Final Report on NFWF Grant for Habitat Restoration at Edgewood Natural Preserve, San Mateo County, CA

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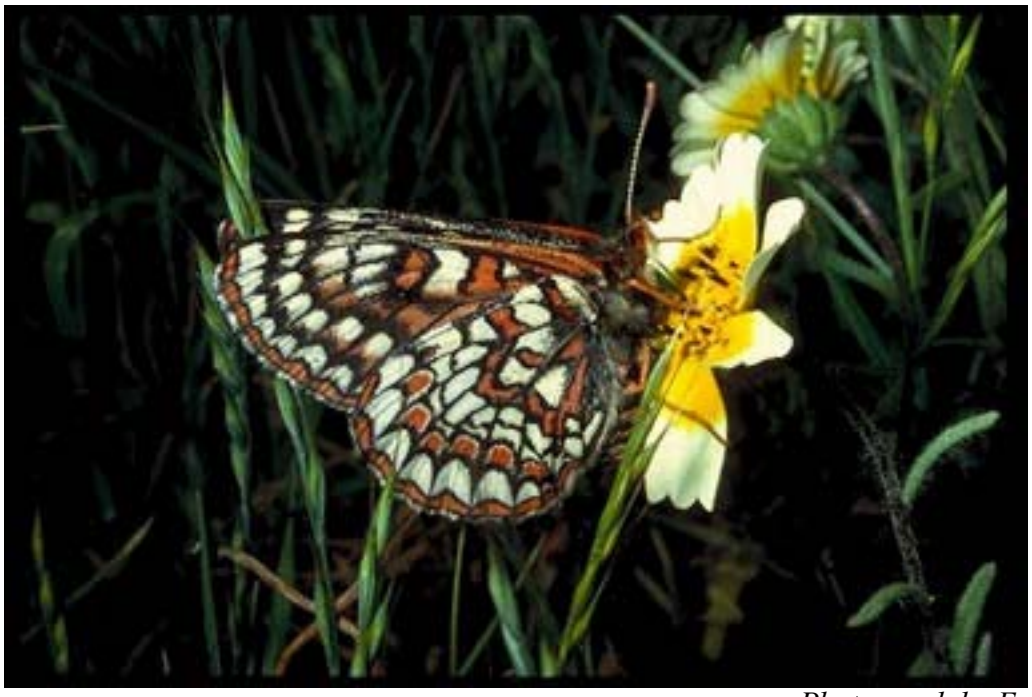

Photograph by E. Ross

Report Summary

This report consists of 11 sections, which are briefly summarized below.

1. (Page 6) The habitat requirements of the Bay checkerspot butterfly are reviewed, and key plant species listed.
2. (Page 9) The history and structure of the Edgewood butterfly population from 1971-2001 showed wide fluctuations, and a crash from thousands in 1997 to near or complete extinction in 2002. The population is unlike to recover on its own, given the extremely small numbers that can be inferred from 2002 larval (1) and adult (0) sightings.
3. (Page 14) Aerial photography in Spring 2001 provided a base map, and an analysis of grass invasion patterns from color IR photography showed that only ~20% of the habitat is not dominated by annual grass.
4. (Page 17) Plant composition across the grassland was surveyed using a transect system. The introduced annual grass *Lolium multiflorum* was the most abundant species (~30% cover), and the key larval hostplant *Plantago erecta* had 9% cover. Two nectar sources were very abundant, the other two relatively uncommon. Comparisons with other sites indicates that Edgewood has higher annual grass cover than other sites, and lower *Plantago* cover.
5. (Page 31) The pattern of grass invasion is consistent with NO_x deposition from Highway 280 enriching the soil. Highway 280 produces 15-58 metric tons of NO_x per kilometer. Grass cover is higher closer to the freeway on the downwind (E) side, correcting for soils depth.
6. (Page 35) Restoration experiments included springtime mowing, raking, disturbance, *Plantago* seeding, and two levels of goat grazing. Mowing was highly effective in reducing *Lolium* cover and increasing *Plantago* cover and native species diversity and cover. Raking and seeding did not produce strong effects, but are being tested again in 2002-03. Goat grazing has not been fully evaluated but the lighter grazing was not as effective as mowing. Fire was not able to be implemented because of late season rains and administrative barriers.
7. (Page 47) *Plantago* seed was propagated from seed collected on site in 2001. Estimated seed production in the first year was ~280,000 seeds. If similar numbers of seed/plant can be produced, there is currently enough seed for both use in seeding experiments and growing enough seed to treat many acres at 400 seeds/m^2 if necessary.
8. (Page 48) A preliminary list of considerations for reintroduction of the butterfly addresses issues of potential timing and needs for such a project
9. (Page 50) Impacts on other species, including grassland nesting birds, are considered
10. (Page 51) Management options are considered and a preliminary plan is presented for rotational mowing. Costs and time are estimated with a maximum cost of $1000/acre.
11. (Page 56) The next steps to be taken by San Mateo County Parks and Recreation are suggested.

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Introduction

The nutrient poor serpentine grasslands at Edgewood Natural Preserve support the last remaining population of the threatened Bay checkerspot butterfly on the San Francisco Peninsula, along with a dazzling diversity of native wildflowers and bunchgrasses. The Edgewood population numbered in the thousands in the mid-1990's, but numbered less than 100 butterflies in 2000. A major cause of the decline has been invasion by introduced annual grasses that choke out the larval hostplants of the butterfly, an invasion that has progressed rapidly since 1993.

In March 2001, San Mateo County Parks and Recreation Foundation obtained a $70,000 NFWF grant to initiate habitat restoration studies at Edgewood Natural Preserve. Funding was provided for the period March 2001 to Oct. 2002. Grant activities included an inventory of current habitat conditions including aerial photography (color and IR), ground level transects, and small-scale restoration experiments such as prescribed fire, mowing, goat grazing, and seeding in larval hostplants.

This document serves as a final report on activities under the grant, and present a set of management recommendations for initiating long-term restoration of the serpentine grasslands.

Section 1: Habitat Requirements of the Bay Checkerspot Butterfly

The Bay checkerspot butterfly requires both larval food (hostplants) and adult nectar. The key plant species for the butterfly are listed below (Table 1.1). Serpentine grassland generally provides an abundance of larval food and nectar, but the annual plants undergo wide fluctuations in abundance and vigor. *Plantago erecta*, the primary larval hostplant (foodplant) is generally one of the most abundant species on serpentine and can reach > 50% cover locally. *Castilleja sp.* (Owl's clover) also provides larval food for a short time in the spring, but is much more variable in abundance than *Plantago*. A diversity of nectar sources supplies nectar through the entire flight season. Edgewood supports at least four known nectar sources (Table 1.1) but they vary greatly in distribution and abundance, and fluctuate widely from year to year. Reviews of the entire life-cycle and biology of the butterfly are available (Murphy and Weiss 1988a).

Photo 1.1 shows an area of high quality habitat at Edgewood with 15-20% *Plantago* cover, numerous *Castilleja densiflorus*, *Lasthenia,* and *Layia*. Photo 1.2 shows high quality habitat on Coyote Ridge in Santa Clara County, with average ~20% *Plantago* cover and all major nectar sources.

Bay checkerspot populations respond strongly to annual weather, and require substantial areas to persist through climatic extremes. Coyote Ridge, in Santa Clara County, supports the largest populations of checkerspot butterflies (100,000-1,000,000+) on thousands of acres of topographically diverse habitat (Photo 1.2). Edgewood contains the largest remaining continuous serpentine grasslands on the Peninsula, and has supported moderate and large populations (1000 -100,000 butterflies) up until the late 1990s (see below). Edgewood is relatively flat, with only limited topographic diversity, and the habitat is naturally fragmented into patches by intervening non-serpentine rocks, as well as by Highway 280. Butterfly populations occupying small serpentine grassland patches on Jasper Ridge Biological Preserve (~4 acres in JRH and ~20 acres in JRC) fluctuated over a range of 100-10,000 butterflies during 1961-1990. JRC went extinct in the 1990, and JRH went extinct in 1997, following several years in which only a few individual butterflies were sighted.

Serpentine grassland is threatened by invasions of introduced annual grasses, which can crowd out the small-statured native wildflowers (Weiss 1999). Italian ryegrass, *Lolium multiflorum*, is the major invasive grass in degraded sites in Santa Clara County, and dominates the dense sward to the right of the fenceline (Photo 1.3). The grazed side still supports abundant *Plantago* and nectar and serves as butterfly habitat. Several large populations in Santa Clara County have gone extinct because of these grass invasions following removal of cattle. Butterfly populations do not persist when *Plantago* is reduced to small isolated patches on thin soils where grass invasion is weak. Grass invasions are linked to deposition of reactive nitrogen oxides from air pollution (see smog cloud in background of Photo 1.1). Cattle grazing is used extensively in Santa Clara County sites to maintain suitable habitat. The N-deposition process and supporting evidence are found in Weiss 1999.

Similar grass invasions and a reduction of *Plantago* habitat at Edgewood were noted from 1998 through 2002. Highway 280 bisects the serpentine at Edgewood and provides a source of reactive nitrogen, which may be the primary cause of habitat deterioration and must be considered in any restoration plan. This possibility is explicitly considered in Section 5 below.

Table 1.1

Species	**Role**
Plantago erecta	Primary larval food
Castilleja densiflorus	Secondary larval food
Lasthenia californica	Adult nectar source
Layia platyglossa	Adult nectar source
Lomatium sp.	Adult nectar source
Muilla maritima	Adult nectar source
Lolium multiflorum	Invasive annual grass
Bromus hordaceous	Invasive annual grass

Photo 1.1 High quality habitat at Edgewood

Photo 1.2 Coyote Ridge Habitat and smog

Photo 1.3 Fenceline on Coyote Ridge

Section 2: History of the Edgewood Population

Prior to urban development on the San Francisco Peninsula, large areas of serpentine soils supported multiple populations of checkerspot butterflies, including San Francisco, Hillsborough, Pulgas Ridge, Edgewood, Woodside, and Jasper Ridge. (The San Bruno Mountain population was not on serpentine soils, but was still in a native grassland rich in *Plantago* and nectar sources). Through time, housing, freeways, and golf courses have progressively reduced and fragmented the habitat, driving populations to extinction (Murphy and Weiss 1988).

The Edgewood population has occupied 6 distinct patches of serpentine grassland in and near Edgewood Preserve (Map 2.1, Table 2.1). EWB is the main block of habitat (34.1 acres) extending east from Highway 280. EWA is a small area (5.6 acres) on the Triangle west of Highway 280. EWC extends across 5.1 acres in the saddle near the Sunset Gate, and EWD is the isolated patch (2.8 acres) of grassland below Hillcrest Drive. EWE is the flat area north of the main hill (17.1 acres), and EWF (6.8 acres) is directly adjacent to Highway 280, north of the drainage swale. Intervening habitats between patches include open grassland, chaparral, an 8 lane freeway, oak woodland, and various combinations thereof.

The Edgewood population has studied intermittently since 1970 by Stanford University biologists. Data prior to 1993 have been derived from published and unpublished material. Mark-recapture studies were done in several years, which provide population estimates and dispersal rates. A detailed description of the population structure at Edgewood is given in Attachment A6 in the Master Plan Report.

In 1993, standard searches for postdiapause larvae were first done at Edgewood, according to protocols developed at Kirby Canyon and other sites in Santa Clara County (modified from Murphy and Weiss 1988b). Larval counts in a 10-person minute search over a 1500-2000 m^2 area can be translated into absolute larval densities, which can then be averaged across the habitat to estimate the total number of larvae. Systematic larval searches began again in 1997 and extend to the present. The number of adult butterflies is less than the number of larvae because of late larval and pupal mortality and a figure of 50% is used in the absence of field data (Weiss et al. 1988,).. Pupal mortality rates do vary from year to year – the maximum recorded was 80% during extended El Nino rains in 1983 (White 1986). Adult estimates are therefore doubled to develop larval estimates.

The first recorded estimates were 10-20,000 butterflies in the early 1970's. Highway 280 was constructed through the site soon thereafter. No records indicate population response to the 1975-77 drought, an event that greatly reduced local Bay checkerspot populations. By 1981, the population had exploded to more than 100,000 butterflies. All outlying areas beyond EWB were occupied. The population crashed to around 1000 butterflies in 1984, following the 1982-83 El Nino deluges. The population west of 280 (EWA) went extinct around 1985. The population north of the main hill (EWE) went extinct at the same time. EWB recovered to several thousand butterflies

from 1985 to 1992, based in qualitative yearly surveys by SBW. Populations in the hundreds persisted in the other areas (EWB, EWC, and EWD).

In 1993, the population in EWB was estimated at 3500 larvae (~1750 adults) (Table 2.2). EWC and EWD had 200-400 hundred larvae each. In 1997, the population in EWB had increased to 8000, and EWC and EWD were still occupied by larvae. EWB then declined sharply to 3000 in 1998 and 500 in 1999. EWC and EWD were extinct by 1999. In 2000, the estimate from larval counts was less than 100 larvae. Only 5 adults were observed that year, three on the small hilltop in EWB, 1 near the E-end of EWB, and one N of the PG&E road.

No postdiapause larvae were observed in 2001. Three adults were sighted on the small hilltop on Mar 29, Mar 30 and Apr 5. The first two may have been the same freshly emerged male. The third sighting was of undetermined sex.

In 2002, 1 postdiapause larva was observed near the small hilltop on February 19 (Photo 2.1). No adults were observed. All observations in 2001 and 2002 show a butterfly population at the brink of extinction. Based on the larval encounter rate in 2002, the larval population was likely on the order of 10 individuals, and the population is clearly at the edge of extinction. Only 3 adult sightings the year before along with the lack of adult sightings in 2002, despite multiple deliberate searches and numerous incidental search time, suggests that the population may be extinct. Low numbers (1-10 butterflies) were seen in the final years of each Jasper Ridge subpopulation, and fluctuations at low numbers over several additional years may be possible. However, the likelihood of substantial recovery is low, at best. Reintroduction options will be discussed later in the report.

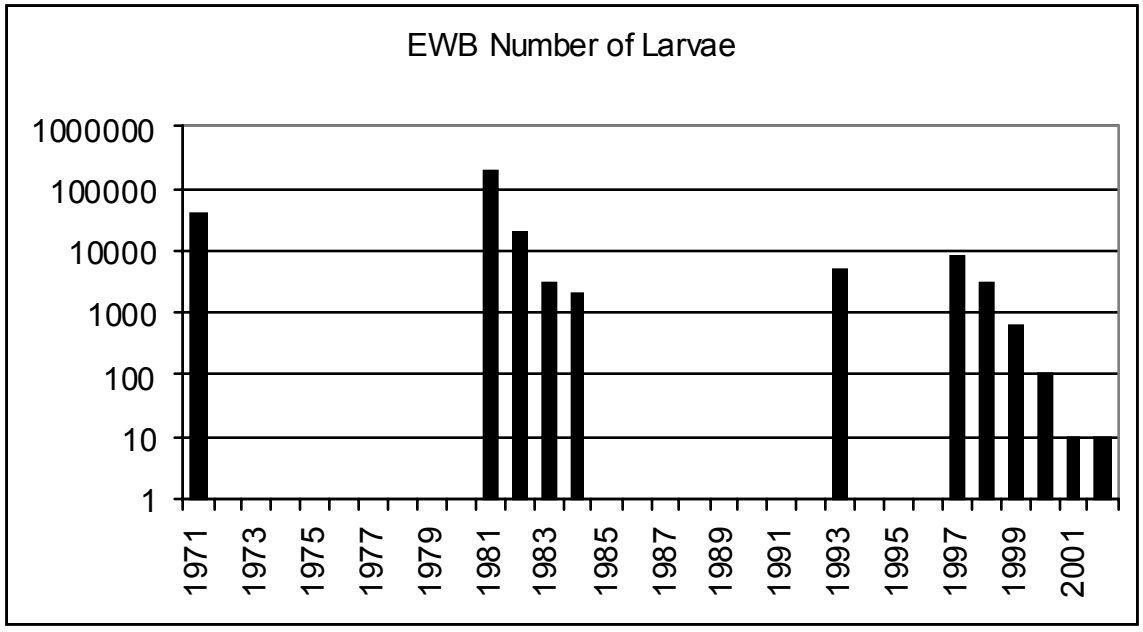
Table 2.1 Subarea Acreage

Subarea	Acres
EWB	34.1
EWA	5.6
EWE	17.1
EWD	2.8
EWC	5.1
EWF	6.8

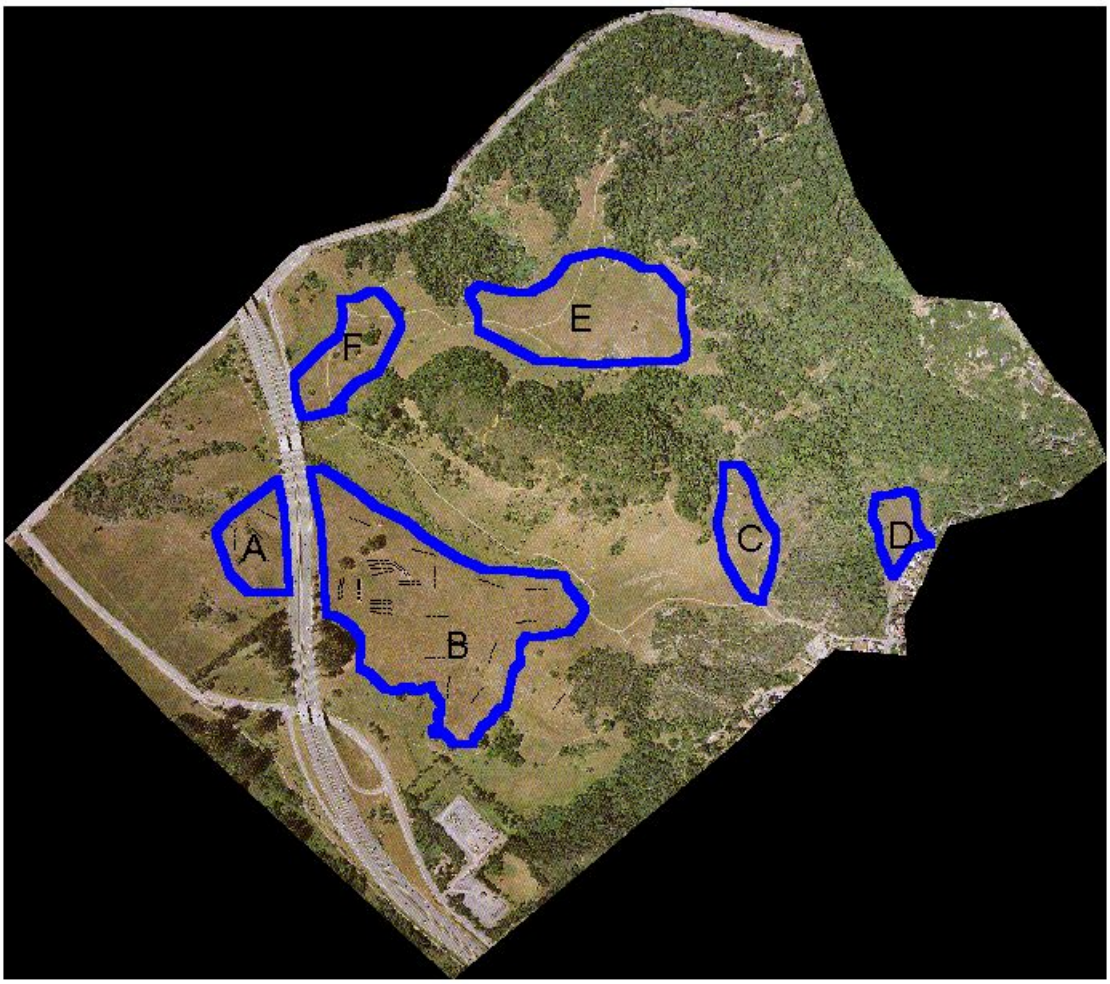
Table 2.2 Larval counts 1993-2002

Year	Number Sites	#larvae/ site	Larvae/ m^2	Std Dev	Std Err	Lower 95%	Upper 95%
1993	12	2.3	0.026	0.023	0.007	0.012	0.037
1997	15	5.1	0.059	0.045	0.012	0.034	0.084
1998	10	1.4	0.022	0.025	0.008	0.004	0.040
1999	10	0.4	0.005	0.007	0.002	0.000	0.010

Figure 2.1 History of EWB



Map 2.1 Edgewood Park Serpentine units



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1000 0 1000 Feet

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Photo 2.1 Postdiapause larva Feb 19, 2002

Section 3. Aerial Photography 2001

Aerial photography with 1 ft resolution was flown on May 7 2001, and orthorectified color and color IR (CIR) images produced. Grasses were still green but annual forbs had largely senesced. The CIR image was classified into four classes for habitat assessment – bare, forb-dominated, grass dominated, and non-grassland -- using an unsupervised classification in ArcView Image Analyst and manual selection of breakpoints along the green vegetation gradient.

The true color photo shows the mosaic of vegetation at Edgewood (Map 2.1). The serpentine areas are outlined and labeled A-F, described in Section 1. The vast majority of the work was done in Area B, where the last butterflies were seen. The smaller patches once supported populations, but now appear to be extinct. The distribution of all transects are shown.

The close in CIR photo of Area B (Map 3.1) shows green grass-dominated areas as red, and dry senescent forbs with some grass as pink, and relatively bare areas as blue. Note the complex fine-scale patterns in the grassland. Areas of thick soils on mounds dominated by grass alternate with thinner soils dominated by forbs.

The habitat classification (Map 3.2) based on live vegetative cover further highlights the vegetation patterns. The red areas within the serpentine grasslands are heavily invaded by grasses, and currently have little *Plantago*. The yellow areas are forb-dominated and may or may not contain *Plantago* in high densities, but represent an upper limit on available habitat.

According to this analysis, the amount of forb habitat in the 34.1 acre Area B is about 6 acres (<20%). <2% is covered by rocks, and the remainder is dominated by grass (Map 3.2). It is important to note that not all forb dominated areas support dense *Plantago erecta* stands (see below Section 4).

Map 3.1 EWB and EWA Color Infrared (CIR)

Map 3.2 Habitat Classification