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Increasing Native Plant Species Richness can Increase Ecosystem Multifunctionality under Intense Livestock Grazing

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Abstract
Species rich native grasslands are frequently converted to species poor exotic pastures; however, the consequences of these land use changes for ecosystem functioning remain unclear. Specifically, it is unclear whether: 1) intense livestock grazing will have similar effects in native and exotic ecosystems, and 2) pasture productivity can be increased by increasing species richness, by changing from native to exotic species, or simply by identifying the most productive species.

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RFR-A9070

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Introduction

Species rich native grasslands are frequently converted to species poor exotic pastures; however, the consequences of these land use changes for ecosystem functioning remain unclear. Specifically, it is unclear whether: 1) intense livestock grazing will have similar effects in native and exotic ecosystems, and 2) pasture productivity can be increased by increasing species richness, by changing from native to exotic species, or simply by identifying the most productive species.

First, we hypothesized that intense grazing would decrease aboveground ecosystem functioning (i.e., aboveground productivity, light interception, and resistance to weed invasion) more in native than in exotic plots, due to greater resistance to consumption and resilience after grazing by exotic species. Second, we hypothesized that intense grazing would decrease belowground ecosystem functioning (i.e., fine root biomass and nitrogen uptake) more in exotic than in native plots, due to greater resilience after grazing by exotic species. Third, we tested whether species richness enhanced ecosystem functioning similarly in native and exotic plots that were either ungrazed or intensely grazed by cattle.

Materials and Methods

We experimentally manipulated livestock grazing (with or without intense cattle grazing), plant species origin (native or exotic), and species composition in four-species mixtures and monocultures. Seedlings were grown in a greenhouse and transplanted into 1 m^2 plots during spring 2007. The plots were established during 2007, and the intense grazing treatment was applied during 2008. Ecosystem functions were measured during 2008, after the intense grazing treatment was applied. We used general linear models to test our hypotheses.

Results and Discussion

Consistent with our first hypothesis, intense grazing decreased invasion resistance by 93% in native plots and had no affect on invasion resistance in exotic plots (Figure 1). Consistent with our second hypothesis, intense grazing decreased fine root biomass by 53% in exotic plots and had no affect on fine root biomass in native plots (Figure 1d). Contrary to our first two hypotheses, intense grazing marginally decreased aboveground productivity by 25% (Figure 1a), decreased light interception by 14% (Figure 1b), and decreased nitrogen uptake by 54% (Figure 1e), regardless of whether plant species were native or exotic. Consistent with our first two hypotheses, there was more resistance and resilience to grazing in exotic than in native plots (Figure 1f-h). The effects of intense grazing rarely depended on plant species composition, but the differences between native and exotic plots often depended on species composition.

Increasing from one to four species often enhanced ecosystem functioning similarly in ungrazed and intensely grazed native plots, but had no effect in exotic plots. Specifically, aboveground productivity was 42% greater

(Figure 1a) and light interception was 44% greater (Figure 1b) in native mixtures than in native monocultures, regardless of whether plots were ungrazed or intensely grazed. Invasion resistance was 132% greater in ungrazed native mixtures than in ungrazed native monocultures, but did not differ between the other mixtures and monocultures (Figure 1c). Ecosystem functioning was never greater in exotic mixtures than in exotic monocultures (Figure 1). Belowground ecosystem functioning did not differ between monocultures and mixtures (Figures 1d and e).

Mixtures of native species (Figure 1a) were considerably more productive than monocultures of *Bromus inermis* (mean ± s.e.m. = 116.2 and 128.7 ± 100.7 g m^{-2} yr^{-1} for ungrazed and intensely grazed smooth brome monocultures, respectively), an exotic forage species that is common near our study site. No species in our study had the greatest influence on all ecosystem functions, suggesting that multiple species are needed to promote ecosystem multifunctionality. Together these results suggest that ecosystem multifunctionality can be enhanced by increasing the number of native plant species in pastures.

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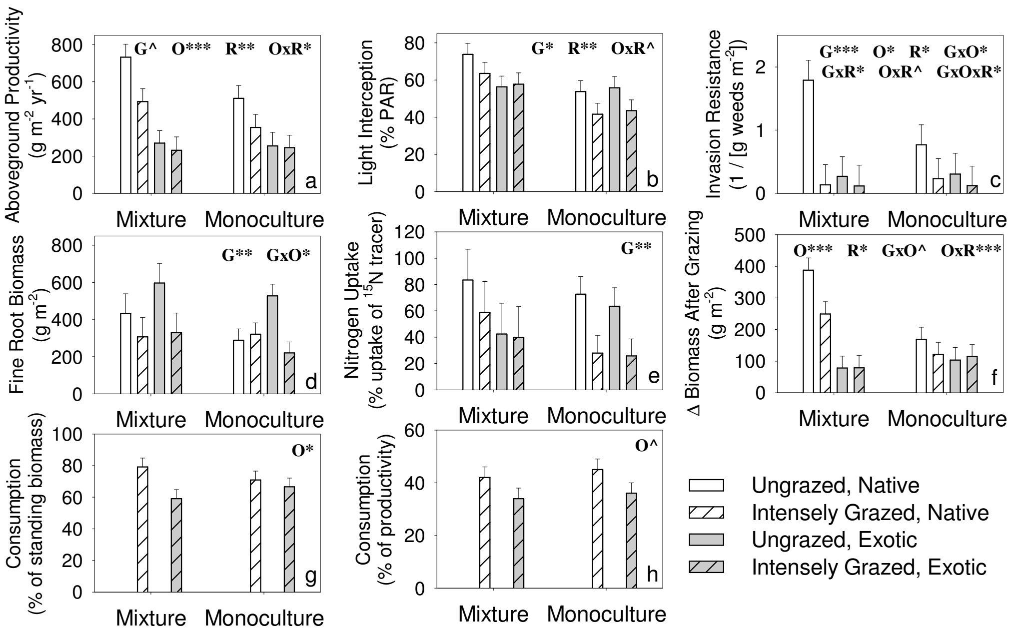

Figure 1. Ecosystem functioning in ungrazed or intensely grazed monocultures and mixtures that were planted with either native or exotic species: (a) aboveground productivity, (b) light interception, (c) resistance to weed invasion, (d) fine root biomass, (e) nitrogen uptake, (f) change in aboveground biomass after grazing, (g) percent of standing biomass consumed, and (h) percent of aboveground productivity consumed. Error bars indicate 1 s.e.m. Treatment abbreviations: G = grazing (ungrazed or intensely grazed by cattle), O = origin (native or exotic), R = richness (mixture or monoculture), ^P < 0.10, *P < 0.05, **P < 0.01, and ***P < 0.001.