Testing methods of weed management in the restoration of Riverside County agricultural land

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Abstract

The high rate of urban development in California has put increasing pressure on open spaces to accommodate mitigation. In the case of the Quino Checkerspot butterfly (QCB), a federally endangered species, old fields in western Riverside County were used as mitigation under an agreement to restore the area from exotic grassland to native plants important to the QCB. Restoration experiments were conducted for two years in order to determine the best site-specific method. Experiments included disking plus post-disking treatments of grass-specific herbicide, mowing, or winter solarization, seeded with a mix of natives. In the second year, herbicide and mowing treatments were repeated on first year plots with new control and solarization plots. Treatments were evaluated using percent (%) cover, diversity and biomass of native and nonnative plants. Disking alone reduced nonnative grasses, but solarization was most effective in reducing nonnatives in both years. Solarization also produced the highest percent cover of natives in both years, especially those important to the QCB. Native diversity was greatest in solarization plots in the first year, but equal between first year solarization and herbicide plots in the second year. Herbicide application reduced nonnative species and increased native species over disking or mowing, but produced higher exotic forb biomass than solarization plots in the second year. Mowing reduced grass biomass and cover in both years, but did not improve native establishment over disking. Results suggest that solarization is the most effective restoration method, but that grass-specific herbicide is a useful alternative.

INTRO

Ecology has been continually inspired by observing agricultural land return to native vegetation, but until recently, most research focused on natural processes of regeneration (succession). However, when a specific habitat type is desired, active restoration is more desirable. In Southern California, historic ranch lands now constitute much of the valuable open spaces used for mitigation from urban development.

In order to meet current state and federal laws, most mitigation requires habitat restoration for specific threatened and endangered species. One such species is *Euphydryas editha quino*, or Quino checkerspot butterfly (QCB) (Photo 1), a once-common native throughout California's coastal sage scrub. This research was conducted in order to find the most effective method for reestablishing coastal sage scrub in abandoned farmland in order to increase habitat for the QCB and foster its recovery.

The site: Johnson Ranch is a preserve in the Riverside-Perris plain consisting of abandoned agricultural land and remnant Riversidian coastal sage scrub. The site was sold to Riverside County for mitigation and conservation of threatened and endangered (T&E) species under the AD 161 Multiple Species Subarea Habitat Conservation Plan (MSHCP). Johnson Ranch and other adjoining lands were established as a preserve and cooperatively managed by California Fish and Game, the Center for Natural Lands Management (CNLM), and others. The MSHCP requires that more than 500 acres of old fields be converted back to Riversidian coastal sage scrub for T&E species. Johnson Ranch is unique in that it contains one of three existing populations of the endangered Quino Checkerspot butterfly (QCB). Most of Johnson Ranch is heavily dominated by exotic annual grasses, primarily *Avena spp.* and *Bromus diandrus*. Remnant coastal sage scrub patches are composed of *Eriogonum fasciculatum* interspersed with native perennial grasses and both native and nonnative forbs, including the QCB larval foodplant *Plantago erecta* (Photo 2). The CNLM manages Johnson Ranch using a variety of methods, including mowing an annual spring burns, with the purpose of reducing the exotic seedbank.

Photo 3: Control plot background, solarization foreground.

Photo 4: Mowed plot

Photo 5: Herbicide plot. Note large exotic forbs.

Photo 6: Solarization plots, with *Layia platyglossa*

All treatment plot photos taken in April 2005 during year 1 of the restoration study.

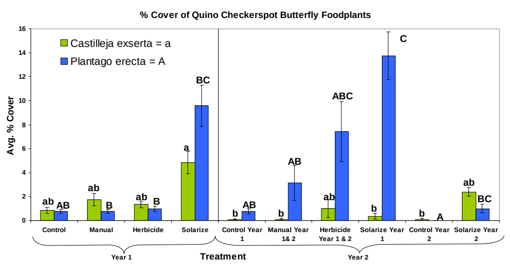

Figure 7: Response of QCB larval foodplants to different methods of weed control.

METHODS

A representative site was chosen in fall 2004. The site is level and burned annually. Early fall rains caused a flush of exotic grass germination in October, which was disced under to kill the grass, break the soil crust, and provide adequate surface soil moisture for solarization. An adjacent site was similarly disced in early Dec. 2005 for the second year treatments. First year plots were not allowed to burn in second year fires.

Experimental Design: A randomized 5-block design comparing four treatments was used: solarization, mowing, grass-specific herbicide, and a control. Each plot measured 5 m^2, with a .5 m buffer zone on each side to total 6 m^2. During the second year, the herbicide and manual treatments were repeated on first-year plots only. A new randomized block design of control and solarization plots was set up near the first-year plots at the same site. All plots were seeded with a mixture of *Eriogonum fasciculatum* and native forbs on Jan. 25, 2005; new plots were seeded with the same mixture on Feb 17, 2006. The forb mixture was designed for QCB success, including QCB larval foodplants, known nectaring sources, and dominant local native forbs (See Table 1). Seeds were obtained from S&S Seeds using various sources as nearby to Johnson Ranch as possible. Seeds were hand broadcast at ~1900 native seeds/m2 or ~25 lbs/acre.

Treatments:

- Solarization: Solarization began in Nov. 2004 by laying 6-mil black plastic over moist soil in the 6 m^2 area. Plastic was sealed to the ground by digging a 10 cm-deep trench around the sides and burying the edge of the plastic. The plastic remained in place until early January 2005 (~ 2 month duration). The second year, drier conditions delayed application of the same plastic until Jan. 3, 2006, which was removed Feb. 17 (~1.5 month duration).
- Herbicide: Fusilade® was applied using .75 fl. oz/gallon or 68 ml/ha to herbicide plots on Feb. 7, 2005. The same concentration of herbicide was applied to the first-year plots on Mar. 6, 2006.
- Mowing: Mowing was done using a handheld weed-whacker twice during the first year (Feb. 7 and Mar. 22 2005), and twice during the second year on the same first-year plots (Mar. 6 and April 17 2006). Plots were evenly mowed throughout the plot to a height of 10-20 cm.
- Control: Control plots were seeded, but no other treatments were applied.

Data Collection: Each treatment plot was subdivided into four quarters. One .5 m^2 plot was randomly chosen and marked in each quadrant on the same day the plots were seeded. Each plot was assessed for percent (%) cover by species once before herbicide and mowing treatments and once after (Apr. 25, 2005 and May 3, 2006). Biomass was also collected by functional group (native forb, nonnative forb, nonnative grass) using .25 m^2 frames in a random, non-marked area in one of the four quadrants.Ten .5 m^2 plots were also collected in the disced-only and undisced portions of the site.

Data Analysis: Data were averaged within plots, then averaged across plots within treatments. Treatment averages were compared using nested analysis of variance (ANOVA) in JMP 6.0 (SAS 2005). Tukey's Honestly Significant Difference test in JMP was used for pairwise comparisons.

RESULTS:

<u>% Cover</u>:

- *Discing* alone reduced annual grasses and increased the presence of unseeded natives in the first year of treatment, but there was no benefit from discing alone in the second year (Fig. 1).
- Seeding and discing together (*control* plots) did not increase native cover in first year plots (Figs. 1 and 2), but did increase native cover in second year plots (Fig. 2).
- *Mowing* reduced exotic plant cover only during the first year (Fig. 1), and did not significantly increase native cover over unseeded plots in either year (Figs. 1 and 2).
- *Herbicide* was effective at decreasing exotic cover over discing alone. *Herbicide* increased native cover over undisced plots, but was not significantly different from *discing* or seeded treatments in the first year (Fig.1). In the second year, however, *herbicide* application resulted in significantly greater native cover than any other treatment except *solarization* (Fig. 2).
- *Solarization* produced the highest cover of natives in both years. *Solarization* also produced the greatest percent cover of QCB foodplants, namely *Plantago erecta* and *Castilleja exserta* (Fig. 7).

<u>Diversity</u>

- Native diversity increased with increasing levels of treatment.
- *Mowing and control* were equal in their native diversity, but both *herbicide* and *solarization* had increasingly greater numbers of native species in year 1. (Fig. 3).
- In year 2, year 1 *mowing, herbicide* and *solarization* plots did not have significantly different native diversity (Fig. 4).
- *Solarization* had the highest number of native species (Figs. 3 &4).
- Although no *Eriogonum fasciculatum* were found in year 1, seedlings were relatively common in year 1 *herbicide* and *solarization* treatments during year 2 (data not shown).

<u>Biomass:</u>

- Biomass of annual grasses was dramatically reduced with soil and vegetation treatments.
- *Disced* and *control* plots had significantly less biomass than *undisced* (Figs. 5 and 6).
- *Mowing, herbicide*, and *solarization* plots produced even less annual grass biomass, although differences between the treatments were not significant (Figs. 5 and 6).
- Exotic forb biomass was significantly greater in *herbicide* plots during year 2 from year 1, and was significantly greater than year 2 *solarization* plots, but was not significantly different from year 2 *disced* or *control* plots (Fig. 6).
- Native forb biomass was greatest in *disced, herbicide*, and *solarization* plots during year 1, but *solarization* treatments had the greatest native forb biomass of all treatments during year 2 (Figs. 5 and 6).

DISCUSSION

In this study, solarization proved to be the most effective method of weed control. However, simple discing and/or mowing treatments will reduce annual grasses and may promote annual forbs. However, solarization is the only method tested that can functionally eliminate the weed seedbank from a restoration site. Eliminating the seedbank has the potential of for reducing weed control costs later, and reduces competition for planted natives, increasing the probability of restoration success. Solarization provides the benefit of a "clean slate" with which to begin a restoration project. Because it kills all seeds, not just weed seeds, it is not an appropriate method for sites where native species are still a valuable component. Because solarization requires a large amount of plastic, the initial cost is much higher than other methods. Based on results from this study, solarization would be the recommended method of weed control for restoration at Johnson Ranch. Because no native grasses are required for this site, solarization could be especially effective if combined with grass-specific herbicide application in the years following initial restoration.

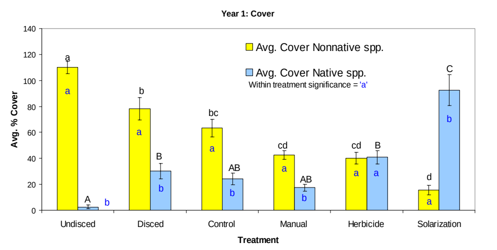

Figure 1: Differences in native and nonnative percent cover with weed control treatments, year 1.

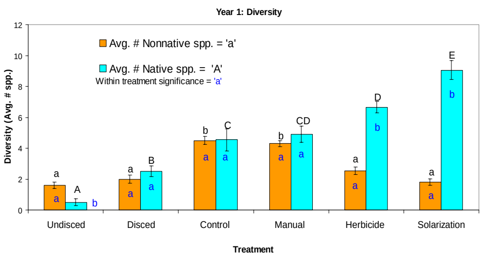

Figure 3: Differences in native and nonnative diversity with weed control treatments, year 1.

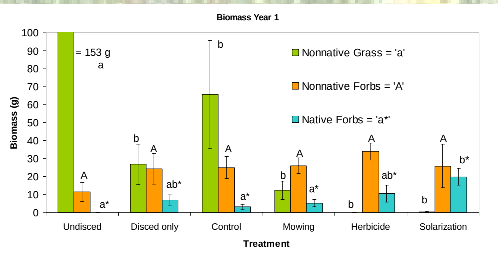

Figure 5: Differences in native and nonnative diversity with weed control treatments, year 1.

SCIENTIFIC NAME	Collection Source	lbs/acre
Amsinkia intermedia	San Bernardino	1
Antirrhinum coulterianum	Hemet	1
Calandrinia ciliata	Commercially grown	0.5
Camissonia bistorta	San Bernardino	0.25
Castilleja exserta	Northern CA	1
Cryptantha intermedia	Hemet	1
Eriogonum fasciculatum	San Bernardino	4
Hemizonia pungens	Murrieta	2
Keckiella antirrhinoides	Lake Skinner	1
Lasthenia californica	Riverside	0.5
Layia platyglossa	Hemet	1
Lessingia filaginifolia	San Bernardino	2
Nemophila menziesii	Commercially grown	2
Phacelia distans	Hemet	1.5
Plantago erecta	Moreno Valley	5
Salvia columbariae	Lake Elsinore	1
QCB larval foodplants		

Table 1: Seed mixture and rate planted at restoration site.

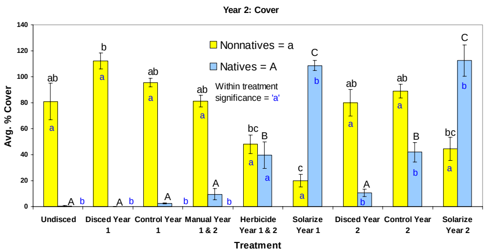

Figure 2: Differences in native and nonnative percent cover with weed control treatments, year 2.

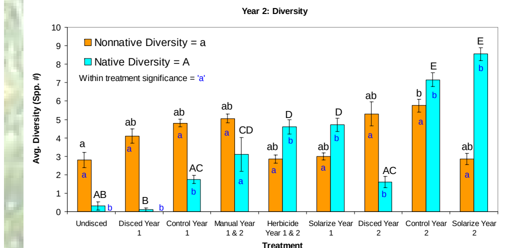

Figure 4: Differences in native and nonnative diversity with weed control treatments, year 2.

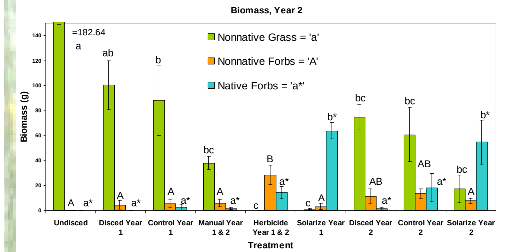

Figure 6: Differences in native and nonnative diversity with weed control treatments, year 2.

Photo 1 and 2: *Euphydryas editha quino*, or Quino checkerspot butterfly (QCB) (right) and its primary larval foodplant, *Plantago erecta* (left).

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