Final Project Report
Elvenia J. Slosson Endowment Fund for Ornamental Horticulture

I. Project Title: Using small-scale monocultures and temporal priority to maintain rich native garden plantings (Year 2)

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I do not need my electronic images returned.
This is a final report for work performed from 2009 to 2010 for our 2009/10 Slosson award.

Introduction

A major trend in home gardening, particularly in the Western U.S., is toward low impact (xeriscape) and native plant gardens. These gardens greatly reduce dependence on precious water resources, are often more tolerant of local pests and diseases, and are far less likely to involve plants that escape and become noxious invasives. Often native plants are planted as individual species, but increasingly, home gardeners are attracted to producing more natural mixtures of native species, often attempting to produce native meadows or grasslands in their yards (see the California Native Plant Society web site at http://www.lasmmcnps.org/plantingtips.html, and the Las Postitas Nursery website at http://www.mynativeplants.com/).

Commercial native seed producers have responded to this growing demand by offering native seed mixes designed for the home garden market. The Theodore Payne Foundation offers 15 native California seed mixes, mostly for the home gardener (see http://www.theodorepayne.org/Merchant2/merchant.mvc?Screen=CTGY&Category_Code=SEED_M). Larner Seeds of Bolinas, California offers four different native garden seed mixes (see http://larnerseeds.com/). S & S Seeds of Carpinteria offers multiple wildflower and turfgrass mixes (see http://www.ssseeds.com/wildflower_mixes.html). As examples of the broader importance of this trend, The Oregon Wholesale Seed company offers seven different native seed mixes for different situations http://www.oregonwholesaleseed.com/native_seed_mix.html), and the Ohio Prairie Nursery offers over 35(!) different native seed mixes, many designed specifically for home gardens (see http://www.ohioprairienursery.com/seed_information.htm).

Despite their promise, a major problem with native seed mixes is that often a single or few more aggressive species quickly overtake the less aggressive species, producing a much less diverse planting than desired. This problem is shared with native plant restoration sites. In our experience, mixed-species plantings often become monocultures within a year or two (Lulow 2004; Young, unpublished data; J. Anderson, pers. comm.). Traditional gardening placement of individual species or separate species groupings mitigates this problem to a certain extent, but the goal in native plant mixes is usually to create a more intricate mixture of species.

We are testing two alternative planting models designed the give less aggressive species greater resistance to being quickly out-competed by more aggressive species in a mixed native planting: small-scale monocultures and temporal priority. Both of these are designed to give the less aggressive species more time to establish before coming into competition with other, more aggressive species. The results of these experiments will be of use to a wide variety of garden plantings in California and elsewhere, and to restoration plantings as well.

Temporal priority effects have been proposed as important drivers of community assembly (Young et al. 2001), but actual experimental studies are rare. We have preliminary data suggesting that giving less-aggressive species a years' growth advantage may protect them from being competitively eliminated from a planting mix (Lulow 2005), but we still lack rigorous tests of this hypothesis. Spatial priority effects have received even less attention. Several studies have explored the differences in recruitment and performance of species planted in monocultures vs. mixtures (e.g. van Auken et al. 1994), but these studies generally considered isolated monocultures rather than monoculture mosaics. Although modeling studies suggest that intraspecific aggregation should facilitate species coexistence (e.g. Hartley and Shorrocks 2002, Chesson 2000), there are few empirical studies that test these predictions (Murrell et al. 2001, Stoll and Prati 2001, Rejmanek 2002). In particular, there has been virtually no work done on the scale at which such effects operate.

Methods

Spatial priority experiment (small-scale monocultures)

This part of the project investigates (1) the impacts of spatial priority effects on community assembly dynamics and (2) the scale-dependence of these impacts. We established 25 octagonal plots in a square grid, located at one of the Plant Sciences fields along Hutchison Road. Each 5m diameter plot is separated from others by 2 m. Different treatments were assigned randomly to the 25 plots. We have chosen eight native California meadow grassland species that occur in standard seed mixes (Table 1). In the early winter, we seeded all plots with their designated grass species. Prior to sowing, each plot was cleared of all vegetation by shallow tilling and herbicide, if needed.

Twelve 'interspersed' plots were broadcast-seeded with the eight-species mixture. In the 13 remaining plots, each of the eight species was broadcast-seeded onto a one of the eight wedge-shaped sectors of the plot to create intraspecific aggregation via a series of small-scale monocultures (Figure 1). The scale of these monocultures varies from less than 0.5 m toward the center of each plot to ~2m at the periphery. All plots received the same total seed density. Within the 13 aggregated plots, we chose species arrangements that allow us to examine the impacts of various guild and aggression configurations on spatial priority. All of the individual species pairings are replicated at least three times across the 13 plots.

Table 1: Characteristics of the eight target species in the experiments

Species	Guild	Aggressiveness
Elymus glaucus	Grass	Aggressive
Leymus triticoides	Grass	Aggressive
Nassella pulchra	Grass	Non-aggressive
Melica californica	Grass	Non-aggressive
Calindrinia ciliata	Non-leguminous Forb	Non-aggressive
Grindelia camporum	Non-leguminous Forb	Aggressive
Trifolium bifidum	Leguminous Forb	Non-aggressive
Trifolium wildenovii	Leguminous Forb	Aggressive

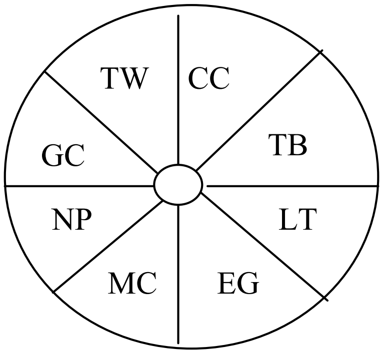


Figure 1. An example of one of the spatial priority plots, with eight monocultures corresponding to the species in Table 1.

Temporal priority

We are currently conducting three separate experiments investigating temporal priority at two different time scales with three plant guilds. The first is a short-term priority experiment investigating competition between native perennial and exotic annuals. The second experiment is focused on the effects of a year of priority between native perennial grasses and native forbs. In the third experiment we are investigating exotic annual weed control in restoration plantings.

There are 25 replicate plots for each experiment, located at one of the Plant Sciences fields along Hutchison Road. Each treatment replicate is a 1.5m x 1.5m plot, with a 1 m buffer between plots. In the early winter, we seeded all plots with their designated grass species. Prior to sowing, each plot was cleared of all vegetation by shallow tilling and herbicide, if needed.

For the short-term experiment four species of native perennial grasses were planted alone, with a mixture of annual grasses or with a mixture of annual grasses delayed by two weeks. For both of the year-delayed experiments, half of the plots were seeded with a mix of less aggressive species at the same time as the more aggressive species. In the other half, we seeded the less aggressive species in the first year, and the more aggressive species one year later. We sowed both mixes at a rate of 750 seeds/m^2, and rake them into the soil.

For all experiments, every three months we collect above-ground abundance measures on the plants. We measure cover using a ten-pin point frame, placed ten times in each plot, counting all hits by species and by plant part (living and dead). We measure plant density of dense species by counting all individuals in four 50cm x 50cm subplots in each plot, and for low-density species, the entire plots. We measure the height and basal diameters of all grasses, and the height and crown diameters of the forb species. We also count the flowers/inflorescences of each species.

Within the first year, several major trends became apparent, but we will continue monitoring the plots for at least three years

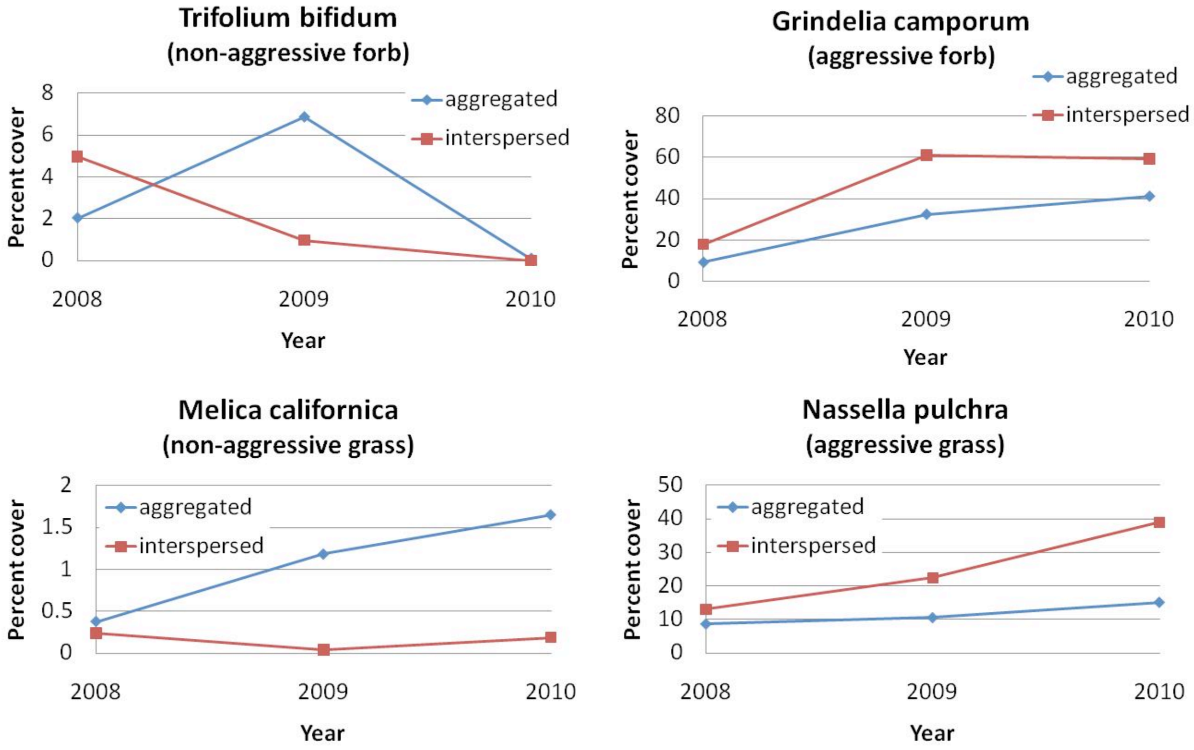
Both the spatial priority and the temporal priority experiments have been implemented. For the spatial priority experiment, all plots have been fully established, and require only ongoing monitoring and weed control. For the temporal priority experiment, all of the first-year plantings have been carried out, and the second-year plantings have already begun. Although last year was very stressful for non-irrigated projects (due to a long mid-winter drought), both projects managed to get good establishment in their plots.

Results and Discussion

Year 1: See our 2009 final report for a summary of the first year's results, many of which continue to apply.

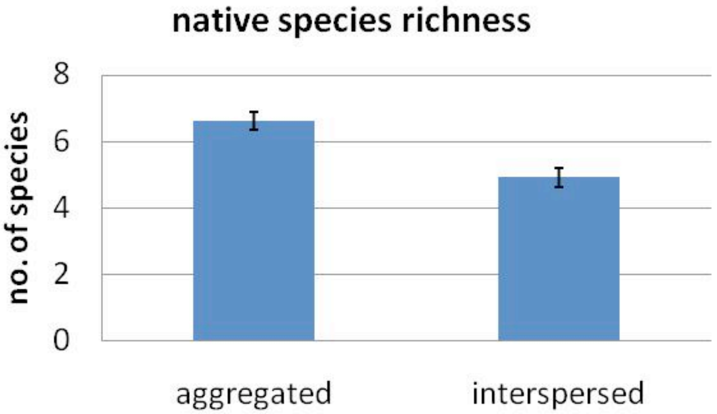
Year 2: After two years, the **spatial priority experiment** has generated some exciting results. Since planting, we have monitored plots once per year for three surveys. As predicted, species abundance and composition patterns differ dramatically between aggregated plots (in which each species was planted in a spatially separated wedge), and interspersed plots (in which all eight species were broadcast-seeded together). As predicted, aggressive species appear to do better in the interspersed plots, while non-aggressive species do better in the aggregated plots (Figure 1).

Figure 1: Mean % cover of four species in aggregated plots and interspersed plots from 2008 – 2010.



In interspersed plots, two species (*Grindelia camporum* and *Nassella pulchra*) account for 89% of total plant cover. In aggregated plots, these two species make up only 76% of total cover. Average native species richness is higher in aggregated plots than interspersed plots (Figure 2).

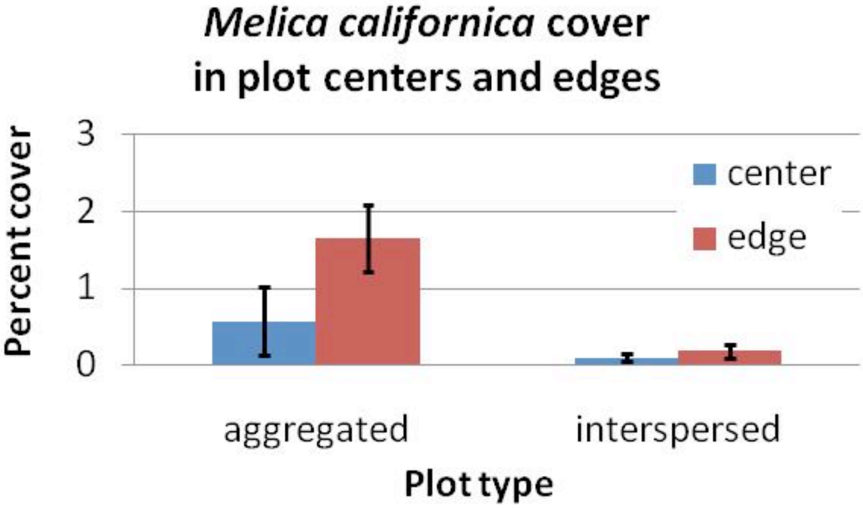
Figure 2: Average species richness of planted species in the outer edges of aggregated plots and interspersed plots in 2010. Data were obtained by sampling eight 0.25x0.25m quadrats per plot.



These data suggest that non-aggressive species have gained some protective benefit by being spatially separated from the aggressive species. Over the long term, the amount of benefit differed depending on species identity. For example, the non-aggressive forb *Trifolium bifidum* appeared to benefit from spatial segregation during 2009, but in 2010 cover values for this species were very low in both plot types. In contrast, the non-aggressive grass *Melica californica* seemed to continue to benefit from spatial segregation during 2010.

The scale of spatial separation among species also affects dominance and species persistence. For non-aggressive species in aggregated plots, cover values were highest in the outer edge of the plot, where species were more spatially separated from their neighbors (Figure 3).

Figure 3: Cover of the non-aggressive grass Melica californica *in plot centers and plot edges. In aggregated plots, the edge region experiences greater spatial separation from neighboring species than the center region.*

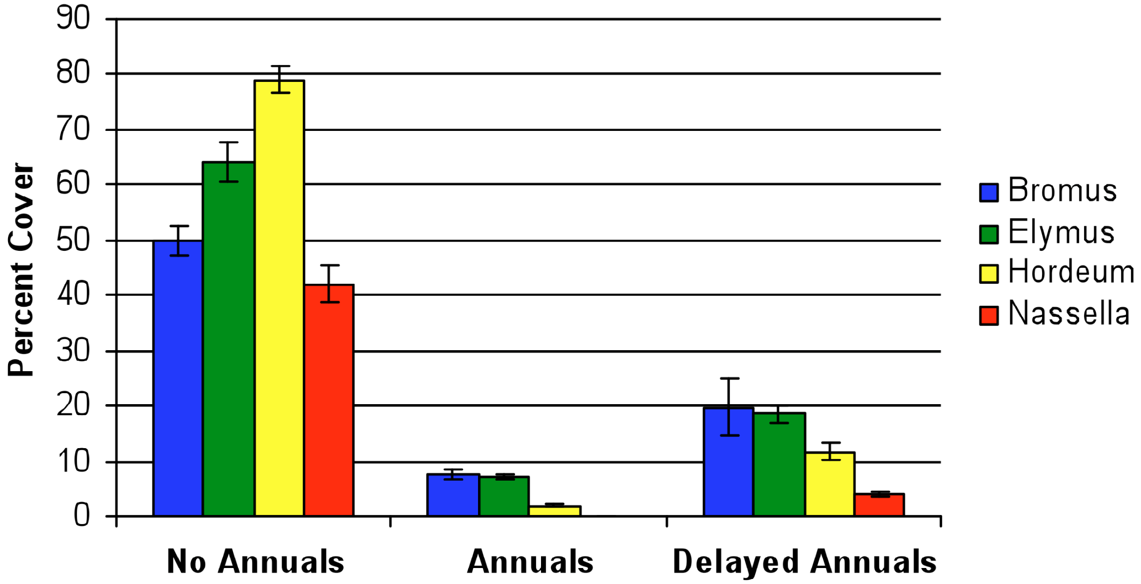


One interesting unexpected result of this experiment was the fact that patchy plantings benefited not only the planted non-aggressive species, but also weeds. Aggregated plantings were much weedier than interspersed plantings. This may be a cause for concern at weedy sites.

Overall, our findings support the hypothesis that patchy (or spatially segregated) plantings benefit non-aggressive species and overall native species diversity. Larger patches may provide more benefit than smaller patches. Unfortunately, patchy plantings can also become weedier than homogenous plantings. We are now beginning to formally analyze the data from this experiment, including patterns that result from specific species-pair combinations, and we hope to produce a peer-reviewed publication on this topic within the next year.

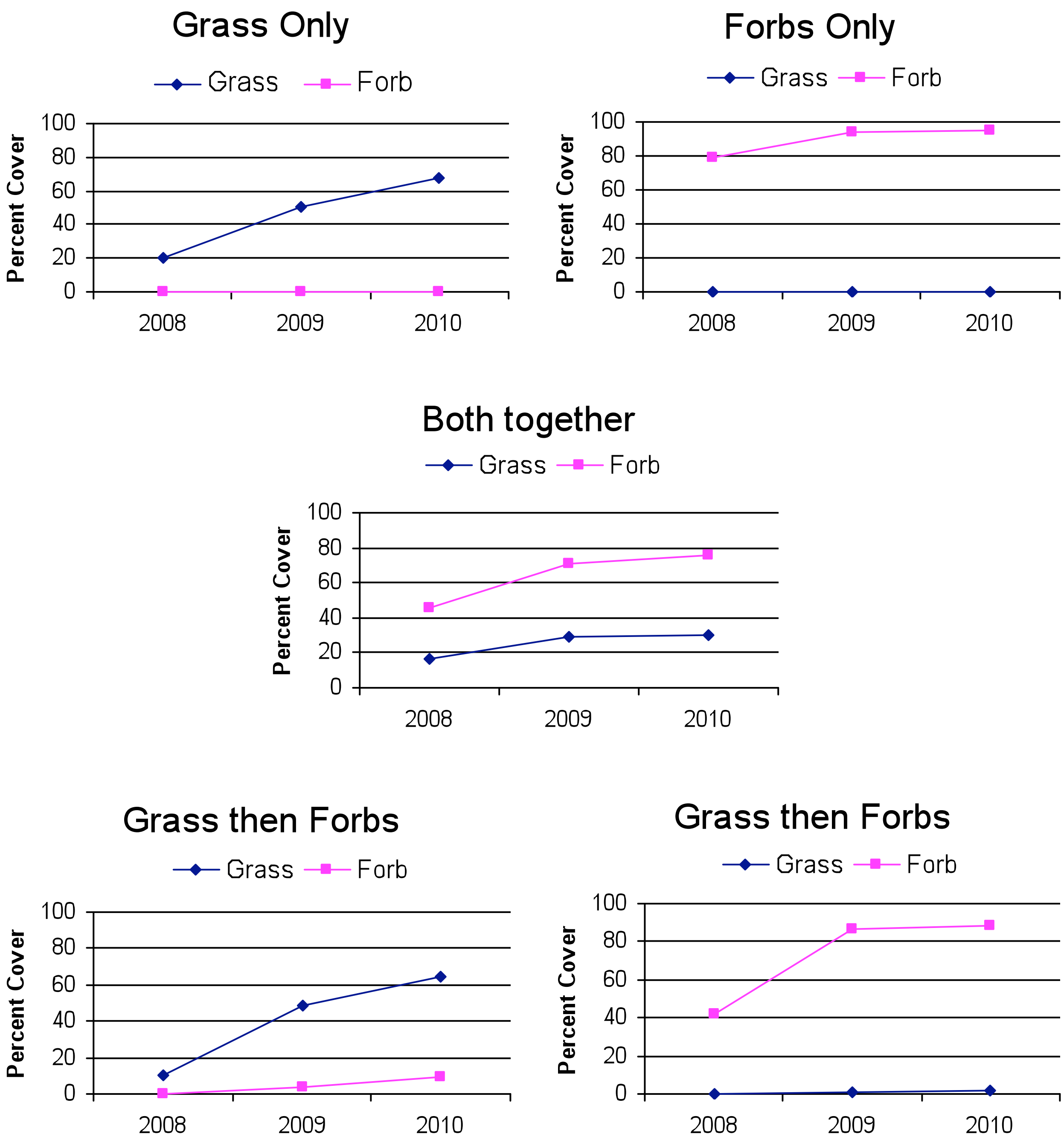
Our initial analyses of the **Temporal Priority experiments have also produced some interesting patterns.** The short-term advantages of temporal priority have shown themselves to be persistent (at least into the second year), a key requirement for this to be an effective management tool for maintaining diverse plantings. As in the previous year, the presence of annuals continued to greatly suppressed the success of perennial plantings. However, the release from this competition provided delayed planting of their competitor continued to be expressed into the second year, as several-fold increase in cover (Figure 4). Other forms of temporal priority that we are testing are providing similar patterns, which will be revealed to be persistent or not in the coming years.

Figure 4: Cover of key perennial species either planted alone, planted at the same time as competitive annuals, or planted two weeks earlier, after two years of growth.



The native perennial grass versus native forb temporal priority experiment has confirmed our predictions that a year of temporal priority gives plant guilds a strong competitive advantage for at least three years (Figure 5). Both grasses and forbs are able competitively exclude the other guild if given a single year advantage. By replicating this experiment across three years, we are currently investigating whether the relative strength of this advantage is dependent on the conditions of the planting year.

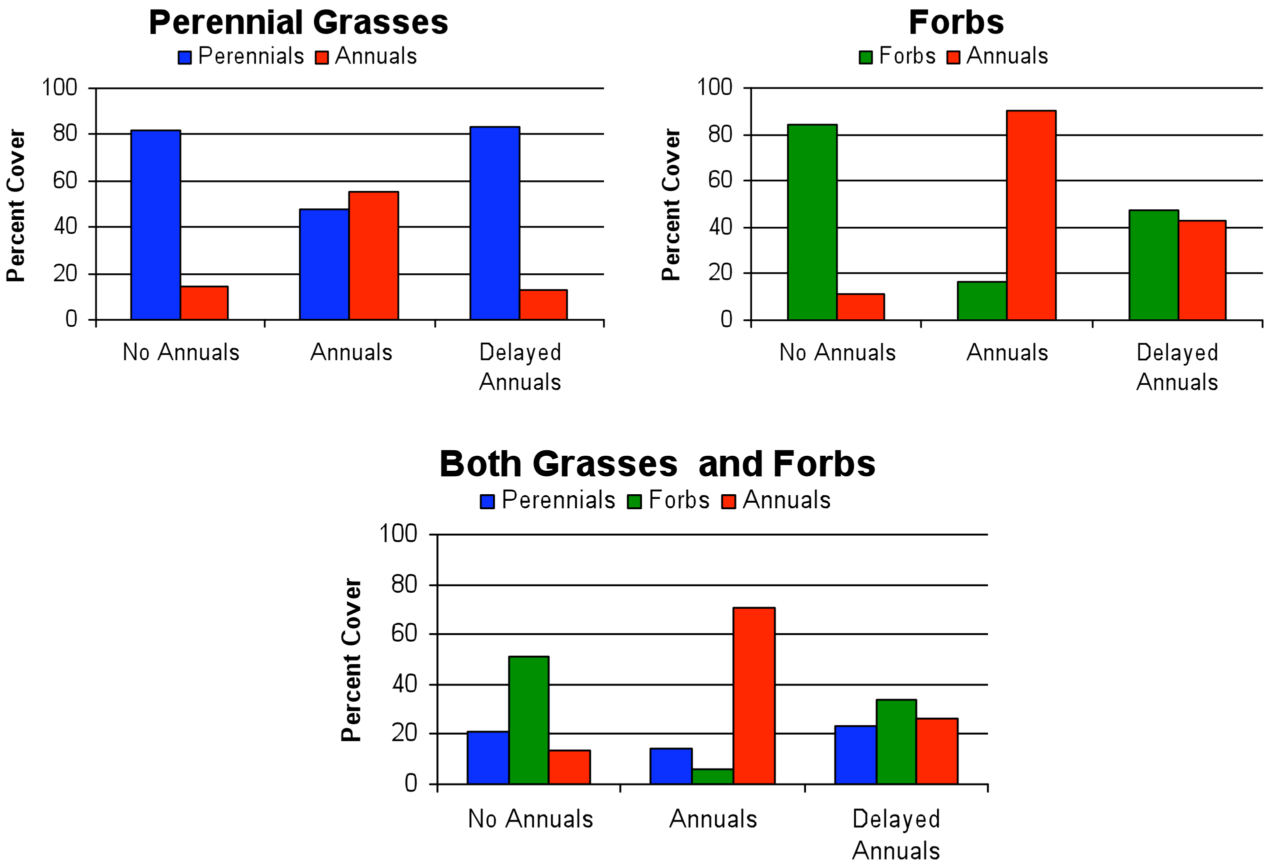
Figure 5: Cover of grasses or forbs either planted alone, planted in the same plot at the same time as each other, or planted one year earlier than the competing guild, through three years of growth.



The exotic annual grass control temporal priority experiment has verified the efficacy of weed control for grassland plantings, but has also generated some surprising results. Both native plant guilds perform better when given a year without annual grass competitors (Figure 6), but the relative strength of this advantage is guild dependent.

Our data also suggest that once established native plant cover can reduce cover of exotic annual grasses. Interestingly, perennial grasses seem to be better able to establish and compete with annual grasses than native forbs but in treatments with no or delayed annuals forbs may be strong competitors with perennial grasses.

Figure 6: Cover of native perennial grasses or forbs or both planted without annual grass competitors, with annual grasses and with annual grasses delayed by one year, through two seasons of growth.



The future:

We will continue to monitor all of the priority experiments for at least another two years, despite the fact that Slosson support is no longer available. We expect that this project will produce at least four peer-reviewed papers in the next two years, and more thereafter.

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