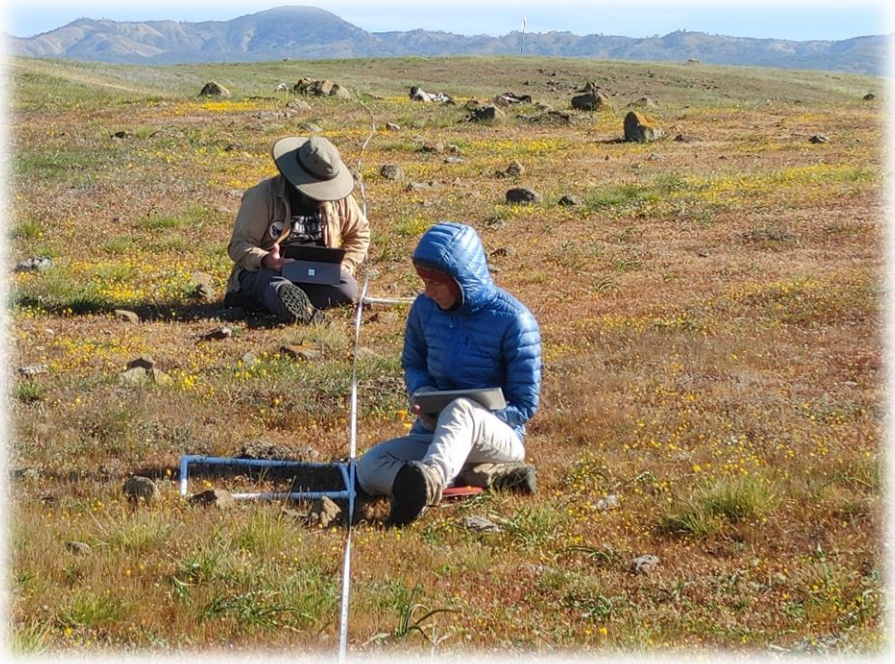
Coyote Ridge Open Space Preserve

BCB and Plant Species Composition Monitoring

Annual Report 2022



Prepared by:
Creekside Center for Earth Observation

Christal Niederer
Marissa Kent
Christopher Schwind
Stuart Weiss, Ph.D.

Creekside Science

Prepared for:
Santa Clara Valley Habitat Agency
535 Alkire Ave.
Morgan Hill, CA 95037
Attn: Julie King
December 2022

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Executive Summary

Coyote Ridge Open Space Preserve (CROSP) is 1,831 acres of mostly serpentine soil on Coyote Ridge in Santa Clara County. The Santa Clara Valley Open Space Authority (SCVOSA) purchased the property in 2015. The Santa Clara Habitat Agency (Habitat Agency) holds a conservation easement over 1,802 acres of CROSP. The conservation easement area is enrolled in the Santa Clara Valley Habitat Conservation Plan/Natural Community Conservation Plan (Habitat Plan) Reserve System. According to SCVOSA (2015), "The Coyote Ridge property encompasses one of the most significant wildlife habitat areas in the Bay Area. Because it contains nearly a fifth of the remaining undeveloped serpentine grassland habitat in Santa Clara County, its lasting protection is vital to the recovery of serpentine-dependent species including the federally threatened Bay checkerspot butterfly and federally endangered Metcalf Canyon jewelflower. For this reason, it is one of the top priorities for protection necessary to implement the Santa Clara Valley Habitat Conservation Plan's conservation strategy."

Creekside Center for Earth Observation (DBA Creekside Science) was tasked with monitoring Bay checkerspot butterfly (*Euphydryas editha bayensis*) larvae and adults, as well as related vegetation composition. A summary of monitoring results are as follows:

Weather. Annual and monthly precipitation and temperature patterns influence the reproductive success of Bay checkerspot butterfly and vegetation patterns. The previous year drives Bay checkerspot patterns, and the current year

drives vegetation patterns. The 2021 water year was an exceptional drought, with only 44% of average precipitation, the majority of it falling in January. The 2022 water year was also exceptionally dry, with only 63% of average precipitation, most of it falling early. 81% of the rain fell by the end of December 2021. Cool springs extend the availability of host plants for the Bay checkerspot butterfly. March 2021 was below average, while April 2021, March 2022, and April 2022 were slightly above average.

Grazing Regime. Tracking cattle stocking rates allows the correlation of grazing intensity with habitat characteristics. The stocking rates were similar to last year at the first and second rockfields. The fencelines at CROSP have been moved to more closely follow property boundaries.

Bay checkerspot butterfly. The ridgetop population complex extending from north of Metcalf Canyon to Anderson Dam is the core of the Bay checkerspot butterfly distribution, and the habitat on CROSP usually supports a high fraction of the overall Bay checkerspot butterfly population. In 2021, we estimated there were ~110,000 larvae on CROSP, which was 15% of the total Bay checkerspot butterfly population on Coyote Ridge. In 2022 that plummeted to ~11,800 larvae on CROSP, which was just under 5% of the total population, estimated at ~230,000 across Coyote Ridge. As recently as 2016, we estimated there were ~200,000 larvae on CROSP, about 25-50% of the entire population). The CROSP population is as low as we've recorded it, similar to the ~16,000 estimated in 2010. The total decrease in numbers can be attributed to extreme drought and warm spring temperatures that are likely drying up host plants before prediapause larvae are large enough to enter diapause during the hot, dry summer when they have no food sources. The above average temperatures of spring 2022 do not bode well for the 2023 larval season. Nearby Kirby Canyon Butterfly Reserve saw only a 10% decrease this year. At this point there is no reason to believe management is causing the larger decrease at CROSP relative to Kirby Canyon. Rather, this appears to be another example of metapopulation dynamics, where colonies within individual areas of a larger habitat fluctuate independently. This is an important process on Coyote Ridge. Adult numbers were down this year compared to last year's high, but were somewhat in line with 2018-2020 records. Compared with the very low numbers of larvae detected, the adult numbers overall show a more positive trend.

Plant Species Composition. BCB host plants were very low again this year but remain within the range of historical variability seen throughout Coyote Ridge. The combination of low host plants and low BCB numbers certainly bears ongoing monitoring. Annual grass cover has decreased over the last five years in the first rockfield, but has remained at similar values in the second rockfield (CROSP-South). Higher grazing pressure is desirable here.

Recommendations. Ongoing monitoring is critical to maintain the ability to manage this property and its covered taxa in an informed way. The Envoy Plus graminicide spraying experiment should continue. This should include retreating the 2021-2022 treatment area and targeting nonnative annual grasses, including barbed goatgrass. The highest concentration recommended by the label should be used. This treatment should improve habitat for BCB and native vegetation, as well as increase visual enjoyment for visitors. We envision such treatments taking place annually at new locations on the ridge, perhaps 2-4 acres a year. More intensive techniques such as mowing and seeding are not recommended at this time. Creating smaller "sacrifice" pastures that don't need to be grazed every year (i.e., off serpentine) could help keep grazing pressure up on the serpentine in years where forage is high and/or herd numbers are low. We concur with Richard Harris's (2021) recommendations to introduce prescribed fire on a trial basis, perhaps as training opportunities for fire agencies. More recommendations are included within the text of this report.

With all its multiple covered taxa and connectivity to adjacent rich habitats, CROSP is an excellent addition to the Habitat Plan's reserve system. CROSP remains one of the best locations to view many of the Habitat Plan's covered species. Creekside Science looks forward to future monitoring and studies on CROSP.

Weather

Interannual changes in California annual grassland habitats tend to be driven by climatic variation (D'Antonio et al. 2006), and Bay checkerspot butterfly habitat is no exception. Because weather can be a more important factor affecting habitat than management, we present yearly precipitation data here.

These data are presented for the Kirby Canyon Butterfly Reserve, located on Coyote Ridge about 1600 m south of CROSP. From 1981 to 2010 (which we will consider a baseline), they show average precipitation at 58.9 cm, with a standard deviation of 22.5 cm. Each weather year runs from October 1 to September 30. Total precipitation in 2022 was well below average at 37.1 cm (WestMap 2022) (Figure 1).

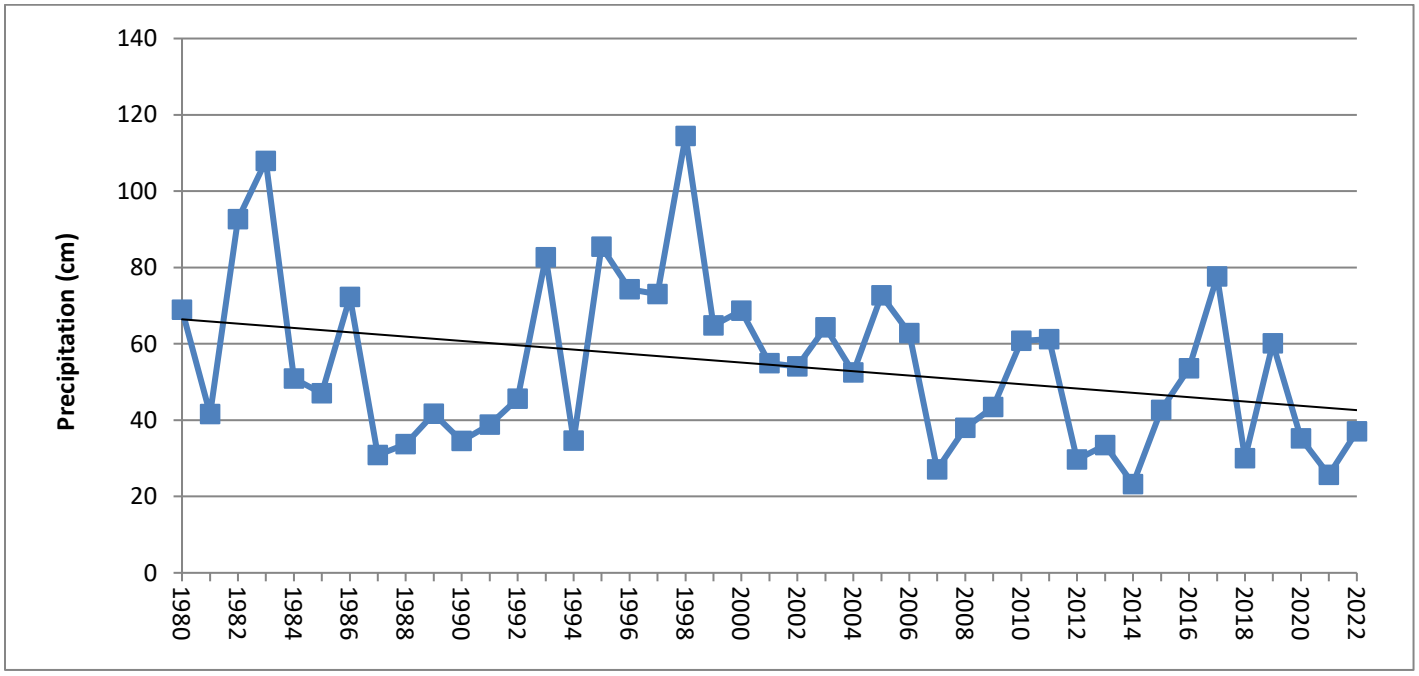


Figure 1. Annual precipitation at Kirby Canyon (WestMap 2022, 2021, 2020, 2019, 2018), with trendline

Perhaps more important than total precipitation is the pattern of precipitation, which also varies widely. Similar amounts of rainfall have different effects on Bay checkerspot butterflies and associated vegetation depending on when it occurs. For example, early rains are usually beneficial as germination events induce Bay checkerspots to emerge from diapause, while heavy rains during the flight season could limit reproductive success.

Monthly patterns for 2021 and 2022 are shown in Figures 2-3. Two years are shown because the previous year drives Bay checkerspot patterns, and the current year drives vegetation patterns.

The 2021 water year was very dry at 25.7 cm, which is about 44% of average. Precipitation only fell in November through April and was well below average (and well below 5 cm) for all these months except for January, where precipitation was slightly above average at 14.8 cm. The last precipitation fell on April 26.

In 2022, precipitation was higher than last year at 37.1 cm, but was still only about 63% of average. The pattern of precipitation was heavily weighted to the beginning of the water year. An unusual 10.7 cm fell in October, and 18.1 cm fell in December. In fact, 81% of the 2022 water year precipitation fell October-December 2021. Almost no rain fell January-March, but April rains extended the growing season for many taxa. The 2.1 cm that fell in September is

technically included in this water year, but certainly had no effect on the vegetation and BCB results reported here for earlier in the year.

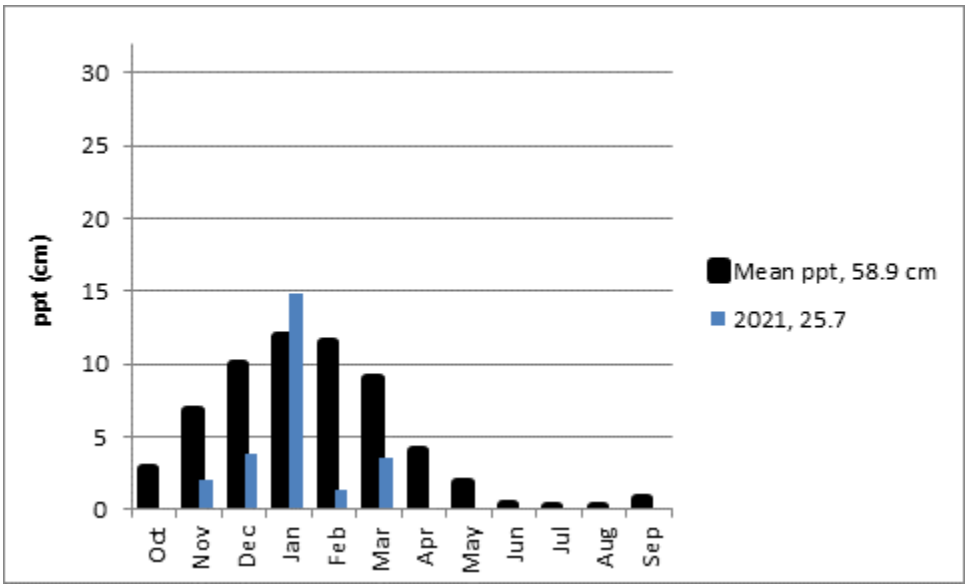


Figure 2. 2021 precipitation compared with average (WestMap 2021)

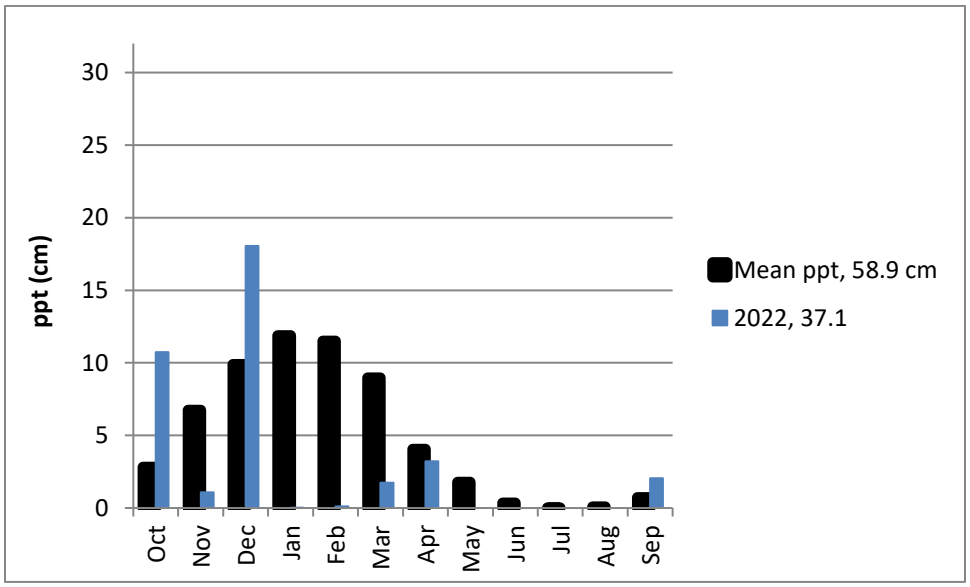


Figure 3. 2022 precipitation compared with average (WestMap 2022)

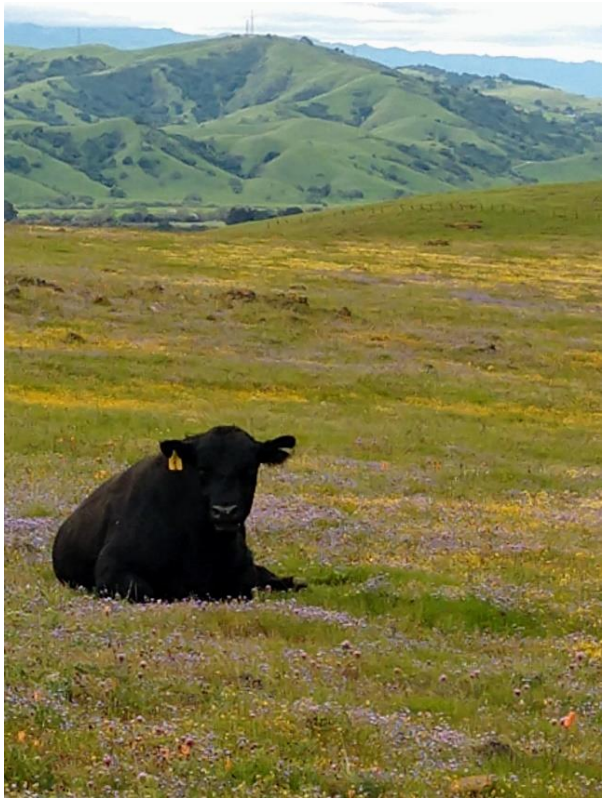
Temperature can be as important as rainfall, especially in the context of Bay checkerspot host plants. Cool springs extend the availability of host plants, greatly increasing the likelihood that pre-diapause larvae get large enough to enter diapause before their host plants dry up and they starve to death. This is the largest source of mortality in Bay checkerspots. It is key to note that April 2021, March 2022, and April 2022 were warmer than average. Other factors being equal, the warm months could decrease larval survivorship into 2023 (Table 1). Note that 2022 temperatures are relevant only to 2023 larval numbers and are presented here to assist larval predictions.

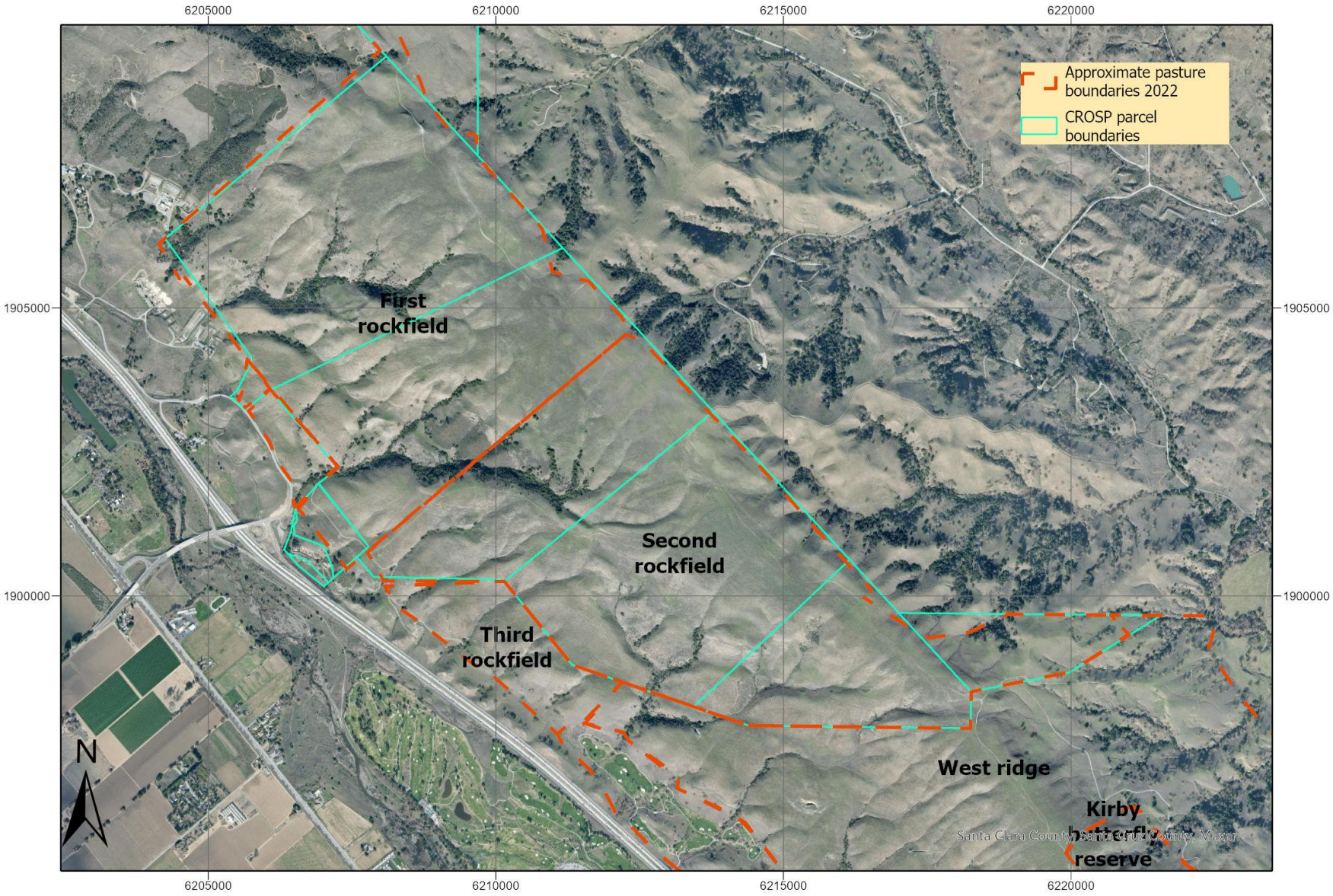
	March	April
2015	21.9	19.9
2016	18.5	20.7
2017	18.8	19.1
2018	16.5	20.2
2019	16.3	21.4
2020	16.1	20.3
2021	16.8	21.0
2022	20.3	21.1
Average 1981-2010	**18.2**	**20.6**

Table 1. Coyote Ridge maximum temperatures (˚C) compared with average (WestMap 2022, 2021, 2020, 2019, 2018)

Grazing Regime

Tracking cattle stocking rates on CROSP allows the correlation of grazing intensity with habitat characteristics. A fence realignment project conducted by SCVOSA was completed in early 2022, which now more closely matches fencelines and property boundaries (Map 1). There are two main pastures that make up the vast majority of CROSP, both of which are a little more than 800 acres (Table 2). Rancher Justin Fields is the cattle grazing tenant for these pastures, known as the first and second rockfields. Both pastures are now entirely on CROSP. The west ridge pasture to the south is now off CROSP. The small triangular parcel in the north is part of a larger pasture also grazed by Justin Fields. Because it is small and off the serpentine soils that support the covered taxa investigated in this report, it is not discussed here. Stocking rates for the two pastures are shown in Tables 3-4. Longer-term data can be accessed for the second rockfield and the west ridge for historical context in the baseline report.





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Map 1. New CROSP pasture boundaries more closely reflect property lines

Pasture	Total acres	Previous acreage
First rockfield	834	840
Second rockfield	822	810

Table 2. Total pasture acreage

Year	Regime
2016	57 cow/calf pairs from Feb. 19 to May 24; 113 dry cows June 15 to Aug. 8.; 93 dry cows Aug. 9 to Sep. 30
2017	38 cow/calf pairs Mar. 10 to May 10; 99 dry cows June 17 to Sep. 1
2018	99 cow/calf pairs April 1 to May 1; 102 dry cows June 1- Sep. 1
2019	102 cow/calf pairs April 1 to May 9; 93 dry cows June 24 to Sep. 15
2020	91 cow/calf pairs April 1 to May 8; 92 dry cows June 2 to Oct 1; 46 dry cows Oct 1 to Dec. 1
2021	89 cow/calf pairs May 23 to Sep. 15
2022	88 cow/calf pairs March 1-April 18; 75 dry cows April 22-June20; 84 dry cows June 22-Aug 25

Table 3. Grazing regime at first rockfield

The stocking rate in the first rockfield was similar to 2021.

Year	Regime
2016	69 cow/calf pairs from Feb. 25 to May 26. 93 dry cows Sep. 30 to Nov. 30
2017	87 cow/calf pairs from March 10 to May 10; 99 dry cows Sep. 1 to ~Nov. 30
2018	99 cow/calf pairs Feb. 1 to April 1; 102 pairs Sep. 1 to Nov. 1
2019	102 cow/calf pairs Feb. 8 to April 1; 91 pairs Sep. 5 to Nov. 25
2020	91 cow/calf pairs Feb. 3 to April 1; 45 dry cows Oct 1 to Dec. 1
2021	92 cow/calf pairs Feb. 15 to April 28; dry 89 cows Sep. 15 to Oct. 31
2022	84 dry cows Aug 25-Nov 1

Table 4. Grazing regime at second rockfield

The timing of grazing changed in the second rockfield this year because a new pasture, the third rockfield, was created with the fence alterations. The herd grazed in this third rockfield, which previously had been inside the second rockfield, from April to June.

Bay Checkerspot Butterfly

The Bay checkerspot butterfly is a federally threatened subspecies. A member of the family Nymphalidae, it is a medium-sized butterfly with a wingspan of about 5 cm. The wings have black bands with orange and white spots. It is an annual, univoltine taxon (USFWS 1998). It is closely associated with serpentine grasslands, which support its larval food plants (dwarf plantain and owl's clover) and various adult nectar sources. The grazing program at CROSP is intended to manage the serpentine grasslands on the property specifically for the benefit of this species and for rare, serpentine-associated plants. Bay checkerspot numbers are naturally prone to large fluctuations. Per the Habitat Plan, the baseline will consist of an average of the first five years (but additional years if determined necessary by the qualified biologist, see Appendix D, *Monitoring Protocols*, Section D.3.1, *Bay Checkerspot Butterfly*) of annual monitoring data for Bay checkerspot butterfly host and nectar plants and post-diapause larvae and adult butterflies. The baseline may also incorporate existing data to reduce overlap in the survey efforts for efficiency.

Previous larval surveys on CROSP go back intermittently into the 1990s, and are consistent since 2008, so there is actually a 10-year baseline that includes population booms and crashes. These methods have been peer-reviewed and provide statistically rigorous population estimation. The population means necessarily are geometric means, because populations function on a logarithmic scale.

Adult surveys are discussed below and are primarily useful to establish occupancy when larval densities are too low to reliably detect using our standard methods. That said, larval densities don't always match adult densities due to large variation in larval mortality from year to year. Weather can also differently affect the length of larval or adult flight seasons within a given season. For this reason, the adult surveys are quite useful in understanding the link between the two. Further adult surveys on CROSP would help to inform these discrepancies.

Methods

Post-diapause larvae

The basic method of population estimation is timed counts of larvae in a stratified sampling design (Murphy and Weiss 1988, Weiss 1996). The habitat is stratified into thermal strata based on March 21 insolation values calculated in GIS. The 5 strata are: Very Warm (>18 MJ/m^2), Warm (16.50-18), Moderate (15 -16.49), Cool (13-14.99), and Very Cool (<13).

Larvae are counted in 10 person-minute intervals over irregularly shaped sample areas (0.25-1 ha) corresponding to patches of relatively uniform insolation, and the counts are converted into density by the equation:

$$\ln(\text{density}) = -4.33 + 0.88*\ln(\text{count}),\ n = 13,\ r^2 = 0.85 \text{ (Weiss 1996)}$$

Larval sample sites are distributed across the landscape and grouped into "population zones" in which average densities and absolute numbers are estimated. These correspond to natural breaks in the landscape, modified locally by property lines for regulatory purposes. If no larvae are found in a population zone, then surveys for adults are conducted to establish presence or absence.

95% confidence intervals on the mean density in each population zone were calculated from methods referenced in Weiss 1996. In cases where low counts caused the symmetrical lower confidence interval to drop below 0, the interval was calculated using a general linear model using a Poisson distribution in JMP 14. A total of 72 plots were sampled across

CROSP in 2022. The CROSP property is divided into multiple population zones, with the majority of larval plots being in CROSP North, South, and Border (Map 2). Forty-nine plots are within those three population zones (Table 5). These are areas where historical population estimates and confidence intervals have been calculated, and provide continuous time series back to 2008, and discontinuous series ranging back into the 1990s. Additional areas where population estimates are calculated include the Kirby Canyon Butterfly Reserve, Young Ranch, and four zones on VTA. Reports that include these estimates and time series can be provided upon request.

The remaining plots (23) fall outside these zones and have not been integrated into population estimates (yet). Furthermore, note that some additional plots straddle boundaries with LTSCV and VTA parcels. These sites establish breeding occupancy and a local density estimate for the plots, but an integrated population density is not feasible across these areas because of low sample sizes. Annual overall occupancy of the plots sampled each year is reported for the 2008-2022 period.

Zone	CROSP North	CROSP South	CROSP Border	Other	Total
# Plots	20	19	10	23	72

Table 5. Larval plots per population zone

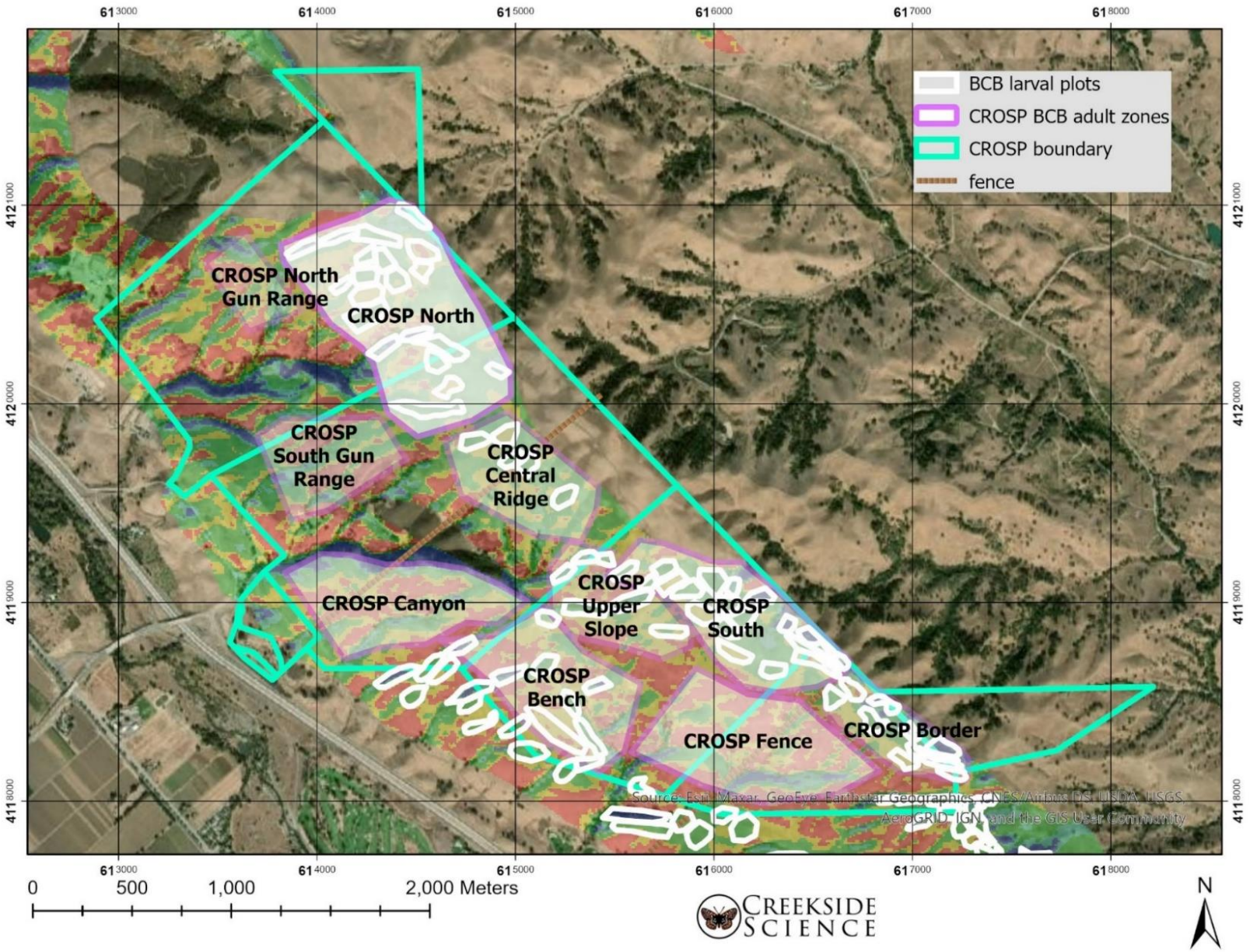
Adults

Bay checkerspot butterfly populations are best quantified through larval monitoring. Adult monitoring supplements larval surveys, and also better informs predictions for the following year's populations. Presence/absence adult surveys will be conducted if no larvae are found in any of the six BCB zones that contain larval plots in Map 2. Presence/absence surveys will take place in the four additional zones that don't have larval plots. We established transects that encompass topoclimatic variation with a focus on north-facing slopes and hilltops where adults are most locally abundant.

No larvae were found in the CROSP South and Bench zones in 2022. The Bench zone had no larvae in 2008, and the South zone has been occupied since 2001. Therefore, adult surveys were conducted in the four zones that do not contain larval plots, plus CROSP South. Adults were confirmed within 100 m of CROSP Bench during on the LESVP parcels, so no separate survey was conducted to establish occupancy.

The transects are visited during peak flight season, on sufficiently warm (65°F +) and preferably sunny days (less than ~50% cloud cover) with winds less than 15 mph. When searching for presence (rather than abundance), sufficiently high temperature and low wind speed are more important than cloud cover, as BCB do fly in good numbers on warm, calm days, even when it is cloudy. Transects will be visited up to three times if no adults are encountered. Observer walks the transects with a pace of about 90 seconds/50 meters, noting adult BCBs within ~5 meters of the transects, stopping to take a GPS point for each butterfly observed. Once the transect loop is completed, the total walking time is recorded. Maps showing the locations of any adults noted during surveys will be provided, as well as a table of the dates and butterfly encounter rates (butterflies per hour).

The adult surveys were completed on March 11, 2022. Weather was ideal, warm with lots of sun and only a slight breeze present.



Map 2. Larval population zones on CROSP with four additional adult monitoring zones in areas without larval plots

Results

Post-diapause larvae

The number of larvae found per 10-minute search in 2022 is shown in Maps 3-4. In 2022, 37 out of 49 plots in larval zones along the ridgeline were unoccupied (compared with two in 2021, zero in 2020, six in 2019, and 13 in 2018). The mid-elevations were largely unoccupied, and the low elevations were totally unoccupied.

Defined population zones

CROSP North decreased significantly this year. The 2022 estimate is 1500 (930-2355). This is the lowest estimate on record. This zone has historically had some of the highest densities of larvae on Coyote Ridge, with a peak estimate of 740,000 ± 280,000 in 2015 (Figure 4a), and has dipped to as low as ~5,000 larvae in 1993 and 2010 (Table 6).

At CROSP South, no larvae were found. Because an adult was located later in the season, we know the area was occupied. We would expect the butterflies to recover eventually in the area, but this is still a concern. Larvae were found just southeast of this area in CROSP Border (10,000 estimated), as well as west downslope. Adult butterflies will disperse in over time. If/when phenology is favorable, the population could rapidly increase. We have observed areas devoid of larvae for several years become reoccupied over subsequent years. Only time will tell. The peak estimate in this zone was 98,000 ± 30,000 in 2015 (Figure 4b), and the lowest estimates were 1,700 ± 1,000 larvae in 1997, and 5,000 ± 2,600 in 2011 (Table 6).

At CROSP Border, numbers decreased to 10,300 ± 8300. Even with this low number, this was the larval zone with the highest larval population. The peak estimates in this zone were 137,000 ± 85,000 in 2003, and 118,000 ± 68,000 in 2015 (Figure 4c) – the difference is not statistically significant. The lowest estimate in CROSP border was 2,800 ± 1,800 larvae in 2010 (Table 6). As documented in the methods section, the Poisson method was used in these three cases due to low counts that caused the symmetrical lower confidence interval to drop below 0.

The total number of larvae within the three defined population zones across the CROSP property plummeted in 2022 to 11,800 ± 8600. This is down tenfold from 112,000 ± 47,000 in 2021, and 182,000 ± 58,000 in 2020. This year is lower than the previous low of 16,000 ± 6,600 in 2010, and of course the previous high of 950,000 ± 310,000 in 2015 (Table 6).

	CROSP North	CROSP South	CROSP Border	Overall	Trend
2008	42,000 ± 31,000	11,000 ± 8,200	5,500 ± 3,459	58,000 ± 33,000	n/a
2009	32,000 ± 19,000	15,000 ± 7,400	10,000 ± 7817	52,000 ± 22,000	Stable
2010	4,400 ± 4000	12,000 ± 8,200	2,800 ± 1,800	16,000 ± 6,600	Decrease
2011	48,000 ± 37,000	5,000 ± 2,600	2,900 ± 3,200	56,000 ± 37,000	Increase
2012	110,000 ± 55,000	11,000 ± 5,600	7,900 ± 4,400	130,000 ± 56,000	Increase
2013	230,000 ± 83,000	28,000 ± 15,000	93,000 ± 73,000	350,000 ± 130,000	Increase
2014	330,000 ± 158,000	69,000 ± 37,000	46,000 ± 3,1000	440,000 ± 170,000	Stable
2015	740,000 ± 280,000	98,000 ± 30,000	118,000 ± 68,000	950,000 ± 310,000	Increase
2016	151,000 ± 81,000	30,000 ± 14,000	10,000 ± 7,000	200,000 ± 82,000	Decrease
2017	59,000 ± 36,000	6,000 ± 2,000	3,310 (650-16,711)*	70,000 ± 36,000	Decrease
2018	47,000 ± 42,000	10,000 ± 6,000	7,800 (2,900-21,000)*	62,000 ± 43,000	Stable
2019	200,000 ± 125,000	95,000 ± 56,000	11,000 (5000—25,000)*	307,000 ± 138,000	Increase
2020	88,000 ± 53,000	67,000 ± 18,000	28,000 ± 14,000	182,000 ± 58,000	Decrease
2021	61,000 ± 43,000	15,000 ± 7,000	35,600 ± 17,600	112,000 ± 47,000	Decrease
2022	1500 (930-2355)*	present	10,300 ± 8300	11,800 ± 8600	Decrease

* an asymmetric CI using a Poisson approximation because of low numbers

Table 6. Integrated population estimate by Defined Population Zone

Overall occupancy trends are shown in Table 7.

Year	CROSP North	CROSP South	CROSP Border	Overall (sum of three zones)	Overall Occupancy Trend
2008	100% 14/14 Occupied	79% 11/14 Occupied	55% 5/9 Occupied	81% 30/37 Occupied	n/a
2009	100% 17/17 Occupied	82% 14/17 Occupied	90% 9/10 Occupied	91% 40/44 Occupied	Increase
2010	50% 7/14 Occupied	71% 12/17 Occupied	55% 5/9 Occupied	60% 24/40 Occupied	Decrease
2011	96% 19/20 Occupied	79% 15/19 Occupied	50% 5/10 Occupied	80% 39/49 Occupied	Increase
2012	100% 20/20 Occupied	84% 16/19 Occupied	80% 8/10 Occupied	90% 44/49 Occupied	Increase
2013	100% 20/20 Occupied	100% 19/19 Occupied	100% 10/10 Occupied	98% 48/49 Occupied	Increase
2014	100% 20/20 Occupied	89% 17/19 Occupied	100% 10/10 Occupied	96% 47/49 Occupied	Decrease
2015	100% 20/20 Occupied	100% 19/19 Occupied	100% 10/10 Occupied	100% 49/49 Occupied	Increase
2016	100% 20/20 Occupied	100% 19/19 Occupied	70% 7/10 Occupied	92% 45/49 Occupied	Decrease
2017	100% 20/20 Occupied	84% 16/19 Occupied	70% 7/10 Occupied	86% 42/49 Occupied	Decrease
2018	95% 19/20 Occupied	84% 16/19 Occupied	30% 3/10 Occupied	78% 38/49 Occupied	Decrease
2019	100% 20/20 Occupied	89% 17/19 Occupied	60% 6/10 Occupied	88% 43/49 Occupied	Increase
2020	100% 20/20 Occupied	100% 19/19 Occupied	100% 10/10 Occupied	100% 49/49 Occupied	Increase
2021	100% 20/20 Occupied	95% 18/19 Occupied	90% 9/10 Occupied	96% 47/49 Occupied	Decrease
2022	20% 4/20 Occupied	0% 0/19 Occupied	80% 8/10 Occupied	24% 12/49 Occupied	Decrease

Table 7. Percent of surveyed plots occupied

Some weather patterns and population trends are shown in Table 8. The reader is reminded that larval populations are most affected by the previous year's weather patterns. A comprehensive analysis is not possible at this point with this short data series and would be a much larger effort than the scope of this report allows.

Year	Integrated BCB Larval Population Estimate	Rainfall (cm)	Coyote Ridge maximum temperatures (˚C)	
			March	April
2008	58,000 ± 33,000	37.9	19.4	21.7
2009	52,000 ± 22,000	43.4	18.1	20.9
2010	16,000 ± 6,600	60.8	18.7	18.2
2011	56,000 ± 37,000	61.2	16.6	19.6
2012	130,000 ± 56,000	29.6	15.9	18.5
2013	350,000 ± 130,000	33.4	19.6	21.7
2014	440,000 ± 170,000	23.3	19.9	20.3
2015	950,000 ± 310,000	42.6	21.9	19.9
2016	200,000 ± 100,000	53.6	18.5	20.7
2017	70,000 ± 35,000	77.7	18.8	19.1
2018	62,000 ± 43,000	30.0	16.5	20.2
2019	307,000 ± 138,000	59.7	16.3	21.4
2020	182,000 ± 58,000	35.2	16.1	20.6
2021	112,000 ± 47,000	25.7	16.8	21.0
2022	11,800 ± 8600	37.1	20.3	21.1
Average 1981-2010		58.9	18.2	20.6

Table 8. Comparison of integrated population estimate and weather

Outside defined population zones – 2016-2022

At CROSP Central Ridge, only one larva was found, indicating a population of up to 100 larvae/hectare. Counts in 2021 ranged from 6 to 40 larvae, corresponding to 600-3400 larvae/hectare. Counts in 2020 ranged from 8-66 larvae corresponding to 800-5,300 larvae/hectare. In 2019, counts ranged from 18-264 larvae corresponding to 1,700-18,000 larvae/hectare. In 2018, counts ranged from 4 larvae to 68 larvae/plot corresponding to 400-5,400 larvae/ha. In 2017, counts ranged from 4-84 larvae/plot corresponding to 400-6,500 larvae/ha. Counts in 2016 ranged from 1-115 larvae/plot corresponding to 130-8,600 larvae/ha.

At CROSP Upper Slopes, only three larvae were found, indicating a population of up to 300 larvae/hectare. Counts in 2021 ranged from 2 to 58 larvae, corresponding to 200-4700 larvae/hectare. In 2020, counts ranged from 7-130 larvae/plot, corresponding to densities of 700-9500 larvae/hectare. In 2019, counts ranged from 0-79 larvae/plot, corresponding to densities <100 to 6,250 larvae/hectare. In 2018, these numbers ranged from 0-23 larvae/plot, corresponding to densities <100 to 2,100 larvae/hectare. In 2017, these numbers ranged from 0-7 larvae/plot, corresponding to densities <100 to 700 larvae/hectare. Counts in 2016 ranged from 9-31 larvae/plot, corresponding to densities of 900-2,800 larvae/hectare.

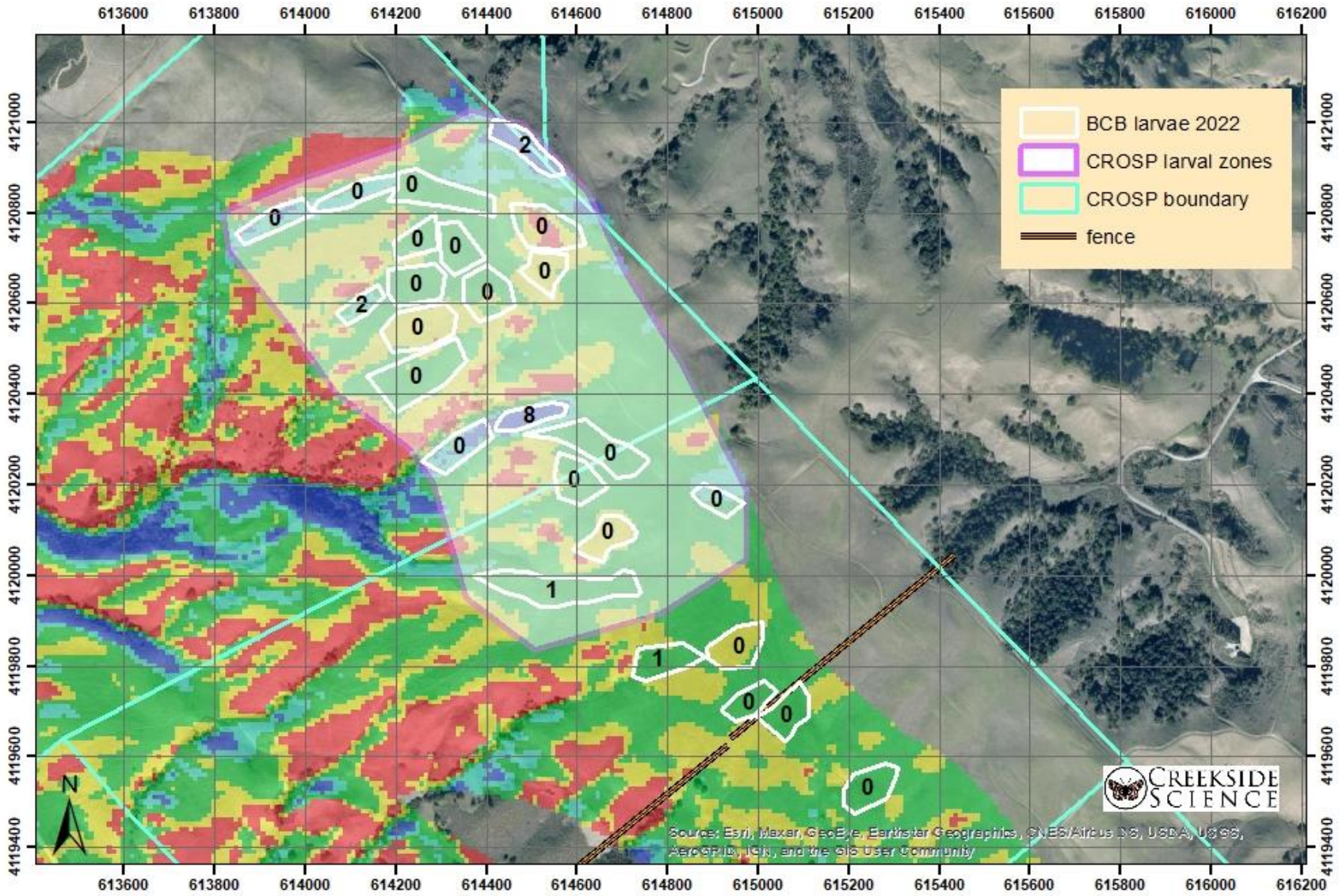
No larvae were found at CROSP Bench in 2022. Adults were found within 100 m at the adjacent LESVP parcels, indicating local presence in the low hundreds. Densities across the lower slopes of CROSP Bench in 2021 ranged from 0 to 23 larvae, corresponding to densities <100 to 2,000 larvae/hectare. In 2020, counts ranged from 0-39 larvae/plot, corresponding to densities <100 to 3300 larvae/hectare. As in the other zones, densities across the lower slopes of CROSP Bench increased in 2019 to 1-7 larvae/plot, corresponding to 100-700 larvae/hectare. Numbers in 2016, 2017, and 2018 were similar, with counts ranging from 0-4 larvae/plot, corresponding to densities <100 to 400 larvae/hectare in those three years. No larvae were found in this zone in 2008.

The remainder of CROSP was not surveyed for larvae, and adult surveys took place instead.

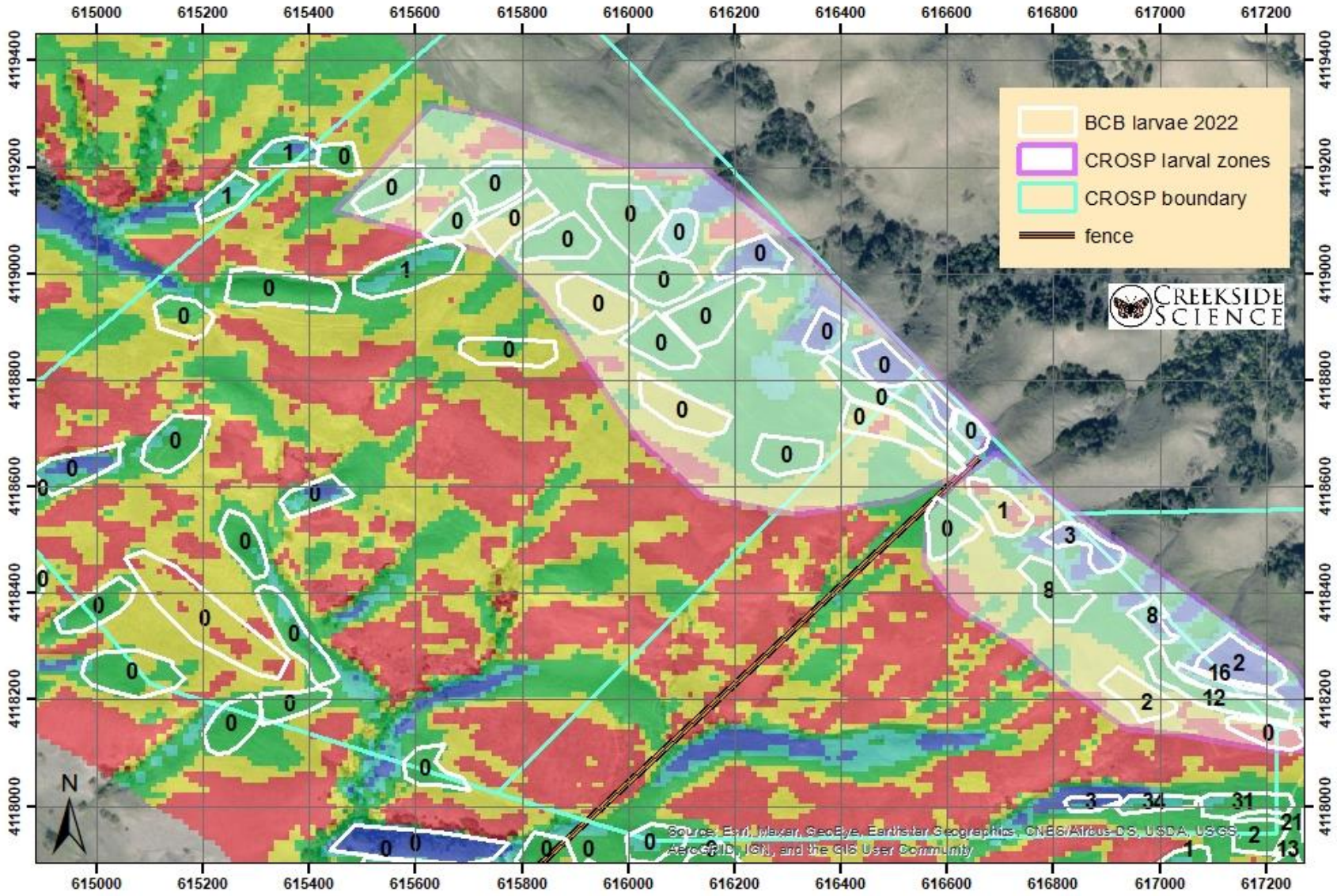
Occupancy trends outside the defined population zones are shown in Table 9.

Year	CROSP Outside Zones	Overall Occupancy Trend
2008	60% 6/10 Occupied	n/a
2009	44% 7/16 Occupied	Stable
2010	18% 2/11 Occupied	Decrease
2011	33% 6/18 Occupied	Increase
2012	50% 9/18 Occupied	Increase
2013	75% 15/20 Occupied	Increase
2014	90% 18/20 Occupied	Increase
2015	90% 19/21 Occupied	Stable
2016	75% 15/20 Occupied	Decrease
2017	62% 13/21 Occupied	Decrease
2018	62% 13/21 Occupied	Stable
2019	81% 17/21 Occupied	Increase
2020	87% 20/23 Occupied	Increase
2021	96% 22/23 Occupied	Increase
2022	30% 7/23 Occupied	Decrease

Table 9. Percent of surveyed plots occupied



Map 3. Larval counts (# per 10 person-minutes) at CROSP North in 2022



Map 4. Larval counts (# per 10 person-minutes) at CROSP South (left) and CROSP Border (right) in 2022

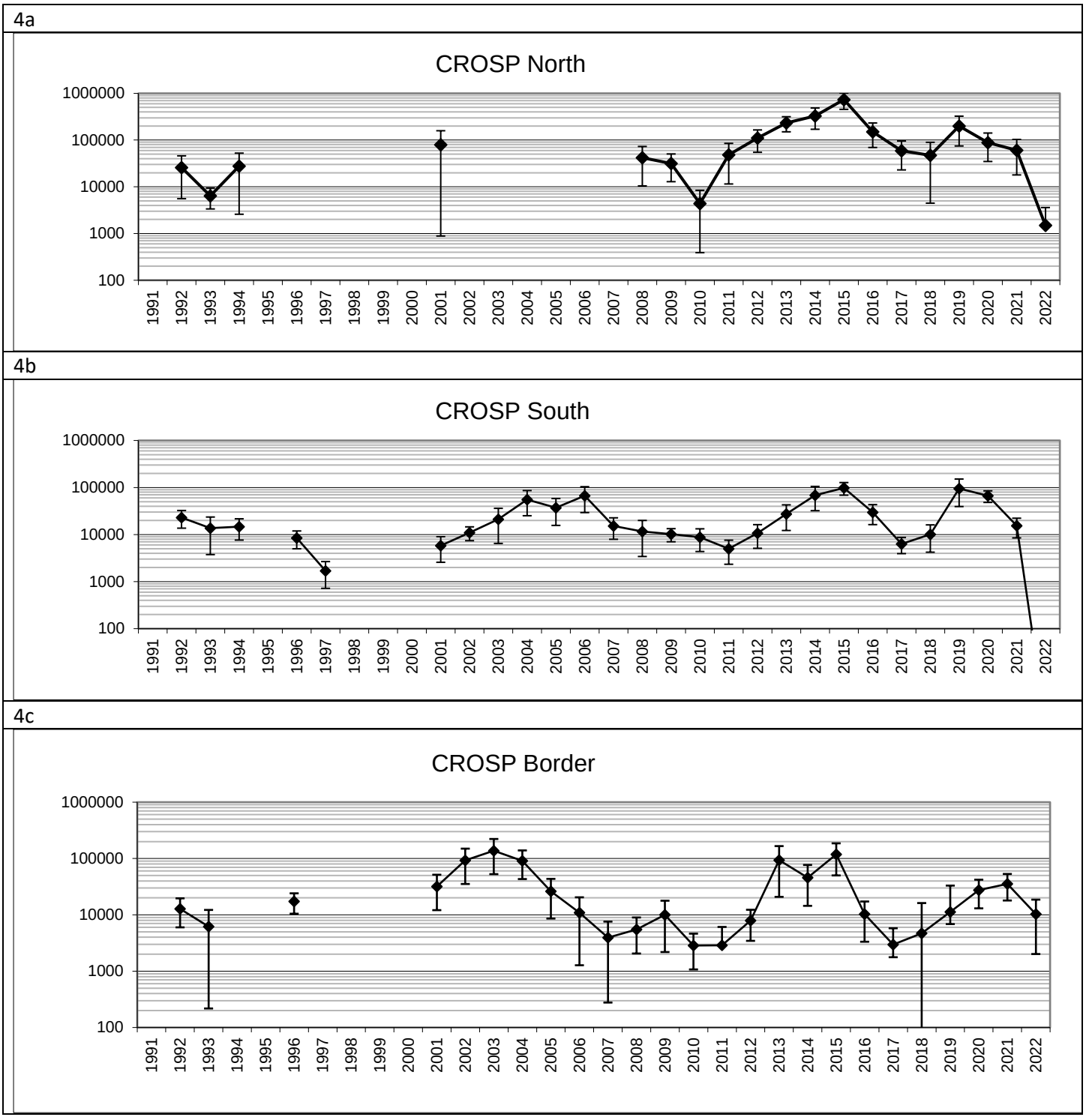


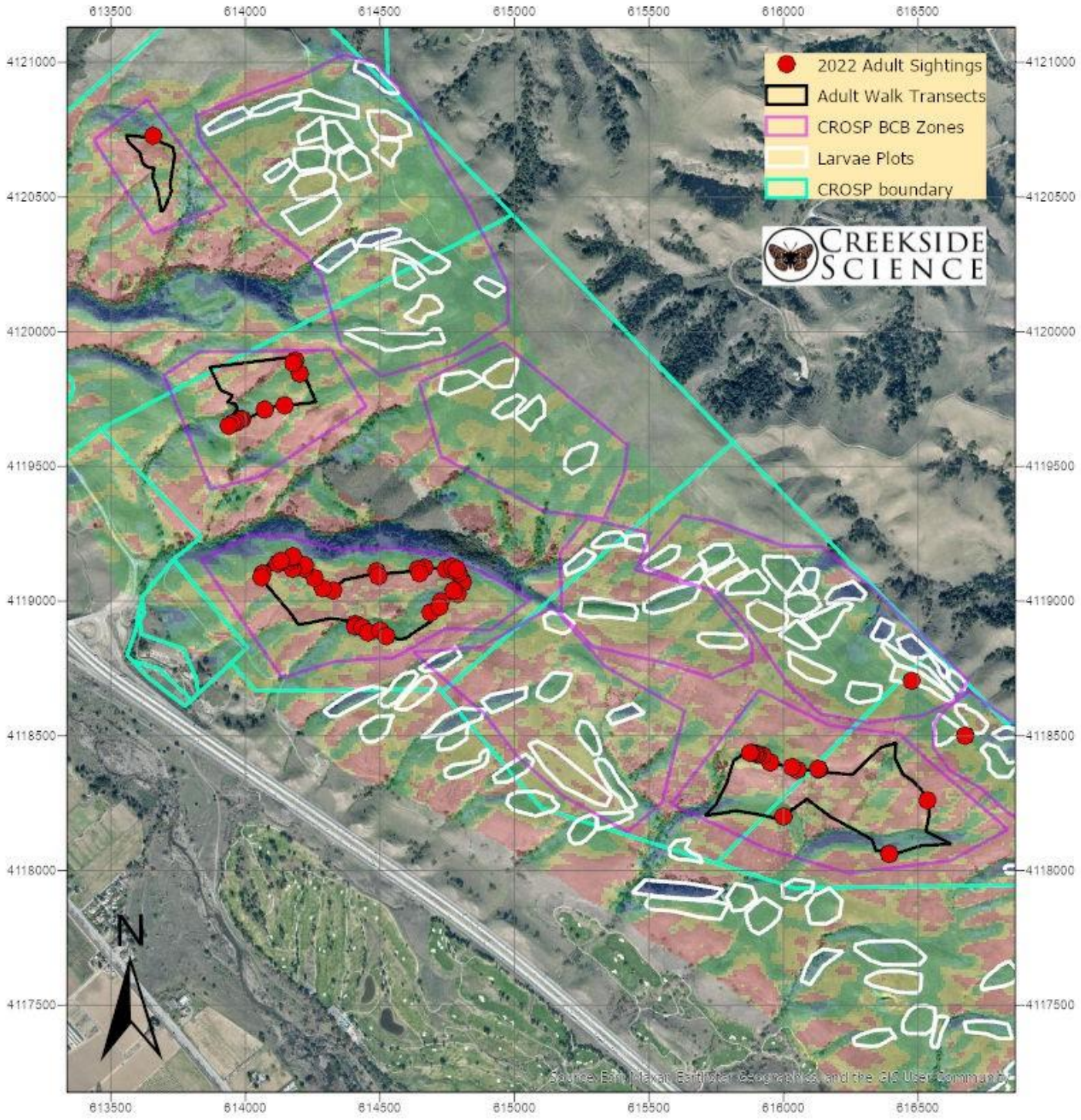
Figure 4a-c. Bay checkerspot population history on CROSP, ± 95% CI

Adults

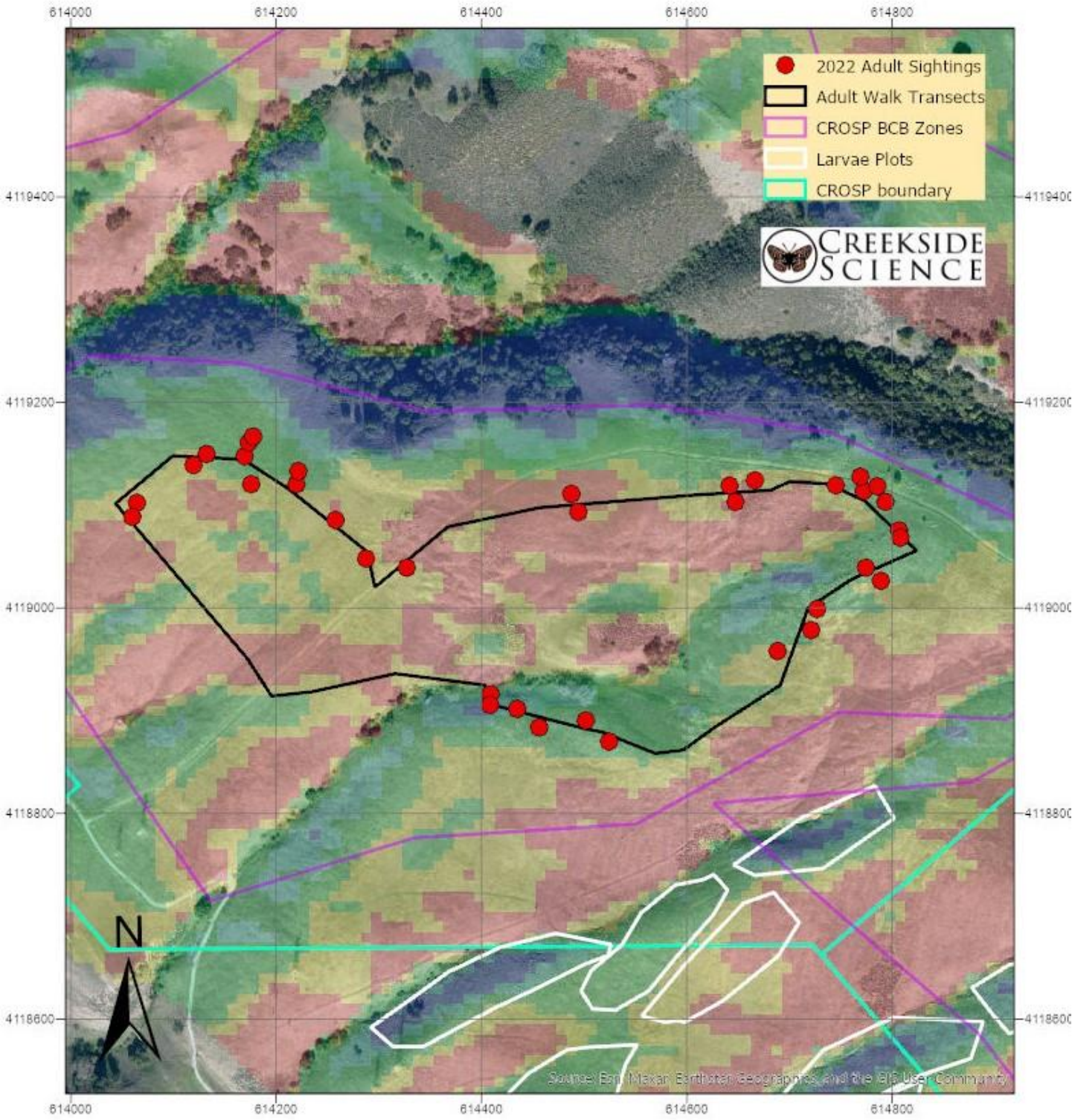
Adults were encountered on each of the four transects on the first visits. Multiple adults were seen on three of the transects, but only one adult was seen at CROSP North Gun Range. The locations of each of these sightings is provided in Maps 5-9. The encounter rates at all transects were a lot lower than the high rates seen in 2021, although they are a mixed bag compared with 2018-2020. North Gun Range is at an all-time low, while CROSP Canyon is higher than those years. The other two are on the low end, but mostly similar (Table 10). Additionally, because no larvae were detected in the CROSP South Larval Zone, we mapped adult presence there during flight season (Map 5).

Transect	2022 Encounter Rate (butterflies/hr)	2021 Encounter Rate	2020 Encounter Rate	2019 Encounter Rate	2018 Encounter Rate
CROSP Canyon	41	160	6	11	17
CROSP Fence	17	75	27	21	11
North Gun Range	3	94	24	60	53
South Gun Range	19	218	25	29	19

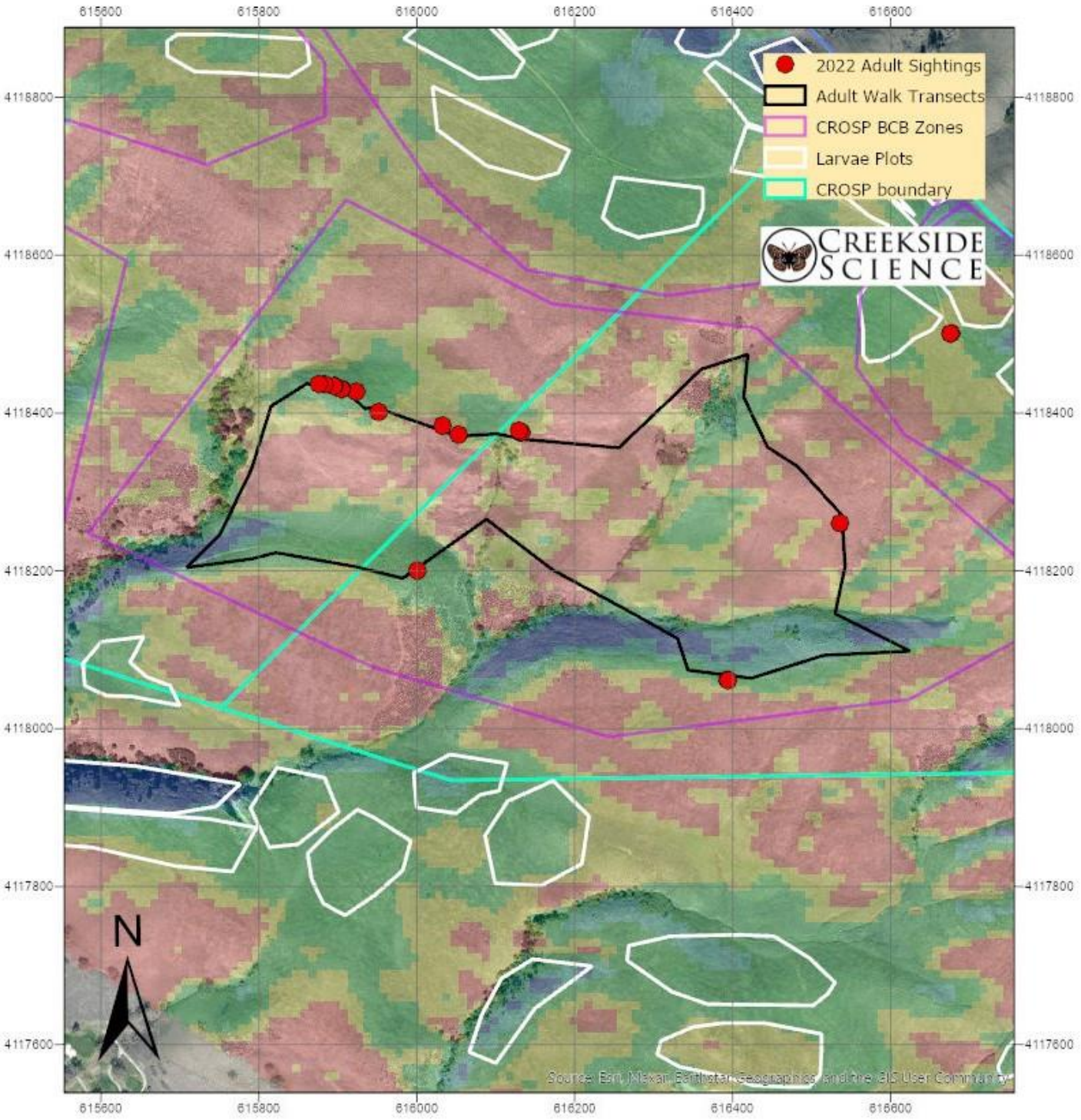
Table 10. Adult transect survey dates and encounter rates



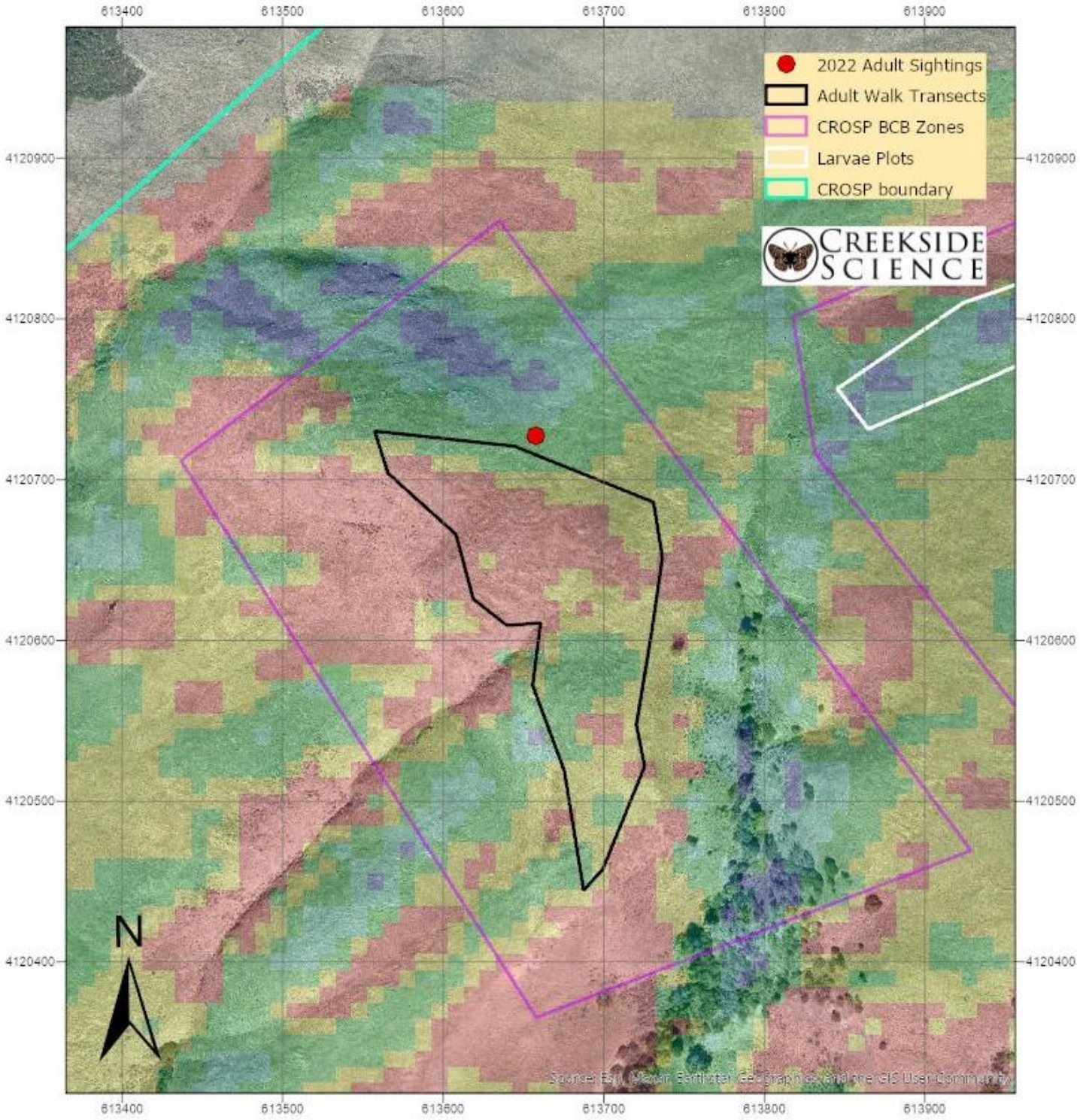
Map 5. CROSP overall BCB adult sightings in 2022



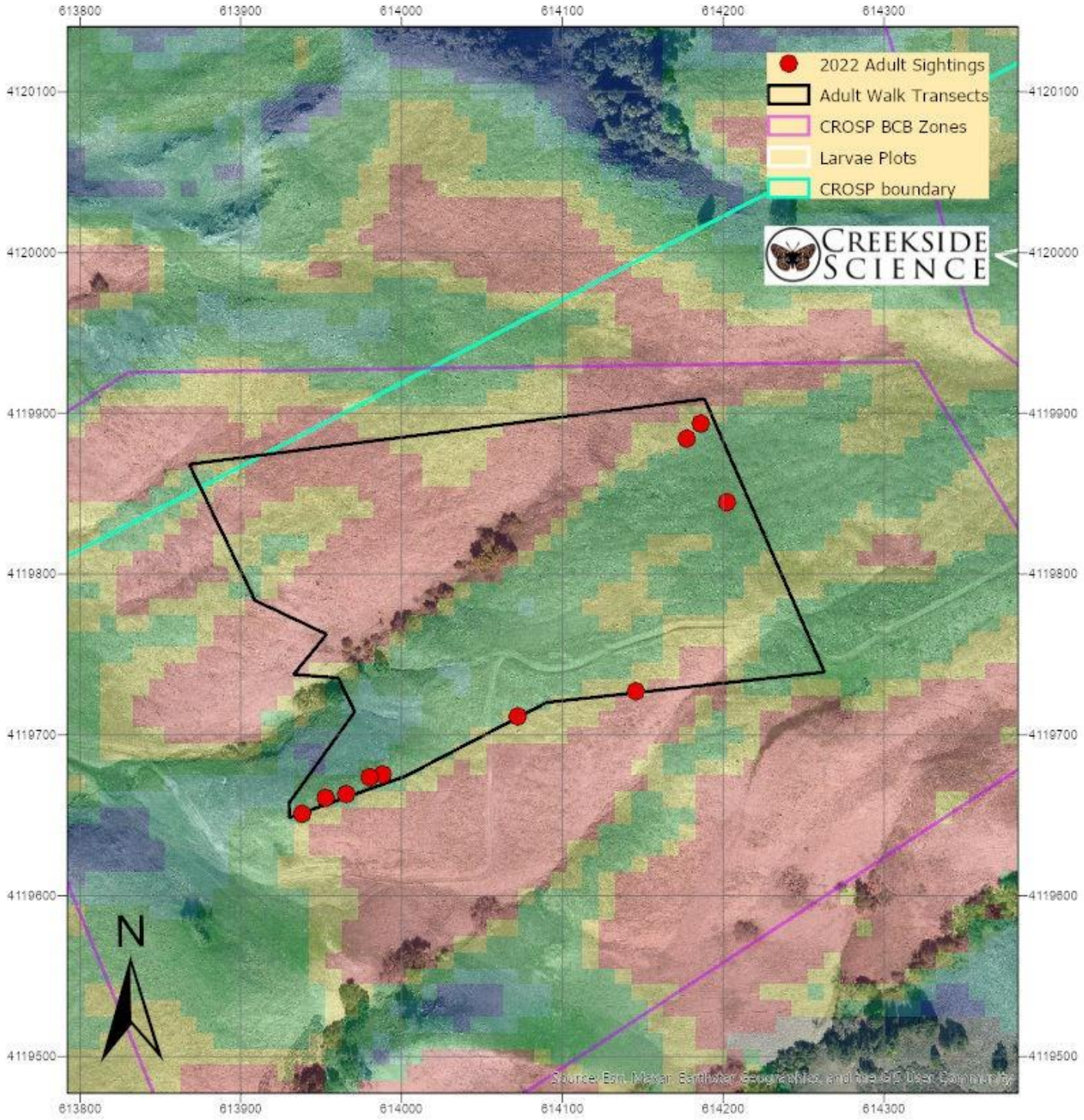
Map 6. CROSP Canyon BCB adult sightings in 2022



Map 7. CROSP Fence BCB adult sightings in 2022



Map 8. CROSP North Gun Range BCB adult sightings in 2022



Map 9. CROSP South Gun Range BCB adult sightings in 2022

Discussion/Recommendations

The ridgetop population complex extending from north of Metcalf Canyon to Anderson Dam is the core of the Bay checkerspot butterfly distribution, and the habitat on CROSP usually supports a high fraction of the overall Bay checkerspot butterfly population. In 2021, we estimated there were ~110,000 larvae on CROSP, which was 15% of the total Bay checkerspot butterfly population on Coyote Ridge. In 2022 that plummeted to ~11,800 larvae on CROSP, which was just under 5% of the total population, estimated at ~230,000 across Coyote Ridge. As recently as 2016, we estimated there were ~200,000 larvae on CROSP, about 25-50% of the entire population). The CROSP population is as low as we've recorded it, similar to the ~16,000 estimated in 2010.

The total decrease in numbers can be attributed to extreme drought and dry spring temperatures that are likely drying up host plants before prediapause larvae are large enough to enter diapause during the hot, dry summer when they have no food sources. The above average temperatures of spring 2022 do not bode well for the 2023 larval season.

While numbers were down throughout Coyote Ridge this season, they decreased the least at the Kirby Canyon Butterfly Reserve to the south. Numbers there decreased from 187,000 ± 42,000 in 2021 to 170,000 ± 43,000 in 2022, or about a 10% decrease.

At this point there is no reason to believe management is causing the larger decrease at CROSP relative to Kirby Canyon. Rather, this appears to be another example of metapopulation dynamics, where colonies within individual areas of a larger habitat fluctuate independently. This is an important process on Coyote Ridge.

Adult surveys again illustrated that Bay checkerspot butterfly are found throughout the preserve and were encountered at rates ranging from 3 to 41 butterflies/hour. This was clearly a decrease from the high numbers of 2021, but a somewhat mixed bag compared with previous records from 2018-2020. North Gun Range had its lowest encounter rate since records began in 2018, while South Gun Range equaled its 2018 low. The encounter rate at CROSP Fence was similar to those seen in 2018 and 2019. CROSP Canyon had a higher rate than those seen in 2018 to 2020, but was only a quarter of what we saw in 2021. Compared with the very low numbers of larvae detected, the adult numbers overall show a more positive trend.

Regardless, the decrease in adults observed across the board, in conjunction with the low larvae numbers, underscores the difficult conditions present in 2021 and 2022. Continued drought conditions, most notably dry and warm springs that drive early host plant senescence, are resulting in low densities.

The habitat on CROSP is clearly essential for the long-term persistence of healthy Bay checkerspot butterfly populations. The different pastures on CROSP represent slightly different grazing regimes, each of which have been functioning to provide Bay checkerspot butterfly habitat over time. CROSP encompasses key Bay checkerspot butterfly habitat, and the current grazing management is a critical part of this taxon's long-term success here.

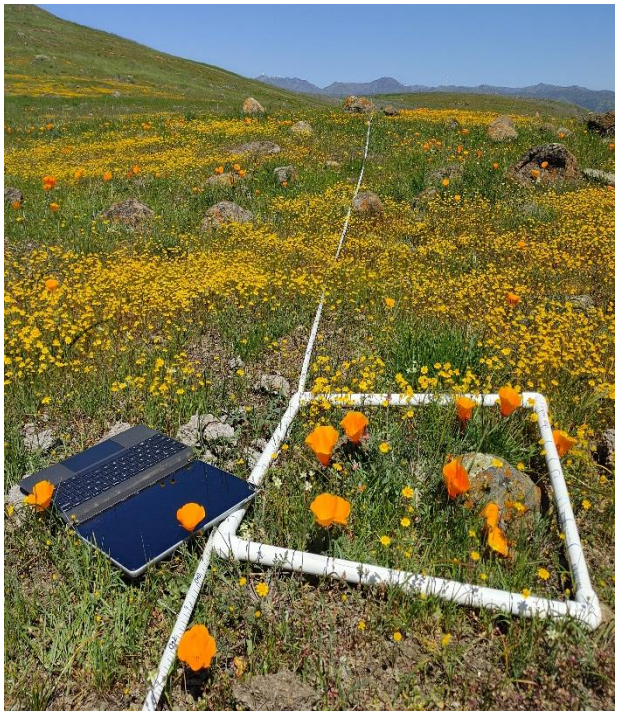
The surveys illustrate some of the variability inherent in Bay checkerspot populations. This year is slightly below our previous low recorded in 2010 of ~16,000 larvae at CROSP. Within five years those estimates jumped to ~950,000 in 2015. Bay checkerspot populations follow a boom and bust cycle; just as the high numbers of 2015 were not likely to be maintained indefinitely, there is certainly room to expect an increase over the next few years. The following are recommendations based on the Habitat Plan biological goals and objectives and the survey results.

1. Maintain current grazing regime in the different pastures at CROSP, which includes providing the ranchers flexibility in adjusting annual stocking rates and timing as documented over the last decade (see Grazing Regime section above). The grazing tenants have shown they have the experience and skills necessary to balance their

goals (removing mostly nonnative grass to feed livestock) with conservation goals, while responding to the extreme interannual climatic variations of the region. The current regime supports a rich variety of native species, both common and covered. Managers should be cautious about making major changes. More intensive techniques such as mowing and seeding are not recommended at this time. Additional grazing comments are provided in the Discussion/Recommendations of the Plant Species Composition section below.

2. Continue the Envoy Plus graminicide spraying experiment. This should include retreating/expanding the 2021-2022 treatment area, targeting nonnative annual grasses, including barbed goatgrass. Use the highest concentration recommended by the label. This treatment should improve habitat for BCB and native vegetation, as well as increase visual enjoyment for visitors. We envision such treatments taking place annually at new locations on the ridge, perhaps 2-4 acres a year. More details are available in the Plant Species Composition section.
3. Large population fluctuations are natural but require ongoing data collection to detect problematic declines.

Plant Species Composition



The serpentine grasslands of Coyote Ridge support many covered species, including Bay checkerspot butterfly, Tiburon paintbrush, Santa Clara Valley dudleya, fragrant fritillary, smooth lessingia, Metcalf Canyon jewelflower, and most beautiful jewelflower. The purpose of monitoring the overall composition of the serpentine grassland is to provide a reliable system for detecting major changes in grassland composition in response to climate, topography, and management. A standard methodology is being used at multiple sites in the region (i.e., Kirby Canyon Butterfly Reserve, VTA-Coyote Ridge, Los Esteros Critical Energy Facility Ecological Preserve, Don von Raesfeld Ecological Preserve/Silicon Valley Power, and Metcalf Energy Center Ecological Preserve on Tulare Hill). The system is designed to monitor large changes in composition from year to year (interannual), across topography (elevation and slope/aspect), and edaphic (soil) gradients, while at the same time being efficient for data collection and interpretation. Key data include cover of Bay checkerspot butterfly host plants, which are larval food sources, and nectar plants, which are adult food sources. Other important parameters for assessing Bay checkerspot butterfly habitat quality are cover of nonnative annual grass, native perennial grass, perennial forbs, annual forbs, native cover, nonnative cover, native richness, thatch, and bare ground. Results are used to determine if different pastures or parts of the property are responding similarly to weather, or whether management changes (usually changes in grazing pressure) are recommended, in the context of managing for Bay checkerspot butterfly and overall native cover and richness. Bay checkerspot butterfly host and nectar sources, native cover, and richness are all desirable. The forbs (non-woody, non-graminoid plants) mostly include what are commonly called wildflowers. Nonnative forbs include thistles and other broadleaf weeds, but these are mostly absent from the serpentine soil areas of the property. The nonnative cover in the region's serpentine grasslands is almost entirely nonnative annual grass, which is undesirable at high cover because they and their associated thatch compete with forbs, especially the annual forbs that are important Bay checkerspot resources. The native perennial bunchgrasses do not outcompete these plants and are considered desirable. Bare ground is also desirable because it favors forbs over grass.

Methods

Three plant species composition/cover monitoring clusters, consisting of four sampling transects each, were established on serpentine soils of CROSP. One cluster, CROSP South, was installed in 2007 and originally had 6 transects, two of which were dropped in 2016 to conform with other clusters. The CROSP North and Mid clusters were installed in spring 2016.

The clusters were spread throughout the site to target different elevations and pastures/grazing regimes. CROSP North and Mid are in the same pasture (first rockfield), which is generally grazed winter and spring. CROSP South is in a pasture (second rockfield) that is normally grazed spring through fall.

The different elevations encompass different rates of nitrogen deposition. Serpentine soils are characteristically low in nitrogen and thus nutrient deficient for the growth of most plant species. Species associated with serpentine habitats are more suited to low nitrogen levels. Nutrient amendment in the form of nitrogen deposition can have a significant impact on vegetative species composition. Deposition can further encourage the growth and spread of nonnative

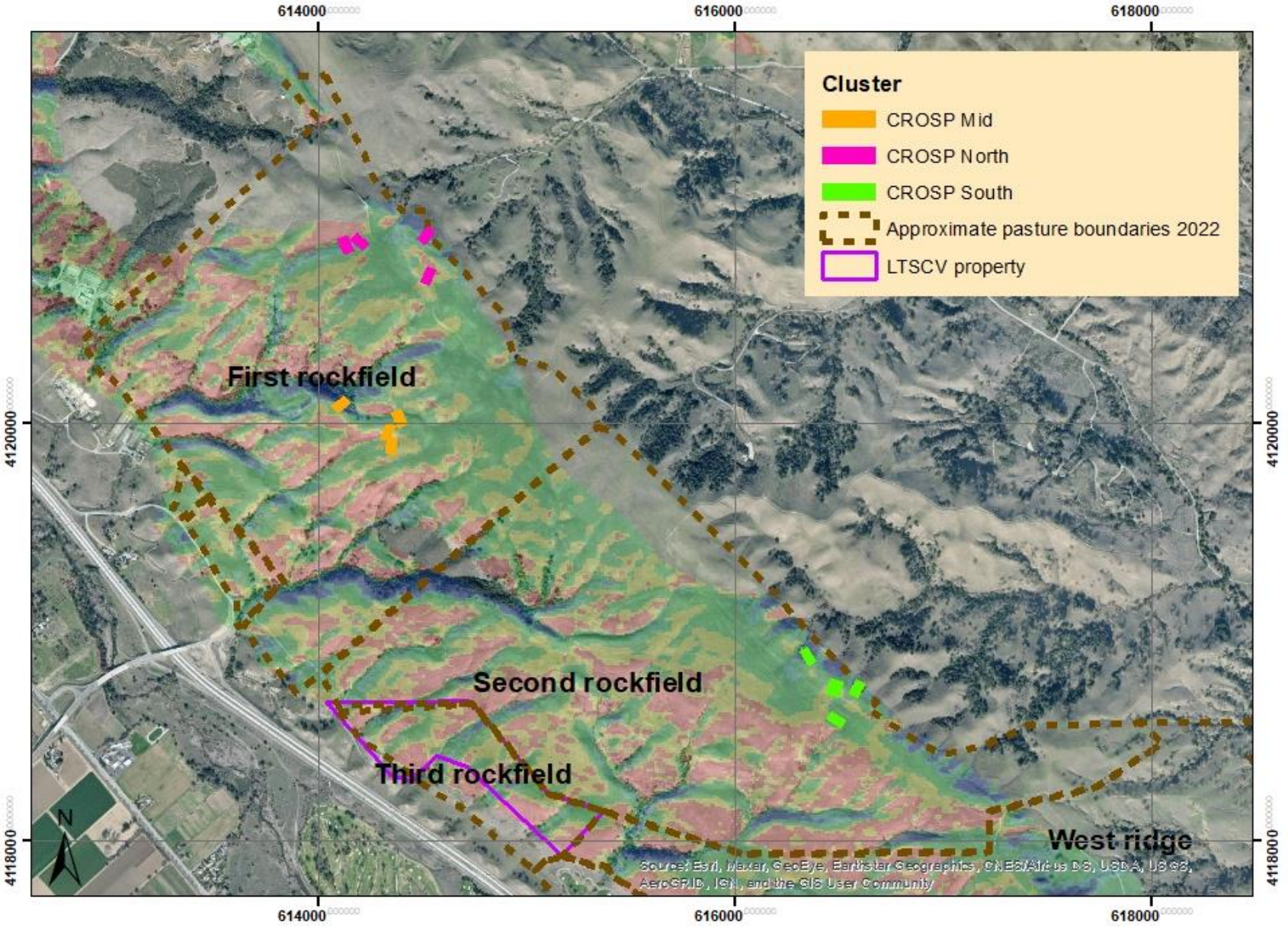
grasses that compete for space with native species such as Bay checkerspot host and nectar plants. Nitrogen deposition is caused by air pollution and formed by fuel-burning sources such as combustion vehicles and natural gas power plants (Weiss 1999). The North and South clusters are at the ridge's summit, and Mid is about halfway down. The summit of Coyote Ridge generally has lower nitrogen deposition rates (~11 kg/ha/yr), and the mid elevations are ~14 kg/ha/yr (H.T. Harvey and CCEO 2008).

It should be noted that the Los Esteros Critical Energy Facility and Don von Raesfeld Ecological Preserves, outlined on Map 10 as LTSCV property, are no longer in the same pasture as CROSP South. As of spring 2022, the new fenceline created a third rockfield that encompasses these LTSCV properties. At this point there are no vegetation transects low on the second rockfield pasture. There is also no longer any CROSP property in the west ridge pasture. (Reports for those properties are available upon request.) Closeups of each cluster are shown in Maps 11-13.

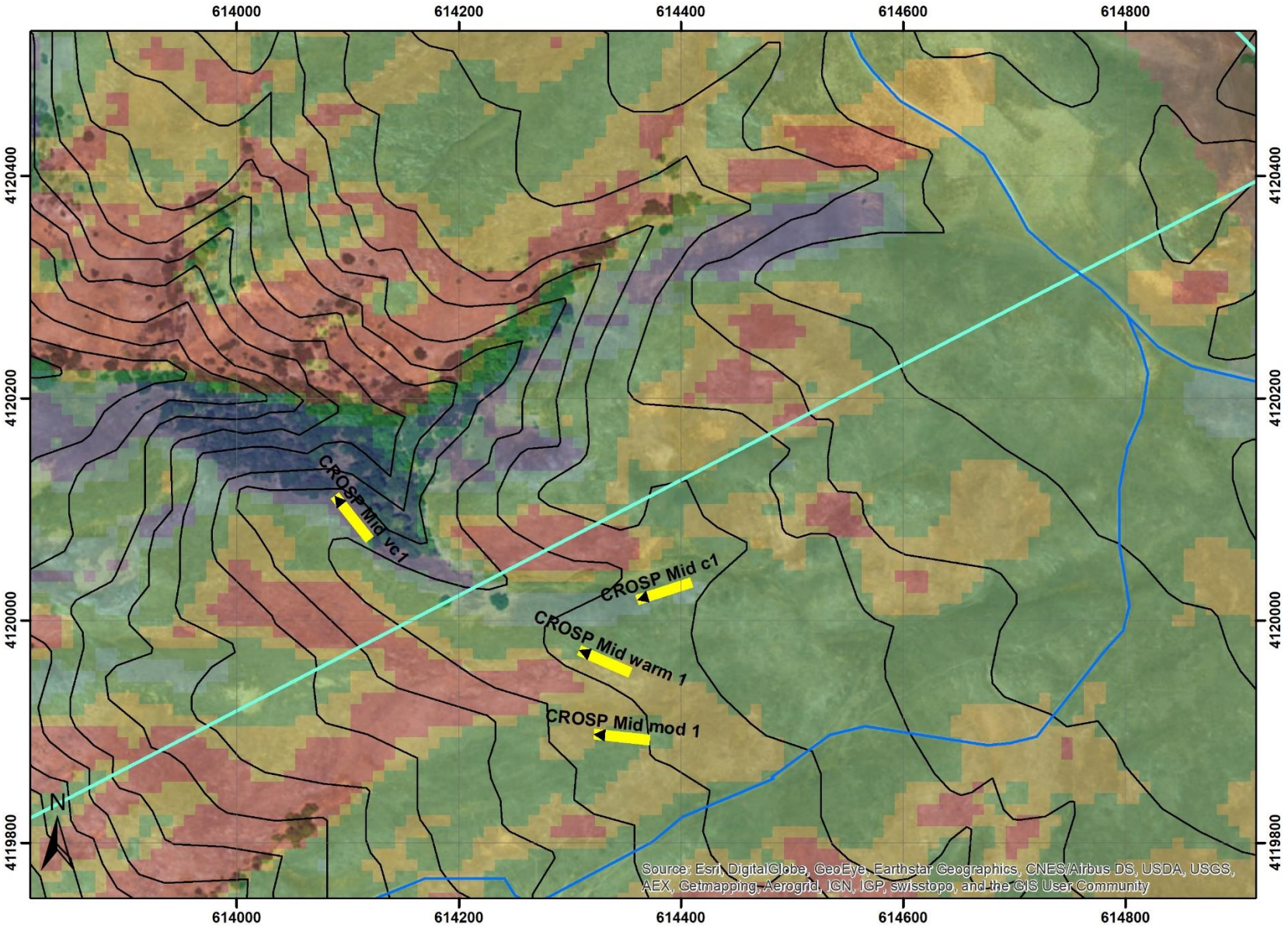
Each of the four clusters has a transect set up in a warm (south-facing >10° slope), moderate (mostly flat), cool (north-facing >10° slope, and very cool (north-facing >20° slope) topoclimate. Transects are 50 meters long and permanently marked at each end with rebar. During sampling, a 50-m tape is stretched along the transect, and a 0.5 x 0.5 m (0.25 m^2) quadrat is placed at 10, 20, 30, 40, and 50 m along the right side of the tape, and at 5, 15, 25, 35, and 45 m along the left side of the tape. The percent relative cover (on a cover class scale of 1, 2, 5, 10, 20, 30, 40 . . . 100%) of each plant species within the quadrat is recorded. Percent cover of bare ground, rock, and thatch are included in the cover total, which should fall between 96% and 105%. Rocks that take up less than 1% cover are considered bare ground.

Monitoring is conducted during the peak spring flowering season (this year early to late March). Timing of monitoring varies with transect location due to differences in phenology among areas with different topoclimates, and will vary among years. This year monitoring took place between March 7 and March 29, 2022.

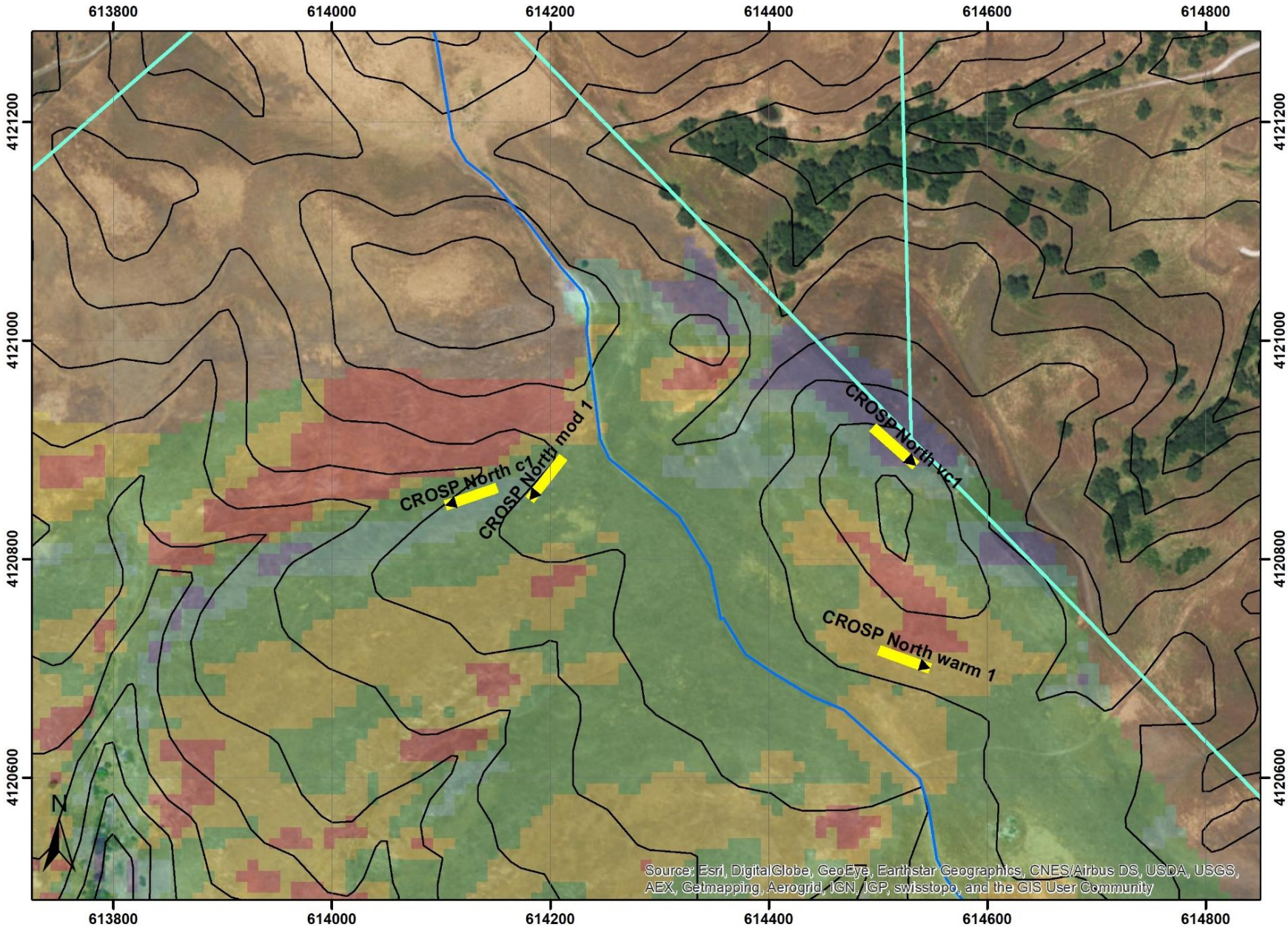
Photopoints are taken at each transect and are shown in Appendix A.



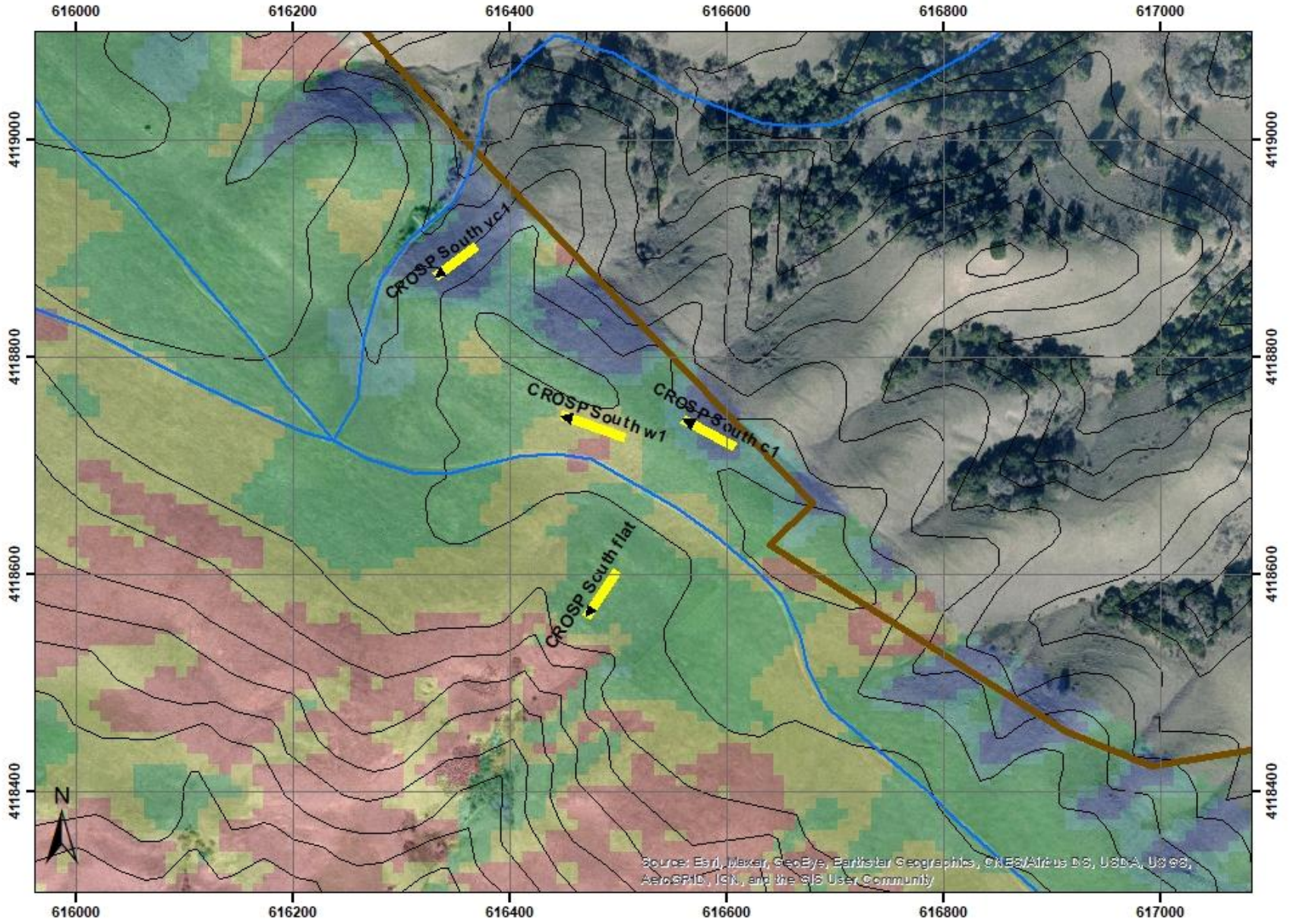
Map 10. Vegetation composition clusters on CROSP. Note new fenceline.



Map 11. Closeup view of CROSP Mid cluster



Map 12. Closeup view of CROSP North cluster



Map 13. Closeup view of CROSP South cluster

Results

Cover of key species and guilds is shown below in Tables 11-13. Five years of data are shown for context.

Key Species and Guilds	2018	2019	2020	2021	2022	Change from 2021 to 2022
Checkerspot Host and Nectar Plants						
Dwarf plantain (*Plantago erecta*)	3.9 ± 0.7	3.1 ± 0.8	0.6 ± 0.1	0.6 ± 0.1	0.6 ± 0.1	Stable
Owl's clover (*Castilleja* spp.)	0.10 ± 0.04	0.1 ± 0.1	0.1 ± 0.1	0.03 ± 0.03	0.05 ± 0.03	Stable
Goldfields (*Lasthenia californica*)	0.6 ± 0.2	0.7 ± 0.2	0.3 ± 0.1	0.2 ± 0.1	0.1 ± 0.1	Stable
Tidy tips (*Layia gaillardioides*)	0 ± 0	0 ± 0	0.03 ± 0.03	0 ± 0	0 ± 0	Stable
Jeweled onion (*Allium serra*)	0 ± 0	0.08 ± 0.04	0.03 ± 0.03	0.03 ± 0.03	0.3 ± 0.3	Stable
Seaside muilla (*Muilla maritima*)	0.7 ± 0.3	0.5 ± 0.2	0.4 ± 0.1	0.5 ± 0.2	0.3 ± 0.1	Stable
Functional Guilds						
Native perennial grasses	0.8 ± 0.2	1.2 ± 0.4	1.6 ± 0.4	1.2 ± 0.3	2.1 ± 0.5	Increase
Nonnative annual grasses	20.7 ± 2.7	21.5 ± 2.2	24.4 ± 2.5	31.0 ± 3.6	27.4 ± 3.3	Stable
Perennial forbs	2.1 ± 0.4	2.3 ± 0.5	2.3 ± 0.3	2.4 ± 0.5	3.1 ± 0.7	Stable
Annual forbs	13.6 ± 1.3	13.1 ± 1.2	10.7 ± 1.0	6.4 ± 0.5	7.2 ± 0.6	Stable
Native/Nonnative						
Native species richness	12.1 ± 0.7	13.7 ± 0.5	13.2 ± 0.5	10.5 ± 0.5	11.2 ± 0.4	Stable
Native cover	21.0 ± 1.7	25.7 ± 2.0	20.1 ± 1.3	16.7 ± 2.0	20.2 ± 2.2	Stable
Total nonnative cover	20.8 ± 2.8	21.6 ± 2.2	24.5 ± 2.5	31.2 ± 3.6	27.4 ± 3.3	Stable
Abiotic						
Thatch	3.4 ± 0.8	2.3 ± 0.5	5.7 ± 0.9	8.3 ± 1.4	7.0 ± 1.0	Stable
Bare	51.8 ± 2.8	49.4 ± 2.2	42.9 ± 3.1	41.6 ± 3.3	42.6 ± 3.5	Stable

Table 11. Mean cover ± SE for key species and guilds at CROSP-South over time

Key Species and Guilds	2018	2019	2020	2021	2022	Change from 2021 to 2022
Checkerspot Host and Nectar Plants						
Dwarf plantain (*Plantago erecta*)	2.5 ± 0.6	1.3 ± 0.3	0.9 ± 0.2	0.7 ± 0.1	1.0 ± 0.2	Stable
Owl's clover (*Castilleja* spp.)	0.2 ± 0.1	1.5 ± 0.4	0.4 ± 0.1	0 ± 0	0 ± 0	Stable
Goldfields (*Lasthenia californica*)	7.5 ± 1.3	8.5 ± 1.7	1.6 ± 0.3	4.1 ± 1.4	1.5 ± 0.4	Decrease
Tidy tips (*Layia gaillardioides*)	0.2 ± 0.1	0.3 ± 0.1	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.1	Stable
Jeweled onion (*Allium serra*)	0.03 ± 0.03	0.03 ± 0.03	0.08 ± 0.04	0.05 ± 0.03	0.05 ± 0.03	Stable
Seaside muilla (*Muilla maritima*)	0.7 ± 0.1	0.8 ± 0.1	1.5 ± 0.3	0.9 ± 0.1	1.0 ± 0.3	Stable
Functional Guilds						
Native perennial grasses	2.5 ± 0.5	3.1 ± 0.9	5.7 ± 1.2	3.0 ± 0.8	4.1 ± 0.9	Stable
Nonnative annual grasses	26.0 ± 3.6	24.5 ± 3.2	9.3 ± 2.6	16.1 ± 3.1	12.3 ± 2.8	Stable
Perennial forbs	2.3 ± 0.4	3.1 ± 0.5	3.6 ± 0.8	3.5 ± 0.8	3.3 ± 0.9	Stable
Annual forbs	17.7 ± 1.9	17.3 ± 2.0	10.0 ± 1.1	11.5 ± 1.7	13.2 ± 1.9	Stable
Native/Nonnative						
Native species richness	11.2 ± 0.4	12.8 ± 0.4	11.7 ± 0.4	12.5 ± 0.5	11.9 ± 0.6	Stable
Native cover	30.9 ± 2.7	41.3 ± 2.7	27.0 ± 2.0	32.9 ± 3.0	39.3 ± 3.6	Stable
Total nonnative cover	26.0 ± 3.6	24.5 ± 3.2	9.3 ± 2.6	16.1 ± 3.1	12.3 ± 2.8	Stable
Abiotic						
Thatch	4.0 ± 0.7	5.3 ± 1.4	14.2 ± 1.9	7.1 ± 1.4	2.7 ± 0.5	Decrease
Bare	38.2 ± 2.6	26.6 ± 2.2	35.9 ± 2.4	41.5 ± 2.3	42.1 ± 3.1	Stable

Table 12. Mean cover ± SE for key species and guilds at CROSP-North over time

Key Species and Guilds	2018	2019	2020	2021	2022	Change from 2021 to 2022
Checkerspot Host and Nectar Plants						
Dwarf plantain (*Plantago erecta*)	6.8 ± 1.3	3.6 ± 0.9	1.7 ± 0.5	0.9 ± 0.04	1.0 ± 0.1	Stable
Owl's clover (*Castilleja* spp.)	0.08 ± 0.04	0.5 ± 0.1	0.5 ± 0.1	0.03 ± 0.03	0.05 ± 0.03	Stable
Goldfields (*Lasthenia californica*)	1+.8 ± 0.6	2.6 ± 0.7	1.2 ± 0.2	1.9 ± 0.6	1.6 ± 0.8	Stable
Tidy tips (*Layia gaillardioides*)	0.1 ± 0.1	0.2 ± 0.1	0.2 ± 0.1	0.2 ± 0.1	0.1 ± 0.1	Stable
Jeweled onion (*Allium serra*)	0.03 ± 0.03	0.08 ± 0.04	0.10 ± 0.05	0.03 ± 0.03	0 ± 0	Decrease
Seaside muilla (*Muilla maritima*)	0.3 ± 0.1	0.4 ± 0.1	0.4 ± 0.1	0.4 ± 0.1	0.5 ± 0.1	Stable
Functional Guilds						
Native perennial grasses	1.8 ± 0.7	1.6 ± 0.5	1.5 ± 0.4	1.6 ± 0.4	2.2 ± 0.5	Stable
Nonnative annual grasses	16.3 ± 1.9	17.9 ± 2.7	9.8 ± 1.4	9.4 ± 2.0	6.8 ± 1.6	Stable
Perennial forbs	2.4 ± 0.7	2.7 ± 0.5	4.2 ± 0.7	3.4 ± 0.6	3.2 ± 0.5	Stable
Annual forbs	20.6 ± 2.0	19.8 ± 1.8	12.3 ± 1.2	10.7 ± 1.1	15.7 ± 2.1	Increase
Native/Nonnative						
Native species richness	10.9 ± 0.3	13.7 ± 0.4	13.6 ± 0.4	13.0 ± 0.5	12.2 ± 0.4	Stable
Native cover	30.1 ± 2.3	38.1 ± 2.5	28.8 ± 2.0	30.2 ± 2.9	43.9 ± 3.8	Increase
Total nonnative cover	16.4 ± 1.9	18.0 ± 2.7	10.0 ± 1.4	9.6 ± 2.0	6.9 ± 1.6	Stable
Abiotic						
Thatch	4.3 ± 0.9	2.6 ± 0.7	5.1 ± 1.3	4.0 ± 1.1	3.3 ± 0.9	Stable
Bare	44.9 ± 2.4	39.0 ± 2.5	49.5 ± 2.6	52.0 ± 2.9	41.3 ± 3.3	Decrease

Table 13. Mean cover ± SE for key species and guilds at CROSP-Mid over time

Bay Checkerspot Host Plants. Dwarf plantain cover remained at low levels at all CROSP sites in 2022. Values were highest at the North and Mid cluster at 1.0% each. They were lowest at CROSP-South at 0.6%. All cover values were just shy of being historical lows (Figure 5). This year owl's clover was not detected at CROSP-North and was barely detectable at CROSP-South and CROSP-Mid (both had 0.05% cover). These very low values were similar to 2021. (Figure 6).

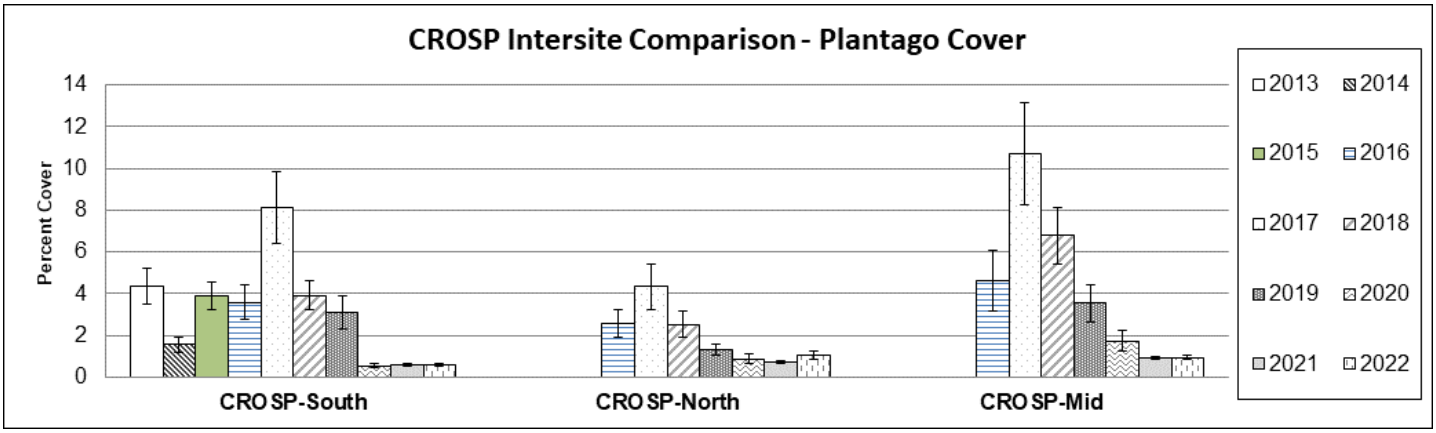


Figure 5. Average cover of dwarf plantain (*Plantago erecta*), ± SE

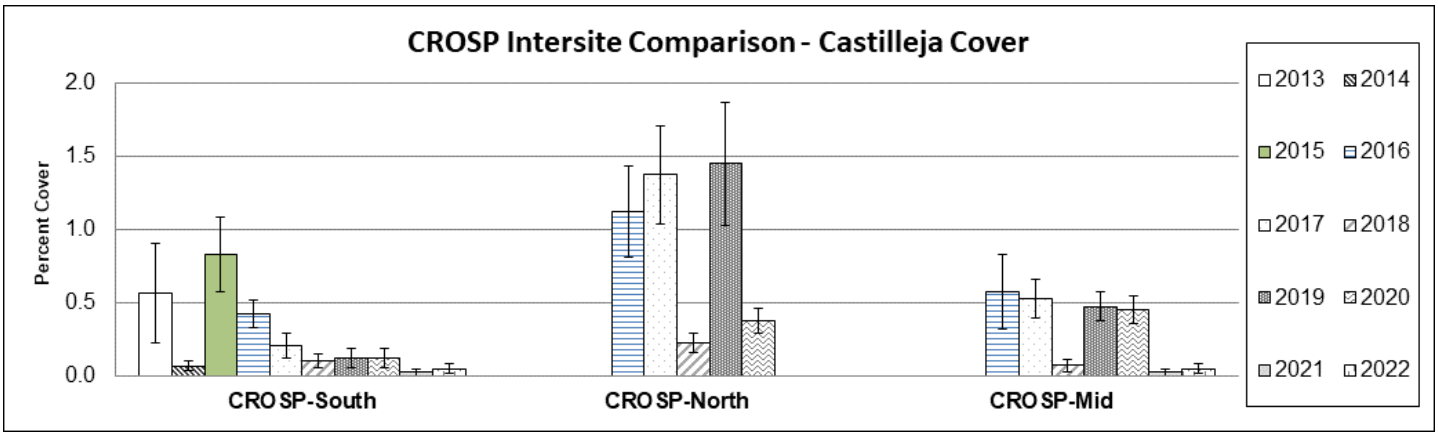


Figure 6. Average cover of owl's clover (*Castilleja* spp.), ± SE

Bay Checkerspot Nectar Sources. Goldfields decreased at CROSP-North this year from 4.1% to 1.5% cover, a low value. At CROSP-Mid, values remained low at 1.6% and CROSP-South held steady at very low values (0.1%). Tidy tips were low across the three sites at 0-0.2%. Jeweled onion values were also low. They went undetected at CROSP-Mid and had 0.05% cover at CROSP-North. CROSP-South saw the second highest cover values since 2005 at 0.3%. Muilla cover values remained stable at all sites this year ranging from 0.3% to 1.0%. Overall Muilla was at moderate amounts (Figures 7-10).

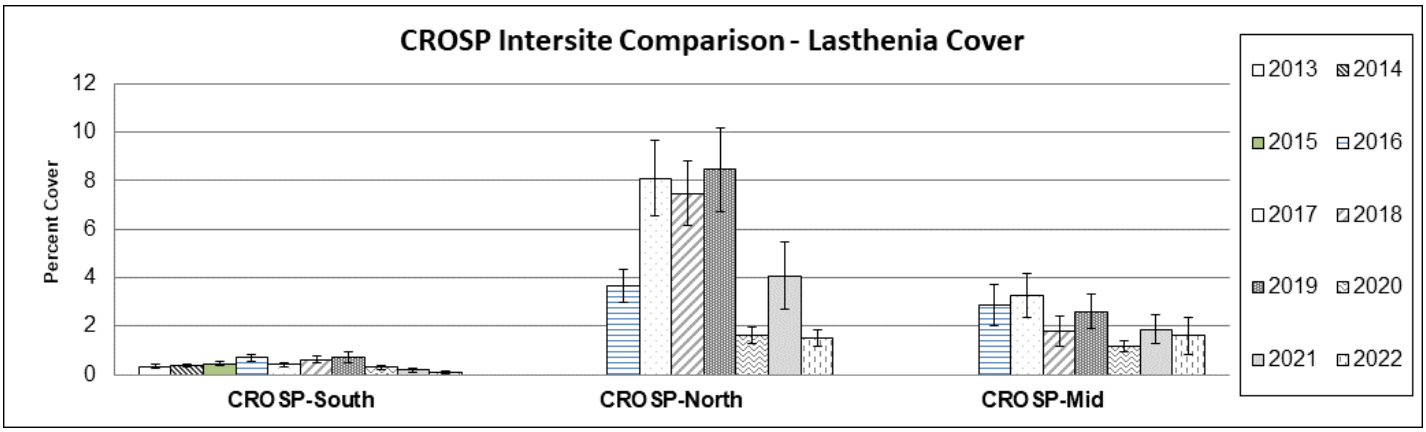


Figure 7. Average cover of goldfields (*Lasthenia californica*), ± SE

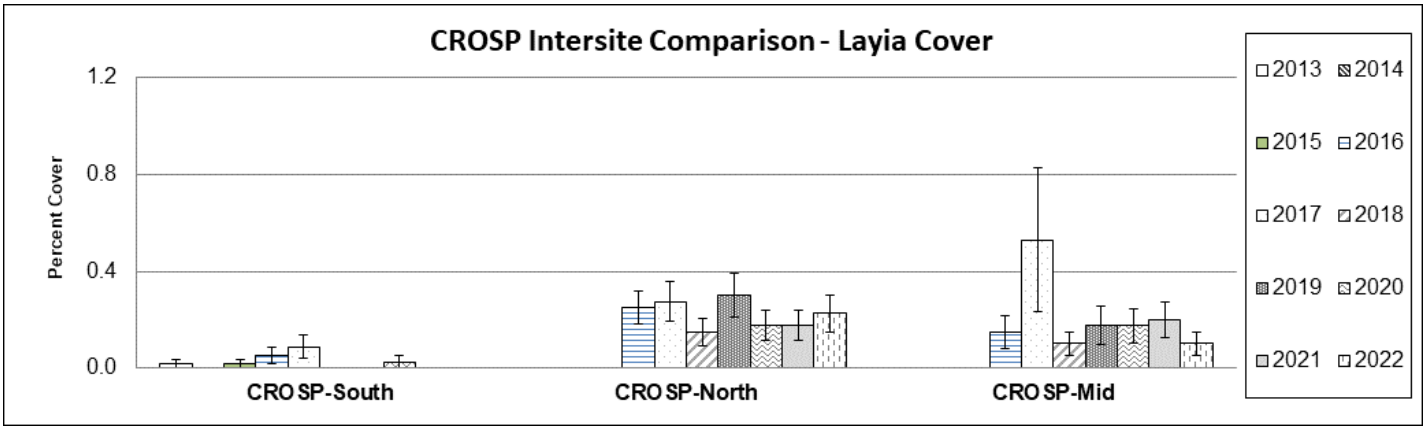


Figure 8. Average cover of tidy tips (*Layia gaillardioides*), ± SE

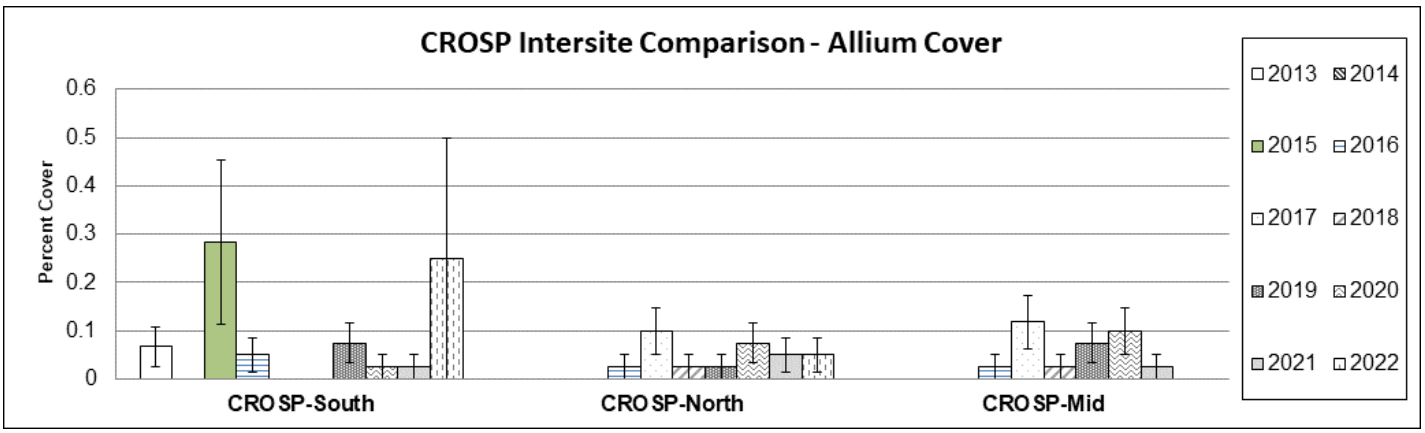


Figure 9. Average cover of jeweled onion (*Allium serra*), ± SE

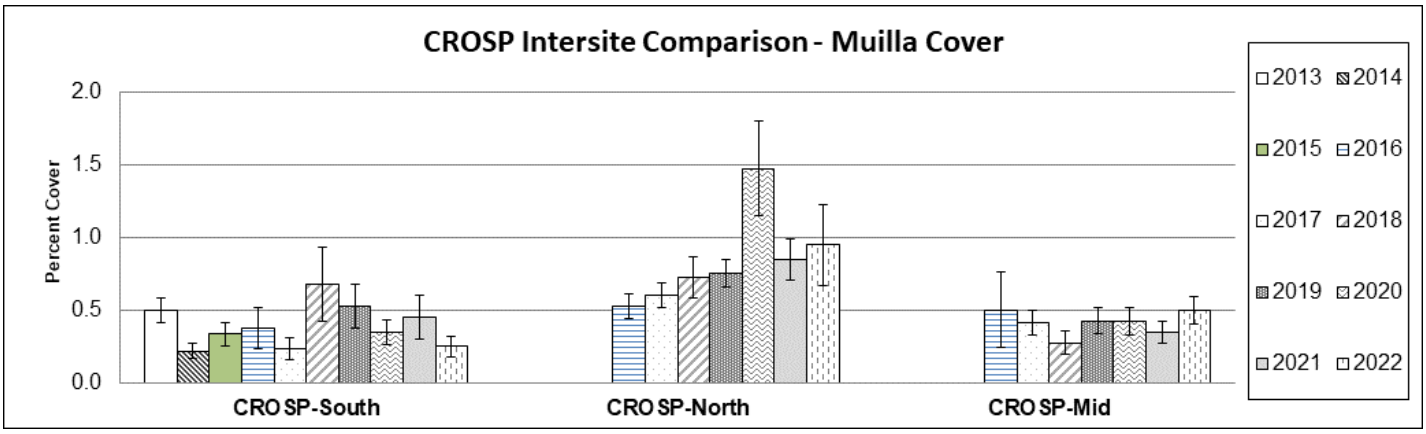


Figure 10. Average cover of seaside muilla (*Muilla maritima*), ± SE

Grasses and Thatch. The perennial grasses (bunchgrasses) measured are all native. CROSP-North had the highest value at 4.1% and CROSP-South had the lowest at 2.1%. Nonnative annual grasses remained stable to slightly down in comparison to last year with a high value observed at CROSP-South (27.4%) but relatively low values observed at CROSP-North and CROSP-Mid (12.3% and 6.8%, respectively). The 6.8% cover at CROSP-Mid represents a historical low for the site. Thatch cover was low to moderate at all sites this year. CROSP-South had the highest value at 7.0%, which is the second highest value for the site. CROSP-North decreased from 7.1% to 2.7%. CROSP-Mid remained stable at 3.3% cover (Figure 11-13).

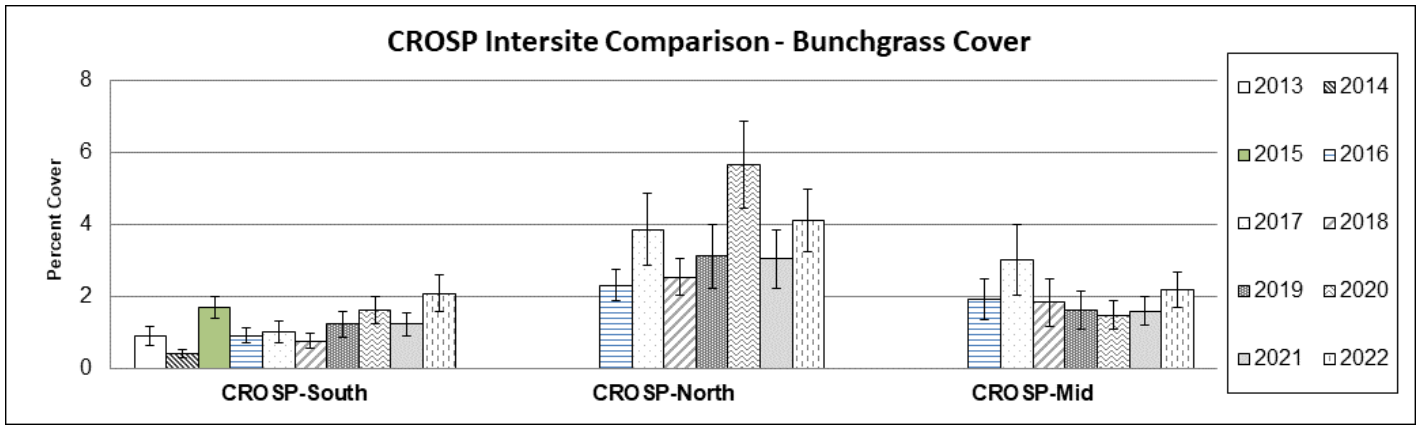


Figure 11. Average cover of perennial grasses, ± SE

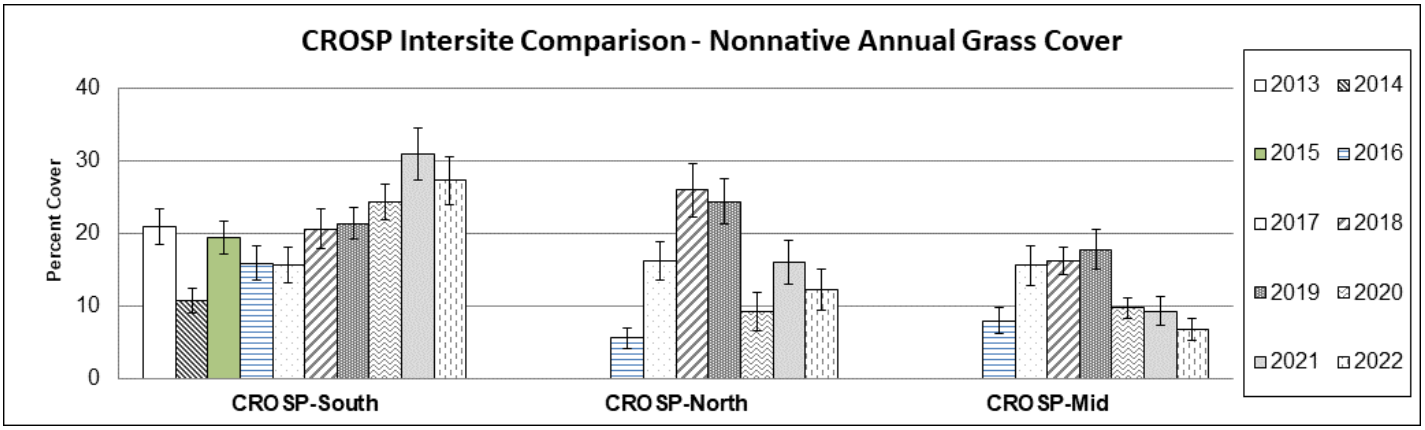


Figure 12. Average cover of nonnative annual grasses, ± SE

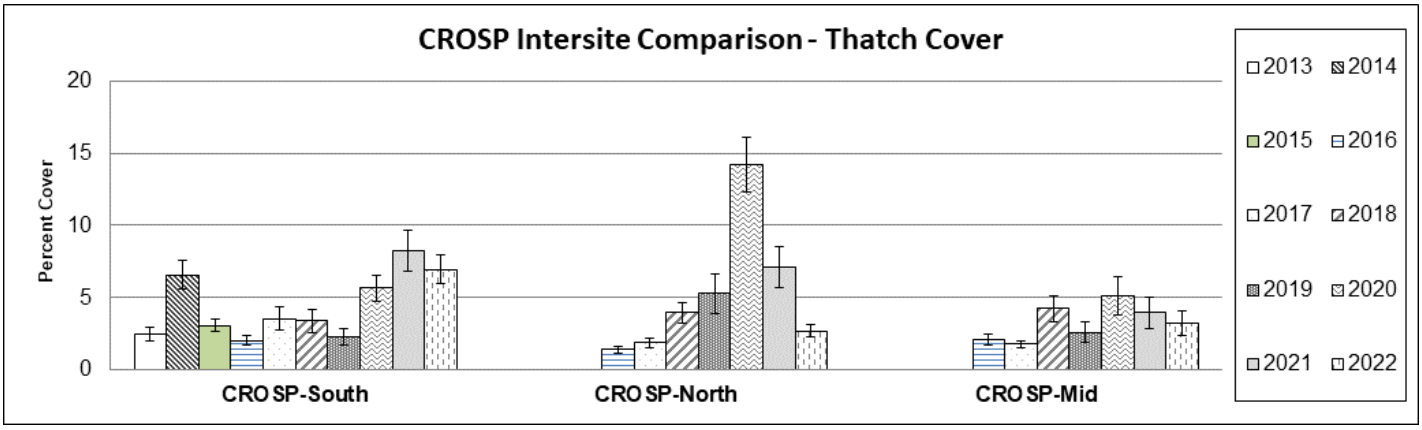


Figure 13. Average cover of thatch, ± SE

Annual forbs are almost entirely native on CROSP's serpentine soils. They increased or remained stable this year at low to moderate values. Cover values ranged from 7.2% at CROSP-South to 15.7% at CROSP-Mid. Cover values for perennial forbs, which are all native in the plots, remained at moderate values at all sites. Values ranged from 3.1% at CROSP-South to 3.3% at CROSP-North (Figures 14-15).

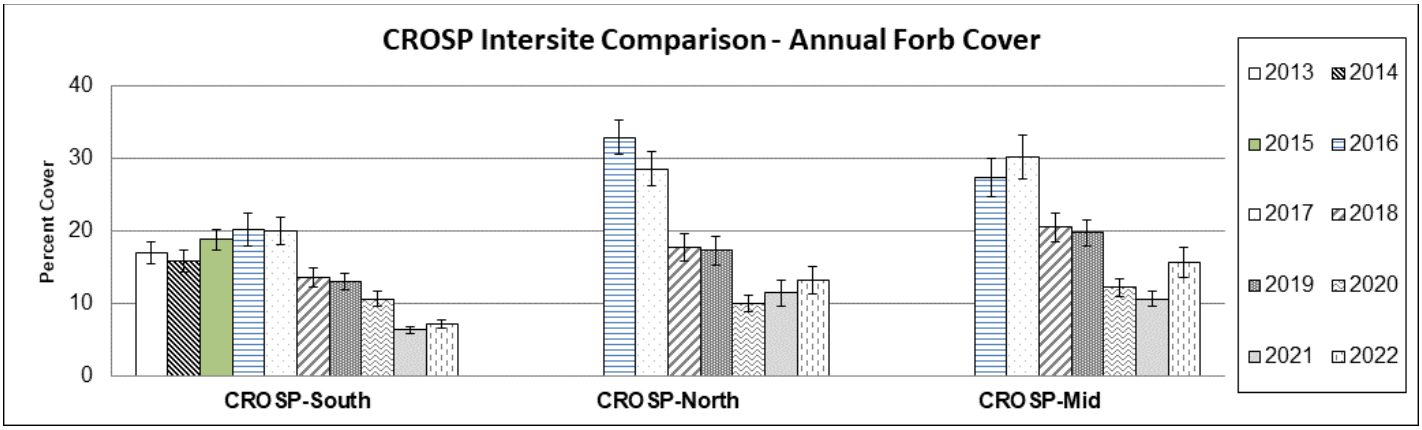


Figure 14. Average cover of annual forbs, ± SE

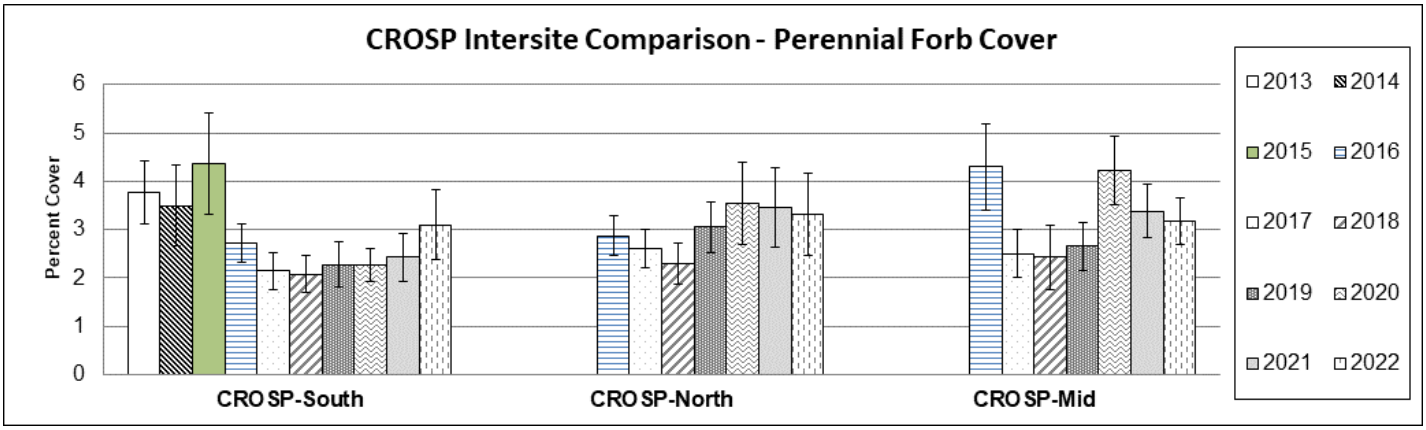


Figure 15. Average cover of perennial forbs, ± SE

Bare was moderate across sites in 2022. It was highest at CROSP-South (42.6%) and lowest at CROSP-Mid (41.3%) (Figure 16).

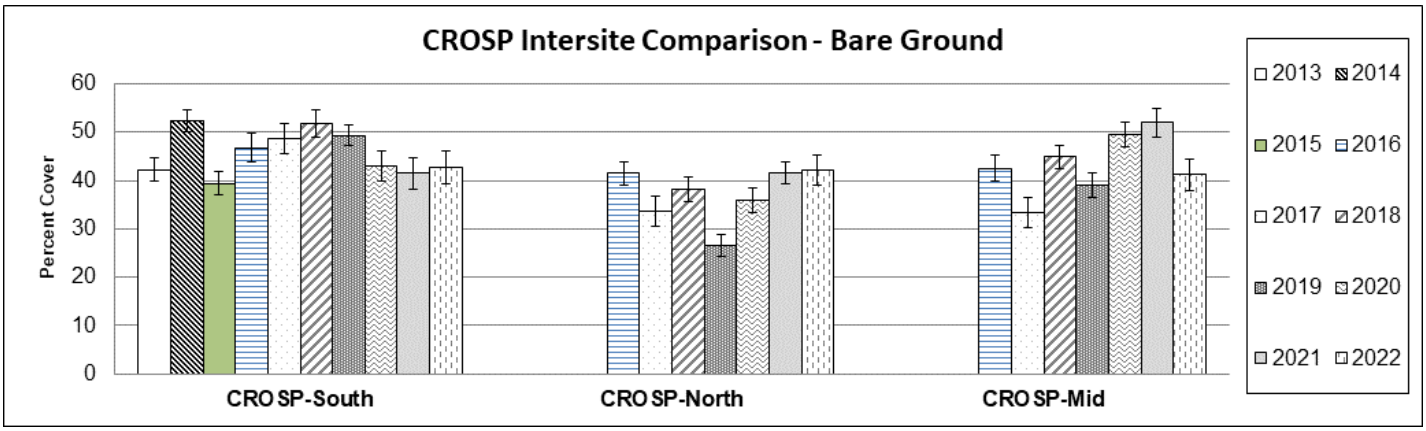


Figure 16. Average bare ground cover, ± SE

Native cover increased at CROSP-Mid from 30.2% to 43.9%, a historic high for the site and the third highest value historically across sites. It had a high value at CROSP-North (39.3%) and remained low at CROSP-South (20.2%). Native richness remained stable at moderate values across sites. Richness ranged from 11.2 species per quadrat at CROSP-South to 12.2 species at CROSP-Mid. Nonnative cover showed slight decreases at all sites this year. It ranged from 6.9% at CROSP-Mid to 27.4% at CROSP-South (second highest value historically for this site) (Figures 17-19). Note that Figures 12 and 19 are nearly identical because nonnative cover throughout CROSP is driven mostly by nonnative annual grass.

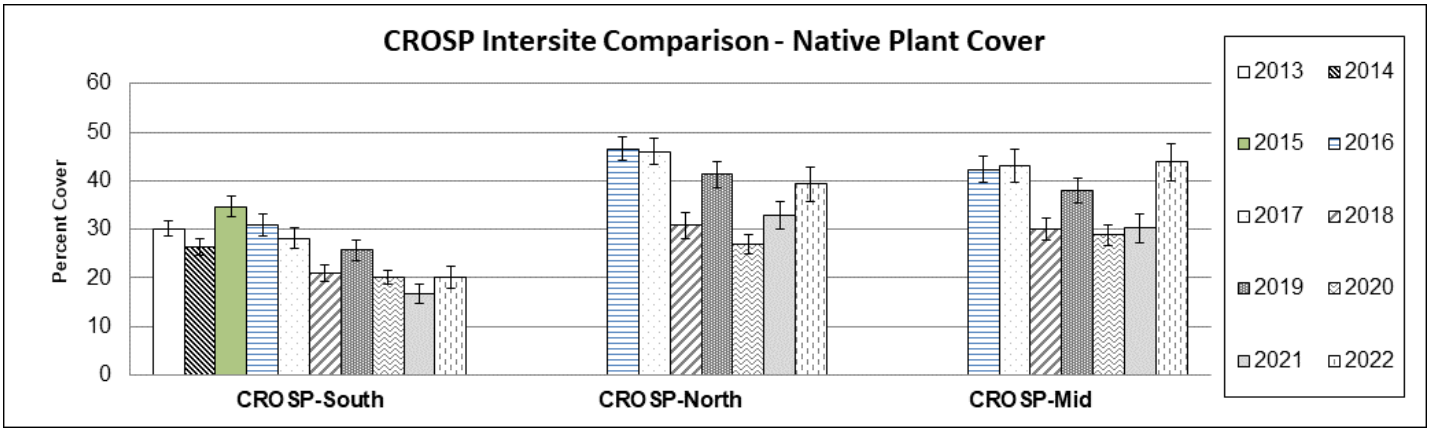


Figure 17. Average cover of native species, ± SE

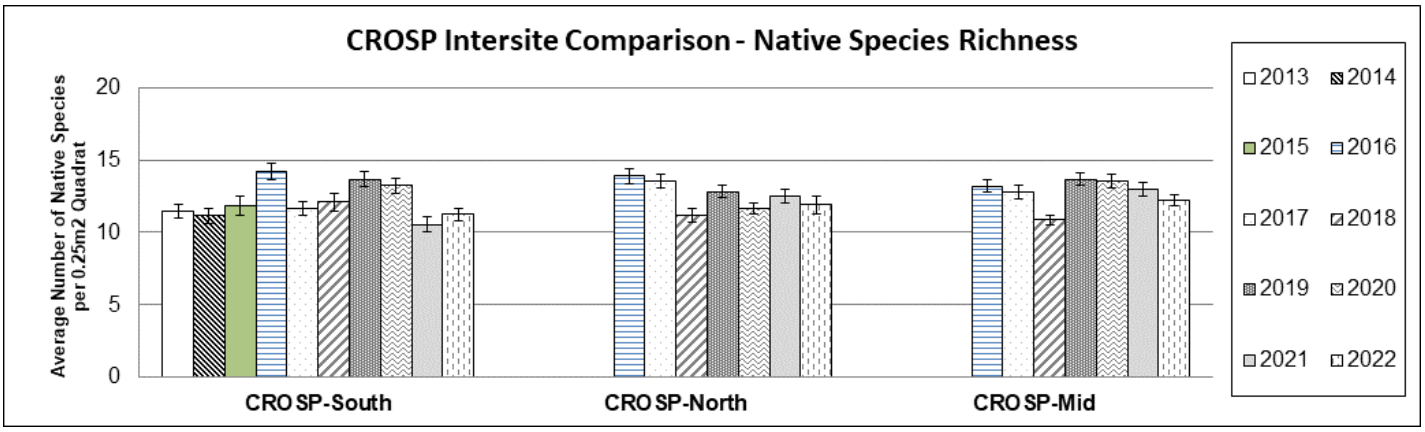


Figure 18. Average number of native species, ± SE

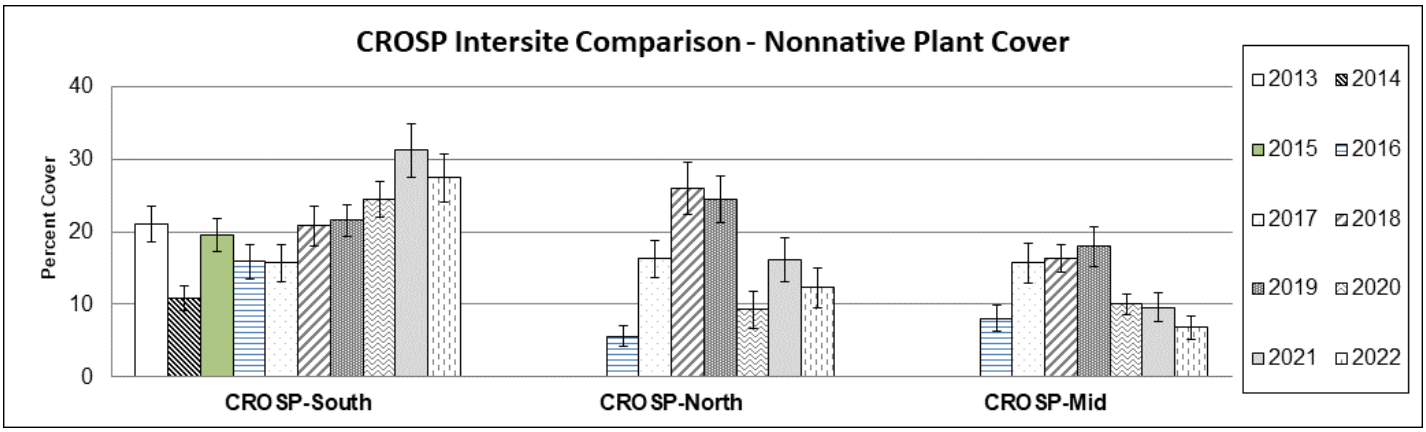


Figure 19. Average cover of nonnative species, ± SE

Discussion/Recommendations

Rainfall in 2022 was higher than last year but still well below average. The pattern of precipitation was heavily weighted to the beginning of the 2022 water year with 81% of the precipitation falling between October-December 2021. Almost no rain fell January-March, but April rains extended the growing season for many taxa. The 2.1 cm that fell in September is technically included in this water year, but certainly had no effect on the vegetation and BCB results reported here for earlier in the year. The total for the water year was 37.1 cm, compared with the 1981-2010 average of 58.9 cm (Westmap 2022). The continuing drought conditions affected vegetation. Regionally, BCB host plants were low and nectar sources were low to moderate. They appeared adequate to support the life cycle, however the connection between low host plants and low BCB is difficult to ignore. BCB populations have stayed stable or increased with similarly low cover, but this does warrant continued close monitoring. As always, the effects of this year's weather and vegetation availability will be reflected in next year's larval monitoring numbers. Nonnative grass cover was variable across the site.

The CROSP property continues to have high quality serpentine grassland habitat, supporting diverse and beautiful stands of native wildflowers that include BCB host plants and nectar sources, as well as other species covered by the Habitat Plan. This is one of the core remaining properties in which BCB are persisting, fluctuating, and thriving. BCB host plants were very low this year but remain within the range of historical variability seen throughout Coyote Ridge. Again, this

year both hosts were unfortunately at all-time lows. Generally, *Castilleja* plays the role of extending the pre-diapause feeding season, which tends to lead to higher numbers in the next season when post-diapause larvae are monitored. But with values of 0.05% and below at all sites, this year *Castilleja* did not play as significant a role for the BCB as it often does. This, along with high spring temperatures that instigate early *Plantago* senescence, likely cut short the pre-diapause feeding season and negatively impact next year's larval population.

Adult nectar sources are varied and abundant at Coyote Ridge (especially when the different taxa are considered as a whole). When adult female BCB emerge, they tend to mate almost immediately with waiting males and lay their largest cluster of eggs soon after. Therefore, the BCB can complete its life cycle without nectar. With nectar sources, adults may live longer and be more likely to reach maximum reproductive potential. Nectar tends not to be limiting for BCB but is an indicator of good habitat. Nectar sources were low to moderate this year.

This year saw high native plant cover at two of the sites and low cover at the other site. Native richness remained stable at moderate values throughout the property. Nonnative grass cover hit a historical low at CROSP-Mid but was variable across the property in 2022.

CROSP-Mid had the highest habitat quality again this year, with the highest dwarf plantain (along with CROSP-North) and the highest goldfields. It also had the highest native cover, species richness and annual forbs. This site had the very low nonnative annual grass and overall nonnative cover, as well as low thatch cover. For this year, it had moderate nectar sources and perennial forbs. CROSP-Mid is in the CROSP Upper Slope BCB zone, which had low larval densities in 2022, but was occupied.

CROSP-North had similarly high habitat quality with CROSP-Mid. With CROSP-Mid, it tied for highest dwarf plantain. It also had the highest bunchgrass and seaside muilla cover as well as the highest perennial forbs. This site had high native cover and moderate species richness. Nonnative grass cover was moderately low, and thatch was lowest here. BCB larvae plummeted to a historical low here, although the zone remained occupied.

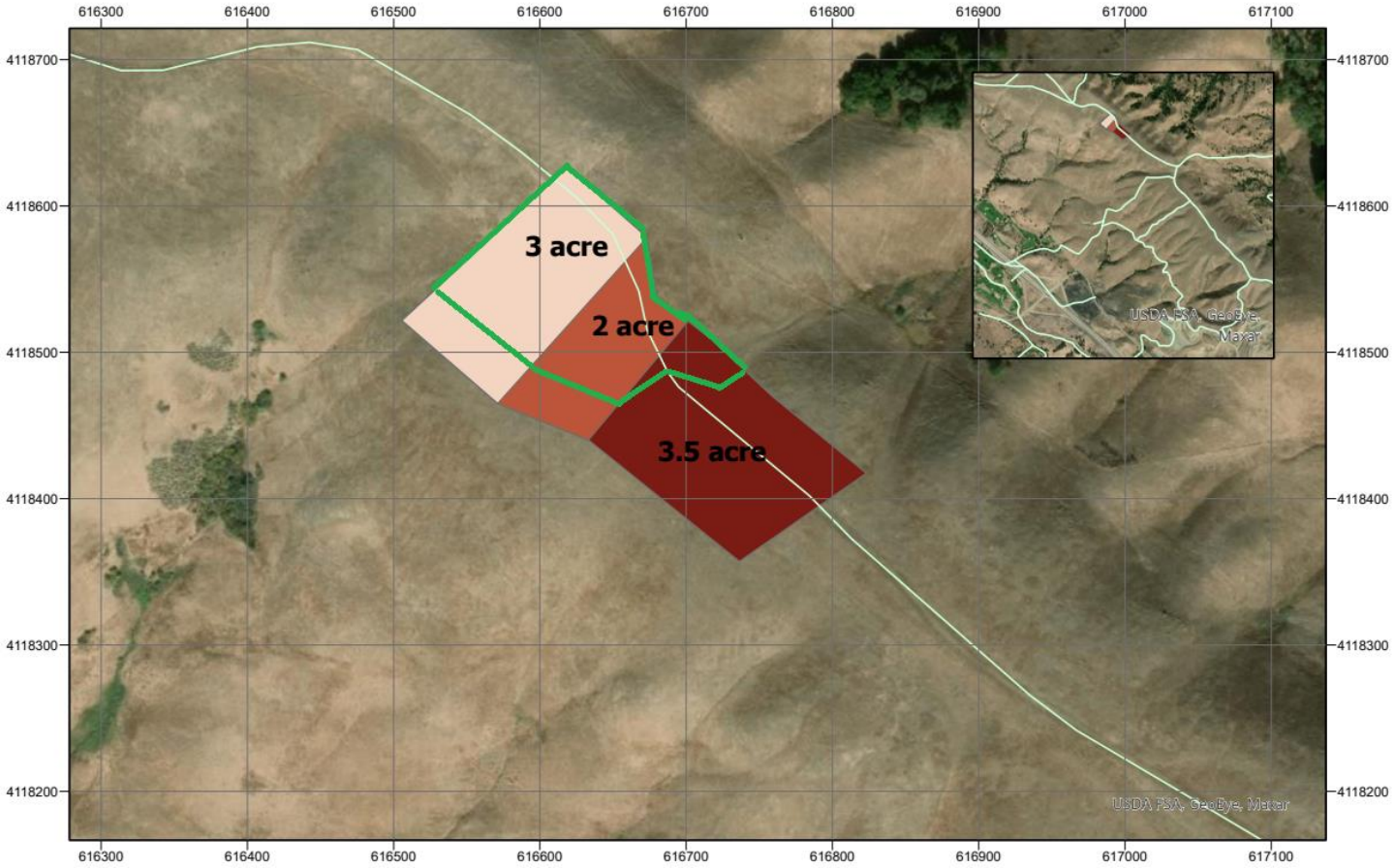
CROSP-South had the highest jeweled onion and adequate host sources. Unfortunately, it also had the lowest goldfields and bunchgrasses. Nonnative annual grass and thatch cover was highest here again this year. CROSP-South had the lowest native cover and annual forbs, however it did have moderate native richness and the highest bare. BCB larvae were undetected this year, although adults were later found present. Note that CROSP-South is the only cluster in the second rockfield.

It should be noted that the North and South clusters are infested with barbed goatgrass. (Barbed goatgrass is reported with the nonnative annual grass guild but can be queried separately). Some studies are underway to assess the impacts of goatgrass on high quality habitats, and to see if goatgrass necessitates different management responses relative to other nonnative grasses.

Creekside Science has been working with David Mauk, Natural Resources Technician at SCVOSA to treat barbed goatgrass and other nonnative annual grasses at the southern summit border of CROSP. A pilot spraying effort took place February 18-19, 2021 (Map 14). This area is seen as a key location because it is mostly the southern edge of the barbed goatgrass infestation, and because other nonnative annual grasses like Italian ryegrass are decreasing otherwise high habitat value, as documented in a previous RDM report (Guenther 2020 sic). Mauk applied Envoy Plus at its lowest concentration recommended on the label to the areas outlined in green below, about four acres. Creekside Science recommended the lowest concentration in the belief that it would kill the annual grasses but not the native perennial bunchgrasses. Unfortunately, the results were barely visible, with only the first pass showing a kill line (Photos 1a and b). We are unclear why there was a variable response to the treated area. The phenology was excellent, with grasses

germinating but not bolting. Weather was sunny with low wind. It's not clear whether the tanks were unevenly mixed or whether there was some other equipment failure. We recommended repeating the experiment in 2022, with a higher concentration of the Envoy Plus.

Spraying took place again in February 16-17, 2022, which was a calm, mild window. The total amount of herbicide used was 64 ounces of Envoy and 60 ounces of Target Pro-spreader activator (surfactant) on about 5 acres sprayed (Map 15). The PCA recommendation is 32 fl oz per acre. The concentration again was likely too low, and no obvious effect was seen. Mauk will more closely calibrate the amount of product used to the area covered. We may try spraying later in February, to see if more mature vegetative plants are more vulnerable to spraying, but phenology was probably not the problem.



Map 14. Area treated by Envoy Plus in February 2021 is marked in green.

Photos 1a and b. The Envoy Plus spray line was visible only at the first pass and otherwise had no visible effect.

Map 15. The area treated with Envoy in 2022.

All CROSP sites surveyed are Bay checkerspot butterfly habitat, with sufficient host plants and nectar sources. The data among sites show that different locations, elevations, and grazing regimes can support Bay checkerspot butterfly and their associated diverse native flora. This year's drastic decrease in Bay checkerspot butterfly larvae is concerning. It does not appear to be due to an overall lack of appropriate vegetation, but is more likely tied to early drying of host plants during the dry winter and warm spring.

Data for nearby ungrazed serpentine sites can be supplied on demand to better understand the habitat thresholds where Bay checkerspot butterfly disappear.

The following are recommendations based on the Habitat Plan biological goals and objectives and the survey results.

1. Mostly maintain current grazing regime in the different pastures at CROSP, which includes providing the ranchers flexibility in adjusting annual stocking rates and timing as documented over the last decade (see Grazing Regime section above).
2. To better assist ranchers in meeting both resource management and beef production goals, consider creating smaller "sacrifice" pastures. This is a method ranchers can use to address the problem of grass cover that changes dramatically with interannual weather fluctuations. A smaller pasture is created that doesn't need to be grazed every year (i.e., off serpentine). In years where forage is high and/or herd numbers are low, the cattle can be maintained in the higher priority pastures, i.e., those with Bay checkerspot butterfly and associated native annual forbs. In years where forage is low and/or herd numbers are high, the sacrifice pasture is grazed. The sacrifice pasture addresses the fact that while cattle are land management tools, they are living creatures that can't just be left in storage when not needed. This prescription isn't critical now, but is standard grazing practice that is especially useful in regions like this that have large interannual weather and forage fluctuations.
3. Continue the Envoy Plus graminicide spraying experiment. This should include retreating/expanding the 2021-2022 treatment area, targeting nonnative annual grasses, including barbed goatgrass. Use the highest concentration recommended by the label. Personnel should carefully calibrate the amount of product used per area treated. This treatment should improve habitat for BCB and native vegetation, as well as increase visual enjoyment for visitors. We envision such treatments taking place annually at new locations on the ridge, perhaps 2-4 acres a year.
4. Continue annual monitoring to track vegetation community changes. Share key results with grazing tenants.
5. Manage key invasive plants.
6. Introduce prescribed fire on a trial basis, as supported by Richard Harris's 2021 Wildfire Management Coyote Ridge Open Space Preserve (CROSP) document. Prescribed fires were conducted on CROSP in 2006 and 2007 to treat barbed goatgrass, but lack of fuel in the selected burn unit resulted in poor burn coverage. We recommend further studies as described in GRASS-2. Wildfires provide limited opportunity to study fire effects, because pre-burn data are lacking (i.e., the fire tends to burn a very small number of already established plots).

Conclusion

CROSP is a biologically rich property that supports multiple taxa covered by the Habitat Plan. This report noted:

- While 2022 had more precipitation than 2021, the exceptional drought continued. Climate change is likely to be a long-term concern.
- Bay checkerspot butterflies on CROSP historically make up a major component of the Coyote Ridge metapopulation complex, but larval numbers on the property plummeted tenfold this year. The entire region saw declines, although they were small in some areas, such as the 10% decrease at the Kirby Canyon Butterfly Preserve. Large population fluctuations are natural but require ongoing data collection to detect problematic declines. Annual larval and adult monitoring should continue.
- The current grazing regime supports both Bay checkerspot butterfly and associated vegetation. Low cover of host plants is within the range of historical variability, but could be problematic in conjunction with the low BCB numbers. Annual vegetation composition monitoring should continue.
- Annual grass cover has decreased over the last five years in the first rockfield, but has remained at similar values in the second rockfield (CROSP-South). Higher grazing pressure is desirable here. Creating smaller "sacrifice" pasture(s) may help ranchers address the problem of grass cover that changes dramatically with interannual weather fluctuations.
- The Envoy Plus graminicide spraying experiment should continue. This should include retreating the 2021-2022 treatment area and targeting nonnative annual grasses, including barbed goatgrass. Use the highest concentration recommended by the label. Personnel should carefully calibrate the amount of product used per area treated. This treatment should improve habitat for BCB and native vegetation, as well as increase visual enjoyment for visitors. We envision such treatments taking place annually at new locations on the ridge, perhaps 2-4 acres a year.
- We concur with Richard Harris's (2021) recommendations to introduce prescribed fire on a trial basis, perhaps as training opportunities for fire agencies.

CROSP is an excellent part of the Habitat Plan's reserve system. Its high number of covered taxa and connectivity to additional sensitive habitats make it a critical property in the conservation of the covered taxa. Creekside Science looks forward to assisting with the Habitat Agency's mission over the coming years.

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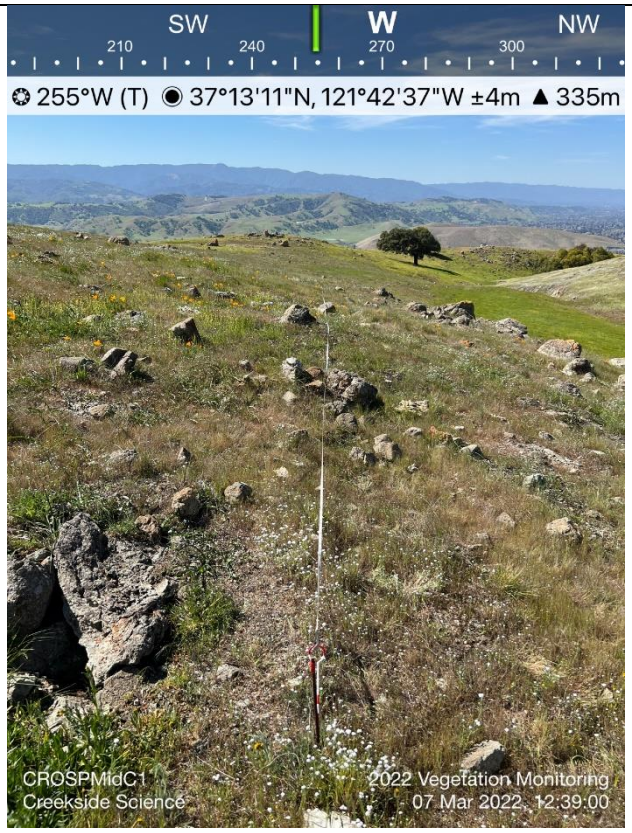
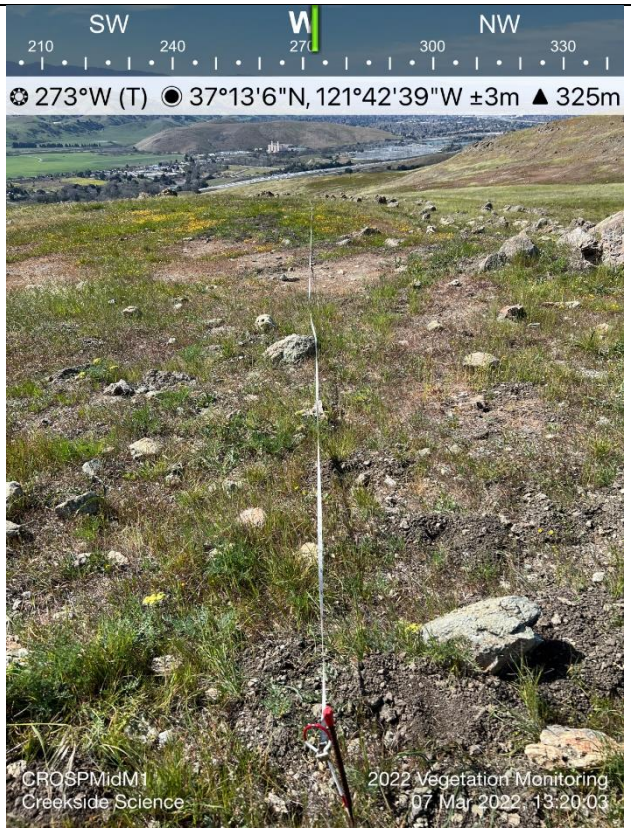
Appendix A: 2022 Vegetation Composition Transect Photopoints

CROSP Mid C1

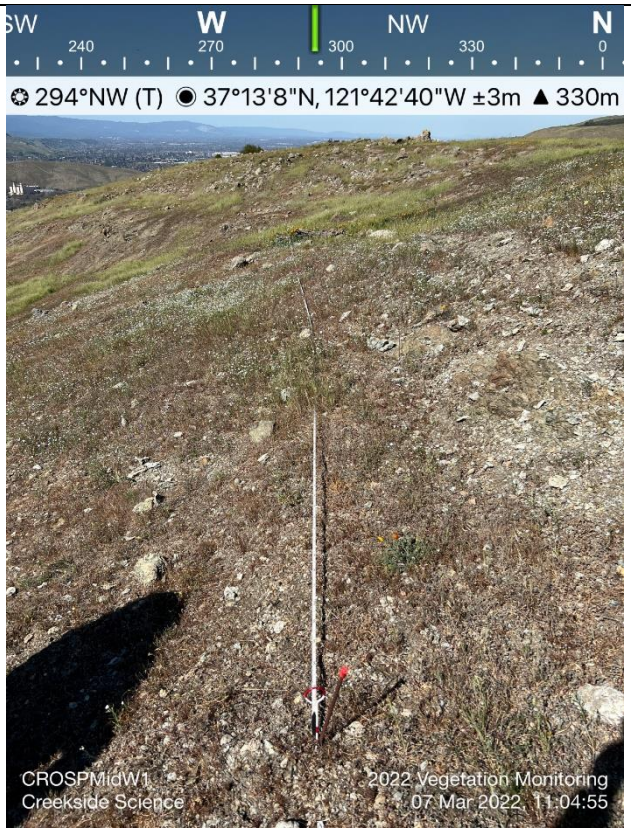


CROSP Mid M1



CROSP Mid VC1

CROSP Mid W1



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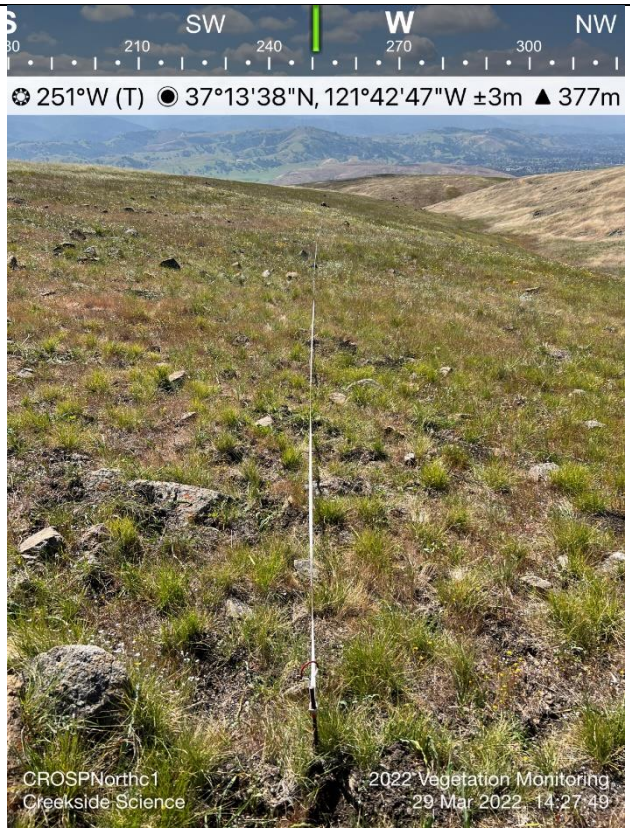

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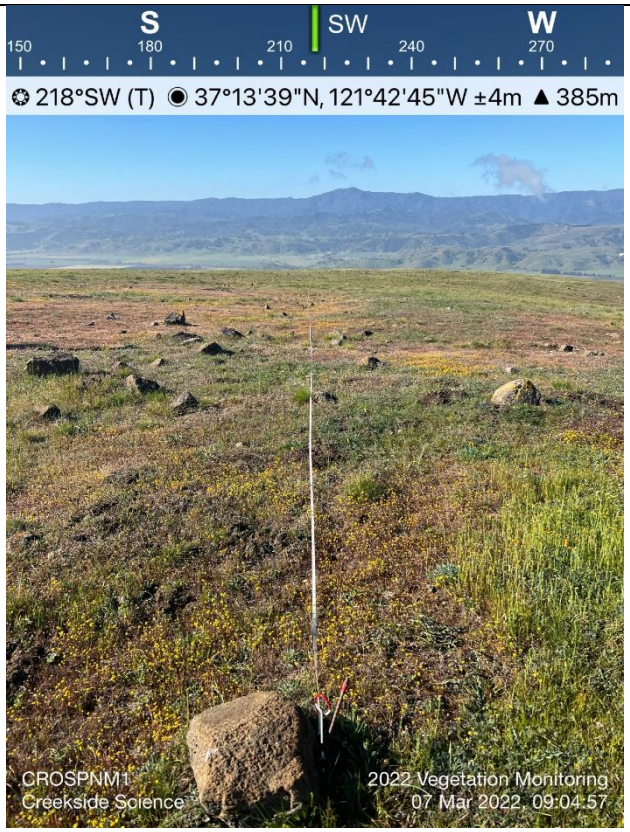
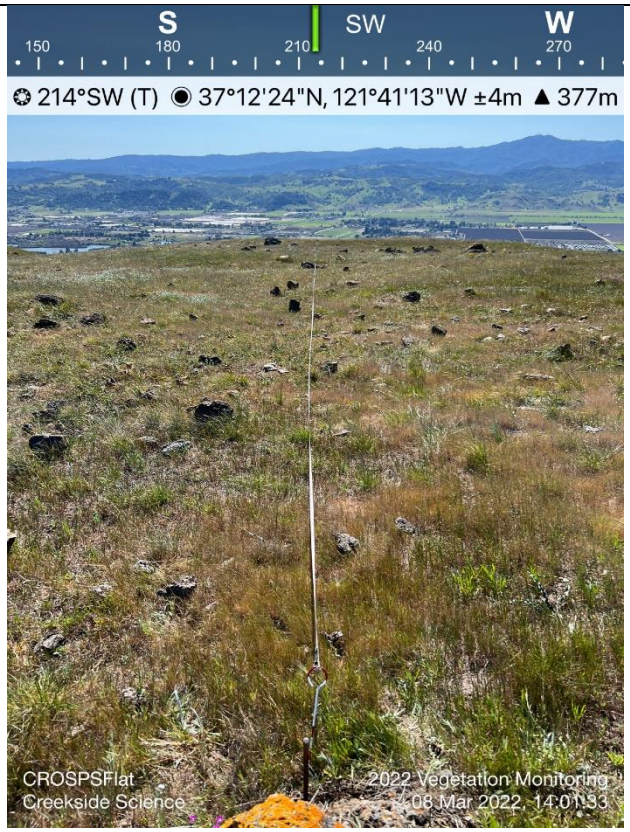


CROSP North VC1

CROSP North W1

CROSP South C1

CROSP South M1



CROSP South VC1

CROSP South W1