.

In conclusion, we found that species diversity was important in allowing prairie plantings to persist long term. Plots with higher richness and evenness (as long as species were all tall in stature) continued to have higher productivity than less diverse plots. Invasion by weeds had the most detrimental effects on monoculture plots and plots that contained short species. This suggests that we should continue to encourage high diversity in restoration plantings. Short species were the most likely to be replaced completely by invaders and were more likely than tall species to be lost over time, consistent with studies of diversity decline in remnant prairies. Further research is needed on how to prevent short species from going extinct over time in prairie plantings.

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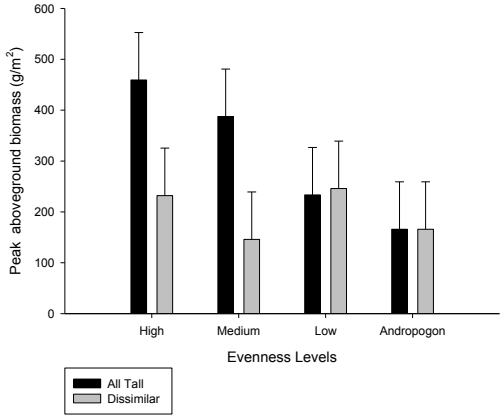

Figure 1. Productivity of four-species mixtures and big bluestem monocultures (*Andropogon*) with species with all tall species or with species with different heights. Linear relationships were significant (P<0.01) and were similar to relationships pre-invasion.

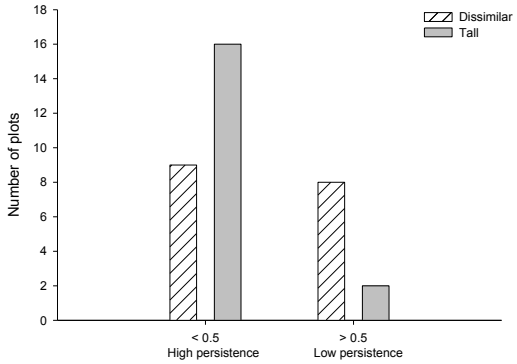

Figure 2. Number of plots in which less than (High persistence) or greater than 50 percent of species went locally extinct (Low persistence) in mixtures with all tall- and dissimilar-height species.