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 1)

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This is a final report for work performed from 2008 to 2009.

This is the "final" report for our 2008/9 Slosson award. Note that for this multi-year study, we also have a 2009/10 Slosson award, so the results presented below will be updated with time. Here we summarize progress to date.

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 'mixture' 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 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 monoculture 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	Aggressive
Grindelia camporum	Non-leguminous Forb	Non-aggressive
Trifolium bifidum	Leguminous Forb	Aggressive
Trifolium wildenovii	Leguminous Forb	Non-aggressive

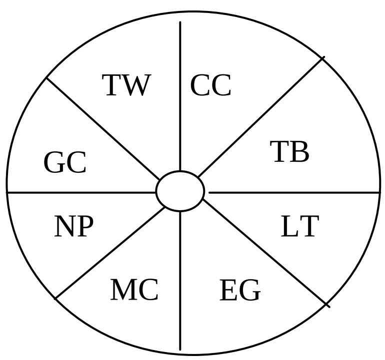


Figure 1. An example of one of the spatial priority plots, with eight monocultures corresponding to the species in Table 1.

Temporal priority

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.

In half of the plots we seeded the 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 both 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

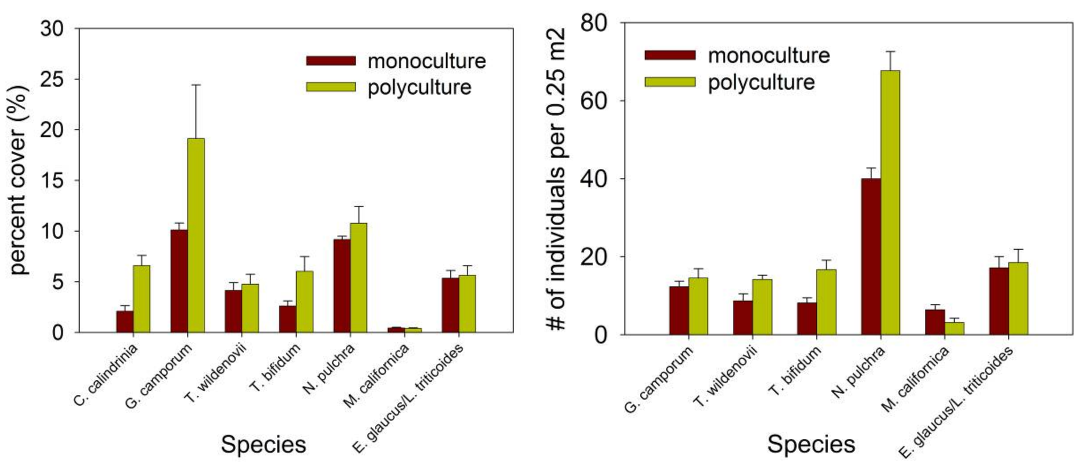
Both the spatial priority and the temporal priority experiments have been implemented. For the spatial priority experiment, all plots have been fully established, and require only ongoing monitoring and weed control. For the temporal priority experiment, all of the first-year plantings have been carried 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

The **spatial experiment** is already generating exciting results, even in the first year. Four months after planting, we monitored density and percent cover of seedlings in all plots. All of the planted species were present in all but one plot. Comparing between polyculture (species intermixed) and monoculture (species separated) plots, we observed evidence for either self-thinning in the monoculture plots or interspecific facilitation in the polyculture plots. For seven of the eight species, polyculture plots had higher percent cover and higher numbers of individuals than monoculture plots. These patterns were especially strong for the forb species (Figure 1).

As predicted, the initial positive impacts of mixing species are starting to be offset by the increased dominance of a few aggressive species. Our most recent survey, after ten months, revealed that one species (*Grindelia camporum*) is exhibiting the kind of population and community behaviors that are at the heart of our experiment. In polyculture plots, this species is increasing in percent cover and starting to dominate the planted community (Figure 2a, 3). In monoculture plots, *G. camporum* plants have begun to overhang and drop seed into adjacent sub-plots (Figure 2b).

Figure 1. Density (near plot edges) and overall percent cover of each species in monoculture and polyculture plots. *E. glaucus* and *L. triticoides* were difficult to tell apart at the seedling stage, and were therefore monitored together during the first census.

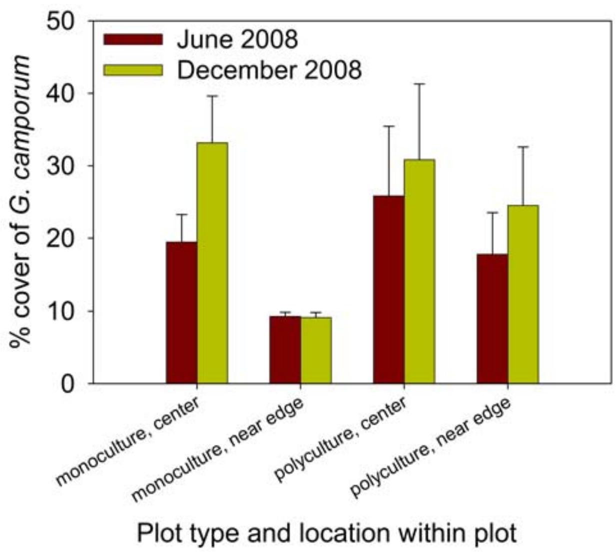


We are also finding that the scale of spatial separation among species affects the behavior of dominants like *G. camporum*. In the centers of monoculture plots (where *G. camporum* is closest to other species), its percent cover has increased substantially, but near plot edges (where *G. camporum* is farther from other species), its percent cover has not increased (Figure 3). Our most aggressive planted grass species (*Leymus triticioides*) had low establishment last winter (due to the drought), but we expect the surviving individuals of this clonally spreading species to exhibit similar patterns in the near future. The aggressive behavior of such species will allow us find out whether, and at what scale, spatial separation can improve the maintenance of long-term diversity in native plantings.

Figure 2. a) In interspersed plots, *Grindelia camporum* is beginning to dominate. B) In aggregated plots, *G. camporum* is starting to overtop its neighbors (sub-plot boundary is demarcated by the bamboo stake).

a)  b) 

Figure 3: Changes in percent cover of *G. camporum* between June and December 2008.



The priority effects in the **temporal experiment** (Figure 4) have also begun to show results. It appears that even a few weeks temporal priority is sufficient to produce a large (initial) competitive advantage. Of course, the real test will be whether this initial advantage produces long-term difference in the trajectory of community composition.

Figure 4. Left: Close-up of a one-year-old forb plot just after seeding with grasses (below) and a one-year-old grass plot just after seeding with forbs (above). Right: Overview of the larger experimental design.

Conclusion

The results of both our spatial priority experiment and out temporal priority experiment strongly suggest that both of these can be effective tools for establishing greater diversity in native plantings, and favoring some species over others (noxious species). In the subsequent year(s), we will get a better sense of how these effects parlay into long-term consequences for mixed-species plantings.

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