

Initial Assessment of Monarch Butterfly Overwintering Habitat in Bolinas, California:

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Monarchs sunning at BPUD North Grove, Nov 7 2023. Photo by S.B. Weiss

Introduction and Background

The Bolinas Eucalyptus Project (BEP) has identified major public safety hazards from the grove of blue gum eucalyptus at Mesa Rd. and Olema-Bolinas Rd on Bolinas Public Utility District (BPUD) Lands. The site is also used by monarch butterflies during the overwintering season. This document provides a brief outline of the major issues and proposes alternatives and weighs their feasibility and ability to meet multiple objectives. Because of the urgent nature of decision-making, I am providing my professional opinions on the various issues, with more detailed analyses of the suitability of monarch habitats to follow in a second phase.

The ultimate goal is to secure public safety in the short-term and also provide suitable monarch habitat in the long-term in and near Bolinas.

State of the BPUD North Grove

The professional arborist/forestry reports definitively conclude that this grove is a continuing hazard to public safety, as demonstrated by dozens of treefalls over the past two seasons that blocked the road, took down powerlines, and nearly killed some people. The latest storm in mid-February 2024 downed yet more trees and cut power and access to much of Bolinas for several days. The reports also concluded that the initial establishment of the grove, history of management (or lack thereof), and current structure will lead to continued deterioration of the stand and further treefalls, with positive feedback as thinning increases wind vulnerability, treefalls, and hazards. As such, the only way to mitigate the hazards is complete removal of the grove; partial thinning and removal will only delay the inevitable and maintain the hazardous conditions.

I concur with this assessment – the grove is an immediate urgent hazard to public safety, and its condition and future trajectory makes it unsustainable as monarch habitat. The question then becomes how to accommodate monarch butterfly habitat in Bolinas commensurate with public safety.

Monarch Butterflies in Bolinas

As of 2023-24, Bolinas is the northern range limit of substantial numbers (>1000) of clustering monarchs. Small numbers (100 or fewer) have been observed at sites along the Sonoma Coast where monarchs formerly clustered in larger numbers (in the 1990s and before) when monarchs numbered in the millions in California. The large reductions in western monarch numbers are primarily a function of conditions in the breeding habitats extending from near-coastal California to the Rocky Mountains and north into the Pacific Northwest, as multiple generations of monarchs breed in milkweed stands. How they sort out among the various overwintering groves is a complex process whereby monarchs roost in groves and remain or leave depending on the microclimatic suitability (wind, temperature, and sun), eventually settling on a number of groves that can provide those microclimate conditions.

There are several sites in Bolinas that act as a “meta-colony” of monarchs, in which monarchs move in during the initial migration in October and redistribute themselves among the various discrete sites. As of 2023-24, the sites used by clustering monarchs include:

- 1) BPUD North (Site 2915) – this is the hazardous stand along Mesa Road and is also referred to as “Goat Pen.”

- 2) Other BPUD sites (Site 3163) – south of the hazard stand are several areas where monarchs have clustered in the past and small numbers were observed in 2023-24. These sites include “Toyon” on the south border of BPUD, and a “Bowl” SE of the Toyon site.
- 3) Kale Ave (Site 3227)- the stand of blue gum eucalyptus south of Elm between Kale and Juniper on private land.
- 4) Agate Beach/Alder Vortex (Site 2912) – spread across multiple properties especially southern windbreak trees.
- 5) Purple Gate (Site 2899)
- 6) Mesa Road (Site 2913) – monarchs clustering observed only in 2022

Other sites in Bolinas proper appear to be degraded and unsuitable, notably Terrace Ave (2901), Hawthorne (2917) and Grove and Alder (2900) which do not have counts recorded and are unoccupied by clustering monarchs as far as we know. The full array of counts is in Table 1 below.

Farther afield, Palomarin Trailhead (Site 2904, N of the map) once supported monarchs in the 1990s, but no counts are reported since 1997. The MCI site (2918) and Sites 2916 and 2914 do not have annual counts.

An initial look at these sites using 2023-2024 hemiphotos and 2019 LiDAR data will be presented below. Some ideas for site enhancements are presented as well. But a full analysis of the existing conditions, and detailed suggestions for site enhancements will require future analysis as feasible options become more clear.

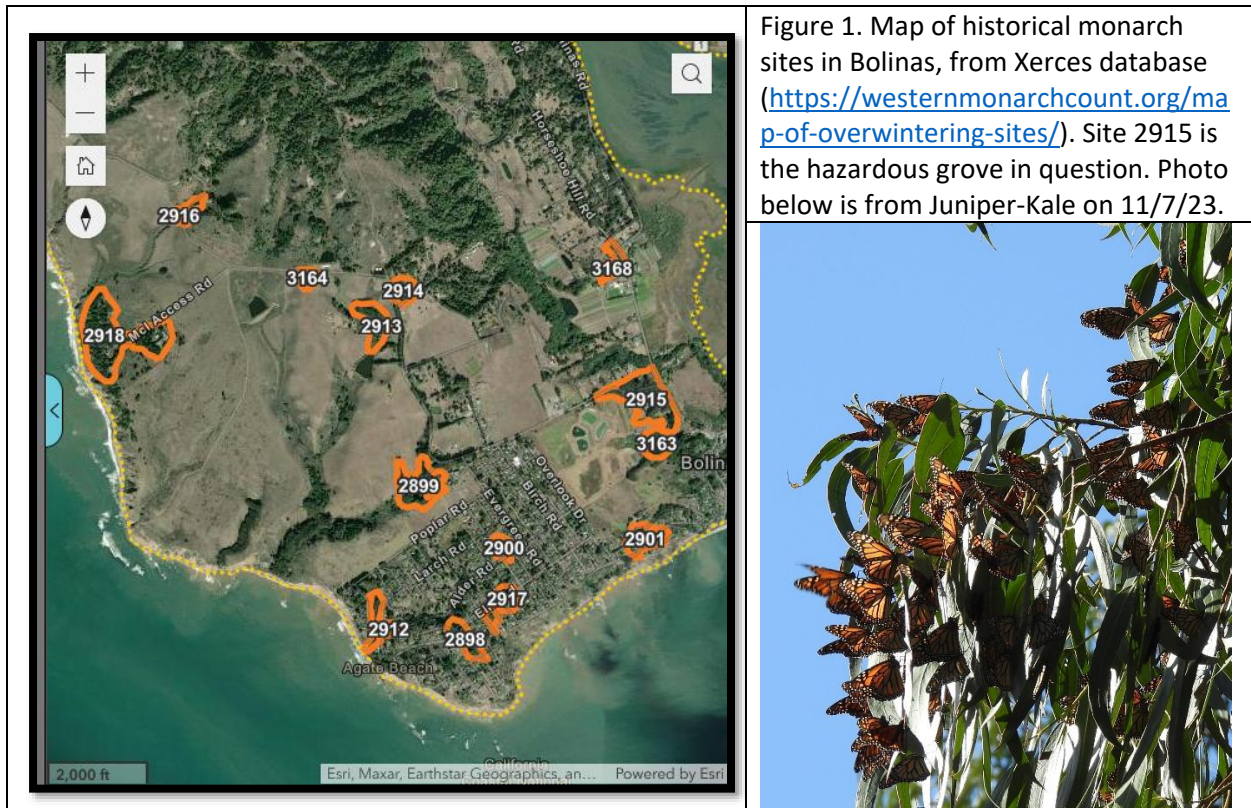


Figure 1. Map of historical monarch sites in Bolinas, from Xerces database (<https://westernmonarchcount.org/map-of-overwintering-sites/>). Site 2915 is the hazardous grove in question. Photo below is from Juniper-Kale on 11/7/23.

Monarchs in Marin and Sonoma Counties 1997-2023

Table 1 has compiled Xerces Thanksgiving Count (TG) data for Marin County sites, and a total for Sonoma and a total for Bolinas. The limitations of the TG Counts are acknowledged (i.e., changing number of sites, sampling idiosyncrasies, illusory precision, etc.) but they are useful for a broad brush look at the overall population and relative contribution of different regions.

Monarch numbers in Bolinas exceeded 15,000 as recently as 2015-2017, with a peak >20,000 in 2015. During this period, they contributed 6-9% of the California total. During the 2020 collapse, Bolinas contributed 7%. In 2021, the overall California population recovered, but the Bay Area numbers remained low, so the contribution dropped to 0.1%. In 2022 and 2023 Bolinas contributed 1.2-1.4%.

The retention rate between Thanksgiving and New Year’s counts (years designated by the Thanksgiving Count) ranged from 2-3% in 2016, 2018, 2019, and 2022 to ~50% in 2017, 2020, and 2021 (Figure 2).

Bolinas is at the northern range limit of overwintering monarchs in California. Sonoma sites have been nearly vacant since 2018, and (even if undercounted by an order of magnitude) do not provide a substantial source of migrants from the north.

SITE ID		2912	2915	2903	3226	2909	2675	3227	2913	2899	2901	2897		
SITE NAME	Sonoma Total	Alder Rd., vortex (Larch, Ocean St)	Bolinas Sewage Facility	Chapman Ravine, Stinson Beach	Charlotte, Muir Beach	Fort Baker, GGNRA	Fort Barry, Marin Headlands (Youth Hostel)	Juniper & Kale, Bolinas	Mesa Road, north of Bolinas	Purple Gate, Bolinas	Terrace Ave., Bolinas	Terwilliger Grove, Muir Beach	Total Bolinas	% of California
1997	6,660			15,500			2,550			12,000		2,100	12,000	1.0%
1998	1,600			4,000		1,600	0			8,050	2,050	500	10,100	1.8%
1999	750			3,000		200	0			1,500	1,000	500	2,500	0.9%
2000	3,206		1,500	15,150		310	0			12,050	2,000	305	15,550	4.0%
2001	7		0	1,000		15	0			3	0	0	3	0.0%
2002	0	2,300	0	2,000		0	0			2,000	0	35	4,300	4.3%
2003	160	10,400	5	2,000		9	0			300	0	54	10,705	4.2%
2004	34	8,880	122	8,050		2,200	0			7,200			16,202	7.9%
2005	0	950		0		0	1			130		365	1,080	0.5%
2006	0	3,520	0	0		550	0			2,600	0		6,120	2.8%
2007	0	1,000		0		0	0			0	0	0	1,000	1.2%
2008	0	390		3		5	0			20	0	0	410	0.3%
2009	0	1,700	0	49		0	0			27	0	0	1,727	3.0%
2010	0	0	0	0		0	0			0	0	0	0	0.0%
2011	600	7,700	0	800		500	0			400	0	0	8,100	3.6%
2012	10	150	0	0		10	5			530	0	0	680	0.5%
2013	5	1,013	0	503		0	0				0	2	1,013	0.5%
2014	8	3	0	2		0	2			0	2	0	5	0.0%
2015	911	4,050	3	8,200	8,000	250	5	10,200		8,000	0	0	22,253	7.6%
2016	50	13,375	0	4,000	1,206	259	0	4,060		1,020	0	0	18,455	6.2%
2017	15	12,360	410	210	414	5	1	4,310		625	1	0	17,706	9.2%
2018	5	1,256	0	1	8	0	0	200		975	0	9	2,431	8.8%
2019	0	200	5	0	0	5	0	113		10	0	0	328	1.1%
2020	7	100	10	5	2	0	0	19		5	0	5	134	7.0%
2021	13	105	10	5	0	25	0	20		0	0	0	135	0.1%
2022	3	1,012	432	56	30	3	0	1,042	29	1,393	0	0	3,908	1.2%
2023	3	925	1265	68		26	0	911	0	220		0	3,327	1.4%

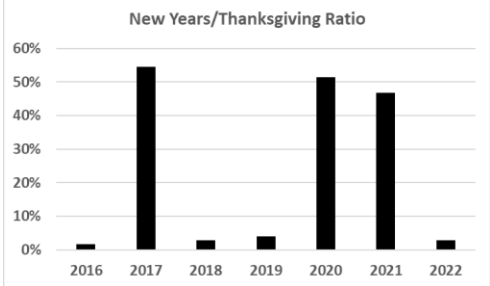


Table 1. Thanksgiving Counts for Marin County and a sum of Sonoma sites, with percentage of California monarchs in Bolinas calculated.

Figure 2. Retention rate between TG and NY counts 2016-2022 (tear designates the TG count year).

Monarch Butterflies in Bolinas 2023-2024

We are fortunate to have a nearly daily record of clustering monarchs in 2023-2024 by Davis Ainley and Janice Tweedy that show some of the dynamics of the meta colony. The stacked area chart graph (Figure 1) shows daily counts at the three major aggregation sites. Because not all sites were surveyed on each day, a second graph (Figure 2) with the maximum weekly counts for Bolinas as a whole smooths over the sampling variability. The third graph shows the weekly maxima at each individual site so that the distribution among sites is apparent.

- 1) The raw daily counts (Figure 2) showed high short-term variability, with peak total counts >2500 butterflies. Some of the low numbers are days when not all the sites were counted, others are when monarchs abandoned sites temporarily.
- 2) All three sites had some clustering monarchs throughout the season. Juniper Kale attracted the most monarchs through late October, and ~50% moved primarily to Alder-Vortex in early November. The numbers at Juniper-Kale declined steadily through the season.
- 3) BPUD supported a small fraction until early-November, but increased to ~50% in November and December.
- 4) Smaller numbers of butterflies (<200) clustered in Bolinas in January.
- 5) On January 27, afternoon observations of dozens of butterflies flying and sunning at Juniper Kale and BPUD indicated that numerous monarchs were still present in Bolinas but were not clustering *en masse*.
- 6) Monarchs were observed flying and resting at other sites on and adjacent to BPUD lands, getting an accurate count is not feasible although there were likely dozens on the wing, and some unknown number resting and undetectable. The presence of some of these butterflies are noted in the Ainley/Tweedy data set. Monarchs are exploring numerous sites during good flight conditions.

Interpretations

Based on my decades of experience with overwintering California monarchs, my interpretation of the monarch occupancy patterns is as follows:

- 1) Bolinas is the farthest north region that supports more than a handful of overwintering monarchs at present.
- 2) In October, monarchs from the North Coast Ranges and Pacific NW migrate in numbers into the Bolinas area and find the various eucalyptus stands in Bolinas. The presence of monarchs in a site attracts more monarchs that are flying by.
- 3) The high variability in overall numbers, and dynamic distribution among sites indicates that none of the three major sites is providing suitable microclimate conditions for season-long clustering.
- 4) The smoothed weekly abundance curve (Figure 4) shows the rise and fall of the entire Bolinas metacolony.
- 5) The lower numbers later in the season (January) are typical for monarch aggregations – attrition and emigration are normal population phenomena.
- 6) The pattern of high numbers, followed by low numbers, and recovery to higher numbers can be interpreted as monarchs leaving sites that are too exposed to wind, scattering across Bolinas,

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and re-aggregating a few days later. This pattern was repeated several times over the season. Scattered monarchs are difficult to observe when roosting.

- 7) An alternative explanation of Bolinas being a stopping point on a directional migration is not supported by observations north and south of Bolinas, such as the very low numbers observed in Sonoma overwintering sites and lack of observations of monarchs on the move outside the overwintering sites.

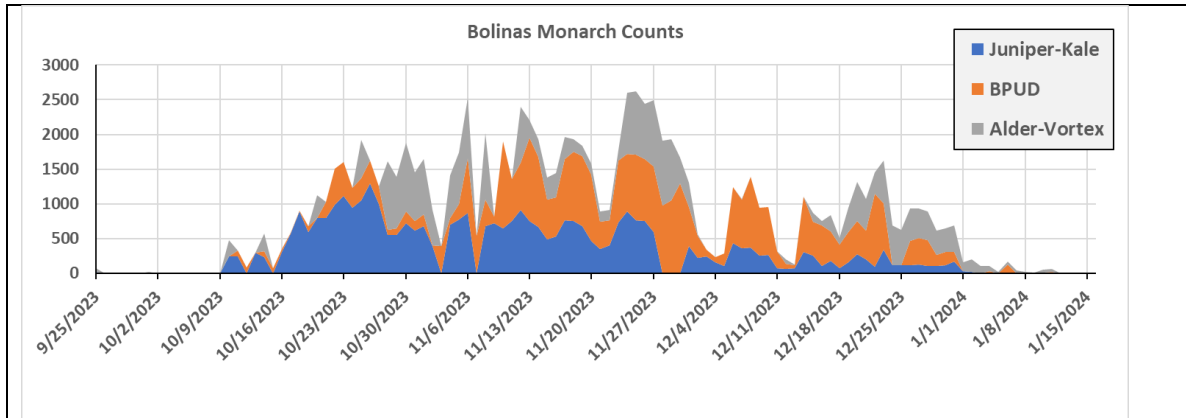


Figure 3. Stacked area daily counts of monarchs at three major sites in Bolinas.

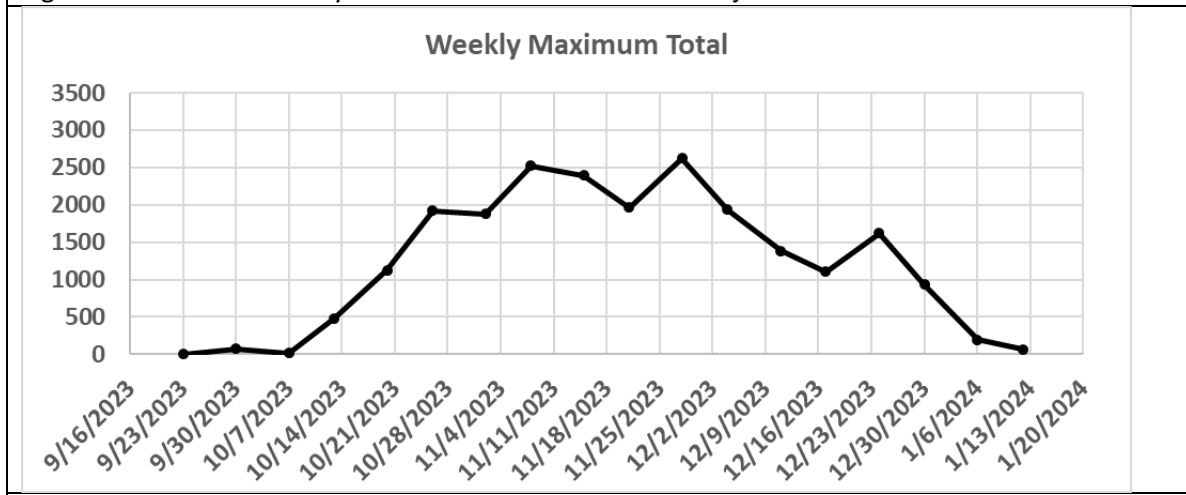
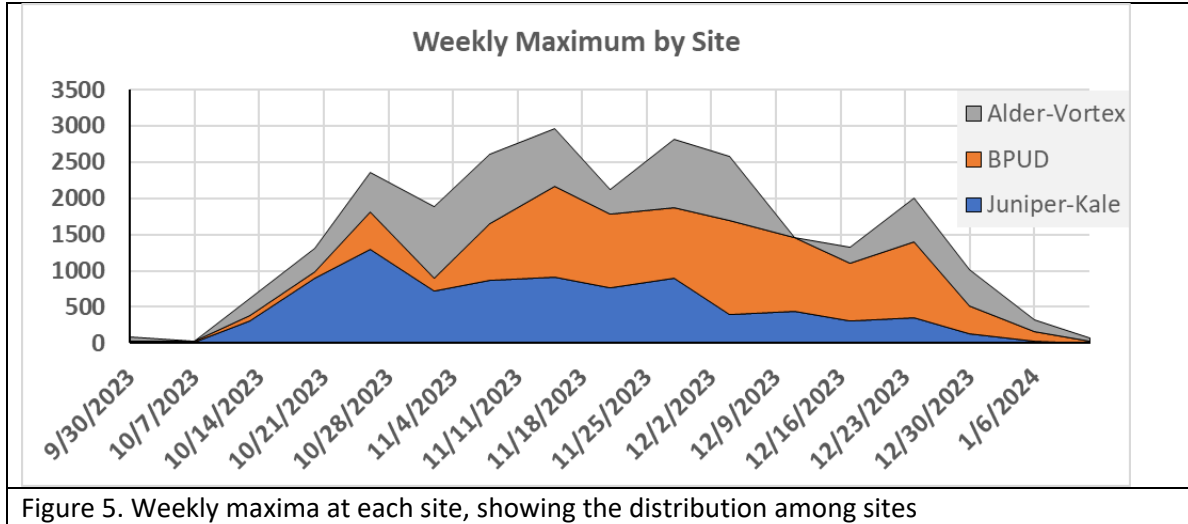
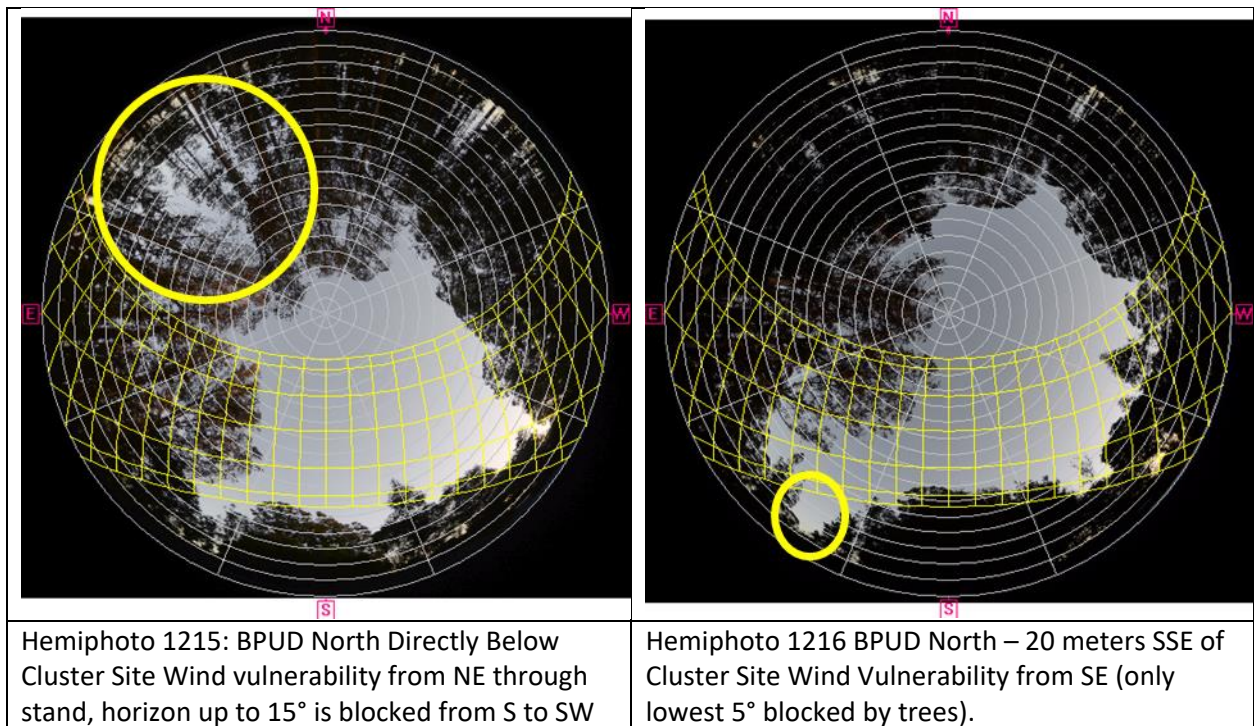


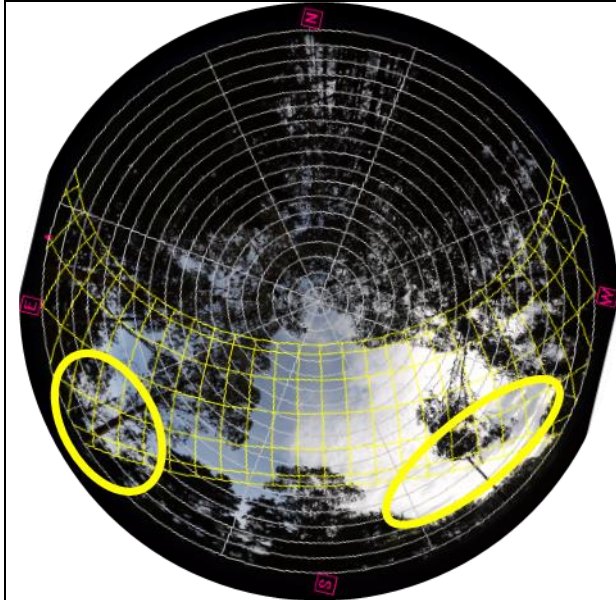
Figure 4. Weekly maximum of sum of three sites, showing the overall progression of the season.



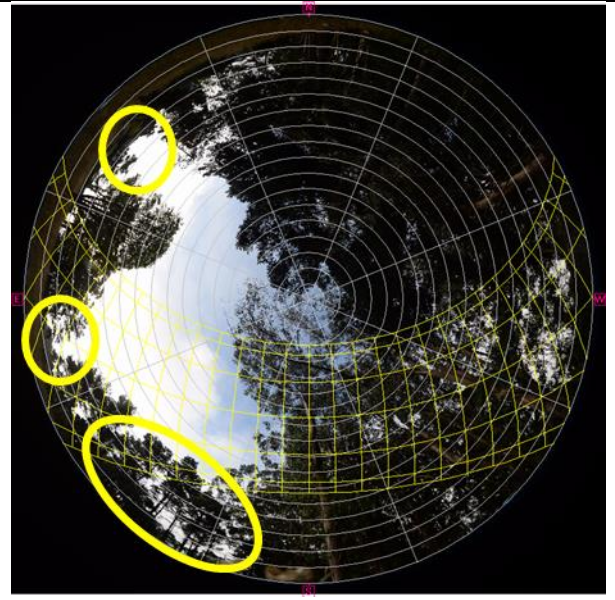
Sample Hemiphotos at each site.

The hemiphotos below show an example from each site, usually a known cluster site, to qualitatively identify wind vulnerabilities where open sky is visible close to the horizon. Note that east and west are reversed from map views because the photos are taken looking up..

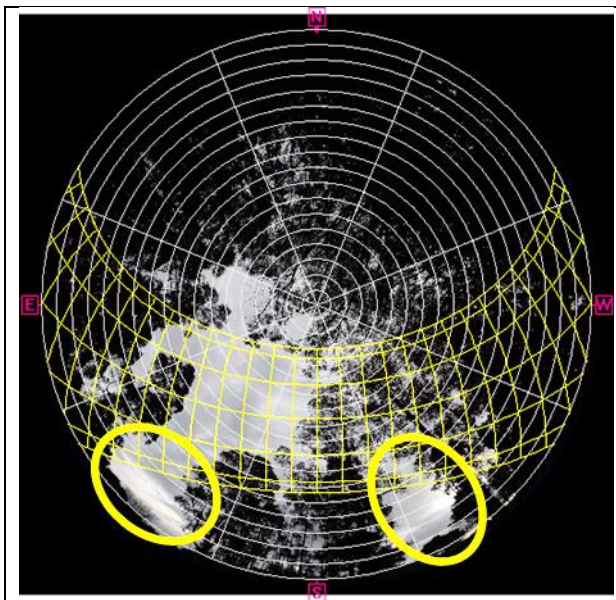




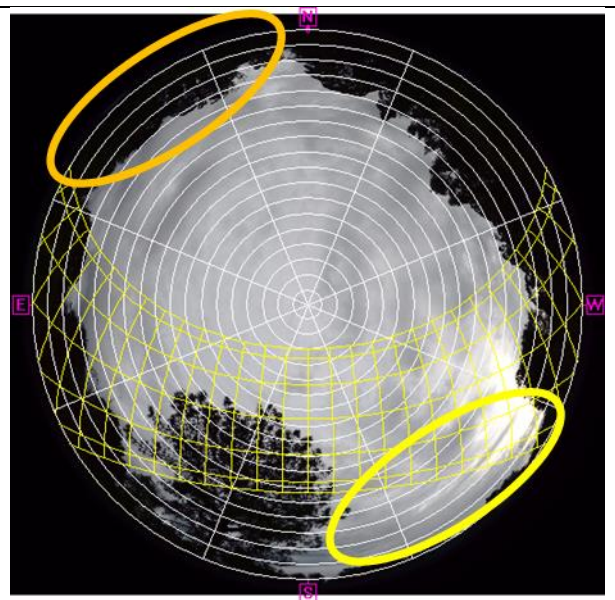
Hemiphoto 1235: Cluster site at Juniper-Kale. Vulnerability from SW, this sector is where PG&E cut a eucalyptus tree that provided wind shelter. Additional wind vulnerability from SSE.



Hemiphoto 1195: Alder-Vortex. Pines with open understories to SE, other wind vulnerabilities from E and NE. The relative directions of gaps varies along the row of cluster trees so short-distance movements can regain wind shelter.



Hemiphoto 1251. Toyon site. Wind vulnerabilities from SE and SW. Resprouting eucalyptus to S allow some dappled sun mid-day near ground, and direct sun at heights..



Hemiphoto 1257. At S edge of Bowl. Large Torrey Pine in SSE foreground. Large gap to SW could be filled with Torrey pines Potential monarch cluster trees in orange ellipse to NE across Bowl.

Potential for Monarch Habitat Enhancements in Bolinas

Because the BPUD North grove is unsustainable as monarch habitat given the demonstrated extreme hazards, looking elsewhere on the Bolinas Peninsula for opportunities to actively manage and enhance monarch overwintering habitats.

The following maps show LiDAR views of three sites, and some potential enhancements. Note that these are exploratory for now, and many issues need to be addressed regarding site ownership, long-term management, and the time lag for tree growth. Here are some initial thoughts to be explored.

BPUD: BPUD and adjacent properties have two sites that attract some monarchs, one of which supports clusters in some years (see photos 1251 and 1257).

BPUD North (Hemiphotos 1215 and 1216): It may be possible to design an aggregation site using Douglas-fir trees to replace N and E wind shelter that is currently provided by the eucalyptus stand. Trees would be planted just S of the existing eucalyptus, well away from the roads and powerlines. New healthy trees would not pose a threat to the trail. Some enhancement of the southerly wind shelter could create a sheltered cove with good sun exposure. Such a grove would take 10-15 years to grow tall enough to function as monarch habitat.

BPUD South: This infrequently used site will not be suitable once the main BPUD North grove is removed and there are no straightforward enhancements.

Toyon: (Hemiphoto 1251) Sealing up the SE and SW gaps at Toyon, while maintaining the thin eucalyptus canopy to the S would establish wind shelter and dappled light. Torrey pines might be ideal, as they thrive in the area and provide dappled light in addition to wind shelter. This site is largely on the parcel adjacent to BPUD (#19303003) and landowner participation would be essential.

Bowl: (Hemiphotos 1257) Planting additional Torrey pines at the S edge in line with the existing tree would establish wind shelter for the eucalyptus trees to the north. This site is entirely on the adjacent parcel (#19303003) and landowner participation would be essential.

The dense stand of eucalyptus and pine on BPUD north of Toyon may have potential with a gap cut to increase sun in the wind-sheltered interior. Such gaps have been cut at three other monarch sites; Monarch Lane in Los Osos, San Luis Obispo County, Andrew Molera State Park in Big Sur, and Point Pinole Regional Shoreline in Richmond.

Juniper-Kale: (Hemiphoto 1235) This site has been degraded by PG&E cutting and trimming trees to protect a powerline, which has opened the site to SW winds. A new row of fast-growing Douglas-fir planted an appropriate distance from the powerline could seal this vulnerability in a decade.

Alder-Vortex (Hemiphoto 1195): This site has some existing wind vulnerabilities that are ameliorated by short distance movements to avoid winds through the gaps. The major short-midterm threat is the loss of the older pines to the SE, some of which have already fallen. One idea is to plant a row of Douglas-fir at an optimal distance from the cluster row to eventually replace the wind shelter. The multiple ownerships of the overall site, including the wind shelter areas, could greatly complicate any management.

Purple Gate: This site once was one of the major sites in Bolinas. It has been opened up by recent removal of trees (2023) to ameliorate hazards and may not be salvageable as monarch habitat.

Mesa Rd. North of Bolinas: This site is just outside the LiDAR analysis footprint (but is within the 2019 LiDAR flight and can be analyzed. The dense stand in the drainage appears to have good wind shelter but may be too dense and dark for monarchs. It would benefit from a detailed LiDAR and hemiphotograph analysis. Numerous nectar plants have been established on the property with assistance from the Xerces Society, and the owner is willing and eager to improve the site for monarchs.

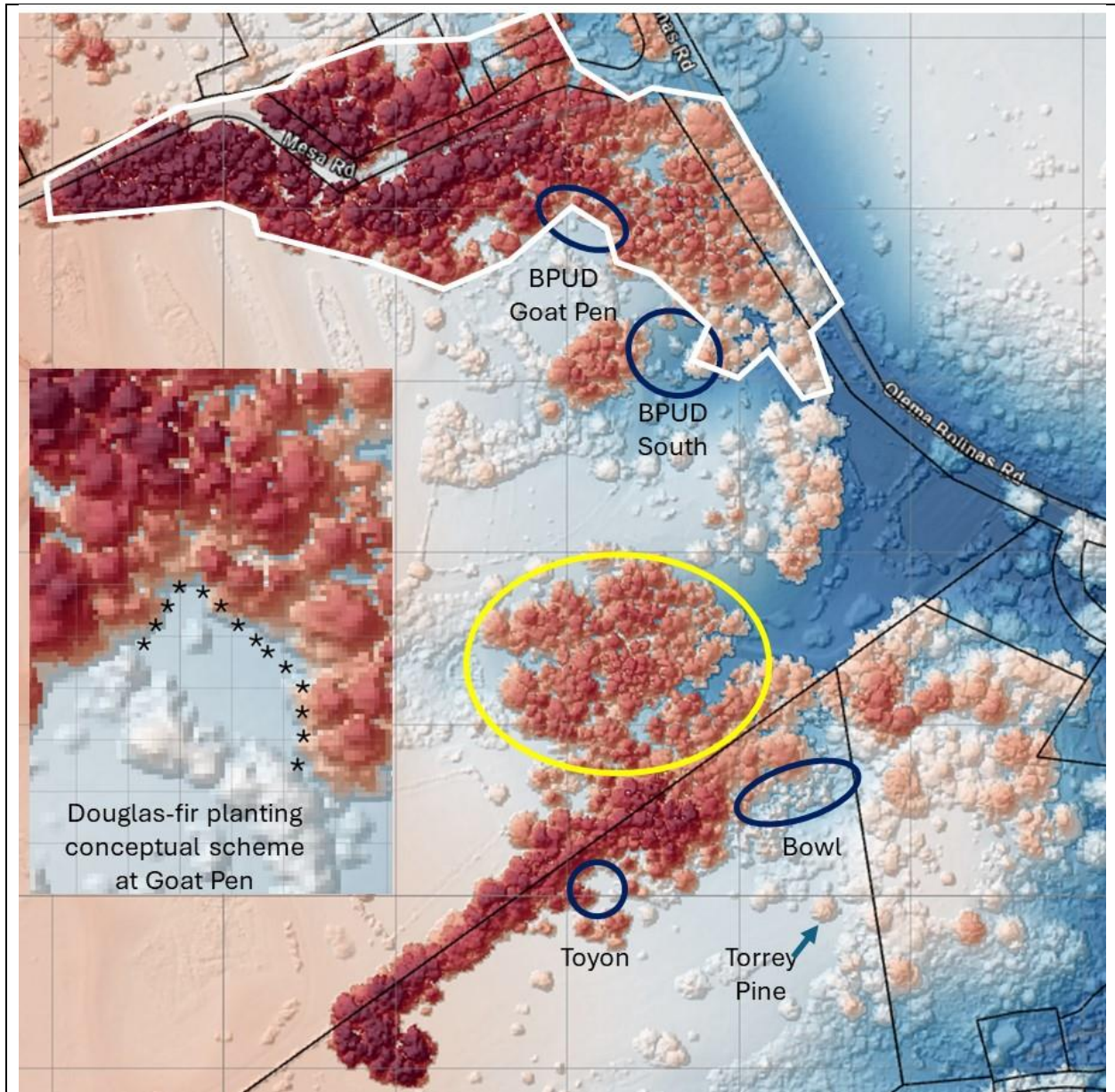
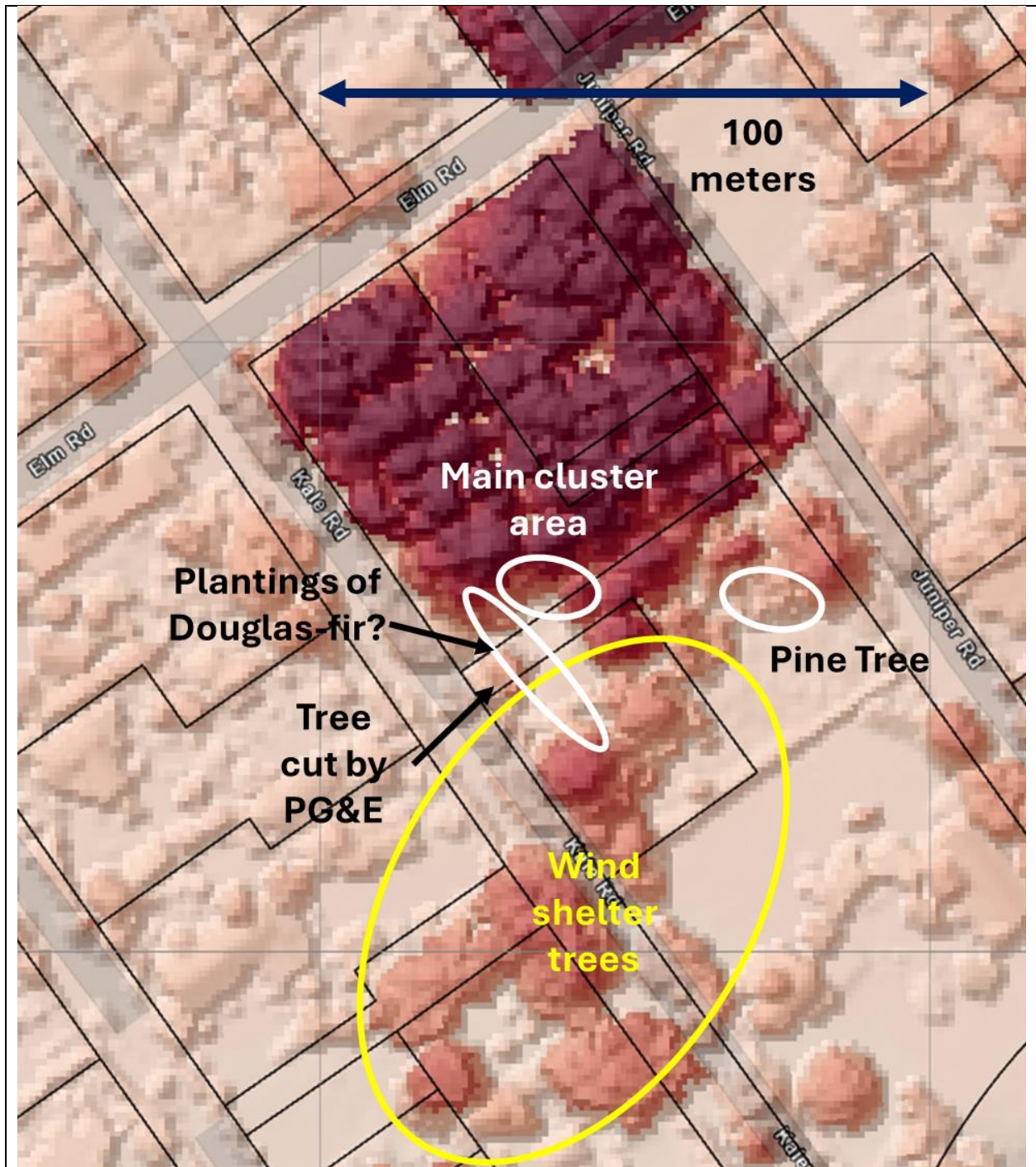
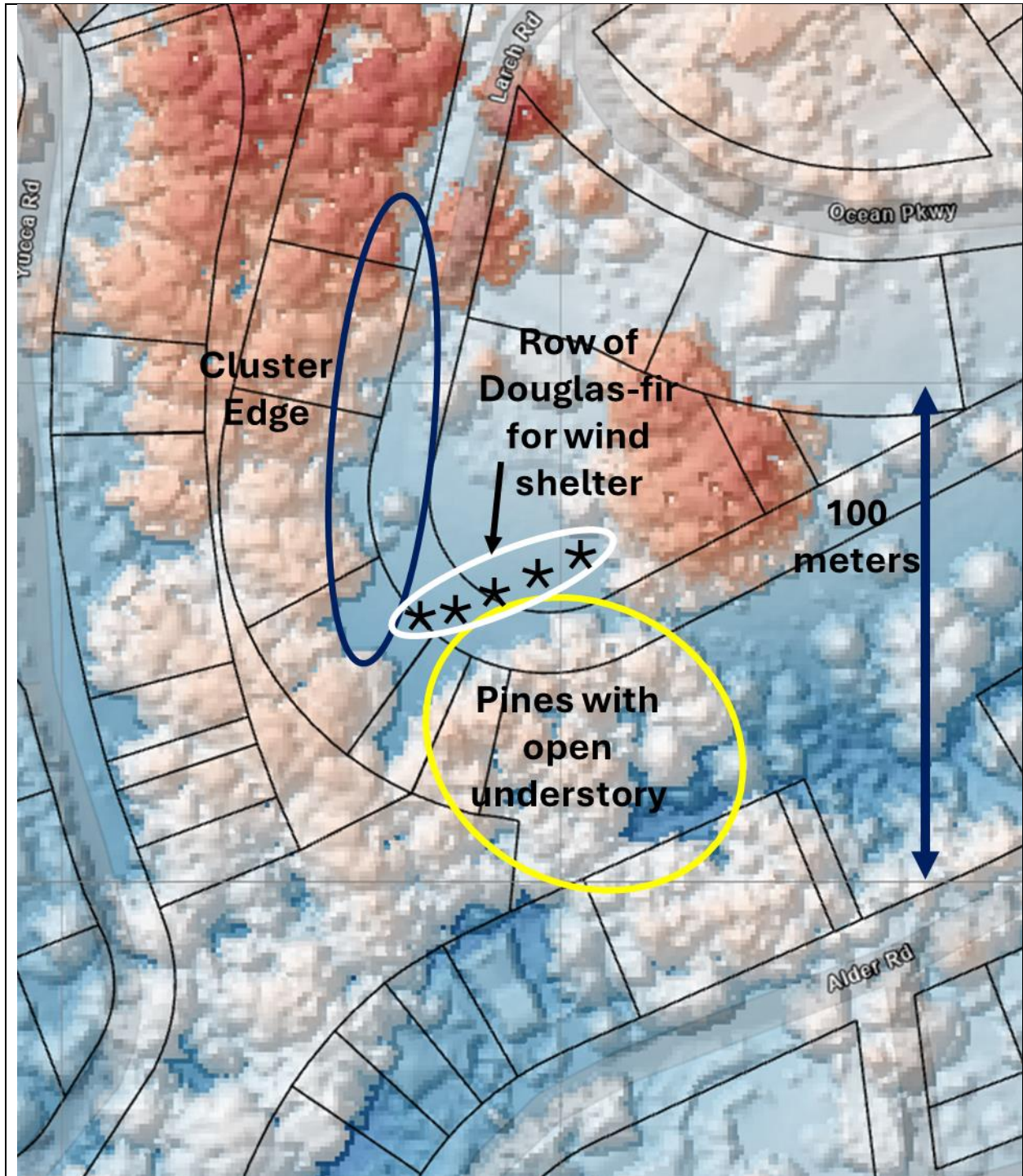


Figure 6. LiDAR map of BPUD area, with monarch sites identified. The white outline is the proposed grove removal. Toyon and Bowl on the adjacent property could provide alternative cluster sites with some additional shelterbelt plantings. The wind-sheltered interior of the grove of trees north of Toyon (yellow oval) does not receive enough sun to support monarchs, but a well-designed gap could be cut. The inset is a conceptual plan for planting Douglas-fir to eventually replace the wind shelter provided by the eucalyptus. A second row could be planted once the eucalyptus have been removed.



LiDAR view of Juniper-Kale. Monarchs cluster on the southern edge of the grove in a protected alcove. They also regularly sun themselves on a pine tree to the east during calm weather. The loss of the eucalyptus trees trimmed/cut by PG&E exposed the cluster area to SW winds. With some selected plantings of fast-growing Douglas-fir the wind shelter could be replaced in about a decade. The trees need to be planted far enough from the powerlines to not interfere. Most of the core site is owned by a single person, but the trees across Kale are on a different parcel.



LIDAR view of Alder-Vortex. Monarchs cluster along the E edge of the dense eucalyptus along a drainage. To the SE of the cluster edge, a stand of older pines has an open understory (see Hemiphoto 1195). One possibility to ameliorate the eventual loss of wind shelter is to establish a row of Douglas-fir in the area indicated (tree spacing and number not to scale) The multiple private parcels will make this a difficult site to manage.



Site # 2913 – Mesa Rd. North of Bolinas. This grove falls outside the current LiDAR analysis extent. The grove has potential – it may be too dense for monarchs, but a detailed microclimate analysis with hemiphotos and LiDARr is warranted. Selective thinning and gap creation may work here. Diverse nectar plants have been established on the property with assistance from Xerces Society, and the landowner is willing to consider monarch habitat improvements.