Monarch Butterfly Overwintering Site Management Plan for Pismo State Beach

North Beach Campground Site
Pismo Beach, California

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Left photo by Katie Hietala Henschell/The Xerces Society; Right top by Brian Baer/California State Parks; Right bottom by Grant Johnson/Coastal RCD

Acknowledgments

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INTRODUCTION

Hundreds of thousands of monarch butterflies (*Danaus plexippus plexippus*) rely on the forested groves of the Pacific coast stretching from Mendocino County, California to Baja to overwinter. However, between the 1980s and the mid-2010s this overwintering population declined by ~97% (Schultz et al. 2017), and, as of 2018 and 2019, the population is at an all-time low, <1% of its historic size (Pelton et al. 2019).

These startlingly declines have put the western migratory phenomenon at risk. The causes of decline likely include a combination of stressors such as breeding habitat loss, pesticide use, climate change, and overwintering habitat loss and degradation (Crone et al. 2019; Pelton et al. 2019). Protecting and restoring existing overwintering habitat is a vital part of the western monarch population's recovery (WAFWA 2019).

Pyle and Monroe (2004) suggest that overwintering is the most vulnerable element of the monarch's life cycle. The abundance of native tree groves along the California coast has changed significantly since European settlement; many remaining groves of suitable native and nonnative tree species are threatened by development. Degradation of habitat is also a threat, as monarchs require specific microhabitat conditions to successfully overwinter, including protection from freezing temperatures and high winds, sufficient humidity, dappled sunlight, fresh water, and nectar sources. Grove microclimate conditions change as forests age and as the result of human activities—implementation of adaptive management plans is needed to maintain suitable conditions for monarch aggregations at important overwintering sites into the future.

Pismo State Beach's North Beach Campground Site (hereafter referred to as "Pismo Beach"), like most overwintering sites, has undergone a severe reduction in its monarch population. However, the site still hosts thousands of monarchs annually, and has been ranked as the most important site for conservation and restoration out of 111 California overwintering sites (Pelton et al. 2016). The site is also an incredibly valuable opportunity for education, as it is one of the most popular overwintering sites with over 80,000 visitors annually.

In order to help ensure that Pismo Beach continues to provide high quality habitat for monarchs, The Xerces Society for Invertebrate Conservation ("Xerces Society"), in coordination with staff from California Department of Parks and Recreation ("State Parks") and Stu Weiss of Creekside Center for Earth Observation ("Creekside Science"), has prepared this site management plan with recommendations for State Parks to better plan and implement management actions which support overwintering monarchs in both the short- and long-term.

OVERWINTERING SITE MANAGEMENT GOAL

The overall goal of overwintering site management is to restore, maintain and improve the sites' value as habitat for overwintering monarchs. This entails providing the appropriate microclimate conditions for clustering as well as providing nectar resources and minimizing stressors to the butterflies.

To further this goal, the specific objectives of this site management plan are to:

1) Summarize past use of the site and identify current habitat status.
2) Recommend specific habitat management actions to improve the site's value for overwintering monarchs based on the best available science, monitoring data, and docent, staff, and expert opinion about monarchs' use of the site.
3) Provide guidance on improvements to outreach, education, and monitoring aspects associated with the site.
4) Provide a path forward for site management plan implementation.

OVERWINTERING SITE HISTORY AND DESCRIPTION

History of Site Land Use and Visitor Services

Written by State Park volunteers and edited by Emma Pelton of the Xerces Society and Robert Pavlik of State Parks

The area in which the grove is now located was once part of the Mexican-era *Rancho Pismo,* granted to Jose Ortega in 1840 and later sold to Isaac Sparks in 1846. The eucalyptus (*Eucalyptus* spp.) trees were planted from the mid 1880's to 1900 as a windbreak for surrounding artichoke fields. The Southern Pacific Railroad (now owned by Union Pacific Railroad Company) was established by 1895; Highway 1 was built in the early twentieth century. The grove came under state ownership with the establishment of Pismo State Beach in 1951; and in 1963, the artichoke field directly to the north and west was transformed into the North Beach Campground.

First use of the Pismo Grove by monarchs was not documented, but we know that in the late 1940s servicemen and women from a USO type facility across the tracks visited the grove. In 1956, a small fire broke out in the grove. It was quickly extinguished, but the incident brought publicity about the butterflies because they were suddenly "found." Local townsfolk knew about the butterflies, but the policy of nature groups and the media in the 1970's was to keep silent. Mrs. Jean Hubbard, local historian who came to the area in 1967, says, "The intent was to keep the grove a secret; the theory being that

visitors would disturb the monarchs." This policy gradually changed as State Parks came to realize that visitors under controlled viewing would not bring harm to the butterflies. In the 1970's, a "beaten path" ran back into the grove, and the highway fence, with a temporary sign reading "Butterfly Grove," was installed in 1980.

In the 1980s, State Parks Ranger Jeff Jones and docents Marylou Gooden and Dick Simpson gave the first public butterfly talks. Regular weekend talks started in 1986. A small surplus kiosk was installed in the grove primarily due to the work of Juvie Ortiz. Volunteers, including Elizabeth Chester and Jack and Grace Beigle, staffed the kiosk, answered questions, and sold a few items. The first bus tour groups came in the late 1980s. A proclamation dated 1982 reads, "The State Legislature takes pride and pleasure in presenting this proclamation to Rangers Nancy Dreher and Juvie Ortiz and volunteer Dick Simpson for their vital role in protecting the monarch butterfly and extending their information to the general public." We appreciate these pioneers who worked so diligently to protect the butterflies at Pismo Beach. Others who have had a long-time association with the grove and who have done much to enhance the interpretive program include Jack Beigle, Marylou Gooden, Elizabeth Chester, Doug Bosch, Ranger Tony Villarreal and Ernie Glenesk.

The Retired Telephone Pioneers built the first wooden bridge across Meadow Creek in 1988, providing access from the North Beach Campground to the butterfly grove. About 1991, a gravel path was added in the grove, widening over the years until the railings were added to keep visitors from walking under the eucalyptus trees and altering low vegetation that provided a safe refuge for monarchs that had fallen. The kiosk was upgraded to a small trailer in the mid-1990s. It was financed by the CCNHA (Central Coast Natural History Association) and donated to State Parks. An anonymous donor provided funds to have the mural of the butterflies painted on the back of the trailer. The mural was designed by local artist Suzanne Love. This trailer was also used before and after the butterfly season at special events in the area. In 1998, talks on Fridays and holidays were added, then Mondays in 1999. Because of the ever-increasing numbers of visitors, the decision was made in 2000 to go to a seven days per week operation with two shifts (10am-1pm and 1pm-4pm). In the fall of 2003, a larger trailer was made possible through the gift of an anonymous donor. Ernie Glenesk designed the art on this trailer and State Parks maintenance staff painted it on the trailer. In 2005, management of Pismo State Beach was transferred within State Parks from San Luis Obispo Coastal District to the Oceano Dunes District.

State Parks runs an interpretive program for the public at the grove which has grown from its infancy with a small number of visitors and docents to the large program we have today. Attendance at the grove has grown from 8,000 in 1987-88 to over 80,000 in recent years. Sales at the trailer have grown from $950 to over $100,000 over the same

period. In 2018, a new trailer was purchased and installed at the grove. Activities include an annual “Monarch Day”, junior ranger programs, campfire programs, and a social media presence. The usual opening date is close to November 1st and accompanied by an annual grand opening event called “Brush with the Butterflies”; the usual closing date is around March 1st each year. Peak visitation typically occurs in the month of November.

Since 2009, State Parks has also run an educational program for visiting school groups in the grove, with additional programming conducted in local schools. State Parks also brings its outreach to community events and groups throughout the city and local area (e.g., Moose lodge groups, elder care homes, etc.)

Habitat Description

The Pismo Beach monarch overwintering site is a wedge-shaped area of ~2 acres consisting primarily of a mixed forest of nonnative and native tree species with a more open, coastal scrub plant community in the southeast corner (Map 1). The State Parks owned site is bounded by Hwy 1 to the east, the houses along Park Lane to the south, and Meadow Creek and the campground to the northwest. This entire area (including the forested and non-forested areas) makes up the geographic scope of the overwintering site for the purposes of this plan. However, eucalyptus trees due east of the grove, between Highway 1 and Front Street run parallel to the State Parks’ owned property and are functionally part of the overwintering grove as they provide a crucial windbreak. While the forested areas of this grove are what overwintering monarchs rely on for clustering, the open areas are also an important component of the overwintering site for nectar and for influencing the microclimate of the cluster area (e.g., sun and wind exposure). Both open areas and off-site structures such as the trees on the eastside of Highway 1 (Hwy 1) influence the ecological complex that makes up this overwintering site.

The core forested area is a stand of blue gum eucalyptus (*Eucalpytus globulus*) and Monterey cypress *(Hesperocyparis macrocarpa)* in the northern half of the site. This is also the area where monarchs have historically clustered (see Map 1). In 2012-13, a large blue gum eucalyptus tree fell in the northeast of this area, along Carpenter Creek by the bridge at Hwy 1. In 2016-17, another large blue gum eucalyptus tree in this area fell on a

mature Monterey cypress tree during a storm and wind event; both trees had previously been used by monarchs for clustering. The eucalyptus tree was lost, and Monterey cypress is still standing but only a portion of the living tree remains. In 2017, ~15 Monterey cypress saplings which were planted in the main grove with funding from a Disney conservation grant, in part, to replace the trees lost in 2016-17. Myoporum (*Myoporum laetum*) are found on the south edge of the core grove. Arroyo willow (*Salix lasiolepis*) and blue gum eucalyptus are found along the northern edge of Meadow Creek; blue gum eucalyptus predominates on the southern part of the creek's banks.

Blue gum eucalyptus saplings were planted by volunteers in the southwestern portion of the grove prior to 2009. Photo by Emma Pelton/The Xerces Society

There are two "islands" of trees near the core forested area as well, consisting of blue gum eucalyptus and Monterey cypress. The larger, more western island is referred to as the "big island" and has two cypress trees that monarchs used to cluster on. One of the cypress trees lost a limb in winter 2013-2014 and both trees underwent phased hazardous limb removal over the several years and eventually the two trees were topped. As a result, the monarchs do not typically cluster on those trees anymore. The smaller, more eastern island is referred to as the "small island" and consists of blue gum eucalyptus. Surrounding the islands and separating the core forested area from the coastal scrub area are visitor access trails composed of decomposed granite.

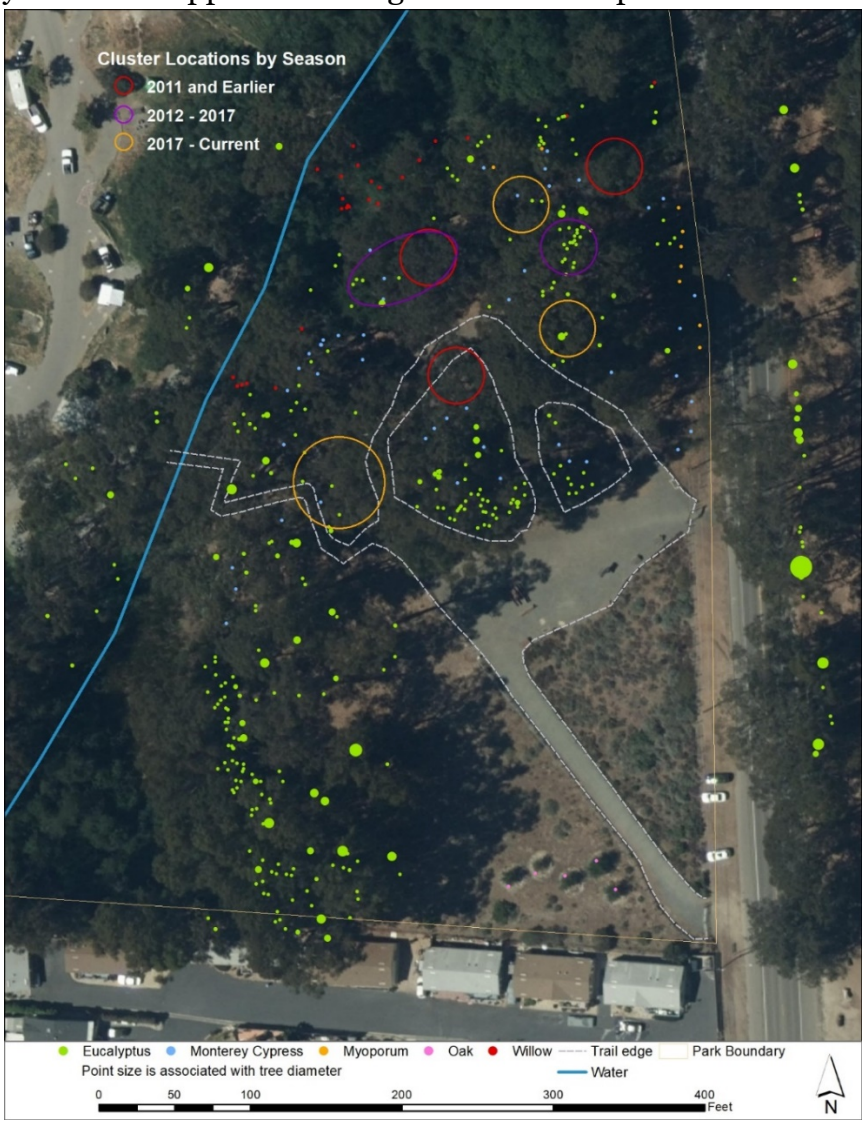
The western and southwestern corner of the site consists of mostly mature blue gum eucalyptus while a smaller number of saplings have been planted in recent years by volunteers. Along the far southeastern edge of the area, a row of coast live oaks (*Quercus agrifolia)* were planted by volunteers between 2010-2011 and are ~20' tall. Unlike many other overwintering sites, the blue gum eucalyptus trees at Pismo Beach are relatively healthy and not overly stressed by recent droughts. There is a mixture of mature blue gums and Monterey cypress and some younger blue gum trees which have reached canopy heights. There is some natural recruitment of saplings occurring which has been supplemented by occasional plantings of blue gum eucalyptus and Monterey cypress by staff and volunteers.

A coastal scrub restoration area was planted by volunteers in the early-2000s in the triangle-shaped area on the eastern edge of the site. The stated aim of the planting was to develop an example of dune habitat with native species including coyote bush

(*Baccharis pilularis*)—which is now dominant—as well as coast buckwheat (*Erigonum latifolium*), mock heather (*Ericameria ericodies*), deerweed (*Acmispon glaber*), California sagebrush (*Artemisia californica*), black sage (*Salvia mellifera*), and lupine (*Lupinus* spp.).

A thorough assessment of site characteristics (including soil characteristics and potential for salt-water intrusion into groundwater, etc.) could be useful in the future.

Map 1. Aerial view of Pismo State Beach monarch overwintering site with trees identified by points denoting species and relative size and site paths and boundaries represented by lines. See Appendix A for ground-truthed path widths.



LEGAL STATUS OF MONARCHS AND THEIR HABITAT

Federal

The monarch butterfly was petitioned to be listed as a threatened species with an associated 4d rule under the federal Endangered Species Act in 2014, and it is currently under review by USFWS after a positive 90-day finding. A final ruling is expected in December 2020.

State

The monarch butterfly is designated as a Species of Greatest Conservation Need in the state of California, and is included in the State Wildlife Action Plan. The species is also recognized by California Department of Fish and Wildlife as a Special Status Invertebrate. The California Coastal Commission also considers all monarch overwintering sites within the Coastal Zone to be Environmentally Sensitive Habitat Areas (ESHA), including Pismo Beach. However, many Local Coastal Plans do not explicitly list them as such, and thus enforcement of overwintering sites' ESHA status is uneven.

California State Parks

There are at least 50 known overwintering sites located on property owned by State Parks, including Pismo State Beach North Beach Campground. Monarchs are partially protected on State Parks property, because collecting or harming animals is prohibited. However, this level of protection does not mean that trees at overwintering sites are protected from trimming which may be done under State Parks hazardous tree program. Many overwintering sites contain nonnative vegetation which is not specifically legally protected— even if the vegetation hosts overwintering monarchs for a portion of the year.

See International Environmental Law Project and Xerces Society (2012) for more information about the legal status of monarch overwintering sites in California.

RESEARCH AND MONITORING OF MONARCHS AT PISMO BEACH

Research Projects

In the 1980s, Chris Nagano and Walter Sakai were the first monarch researchers to study the grove. Pismo Beach was part of their statewide survey of overwintering sites in

winter 1989-90. Dennis Frey and Kingston Leong, professors at Cal Poly, began their research work at the grove in 1990 including a mark-recapture study and microclimate study. Cal Poly students also visited the site to pilot more detailed monitoring of the monarchs' use of the grove in the early 2010s.

More recent research projects at the site include:

- Testing of LiDAR techniques to estimate the number of overwintering monarchs present. Fieldwork was performed in 2016-2017, 2017-2018, and 2018-2019 by Nikolai Hristov and associates of the Center for Design Innovation in Winston-Salem, NC in concert with the project iSwoop: http://www.iswoopparks.com/.
- Microclimate monitoring—including measuring temperature, humidity, wind speed and solar radiation—by graduate student Kiana Saniee, biologist Charis van der Heide, and professor Francis Villablanca of Cal Poly in 2018-2019.
- Assessment of overwintering monarch survivorship, body condition, and female fecundity as part of a National Science Foundation project by professor Cheryl Schultz and technician Cameron Thomas of Washington State University and professor Elizabeth Crone of Tufts University in 2019. Additional partners on the project include professor Marm Kilpatrick of University of California-Santa Cruz and the Xerces Society.

Research at the grove is subject to review and a permit by the California Department of Parks and Recreation; any project which includes handling of monarchs also requires a permit from the California Department of Fish and Wildlife.

Monitoring of Monarch Population Size

Early Monitoring

Before regular monitoring was initiated in 1997, monarchs were estimated during seven seasons between 1988 and 1996. Pismo Beach was part of statewide overwintering site surveys by Walt Sakai in the winter of 1989-90; Sakai estimated 15,000 monarchs overwintering in early January. The peak count reported at this site came the following winter (1990-91) when 200,000 monarchs were estimated to be overwintering in the largest aggregation reported that year (and the largest aggregation ever reported in California according to the Xerces Society Western Monarch Overwintering Sites Database 2020). A report of count estimates for 1997 to 2019 and site assessment notes are included in Appendix B.

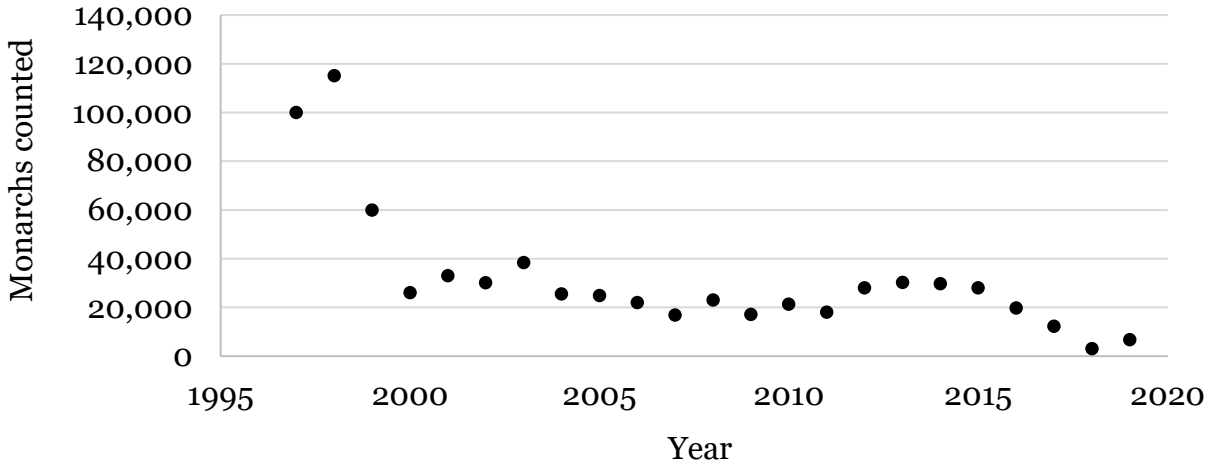
Thanksgiving and New Year's Counts

More rigorous, annual monitoring of monarch numbers at Pismo Beach began in 1997 with the inception of the Western Monarch Thanksgiving Count. The Thanksgiving

Count is a community science based monitoring effort coordinated by the Xerces Society, Mia Monroe, and regional coordinators. Counts are conducted using a standard protocol during a three-week period centered on the Thanksgiving holiday each year. In the winter of 2016-2017, a second count period was added to the monitoring effort, which covers a two-week period in early January, beginning the weekend before the New Year's holiday. Data obtained from these counts are incorporated into the Xerces Society Western Monarch Overwintering Sites Database and shared with the California Natural Diversity Database (within the California Department of Fish and Wildlife) annually.

Thanksgiving counts have been conducted at Pismo Beach every year since 1997 (Table 1 and Figure 1), largely by docents and with support from Thanksgiving Count regional coordinator Jessica Griffiths. The peak count was recorded in 1998, with 115,100 monarchs present; in the most recent Thanksgiving count (2019), 6,735 monarchs were recorded. Because monarch populations, like those of many insect species, naturally fluctuate from year-to-year, examining trends over decades provides a more accurate estimate of the population at the site than comparing any two individual years. In addition, these local changes should be interpreted in the context of the overall decline observed in the monarch overwintering population in California, which declined >99% between the 1980s and 2018 (Pelton et al. 2019). In that context, the decline in the number of monarchs overwintering at Pismo Beach is somewhat less severe than the range-wide decline.

Figure 1. Pismo Beach Monarch Thanksgiving Counts 1997-2019.



Three years of New Year's Counts at Pismo Beach have shown that monarch numbers sometimes decline between Thanksgiving and New Year's counts (-33% in 2016-17 and -46% in 2019-2020); other years, the counts remain relatively stable over the two count periods (-2% in 2017-18 and 0% in 2018-19); see Table 1.

Table 1. Thanksgiving and New Year's Counts at Pismo Beach 1997-2018.

Year	Thanksgiving Count	New Year's Count
1997	100,000	
1998	115,100	
1999	60,000	
2000	26,100	
2001	33,000	
2002	30,160	
2003	38,438	
2004	25,575	
2005	24,840	
2006	22,050	
2007	16,900	
2008	23,050	
2009	17,200	
2010	21,286	
2011	18,000	
2012	28,086	
2013	30,293	
2014	29,804	
2015	28,073	
2016	19,755	13,303
2017	12,284	12,005
2018	3,082	3,089
2019	6,735	3,625

Clustering monarchs on Monterey cypress at Pismo Beach. Photo by Katie Hietala-Henschell/The Xerces Society

Docents monitoring monarch clusters at Pismo Beach. Photo by Katie Hietala-Henschell/The Xerces Society

Pismo Beach as Part of a Site Complex

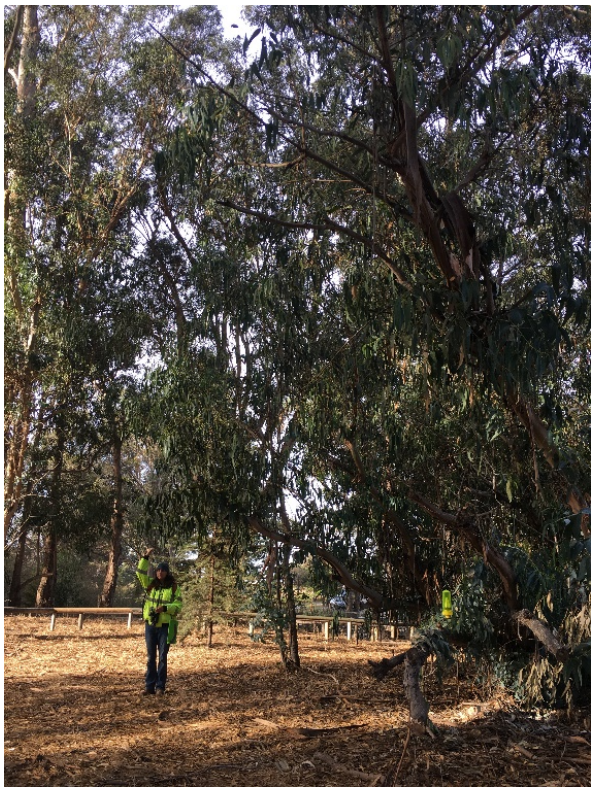
Through tagging research, overwintering monarchs are known to move not only within, but between overwintering sites throughout the course of the winter. It is hypothesized that they are most likely to move between sites which are nearby (within 1-5 miles). In the case of Pismo Beach, monarchs are likely moving between this site and a nearby site (Xerces' Site ID 3082) which is ~1 mile away and also on State Park property, as well as other local overwintering sites a few miles away in nearby Oceano.

Intensive Monitoring

Starting in 2018-2019, State Parks staff and docents initiated a more intensive monitoring of overwintering monarchs' use of the grove, in part, to inform the development of this site management plan. Monitoring was completed starting in late October/early November and mid-February/early March (until monarch numbers dropped very low) using two complementary methods by docents and staff:

1) Docents used an aerial map to circle general areas where they saw monarchs clustering each morning. These aerial maps included labels showing individual trees and other major grove features identified (e.g., fences, pathways and a creek) to aid in orientation. In 2018-19, docents achieved monitoring 75 out of 114 days (between 10/31/2018-2/21/2019) for an average rate of 4-5x per week. In 2019-20, docents achieved monitoring 81 out of 104 days (between 10/12/2019-1/23/2020) for an average rate of 5-6x per week.

2) Staff identified individual trees that monarchs were using and performed a count of all monarchs present (following the Thanksgiving count protocol) at the grove every two weeks (see Table 2). Staff also used zoomed-in photos taken within the grove of the cluster areas to more precisely identify the location of clusters within the grove and within individual trees.



View of the tilted blue gum eucalyptus tree which monarchs primarily clustered in during winter 2018-19. Photo by Katie Hietala-Henschell/The Xerces Society

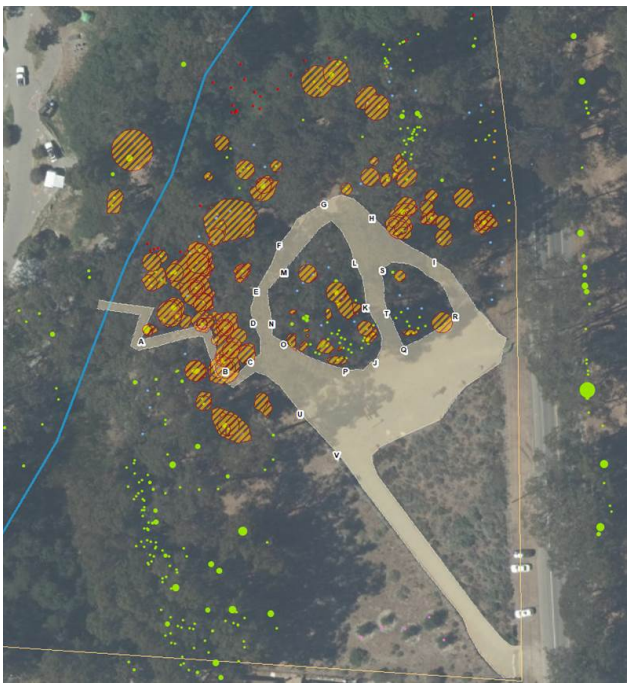
Table 2. State Parks staff biweekly estimates of total monarchs at Pismo Beach and a nearby overwintering site on State Parks property (Xerces' Site ID 3082).

Date	Pismo	Site 3082	Total	State Parks staff
2018-19 season				
11/7/2018	2,645	not checked	N/A	Amber Clark, Ryan Slack
11/20/2018	2,812	613	3,425	Amber Clark, Ryan Slack, Joanna Iwanicha
12/4/2018	4,570	0	4,570	Amber Clark
12/19/2018	4,315	1,000	5,315	Amber Clark, Ryan Slack
12/31/2018	4,300	900	5,200	Amber Clark
1/14/2019	1,900	0	1,900	Amber Clark, Ryan Slack
1/28/2019	1,193	483	1,676	Ryan Slack
2/11/2019	1,040	0	1,040	Amber Clark
2/25/2019	345	53	398	Amber Clark, Ryan Slack
3/11/2019	50	0	50	Amber Clark
2019-20 season				
11/4/2019	3370	570	3,940	Amber Clark, Ryan Slack, Stephanie Little
11/20/2019	5380	1595	6,975	Amber Clark
11/26/2019	6735	1775	8,510	Ryan Slack, Stephanie Little
12/12/2019	3926	1385	5,311	Stephanie Little, Jessica Griffiths
12/30/2019	3001	1400	4,401	Ryan Slack, Stephanie Little
1/3/2020	3625	1470	5,095	Ryan Slack, Stephanie Little
1/22/2020	1995	1050	3,045	Ryan Slack, Stephanie Little
2/4/2020	1030	180	1,210	Ryan Slack, Stephanie
2/18/2020	166	not checked	N/A	Amber Clark, Ryan Slack
2/19/2020	not checked	1	N/A	Ryan Slack

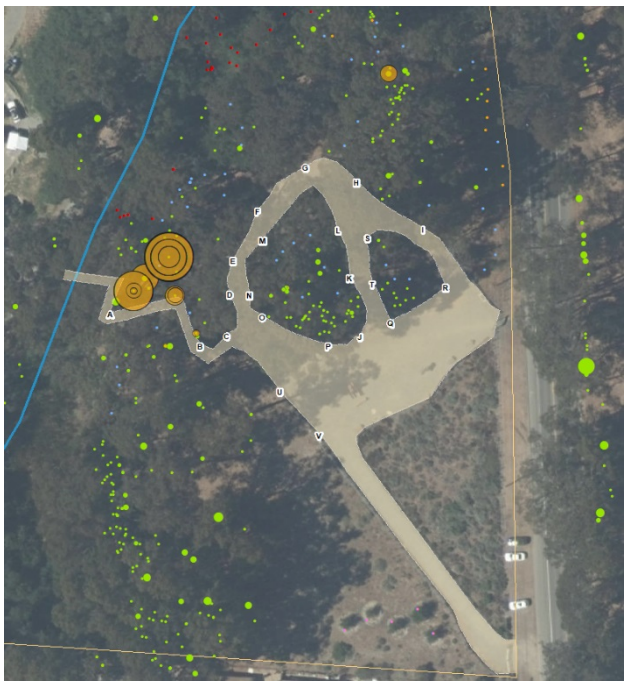
Data on the location and size of clusters was digitized into a geodatabase. These data were overlaid with the tree mapping layers developed previously by State Parks in ArcMap. For the docent-generated map, circles were digitized based on the drawings by the docents and do not indicate monarch cluster size. However, for the staff-generated map, the size of circles scales with the number of monarchs estimated for that cluster (Map 2). A hypsometer can be used to measure height of these clusters by returning to the field and pointing the hypsometer to the approximate height based on the photos. In future years, the hypsometer can be used in real time, when the data is collected.

Map 2. Locations of monarch clustering based on docent and State Parks staff monitoring. *Note: the size of circles represents the number of monarchs estimated only in the State Parks' staff maps.*

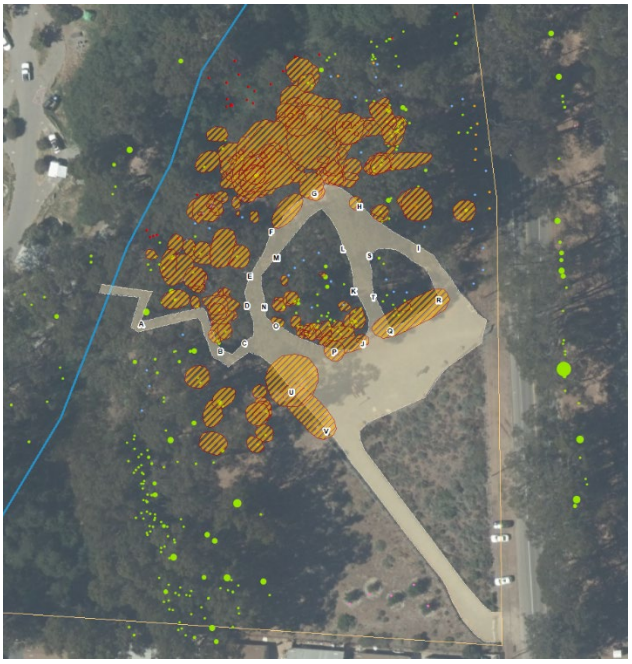
2018-2019 cluster monitoring by docents



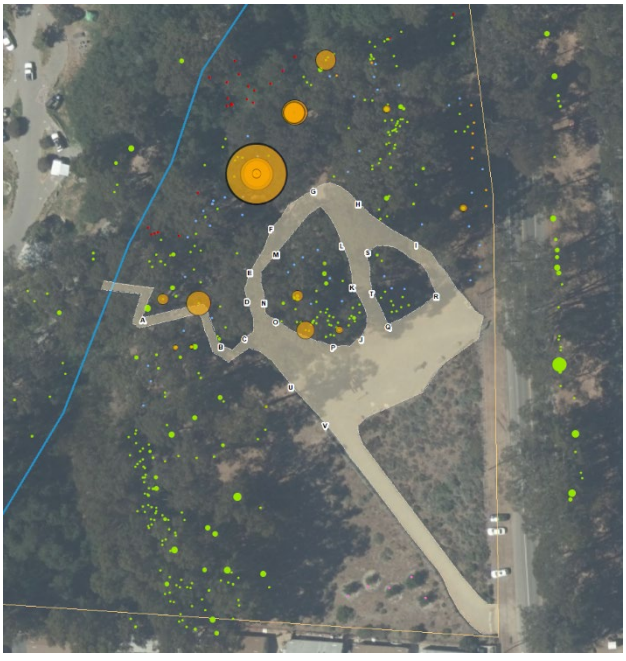
2018-2019 cluster monitoring by State Parks



2019-2020 cluster monitoring by docents



2019-2020 cluster monitoring by State Parks



The docent and staff maps are complementary—together building a more comprehensive picture of clustering monarchs' use of the grove, while also revealing differences in the methods and frequency of monitoring. For example, the docent map shows the broad use of the grove by clustering monarchs over the course of the season—underlining the value of daily and weekly monitoring to truly assess the locations monarchs may use under different conditions. Meanwhile, the staff map, along with accurate count estimates, reveals that monarchs consistently cluster in large numbers in only a small subset of the areas reported by docents. For example, the core cluster area (see Map 2's State Parks monitoring above) during winter 2018-2019 was on a mature blue gum eucalyptus that tipped on its side but is still alive.

While valuable (and perhaps one of the most detailed, regular monitoring of cluster locations by docents and staff attempted at an overwintering site), this represents just two seasons of data. Monitoring for additional overwintering seasons will provide valuable data on how monarchs' use of the site changes across years. In past years, staff and docents have reported that monarchs typically cluster in areas of the grove north of sign markers G and H in Map 2.

PLAN DEVELOPMENT

Beginning in fall of 2017, Xerces partnered with State Parks staff at Pismo Beach and Stu Weiss of Creekside Science to launch a project to develop a site management plan for the overwintering grove. The project builds off previous work and this newest effort brings in multiple disciplines to develop a more comprehensive plan. While written by Xerces, this plan is a product of multi-year collaboration between State Parks, Xerces, and Creekside Science which included site visits in 2017-2019, regular in-person and phone meetings, financial contributions by State Parks and Xerces to fund consultants, monitoring and information gathering by Pismo Beach staff and docents, as well as review of the plan by monarch researchers including Jessica Griffiths, Dan Meade and others (see Acknowledgements at the beginning of this plan).

Key Project Outcomes (2017-2020)

- Hemispherical photography and microclimate modeling of the grove by Creekside Science. See *Habitat Modeling Using Hemispherical Photography* on page 16 for a more detailed summary.
- A workshop of overwintering site managers and researchers hosted by Pismo Beach and organized by the Xerces and Samantha Marcum of the US Fish & Wildlife Service, with presentations by project partners. Over 25 biologists came

together to share insights on management and foster relationships among managers in February 2018.
- Multiple joint, in-person site visits with State Parks, Xerces, Creekside Science as well as visits by other monarch researchers (Jessica Griffiths and Dan Meade) and an arborist to discuss site quality and identify management needs.
- Tree-specific cluster monitoring of the grove. State Park staff and docents initiated intensive monitoring of monarch use of the grove in winter 2018-2019 (see *Intensive Monitoring* on page 11) with monitoring design input from Xerces and Creekside Science.
- A Q & A session with docents at Pismo hosted by Xerces to discuss the draft version of this plan and provide a general update about monarch science took place in January 2019.
- An analysis of wind and light effects on the main cluster area based on tree planting and removal (see *Scenario Modeling* on page 17 for more details).
- This written site management plan.
- The implementation of some tree and nectar management activities identified in this plan including planting 64 trees and 98 nectar plants.

See *Next Steps and Plan Implementation* on page 32 for a summary of future work.

This plan aims to synthesize the efforts of many partners over multiple years and provide a common vision and roadmap to implementation at Pismo Beach. The plan was developed based on principles outlined in the publication *Protecting California's Butterfly Groves: Management Guidelines for Monarch Butterfly Overwintering Habitat* (Xerces Society 2017) and adapting a template for site management plans developed by Samantha Marcum of the US Fish and Wildlife Service and Emma Pelton of Xerces, with input from many other overwintering site restoration experts, available at: https://www.westernmonarchcount.org/overwintering-site-management-and-protection/. We also referred to an earlier site management plan developed for Pismo Beach, *Monarch grove management plan for North Beach Campground Site* developed in 2008 (Appendix C).

Arborist Report

Prior to this planning effort, State Parks commissioned an arborist report to assess grove health after winter storms in 2016-2017 caused many large trees to fall. See the *HortScience arborist report* and *HortScience best management practices for tree planting and aftercare,* in Appendix D and E for the full documents. In summary, the arborist conducted an inventory of trees within the grove including the following components: a) Identify the species, b) Estimate trunk diameter, c) Assess tree condition based on a visual assessment from the ground, d) Note structural and health

characteristics important to management. e) Perform a level 1 limited visual assessment of tree risk using the method found in the International Society of Arboriculture's Best Management Practices *Tree Risk Assessment* (2012 edition), and f) Identify abatement procedures.

The arborist also provided recommendations about grove suitability for monarchs, some of which have been incorporated into this plan. State Parks followed the arborist recommendations and pruned 6 blue gum eucalyptus trees and removed 1 blue gum eucalyptus and 1 Monterey cypress during September 2018.

Tree Mapping

This plan also benefited from the detailed mapping of 322 of the grove's trees in 2017 by State Park staff. Eighty percent (80%) of mapped trees are blue gum eucalyptus, with willow as the next dominant tree, followed by Monterey cypress, Myoporum and coast live oak (respectively; see Table 1 in Appendix D). Each tree was identified to species, measured for diameter at breast height (DBH), and assigned a latitude/longitude. This information was digitized into a geospatial database and each tree was given a unique ID number. This mapping improves the ability to track individual trees and monarch use of them over time.

Habitat Modeling Using Hemispherical Photography

Creekside Science conducted analyses of the canopy structure and microclimatic factors of wind and sun exposure (insolation) developed through the use of hemispherical photography in the grove. See Creekside Science report *Habitat Assessment of Pismo Beach North Campground Monarch Grove* (Appendix F). A subset of key points the report makes about current habitat suitability for monarchs:

- The grove provides all the essential components of monarch habitat including wind sheltered spots with moderate direct insolation.
- The 2017-18 cluster site (areas G and H in Map 2) provides good wind shelter, especially from the SE, and receives afternoon insolation early in the overwintering season. Several other sites in the grove also provide this combination to varying degrees, giving the monarchs options for cluster locations.
- The trees to the east across Highway 1 along the Union Pacific tracks are absolutely essential to wind shelter from SE winds, a common wind direction especially for the strongest storm winds.
- Tree buffers to the west and north are also essential; at present they are deep enough for good wind shelter.

- Monterey cypress trees planted near the main entrance are beginning to provide some wind shelter, and as they continue to grow will contribute ever more wind shelter.
- The wind sheltered interior of the southwest grove appears to be too dark to attract monarch clusters.

The Creekside Science report also provides recommendations about site management for monarchs, many of which have been incorporated into this plan.

Scenario Modeling

Creekside Science conducted a simulation of hypothetical tree removal/tree loss and tree addition/tree plantings by manipulating the hemispherical photos taken at Pismo Beach in 2019. The aim of scenario modeling was to help refine an understanding of impacts to light and wind conditions in the grove based on hypothetical management scenarios. The scenarios explored included removing the Union Pacific eucalyptus trees and adding trees in key areas of the grove on State Park land, specifically in the eastern footpath and in the nectar planting area. See *Simulation of Tree Removals and Shelterbelt Planting at Pismo North Campground Monarch Habitat* (Appendix G) for the full report. Associated with the report is a *Summary of Pismo Tree Scenarios* (Appendix H). Key points from the scenario modeling:

- The overwhelming importance of the row of trees between Highway 1 and Front Street for wind shelter
- The positive impacts of planting a shelterbelt south of interpretive trailer area
- The desirability of closing off the easternmost trail into the grove interior

Based on these findings, the *Tree Management Plan* was refined and helped inform which tree planting activities are of the highest priority for State Parks to implement.

Tree Species Selection

To select tree species for restoration, we reviewed the existing science (which is quite limited: Griffiths and Villablanca 2015), database of tree species used by monarchs (Xerces Western Monarch Overwintering Sites Database 2020), and solicited expert opinion including those of restoration practitioners and researchers of monarch microclimate needs (including Francis Villablanca, Jessica Griffiths, Dan Meade, and Matt Ritter). While all partners strongly support using native plants whenever possible in restoration, they acknowledged the unique role that eucalyptus (especially blue gum eucalyptus) play in monarch overwintering habitat in California today (see pages 23-25 of Xerces Society 2017 for further discussion on this topic).

This management plan includes eucalyptus species as "part of the toolbox" along with native tree species. Eucalyptus is an important species in overwintering habitat restoration for the following reasons:

- Fast-growing—Eucalyptus more quickly establishes and reaches a height and size that provides shelter for monarchs compared to most native trees like Monterey cypress.
- Creates the right microclimate—Blue gum eucalyptus is one of very few tree species known to create the right microclimate for monarchs.
- Currently the dominant tree used by monarchs—Blue gum eucalyptus is, by far, the dominant tree in overwintering sites through the monarchs' overwintering range in California (Xerces Western Monarch Overwintering Sites Database 2020).
- Small footprint—Incorporating eucalyptus into monarch overwintering site restoration requires conserving and planting these nonnative trees within only a very small footprint in California and within State Park properties.
- Closely managed—The planting of eucalyptus for monarch overwintering site restoration would be carefully planned, managed, and monitored through the development of overwintering site plans. This is not a widespread planting, nor an introduction into new areas, but a precise planting in existing eucalyptus-dominated groves to improve site value for monarchs and health of the grove.
- Best suited for site conditions—The soil of these eucalyptus-dominated groves is generally best suited to planting more eucalyptus.

And, most critically, the western monarch population is currently in crisis and protecting and restoring their overwintering sites is crucial to their recovery. Using the existing tree species known to establish well, quickly, and provide the correct microclimate for monarchs is of the greatest value to the species.

Management Actions Taken To Date

During the development of this plan, State Parks took the following actions based on the arborist report and their own assessment.

- Oceano Dunes District Environmental Scientists worked alongside a hazardous tree crew to carefully trim the trees as outlined by the arborist report.
- All existing and newly planted trees were given a tree tag and added to the State Parks tree map and database.
- Staff raked away duff to allow planted trees to grow.
- Staff removed hybrid Monterey cypress (that were a result of a nursery error) and replanted with non-hybrid trees.
- Oceano Dunes District Environmental Scientists took a more active role in data collection of monarchs at the grove.

TREE MANAGEMENT PLAN

Planting eucalyptus at Pismo Beach. Photo by Grant Johnson/Coastal RCD

The focus of tree management at groves with overwintering monarchs should be to maintain or restore suitable microclimatic conditions—the most important factors to consider are wind protection and solar radiation (Leong 1990, 1991). Grove structure should be managed to act as a "thermal blanket and a rain umbrella"—suitable canopy cover minimizes heat loss during the night, provides both sun and shade, and protects from excessive winds and storms which typically come from the southeast. Monarchs do not persist at sites with high wind speeds (Leong 1990, 1991), so providing mid-story vegetation is crucial for wind protection of the clusters. A grove with varied vertical structure is also important because monarchs benefit from having multiple heights to cluster on when microclimate conditions such as wind and temperature fluctuate. See *Protecting California's Butterfly Groves: Management guidelines for monarch butterfly overwintering habitat* (Xerces Society 2017) for more information about managing groves for overwintering monarchs.

The following tree management recommendations were developed under the influence of current land ownership goals and policies. It should be acknowledged that these goals and policies may not be focused on creating optimal habitat for monarchs, but instead, on the multi-use mission of California Department of Parks and Recreation. In particular, it should be noted that the planting recommendations in this plan were developed under the following constraints:

- State Parks does not currently support planting of eucalyptus species outside of the plants' existing footprint.
- State Parks has a Public Works Plan (PWP) currently in development. Both the PWP and this document are working to develop the most effective plan for their purposes while taking the other plan into consideration.
- Tree planting recommendations were confined to areas owned by State Parks.
- All actions taken under this plan should comply with applicable local, state, and federal regulations.

Proposed Tree Planting

For all tree planting actions, refer to *HortScience best management practices for tree planting and aftercare* (Appendix E) and any other guidance on plant materials

required by State Parks. For specific tree placement within areas, consider set-backs for utilities and neighboring land owners (e.g., CalTrans, housing development).
If only 1-gallon container trees are available at the time of planting, plant three trees 5-10 feet apart in place of each single tree to improve chances of survival. Over time, thin two trees so only one tree per cluster will remain after 5-10 years. If 5-gallon trees are available at the time of planting, plant a single tree instead of clusters of three.

Tree species and quantity to be planted are described below for designated areas within the monarch butterfly grove. Letters in parentheses indicate areas shown on Map 3. Table 3 provides a summary of tree species and quantity by area.

(A) Plant up to five Monterey cypress in the south end of this area to fill in gaps where hybrid Monterey cypress were removed.
- Note of progress made during the development of this plan: in March 2019, two dead Monterey cypress were removed and two new individuals were planted in the same places. In addition, five new trees were planted in this area and two more dead trees were replaced in March 2020.

(B) See below in *Future Recommended Actions*.

(C) Plant up to 20 Monterey cypress trees in two rows in the coastal scrub restoration area to maintain and strengthen the windbreak southeast of the main clearing. Plant trees away from the trailer and walking path. Cut away coyote brush as needed. Trees should be planted in two rows, each with 10 trees and offset from each other, spaced ~5 feet apart.
- Note of progress made during the development of this plan: in April 2020, 20 Monterey cypress trees were planted in two rows with approximately 12' spacing.

(D) Plant up to 20 trees—16 eucalyptus (diversicolor or blue gum) and four Monterey cypress. These trees will diversify age and tree species, and may become potential monarch cluster trees in a gap within the main clearing. State Park will also maintain the clearing through tree management.
- Note of progress made during the development of this plan: in March 2020, three dead Monterey cypress were removed and four new individuals replanted in the same places. In addition, fifteen blue gum eucalyptus (6 one gallon, 9 five gallon) and five diversicolor eucalyptus (five gallon) trees were planted.

(E) Plant up to five trees—three eucalyptus (blue gum or diversicolor) and two Monterey cypress. These trees may become potential cluster trees for monarchs in the large island where Monterey cypress have fallen.

- Note of progress made during the development of this plan: in 2020, three blue gum eucalyptus trees (five gallon) and two Monterey cypress trees were planted.

(F) Plant up to five trees—three Monterey cypress in the southwest by the houses with consideration in tree placement to minimize impacts on neighbors (at least 50' away from homes); and two live oaks among existing oaks.

- Note of progress made during the development of this plan: in 2020, three Monterey cypress trees and two live oak trees were planted.

(G) Plant up to five trees— either eucalyptus or Monterey cypress— as additional windbreak along the creek to the northwest. Cal Poly botany professor Dr. Matt Ritter, will help State Parks determine which tree species to plant that will do best in this area.

- Note of progress made during the development of this plan: in 2020, five Monterey cypress trees were planted.

Future Recommended Actions

(B) Consider closing the pedestrian path in this area. Plant up to 3-5 Monterey cypress trees in that area to create additional mid- and tall-story protection from the southeast. See Appendix A for ground-truthed path widths.

Table 3. Proposed and completed tree plantings by species and planting area

Planting area	Tree species	Goal # of new trees	Trees planted*
A	Monterey cypress	Up to 5	5
B	Monterey cypress	Up to 3-5	0
C	Monterey cypress	Up to 20	20
D	Monterey cypress	Up to 4	4
	Blue gum or diversicolor eucalyptus	Up to 16	20
E	Monterey cypress	Up to 2	2
	Blue gum or diversicolor eucalyptus	Up to 3	3
F	Monterey cypress	Up to 3	3
	Live oaks	Up to 2	2
G	Monterey cypress	Up to 5	5
Total	All species	Up to 70	64

**as of fall 2020*

Planting Monterey cypress at Pismo Beach. Photo by Grant Johnson/Coastal RCD

Map 3. Proposed tree planting areas. Letters denote individual areas outlined in colored blocks. Refer to *Proposed tree planting* text and Table 3 above for a list of proposed actions.

Adaptive Management

If and when site conditions change (e.g., tree falls, hazard tree removed, fire moves through the site), this plan may be revised to add new management priorities to restore the site. At a minimum, there should an evaluation of where and why tree(s) have had to be removed (hazardous trees) or otherwise lost (due to fire, disease, drought, weather) and then develop planting strategies based on those changed conditions. Additional trees may need to be planted to compensate for tree losses and native trees will be selected as much as possible if the site conditions are suitable for that tree species. Best available science will help guide the tree species selection and planting location decisions. The long-term management goal will be to phase out new eucalyptus plantings over time as native trees grow sufficiently to replace them.

In addition, as research into monarch requirements and management techniques for overwintering habitat continues, this plan should be updated with the latest advances in science and restoration practices.

Off-Site Tree Management

(Not shown in entirety on Map 3)

Work on Adjacent Properties

Work with Union Pacific Railroad, Caltrans, the City of Grover Beach, and adjacent residents to minimize unnecessary trimming or removal of mature blue gum eucalyptus trees along the line of eucalyptus trees between Highway 1 and Front Street. These trees serve as an important windbreak. Ideally, replacement trees would be planted in the coming years as the current trees are of an advanced age.

View of the blue gum eucalyptus outside of State Parks property near the railroad tracks and Front Street which form an important windbreak to the overwintering site. Photo by Emma Pelton/The Xerces Society.

According to *Monarch grove management plan for North Beach Campground* 2008 (Appendix B), Union Pacific has a 100' right-of-way along the east side of Hwy 1 and CalTrans has a 60' wide right-of-way (30' center) along Hwy 1. These rights-of-ways should be verified.

View of the campground where additional tree plantings may be useful for mid-story wind protection. Photo by Emma Pelton/The Xerces Society

Also, according to the City of Grover Beach, the city has a 15' wide right-of-way beyond the curb along Front Street.

Campground Plantings

As funding and staff are available, consider planting additional trees to create an outer windbreak of mid-story wind protection in the State Park campground to the east of the grove. Appropriate species include arroyo willow (*Salix lasiolepis*), California bay (*Umbellularia californica*.), and California wax myrtle (*Morella californica*). These species are unlikely to be used as cluster trees, but would provide a mid-story windbreak to the grove and are less likely to shed large limbs and bark like blue gum eucalyptus which can be a safety hazard in a campground.

General Forest Management Recommendations

Forestry actions should be undertaken in close collaboration with State Parks, a certified arborist, and a monarch butterfly overwintering site expert. Any forest management recommendations by outside arborists will be reviewed by State Parks prior to implementation. See Appendix E for general forestry best practices.

Forestry management actions such as tree removal or trimming in clustering areas should be taken each September, outside of the overwintering season when monarchs are not present and outside of bird nesting season. Saplings should be planted in phases (over the course of multiple years) or saplings and more mature trees can be planted simultaneously to create age and structure diversity. Monterey cypress trees should generally be planted 12-15' apart and eucalyptus species should generally be planted 5' apart, but overplanting followed by periodic thinning will compensate for moderate sapling mortality. Due to the recent years of drought in California, irrigation for the first 2-3 years after tree planting is recommended. Because of the eucalyptus biomass that can accumulate when bark and leaves are shed, State Parks staff will rake away duff around the perimeter of newly planted trees so they are not smothered under excess litter.

Downed Wood Guidance

Periodically remove fallen trunks and large branches from the overwintering site. Freshly fallen material can harbor eucalyptus herbivores such as eucalyptus longhorned borer.

Nursery Stock Guidance

Source Monterey cypress trees that have not been hybridized. Source disease-free nursery stock from nurseries that use *Phytophthora* spp. best management practices. This water mold pathogen can negatively impact both Monterey cypress and blue gum eucalyptus trees at the site and should be avoided. Examples of *Phytophthora* spp. best

management practices are described here:
http://phytosphere.com/BMPsnursery/index.htm and
http://ccuh.ucdavis.edu/Programs/pramorum.

Hazard Tree Guidance

Each year, State Parks staff trained in tree hazard assessment and a certified arborist will be utilized for all Tree Hazard Inspections of the monarch grove. The site should be assessed to identify trees that pose threats to public safety or structures; these trees should be the first priority for trimming/removal. Any trimming or removal actions proposed for trees monarchs are known to cluster on or trees immediately adjacent to cluster trees should be carefully considered for benefits/risks. If a management action is deemed necessary, State Parks, a certified arborist, and monarch butterfly overwintering expert should consult on appropriate actions. Human safety should take precedent over public access— additional fencing and signs may be useful to restrict public use of the area in the case of an emergency. Ideally, the tree hazard assessment and any forestry actions will take place in September to avoid conflicts with nesting bird season, but before the monarchs' arrival at the overwintering site.

NECTAR MANAGEMENT PLAN

Managing Existing Nectar Resources

In the coastal scrub restoration area, male coyote brush should be cut out (because it does not bloom) and female coyote brush should be trimmed back to promote flowering. This will also promote the growth of other plants.

Establishing Additional Native Nectar Resources

Nectar plantings are proposed in the current coastal scrub restoration area and in the open habitat on the south/southwestern edge of the site near the oak trees (see Map 4).

The goal of these plantings is to enhance the existing open areas with additional plantings of native, fall-, winter-, and early spring-blooming (October-March) nectar resources which are attractive to monarchs and other native pollinators. A list of native, commercially available species which have been documented as nectar flowers for monarchs are provided in Table 4.

- Note of progress made during the development of this plan: in July 2020, 49 California aster (*Corethrogyne filaginifolia*), 24 mock heather (*Ericameria ericoides*), and 25 Blochman's ragwort (*Senecio blochmaniae*) plants were planted in the coastal scrub restoration area.

Nectar plants should be planted in sunlit areas close to the grove and should be installed in multi-year phases with monitoring to ensure good establishment and to avoid creating a gap in nectar availability during the planting/disturbance year. An effort should be made to select a mix of species to ensure overlapping bloom times to cover the entire overwintering season. Plants should be sourced from nurseries which do not use systemic neonicotinoid insecticides which have been shown to harm monarchs (Krischik et al. 2015; Pecenka and Lundgren 2015) or other insecticides which have pollinator or mammalian toxicity. Ideally, management to maintain the plantings will rely on alternatives to pesticides to control weeds and pests.

Map 4. Proposed nectar planting areas.

Table 4. Recommended native nectar plants for overwintering monarchs and other pollinators. Table adapted for Pismo Beach from Xerces' guide "Recommended Nectar Plants for Western Monarchs: California" with input from State Parks and calscape.org.

Bloom	Common Name	Scientific Name	Color	Height	H20	Notes
Year Round	Pink sand verbena	*Abronia umbellata*	Pink	6"	Low	Perennial herb
Year Round	Mulefat	*Baccharis salicifolia*	White	3-8'	Med	Likely entire genera attractive to monarchs. Blooms year-round
January-July	Suffrutescent wallflower	*Erysimum suffrutescens*	Yellow	3'	Low	Perennial herb
January-August	Beach primrose	*Camissoniopsis cheiranthifolia*	Yellow	<1'	Low	Attracts Sphinx moths
February-July	Hummingbird sage	*Salvia spathacea*	Pink	1-2'	Low	Attractive to hummingbirds
February-August	Golden yarrow	*Eriophylum confertifolium*	Yellow	2'	Low	Very attractive to pollinators, especially butterflies
February-August	Prickly phlox	*Linanthus californicus*	Pink	3'	Low	Pollinator plant
March-July	Black sage	*Salvia mellifera*	Purple	3-6'	Low	Attractive to bees, butterflies, and hummingbirds
March-August	Deerweed	*Acmispon glaber*	Yellow	1-3'	Low	Pollinator plant
March-August	Seaside golden yarrow	*Eriophylum staechadifolium*	Yellow	2-4'	Low	Pollinator plant
April-July	Scarlet bugler	*Penstemon centranthifolius*	Red	1-3'	Low	Attracts hummingbirds
April-August	Yarrow	*Achillea millefolium*	White	1-3'	Low	Attractive to many insects
April-October	California sagebrush	*Artemesia california*	White	1-8'	Low	Attracts insects and birds
April-October	Southern goldenrod	*Solidago confinis*	Yellow	2-3'	Low	Numerous insects are attracted to the flowers
May-August	Dune buckwheat	*Eriogonum parvifolium*	White, pink	2'	Low	Important pollinator plant, attracts many insects
June-August	Blochman's leafy daisy	*Erigeron blochmaniae*	Purple	2'	Low	Pollinator plant
August-October	Blochman's ragwort	*Senecio blochmaniae*	Yellow	3'	Low	Very attractive to monarchs
August-October	California fuchsia	*Epilobium canum*	Red	1.5'	Low	Attracts hummingbirds
September-November	Mock heather	*Ericameria ericoides*	Yellow	3'	Low-Med	Great late season resource for bees and butterflies
September-January	Coyote bush	*Baccharis pilularis*	Cream	1-10'	Low	Very attractive to insects, especially when in flower

Note: many of these plants can be grown in our State Parks' greenhouse from locally collected seed.

Guidance About Milkweed Near Overwintering Sites

Nonnative, evergreen milkweed—particularly *Asclepias curassavica* –has been shown to increase the rate of *Ophryocystis elektroscirrha* (OE), an obligate, protozoan parasite, in winter-breeding monarchs in California (Satterfield et al. 2016), and may disrupt the natural reproductive diapause monarchs enter during the fall. Thus, evergreen milkweed and OE can have negative impacts on monarch health and have been linked to lower migration success in the Eastern monarch population (Altizer et al. 2015). In coastal California, even California-native milkweed species (e.g., *A. fascicularis*) planted close to the coast can be problematic because the mild climate may prevent or delay these species from going dormant, which causes parasite build-up and natural cycle disruption similar to that seen with nonnative milkweed. According to the best available records, native species of milkweed did not historically grow along most parts of the Central and Northern California coast, including the Pismo Beach area (Pelton et al. 2016).

For these reasons, as well as other concerns about moving plants outside of their native range, the Xerces Society does not recommend planting milkweed, nonnative or native, close to overwintering sites in the Central and Northern coast (generally within 5 miles of the Pacific coast) where it did not historically occur. While there is currently no nonnative milkweed present at Pismo Beach, any outreach activities related to this site should discourage the planting of milkweed at nearby yards, schools, etc. Removal of nearby stands of nonnative milkweed species is also recommended.

Coyote bush now dominates the coastal scrub area. Cutting back the coyote brush and adding more native nectar species is proposed. Photo by Emma Pelton/The Xerces Society

View of the open habitat in the south/southwestern edge of the site near the oak trees where additional nectar plantings are proposed. Photo by Emma Pelton/The Xerces Society

OUTREACH AND EDUCATION PLAN

State Parks Educational and Docent Programs

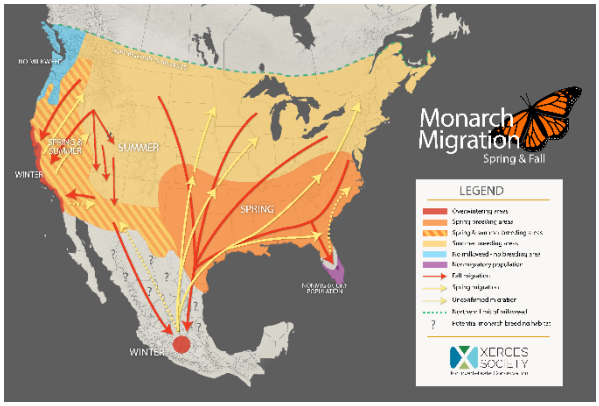
- Continue to engage Thanksgiving regional coordinator and overwintering monarch expert Jessica Griffiths to provide trainings for the Thanksgiving counts as well as the latest monarch science.
- Continue to engage Cal Poly professor Francis Villablanca and other researchers to give regular talks about current research projects.
- Continue to participate in iSwoop if they continue their work at Pismo.
- Provide support for continued engagement in docent monitoring of monarch use of the grove. See *Intensive Monitoring* on page 11 for a more detailed summary.

Signage and Other Interpretive Materials

- Update language on existing signage to reflect the current state of monarch science.
    - Signs which need updating include the "Habitat Restoration" sign near the coastal scrub area. The last paragraph inaccurately states that monarchs do not require winter nectar.

- Create additional signs including one of which shows a map of the North American monarchs' range and migration (example image provided below). In addition, develop signage or a poster display providing more information about the western monarch's population status and how members of the public can aid in their conservation.

Existing signage on the fence near the coastal scrub restoration area which could use updating. Photo by Emma Pelton/The Xerces Society



Monarch migration figure courtesy of the Xerces Society

For more context of Pismo State Beach's outreach and education efforts, please refer to State Parks' interpretive master plan.

OTHER MANAGEMENT RECOMMENDATIONS

Managing Undesirable Plants and Insects

- Continue to install and maintain traps for yellow-jacket wasps in the grove during the overwintering season. Use a food (lure)-based trap instead of an insecticide-based trap. Staff and docents have reported observing high levels of monarch mortality by yellow-jackets and preliminary research suggests that overwintering mortality is higher now than in the 1970s (Pelton et al. 2019).

Nonnative English ivy is found along the creek at Pismo Beach. Photo by Emma Pelton/The Xerces Society

- Remove the nonnative English ivy (*Hedera helix*) before it spreads farther along the creek. Hand pulling or cutting is recommended.
- Continue to maintain facilities and vegetation on the site without the use of chemical insecticides. These substances are known to have negative direct impacts on the monarchs.

Safe Public Access

Safe public access—especially pedestrian access and parking along Hwy 1 remain major issues at the site. There is currently no designated parking along Hwy 1 and insufficient space for tour, school, and ADA transport buses to access the Hwy 1 entrance to safely unload passengers. Despite no designated parking along Hwy 1, many vehicles and visitors use this entrance by parking on both sides of Hwy 1—necessitating dodging two-way traffic including southbound traffic which is just coming out of a curve. Alternative public access is available through a coastal trail on the westside, but that area lacks public parking for non-campground users and does not have sufficient space for buses. Designated parking, including ADA, is located at the Grand Avenue parking lot, and accessed by way of a boardwalk trail.

State Parks' Public Works Plan (PWP) is currently considering a proposal to improve access at the site including developing part of the existing open areas of the overwintering site for a parking lot and bus turnaround. Removal of natural vegetation may affect the microclimate of the site including by having an increased surface area of impermeable (or quasi-permeable) materials which can increase local air temperatures. We recommend ensuring that any improved access plans are designed in a way which

minimizes the negative effects on monarchs including additional noise, light, and/or heat of parking accommodation and which does not further limit the amount of suitable habitat available for monarchs. We recommend referring to this site management plan in making decisions about improvements in access. Any new development proposed within the core monarch grove area should be consistent with the Overwintering Site Management Goals to restore, maintain and improve the sites' value as habitat for overwintering monarchs including enhancing the appropriate microclimate conditions for clustering, providing nectar resources, and/or minimizing stressors to the butterflies.

Aerial view of the site from Google Maps showing cars parked along Hwy 1, including on the east side of the highway under the eucalyptus trees.

View of the bridge crossing the creek to the campground which provides the only alternative public access to the site. Photo by Emma Pelton/The Xerces Society.

Besides addressing safe public access, safety for visitors within the grove should continue to be a focus of efforts. It has been State Parks practice to close the grove during periods of high wind and rain. These are the conditions under which blue gum eucalyptus trees are most likely to shed large limbs or fail—possibly threatening structures and human life.

MONITORING PLAN

Monitoring Monarchs

- At a minimum, continue to support docents and/or staff's participation in the Thanksgiving and New Year's counts: www.westernmonarchcount.org.
- If feasible, continue the monitoring scheme developed for use by docents and staff. See *Intensive Monitoring* on page 11 for a more detailed summary.
- Monitoring reports will be sent to Natural Resources Division for review.

Monitoring Habitat

Complete an annual walk-through with State Parks staff, maintenance crews, and other partners as appropriate to assess grove suitability for monarchs and prioritize management actions for the upcoming season. One of the best times to do a walk-through is in the spring (after the monarchs have departed) or early summer. This ensures that memories of the previous season are still fresh in everyone's mind, but there is sufficient time to accomplish any necessary tree trimming outside of the overwintering season and/or plan for fall planting. If necessary, engage an arborist/tree services company to assess limb and tree trimming needs and remove any hazard trees and branches as identified during the month of September (after bird breeding season and before the monarchs arrive).

Ongoing Habitat Monitoring

- Each newly planted tree will be given its own tree tag once the tree is large enough to accommodate the tag.
- Ensure that tree seedlings and saplings are receiving sufficient irrigation water for the first years of establishment. State Parks has installed a drip irrigation system set up on automatic timers. The trees currently have 2 gallon per hour emitters. The eucalyptus trees and the cypress trees are on the same lines so they will get the same amount of water. If it is determined that they need different amounts, extra emitters can be added to increase the water volume at specific trees.
- Ensure nectar plantings are also being watered and monitored for establishment success.
- As needed, update GIS-based tree database developed by State Parks based on what trees have fallen, died, been trimmed or planted, or received a tree tag.
- Coordinate with outside entities (e.g., CalTrans, PGE) to ensure tree trimming which may affect the site minimizes any potential negative impacts on the overwintering site (e.g., trim at appropriate times of year, minimize trimming)
- Keep written records of all management actions—adding as notes to this plan or in another format that can be referred back to.

NEXT STEPS AND PLAN IMPLEMENTATION

This section outlines the next steps for the plan's implementation on the ground. This is the section most likely to change and adapt over time, but reflects the current status of the project as of October 2020.

Documentation

Records and documentation of decision-making regarding the implementation and modifications to this site management plan are crucial to continuing to learn, adapt, and assess project progress. State Parks has created a folder on their server to share documents and files related to this project including photos, monitoring records, geospatial databases, this plan, etc. It is also recommended that annual walk-throughs of the grove are summarized in writing and added to this folder located on the Oceano Districts Resources folder on the W and N drive.

It is also the authors' aim that this plan may serve as a model for other overwintering land managers to develop and implement their own site management plan, adjusting for their site's needs. To help facilitate that usefulness of this plan as a model, the Xerces Society will make this plan available to interested managers as an editable Word document (email monarchs@xerces.org for access). This plan may also be shared at workshops and meetings by Xerces, State Parks, and/or Creekside Science to provide an example of a successful partnership to restore and enhance overwintering sites.

Tree management

- Pursue tree management actions which have not been accomplished to date from the *Proposed Tree Planting* section on page 19.
- Continue to monitor irrigation needs and adjust accordingly.

Nectar management

- Resource staff will cut back the coyote bush as needed after bird nesting season.
- State Parks staff will coordinate with Xerces and their preferred local plant sources to refine their planting lists for nectar plantings and perform site preparation as needed during fall 2020. They will also determine irrigation or watering needs and set-up a planting plan prior to purchasing or planting of plant materials.
- Nectar plantings using transplants (plugs or pots) will take place once rains have begun, likely in fall or winter 2020.

Outreach and Education

State Parks will coordinate with Xerces during to update the signage outlined in *Signage and Other Interpretive Materials* section on page 29.

Monitoring

Monitoring by docents and State Park staff will continue in the 2020-2021 overwintering season, with support on adaptations to the monitoring scheme from Xerces as needed. Coordination will continue between State Parks staff, docents and

Jessica Griffiths for participation and submission of data to Xerces for the annual Thanksgiving and New Year's counts.

Research

Xerces will continue to communicate with State Parks about advances in understanding of overwintering site management research and science. We encourage State Parks continued participation in studies such as the microclimate study by Cal Poly.

Due to the extremely small overwintering monarch population recorded in coastal California as of 2020, we do not recommend permitting any lethal sampling of monarchs at Pismo Beach or other overwintering sites in 2020-2021 or in future years until the overwintering population has greatly increased.

After Five Years

While this plan provides a blueprint for the state of the grove and current recommended management actions, overwintering sites are dynamic habitats. After ~5 years, State Parks should revisit this site management plan (including re-engaging monarch overwintering site experts such as Xerces, Creekside Science, and/or others) to revise the plan as needed especially if any additional tree planting or modifications to the grove are required. It is also recommended that a new arborist report and tree map be prepared to document changes to the grove over time and the status of the new trees. This will help document how rapidly native and nonnative trees can provide adequate canopy for clustering monarchs.

APPENDICES

Appendix A. Map of site with ground-truthed path width 2019.

Appendix B. Pismo Beach assessment and count records from the Xerces Society Western Monarch Overwintering Sites Database 2020.

Appendix C. Monarch grove management plan for North Beach Campground Site 2008.

Appendix D. HortScience arborist report for Pismo Beach, revised 2018.

Appendix E. HortScience best management practices for tree planting and aftercare 2017.

Appendix F. Creekside Science report “Habitat Assessment of Pismo Beach North Campground Monarch Grove” 2018.

Appendix G. Creekside Science report “Simulation of Tree Removals and Shelterbelt Planting at Pismo North Campground Monarch Habitat” 2019.

Appendix H. Creekside Science report “Summary of Pismo Tree Scenarios” 2020.

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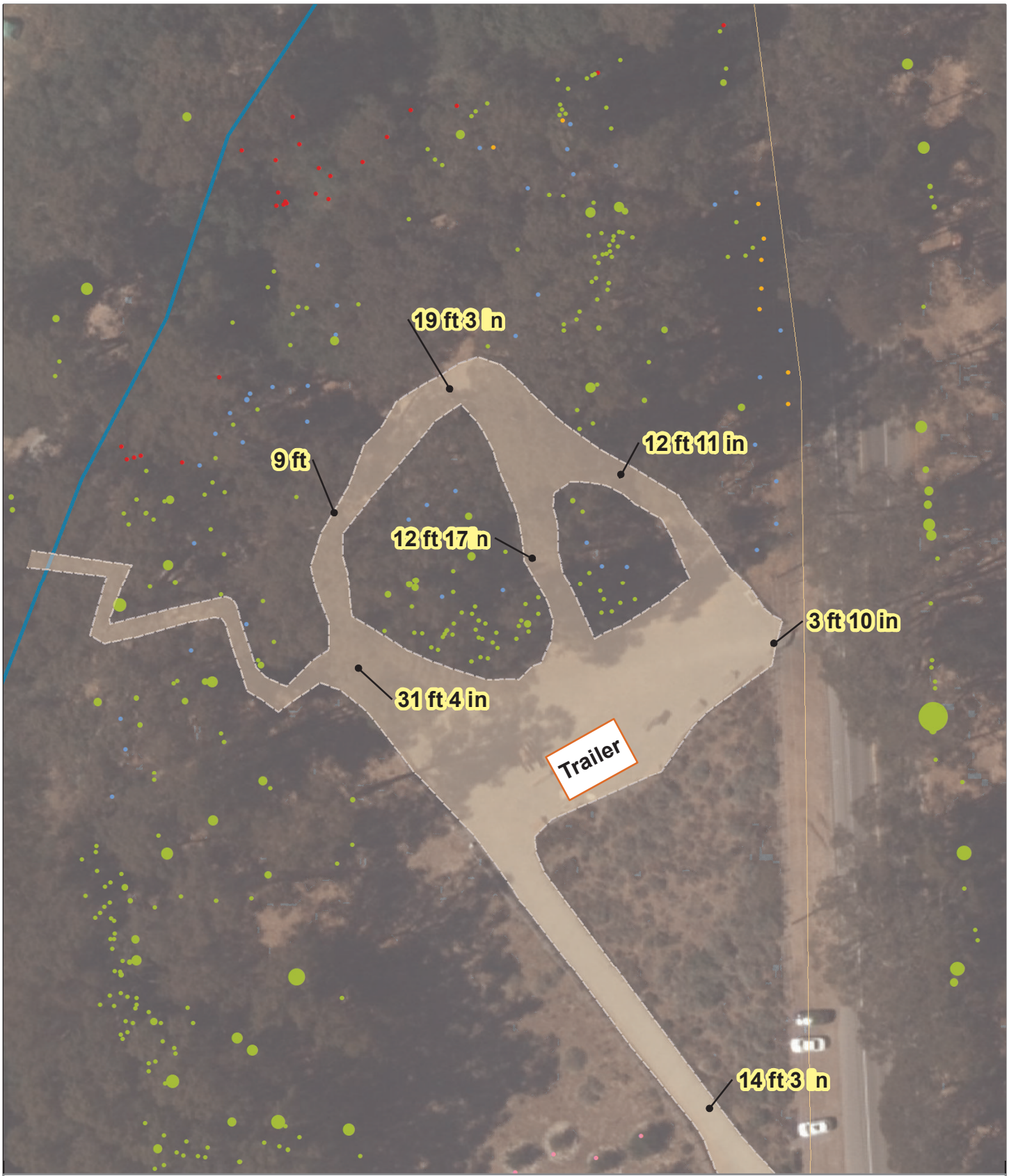
Appendix A.
Map of site with ground-truthed path width 2019

Narrow Path Points in Feet



Appendix B.
Pismo Beach assessment and count records from the Xerces Society
Western Monarch Overwintering Sites Database 2020

Site Name: Pismo Beach, North Beach Campground

SiteID: 3060

CNDDB #: 127

Aka:

Sensitive Data (yes if checked)? ☐

County: San Luis Obispo

Owner Name:	CA Dept. of Parks and Rec
Property Name:	PISMO SB
Primary Land Use:	State Park

Land Use Update: 3 /15/2012
Ownership Update: 1/25/2011

Site Status: Active Status Update: 12/1/2013

Status Comment

Directions: NORTH BEACH CAMPGROUND, NEAR MEADOW CREEK, PISMO STATE BEACH, NW OF GROVER BEACH

Site Description:

Comment: Site Observation data from the Thanksgiving Count is from Dennis Frey's mark-release-recapture study; not Monarch Alert's count data.

Aspect of Site: South **Slope of Site:** 0-10% **Water Source:** Stream/river

SITE CHARACTERISTICS (by date reported):

Source Code: SAK90F0013 **Source Year** 1990

Site Characteristics Date Reported: **xx/xx/1990**

Author First Name: Walter

Author Last Name: Sakai

Aggregation Type Reported:

Site Quality Reported: Excellent

Ecological Description: Cluster trees are a windrow of eucalyptus, pine, cypress, and oaks.

Aggregation Comments: Grove occurs along the creek, adjacent to the highway, near the ranger station.

Cluster Tree Species

Scientific Name	Common Name
Cupressus spp.	cypress
Eucalyptus spp.	eucalyptus species
Pinus spp.	pine
Quercus spp.	oak

Threats Comments:

Threatened by gradual loss of roost trees, without replacement.

Source Code: XER12U0001 **Source Year** 2012

Site Characteristics Date Reported: **10/28/2011**

Author First Name: Carly

Author Last Name: Voight

Aggregation Type Reported: Overwintering

Site Quality Reported:

Ecological Description: About half of the monarchs were clustering on the eucalyptus and the other half were clustering on the cypress. Other trees present at the site include Monterey pine and coast live oak.

Aggregation Comments: Grove occurs between the creek and the highway, among the many trails.

Cluster Tree Species

Scientific Name	Common Name
Cupressus macrocarpus	Monterey cypress
Eucalyptus globulus	blue gum

Other Tree Species

Scientific Name	Common Name
Cupressus macrocarpus	Monterey cypress
Eucalyptus globulus	blue gum
Pinus radiata	Monterey pine
Salix spp.	willow

Nectar Species

Scientific Name	Common Name
Ericameria ericoides	Mock heather
Lotus scoparius	Common deerweed
Monardella crispa	Crisp dune mint
Senecio blochmaniae	Dune groundsel/ragwort
Solanum sp.	Unknown nightshade

Site Threats

Threat Description
Cut trees/Tree removal
Old/aging trees
High visitation load
Extensive trails

Landscape Threats

Threat Description
Roads/highways
High vehicle traffic area
Housing developments

Future Threats

Threat Description
High possibility that overwintering trees will be cut or trimmed
Site might not offer enough wind protection in the future

Threats Comments:
Site continues to be threatened by a loss of aging roost trees, without replacement.

Source Code: XER14F0006 **Source Year** 2014

Site Characteristics Date Reported: **12/05/2012**

Author First Name: See: Observor

Author Last Name: Xerces Society

Aggregation Type Reported:

Site Quality Reported:

Ecological Description: Site is protected by staff/docent presence, they monitor visitors. Grove managers (w/ State Park permission) have planted Euc and Cypress saplings to maintain the grove.

Aggregation Comments:

Cluster Tree Species

Scientific Name	Common Name
Cupressus macrocarpus	Monterey cypress
Eucalyptus globulus	blue gum

Other Tree Species

Scientific Name	Common Name
Pinus radiata	Monterey pine
Salix spp.	willow

Nectar Species

Scientific Name	Common Name
Ericameria ericoides	Mock heather
Eucalyptus globulus	Blue gum

Site Threats

Threat Description
Other -- describe in comments field
Trimmed trees
Trees diseased from Eucalyptus leaf beetle
High visitation load
Extensive trails

Landscape Threats

Threat Description
Roads/highways
High vehicle traffic area
Housing developments
Pavement
Parking lot
Other -- describe in comments field

Threats Comments:
Large packed gravel interpretive area, railroad tracks on other side of Hwy 1 - sometimes noisy. Hwy 1 right next to grove. Trees overhanging trail are occassionally trimmed for vistor safety, but not much. Tens of thousands of visitors each year.

SITE OBSERVATIONS

Dates portrayed with a "TC" in place of the date represent Thanksgiving Count data; "xx" for any portion of the date indicates only a portion of the date was reported for the observation.

11/26/19	6,735	
11/20/19	5,380	
01/04/2019	3,089	3089 clustered, 2 tagged monarchs
11/26/18	3,082	3058 Clustered, 8 sunners, 12 fliers, 4 loners
11/20/18	2,757	
12/30/2017	12,005	
11/19/17	12,284	
01/03/2017	13,303	3 loners, 13300 clustered
12/02/2016	19,755	27 clusters in Euc and Cyp trees
11/14/2015	28,073	Custered in 10 trees (8 Eucs, 2 Cyp), 49 sunners, 49 fliers, 1 loner, 1 grounder. Observed one mating monarch.
TC/TC/2014	29,804	
TC/TC/2013	30,293	
TC/TC/2012	28,086	
TC/TC/2011	18,000	
TC/TC/2010	21,286	
TC/TC/2009	17,200	
TC/TC/2008	23,050	
TC/TC/2007	16,900	
TC/TC/2006	22,050	
TC/TC/2005	24,840	
TC/TC/2004	25,575	
TC/TC/2003	38,438	
TC/TC/2002	30,160	
11/27/2001	33,000	Secondary Source (date): 71
11/26/2000	26,100	Secondary Source (date): 71
11/26/1999	60,000	Secondary Source (date): 71
11/19/1998	115,100	Secondary Source (date): 71
xx/xx/1998	100,000	80-120K observed between Nov 97 and 19 Jan 98
11/27/1997	100,000	Secondary Source (date): 71
01/03/1996	150,000	
xx/xx/1995	12,000	
xx/xx/1994	17,000	
01/xx/1993	20,000	
xx/xx/1991	200,000	wintered in 1990-91 (largest in CA)
01/20/1990	15,000	
xx/xx/1988	100,000	
	0	

37	Total # observations reported:
36	Total # observations with monarchs present (>0):

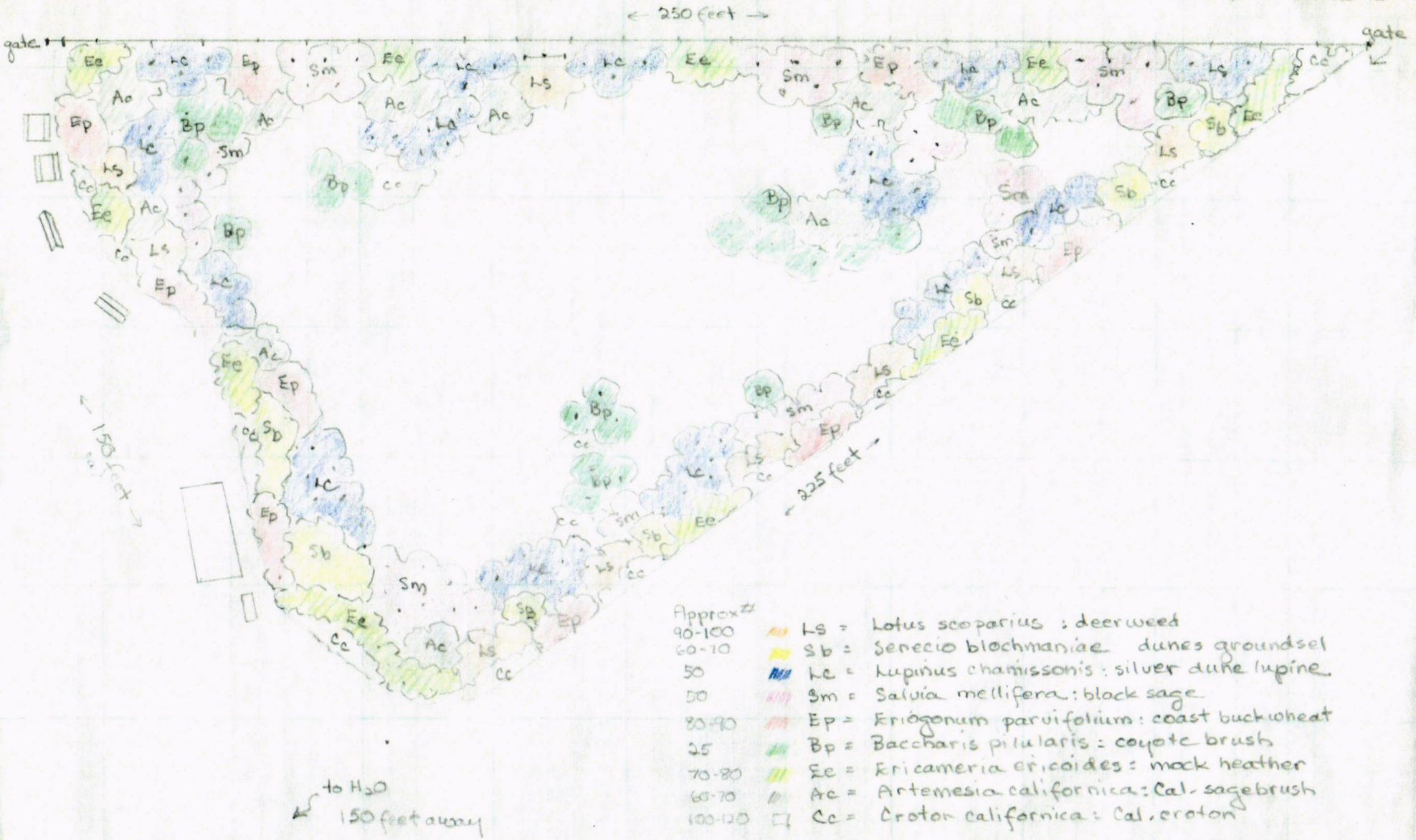
Observation Data Source(s)

1990	Walter	Sakai	FIELD SURVEY FORM FOR MONARCH OVERWINTERING SITE OBSERVATIONS DURING THE 1989-1990 SEASON.
2014		Xerces Society	Summary of Thanksgiving Count data from 1997-2014
2016	See: Observor	Xerces Society	Field Survey Form for Danaus plexippus overwintering sites, surveyed in winter 2015-2016
2017	See: Observor	Xerces Society	Field Survey Form for Danaus plexippus Overwintering Sites, surveyed in winter 2016-17
2018	See: Observer	Xerces Society	Field Survey form for Danaus plexippus Overwintering Sites, surveyed in winter 2017-18
2019	See: Observer	Xerces Society	Field Survey form for Danaus plexippus Overwintering Sites, surveyed in winter 2018-19
2020	See: Observer	Xerces Society	Field Survey form for Danaus plexippus Overwintering Sites, surveyed in winter 2019-20

Appendix C.
Monarch grove management plan for North Beach Campground Site
2008

Tentative Sketch for Butterfly Grove Master Plan Planting

June, 2008
Susan Grimaud



Approx #		
90-100	Ls =	Lotus scoparius : deerweed
60-70	Sb =	Senecio blochmaniae dunes groundsel
50	Lc =	Lupinus chamissonis : silver dune lupine
50	Sm =	Salvia mellifera : black sage
80-90	Ep =	Eriogonum parvifolium : coast buckwheat
25	Bp =	Baccharis pilularis : coyote brush
70-80	Ee =	Ericameria ericoides : mock heather
60-70	Ac =	Artemesia californica : Cal. sagebrush
100-120	Cc =	Croton californica : Cal. croton

Think about seeding center with native dune plants - (and hope for rain)
(Dune mint, sand verbena, wallflower ? etc...)

DRAFT

MONARCH GROVE MANAGEMENT PLAN

North Beach Campground Site

Pismo State Beach

INTRODUCTION

The spring and summer breeding range of the monarch butterfly (Danaus plexippus L.) extends throughout much of North America. During late summer and early fall, butterflies from the last of several short-lived generations (6-8 week life span) migrate to geographically restricted overwintering sites. Butterflies west of the Rocky Mountains overwinter at one of over 129 small coastal wooded sites situated between just north of San Francisco, CA to Ensenada, Mexico (Urquhart & Urquhart 1977; Sakai, et al. 1989). Numerous small temporary roosts occur within the same range. Monarchs from their eastern North America breeding range migrate in similar fashion to a few small sites in mountainous Central Mexico (Urquhart & Urquhart 1976; Calvert & Brower 1986). At these overwintering sites butterflies spend the majority of the next six months in tight clustering formations with brief forays interspersed to rehydrate, feed, mate, and reposition themselves following storms or other disturbances (Frey et al. 1992; Frey & Leong 1993; Leong & Frey 1991). Most mating occurs during the last few weeks of the overwintering phase followed by colony breakup and spring dispersal marking the beginning of recolonization of their expansive summer range (Hill et al. 1976; Calvert & Lawton 1993; Van Hook 1993).

Monarchs are large, colorful butterflies which together with their widespread, predictable fall and spring migrations renders them aesthetically conspicuous to the public. The highly aggregate roosting condition and large numbers of individuals at many overwintering sites (up to 250,000 in California and several million in Mexico) further adds to their spectacle.

During the late 1800's and the early 1900's, Eucalyptus spp. were successfully introduced along the central coast of California. Certain eucalyptus have the ability to colonize coastal canyons and ephemeral drainages in California due to similarities with habitat found along parts of coastal Australia and environs. Numerous eucalyptus groves exhibit structural characteristics that provide habitat for overwintering populations of monarch butterflies in California. The monarch's annual movement to wintering sites along the California coastline allows the animal to avoid freezing inland temperatures during the fall/winter months that are fatal to all stages of development

-egg, larvae, chrysalis and adult (Nagano and Freese, 1987). At North Beach Campground (NC) in Pismo State Beach, a small grove of eucalyptus has supported a significant wintering population for many years. Although other sites exist in the area, the NC site has one of the three largest overwintering colonies of monarchs in western North America (Chris Nagano, pers. comm.). Long-term abundance estimates are not available at this site but census data from recent mark-release-recapture work indicate that peak early January population numbers ranged from 235,000 in the 1990/1991 season to 25,000 in the 1992/1993 season Leong & Frey 1991; Frey, pers. comm.).

Although the presence of eucalyptus groves within the state park system is a recognized threat to native flora and fauna, groves providing wintering habitat are being managed to maintain the monarch cluster habit. Since DPR directives support the eventual removal of invasive exotic vegetation, the eventual, though not short-term, goal will be to replace exotic vegetation with native species that will provide winter habitat for the monarchs as well as other native species. The specific structure, location (regional), and species complement for this effort has not been determined. In an attempt to understand specific mircroenvironmental requirements associated with wintering habitat, research into monarch butterfly ecology has been ongoing in several San Luis Obispo Coast District parks and adjoining areas since 1988.

GOALS AND OBJECTIVES

This plan will provide guidelines for maintaining wintering habitat, visitor access, and site protection at the Pismo State Beach North Beach Campground site. Management goals will consist of, but not limited to, the following:

1. Define and implement habitat management methods based on site condition and known microenvironmental data;

2. provide interpretation and permanent visitor access to the site; and

3. to the extent possible, restore the adjacent area with native vegetation thereby providing a diversity of wildlife habitat.

The Department of Parks and Recreation has been charged with the preservation of outstanding natural, scenic, and cultural values and the indigenous aquatic and terrestrial fauna and flora. Each state park is to be managed as a composite whole to restore, protect, and maintain its native environmental complexes to the extent compatible with the primary purpose for which the park was established (Public Resources Code 5019.50). All activities within Pismo State Beach shall be carried out under the guidelines established by the DPR Resource Management Directives. (Pismo General Plan, 1975). The guidelines state, ..."except in those areas where it is perpetuated for resource management or historical reasons, aggressively invading exotic vegetation will be systematically removed when it becomes established anywhere

in the state park system..." (#34). Since the re-establishment and/or restoration of native monarch habitat is not yet a reality, roosting sited located on state property dominated by exotic species will be managed to perpetuate wintering habitat.

NATURAL RESOURCES

Plant Communities

The area known as Pismo State Beach has been significantly affected by various types of natural and man-caused physical manipulations and disturbances over the years. The arrival of Europeans has caused and continues to create significant changes in the landscape. The introduction of exotic flora and fauna, changes in hydrology, and direct human disturbance have all contributed to the current conditions in the area.

The North Beach monarch grove is bordered on the east by Highway 1, on the south by the La Sage Riviera Trailer Park, and on the north and west by Meadow Creek, the Pismo foredunes, and the campground. The grove consists primarily of eucalyptus (Eucalyptus globulus) with several Monterey cypress (Cupressus macrocarpa), Monterey pines (Pinus radiata) and myoporum (Myoporum laetum). The upland area adjacent to the grove is dominated by African sand veldtgrass (Erharta calycina), an aggressive exotic species well adapted to sandy coastal areas. Other species within the veldtgrass stand include dune lupine (Lupinus chamissonis), coyotebush (Baccharis pilularis), telegraph weed (Heterotheca grandiflora), and croton (Croton californica).

Native vegetation dominant within and adjacent to the channel containing Meadow Creek include arroyo willow (Salix lasiolepis), tule (Typha latifolia), and bulrush (Scirpus californicus). Additional wetland species found within and adjacent to the grove include saltgrass (Distichlis spicata), jaumea (Jaumea carnosa), rush (Juncus patens), horsetail (Equisetum laevigatum), and pickleweed (Salicornia spp.).

The paucity of vegetation under many mature stands of eucalyptus is attributed to the release of toxins that inhibit seed germination and plant growth, to direct competition for light and moisture, density of planting, and species present. On more mesic (wetter) sites, particularly on north facing slopes, several native understory species can survive under a eucalyptus canopy depending on the species and density of eucalyptus. However, del Moral and Muller (1969) emphasized that toxic fog drip is only one of several mechanisms present in eucalyptus spp. capable of producing herb growth inhibition. Leaf litter possesses many toxic phenolic acids leached out in great quantities by rain. The terpenes are subsequently absorbed by soil colliods, altering soil conditions and inhibiting germination. Allelopathy must be considered an ecological factor of wide significance, capable of influencing succession, dominance, vegetation dynamics, species diversity, community structure, productivity, and other processes and factors (del Moral and Muller 1970).

Wildlife

Although the groves are not faunal deserts, the adjacent plant communities, including coastal dune, riparian woodland, dune scrub communities are, as a rule, considerably richer in numbers and diversity if wildlife. Preliminary findings show that no endangered, threatened, rare, or species of special concern occur in the immediate area. Certain avian species such as bald eagles or Peregrine falcon could pass through the area, but the park is not important habitat. A few species of herps confirmed in the area include the Pacific treefrog, Western fence lizard, gopher snake, and the Western aquatic garter snake. Other herps such as the Western pond turtle and California legless lizard are rumored to be present. Although twenty-two mammal species have been noted in the vicinity of the wetland, the area is not particularly rich in the number of species or individuals of most species. As may be expected in a disturbed site adjacent to an urban area, only a few species, the raccoon, opossum and the feral cat, seemed to have comparatively high numbers. It can be assumed that feral cats would have a deleterious effect on small mammals and herps within the park.

Pismo State Beach does attract large numbers of avian species, and is a popular area for bird watching along the south central coast. A diversity of local habitats attracts many types of birds. An unusual number of "rare" species have been noted, species found outside of their normal range. These include the great-tailed grackle, back and white warbler, prothonotary warbler, white-throated sparrow, and summer tanager. In addition, numerous raptors frequent the area.

Hydrology

Over the years major modifications have drastically altered the drainage patterns, amount of run-off and amount of soil erosion from the watershed. The upper section of the watershed, including Pismo Lake Ecological Preserve, has an area of 3,735 acres. Most of the watershed lies in gently sloping hills on the east side of Highway 101. These portions of the watershed either have been, or are likely to be developed with both housing and commercial structures. The collection area for the lower section of the watershed is about 2,688 acres, dominated by developed, urban land. Annual average rainfall is 16 inches, but highly variable. The present Meadow Creek channel below Pismo Lakes Ecological Preserve was formerly the channel of Pismo Creek, which drained into Oceano Lagoon. The present mouth of Pismo Creek developed in 1911. The geology is dominated by poorly consolidated Pliocene marine sands, or by similar, but younger sands of similar composition derived from the Pismo Formation.

Just upstream from the site lies the Pismo Lake Ecological Preserve, managed by the California Department of Fish and Game. Until recently the preserve was a marsh dominated by tules with little open water surface. In an attempt to restore open water and upland habitat, the preserve was dredged, and island wildlife refuges constructed in the center of the lake. In addition, valuable open space and oak woodland communities occur near the preserve.

Runoff from Pismo Lake flows under a railroad Right-of-Way and Highway One, thence into a leveed channel that passes on the east side of the North Beach Campground adjacent to the monarch wintering site. Preliminary hydrologic data have shown that the channel has a low capacity, due to low levees and low channel slope, and will flood at discharges of 200 cubic feet per second. This may be compared to 100-year storm discharges of 1,000-2,000 cfs. In this area, a flood control channel named Carpenter Creek, which forms the southern boundary of the North Beach Campground, was constructed to facilitate flood runoff. The Meadow Creek channel then flows past a golf course, under Grand Avenue, into the Grand Dunes Marsh, and thence into a densely vegetated riparian zone that terminates in the South (Pismo) Campground and Oceano Lagoon. The North Beach Campground and golf course were constructed in the floodplain of the creek.

METHODS AND MATERIALS

Habitat Management

The NC grove consists primarily of eucalyptus with a few other tree species introduced to the area. Monarchs roost on E. globulus, C. macrocarpa and P. radiata at various times throughout the season at NC by 95% of clustering by monarchs occurs on E. globulus (Frey, unpubl. data). The roosting grove lies in a somewhat precarious position as habitat due to the age of the protective trees, the random chance of tree loss from storm, or fire. Other factors such as disease or vandalism may also impact habitat. Major decisions regarding habitat management will be made in coordination with the Monarch Management Committee. The committee consists of state park personnel including the District Ecologist, State Park docents, and other volunteers.

To maintain the monarch cluster habit at the site, several management actions will be taken, including but not limited to:

1. Tree Pruning and Replacement (enhancement of monarch habitat)

   Generally, tree pruning and replacement will occur with the existing grove but may also include other wooded (e.g., riparian) areas adjacent to the roosting site. New recruits (seedlings) within the grove will remain in place or removed based on decisions made by the monarch committee. Tree replacement with introduced species will occur only within the canopy of the existing grove (as of 1993). Any tree pruning in the area (limited to state park property) will be done after advisement with the monarch committee. Clearing, thinning and pruning of all vegetation or alteration of the local topographic characteristics should be closely monitored to minimize impacts to the site. For example, a surviving, fallen blue gum has sprouted leaders from the trunk. These upward growing limbs lack

significant structural support and could twist off in the near future. In addition, these "branches" will likely interfere with recruitment in the immediate area.

Activity should be avoided from October - March to lessen impacts to wintering monarchs. State Park personnel (i.e., maintenance, visitor services) will need to be familiar with the intent of the management action.

2. Off property tree management

A potentially significant "windbreak" of eucalyptus trees are located opposite state park property along Hwy 1. These trees are very likely to be important habitat maintenance trees. It will likely be necessary to coordinate with Caltrans, Southern Pacific Railroad and/or city crews to manage or replace these trees.

Highway 1 adjacent to the site is maintained by Caltrans. The highway right-of-way is approximately 60 feet wide (30' center). It may be possible to coordinate with CalTrans to plant more trees along the Hwy 1 R/W thereby providing an additional wind buffer.

S.P. Railroad "manages" a 100' R/W along the east side of Hwy 1. Several eucalyptus occur within this area. It will be necessary to coordinate with the railroad to maintain this buffer.

3. Coordination with state park personnel

As previously mentioned, it will be important to coordinate maintenance work that occurs in or directly adjacent to the grove with all pertinent state park personnel in the District, particularly at Pismo State Beach. This action will prevent unnecessary pruning and/or tree removal from the vicinity of the site. It should be noted that recognized hazard trees within and adjacent to the North Beach Campground will be removed as necessary. The identification and removal of hazardous trees in the park will unlikely be subject to negotiation. Although the monarch committee may be notified, hazard trees within the campground or adjacent to the grove will be removed.

Pesticide/herbicide use near the monarch grove will also require coordination with the park maintenance supervisor or the Monarch Committee.

4. Willow management

Although Meadow Creek has been channelized, a small, remnant riparian area dominated by Salix lasiolepsis (arroyo willow) is established along the western and northern border of the monarch grove. The willow thicket may provide both general wildlife habitat and a wind buffer/thermal blanket for the monarchs.

Protection, enhancement and perpetuation of this habitat will be pursued. Areas along the levee system will be planted with willow to enhance habitat.

It is advisable to remove eucalyptus growing in "bottomland" areas due to susceptibility of root and crown rot in the species. Trees greater than 15" dbh should be removed and replaced, where possible, with willow species. Where possible, native tree species will be established prior to eucalyptus removal. Species will include arroyo willow, wax myrtle, coast live oak, and possibly sycamore.

It should be noted that the southwestern pond turtle has been observed within the creek. This observation requires corroboration.

5. Veltgrass Removal and Site Rehabilitation

Restoration of upland site adjacent to the grove with native coastal dune scrub species. Because of the tenacity of veldtgrass, this will likely be a long term project. Included in the species mix will be woody species such as coast live oak and wax myrtle. CLO and myrtle may provide an addition wind buffer for the monarch grove and the habitat diversity needed in the area. Other species would include the following:

Species	**Common Name**
Ericameria ericoides	mock heather
Lupinus chamissonis	dune lupine
Lotus scoparius	deerweed
Artemisia californica	California sage
Salvia mellifera	black sage
Senecio Blochmanae	Blochman's groundsel
Baccharis pilularis	coyotebrush
Eriogonum parvifolium	buckwheat
Croton californica	croton

All plant material would be collected from local plant communities (seeds, cutting, etc.) in order to preserve the genetic integrity of the area.

6. Managing Saltgrass/pickleweed habitat

Although the habitat value of the saltgrass habitat may have been reduced due the presence of the campground, this area may provide a periodic watering source (dew) for the monarchs and should be protected. Material chipped within the campground will not be deposited in the pickleweed/ saltgrass area.

7. Fuel management

Due to the presence of veldtgrass, the fine fuels that build up yearly are considered a potential fire hazard. In recent years, the perimeter of the site has been mowed by park personnel to reduce the risk of fire. Prior to the replacement of veldtgrass by native species, it may be beneficial to mow the entire area if care is taken to avoid the few native species that have managed to survive. Mowing can occur prior to seed set (early spring; timing to be coordinated with monarch committee) to eliminate most of the year's seed crop. The fine fuel hazard will be greatly reduced when the area is restored to native coastal scrub cover. It may be necessary to maintain a perimeter fire break.

INTERPRETATION AND ACCESS

Interpretation

The interpretive trailer has been designated a permanent location (see map). The trailer will be set in place and operated during the migration and wintering period. Further the interpretive display case has a permanent location. Other interpretive signs may be located along the viewing area railing as deemed necessary. Any additional excavations at the site will require State Park approval (CEQA).

Milkweed enclosure

As part of the interpretive process, a milkweed enclosure may be developed to interpret the live cycle of the species. Although this summer annual has usually senesced prior to the wintering season, the enclosure may be "gardened" to extend the length of the growing season into October or early November. Variable weather patterns and logistics will require some experimental efforts.

Access

The preferred access and viewing area and a bridge linking the campground to the monarch grove has been established. Barring flooding or other disturbance, these facilities will be open to the public year round.

Regulatory signs are in place. It may be determined that additional signs such as "Stay on path" or directional signs may be needed. These signs will be placed where necessary to facilitate visitor use.

The North Beach Campground is the Department's preferred access and parking area to the site. Campsite(s) # 72 through 81 will be identified as the preferred parking/

access during the wintering season. Campsites 76 - 79 may be used as pull through parking for larger vehicles. Other campsites may be used on an as need basis providing no conflicts occur with campers. Signs indicating monarch parking will be useful in these areas.

Parking and access may require special attention during the busy Thanksgiving or Christmas weekend. Due to the Department's requirement to provide campsites, parking will be restricted during these times. If parking is allowed during the Thanksgiving/Christmas weekend, an day-use fee will/may be charged.

Disabled Access

Campsite #78 will be identified as a disabled access parking area. This campsite is directly adjacent to the bridge over Meadow Creek. Disabled access from this site to the viewing area will be improved.

RESEARCH

Research, inventory and monitoring efforts must be focused and designed to provide information for park managers and the public. Researchers will contact the District Ecologist and park personnel in order to obtain appropriate permits.

ACKNOWLEDGMENTS

Special thanks to the Monarch Committee for comments regarding management guidelines discussed in the plan. In addition, Dennis Frey directly contributed sections of the introduction.

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Appendix D.
HortScience arborist report for Pismo Beach, revised 2018

California Department of Parks and Recreation

Tree Management Plan
Pismo State Beach

Prepared for:
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February 18, 2018

HORT SCIENCE

Tree Management Plan

Pismo State Beach
California Department of Parks and Recreation
Pismo Beach CA

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Introduction and Overview

Pismo State Beach is managed by the California Department of Parks and Recreation (CDPR). Among the features of Pismo State Beach, within the North Beach Campground, is a grove of trees that supports an over wintering population of Monarch butterflies (*Danaus plexippus*). During the winter of 2016 – 2017, severe storms caused a number of large trees to fail including several that were either within the grove or immediately adjacent to it.

Tree failures raised two concerns among Park staff including:

1. The risk to park visitors and staff posed by future tree failures.

2. Sustaining appropriate habitat for butterflies.

The CDPR contacted HortScience, Inc. to assist in addressing both concerns by:

1. Consulting with the project team regarding goals of the Monarch Grove Management Plan, recent history, key issues and opportunities, a work plan, and a map for the placement and planting of future trees.

2. Conducting an inventory of trees within the grove including but not limited to:
   a) Identify the species,
   b) Estimate trunk diameter,
   c) Assess tree condition based on a visual assessment from the ground,
   d) Note structural and health characteristics important to management.
   e) Perform a level 1 limited visual assessment of tree risk using the method found in the International Society of Arboriculture's Best Management Practices *Tree Risk Assessment* (2012 edition),
   f) Identify abatement procedures.

HortScience, Inc. visited the park in November 2017 and January 2018.

Overview of the Site

The monarch butterfly grove is located within the southeast corner of North Beach Campground, which is within Pismo State Beach (Photo 1). The grove is roughly the shape of a right triangle with the base on the south side. The east side borders Highway 1. The grove is approximately 1,000 yards from the ocean.

Prior to development of the region, the area of the grove was likely a mix of dune and coastal scrub vegetation. Willow trees may have been present along the existing creek. The vegetation was unlikely to have included any other tree species. The southeast corner of the grove has been managed to restore native plants, largely coastal shrub chaparral. Several isolated coast live oaks (*Quercus agrifolia*) are present.

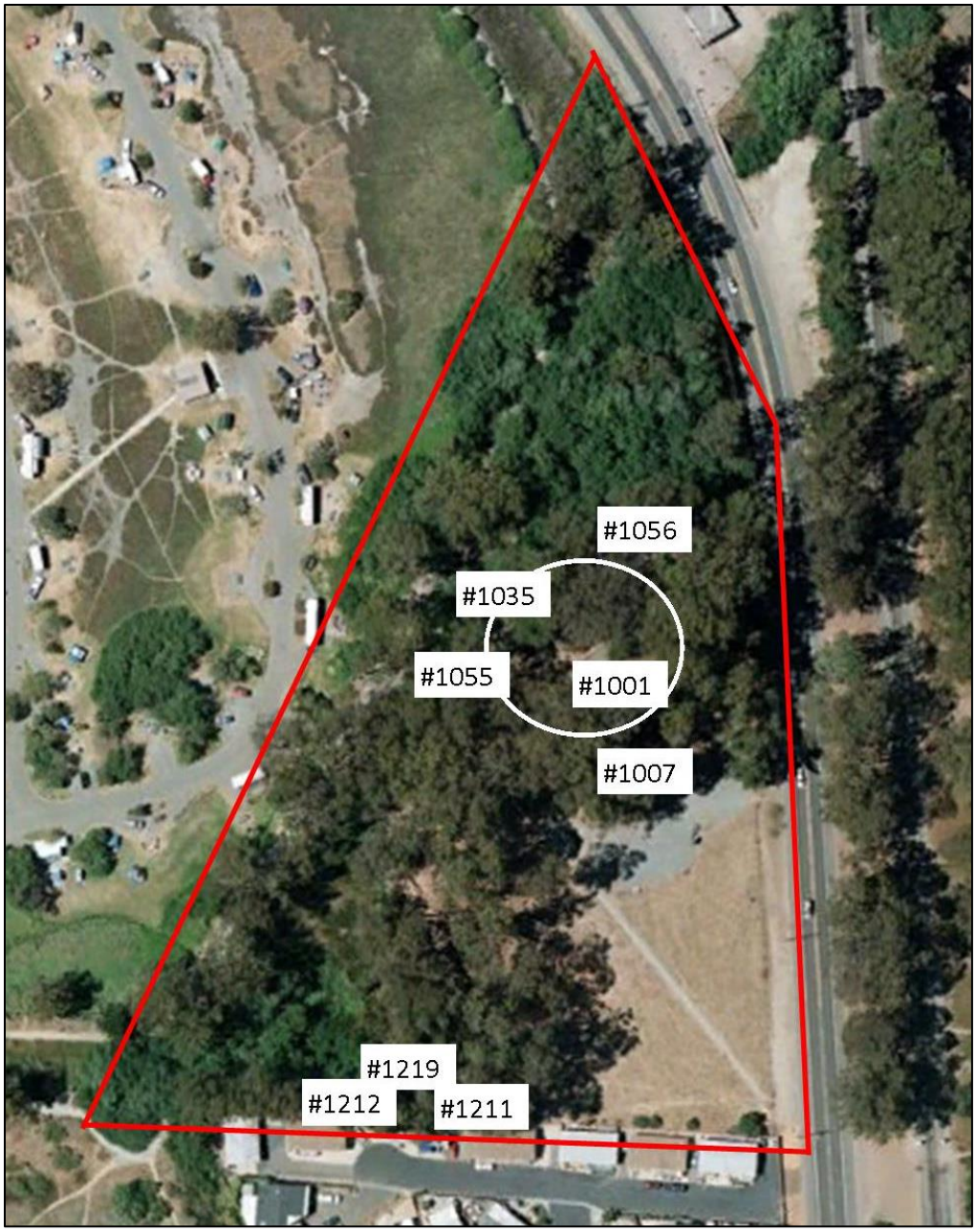


Photo 1. 2017 aerial photograph of the Butterfly Grove. Red lines indicate approximate boundary. Note restoration area in southeast corner. Butterflies were concentrated in the area defined by the white circle. Tree numbers refer to recommendations for action.

The grove is bisected by a seasonal creek that runs from northeast to southwest, forming the north boundary of the primary butterfly viewing area. Vegetation in the creek area is dominated by willows and other wetland and riparian plants. Blue gums are present along the banks. The north boundary of the grove, however, lacks a defined bank. During periods of high rainfall, water ponds inundating trees in the area where butterflies congregate.

The coastal climate of Pismo Beach reflects a Mediterranean pattern of mild dry summers and cool wet winters. Most precipitation falls in the winter months (November to March). Rain is often associated with periods of high wind. Fog and overcast skies are common in the summer months.

Butterflies are present any time from November to March, the prime season for visitors and tour groups. Visitors are restricted to designated trails that extend through the north side of the grove.

Field Inventory

Pismo State Beach staff inventoried and mapped 322 trees within the grove (Table 1). All species except the willow were planted as part of landscape development of the site.

Blue gum was the dominant tree in the grove, by both overall size and numbers (Table 1). The 257 blue gums comprised 80% of all trees within the grove. Of the 51 trees that were 30 in. or greater in diameter, 49 of them were blue gums. The largest blue gums were #1069 at 82 in. and #1229 at 84.5 in. Six trees (#1075, 1085, 1094, 1211, 1299, 1339) were larger than 50 in.

As is typical of blue gum stands, most trees (approximately 45%) were small diameter saplings less than 10 in. In general, these trees are in poor condition, having been suppressed by large diameter, taller trees. They rarely become large trees and are likely to die over time. Another 100+ blue gums were intermediate in size, between 10 in. and 39 in. diameter.

Staff described failures of blue gum during the winter of 2017 as concentrated in the area of the butterfly “cluster area”, particularly at the edge of the seasonal creek. Whole tree failures occurred during periods of high water, often falling from south to north. At least one blue gum tree failure was not associated with the creek but failed from south to north.

Field Observations

Monarch butterflies were present in the grove at the time of our field assessment. Butterflies were not evenly distributed through the grove but were concentrated in a relatively small area (Photo 1). Within this area, butterflies formed clusters or groups. Outside this area, individual butterflies were observed but groups were not.

This “cluster area” of butterfly activity was located just south of the seasonal creek and north of the restoration area. It comprised a relatively small section of the entire grove. Walking trails extended in and around the cluster area.

A continuous canopy of tree cover was present except in the restoration in the southeast corner. The grove’s primary tree species are blue gum eucalyptus (*Eucalyptus globulus*) and a native willow (*Salix* sp.). Also present are Monterey pine (*Pinus radiata*) and Monterey cypress (*Hesperocyparis macrocarpa*) trees. A row of mature blue gums is present on the east side of Highway 1, property not owned by CDPR.

Tree cover within the butterfly area was dominated by blue gum. Mature Monterey pines were present in the past but have been lost to diseases, insects, and structural failure. There was an opening in its center of the tree canopy cover.

Taken together, these blue gums formed a significant barrier to wind, particularly from west to east and southwest to northeast.

Table 1. Trunk diameter and species composition. Monarch Butterfly Grove. Pismo State Beach.

Common name	Scientific name	Diameter Class (in.)	No. of Trunks			No. of Trees
			One	Two or more	Sub-total	
Blue gum	*Eucalyptus globulus*	<10	100	19	119	257
		10 to 19	40	18	58	
		20 to 29	26	5	31	
		30 to 39	16	7	23	
		40 to 49	19	7	26	
Monterey cypress	*Hesperocyparis macrocarpa*	<10	25	1	26	34
		10 to 19	3	--	3	
		20 to 29	3	--	3	
		30 to 39	2	--	2	
Myoporum	*Myoporum laetum*	<10	5	2	7	9
		10 to 19	1	1	2	
Coast live oak	*Quercus agrifolia*	<10	4	1	5	5
Willow	*Salix* sp.	<10	16	--	16	17
		10 to 19	1	--	1	
Total, all trees inventoried						**322**

Note: Data collected by CDPR staff.

Thirty-four (34) Monterey cypresses were present. Almost all were less than 10 in. in diameter, having only recently been planted. Trees were a mix of those in good and poor condition.

Willows dominated the canopy within the seasonal creek. Trees were typical of the genus: small in size, forming dense thickets.

Tree Structure Assessment

Trees were examined from the ground for their potential to fail and impact a specific target. In the grove itself, the target was a person walking on one of the trails. On the south edge of the grove, the target was an adjacent home. Only trees with obvious defects that required abatement were recorded. Risk ratings were not assigned.

Given the dominance of blue gum in the grove, one key to risk management is understanding the pattern of failure of this species. Using data from the California Tree Failure Report Program (http://ucanr.edu/sites/treefail/), seasonal patterns of failure have been described (Figure 1). Key features include:

- Failures of all types are concentrated during the winter months and are associated with periods of rain and wind.
- Branch failures may occur during summer months. Failures are most often associated with heavy branches.
- Branch (and root) failures are likely to occur than trunk failures.
- Defects most commonly associated with root failure were dense crown, kinked/girdling root and lean.

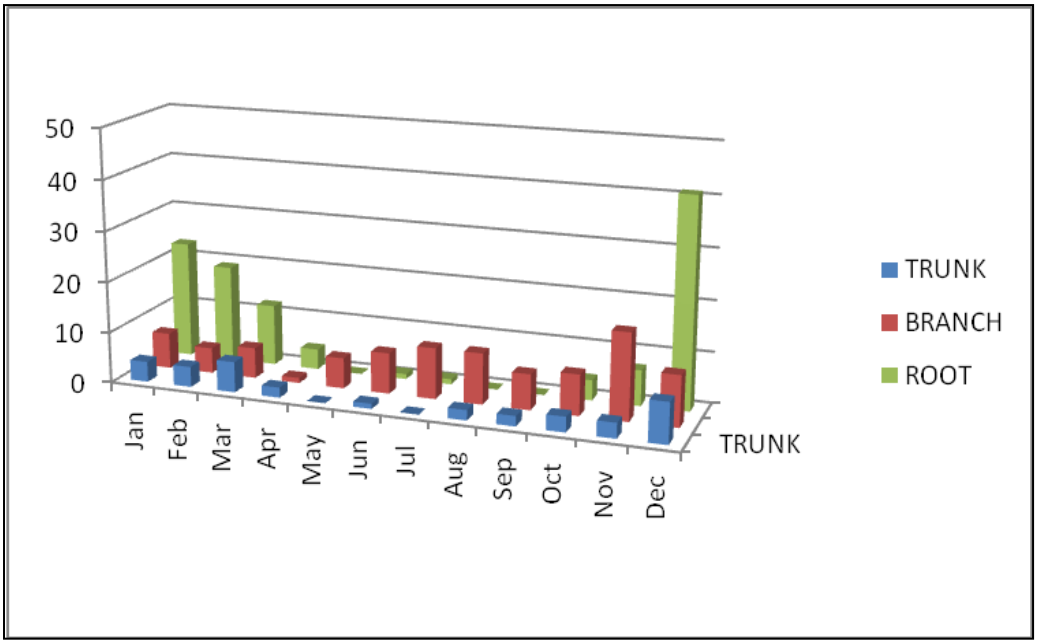


Figure 1. Monthly pattern of failure in blue gum. Source: California Tree Failure Report Program.

Restoration and Replanting

In order to sustain the presence of Monarch butterflies at the grove, the trees must provide suitable habitat. Trees provide cover, a food source, and protection from the wind. Appropriate species would be evergreen and winter-flowering. In addition, species must adapted to the climate and soils of the area and be drought- and wind-tolerant.

A list of potential tree species includes:

- Blue gum. Present in the grove.
- Monterey pine. Previously present. Plant only is well-drained areas.
- Monterey cypress. Present in the grove. Plant only in well-drained areas
- River red gum (*E. camaldulensis*). Tolerates wet soil. Limited invasive potential. Winter flowering.
- Karri (*E. diversicolor*). Not invasive.
- Flooded gum (*E. rudis*). Tolerates wet soil.
- Swamp gum (*E. regnans*). Tolerates wet soil.
- Swamp mahogany (*E. robusta*). Tolerates wet soil.

The primary challenge in using the above species is their requirement for full sun growing conditions. Trees of these species are unlikely to survive let alone thrive under the shade of existing trees. A secondary challenge is the requirement for irrigation during the establishment period. Although all the species are drought-tolerant, they require irrigation for at least the first few years after planting. As a general rule, trees should be irrigated every week the first year after planting, every second week during the second and third years after planting, and once a month for the next two or three years.

Analysis and Management Recommendations

Monarch butterflies were first observed at Pismo State Beach in the 1960s and 1970s. Since that time, butterflies have congregated in the grove during the winter months. Ensuring the presence of butterflies into the future requires maintaining suitable habitat. Monarch butterflies are thought to select sites that provide 1) protection from high wind and storms, 2) variable light mix ranging from full sun to light shade to dappled light, 3) high humidity and 4) availability of water.

Because the existing “cluster area” of butterfly activity is relatively small in comparison to the overall size of the grove, there is concern that the loss of even a few key trees would have dramatic influence on habitat quality. At the same time, the safety of visitors and staff from falling trees must be considered.

To achieve these goals, we recommend a program of inspection and care of the existing trees as well as planting new trees to enhance the butterfly habitat and provide for the loss of trees over time. The existing mix of mature large canopy blue gums and understory trees should be maintained. The understory trees provide a ladder of foliage for the butterflies as well as block wind.

We recommend planting eucalyptus species that are more tolerant of periods of flooding along the creek. We recommend planting trees in the south and east areas of the site in order to provide additional wind protection to the cluster area. Any new tree planting must match the growing conditions at the site with the needs of the species. For example, eucalypts, Monterey pine and Monterey cypress are require full sun and will not develop under shade.

Specifically, we recommend the following:

1. **Management of existing trees**
   - Close the grove during periods of high wind and rain. It is during these periods that blue gums are most likely to fail.
   - Treat trees to reduce likelihood of failure onto public use areas (see Table 2). We recommend pruning six trees and removing two trees after the butterflies have left the grove. While in the tree the climbing arborist should perform an aerial inspection to identify any defects requiring treatment that are not visible from the ground.
   - Inspect trees for structural condition and provide treatments to reduce risk as needed. See the General Tree Assessment Procedure in the Attachments.
   - Inspect trees after major storms to identify any storm damage to trees including broken or hanging branches and stems, partial root failures, and changes in lean.

2. **Establish a risk management policy** that defines acceptable risk in a manner that is reasonable as well as proportionate to benefits trees provide to the grove and the community.

3. P**lant new trees**
   - As a general recommendation for eucalyptus, use 5-gal. to 15-gal. nursery stock.
   - Install river red gum and other species tolerant of wet soils on the margins between the grove and seasonal creek. Clear adjacent non-eucalyptus vegetation to provide full sun. Test a few plants of each species and monitor performance.
   - Install one or two new eucalyptus trees in the area of the existing hot spot.
   - As new trees become established and a permanent part of the canopy, they should be added to the tree map and database.

4. **Improve drainage of the seasonal creek**
   The seasonal creek does not appear drain to the ocean but ponds in an area just north of the grove's hot spot. Flow may be affected by rushes and other wetland plants located just below the existing pedestrian bridge. Allowing water to move away from the butterfly "cluster area" would 1) reduce the likely of whole tree failure and 2) create additional space for planting new trees. We recommend that the creek and patterns of water flow be assessed by a hydrologist or riparian specialist.

5. **Allow duff to accumulate beneath tree canopy.**
   Allowing leaves and other plant litter to accumulate will reduce overall water loss and act as a deterrent to weed development. New trees should have a 2-feet radius from the trunk covered with mulch.

6. **Extend the existing grove into the southeast corner.**
   The southeast corner of the grove has been converted to low-growing native plants. Several coast live oaks are located in this area but cannot be expected to become 50' or 60' tall. We suggest the CDPR install eucalyptus trees across the restoration site ending close the Highway 1. This planting could consist of a single row of trees or some variation. The goal would be to create a wind-break that would reduce wind speeds affecting trees in the cluster area.

Table 2. Recommended Tree Care. Monarch Butterfly grove. Pismo State Beach.

Tree No.	Common name	Trunk Diameter (in.)	Recommended treatment
1001	Blue gum	48.5	Prune to remove branch over path/bench at attachment.
1007	Blue gum	48	Prune to remove branch at attachment.
1035	Blue gum	38.5	Prune to reduce long, large branches over trail.
1055	Blue gum	42	Prune to reduce crown on N. & E. to reduce likelihood of failure into grove.
1155	Monterey cypress	31.5	Remove tree.
1211	Blue gum	61.5	Prune to remove/reduce branches that extend over property line.
1219	Blue gum	20	Prune to remove/reduce branches that extend over property line.
1221	Blue gum	27.5	Remove tree.

Our procedures focused on trees with observable defects. This is not to say that trees without significant defects will not fail. Failure of apparently defect-free trees does occur, especially during storm events. Wind forces, for example, can exceed the strength of defect-free wood causing branches and trunks to break. Wind forces coupled with rain can saturate soils, reducing their ability to hold roots, and blow over defect-free trees. Although we cannot predict all failures, identifying those trees with observable defects is a critical component of enhancing public safety.

Furthermore, trees change over time. Our inspections represent the condition of the tree at the time of inspection. The enclosed General Tree Assessment Procedure will assist staff in identifying changes to tree health and structure. In addition, trees should be inspected after storms of unusual severity to evaluate damage and structural changes. Initiating these inspections is the responsibility of the client and/or tree owner.

HortScience, Inc.

James R. Clark, Ph.D.
Certified Arborist WE-0846
Registered Consulting Arborist #357

Attachments

General Tree Assessment Procedure.

Best Management Practices.

General Tree Assessment Procedure

Routine
Visual assessment of tree condition during normal work activities. Of particular concern:

- Declining vigor, particularly in density and color of foliage and dieback of twig and branches.
- Changes in orientation, i.e., increased lean.
- Uplifted and mounded soil at the base of the trunk.
- Increase weight of branches as evidenced by separation from the canopy.
- Presence of fungal fruiting bodies. Trees with fruiting bodies should receive a more detailed assessment of failure and target potential.

Seasonal (fall)
In addition to the above:

- Presence of fruiting bodies of sulfur fungus (*Laetiporus sulfureous*). Look for orange-yellow conks on the lower trunk and old wounds. Conks fade to an ivory color with a chalky consistency.

Upper left. Conks have formed on the face of an old root pruning wound.

Above right. Close-up of color & structure.

Lower right. Sulfur fungus conks rapidly degrade to an ivory-colored, chalky-textured form. These may also be found in the crown of the tree, on old pruning wounds and on the ground.

HortScience, Inc.

Best Management Practices
Pismo Beach State Park
Pismo Beach CA

Planting Programs

Planting specifications must consider site-specific conditions. Because it is very difficult to modify site conditions following planting, a thorough assessment of site characteristics and identification of any factors that could limit plant performance need to occur before planting. Specific chemical deficiencies and toxicities should be identified, as well as any physical constraints to plant development. The following pre-planting procedures should be followed:

1. Review the planting site, noting any plants or weeds existing, their appearance and growth.

2. Collect soil samples as appropriate and submit to testing laboratory. At a minimum samples should be analyzed for phosphorus, potassium, calcium, magnesium, boron, chloride, sodium, salinity (electrical conductivity), sodium adsorption ratio (SAR), lime and texture. Samples may be collected by the soil laboratory or by County staff according to instructions provided by the laboratory.

3. Based on results of soil tests, apply treatments were necessary to improve soil conditions. The testing laboratory can provide treatment recommendations. Examples are:
   - Where salinity is greater than 3.0 mmhos/cm and/or boron is greater than 1.0 ppm – leach with several heavy irrigations, allowing to soil to drain between each irrigation.
   - Where SAR is greater than 6.0 – incorporate gypsum into soil and leach.
   - Where phosphorous or potassium are low, apply and incorporate into the soil.

4. Select plant materials that are adapted to site conditions. We have limited ability to change soil characteristics such as clayey or sandy texture, high pH, high lime and high boron. Therefore, where these conditions exist, it is important to select plants that are tolerant.

Acceptance of Nursery Trees at the Time of Delivery

Future performance of landscape trees and shrubs is dependent on selecting good quality plants from the nursery. All plants should be inspected prior to acceptance and planting to ensure they have good branch and root structure, and are healthy, vigorous and free from diseases and insects.

Specifications

The following specifications can be modified depending on the species, the landscape site, and the intended function of the tree.

1. All trees shall be true to type or name as ordered or shown on the plans and shall be individually tagged or tagged in groups by species and cultivar (variety). Plants shall conform to the most recent version of the American Standard for Nursery Stock (ANSI Z60.1) (American Association of Nurserymen, Washington D.C.).

2. All trees shall be vigorous, have a form typical for the species or cultivar, be well-rooted, be free from wounds, and be properly trained.

3. The height, crown spread, diameter and root size of all trees shall be appropriate for the type of stock and in proportion to one another

4. All trees shall comply with Federal and State laws requiring inspection for plant diseases and pest infestations. Inspection certificates required by law shall accompany each shipment of plants. Clearance from the County Agricultural Commissioner as required by law, shall be obtained before planting trees delivered from outside the County in which they are to be planted.

5. The rootball of all trees shall be moist throughout the crown shall show no signs of moisture stress.

6. Tree crown: (round headed) broadleaved, decurrent trees
   A. Crown is uniform in conformation with a single, straight trunk that has not been headed or that could be pruned to a leader.
      1) Potential lateral scaffolds (height of lowest scaffold depends on landscape use):
         - Small-growing trees (crape myrtle, flowering fruit trees). At least 2" apart vertically, which could be trained in the landscape to 3 to 7 branches 4" or more apart vertically.
         - Large-growing trees (ash, oak, callery pear). At least 6" apart vertically, which could be trained in the landscape to 5 to 9 branches 18" or more apart vertically.
         - Radially distributed around the trunk.
         - Not more than two-thirds (2/3) the diameter of the trunk, 1" above the branch.
         - Free of included bark in attachments (bark embedded between the trunk and a lateral).
      2) No laterals below the lowest potential scaffold should be larger than one-fourth (1/4) the trunk diameter at point of attachment.
      3) Each tree must be able to comply with A1 and A2 above without having or having had to remove, now or within the previous growing season (at least six months), more than 25 percent of the branches of size similar to or larger than those of the potential scaffold branches.
   B. The minimum acceptable length of the most recent season's shoots should be specified, for example, shoots of small-growing trees (that is, red maple, red oak, ginkgo) might be 12"; for large-growing trees the minimum acceptable length might be 18" and preferable 24-36".
   C. It would be desirable to have:
      1) The tree stand upright without support (i.e. following removal of nursery stake).
      2) Small (<1/4 diameter of trunk) temporary branches along the trunk below the scaffolds.

7. Tree crown: broadleaved or coniferous, excurrent (central trunk) trees
   A. Crown is uniform in conformation with a single, straight trunk with no double leaders (codominant stems) or vigorous, upright branches competing with the leader.
   B. Radial and vertical distribution of branches to form a symmetrical crown.

8. Roots: container, boxed, or balled-in-burlap trees regardless of species or mature size.
   A. Check that the tree is free of roots visibly circling the trunk, and free of "knees" (roots) protruding above the soil.
   B. Roots should extend to the edge of the container, box or burlap and be sufficiently dense to hold soil together.
   C. Roots should be examined in the following manner:
      1) If in a tapered container, slip the root ball out; the root-ball periphery should be free of circling roots larger than ¼" in diameter and bottom mat of roots ¼" or larger (the acceptable diameter of circling peripheral roots depends on species and size of the root ball).
      2) Untie the tree trunk from the stake; the trunk should not touch the top rim of the container.
      3) Tip the root ball or container on its side and with a small jet of water expose the roots with 2" of the trunk to a depth of 2.5" below the topmost root attached to the trunk. The trunk and main root(s) should be free of circling roots and kinks. Replace soil washed from around the trunk with a similar soil mix (less than ten [10] percent of the total root-ball volume should to be added).
   D. If the trees pass the above inspections, further inspect the roots by removing the soil from the roots of not less than two (2) trees nor more than two (2) percent of the total number of trees of each species or variety from each source. The trunk and main roots shall be free of circling and kinked roots. Circling roots at the periphery of the root ball shall not be reason for rejecting a tree unless the circling roots are large for the species and shoot growth is not acceptable for the species.

9. In case the sample trees inspected are found to be defective, the buyer reserves the right to reject the entire lot or lots of tree represented by the defective samples. Any plants rendered unsuitable for planting because of this inspection will be considered as samples and will not be paid for.

10. The buyer shall be notified when plants are to be shipped at least ten (10) days prior to the actual shipment date.

Installation

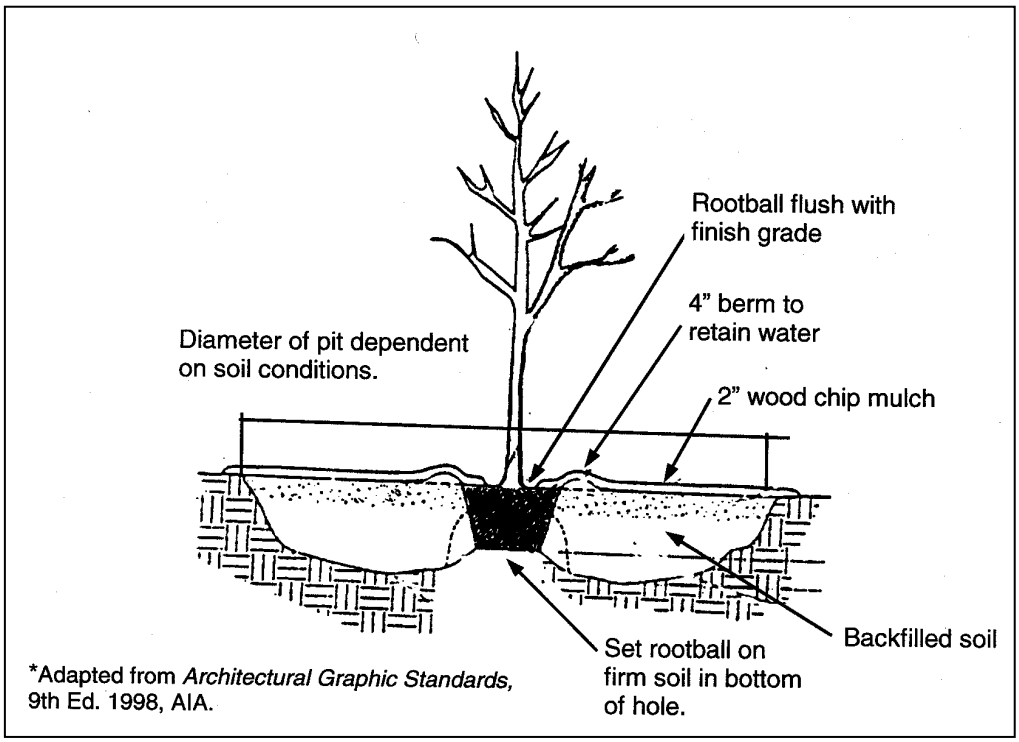
Under ideal conditions, plants would be installed in the fall and winter months.

1. Dig each hole at least three times the diameter of the container and one inch less than the rootball for 1-gallon plants, 2" less for 5-gallon and 3" less for 15-gallon. Planting high allows for soil settling (Exhibit B).

2. Fill each planting hole with water and allow it to drain overnight. If holes do not drain overnight, auger a drainage channel in the bottom of the planting hole. Fill the auger hole with coarse sand.

3. Soil excavated from the planting hole to be used for backfill.

4. To install the plant, remove the rootball from the container and rough up the outside edge of the roots. Sever any circling roots.



*Adapted from *Architectural Graphic Standards,* 9th Ed. 1998, AIA.

5. Place the rootball in the hole and backfill with the excavated/amended soil. Pack soil around the rootball as you backfill. Do not place soil over the top of the rootball. The top of the rootball should be slightly higher than the surrounding soil.

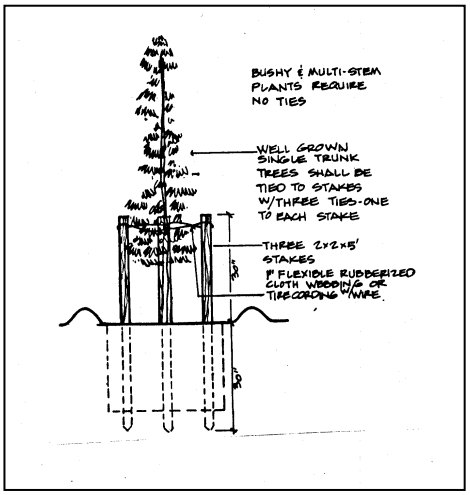
6. Construct a berm or basin around the tree where the container rootball meets native soil. Following establishment (4 - 6 weeks), the berm should be enlarged to the dripline of the crown.

7. Irrigate the tree by filling the basin with water, as often as needed to keep the rootball moist (probably every day during the first few weeks if planting during warm weather).

8. Place 2 - 3" of coarse mulch (e.g. wood chips, bark) over the soil surface to reduce water loss and moderate soil temperature. Do not place mulch against the trunk.

9. Trees with well tapered, strong trunks which will stand alone, bushy multi-stem trees or trees with low branches and good taper (such as conifers) may be installed with minimum staking to anchor the rootballs. Anchor stakes extend only 30" above grade.

For trees that cannot stand alone, stake as described in Staking Specifications.



Post-planting Maintenance

1. Irrigate trees as needed for two years following planting. Irrigation schedule shall be based upon establishment and weather patterns. Immediately following planting, irrigation may be required on a weekly or biweekly basis. Irrigation applied to the turf may not be adequate for young trees. As plants become established, the interval between irrigations should increase. Apply water sufficient to wet the soil to a depth of 2'.

   Irrigation should be eliminated for trees in the non-use area following the second or third year after planting. Eucalyptus should be irrigated at least once per month through the dry season.

2. Controls weeds within a 2' radius of the trunk during the establishment period. As plants enlarge in size, the weed-free area should be expanded. Mulch may be applied to reduce weeds.

3. Maintain turf at least 2' radius from the base of the tree.

4. Prune trees to develop early structure (see next section).

5. After the first year remove stakes. If tree cannot stand without stake, prune to reduce weight in crown. Lower stake ties to the height at which the tree will remain upright. Cut off stakes 1" above ties.

Pruning

The purpose of these specifications is to develop and preserve tree health and structure by providing a communication tool between: 1) contract administrator and contractor, and 2) tree manager and field staff. They are provided as working guidelines, recognizing the unique qualities of some species and individual trees, and may be modified depending upon the site, function of the tree, age and condition of the tree, and objectives of pruning.

General Qualifications of Arborists undertaking Pruning

All pruning should be performed by qualified arborists, as defined by the following:

- ***Are they licensed?*** Some states require that companies providing tree care services be licensed.

- ***Do they hold membership in professional organizations?*** The International Society of Arboriculture (ISA) and Tree Care Industry Association (TCIA) are the professional organizations of tree care professionals.

- ***Are they Certified?*** An ISA Certified Arborist has passed a comprehensive examination covering all aspects of tree care and continue to update their education and skills through continuing education.

- ***Do they have adequate insurance?*** Request proof of liability and workman's compensation insurance. Ask about the limits of coverage.

- ***Will they provide references?*** Request references and feel free to contact them.

- ***Review the planned work***. Good arborists will only perform accepted practices. Do not accept recommendations to top the tree, climb with spikes or remove an excessive amount of foliage.

- ***Will they provide a written contract?*** Reputable arborists will have clients sign a prepared contract.

Time of Pruning
Winter is generally the best time to prune most trees. Pines and eucalyptus should not be pruned between April and October to reduce the likelihood of attracting borers and bark beetles to the trees

All brush and down wood from pines and eucalyptus should be removed from the site or debarked to avoid borers and bark beetles.

Specifications for Training Young Trees
Young trees should be trained to develop sturdy, tapered trunk with well-spaced lateral branches proportional in size. Proper training when trees are young will greatly reduce pruning frequency, intensity and costs as they age, and reduce public risk from tree failures due to structural defects.

Young trees shall be pruned annually for the first 3-5 years until the desired branch structure is established. For large-growing species with decurrent (round-headed) form (e.g. hackberry, ash, elm) this may be accomplished by:

1. Maintaining a single, straight trunk and removing strong branches that could compete with it.

2. Providing adequate vertical and radial spacing of potential scaffold branches. As a general guideline, large-growing trees should be thinned to 5 - 9 main branches by the fourth year. Branches should be one-half (½) the diameter of the main stem and spaced 6 – 12” apart vertically.

3. Maintaining temporary branches (small laterals below the desired height of the lowest main branch) along the trunk for 2 - 4 years or until they become ½” in diameter. Temporary branches should be maintained less than 12” in length.

4. Providing adequate distribution of foliage throughout the crown. One-half (½) of the foliage should be on branches (permanent and temporary) arising in the lower two-thirds (2/3) of the tree.

For excurrent (conical) trees (e.g. pines, redwood, sweet gum) the following guildelines apply:

1. Prune to maintain a single trunk. If trunks develop a fork, remove the weaker and retain the stronger, more upright trunk.

2. Remove any lateral branches that turn upright and compete with the main trunk.

3. Avoid removing lower branches. I clearance is required under tree, raise the canopy gradually over a period of a few years.

Pruning Specifications for Established Trees
The following specifications generally conform to the Best Management Practices for Pruning (International Society of Arboriculture, 2012) and ANSI A300 Pruning Standard (American National Standard Institute). The specifications may be modified based upon either species-specific requirements related either to structure or resistance to pests. Not all items are applicable to all projects. *Italics* indicate factors that should be adjusted for individual situations.

1. Trees shall be pruned to enhance health and structure, as appropriate for the species of tree, existing conditions and desired result. The general goal is to provide uniform distribution of branches and foliage throughout the crown. The basic tools to meet this goal are:

   a) clear the crown of diseased, crossing, weak and dead wood to a minimum size of *1.5"* diameter;

   b) remove stubs, cutting outside the woundwood tissue that has formed around the branch;

   c) reduce end weight on heavy, horizontal branches by selectively removing small diameter branches, no greater than 2-3", near the ends of the scaffolds;

   d) provide appropriate vertical and horizontal clearance over streets, chimneys, roofs, sidewalks, etc.

   Note: Detailed specifications for individual trees may describe which branches should be pruned and how. Consider also requirements for crown reduction and crown raising as dependent upon the specific conditions. Pruning requirements in stands should consider local needs for fire safety. Time of year for pruning may be dictated when pest infestations are influenced by wounding.

2. All pruning shall be performed by a qualified arborist (see notes above).

   Note: It is recommended to specify an I.S.A. Certified Arborist or Tree Worker. In California, arborists are required (by law) to have a State of Calif. Contractors License for Tree Service (C-61/D49) and provide proof of workman's compensation and general liability insurance.)

3. All pruning shall be in accordance with the most recent editions of *Tree Pruning Guidelines* (International Society of Arboriculture) and/or American National Standard for Tree Pruning (ANSI A300). All operations shall adhere to the most recent edition of American National Standard for Tree Care Operations (ANSI Z133.1).

4. The following steps should ensure that pruning operations do minimal damage to the tree:

   a) Interior branches shall not be stripped out.

   b) Pruning cuts larger than 4" in diameter, except for dead wood, shall be avoided.

   c) Pruning cuts shall be made outside the branch collar and neither expose heartwood nor leave stubs. Flush cuts are not permitted.

   d) No more than 20% of live foliage shall be removed within the trees.

e) Appropriate tools and techniques shall be used to ensure that bark is not damaged either during climbing or pruning operations. This may require shortening limbs prior to removal and/or use of specialized climbing gear.

f) Where the length of branches must be reduced, cuts may be made only to lateral branches large enough to assume the position of the removed tissue. As a general rule, lateral branches must be at least 1/3rd the diameter of the removed limb, at the point of attachment between the two.

g) Use of climbing spurs or gaffs is not permitted.

8. Prior to climbing the tree, the arborist shall perform a root crown inspection for signs of weak, uplifted, adventitious or broken roots, cracks or mounding of the soil, and decay, cavities and other trunk defects. While in the tree, the arborist shall perform an aerial inspection to identify defects that require treatment. Any additional work needed shall be reported to the ***contract manager***.

9. Brush shall be chipped and chips shall be spread underneath trees within the dripline to a maximum depth of 6", leaving the trunk clear of mulch.

   Note: Beware of using fresh chips of highly allelopathic species. Toxicities have been reported for uncomposted or unleached eucalyptus sawdust and leaves, redwood and cedar sawdust, Douglas-fir, larch and spruce bark. Do not chip herbicide-killed materials.

Appendix F.
Creekside Science report "Habitat Assessment of Pismo Beach North Campground Monarch Grove" 2018

CREEKSIDE SCIENCE

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Habitat Assessment of Pismo Beach North Campground Monarch Grove

June 2018

Cover photos: Monarch clusters on January 8, 2018, and hemispherical photograph of the cluster site with cluster location circled.

Summary, Conclusions, and Recommendations

This report presents results of analyses of the canopy structure and microclimatic factors of wind and insolation within the monarch butterfly habitat at Pismo Beach North Campground. Hemispherical photography provided the means to map out key microclimatic factors (insolation and wind exposure) at fine scales. Major structures in the grove were identified, and the tree map produced by State Parks staff will allow evaluations of treefall impacts, management actions (planting trees, removing hazard branches and whole trees where appropriate). These conclusions and recommendations are meant as a bridge to the Site Management Plan being produced by the Xerces Society, full integration is beyond the scope of this report.

The conclusions and broad recommendations are presented up front for ease of access, and cross-referenced to maps and figures where appropriate.

Principles

The key principles include *resiliency, redundancy, dynamic ecosystems, robust monitoring, proactive adaptive management, and decision making in the field.*

Resiliency provides a range of conditions that buffer environmental variability. In the case of the overwintering monarchs, the key variables are wind, insolation (sunlight), temperature, and humidity. Ambient conditions outside the grove are filtered by the forest canopy, creating a complex fine-grained environment where microclimates change meter by meter through the site, and hour by hour through the season. As the varied combinations of wind shelter and light exposure change through the day and season, monarch butterflies move about on fine-scales within groves, and on broader scales among groves, as they attempt to track their preferred environmental envelope, and avoid extremes. In particular, extreme windstorms can drive monarchs from sites.

Redundancy within the habitat means multiple lines of "defense" – two rows of trees, rather than one row, wind shelter from multiple directions, areas of full sunlight, dappled sunlight, and shade, multiple wind-sheltered openings, and other features. The loss of branches, individual trees, groups of trees, or species of tree should not fully degrade habitat if redundancy is maintained. Locally complex habitat may provide more opportunities within smaller areas.

Dynamic ecosystems – trees grow and die over years and decades, and even centuries, leading to incremental and even catastrophic changes in microclimate. Large hazard trees may need to be removed for public safety. On a smaller scale, branches naturally fall and may be deliberately removed as hazards. Decisions made today have repercussions for decades to come.

Robust monitoring – Rigorous monitoring of the distribution and abundance of monarchs through the entire overwintering season is an essential component of adaptive management, because monarchs are very good at telling us what they prefer if we document them. The response to major windstorms is particularly important, as well as seasonal preferences driven by changing sun angles.

Proactive adaptive management means that changes are anticipated well in advance, and appropriate management carried out at a deliberate and measured pace. This requires a systematic

adaptive management process among institutions and stakeholders to evaluate, plan, execute, assess, and re-evaluate, on an annual cycle in synchrony with the resource. Utmost transparency is critical for stakeholder buy-in.

Decision making and supervision in the field – All final decisions regarding tree management should be made in conjunction with a field visit, so that exact instructions can be communicated. Management activities – planting and trimming - should be monitored by park staff and qualified volunteers when possible.

Site suitability

1. The main indication of long-term site suitability is the consistent occupancy by large numbers of monarchs year in and year out; 12,000-30,000 butterflies over the last decade (Xerces Thanksgiving Counts), always one of the largest overwintering sites in California. The absolute numbers of monarchs in any given year is a function of conditions in the breeding areas (milkweed stands in the interior West) and along migratory routes. The relative number compared with other overwintering sites in SLO County is affected by relative site suitability within a season, and some degree of chance.
2. The grove provides all the essential components of monarch habitat; wind sheltered spots with moderate direct insolation. The major structure providing this within the grove is the large opening (Main Clearing) surrounded by tall canopy trees, and dense middle-story in most directions.
3. The 2017-18 cluster site has good wind shelter, especially from the SE (Figure 1 Photo 2451, cover photo, Map 7), and receives afternoon (PM) insolation early in the overwintering season (Map 6). Several other sites around the Main Clearing also provide this combination to varying degrees, giving the monarchs options to adjust their microdistribution according to ambient conditions.
4. The trees to the east across Highway 1 along the Union Pacific tracks (UP trees) are absolutely essential to wind shelter from SE winds, a common wind direction (Figure 3) especially for the strongest storm winds (Figure 1 Photo 2448, Figure 2 Photos 2442 and 2447 have the clearest view of these trees).
5. The footpaths into the forest allow ground-level winds (Map 7) and winter insolation (Maps 4 and 5) to penetrate into the grove. At height, it appears that the tree canopies close off somewhat (Photos 2447 and 2472) and provide S and SE wind shelter at sites further N and NW.
6. Tree buffers to the W and N are also essential, at present they are deep enough for good wind shelter.
7. Monterey cypress trees planted near the main entrance are beginning to provide some wind shelter, and as they continue to grow will contribute ever more wind shelter.
8. The wind sheltered interior of the SW grove appears to be too dark in to attract monarch clusters.

Management recommendations

1. Maintain and strengthen the windbreak south of the Main Clearing with additional Monterey cypress and appropriate *Eucalyptus* species.

2. Identify and formally assess near-term and medium-term hazard trees/branches around the Main Clearing
3. Nurture the Monterey cypress planted in the Main Clearing; monarchs appear to select conifers over *Eucalyptus* where wind and insolation are appropriate.
4. Do not plant *Eucalyptus* inside the Main Clearing, only around the edges.
5. Consider closing the eastern footpath so that trees can be planted to fill that gap.
6. Protect and manage the UP trees in coordination with Union Pacific.
7. Consider greatly densifying the eastern edge of the grove for wind shelter, as a back-up to the UP trees. Tall *Eucalyptus* species would be appropriate here, but the powerlines are constraints.
8. Maintain and diversify windbreak trees to the N and W, with species appropriate to the moisture conditions along the drainage.
9. Select a palate of other *Eucalyptus* species to diversify the tall forest. Many *Eucalyptus*-feeding insects are becoming established on blue gums in California, and absent natural controls can have major impacts on grove health. Having other species reduces this risk. Climatic suitability, eventual tree height, and propensity for branch fall are important parameters to consider.
10. Find appropriate sites for native trees (live oak and tall willows) to create middle-story wind shelter. Oaks grow slowly in height, and deciduous willows do not provide wind shelter in mid-winter, so they should not be primary shelter trees.
11. Native understory shrubs and forbs can be planted where there is appropriate light. These provide structure for fallen monarchs to climb if knocked down, escaping chilly and damp ground-level conditions.
12. Monarch monitoring should include tree locations, height of clusters, and estimated numbers so that distribution and abundance can be tracked through the entire season.
13. An existing official local weather station should be used to identify wind and storm events so that monarch movements can be correlated with weather.
14. In general, plan for several decades into the future, the time scale of tree growth. Anticipation of treefall and mortality is critical.
15. Deal with hazards after the overwintering season. During the season, close areas at risk.
16. While not explicitly addressed in this report, identify native fall-blooming nectar sources for planting in the coastal scrub restoration areas. Also consider non-native fall-blooming species in planter boxes in sunny areas. *Eucalyptus* trees provide copious nectar after they bloom in mid-winter. Fall-blooming nectar, while not absolutely essential, attracts and retains migrating monarchs early in the season.

Introduction

The primary purpose of this report is to assess the forest canopy and its ability to shelter monarchs, through the following analyses:

1) Acquire hemispherical photographs in an array of sites, dense enough to do geostatistical interpolations of resultant outputs
2) Analyze those photographs and extract out visible sky, wind exposure, and insolation (solar radiation)
3) Create maps of these factors
4) A brief discussion of the major structural features that create high quality monarch habitat
5) Provide a structural baseline for inclusion into the site management plan.

This report builds on previous work at numerous other monarch overwintering sites (including Weiss et al. 1991, Weiss and Murphy 1992, Weiss 1998, Weiss 2011, Weiss 2016, Weiss 2017), as well as work by Kingston Leong on monarch responses to microclimate (Leong 1990, 1991), and broad-scale assessments of California monarchs by the Xerces Society (Pelton et al. 2016, Xerces Society 2017).

One major goal of the microclimate analyses is to generate understanding of monarch habitat suitability at this particular site, so that a formal site management plan (developed by Xerces and park staff) can incorporate this forest canopy structural assessment into proposed management actions. The impacts of any actions, such as tree plantings, hazard tree management, trail closings, etc. can be evaluated using this report as a baseline.

Methods

A tree map was produced by State Parks staff in 2017. Individual trees within the grove were mapped and trunk number and DBH were measured. An additional map of fences that define trails was provided.

On January 9, 2018 60 hemispherical photographs were taken across the site. The sampling strategy was to take photographs at bright spots, dark spots, and transition areas so that efficient interpolated maps could be generated. Photo sites were located with GPS, and because of GPS inaccuracies generated by the forest canopy, photo sites were adjusted relative to the tree map where needed.

Photographs were analyzed with Hemiview software, and the following "site factors" were extracted:

1) ISFU – Indirect Site Factor Uncorrected, the fraction of visible sky in all directions.
2) ISF – visible sky cosine-corrected for zenith angle, emphasizes overhead and deemphasizes sky near the horizon. The ratio ISF/ISFU is a measure of wind protection from the sides (higher values indicates relatively more visible sky overhead and less near the horizon, conversely lower values indicate more visible sky closer to the horizon).
3) October/March, November/February, and December/January potential direct insolation – calculated from fraction of unobstructed monthly sunpaths assuming clear skies with a simple insolation model. Because sunpaths are symmetrical around the winter solstice, December and

January have essentially the same values, as do November and February, and October and March.

4) AM (before 1200h, and PM (after 1200h) insolation for each month.
5) Wind Site Factors (WSF) – the fraction of sky visible in eight compass directions (octants) centered on cardinal directions, a measure of relative wind exposure.

These site factors are described in practice below in Figure 1.

Interpolated maps

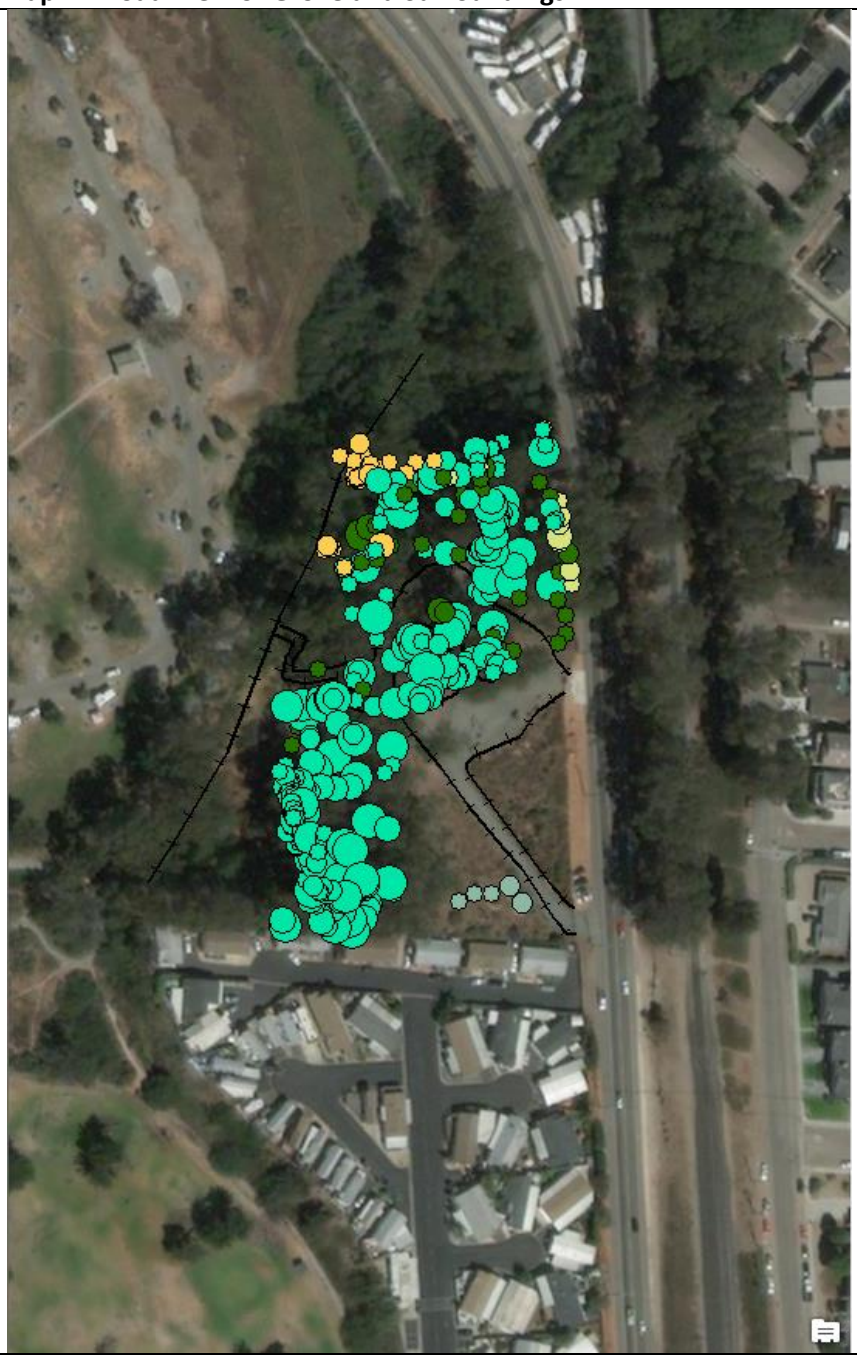
Interpolated maps used ARCGIS Geostatistical Analyst. Radial Base Functions were chosen because they are straightforward to implement, and are an exact interpolator (capture the exact values at each point) and create a smooth surface appropriate to canopy cover, insolation, and wind. The tree map, fences, and 2017-2018 cluster site were superimposed for ease of navigation.

Results

Tree map and setting of grove

The tree map is an essential component of this site assessment. The broad view (Map 1) shows the entirety of the grove, with the mapped portion symbolized by tree species and size; many trees outside that footprint were not mapped. The trees E of Highway 1 along the UP tracks are an essential part of the habitat, as discussed below, as are the buffer trees to the N and W.

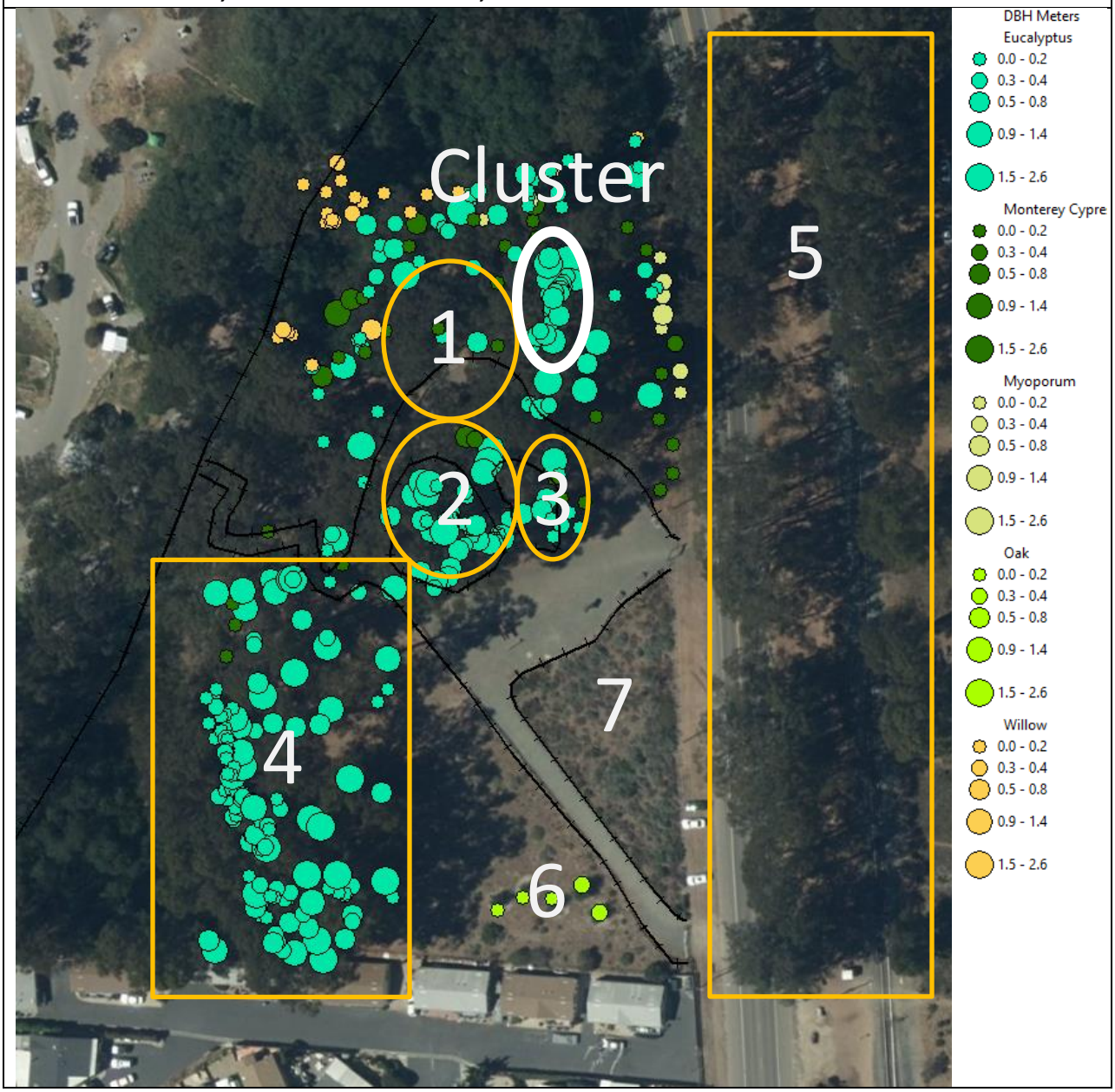
Map 1. Broad View of Grove and Surroundings



The tree map shows the names designated in this report. Most trees are *Eucalyptus globulus* henceforth referred to as blue gum. Monterey cypress are an important component of the grove, as are other tree species in select areas.

Map 2. Close view of tree map with designated area names

1- Main Clearing, 2 - W Island, 3 – E Island, 4 – SW grove, 5 – UP trees, 6 – Oak Grove, 7 – The Field



How to read a hemispherical photograph with examples

A brief description of these site factors in two example photographs (Figure 1) give guidance in interpreting the photographs. North is the top of photographs and South is the bottom. Note that because photos are pointed exactly vertically (at the zenith), East and West are reversed from standard maps (E to the left, W to the right). The sunpaths grid is overlaid in red; starting at the bottom, the southernmost sunpath is for Dec 21 (winter solstice), the next curved line is Nov 21/Jan 21, and the third curved line is Oct21/Feb 21 and the middle curved line is Sep 21/Mar 21. The northernmost sunpath is for Jun 21. Monthly sunpaths are symmetric around the solstices.

Photo 2451 is the primary cluster site in 2017-2018. ISFU (visible sky) is 0.21 (21% of the sky in all directions is visible). ISF is 0.29, higher than ISFU because the openings are concentrated near the zenith where they are weighted higher; conversely, vegetation and obstructions are concentrated toward the horizon. ISF/ISFU is 1.35, indicating relatively higher canopy cover near the horizon. The site receives substantial Oct insolation (179 MJ m^{-2} $month^{-1}$), primarily in the PM (note the large opening along the sunpaths to the SW). Nov insolation is lower (74), but still provides PM direct light for a short period. Dec/Jan insolation is low (39), primarily dappled light through small gaps along the sunpaths. Note that insolation is very sensitive to height above the ground – at the heights monarchs cluster, there will be substantially more insolation especially in the PM because of the visible sky to the SW, but also in the AM because of a more open upper canopy to the SE.

This site has all of the characteristics of a good monarch cluster site. There is ample wind protection from nearly all sides, the exception being SW. There is enough insolation, especially afternoon insolation, so that it is accessible when monarchs settle down at the end of the day. While it appears to have little AM insolation, at cluster heights the canopy is much more open and ample dappled and direct light are received.

In Photo 2447, taken in the easternmost path into the grove, ISFU is 0.43, ISFU is 0.34, and the ratio is 1.23. The wide open horizon due S is the dominant feature, leading to much higher insolation (>240 MJ m-2 month-1), higher S and SE wind exposure (0.86 and 0.55 respectively). The most important feature to note in this photograph is the row of blue gums to the SE across Highway 1. They are a primary contributor to SE wind protection and habitat suitability and will be highlighted in the example photos below. The actual cluster trees are several tiers back to the north. Note also that the canopy closes near the zenith, which indicates that there is some wind shelter at height.

Figure 1. Detailed Sample Photographs with Site Factors

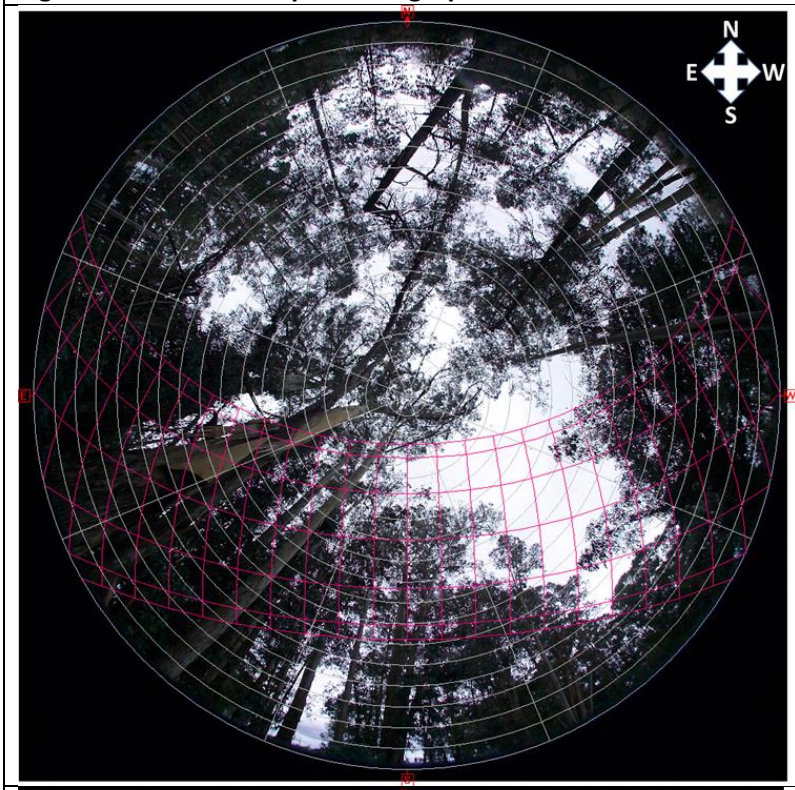


Photo 2451 Cluster Site	
ISFU	0.21
ISF	0.29
ISF/ISFU	1.35
Oct MJ	179
Nov MJ	74
Dec MJ	39
Jan MJ	39
Feb MJ	77
N	0.32
NE	0.13
E	0.05
SE	0.04
S	0.18
SW	0.46
W	0.24
NW	0.25

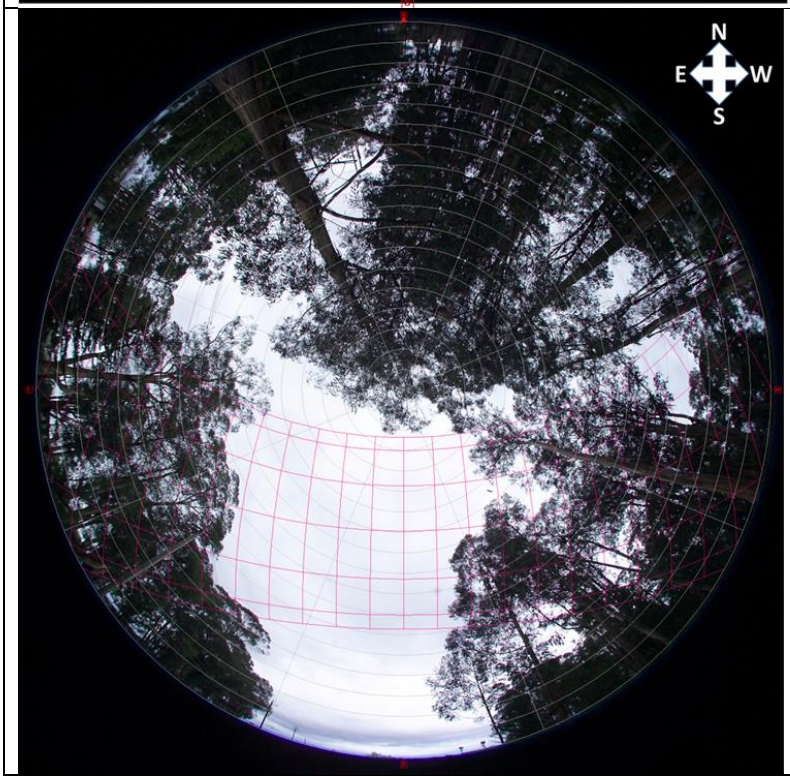


Photo 2447 Non Cluster Site	
ISFU	0.43
ISFU	0.34
ISF/ISFU	1.23
Oct MJ	352
Nov MJ	283
Dec MJ	253
Jan MJ	244
Feb MJ	284
N	0.10
NE	0.23
E	0.24
SE	0.55
S	0.86
SW	0.31
W	0.23
NW	0.11

Sample photographs

The map below shows the positions of sample photographs discussed below.

Map 3. Position of sample photographs

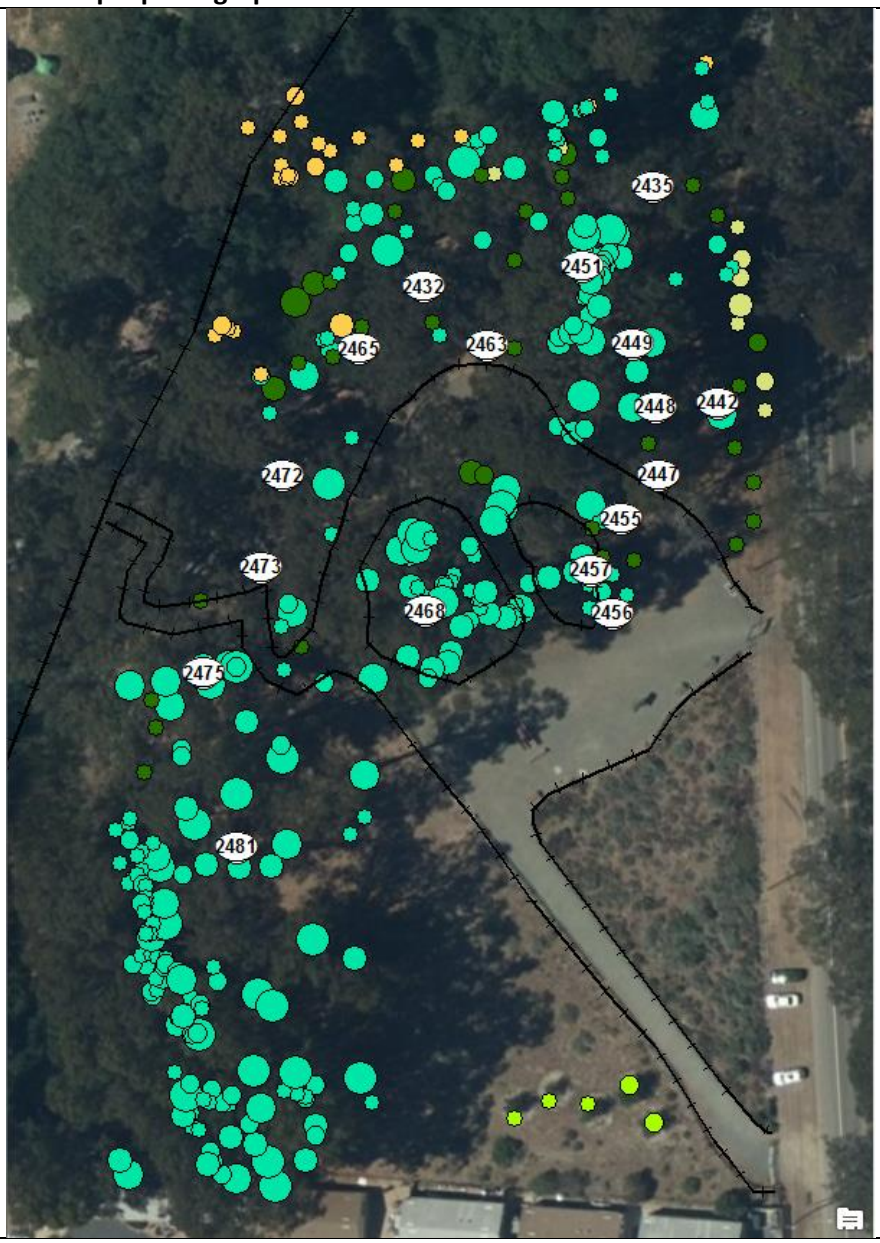


Figure 2. Sample Photos and Notes (N = 16 photos)

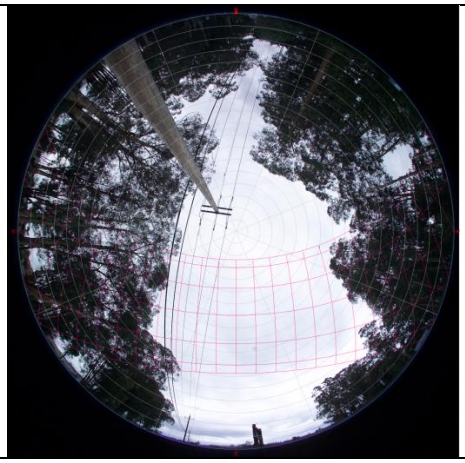
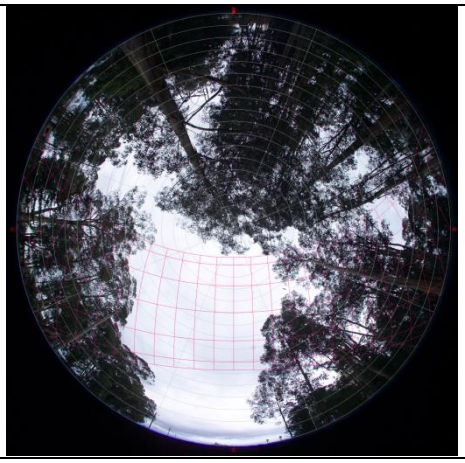
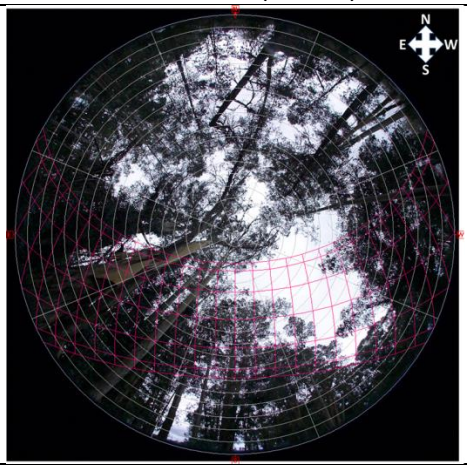
Photo 2442	Photo 2447
	
Along Highway 1, N of entrance. Note the trees to the E, across the road along the UP tracks, providing wind shelter from SE.	On S end of main stand, on E edge of fenced path. UP trees visible to E, note their smaller size relative to 2442. Large gap to S along footpath.
Photo 2449	**Photo 2451 (cluster)**
	
N of 2447, just SE of main 2017-18 cluster site. Gaps close to ground in S nd SE octants. UP trees visible through near trees to ESE, combination of two stands of trees substantiall increases wind shelter	Cluster site, good SE wind shelter, sky opening in Oct-Mar PM sunpath. Discussed in detail above in Figure 1.

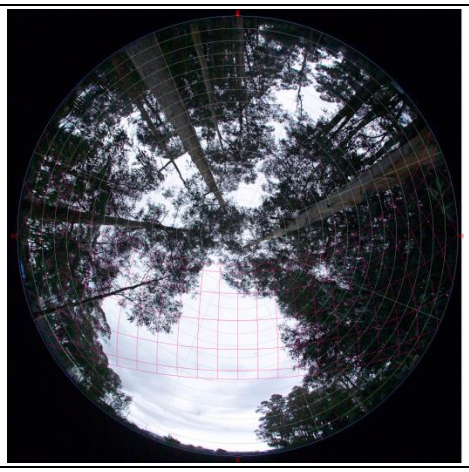
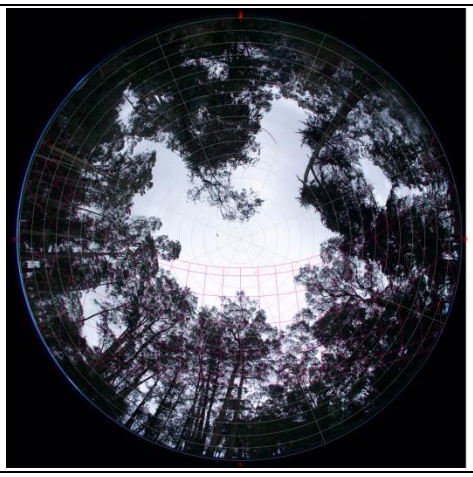
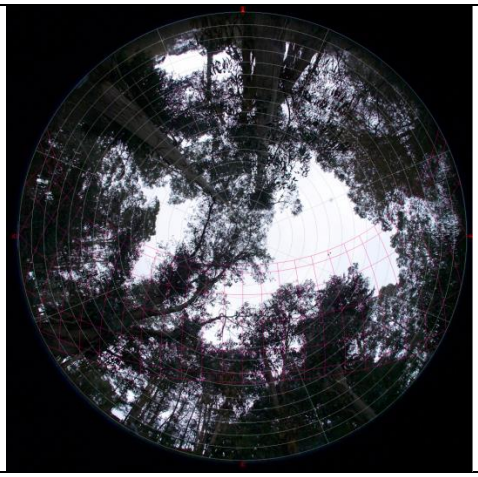
Photo 2456	Photo 2457
	
S-end of main grove, at E-island facing open field. High SE and S wind exposure, high insolation	N of 2456, interior of E-island Near trees to S increase S and SE wind shelter, but still open near horizon, and reduce insolation
Photo 2463	Photo 2432
	
In Main Clearing Overhead gap, good wind shelter to SE and many small gaps along sunpaths providing dappled light.	NW of 2463, north edge of Main Clearing, good wind shelter but low insolation.

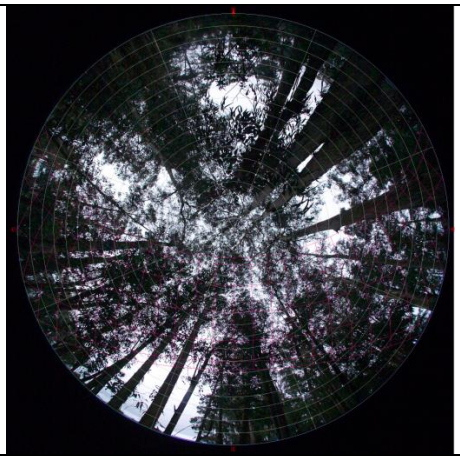
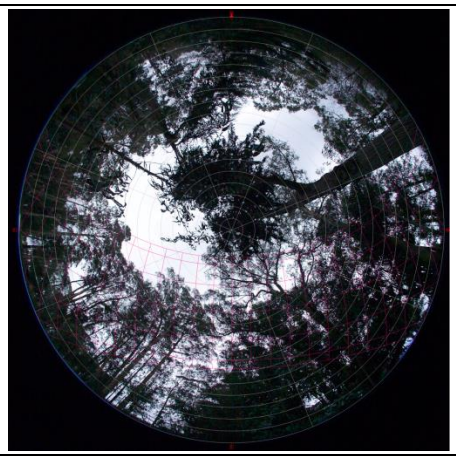
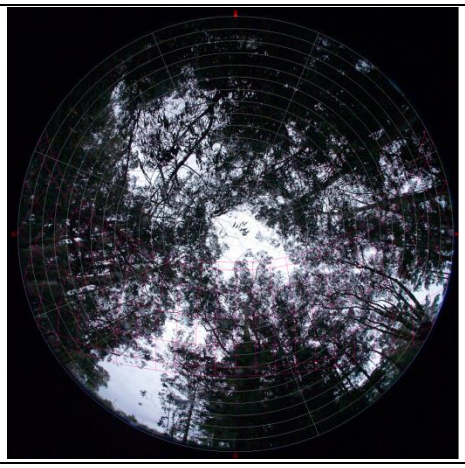
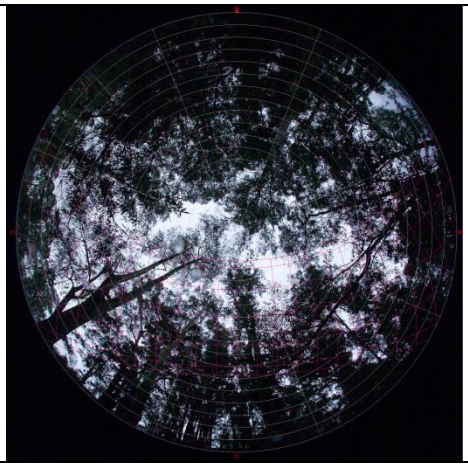
Photo 2468	Photo 2465
	
In W-island among the fenced paths. SE wind exposure high because only tree trunks for shelter. High AM insolation, trees to SW block PM.	Toward the W edge of Main Clearing. Below a large willow tree. NW is more open , trees in drainage visible. Wind shelter provided by trees across opening is evident. Dappled light along the AM sunpaths.
Photo 2472	Photo 2473
	
Toward W edge of grove. Opening to SE is the western footpath.	Just S of 2472, note the shift in tree positions along southern edge of photo.

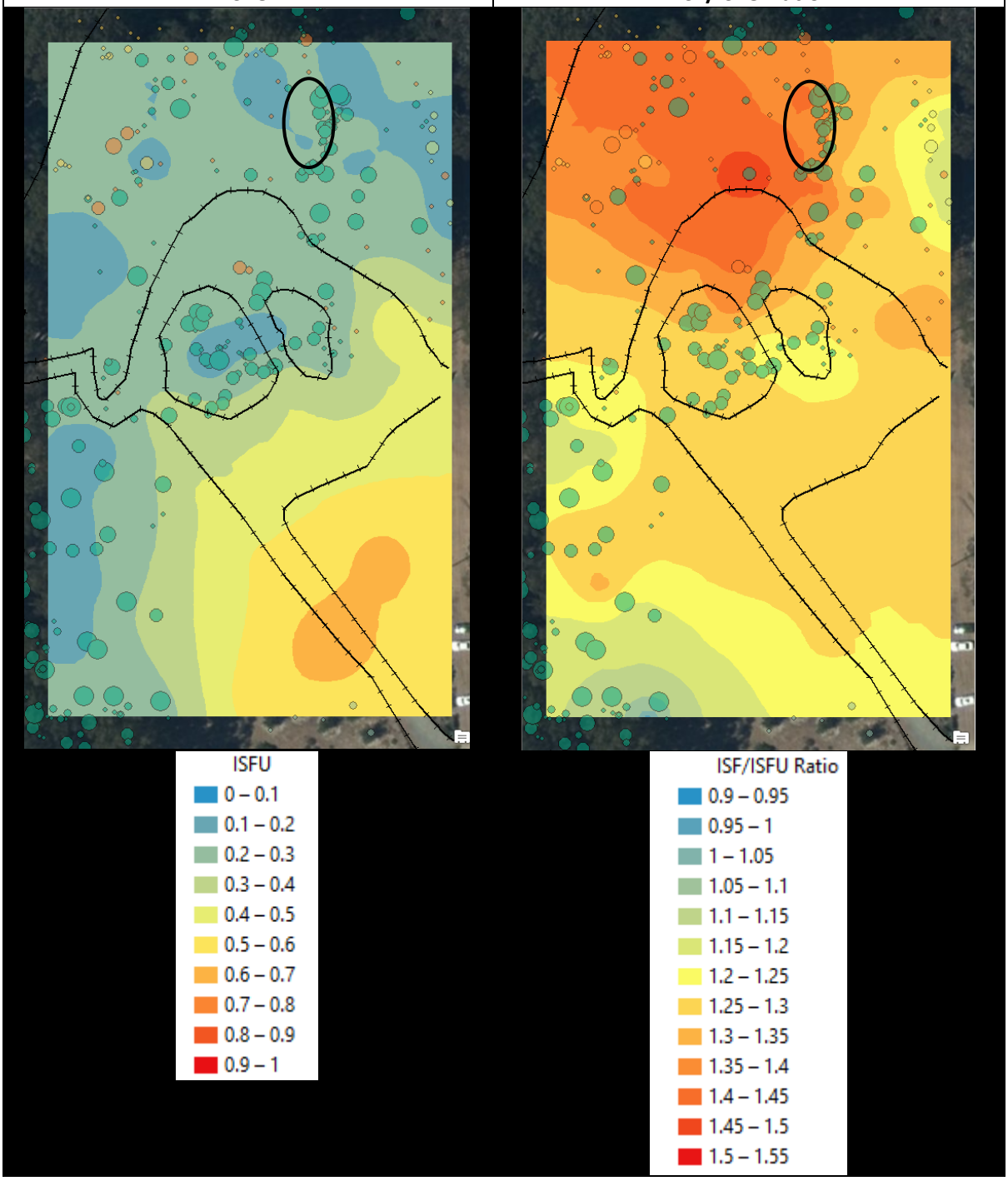
Photo 2475	Photo 2481
	
Near W edge of grove, high SW and W wind exposure. Trees across the drainage are visible.	In dense trees in SW Grove grove. Low insolation, good wind shelter, nearby forked tree to SE effective in closing gap. Potential site for select tree removal to increase insolation
Photo 2448	Photo 2435
	
Monterey cypress growing in SSE gap will provide better wind shelter as it grows. UP trees visible to SE.	In dense NE corner of main grove, cluster site is on the trees to the SW. Low insolation, good wind shelter. UP trees jusr visible to E and SE

Interpolated Maps

The ISFU map is the broadest measure of canopy cover. The obvious gradient is from the open field (0.7) to the interior of the grove which varies from 0.1 to 0.3. Higher ISF/ISFU ratios (red and orange) indicate higher relative canopy cover toward the horizon, a broad indicator of wind shelter from all directions, especially in lower ISFU sites. The cluster site is the black oval.

Map 4. ISFU and ISFU/ISF ratio

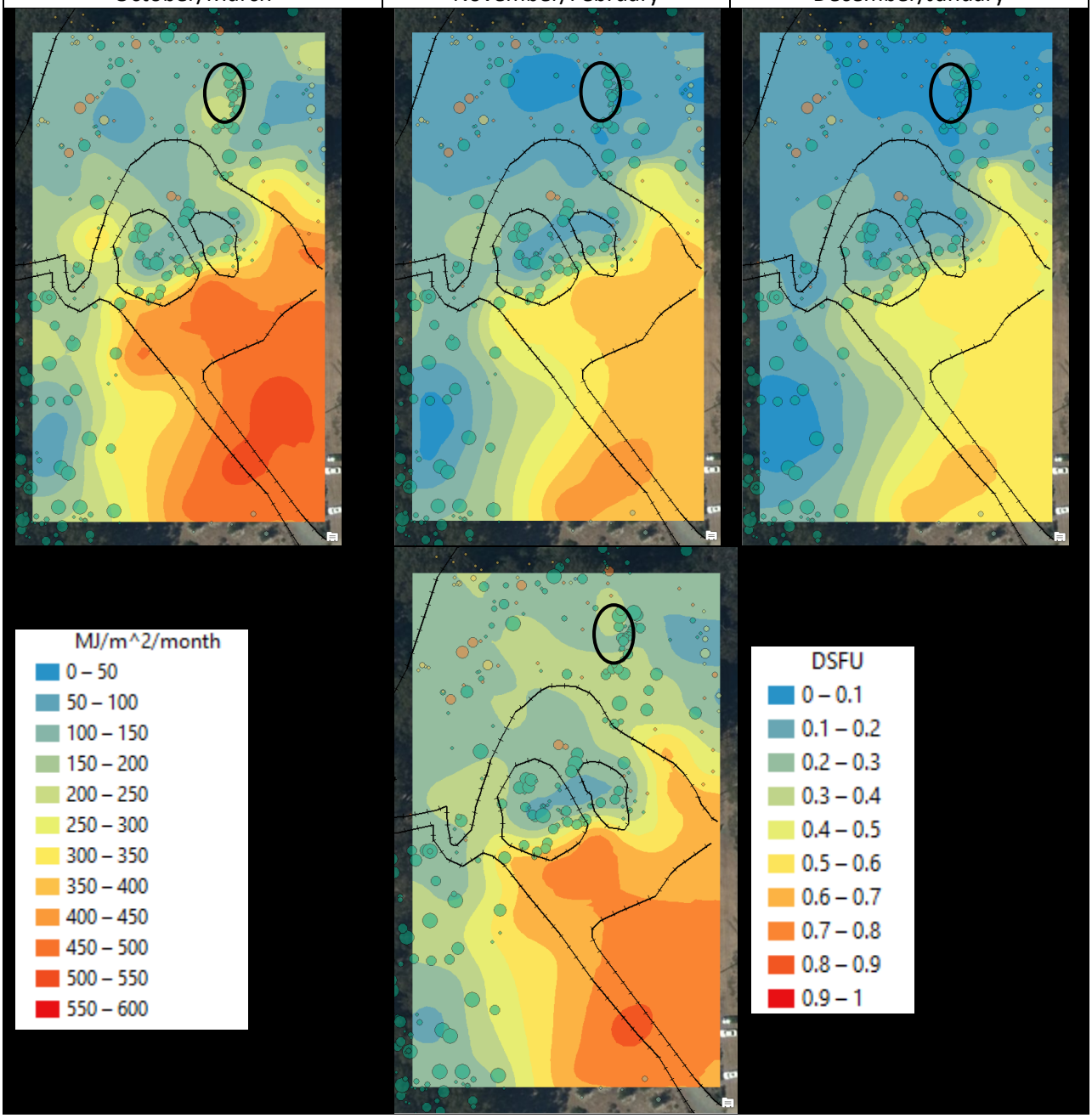
ISFU | **ISF/ISFU Ratio**



Insolation Maps

The insolation maps show the large open field and forest edges clearly. More subtle variations within the grove are important, especially the relatively October higher insolation at the cluster site. Also note the fingers of penetration into the grove along footpaths. Because the overall DSFU (second row) includes spring and summer sunpaths, it provides some indication of insolation higher in the canopy. Note the influence of the Main Clearing and the variability close to the cluster site.

Map 5. Monthly Potential Insolation and Annual DSFU

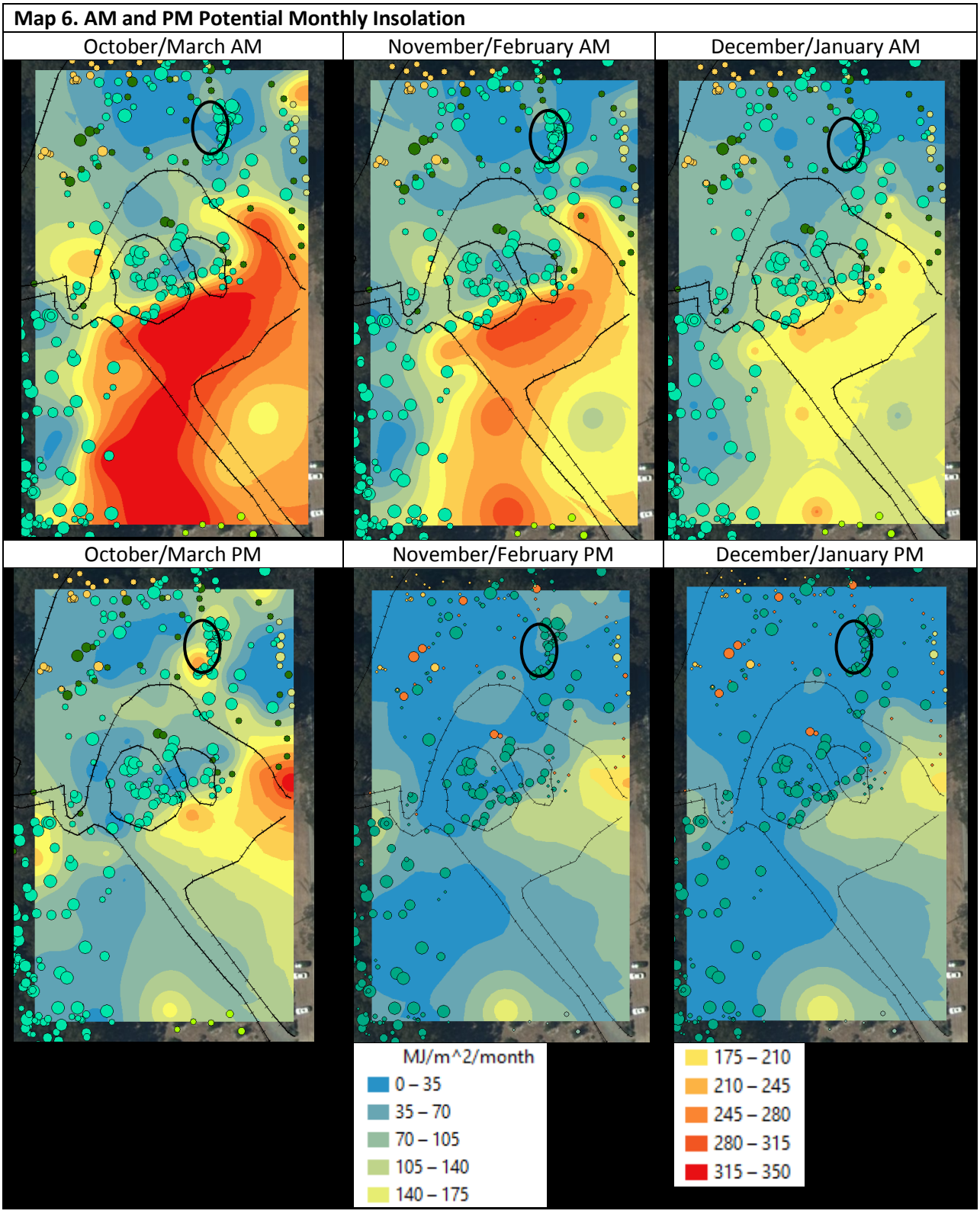


AM and PM Insolation Maps

Figure 6 presents maps of AM (before solar noon) and PM (after solar noon) insolation. AM insolation is strongest along the E and SE edges of the grove, with two fingers penetrating the grove along footpaths. The cluster site receives mixed AM insolation in October and November, and low AM insolation in December-January. PM insolation shows a strong bright spot at the cluster site in October, less so in November, and is low in December. This is an important draw for monarchs seeking cluster sites at the end of the day.

Note again that these are ground-level measures, and that insolation will increase as heights exceed under- and middle-story trees that effectively block ground-level insolation in fall-winter months. At height, even if there are upper tree canopies along the sunpaths, more dappled light will filter through the canopy, and larger gaps will appear.

Map 6. AM and PM Potential Monthly Insolation



Wind Exposure

Monarchs respond strongly to winds on short time scales, from hour to hour even. Monarchs tend to leave cluster sites when ground-level wind speeds exceed ~2 m/s (5 mph) (Leong 1990, 1991), and recluster in calmer sites if they are able to fly. It is important to keep in mind that wind speeds and wind exposure at cluster heights are generally higher than at ground level.

To reiterate, Wind Exposure is the fraction of visible sky in each octant of the photograph. It is more heavily weighted toward horizontal angles, because there is more angular area close to the horizon, and winds blow more horizontal then vertically. The influence of gaps near the zenith on winds at height is increased, as discussed above in Figure 1.

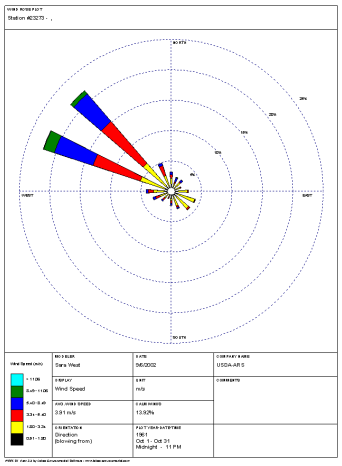
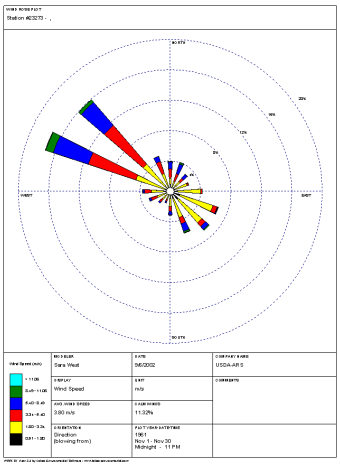
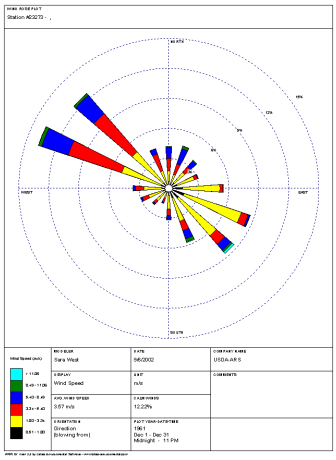
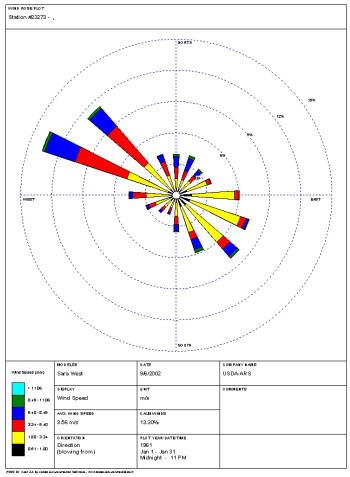
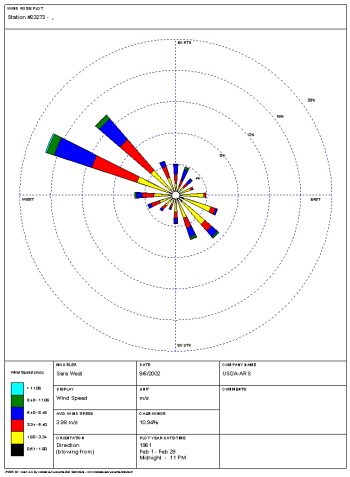
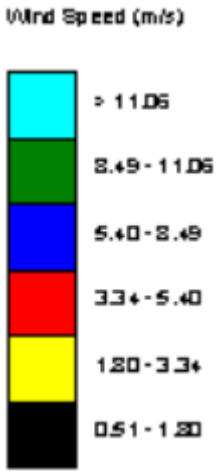
Wind roses for 1961-1990 (Figure 3) show prevailing NW winds in all months, with an increasing proportion of SE winds into the heart of the rainy season, especially December and January. The red and blue parts of the rose petals are winds >3.3 m/s (7.4 mph) and 5.4 m/s (12 mph). Note that high wind speeds can occur from all directions, just in much lower frequencies than from the prevailing directions. The strongest SE storm winds can reach hurricane force (33 m/s), and NW winds following fronts can be quite strong. Santa Ana winds (N-NE-E) include a pronounced drying effect as well.

Wind exposure maps are arrayed by azimuth. Values <0.2 are considered “low”, 0.2 - 0.4 “moderate” and >0.4 “high”

1. SE wind exposure penetrates the grove along the footpaths, but importantly, the cluster site and the northern clearing are well protected. S wind exposure penetrates along the eastern footpath, however the cluster site and nearby sites around the northern clearing are well-sheltered.
2. S wind exposure penetrates along the eastern footpaths, and the Main Clearing is well protected.
3. SW wind exposure penetrates the grove in several areas, and the cluster site is most exposed from this direction.
4. W wind exposure is low at the cluster site, but high to the SE of the cluster site.
5. NW wind exposure is low at the cluster site, and higher to the W in the main Clearing.
6. N wind exposure is low at the cluster site, and moderate in the SW part of the Main Clearing.
7. NE and E exposures are low at the cluster site, and in the Main Clearing.
8. The highest wind exposures (0.4-0.9+) are around the Field from most directions.
9. The Oak Grove at this time provides little wind shelter (Figure 4). Further tree growth will increase wind shelter, but will have minimal effects on the main grove, except that these trees may create some turbulence than can reduce wind speeds downwind.

Exact values for the cluster site can be found in Photo 2451 in Figure 1 above. Wind exposure can rapidly change over short distances (i.e. SW and W wind exposure near the cluster site). This fine scale variation provides opportunities for small readjustments of cluster sites as winds shift.

Figure 3. Monthly Wind Roses

October	November	December
		
January	**February**	**Meters/second**
		

https://www.wcc.nrcs.usda.gov/ftpref/downloads/climate/windrose/california/santa_maria/

Map 7. Wind Exposure

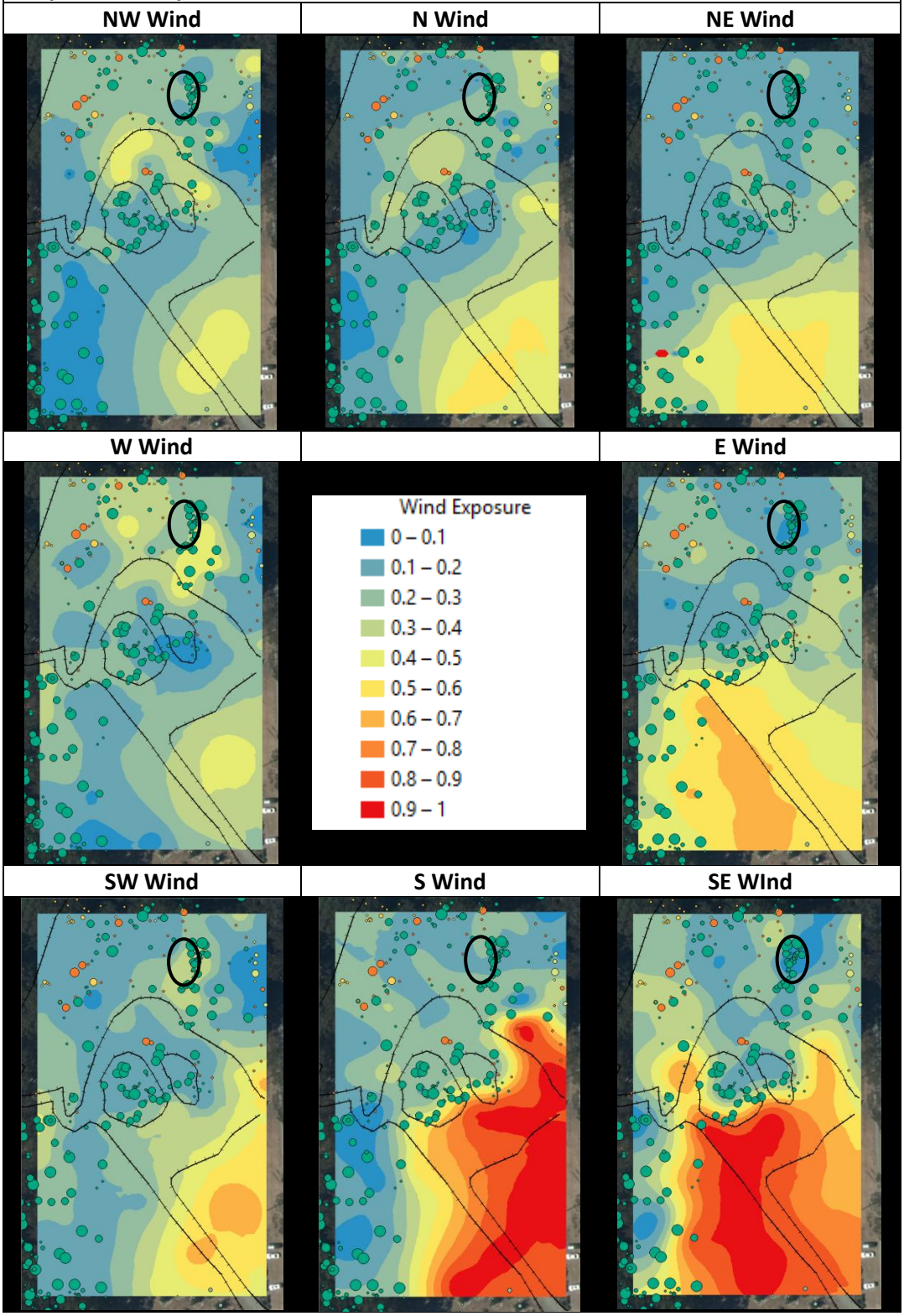


Figure 4 Oak Grove effect on wind in center of Field. Note the houses along the S horizon, as well as the UP trees to the E and NE.

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The Xerces Society. 2017. Protecting California's Butterfly Groves: Management Guidelines for Monarch Butterfly Overwintering Habitat. 32 + vi pp. Portland Oregon

Appendix G.
Creekside Science report "Simulation of Tree Removals and Shelterbelt Planting at Pismo North Campground Monarch Habitat" 2019

CREEKSIDE SCIENCE
P.O. BOX 1553, LOS GATOS, CA 95031

Summary of Pismo Tree Scenarios Report

Stuart B. Weiss, Ph.D. March 2020

This memo is a brief summary of the main points to be drawn from the report "Simulation of Tree Removals and Shelterbelt Planting at Pismo North Campground Monarch Habitat" from December 2019. It covers three aspects of the report:

1. The overwhelming importance of the Union Pacific Trees east of Highway 1 for wind shelter
2. The positive impacts of planting a shelterbelt south of interpretive trailer area
3. The desirability of closing off the easternmost trail into the grove interior

For the more detailed description of methods and results, the report itself should be consulted.

1. Union Pacific (UP) Trees

The simulation of removing the *Eucalyptus* trees along UP railroad tracks east of Highway 1 showed that the eastern parts of the current overwintering site are unlikely to serve as overwintering monarch habitat without he UP trees. At best, the monarchs would have to withdrawal to the westernmost portions of the eucalyptus grove. Note how open the SE and E exposures are in the following photo pair. *It is imperative that State Parks work out an appropriate arrangement with Union Pacific to maintain and enhance the wind shelterbelt function of those trees.*

A. Photo 2449 Unaltered	B. Photo 2449 UP Trees Removed
	

2. Shelterbelt Plantings

Planting additional trees south of the trailer location will create important wind shelter for the main grove. The simulation assumed a 50' tall solid shelterbelt, which could be composed of Monterey cypress with live oak middlestory given current State Park restrictions on planting eucalyptus. Based on estimated growth rates, the cypress would take on the order of 20 years to grow to 50'. The trees would be planted within the existing coastal scrub areas, as close to the edge as possible. Because of the southern exposure, the existing native scrub plantings would be minimally affected by shading, except directly under the new cypress and oaks. For comparison, eucalyptus trees would grow faster and could reach 50' in 10-12 years.

These plantings will provide general wind shelter for the main grove, with the main effects near ground level in the first decades. If extended as far east as possible, it will partially fill the gap created by the easternmost path, but not completely block it. The sheltering effect will increase through time as trees grow, and even a low row of trees will serve to create downwind turbulence. And, in the long run, the trees will approach 100' and provide substantial wind shelter higher in the canopy.

3. Plugging the Eastern Path

The existing path into the main grove closest to Highway 1 (labeled A in the full report) provides a SE wind tunnel into the prime clustering areas. At present, it is partially ameliorated by the UP trees across Highway 1, but even at present, gaps in the UP trees allow substantial SE wind to penetrate deeply into the grove.

Tree and understory/middlestory plantings to plug this gap are extremely desirable. Whether it is possible to still have a narrower path among the trees is an open question.

The hemispherical photo pair below shows how the astern path allows wind to penetrate into the core of the grove from the SE. In the left (A) the UP trees in the distance provide some wind shelter. On the right (B) the removal of the UP trees shows just how open the path is to wind.

A. Photo 2463 Unaltered, yellow circle is path suggested to be closed	B. Photo 2463 UP Trees Removed so path is more visible
	

Appendix H.
Creekside Science report “Summary of Pismo Tree Scenarios” 2020

Simulation of Tree Removals and Shelterbelt Planting at Pismo North Campground Monarch Habitat

Stuart B. Weiss

Creekside Science

Dec 2019

Introduction and methods

This analysis is a supplement to the site assessment of the Pismo North Campground monarch butterfly habitat completed in June 2018. Hemispherical photographs were modified by removal or addition of canopy in key spots. The primary goals were:

1. Simulate the loss of the trees east of Highway 1 along the Union Pacific Tracks (UP Trees)
2. Simulate the addition of a 50' tall shelterbelt south side of the current location of the informational trailer. 50' was chosen as a benchmark that could be achieved within 2 decades.
3. Combinations of the two modifications.

Three sites were chosen for assessment of the impact on wind exposure:

1. East (Photo 2449) – The eastern fringe of the habitat, a site that maximizes the effects of removal of the UP Trees.
2. Center (Photo 2463) – The interior clearing, to represent conditions in the areas where monarchs frequently cluster.
3. West (Photo 2472) – The western part of the cluster areas, near where monarchs clustered in 2019.

Hemispherical photographs were imported into Adobe Photoshop Elements. The UP trees were identified on the photos, and erased.

A solid 50' tall shelterbelt along was added to the photos. Elevation angles of the top of the shelterbelt were calculated as arctan(50/distance). Figure 1 shows the calculation for different combinations of height and distance. The shelterbelt was between 150 and 250' from the photo locations (Figure 2), so the lowest 10 - 20° in the gaps was blocked. Wind shelter was calculated as in the 2018 report, as the fraction of open sky in each 45° octant (wind direction).

Figure 1. Calculations of blocking angles for different distances and height of shelterbelt

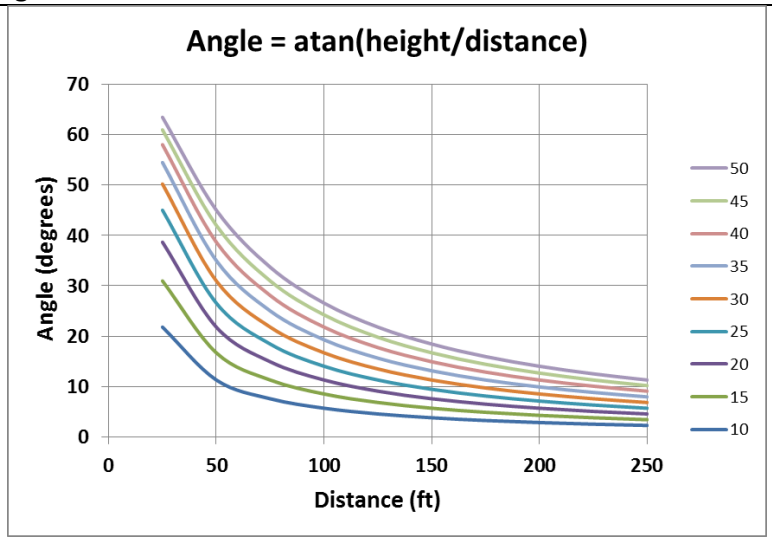
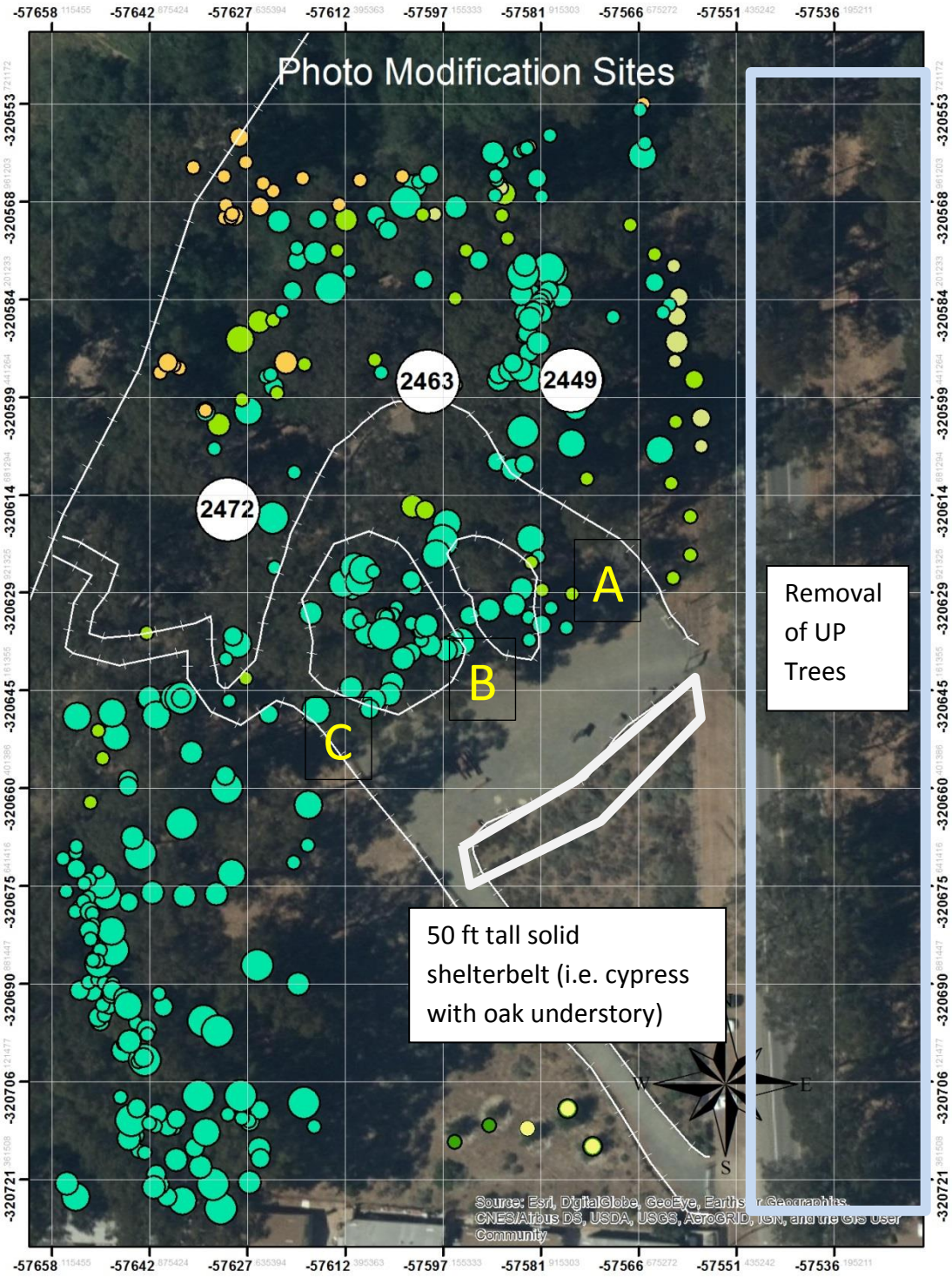


Figure 2 Map of trees, photo locations, and simulated habitat modifications



Results

Eastern site (Photo 2449, Figure 3). The original photo (A) shows highest wind exposure is from the South (0.28). The UP trees block much of the sky to the SE and E, extending to 30-40° elevation (they are ~100 ft tall and ~150' away). The UP Cut scenario (B) increases SE wind exposure from 0.22 to 0.52, and E wind exposure from 0.22 to 0.41.

The 50' shelterbelt (C) has its largest effect on S wind exposure, reducing it from 0.26 to 0.18 by filling in the lower 15° of the existing gap along Trail A. With both the UP Cut and Shelterbelt (D), there is still excessive SE and E wind exposure, because the shelterbelt does not extend to those directions.

Center site (Photo 2463 Figure 4). About 50' west of 2449, in the middle of the large clearing. The overhead gap is clearly seen in all photos, as are the several rows of trees to the south. The UP Trees fill in a gap formed by Trail A to the ESE direction (compare 4A and 4B); their removal increases SE exposure from 0.25 to 0.31 and E wind exposure from 0.20 to 0.27.

The shelterbelt (C) has virtually no effects in the original because those directions are largely blocked by existing trees. If the UP Trees were removed, then the shelterbelt slightly fills in the gap along Trail A (D).

West site (Photo 2472 Figure 5). There is an opening to the SE along Trail C. Only the shelterbelt was simulated here - the UP trees were so distant that differentiating them from the closer trees was not possible. The shelterbelt, which is >200' away, fills in the lowest ~10° of the sky in that gap, reducing SE wind exposure from 0.35 to 0.29.

Discussion and Conclusions

These analyses are a supplement to the original 2018 report, and the developing management plan. The key take homes are as follows.

The UP Trees provide critical wind shelter from the SE and E in the eastern and central parts of the habitat. Maintenance of these trees, and planning for their eventual replacement and filling in existing gaps is a long-term management goal that will require coordination with Union Pacific Railroad. Replacing the wind shelter function of these trees within the State Park is virtually impossible given the constraints of the highway and powerlines.

Planting a dense shelterbelt south of the trailer location would provide important additional wind shelter in the center and western parts of the habitat. A 50' height could be achieved with Monterey cypress in ~15 years (assuming a 3'/year growth rate and starting with a 5' tree). Maximal survival and growth rates could be ensured by providing irrigation and fertilization, but implementation needs to be weighed against the risk of long-term dependency on supplemental water and nutrients. Concurrent planting of live oaks, to the south of the cypress, provides understory and eventual middlestory to solidify the shelterbelt.

The shelterbelt would establish sooner if fast growing *Eucalyptus* were planted instead of cypress. But the proposed shelterbelt area lies outside of the existing *Eucalyptus* footprint. As the shelterbelt grows more than 50' tall, the effects will increase as a function of tree height.

An additional strategy for reinforcing southerly wind shelter is to densify the existing stands by inter-planting additional trees along the south edge of the main grove (within the existing *Eucalyptus* stands). Closing off or narrowing one or more of the trails (especially A) into the grove would reduce the wind tunnel effects.

Figure 3. Eastern site North is top of photo, East is to the left, and west to the right

A. Photo 2449 Unaltered

B. Photo 2449 UP Trees Removed

C. Photo 2449 Wind shelter 50 ft

D. Photo 2449 Wind shelter 50 ft, UP Trees removed

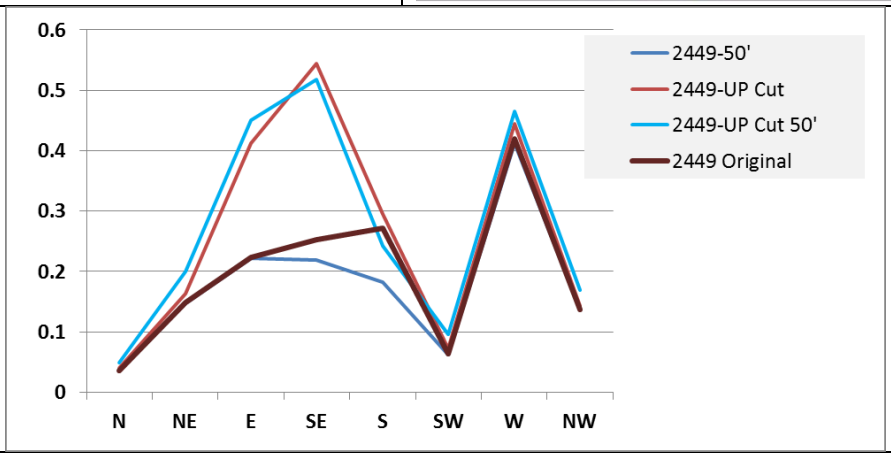


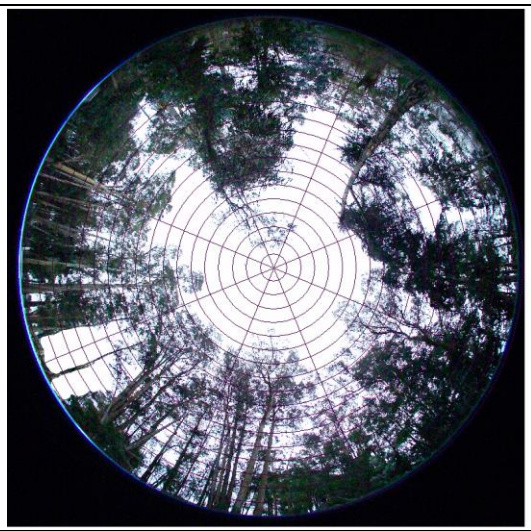
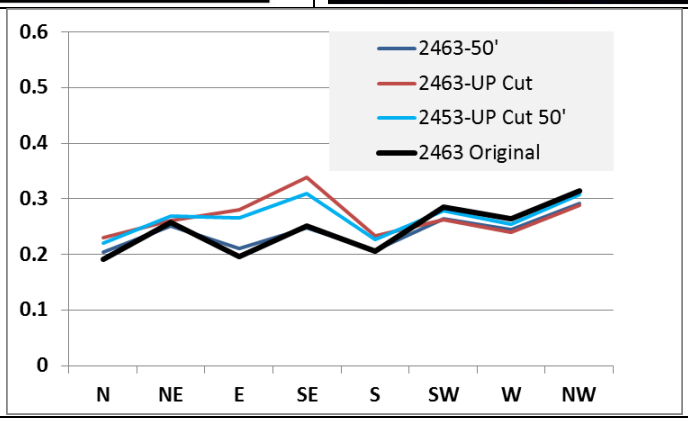
Figure 4 Center site	
A. Photo 2463 Unaltered	B. Photo 2463 UP Trees Removed
	
C. Photo 2463 Wind shelter 50 ft	D. Photo 2463 Wind shelter 50 ft, UP Trees removed
	
	

Figure 5. West site

Photo 2472 West Interior Original	Photo 2472 West Interior 50’ Windbreak