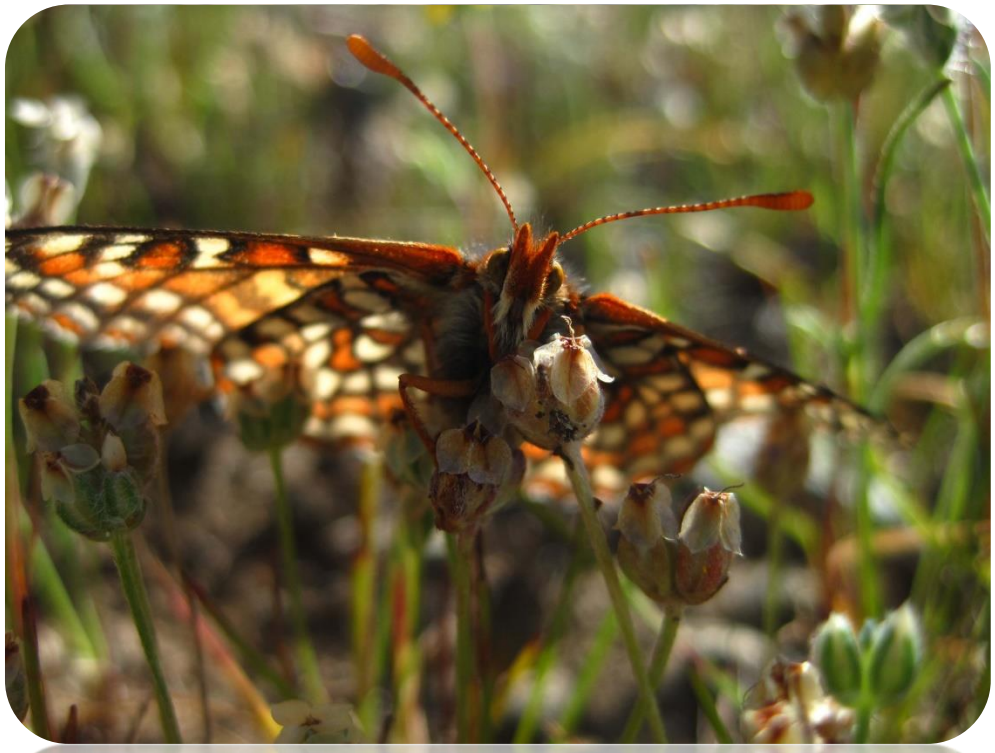
Bay Checkerspot Reintroduction

Coyote Ridge to Edgewood Natural Preserve



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Executive Summary

The main goal of this project is to re-establish a Bay checkerspot butterfly population in restored habitat in Edgewood Natural Preserve, where the population was extirpated in 2002. Extant populations from Coyote Ridge in Santa Clara County numbering in the hundreds of thousands were the source of these butterflies.

The Bay checkerspot larval population was estimated at about 2,300 larvae in January 2015, down from about 4,000 last year. Because this was below the replacement rate, habitat quality remained high, and source populations were also high, 4,463 larvae were released in January and February 2015. An additional 60 adults were released in March.

This year monitors saw 451 adults during timed transects, down from 800 in 2014. Despite another drought year coupled with above average March and April temperatures, host plant *Plantago erecta* remained fresh about six weeks past the flight season. With this long of a period of host plant availability, we may expect numbers to maintain or increase next year.

The decision whether to continue translocations will be made in early 2016. The decision will be based on post diapause larval numbers, the question of whether fewer translocations may increase selection for more sedentary butterflies, and funding. Additional funding must be identified for this project to continue. This project was run concurrently with an enhancement project at Tulare Hill in San Jose, an ongoing project discussed in a separate report.

We remain grateful to the following partners for financial support, volunteer time, and excellence on the job: USFWS, San Francisco Bay Wildlife Society, PGE, San Mateo County Parks, San Mateo County Parks Foundation, the Jiji Foundation, Friends of Edgewood, and of course the Edgewood Checkerspotters.

Project Background

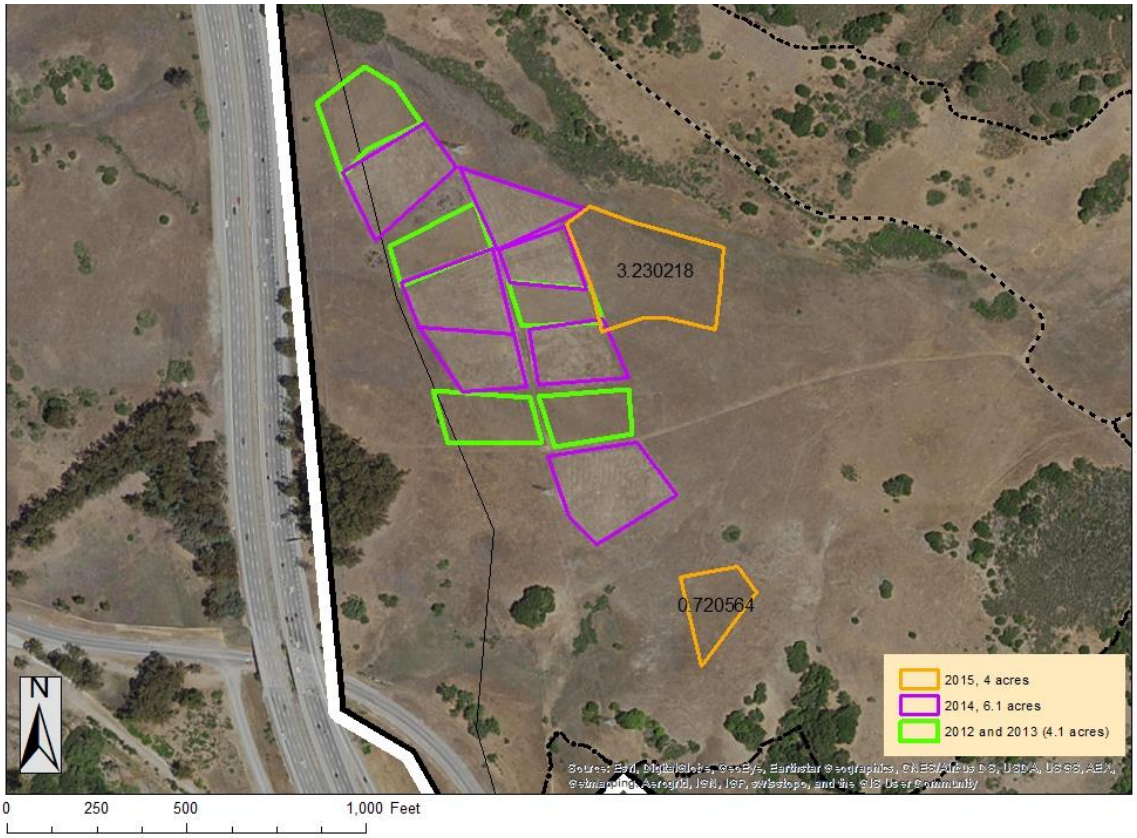
The nutrient poor serpentine grasslands at Edgewood Natural Preserve supported the last remaining population of the federally threatened Bay checkerspot butterfly on the San Francisco Peninsula, along with a dazzling diversity of native wildflowers and bunchgrasses. Maintenance of populations on the Peninsula is a high priority task in the 1998 USFWS Recovery Plan.

The Edgewood population was estimated at 4500 butterflies in 1997, but numbered less than 100 butterflies in 2000, and appeared to be extinct as of 2003. No butterflies or larvae were observed in 2003, 2004, 2005, and 2006. The 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 1997. The grass invasion has been linked to emissions of ammonia and NO_x from 100,000+ cars traveling Highway 280 (Fenn et al. 2010). A reintroduction effort in 2007 was not successful, likely based on a single year effort, a low number of founders (1000 larvae), and a dry, warm, spring season.

Habitat Restoration

Experiments showed a single, well-timed mow and subsequent fall dethatching can be used on a rotational basis to reduce grass and thatch cover and increase Bay checkerspot host plant and nectar source cover (Weiss 2002). San Mateo County Parks continues to mow and dethatch portions of the butterfly habitat to reduce annual grass and thatch cover and increase native forb cover. In 2012, Creekside installed paired mowed and unmowed plots to better address the potential impact of critical habitat management on the diapausing larvae. About 4 of 30 acres were mowed in spring 2012 and 2013 and dethatched the subsequent fall. In April 2014 a different set of plots totaling about 6 acres was mowed. These plots were largely free of annual grass in spring 2015, so a different set of 4 acres was mowed (Figure 1).

Figure 1. Mow plots in Bay checkerspot butterfly habitat, Edgewood Natural Preserve



Plots mowed in 2012 and 2013 had an average of 34.0% *Plantago erecta* and 4.6% nonnative annual grass this year, while paired unmowed plots only had an average of 10.5% *Plantago* and 29.8% nonnative annual grass (Figures 2 and 3). Host plants are clearly responding positively to the management treatment, and nonnatives declining.

Figure 2. *Plantago* in mowed vs. unmowed plots.

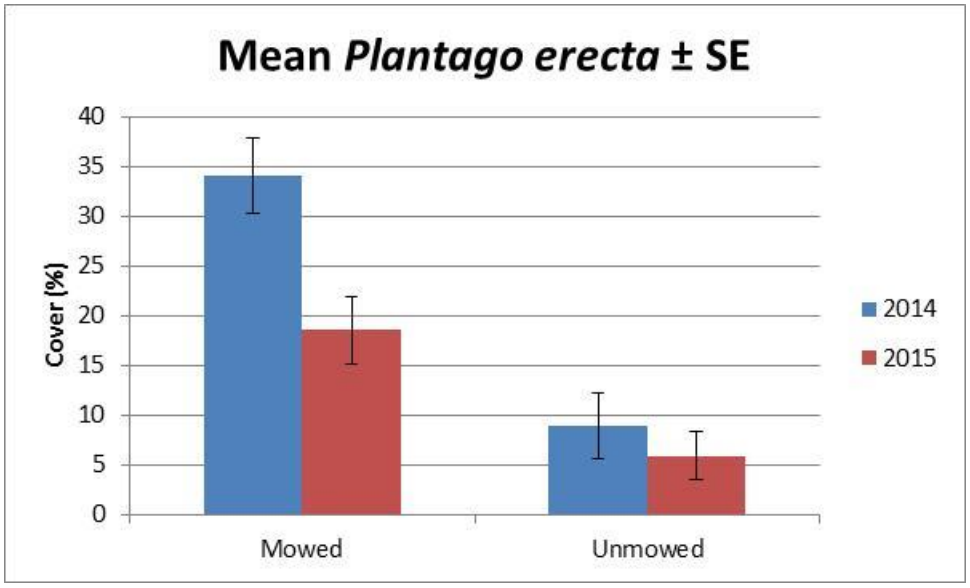
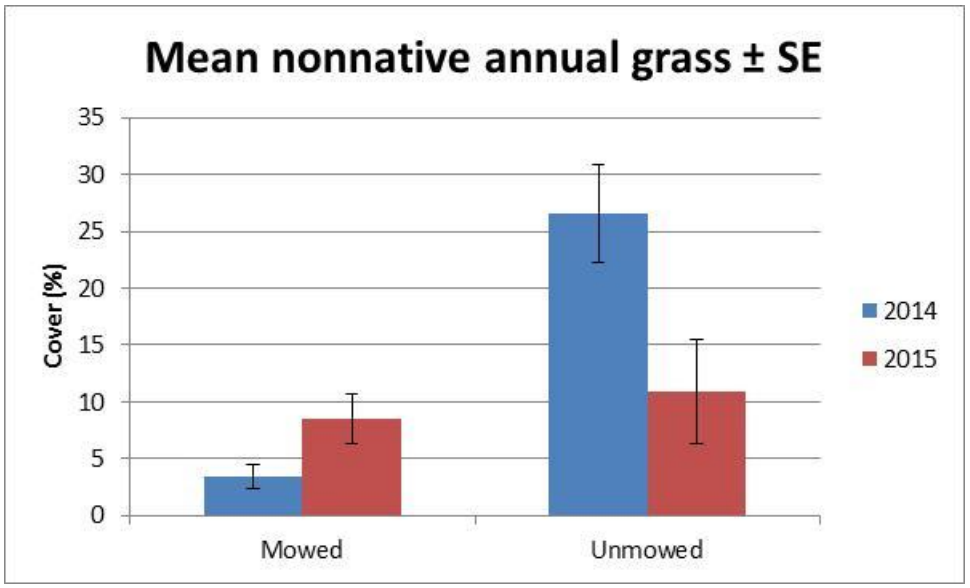


Figure 3. Nonnative grass in mowed vs. unmowed plots.



Larval numbers were extremely low in the paired plots in both 2013 and 2014 (in both years the majority of larvae were found outside the paired plots), precluding statistical comparisons. Presence was noted in both mowed and unmowed plots. Larval numbers in mowed and unmowed plots were not compared in 2015.

Weather Summary

Annual precipitation from 1981 to 2010 averaged 48.1 cm (WRCC 2014) and will be considered the baseline for the project. October 2012 to September 2013 had 40.1 cm, 32.1cm of which fell between October and December (Table 1). While the rest of the water year was very dry, the early start to the growing season was considered to be advantageous to the spring 2013 larvae, which in turn is advantageous to the 2014 generation.

Only 23.3 cm fell October 2013 to September 2014. October-December 2013 saw only 2.7 cm, and January 2014 had zero measurable rainfall (WRCC 2014). By the end of January, the normally green grasslands at Edgewood were still eerily brown. Few annuals had germinated, and many that did died from moisture stress. Those that survived were usually shaded by rocks or small divots in the ground. This very late start to host plant germination is generally considered to be a large disadvantage. Rainfall in February greened up the Preserve, and by the end of spring things appeared more normal. Winter days were largely sunny. By mid-March, however, conditions had changed dramatically. With 11 cm of rain in February to recharge the soils, and host plants developed with little nonnative grass competition. It appeared that many of the nonnative grasses had germinated and then died during the dry January. Those that germinated in February generally lagged behind forbs in growth.

The 2015 water year had closer to average precipitation. Germination began at a fairly normal pace in November. Heavy rainfall occurred in December 2014, but there was no measurable precipitation in January 2015. The site received 10.1 cm in February 2015, and the rest of the spring saw below average precipitation.

Precipitation records for the source population are shown in Table 2 as reference. The source population at Coyote Ridge is about 65 km southeast of Edgewood. Edgewood is about 180 m elevation, and the source population about 360 m.

Table 1. Precipitation records from nearby Pulgas Ridge, 48.1 cm average for 1981-2010 (WRCC 2014)

	Yearly Precipitation (cm)
Oct 2006-Sep2007	31.1
Oct 2007-Sep2008	46.1
Oct 2008-Sep2009	50.2
Oct 2009-Sep2010	70.1
Oct-2010-Jun 2011	72.8
Oct 2011-Sep2012	41.4
Oct 2012-Sep2013	40.1
Oct 2013-Sep2014	23.3
Oct 2014-Sep2015	44.9

Table 2. Precipitation records from Coyote Ridge, 58.9 cm average for 1981-2010 (WestMap 2015)

	Yearly Precipitation (cm)
Oct 2006-Sep2007	27.1
Oct 2007-Sep2008	37.9
Oct 2008-Sep2009	43.4
Oct 2009-Sep2010	60.8
Oct-2010-Jun 2011	61.2
Oct 2011-Sep2012	29.6
Oct 2012-Sep2013	33.4
Oct 2013-Sep2014	23.3
Oct 2014-Sep2015	42.6

Cool March and especially April temperatures also favor checkerspots, as they allow host plants to stay fresh longer as prediapause larvae race to the fourth instar when they can enter diapause. Edgewood had a particularly warm March 2007, and March 2008, 2013, 2014, and 2015 were also above the 30-year average. April temperatures were high in 2013 and 2014, and slightly above average in 2015 (Table 3). Again, these high temperatures are not favorable to checkerspots because they speed up host plant senescence.

Table 3. Pulgas Ridge average maximum temperature (˚C) (WRCC 2015).

	March	April
2007	21.2	20.1
2008	19.1	20.1
2009	18.5	20.4
2010	18.9	18.3
2011	15.8	17.6
2012	16.0	19.5
2013	19.7	22.4
2014	20.4	21.6
2015	22.6	21.0
Average 1981-2010	18.6	20.7

In comparison, Coyote Ridge also had above average March temperatures in 2007, 2008, 2013, 2014, and 2015. April temperatures were higher than average in 2007, 2008, 2009, and 2013 (Table 4).

Table 4. Coyote Ridge average maximum temperature (˚C) (WestMap 2015)

	March	April
2007	21.6	21.1
2008	19.4	21.7
2009	18.1	20.9
2010	18.7	18.2
2011	16.6	19.6
2012	15.9	18.5
2013	19.6	21.7
2014	19.9	20.3
2015	21.9	19.9
Average 1981-2010	18.2	20.6

Coyote Ridge Source Population

The 2015 larval population is a relic of the previous season's conditions. The previous year was extremely dry and had an unprecedentedly late germination season, which seemed to be a bad sign for checkerspot survival. But while the larvae got a very late start, they developed quickly in the long, sunny days. The late-germinating forbs seemed to need a minimal amount of time to complete their life cycle. Based on larval increases in 2015, (and an early flight season with more than five weeks until host plant senescence) large numbers of larvae were able to enter diapause before host plants dried out. Larval numbers throughout the source population are shown in Table 5.

Table 5. Kirby Canyon is 250 acres within the larger ~7000 acres of Coyote Ridge. The Kirby numbers are shown with 95% confidence intervals.

	Kirby Reserve	Coyote Ridge*
2011	94,399 ± 32,025	533,426
2012	145,688 ± 37,606	487,406
2013	202,845 ± 46,487	1,208,297
2014	61,221 ± 35,136	745,945
2015	190,756 ± 70,059	2,102,400

*Confidence intervals across Coyote Ridge have not been calculated.

Larval Monitoring at Edgewood

Monitoring at Edgewood was conducted in January 2015, with estimates of about 2,300 larvae, down from about 4,000 last year. Even with the decline, checkerspots were able to complete their lifecycle at Edgewood in large numbers. Again, this is still below the replacement rate (~4,100 larvae were introduced in 2014). The habitat is still high in host plant and nectar source cover. In order to achieve the high number of butterfly encounters that encourage more sedentary behavior, and because source populations were still very high, additional larvae were transferred to Edgewood in 2015.

Larval Transfers

A total of 23,423 larvae have been released since 2007 (Table 6). Larvae were relatively easy to collect, especially in recent years when the source populations at Coyote Ridge were extremely dense.

Table 6. Summary of larval introductions

Year	Larvae introduced
2007	1,000
2011	4,003
2012	4,852
2013	5,000
2014	4,105
2015	4,463

Post diapause larvae are the focus of the introduction because they are the easiest life stage to locate, handle, and transfer. Larvae are captured by hand or with a spoon, and placed in groups in vented plastic containers kept in coolers until same day release (Table 7).

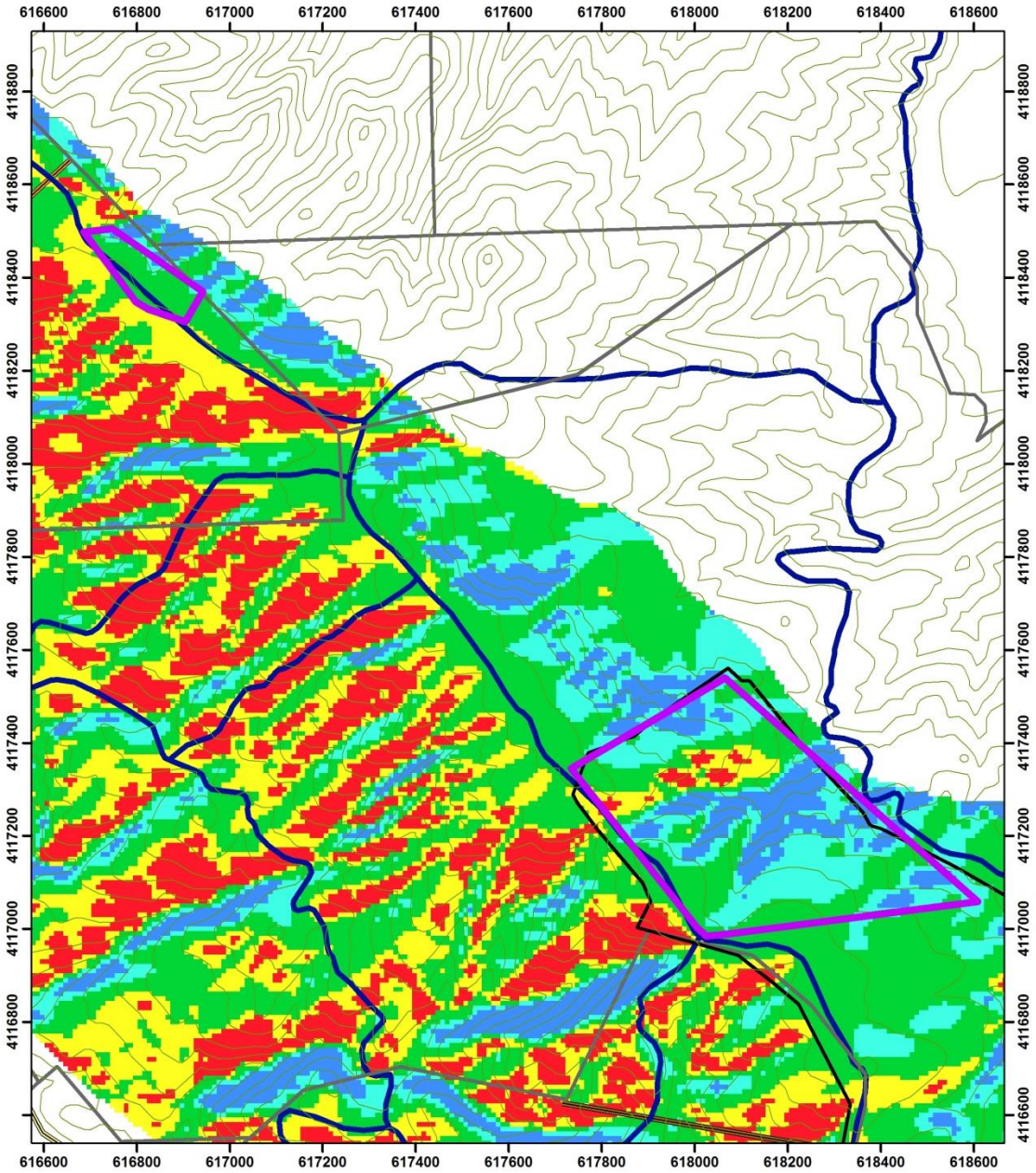
Table 7. Larval Transfers from Coyote Ridge to Edgewood Natural Preserve, 2015

Date	Adults observed	Larvae transported and released at Edgewood	Number injured	Number killed
1/31/2015	0	3879	0	0
2/14/2015	0	584	0	0

Total larvae transferred: 4463

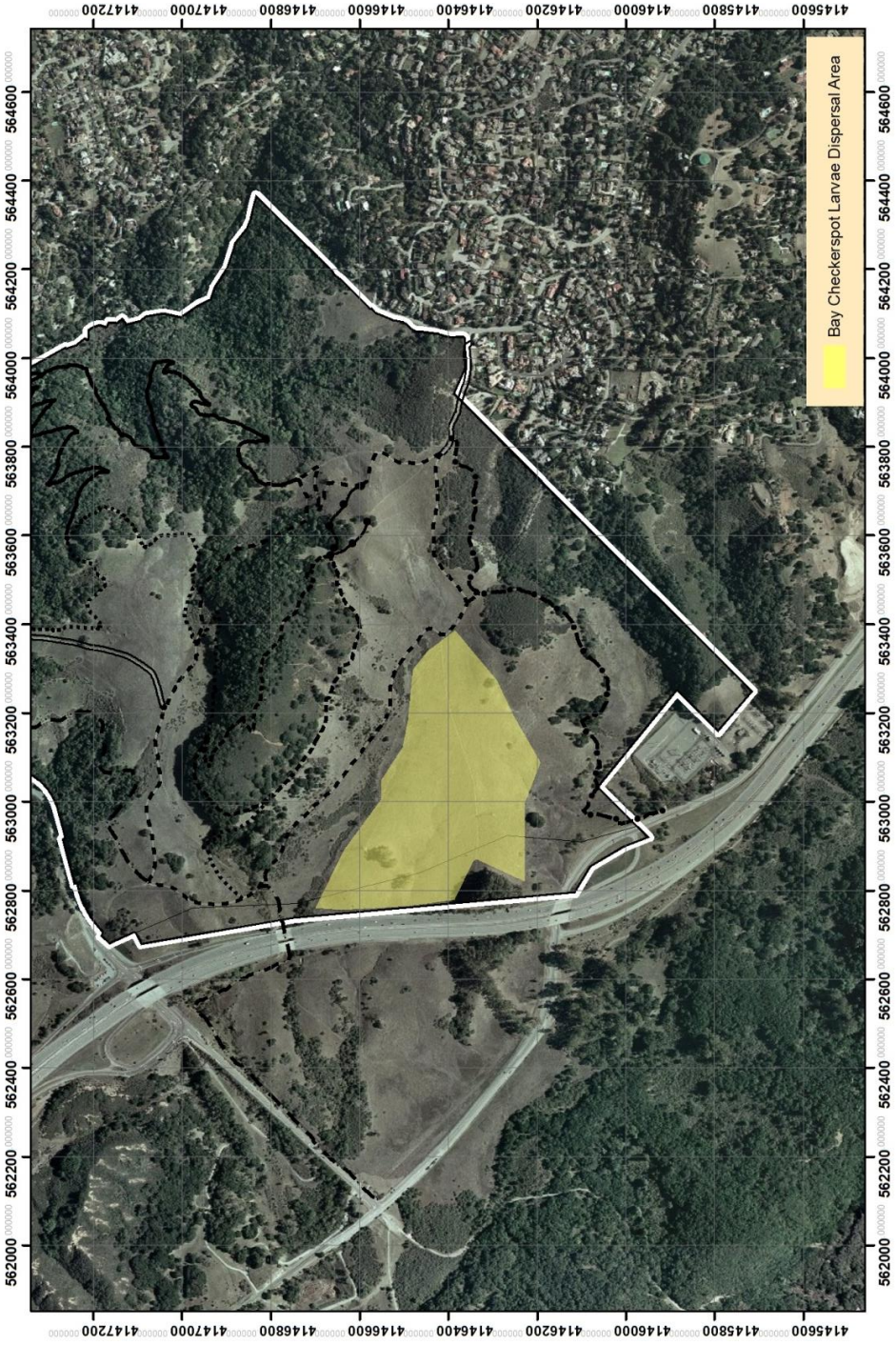
In 2015, 4463 larvae were collected from the area below, estimated to have more than 200,000 larvae (an additional 60 adults were collected here as well). All coordinates are NAD83 (Figure 4). (An additional 3833 larvae were collected from a nearby location for the related Tulare Hill translocations.)

Figure 4. Collection location



As in previous years, larvae were dispersed in the area below at Edgewood Natural Preserve (Figure 5).

Figure 5. Dispersal location



After release, larvae were observed basking, crawling, or eating *Plantago erecta*.

While it is too early to determine whether the reintroduction effort will be a longterm success, the relocation effort has been successful based on the following:

Sufficient larvae are encountered in source populations and captured for release.
Larvae are collected from multiple locations and topoclimates. A range of larval sizes are represented.
Larvae are relocated with minimal impact on individuals.
Larval densities remain relatively high at Edgewood, although larval estimates are at 56% of 2014 reintroduction cohort.

Adult Transfers

Sixty adults were transferred from Coyote Ridge to Edgewood Preserve March 14, 2015 (Table 8). They were collected from the same larval collection areas shown in Figure 4.

Table 8. Summary of adult introductions

Year	Adults introduced	Females	Males
2007	12	12	0
2011	60	40	20
2012	46	26	20
2013	0	0	0
2014	0	0	0
2015	60	40	20

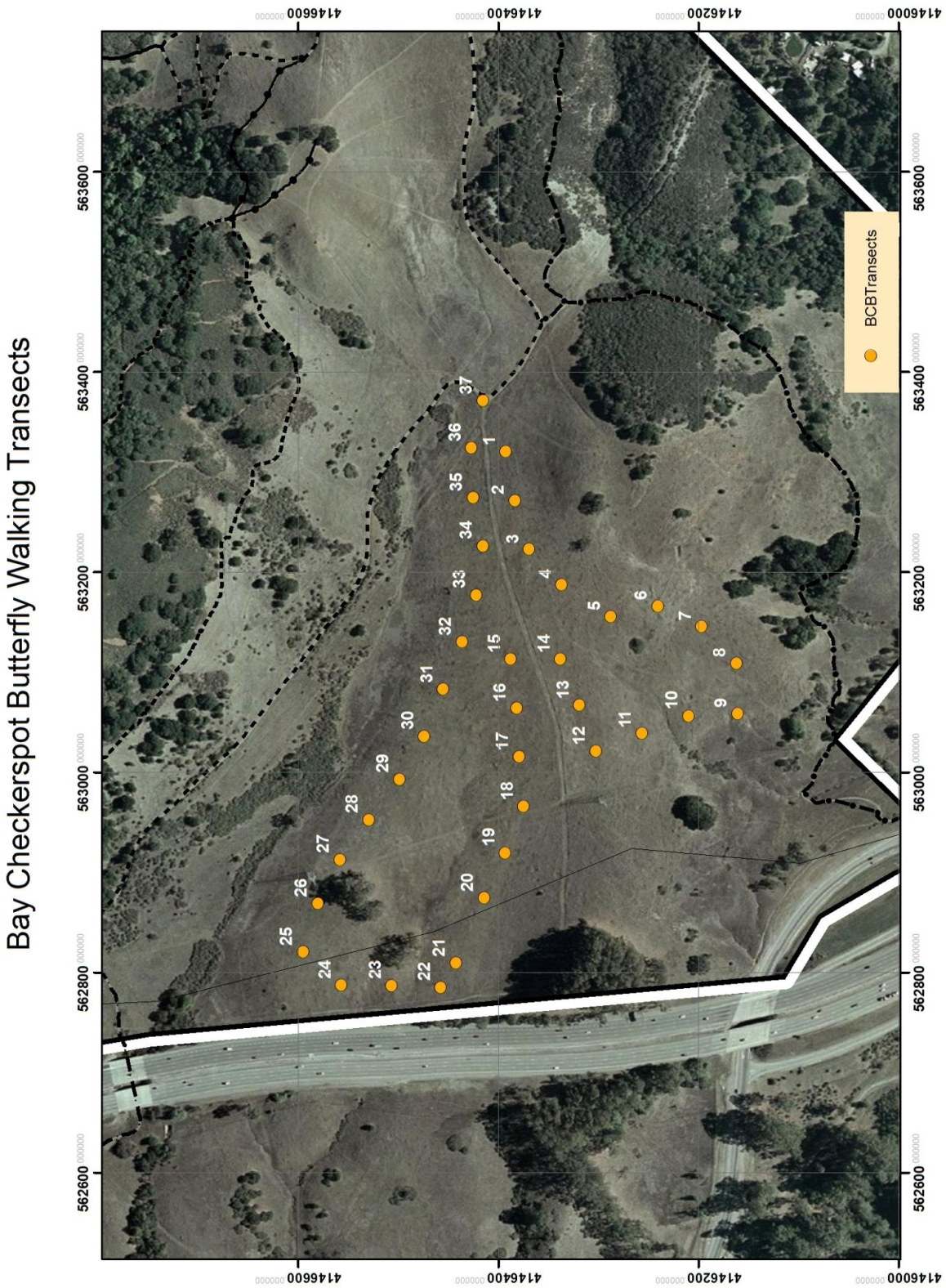
Adult transfers have been successful based on the following:

1. Sufficient adults are encountered in source populations and captured for release.
2. Adults are collected from multiple locations and topoclimates.
3. Adults are relocated with minimal impact on individuals.
4. Adult densities remain relatively high at Edgewood.

Adult Monitoring

Over the course of the flight season, adults are surveyed daily, weather permitting. The adult monitoring consists of a volunteer observer walking through 36 50-m transects set up in the butterfly habitat. The monitoring consists of counting how many Bay checkerspots are seen along each transect. The monitor walks slowly, covering the 50 meters in about 1.5 minutes, looking 5 meters to each side of the transect. The monitor may step off the transect to confirm a sighting (stopping the timer). The course takes about 1.5 hours to walk (Figure 6).

Figure 6. Adult monitoring course



This year, the number of adult butterflies declined (Table 9).

Table 9. Summary of adult sightings during timed monitoring sessions at Edgewood

Year	Adults sighted
2007	9
2011	120
2012	310
2013	625
2014	800
2015	451

The introductions have been successful based on the following:

1. The Edgewood habitat has dense amounts of both host and nectar sources.
2. The adults are dispersing throughout the habitat.
3. A high number of adults was noted in 2015.

The timing of the flight season relative to host plant growth and senescence is critical. An early start and/or an early finish increase the likelihood the new generation of larvae will grow large enough to enter diapause before their host plants dry out. The flight season is compared with a reference site at Kirby Canyon Butterfly Reserve on Coyote Ridge in Figures 7 and 8. The asterisk denotes the midpoint of the flight season, when 50% of the year's butterflies had been encountered. Both sites hit their flight season midpoint about March 17, 2015, relatively early. Also note another relatively long flight season this year at Edgewood, which increases mating opportunities and spreads risk relative to extreme weather events (Table 10).

Note that Kirby is monitored weekly, while Edgewood is monitored daily. Kirby therefore has a much larger population in 2015 and previous years compared with Edgewood. The flight season began early this year, which increases the likelihood the new generation of larvae will grow large enough to enter diapause before their host plants dry out.

Figure 7. Cumulative counts of adult Bay checkerspots, daily monitoring. * marks the midpoint of the flight season

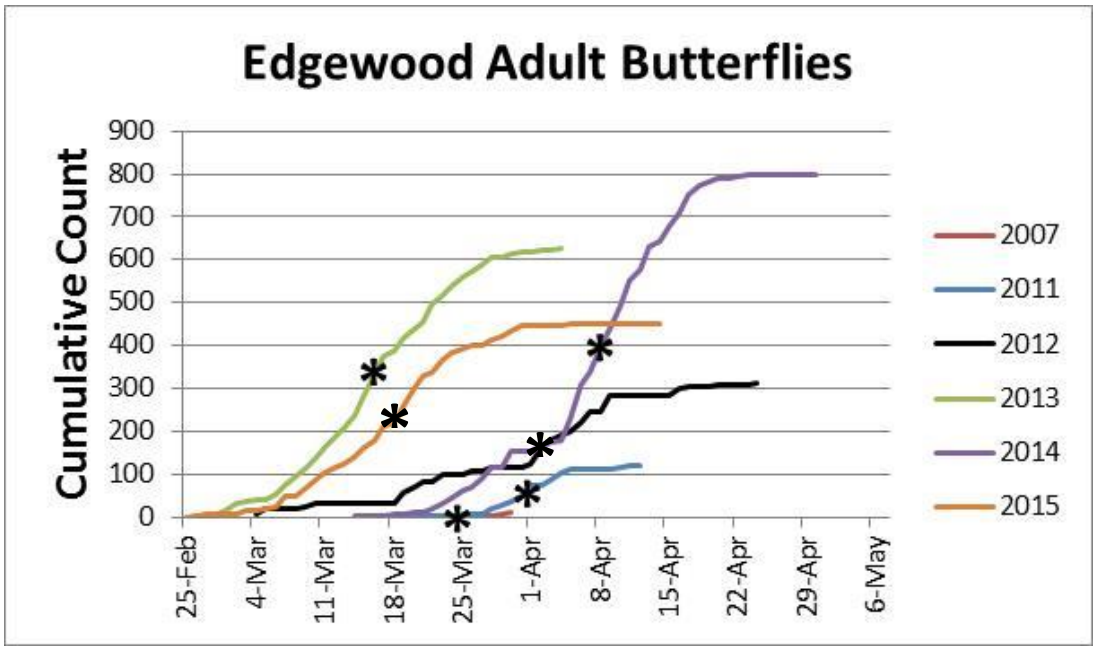


Figure 8. Cumulative counts of adult Bay checkerspots at the reference site, weekly monitoring

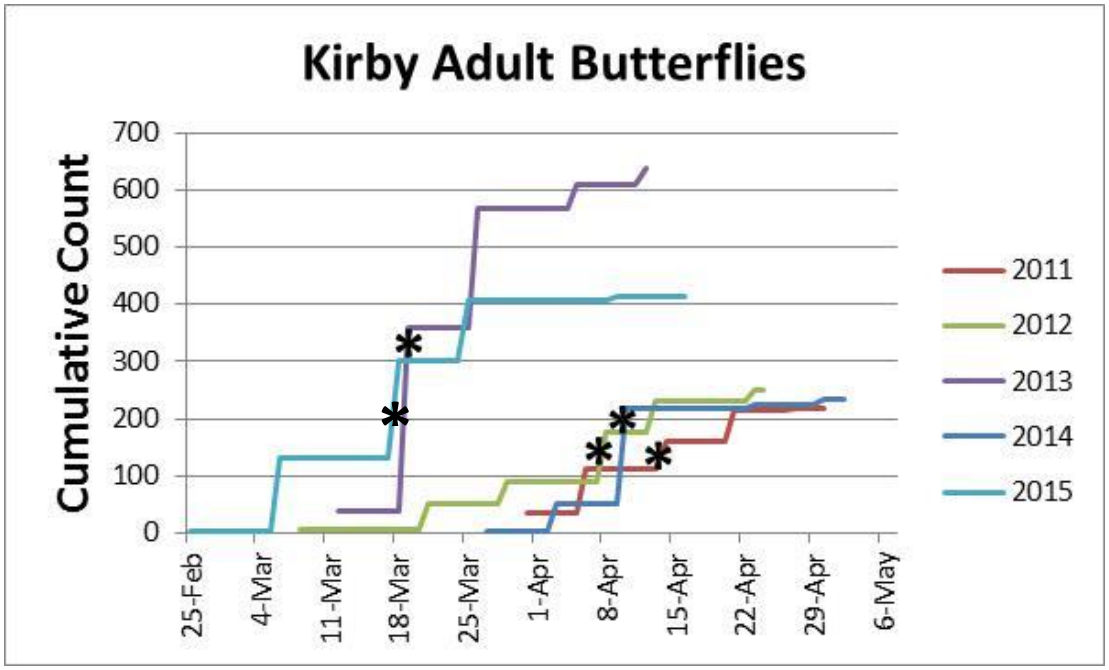


Table 10. Flight season comparisons at Edgewood vs. Kirby. Note 2014 is the latest peak flight recorded for Edgewood.

Year	Weeks of flight, EW	Weeks of flight, Kirby	Peak flight, EW	Peak flight, Kirby
2007	2	n/a	24-Mar	n/a
2011	4	4	1-Apr	14-Apr
2012	7.5	7	2-Apr	8-Apr
2013	6	4.5	18-Mar	19-Mar
2014	7	5	8-Apr	10-Apr
2015	7	6.5	17-Mar	18-Mar

Host Plant Phenology Monitoring

Again, the timing of the flight season relative to host plant growth and senescence is critical. An early start and/or an early finish increase the likelihood the new generation of larvae will grow large enough to enter diapause before their host plants dry out. Hostplants and nectar sources are monitored along transects at different topoclimates (warm to cool) to determine how long they are available to adult butterflies and prediapause larvae. These data are compared with flight season data to estimate whether most butterflies survived to diapause. Low rainfall is less of a concern than continuing cool temperatures.

As a general rule, prediapause larval survivorship increases substantially if host plants remain fresh three weeks or more after the midpoint of flight season. The longer the plants stay fresh, the better. We compare phenology at Edgewood with phenology at Kirby Canyon Butterfly Reserve on Coyote Ridge, which has a large checkerspot population. We use its host plant phenology as a reference.

Plantago densities are usually comparable between Edgewood and Kirby, although Kirby was low again this year. *Plantago* at Edgewood dried out during the last week of April, while Kirby Canyon dipped below the 10 plants/m^2 critical threshold in the first week of April. Although it happened two years in a row, it is uncommon for Edgewood's *Plantago* to stay fresh longer than Kirby, because Kirby has more steep, north-facing slopes. Lower total densities at Kirby probably played a role in early senescense. Castilleja numbers were moderate this year at Edgewood, while Kirby had much higher densities. Both sites had Castilleja present through April (Figures 9-12).

The main nectar source, Lasthenia californica, stayed fresh beyond the end of the flight season at both Edgewood and Kirby. *Layia* spp. also stayed fresh beyond the end of the flight season at both sites (Figures 13-16). Nectar tends not to be limiting for Bay checkerspots.

Figure 9. Edgewood host plant phenology. Ten *Plantago* plants/sq meter is a critical threshold for Bay checkerspot larval use.

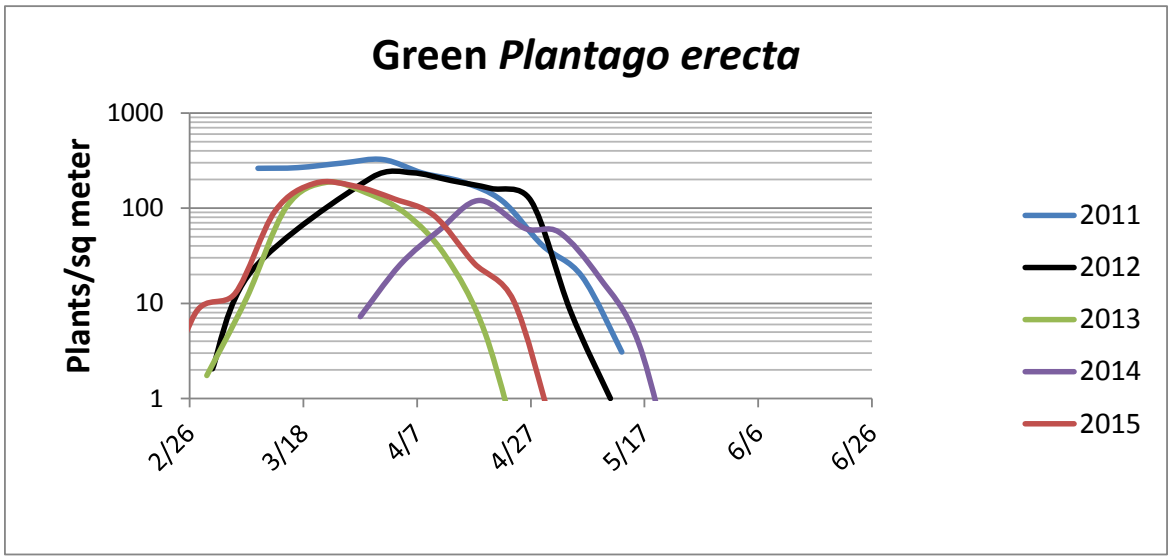


Figure 10. Kirby Canyon host plant phenology

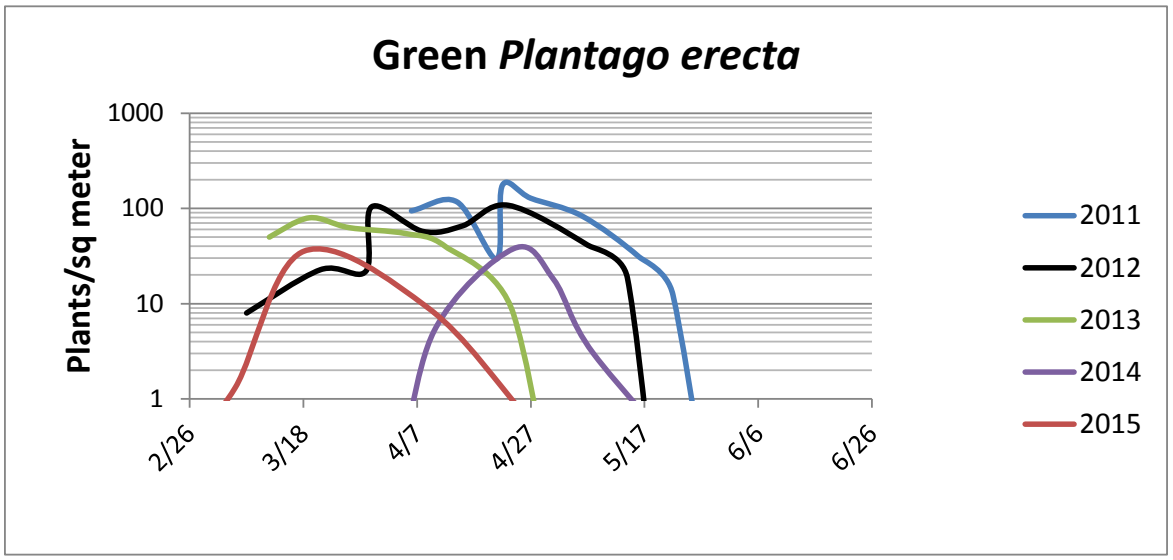


Figure 11. Edgewood host plant phenology

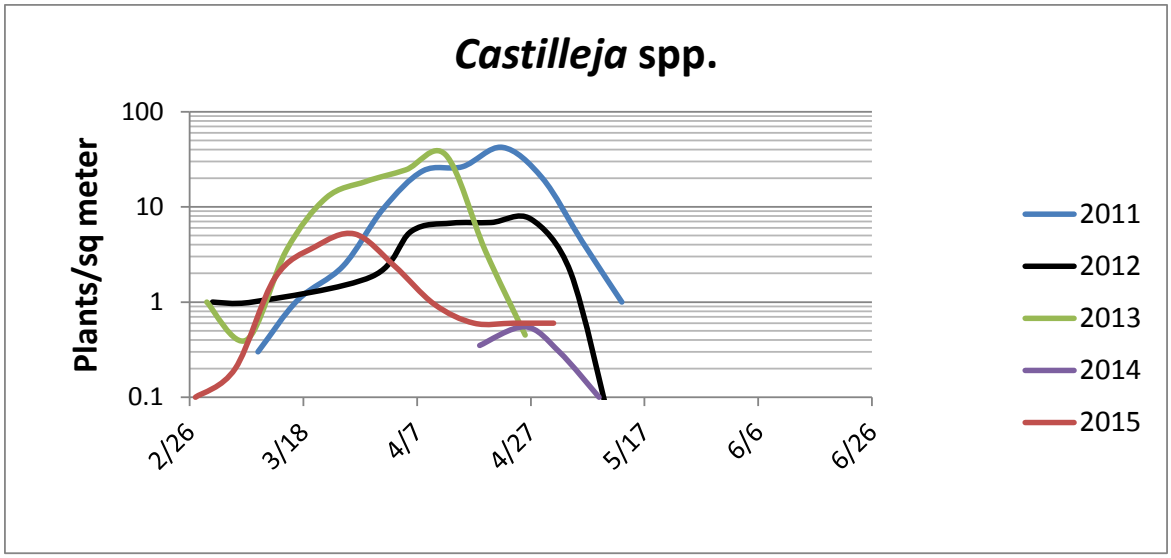


Figure 12. Kirby Canyon host plant phenology

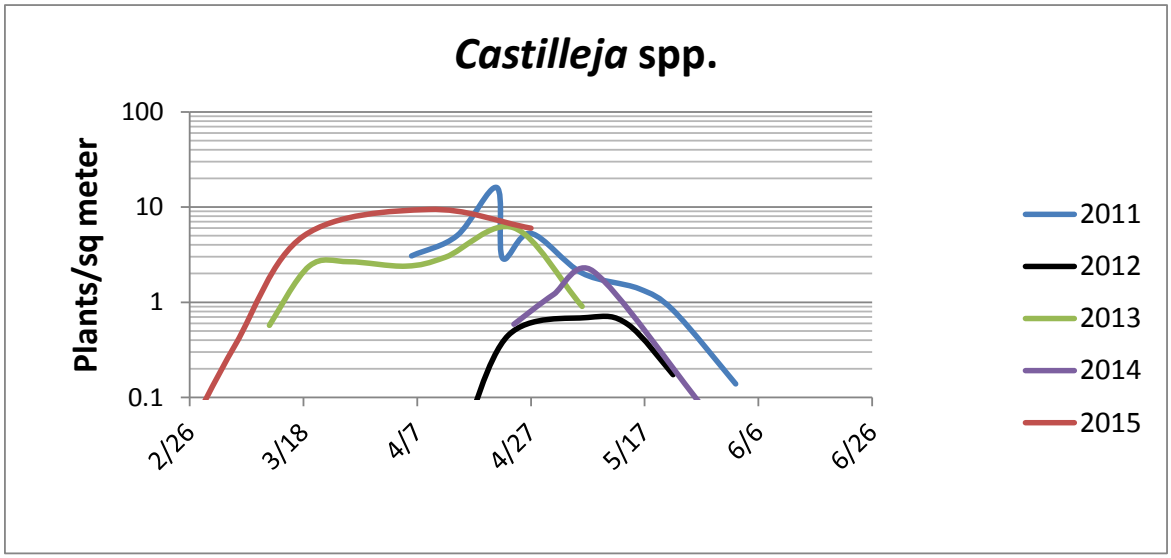


Figure 13. Edgewood nectar phenology

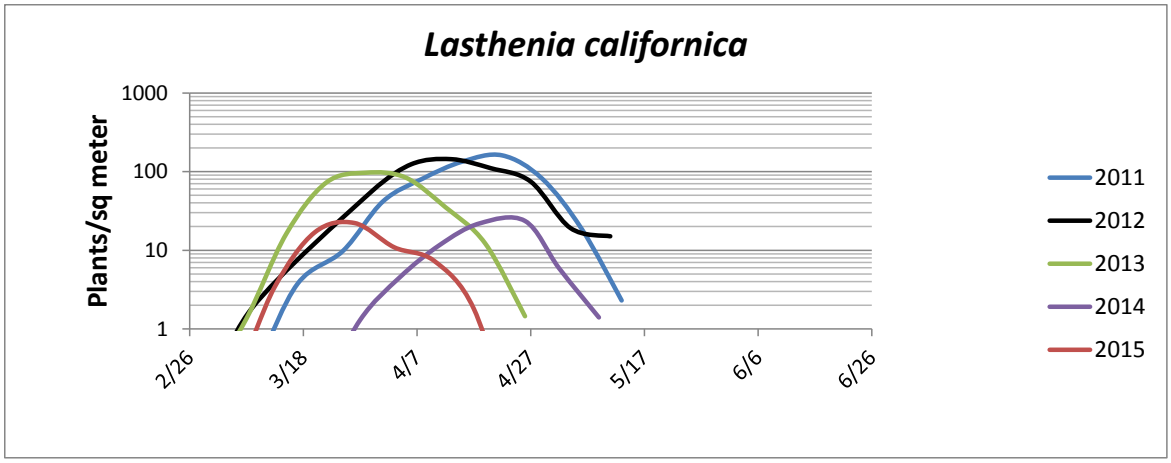


Figure 14. Kirby Canyon nectar phenology

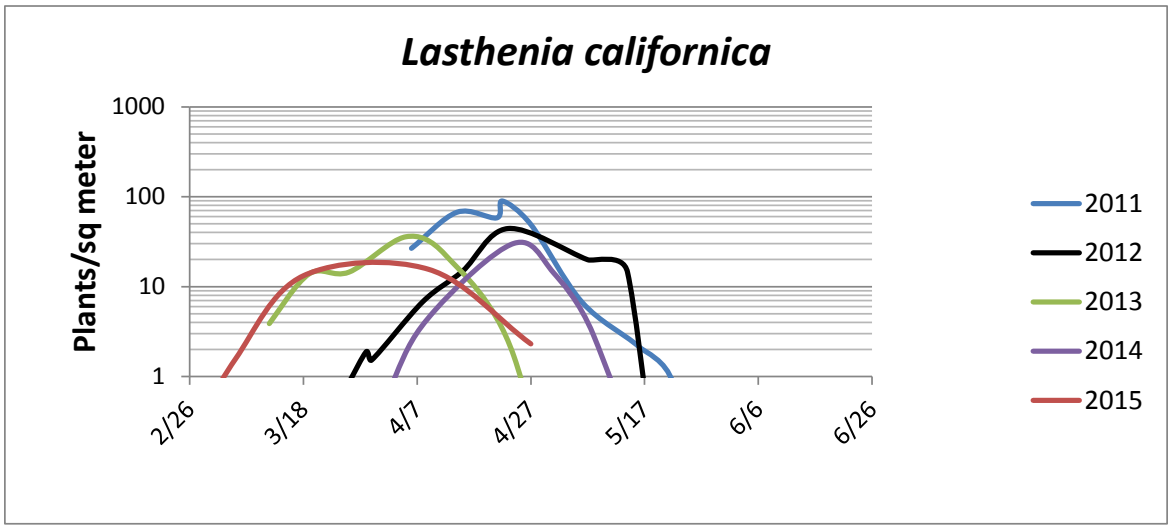


Figure 15. Edgewood nectar phenology

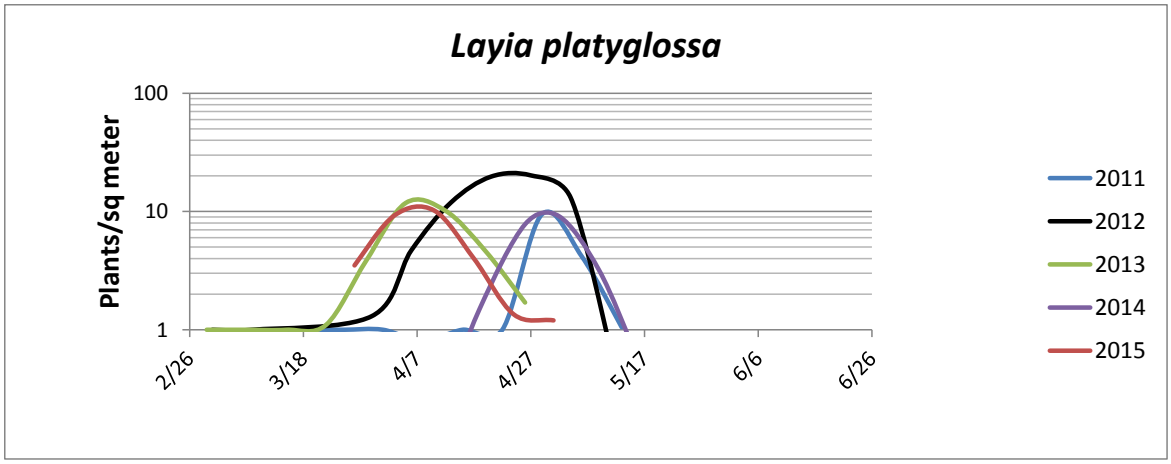
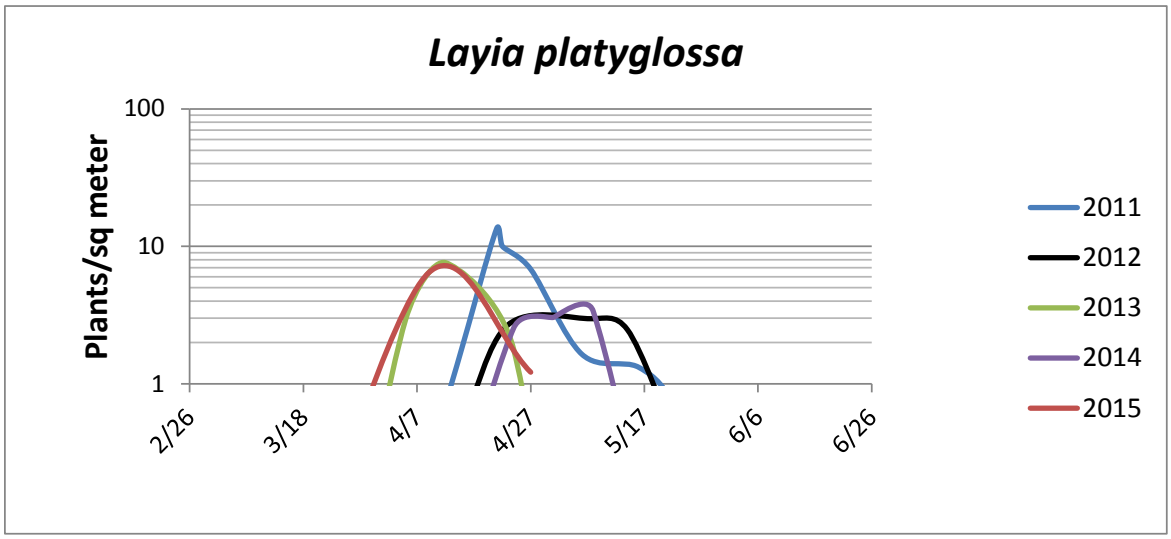


Figure 16. Kirby Canyon nectar phenology



Media

This project continues to attract attention, although on smaller scale this year.

Bay Nature

http://krcb.org/index.php?option=com_hwdmediashare&view=mediaitem&id=473&Itemid=484

Discussion and Next Steps

Bay checkerspot larval and adult numbers decreased this year, although they did remain relatively high. One concern is that numbers increased this year at Tulare Hill, where a related enhancement project is taking place. Tulare Hill has a larger habitat (~300 acres compared with Edgewood's 30 acres) and more topographic heterogeneity, including more steep, north facing slopes that may act as refuges when host plants dry out during warm spring weather.

As a general rule, prediapause larval survivorship increases substantially if host plants remain fresh three weeks or more after the midpoint of flight season, which was on March 17. April 7 is three weeks from that, and *Plantago erecta* plants at Edgewood were fresh until they end of the month, a very positive sign. *Castilleja,* the secondary host, was present at higher numbers this year. Nectar again appeared abundant during the flight season.

The down points to this season were decreasing larval and adult numbers, as well as low rainfall and high spring temperatures. Even with these negative factors, however, the early flight season relative to host plant senescence should be the key factor in determining how many post diapause larvae are present in early 2016. With about six weeks from peak flight to senescence, we may expect numbers to maintain or increase next year. The rotational mowing program continues to maintain high quality habitat.

The decision whether to continue translocations will be made in winter 2016. The decision will be based on post diapause larval numbers (expected in February-early March 2016, depending on weather), funding, and the population densities on Coyote Ridge collection areas. Postdiapause numbers should be within the historical range of variability (>2500 larvae). Funding and availability of dense populations on Coyote Ridge are interacting contingencies that determine the level of effort in collecting for translocation. Coyote Ridge densities will be sampled in February-early March depending on weather

We are also confronted with the balance between bolstering numbers with translocations, and allowing for local adaptation of the Edgewood population. The small size of the Edgewood habitat selects very strongly and quickly for sedentary adult butterflies and those that can recognize habitat edges. These behaviors have a strong genetic component (Ehrlich and Hanski 2004), and we may be swamping the selection process with large introductions each year. In addition, the limited topoclimatic diversity at Edgewood (no very cool steep north-facing slopes) means that the habitat is more highly exposed to the multi-year drought conditions from 2012-2015, and makes the population more reliant on good years for *Castilleja densiflora* (which generally requires high rainfall in December-January (SBW pers. obs.).

Yet, larger numbers do create a buffer against declines. Having observed the reintroduced population over five years now, we have not seen a year of positive population growth (prior to translocation) yet, and stopping translocation is risky if there are not sufficient numbers to allow for some population decline over several years before the population locally adapts. We have not made any final decisions yet, but will be looking closely at the data available at Edgewood, Jasper Ridge, and Coyote Ridge to better estimate the risks.

We remain grateful to our many partners who help with permitting, funding, management, and volunteer hours: the Edgewood Checkerspotters, U.S. Fish and Wildlife Service, San Francisco Bay Wildlife Society, San Mateo County Parks, Friends of Edgewood, California Native Plant Society, PG&E, and San Mateo County Parks Foundation.

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