**_Holocarpha macradenia_ (Santa Cruz tarplant)**
**Plant community composition, seedling density, pollination, seed dispersal and plant vigor/phenology**

**Prepared for:**

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## Introduction

The following report summarizes work funded by CDFG to study various aspects of the ecology of *Holocarpha macradenia* (Santa Cruz tarplant). In 1999 – 2001, I collected data on the plant community composition, seedling density, pollination, seed dispersal and plant vigor/phenology in and around the natural populations at both the Porter Ranch and Arana Gulch.

## Community Composition

### *Introduction*

In the following experiment, I measured the plant community composition in the natural population of *Holocarpha macradenia* as well as grazed and ungrazed areas of coastal prairie near this population and in coastal prairie plots that were experimentally manipulated with grazing-associated disturbances. Comparisons between these sites may further the understanding of the species with which *Holocarpha macradenia* associates and methodologies that might be used to manipulate those associates to better resemble that where the species proliferates.

### *Methods*

-PORTER RANCH POPULATION-

In 2000 and 2001, I randomly placed 8 and 16, 0.5 _ 0.5-m grids within the population of tarplant east of the drainage at the Porter Ranch. I recorded each species once at each sample point if it intersected a 1.8-mm metal pin lowered at intersections of strings that were spread across a 0.5 _ 0.5-m grid at 10 cm intervals (a total of 25 points). I summarize the composition in terms of 4 guilds of species: exotics vs. natives; annuals vs. perennials; and, forbs vs. graminoids.

-ADJACENT GRAZED VS. UNGRAZED COMMUNITY-

Also in 2000 and 2001, I sampled paired grazed and ungrazed sites in the vicinity of the natural population at the Porter Ranch, further east on top of and to the east of the nearby ridge, but where *Holocarpha macradenia* has not been recorded. I placed five 50-m line transects on each side of the fence line that excludes cattle from Hall Road. I employed the point-intercept method to quantify community composition of dominant species. At 1-m intervals, I recorded all species intercepting a 1.8-mm diameter pin, giving a total of 250 points per site. More than one plant species often intercepted the pin, so the total number of hits was >250.

-EXPERIMENTAL POPULATIONS-

In addition, as part of a different research project, I sampled a number of plots subjected to a variety of simulated grazing regimes. I installed a 52 _ 52 m fenced cattle exclosure in fall, 1998 and initiated manipulative experiments within the exclosures in January

1999. I fenced the exclosure to exclude both cattle and feral pigs, as pigs increasingly cause disturbance in this region. At the site, I randomly allocated 30, 7 _ 7 m plots to 10 treatments (Table 2) with three replicates of each treatment. A 1-m buffer separated the plots and there was a 2-m buffer around the edge of the exclosure; I mowed the buffers once every other month during the growing season during all years of the experiments.

For the vegetation clipping treatments, I used a motorized rotary trimmer to clip all vegetation to approximately 5 cm in height. The three vegetation clipping regimes were: (1) minimal clipping – vegetation clipped once in the spring (April) and once in the fall (September); (2) bimonthly clipping – clipping every other month through the growing season (January, March, May); and, (3) continual clipping – vegetation clipped once monthly through the growing season (January – June). I designed these disturbance regimes to provide a gradient of disturbance frequencies and to mimic common management regimes. The first regime was designed to constitute minimal disturbance. Such a regime would be the most practical alternative if cattle were removed from an area and their disturbance replaced by energy intensive, mechanical clipping. This treatment is referred to here as the 2_/year treatment. The second regime provided an intermediate level of disturbance. It mimicked the practice of 'rotational grazing' in which cattle are intensively grazed in an area for 3 to 5 days and rotated through areas at 45 to 60 day intervals (Voison 1959; Savory 1988). In the years leading up to this experiment, landowners in the western United States increasingly practiced this method of grazing in an attempt to maximize forage production. This treatment created disturbances three times a year and is referred to as the "3_/year treatment." The final regime comprised a high level of disturbance and simulated the continual grazing that had been historically typical of cattle ranching along the coast. This treatment created disturbances six times a year and is referred to as the "6_/year treatment." Unclipped treatments are referred to as "control" plots.

In each of these treatments, I planted 25 seedlings of *Holocarpha macradenia* in 1999, 2000, and 2001. I followed the survivorship and growth of these seedlings at monthly intervals and monitored flower and seed production later in their lives. In subsequent years, I monitored recruitment of the offspring of these seedlings. In separate experiments, I monitored seed predation and germination. Full methodogy is described elsewhere (see attached Holocarpha chapter 4 diss.doc)

I recorded each species once at each sample point if it intersected a 1.8-mm metal pin lowered at intersections of strings that were spread across a 0.5 _ 0.5 grid at 10 cm intervals (a total of 25 points). From 1999 – 2002, I sampled 4 grids at permanently marked locations in each plot.

*Results*

-PORTER RANCH POPULATION-

The natural population of *Holocarpha macradenia* at the Porter Ranch in 2000 and 2001 was found in a community dominated by exotic annual grasses with substantial abundance of native annual forbs and exotic annual forbs. Native perennial grasses were not abundant and there were no native annual graminoids (Figure 1).

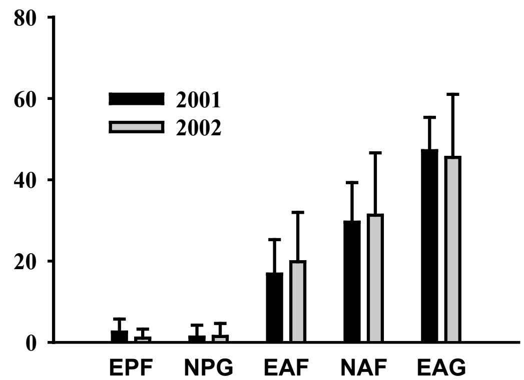


Figure 1: Community composition in the vicinity of the Santa Cruz tarplant population, Porter Ranch population.

-ADJACENT GRAZED VS. UNGRAZED COMMUNITY-

Community composition data at the grazed and ungrazed sites of the Porter Ranch reflect a dominance of exotic annual grasses, with grazing apparently favoring native perennial grasses. Other guilds are less important and less affected by grazing (Figure 2).

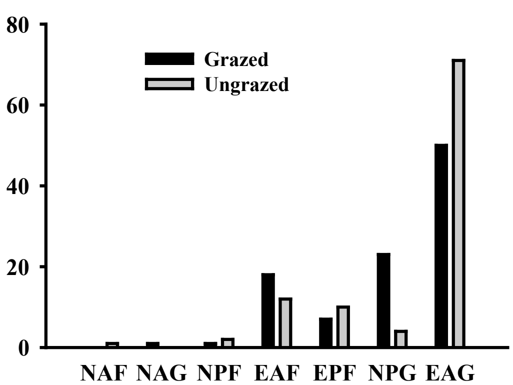


Figure 2: Community composition of grazed vs. ungrazed coastal prairie at the Porter Ranch.

-EXPERIMENTAL POPULATIONS-

More frequent clipping reduced exotic grasses (Figure 3), increased exotic forbs (Figure 4), but had no effect on native grasses (Figure 5). Native forbs were too few and patchily distributed to allow analysis of the treatments.

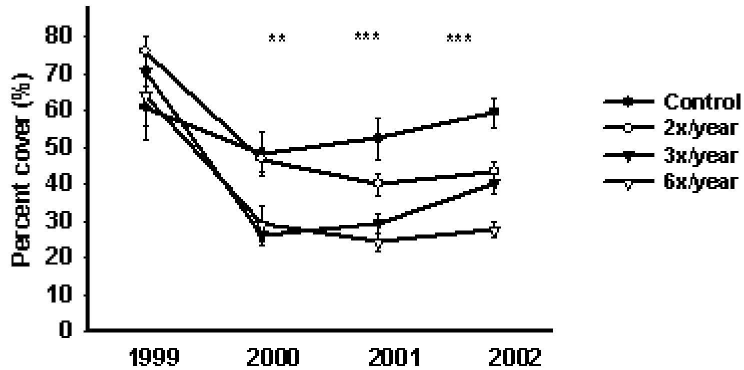


Figure 3: Relative percent cover of exotic grass cover over time. Error bars indicate 1 se; n = 3 for controls, n = 9 for other treatments. Data were analyzed using ANOVA: ** = p<0.01, *** = p<0.001.

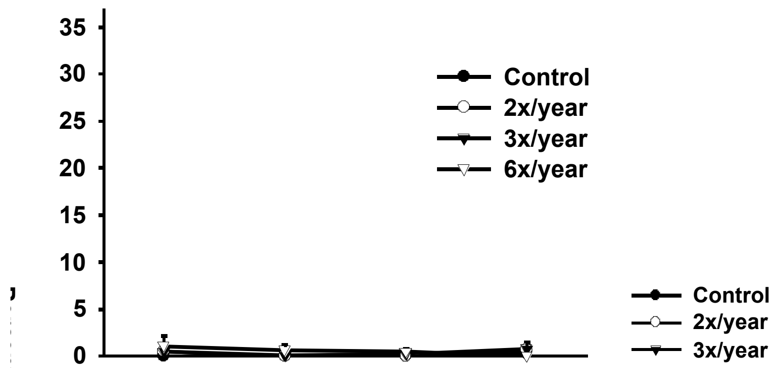


Figure 4: Relative percent cover of exotic forbs over time. Error bars indicate 1 se; n = 3 for controls, n = 9 for other treatments. Data were analyzed using ANOVA: * = p<0.05, ** = p<0.01, *** = p<0.001.

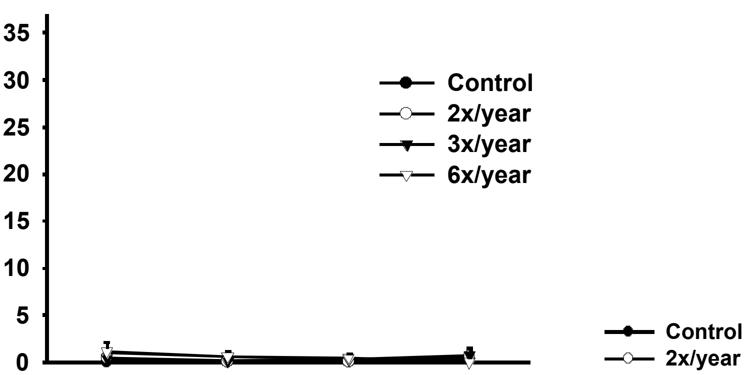

Figure 5: Relative percent cover of native grasses over time. Error bars indicate 1 se; n = 3 for controls, n = 9 for other treatments. There were no statistically significant treatment effects using ANOVA.

*Conclusions*

All three sites sampled are dominated by exotic grass species. Exotic annual forbs are also an important component at all sites. After those similarities, the three separate data sets reveal remarkable variation in community composition in this single, < 50 ha meadow. This variation might be explained by diverse topography, land use history, and unknown variables such as soil texture and chemistry, hydrology, and microclimate.

The abundance of native annual forbs within the area of *Holocarpha macradenia* is due largely to the abundance of the species itself. Topographic variation between the three areas sampled may explain some of the variation. The area sampled comparing grazed versus ungrazed coastal prairie community includes the top of a ridge as well as east-facing and level slopes. The native *Holocarpha macradenia* population is on more or less level slopes. The experimental population is on a south to southeast exposure.

Land use history may explain some of the variation. The native *Holocarpha macradenia* population area was once used as a holding pen for livestock and was probably subjected to extreme trampling and grazing that could have affected the abundance of the more vulnerable native perennial grasses, now lower in abundance than in the site with experimental *Holocarpha macradenia* populations. There could be an issue with competition between native perennial grasses and *Holocarpha macradenia* at the experimental site.

Further work should proceed to explain the variation in community composition to ascertain if other guilds of plants may compete or otherwise interfere with the health of *Holocarpha macradenia*. Comparative studies of vegetation composition between populations should be paired with detailed soil and site history analysis.

**Seedling density**

*Introduction*

In this study, I measured the density of seedling *Holocarpha macradenia* in the Porter Ranch population. This data allows comparison of experimental population seedling density. It also may help to understand site characteristic and/or seed rain heterogeneity.

*Methods*

In March, 1999, I randomly placed 6, 0.5 _ 0.5m grids within the confines of the *Holocarpha macradenia* populations. Each grid was divided into 16, 1-dm subplots, which were sampled for total number of *Holocarpha macradenia* seedlings.

*Results*

There was substantial variation in the density of *Holocarpha macradenia* between and within the sampled plots (Figure 6). Throughout the site, there was a mean of 9 ± 11 plants per square decimeter.

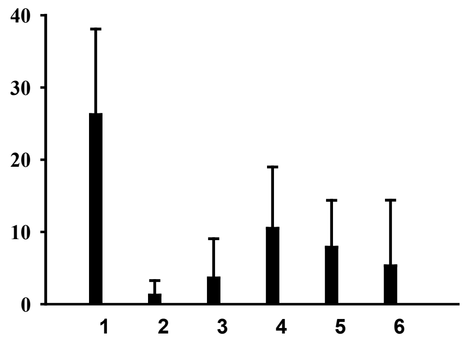


Figure 6: *Holocarpha macradenia* seedling density at the Porter Ranch site in March, 1999.

*Conclusion*

As was reflected earlier, the Porter Ranch *Holocarpha macradenia* population has considerable cover of this endangered species. However, the density of seedlings varies widely within the population despite apparent homogeneity of the topography, hydrology, and soil type. I note further that the density of seedlings found in the natural population generally is much greater than all but the most extremely dense experimental populations in certain treatments at the Porter Ranch site. Further work should consider the importance of either the micro-site variables or the prior years' seed rain in determining the density of seedlings.

**Pollination**

*Introduction*

The importance of insect pollination to *Holocarpha macradenia* is paramount as the species is known to require pollen from unrelated individuals in order to create fertile seeds. Before this work, however, there are no known studies examining pollination of the species. The following study was designed to collect preliminary data on the diversity of potential pollinators at both the Arana Gulch and Porter Ranch populations.

*Methods*

I sampled between 11 a.m. and 1 p.m. in July – August of 2001 and 2002 for pollinators at both the Arana Gulch and Porter Ranch populations of *Holocarpha macradenia*.

Sampling consisted of collecting all insects detected visiting either the flowers or the vegetative portions of plants. Insects were frozen, thawed once dead and mounted using standard entomological techniques. They are now being curated at the University of California, Santa Cruz Natural History Museum.

*Results*

A total of 20 hours were sampled at the Porter Ranch and 10 hours at Arana Gulch. At the Arana Gulch site, I collected a total of 6 different species. At the Porter Ranch site, I collected 10 species. Formal identification of the samples is being pursued through the entomology department of the California Academy of Sciences. Table 1 lists the tentative identities of samples at each site.

| Arana Gulch | Notes | Porter Ranch | Notes |
|---|---|---|---|
| | | | |
| Apidae | 2 on flowers | Anthophoridae | 1 found, on flower |
| Reduviidae | 1 on flower, small | Apidae | 1 found, on flower (same species as 1 at Arana) |
| Curculionidae | 1 on flower, small | Hemiptera | 1 species, 2 collections found both on foliage and flower |
| ANTHOPHORIDAE | 1 found, on flower, small black | Hemiptera | 1 species, 2 collections found both on foliage and flower |
| ANTHOPHORIDAE | 1 found, on flower | Hemiptera | 1 found, on flower |
| | | Orthoptera | Many, various instars on flowers and foliage |
| | | Meloidae | Many, same species various instars on flowers |
| | | Tetrigidae | Many, various instars on flowers and foliage |
| | | Plebeius acmon | On flower |
| | | Noctuidae | 2 collected, on flowers |
| | | Vespidae | On flower |

*Conclusions*

Surprising little diversity of potential pollinators were found visiting *Holocarpha macradenia* despite the apparent nectar and pollen resources offered at the otherwise resource-poor time of year that the species in is bloom. Not surprisingly, the larger, more constant tarplant population at the Porter Ranch appears to support both a greater number of potential pollinators as well as seed/herbage predators.

Further study should determine the importance and requirements of the few pollinators at each site. Actual examination of the collections should determine if pollen transfer is taking place.

**Seed dispersal**

*Introduction*

This study was designed to document the numbers of dispersing *Holocarpha macradenia* seeds and distance that those seeds disperse. Before this study no known research had examined the distance that *Holocarpha macradenia* seeds disperse. Understanding the dispersal distances might help to predict impacts of various human disturbances (i.e., paved roads). This species has no apparent mechanism for seed dispersal: seed pappus or barbs are lacking. Therefore, dispersal may be mainly affected by gravity, wind, or water. This study examined seed dispersal as would be affected by the first two of these forces.

*Methods*

On September 15, 2000, I set up 5 replicates of a seed dispersal monitoring experiment at the Porter Ranch *Holocarpha macradenia* population. Each consisted of 8, 8cm wide and 1 m long metal strips covered with a sticky solution and nailed at and between the cardinal directions surrounding a large, naturally isolated individual *Holocarpha macradenia* plant.

The strips were monitored at weekly intervals for one month. Numbers of seeds and distance from the parent plant were recorded.

*Results*

One *Holocarpha macradenia* seed was recorded dispersing from its parent plant. A disk achene was discovered 45 cm from the parent plant on the strip located to the north east.

*Conclusions*

The sample size of dispersing seeds is too small to be significant

The paucity of seeds dispersing during the dates sampled was expected. Personal observations by Grey Hayes note that most seed heads remain in tact until the advent of the first rains. Seed dispersal may be greatly facilitated by either the winds accompanying the first winter storms or by the impact of rain drops. Rare dispersal events that are unlikely to be recorded – e.g. the occasional seed swept up by unusually strong winds – may be as important to the species as events that are more likely to be recorded during the normal course of scientific experiments. If this is indeed the case, studying seed dispersal with this plant would require a different method and level of study.

**Plant Vigor/Phenology**

*Introduction*

Scientists have used plant height and longest leaf length to characterize plant health. In this experiment, I used these measures to compare with the health of our experimental populations as well as to compare phenologies between the two natural populations. For this report, I summarize the comparisons between the two natural populations.

*Methods*

On March 26, 1999, I measured the height and longest leaf length of *Holocarpha macradenia* seedlings at both the Arana Gulch and Porter Ranch populations. Plant height was measured from the soil surface to the top of the main stem. Longest leaf length was measured from where the leaf met the stem to the tip of the longest leaf on a given plant. Using SAS statistical software, I analyzed the two variables to examine the correlation between the two measurements and I compared the two populations' measurements using a two-sample t test.

*Results*

Plants were shorter at Arana Gulch (1.7cm ± 0.1) than at the Porter Ranch (3.8 cm ± 0.3) ($t$ = -7.54; $P < 0.0001$). Likewise, longest leaf length was shorter at Arana Gulch (2.0 cm ± 0.1) than at the Porter Ranch population (2.9 ± 0.2) ($t$ = -4.37; $P < 0.0001$). Leaf length was not correlated with plant height at the Arana Gulch population ($P < 0.19$) but the two variables were correlated at the Porter Ranch population ($P < 0.0094$).

*Conclusion*

The plants at the Porter Ranch population are morphologically distinct and/or phonologically dissimilar. Previous studies have indicated that the plants at Arana Gulch are genetically dissimilar from the rest of the remaining populations. The plants may have been varying due to differing climate clues. My data from the Porter Ranch from 1999 suggest that the soils there dry out well before soils at the University of California, Santa Cruz, closer to Arana Gulch. And yet, in the years that I have been observing the populations, the Arana Gulch population both flowers and sets seed earlier than the Porter Ranch population. Further studies on these variations might compare the physiologies of the various *Holocarpha macradenia* populations to ascertain if the Arana Gulch population might be experiencing inbreeding depression that may be affecting its vigor or if it is merely responding to site-specific climatic variables.