Monarch Butterfly Overwintering Site Management Plan for Lighthouse Field State Beach

Santa Cruz, California

A view of the core monarch butterfly cluster area at Lighthouse Field State Beach. Photo by Emma Pelton/Xerces Society.

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I. Background

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, in the past 30 years, this overwintering population has declined by over 95% (Schultz et al. 2017), putting 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, disease, and overwintering habitat loss and degradation. Protecting and restoring existing overwintering habitat is a vital part of the western monarch population's recovery.

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 urban and ex-urban development, and to a lesser extent, agricultural 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, high 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.

Lighthouse Field State Beach (Lighthouse Field), like most overwintering sites, has undergone a severe reduction in its monarch population—an 84% decline since the late 1990's. However, the site still hosts thousands of monarchs annually, and it was recently ranked the 7th most important site for conservation and restoration out of 111 California overwintering sites (Pelton et al. 2016). In order to help ensure that Lighthouse Field continues to provide high quality habitat for monarchs, Groundswell Coastal Ecology (Groundswell) and The Xerces Society for Invertebrate Conservation (Xerces Society), in coordination with the U.S. Fish & Wildlife Service (USFWS), has prepared a site management plan with recommendations for California Department of Parks and Recreation (California State Parks) to better plan and implement management actions which support overwintering monarchs in both the short- and long-term.

This plan was developed based on information collected during site visits by Groundswell staff, Samantha Marcum of USFWS, and Xerces Society biologists

during the winters of 2015-2016 & 2016-2017, as well as data available through the Xerces Society Western Monarch Overwintering Sites Database (2017; Appendix I). The plan's authors consulted with Tim Hyland of California State Parks, John Dayton who has monitored the site regularly for over two decades, and Chris Lynch, a local naturalist who has monitored monarch butterflies and the site for years.

II. Site Description

Lighthouse Field is perched on the headlands at the northern boundary of Monterey Bay and is surrounded by the city of Santa Cruz, California.

Historic vegetation and management

Prior to European settlement, this site likely consisted of coastal prairie, northern coastal scrub, and riparian habitat types. In the late 1880's the land became part of the Phelan Estate and was named Phelan Park. Later, the site was converted into a private ranch which safeguarded the land from becoming part of the housing developments built in the surrounding area. The native grassland and scrub landscape became dominated by nonnative forbs and grasses and portions of the site became forested, also dominated by nonnative species. After the ranching operations ceased, the property was slated to be developed into a shopping mall, but in 1974, the California Coastal Commission rejected the plan and no development took place. The property was subsequently sold to the state of California and in 1981, Lighthouse Field State Beach was officially created. The property remains under management of the California State Parks. In 1984, the California State Parks Commission adopted a resolution for a General Plan for Lighthouse Field State Beach. The City of Santa Cruz assisted with park maintenance with financial support from Santa Cruz County. In 1991, a short-lived effort to restore the remaining grassy fields to native coastal prairie and coastal scrub communities was undertaken.

Current vegetation and management

Today, the site contains some historical habitat types but with reduced diversity and a dominance of nonnative species. The soils consist of a shallow hardpan clay layer (2-3' deep) with a rich topsoil. Portions of the site act as a wet meadow fed by rain water with a shallow water table. The wetland areas have a relatively low diversity of plant species and the grasslands are dominated by agricultural and pasture weed species. The forested portions of the site are

dominated by nonnative blue gum eucalyptus (*Eucalyptus globulus*) and California native species Monterey cypress (*Cupressus macrocarpa*) and Monterey pine (*Pinus radiata*). There is also native willow (*Salix lasiolepis*), nonnative palm (Arecaceae family), and one young, dying redwood (*Sequoia* sp.) present at the site.

Lighthouse Field is one of the few urban open spaces of its size in the Monterey Bay, and it is bordered by a suburban matrix. The site is a popular public space for recreation, falling within the City of Santa Cruz Coastal Zone, adjacent to the World Surfing Reserve and used by locals for dog walking, hiking, open air painting, and biking. There is also transient use of the park including camping and other illegal activities.

California State Parks Management

Lighthouse Field is now managed by the California State Parks under management prescriptions detailed in the Lighthouse Field State Beach General Plan adopted in 1984. This plan provides for "low-intensity use of the 32 acre area dealt with in a Resource Management Program which sets policy guidelines for the preservation and perpetuation of the native plant and wildlife population. No concentrated use activities shall be permitted in the field, only informal paths and interpretive trails. This low-use zone will be adequately buffered from the high-intensity use areas across the cliff drive." This plan is protected by the CEQA process.

In general, California State Parks management at Lighthouse Field has focused on maintenance of the heavily used visitor services. Vegetation management has largely been in response to public safety. Tree trimming and coppicing has occurred throughout the field in recent years in response to concerns of potential tree or limb fall and to lift the sub-canopy in order to discourage illegal camping. In 2014, California State Parks and Groundswell began a partnership for ecological restoration of portions of the site to native coastal prairie and scrub vegetation. In 2016, a concession opened along West Cliff Drive which has drawn city residents and visitors to spend more time at the site.

The City of Santa Cruz

The City of Santa Cruz is required by the California Coastal Commission to have a Local Coastal Program to guide coastal development and management. The 1990-2005 Local Coastal Program (and amendments) contains reference to California State Parks' Lighthouse Field State Beach General Plan. This plan

requires the preparation and implementation of a management plan for the natural areas of Lighthouse Field in accordance with the Lighthouse Field policies in ASP pp. 442-447. The City's Local Coastal Program is currently being updated (as of October 2017). City zoning for this site is "Ocean Front Recreational" which includes a stated aim to develop, implement and maintain updated management plans for the protection and enhancement of natural areas within the City. The City of Santa Cruz Local Coastal Program is available at http://www.cityofsantacruz.com/home/showdocument?id=51167.

The City of Santa Cruz recently created a Santa Cruz City Parks Master Plan that is currently in draft form (as of October 2017). The draft plan references possible acquisition of Lighthouse Field State Park by the City of Santa Cruz. The City's Parks and Recreation Commission and City Council has expressed differences in opinion regarding acquiring Lighthouse Field for the City's park system, but agreed to "consider a partnership to improve maintenance of Lighthouse Field." (Pers. comm., Noah Downing).

Santa Cruz General Plan 2030

The City of Santa Cruz has developed a General Plan 2030, which "is a comprehensive, long range and internally consistent statement of the city's development and preservation policies. It summarizes the City's philosophy of growth and preservation, highlights what is important to the community, and prescribes where different kinds of development should go". While not part of the General Plan itself, it references the 1984 California State Parks' Lighthouse Field Management Plan as a "tool the City has adopted to implement General Plan policies concerning the Plan's respective subject matter". The City of Santa Cruz General Plan 2030 is available at http://www.cityofsantacruz.com/departments/planning-and-community-development/general-plan-2030.

The General Plan identifies potential monarch butterfly wintering habitat as part of its "Sensitive Habitat" list and NRC2.4.1 cites a goal to "Maintain a Monarch Butterfly Management Plan." Impacts to identified monarch butterfly wintering sites fall under the Regulatory Authority of City Ordinance and California Environmental Quality Act (CEQA) Review. Within the General Plan, it is recommended that mitigation and management of areas with overwintering butterflies "avoid take of individuals and habitat; maintain suitable habitat conditions; conduct construction activities outside of winter roosting season or develop appropriate mitigation; management from indirect impacts."

Legal status and protection of monarchs

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 June 2019.

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.

California State Parks: There are at least 50 known overwintering sites located on property owned by California State Parks, including Lighthouse Field. Monarchs and their overwintering habitat are protected on California State Parks property, because collecting or harming animals and destruction of native vegetation is prohibited. However, this level of protection does not preclude trimming or pruning trees within overwintering sites (International Environmental Law Project and Xerces Society 2012).

III. Overwintering Monarchs at Lighthouse Field

The first published survey of Lighthouse Field was Walt Sakai and Bill Calvert's 1990 statewide survey of monarch overwintering sites (Sakai and Calvert 1991). They observed 9,000 butterflies on November 10th, 1990, and also noted that, historically, monarchs clustered on the west end of Lighthouse Field, although the grove had since been destroyed by the construction of a large apartment complex.

In 2001, the City of Santa Cruz commissioned a report by the Cal Poly professor and monarch biologist Kingston Leong to assess the site for monarch butterfly overwintering resources. The final report "Lighthouse Field State Beach Monarch Butterfly Overwintering Site: first year study" is found in Appendix II. The Leong report's stated objectives were 1) to establish baseline information on the environmental conditions of the grove, 2) to identify the areas in the surrounding park and neighborhood utilized by monarchs, 3) to determine seasonal variation in population size and location, and 4) to provide recommendations for management based on data collected during the winter of 2001-2002. Leong made nine site visits during the overwintering season between October and February, noting 1-4 roost trees were utilized on each visit. His maps indicate that these trees were located within the site's current

cluster area (Map 1). While providing valuable baseline information about monarchs' use of the site, the management actions recommended by Leong and follow-up studies were never implemented.

Regular monitoring of monarch numbers at Lighthouse Field began in 1997, with the inception of the Western Monarch Thanksgiving Count, a citizen-science based monitoring effort coordinated by the Xerces Society and Mia Monroe. Counts are conducted using a standard protocol (see Appendix III) during a three-week period centered on the Thanksgiving holiday each year. In 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 (California Department of Fish and Wildlife) annually.

Thanksgiving counts have been conducted at Lighthouse Field every year since 1997, except 2001 (Table & Figure 1). The peak count was recorded in 1997, with 70,000 monarchs present; in the most recent Thanksgiving count (2016), 12,000 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. An average of all counts taken during the Thanksgiving Count period between 1997-2001, compared with counts conducted between 2010-2014, shows an 84% decline over the two time periods at Lighthouse Field (Pelton et al. 2016). A summary of additional surveys and counts conducted at Lighthouse Field are summarized in Appendix I.

Year	Monarchs
1997	70,000
1998	50,000
1999	9,500
2000	35,000
2001	
2002	3,200
2003	11,000
2004	9,600
2005	14,000
2006	10,300
2007	5,700
2008	2,607
2009	4,000
2010	4,000
2011	18,100
2012	3,200
2013	4,500
2014	7,000
2015	12,000
2016	12,000

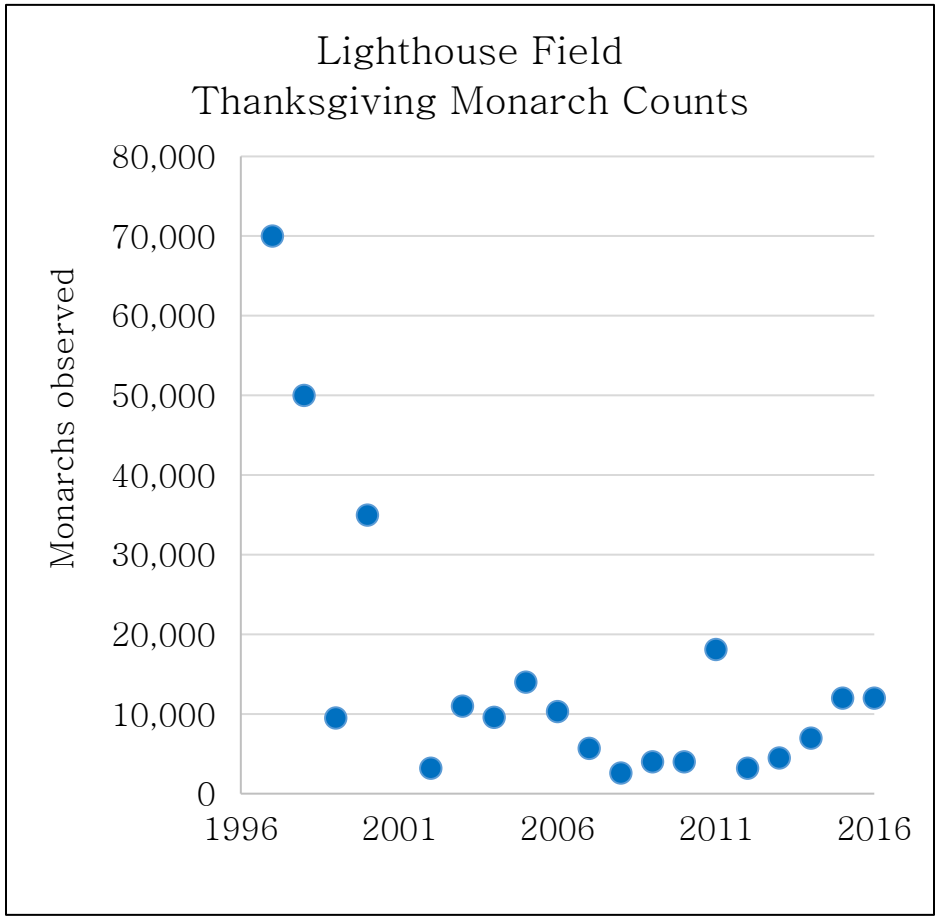


Table & Figure 1. Lighthouse Field Western Monarch Thanksgiving Count Monarch Counts.

Monitoring in 2015-2016 and 2016-2017

For the development of this plan, monitoring of the overwintering habitat took place during the winters of 2015-2016 and 2016-2017. The purpose of these site visits was to assess key areas used by monarchs in order to inform management actions. Site visits included documentation of cluster locations and sizes (Map 1 & Appendix I), predominant wind directions and wind blocking features (Map 2), monarch behavior (e.g., sunning, nectaring) in different areas (Map 3), grove health, and nectar resources. Monarch mortality was also opportunistically assessed in winter 2016-2017, and described in detail in Section IV below. Observations from these site visits were synthesized into management recommendations in the Site Management Plan (Section IV) and summarized in Maps 1-6.

Clustering: Monarchs consistently clustered on mid-story Monterey cypress trees in the center of the tree grove (Map 1 & picture on the cover of this report). The aggregation trees are surrounded by a mature blue gum eucalyptus and Monterey cypress trees whose canopy creates a dappled light environment. In February 2017, monarchs briefly clustered on the eastern edge of the grove in mature blue gum eucalyptus –perhaps in response to the interaction of WSW winds and recent tree falls. In previous years, monarchs have been observed clustering on other blue gums within the grove as well.

Map 1. Overwintering monarch cluster areas in winters 2015-2016 and 2016-2017.

Wind direction and wind blocking features: In the winter months, the wind directions at this site are variable based on storm activity. During periods of calm, cool offshore winds blow from the north; during storms, winds blow from the southeast to southwest. The core cluster area has insufficient protection from winds coming from the north and southwest due to existing gaps in the lines of trees, exacerbated by recent tree falls (Map 2). To a lesser extent, there is also additional wind gaps to the southeast of the grove.

Map 2. Existing windbreaks, dates when trees recently fell, dead standing tree location, and critical wind vulnerability to the core clustering area.

Areas of monarchs sunning, nectaring, and drinking behavior: Monarchs primarily use the outer eucalyptus and Monterey cypress trees to the south and east of the cluster area for sunning. The open fields adjacent to the cluster area (to the east and the west) are used extensively for nectaring and imbibing dew. Monarchs were observed nectaring on the following species: nonnative blue gum eucalyptus, sourgrass (*Oxalis* sp.), ice plant (*Aizoaceae* family), English ivy (*Hedera helix*), wild radish (*Raphanus sativus*), *Prunus* spp., and native Pacific aster (*Symphyotrichum chilense*), Western goldenrod (*Euthamia occidentalis*), arroyo willow (*Salix lasiolepis*). Monarchs also nectar on a diversity of cultivars in gardens of the surrounding suburban matrix and Gateway School Life Lab.

Map 3. Nectaring, drinking, and sunning areas adjacent to the cluster areas.

IV. Monarch Butterfly Habitat Site Management Plan

The overall goals of this site management plan are to sustain the current monarch overwintering population for the short-term, and to increase the overwintering population in the long-term at Lighthouse Field through: 1) strategic tree planting and forest management, 2) reducing monarch mortality, 3) increasing native nectar resource availability, and 4) improving positive public engagement with the site.

1. Strategic tree planting and forest management

The focus of forest 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). Forest 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. 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 forest 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.

At Lighthouse Field, the core cluster area (Map 1) has been documented as occupied in both 2001-2002 (Leong 2002) and more recently in 2015-2017. The fidelity of monarchs to this location is a product of its highly suitable microclimate conditions and sun exposure. However, to the northwest of where the monarchs cluster, a wind tunnel (see Map 2) formed in 2015, which increases monarch vulnerability to high winds and storms. The wind tunnel was formed when one eucalyptus tree blew down after storms, followed by the topping of additional trees (Picture 1). This new gap allows storm winds to blow monarchs onto Pelton Avenue, where mortalities were documented in winter 2016-17 (see page 18).

Blue gum eucalyptus trees at the site show damage from eucalyptus leaf beetle (*Chrysophtharta* spp.) and may also host eucalyptus longhorned borer (*Phoracantha* spp.) and sulphur shelf (*Laetiporus* spp.) infestations. The cluster area contains multiple large, downed limbs and trunks of blue gum eucalyptus, which may be providing habitat for the commonly occurring eucalyptus longhorned borer. These insect pests and fungal infestations exacerbate drought

stress, leading to reduced flowering (and hence nectar availability), and potentially causing limb or tree mortality.

In addition, the densely forested portion of Lighthouse Field that is used by monarchs is relatively small (<1 acre). This restricted area makes the cluster area vulnerable even if only a small number of surrounding trees fall or die in the coming years.

Management recommendations

✓ **Plant trees in the north windbreak to decrease wind tunnel effect** (see Map 4). Tree plantings in this area will help prevent monarchs from being blown onto adjacent streets and reduce a major cause of monarch mortality at this site. Three-to four blue gum eucalyptus saplings (possibly sourced from within the site) could be transplanted to block this gap. One- to two slower growing Monterey cypress trees should be planted just north of the eucalyptus to eventually replace the eucalyptus.

Picture 1. Tree topping and removal of blue gum eucalyptus trees within the cluster area has created a wind tunnel which negatively impacts clustering monarchs during storm events.

✓ **Expand windbreak tree plantings in the southwest and eastern portions of the site to increase wind protection (see Map 4).** Tree planting is needed to close small wind gaps in these areas and to create redundant windbreaks outside of

the main cluster area. This area experienced tree fall in January 2017, and it is in need of replacement plantings. Trees recommended for planting include species which are native to coastal California, are known to host overwintering monarchs, and/or are effective wind breaks. Selection of tree species should be based on soil type, irrigation needs, cost, and availability. Recommended species for windbreak plantings include:

1. Monterey cypress (*Cupressus macrocarpa*) is the tree species native to California which is most commonly used by clustering monarchs at overwintering sites along the coast, including at Lighthouse Field. While only native to the Monterey peninsula, the tree has been widely planted elsewhere and is suitable as both a cluster tree and an effective wind break. Plant in low saturation portions of the site—highly saturated soils may have resulted in recent Monterey cypress tree falls (Map 2).
2. California bayberry (*Morella californica*) is a species with dense foliage which provides an effective wind break at moderate heights. It is adapted to saturated soils and is fasting growing. This species should only be used in wind break plantings outside of the grove as it is not suitable as a cluster tree for monarchs.
3. Coast live oak (*Quercus agrifolia*) is a species typically used by monarchs clustering early in the season and for sunning. Its low stature typically makes it unsuitable as a season-long cluster tree. This species provides wind breaks at low-to-moderate heights.

Map 4. Proposed wind break planting areas and core clustering area.

Additional tree species selection guidance: While Monterey pine (*Pinus radiata*) is a commonly used cluster tree, the species is very susceptible to the fungal disease pitch canker (*Fusarium circinatum*), which can cause extensive crown die-back and even tree mortality. Monterey pine trees currently present at Lighthouse Field are exhibiting signs of pitch canker, so additional planting of this species is not recommended unless pitch-canker resistant varieties are available.

Blue gum eucalyptus trees are relatively fast-growing and provide suitable canopy structure and nectar for overwintering monarchs. However, eucalyptus are nonnative, can be invasive, and research shows monarchs in mixed species stands do not prefer eucalyptus over native tree species (Griffiths and Villablanca 2015). For these reasons, additional planting of blue gum at Lighthouse Field is limited to filling in the northwest wind break gap of the cluster area by relocating blue gum saplings currently growing at the site.

Picture 2. Newly downed woody debris within the cluster area may harbor eucalyptus pests such as eucalyptus longhorned borer. Photo by Emma Pelton/Xerces Society

- ✓ **Remove fallen trunks and large branches from the cluster area.** Freshly fallen material can harbor eucalyptus herbivores such as eucalyptus longhorned borer. These materials may be chipped on-site and spread on existing foot paths which are often muddy due to winter rains and localized flooding.

General forestry action guidance: Forestry actions should be undertaken in close collaboration with a certified arborist, a monarch butterfly expert (such as the

Xerces Society), and land managers. All forestry management actions in or close to the cluster areas (500' buffer minimum) should be taken during April-September, outside of the overwintering season when monarchs are not present and outside of breeding bird season. Saplings should be planted in phases (every 3-5 years) or saplings and more mature trees can be planted simultaneously to create age and structure diversity. Trees should be planted 3-5 m apart, but overplanting followed by periodic thinning will compensate for moderate sapling mortality. Wet areas where soils are perched on thick clay layer are predisposed to tree falls, so plantings should target microsites that are higher and less wet. Due to the recent years of drought in California, irrigation for the first 2-3 years after tree planting is recommended. Water truck delivery may be more feasible than irrigation lines at this site. Also, although there is currently sufficient canopy openness across the grove, in the future, selective limb removal can also be used to create additional, small canopy gaps (10-15m wide) if needed, for monarchs to have access to dappled and direct sunlight.

Nursery stock guidance: 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, 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 management action is deemed necessary, 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.

Management Timeline

	Action area	First year	Every 3-5 years	Every year
Management	Strategic tree planting and forest management	Plant additional trees in the north, southwest, and eastern windbreaks (and irrigate as needed).	Plant additional saplings if needed. Thin trees and limbs in windbreaks as needed to avoid overcrowding	Assess hazard trees and consult with a monarch expert & arborist if action is needed.

		Remove woody debris from cluster area. Chip and spread on footpaths.	and to maintain canopy openings near cluster area.	

2. Reducing monarch mortality

Monarchs, like many insect species, face naturally high rates of mortality from parasites (especially during their immature stages), predators, and storms. However, given the western monarch population's severe decline and the additional stress of human-modified landscapes (including the presence of nonnative predators) and severe winter storms linked with climate change, management actions should be taken to minimize excessive mortality events at overwintering sites.

Monarch mortality monitoring at Lighthouse Field

Monarch mortality events were monitored opportunistically four times from December 2016 to January 2017 by searching for dead monarchs within the grove and on adjacent streets (Map 5). Searches were roughly synchronized to the day of or immediately following major storm events (December 20, January 10, 13, & 19). Wings were grouped by sex and wing type (left front, right front, left rear, and right rear wings) and the maximum number by wing type was used as the minimum number of mortalities. In total, there were 650 dead monarchs collected with 55 (8.5%) encountered on adjacent surface streets and 595 (91.5%) within the grove; 57% male and 43% female. This represents 5.4% of the Thanksgiving count population estimate of 12,000 monarchs. Note: this total should be treated as a minimum estimate as some mortalities likely went undetected.

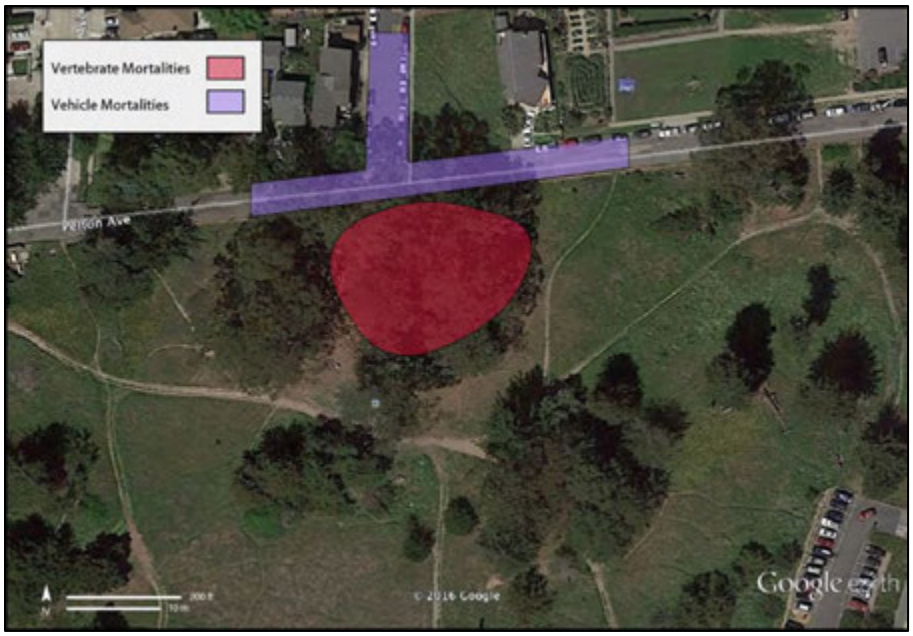
Road mortalities were associated with warm wet windy conditions when WSW winds created a wind tunnel in the northwest portion of the cluster area (Map 2), blowing monarchs to the NNE towards the adjacent surface streets including Pelton Avenue. During these conditions, butterflies often landed on pavement becoming stuck as their wings touched the wet road surface and were then crushed by passing vehicles.

Mortalities encountered in the grove included butterflies found with missing abdomens (65%) or as sets of wings (35%). Monarchs missing abdomens (both dead and still alive) were observed caught in Monterey cypress foliage beneath

clusters, suggesting that at least some predation occurred in the trees. The majority of wing fragments (>85%) were located in 8-10 caches with rodent feces (~1.5x5mm in size) located in coarse woody debris on the grove floor under or near the clustering sites. Black rats (*Rattus rattus*) are common in coastal areas and are associated with the abundant coastal rock armoring found along adjacent West Cliff Drive. Other rodent species which are known to predate overwintering monarchs in California include squirrels (*Sciurus* spp.) (Xerces Society, unpublished records).

A smaller portion (<15%) of the dead monarchs found at the grove had damaged abdomens and rear wings with long wounds suggestive of avian predation. While no bird predation was observed, American crows (*Corvus brachyrhynchos*) and chestnut backed chickadees (*Poecile rufescens*) were often present. Bird species which are known to predate monarchs at other overwintering sites include jays (Pers. comm., Chris Lynch, observed at nearby Natural Bridges State Beach), crows (Pers. comm., David Marriot, observed at nearby Moran Lake), and chestnut backed chickadees (Xerces Society, unpublished records).

While vertebrate predation is somewhat common at overwintering sites, large predation events such as caches of 100s of monarchs is reason for concern as some observers have hypothesized that animals learn and spread this behavior to others at a single site In addition, most of the possible predator species are human commensal (e.g., crows, jays, rats, squirrels).



Map 5. Areas with documented monarch mortality December 2016-January 2017.

Management recommendations

✓ **Evaluate species involved in large predation events and develop a predator mitigation plan.** Deploy camera traps in both the canopy and near ground-level to determine the species involved and develop a predator mitigation plan. If necessary, predator deterrents or live traps can be used to remove problem individuals. Barn owl nest boxes and/or other raptor perches may be useful to promote natural predation of rodents.

✓ **Improve trash management** to help deter human commensal predator attraction to the site. Improvements may include holding volunteer trash pick-up days and/or installing additional waste receptacles with scavenger-proof lids.

✓ **Remove nonnative predator habitat** such as large brush piles and nonnative palm trees to reduce available habitat for rats. The nonnative ice plant growing to the west end of the cluster area may also be providing rat habitat; however, its blooms are frequently visited by nectaring monarchs and so removal is not recommended until (and if) sufficient and self-sustaining native nectar resources can be planted on site to replace the quantity and availability (late fall-early spring) of nectar provided by this resource.

Management Timeline

	Action area	First year	Every 3-5 years	Every year
Management	Reducing monarch mortality	Evaluate predator species & develop predator mitigation plan. Remove brush piles and improve trash management.		Document the extent and cause of large mortality events if observed.

3. Increasing native nectar resource availability

Monarchs rely on nectar sources during overwintering to maintain lipid levels needed for spring migration (Tuskes and Brower 1978). At Lighthouse Field, blue gum eucalyptus provides nectar resources within the cluster area; however, drought and pest pressure are reducing the abundance and duration of blooms on the eucalyptus trees, with possibly negative effects on monarchs' ability to locate sufficient nectar (Pers. comm., John Dayton). The surrounding areas (Map 3) contain additional nectar sources such as nonnative sourgrass (*Oxalis* sp.), ice

plant (*Aizoaceae* family), and wild radish (*Raphanus sativus*). Ice plant provides nectar in late fall and early spring, however the plant is mat forming and provides habitat for nonnative rats which may predate on grounded monarchs. Wild radish is present in dense stands throughout the open fields of the site. Radish provides nectar resources in late winter/early spring but may also create fire hazards when dry. Sourgrass is an agricultural weed also present in the fields which may provide nectar during the winter months. In 2014, Groundswell began a coastal scrub restoration project at the corner of Pelton Ave and West Cliff Drive. Plants included in the 700 m^2 area include late-flowering butterfly nectar resources listed in Appendix V. In 2016 and early 2017, Groundswell expanded restoration to include an additional 450 m^2 planting of late-flowering plants in a triangular plot southeast of the grove and in a 930 m^2 riparian area of late and early flowering plants located east of the grove (Map 6). Monarchs were observed nectaring on the 2016/2017 plantings in October 2017.

Map 6. Locations of current and future habitat types through proposed restoration actions.

Management recommendations

✓ **Incorporate native fall, winter, and early spring (October-March) blooming flowers** into plantings at the site. Flowers should be planted in sunlit areas close to the grove and should be implemented in multi-year phases with monitoring to ensure good establishment and to avoid creating a gap in nectar availability during the planting/disturbance year. The plantings should include both upland

and riparian species which are attractive to monarchs and other native pollinators. Perennial forb and shrub plantings can be accelerated by transplanting rhizomatous species. A list of native, commercially available species which have been documented as nectar flowers for monarchs are provided in Appendix IV and a list of locally appropriate butterfly-friendly native plants is available in Appendix V. A mix of species should be selected 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.

✓ **Monitor native nectar species for establishment success and monarch preference.** Additional monitoring is needed in the first year after planting to assess the success of native nectar plantings as there are currently no significant native nectar sources at this site. This monitoring is two-fold: 1) monitoring establishment and which species thrive with minimal management and 2) which species are preferred by monarchs for nectaring. Establishment success can be assessed by making ocular estimates of plant survival (by species and location) six months after planting. Monarch nectaring preference can be assessed by conducting ten-minute floral observations of each flowering species (n=10), repeated at least twice over the species' bloom period.

Picture 3. A grassy field and ice plant patch on the west end of the cluster area where monarchs seek out nectar and dew. Photo by Emma Pelton/Xerces Society

Guidance about milkweed at 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 Santa Cruz area (Western Monarch and Milkweed Occurrence Database 2017).

The Xerces Society and the U.S. Fish & Wildlife Service do not recommend planting milkweed, nonnative or native, close to overwintering sites (within 5-10 miles of the coast) where it did not historically occur (see Pelton et al. 2016 for additional information). Planting native nectar plants provides resources for monarchs and other pollinators and is recommended as an alternative to milkweed (see Appendix IV for list of recommended species). While there is currently no nonnative milkweed present at Lighthouse Field, any outreach activities related to this site should discourage the planting of milkweed in at nearby schools, etc. Removal of existing stands is also recommended.

Management Timeline

	Action area	First year	Every 3-5 years	Every year
Management	**Increasing native nectar resource availability**	Incorporate native nectar species into plantings. Evaluate monarch utilization of restoration planting to inform future species selection.	Continue to plant additional nectar resources as needed.	

4. Improving positive public engagement

Lighthouse Field is a popular area for dog walkers, joggers, bike riders, surfers, wildlife watching, and other recreational activities. There are also known issues with transient camping and drug use. Effective site management of the monarch overwintering habitat will find opportunities to both minimize negative impacts of people's activities on the butterflies, and to increase positive public use of the park—which may also reduce problematic uses of the site and enhance community resources.

Currently, there is minimal education and outreach occurring at Lighthouse Field about the natural resources of the site. There is one permanent interpretative sign on the south central end of the cluster area which includes information about monarch butterfly biology and cable fencing around the core cluster area. The site has had no dedicated docent program in previous years, but California State Parks has indicated that they intend to have a presence here starting in winter 2017 (Tim Hyland, personal communication).

Recommendations

- ✓ **Expand fencing** to include the blue gum eucalyptus on the southwest side of the cluster area which is an important part of the main grove. Replacing the cable fencing with manila rope may deter theft of the cable which has been a problem in the past.
- ✓ **Add additional signage** to 1) increase awareness of the monarch butterflies' migration and conservation needs and 2) alert the public to the sensitivity of the cluster area and deter disturbances. This sign could be located on the west end of the grove near the foot path.
- ✓ **Develop a docent program or partner with Natural Bridges docent program.** Programming by knowledgeable docents can increase the enjoyment and engagement of visitors at an overwintering site. In addition to docents, an expanded presence of California State Parks staff may help encourage more positive engagement of the public with the site.
- ✓ **Conduct an outreach campaign** to neighbors, especially in the nearby residential development to the north, which may increase community participation in monarch conservation. This campaign could consist of alerting them to monarch conservation efforts and ways they can participate such as planting native and pesticide-free nectar sources. This campaign could consist

of emailing a neighborhood listserv, distributing fliers, and/or holding a neighborhood event held at the site and paired with a park clean-up day.

✓ **Engage Gateway School and other schools in the area** such as Bay View Elementary School, Mission Hill Middle School, and Santa Cruz High School in monarch conservation. Engagement with teachers and students, especially at adjacent Gateway School, could be an important approach for achieving monitoring goals, supporting science and environmental education, and increasing civic involvement. Possible projects could involve planting native nectar plants, studying monarch use & preference of nectar plantings, participating in the Western Monarch Thanksgiving Count, and tagging monarchs for research purposes (see Monarch Alert http://monarchalert.calpoly.edu/ for details). If Gateway School is engaged, the current stand of nonnative milkweed (balloon plant [*Gomphocarpus physocarpus*]) should be replaced with native nectar species, as the presence of nonnative milkweed planted at the school may also send the wrong message to students and visitors, encouraging them to plant milkweed at their home gardens.

Picture 4. Interpretative sign and cable fencing in the monarch cluster area. Photo by Emma Pelton/Xerces Society

Public Engagement Timeline

	Action area	First year	Every 3-5 years	Every year
Public Engagement	Improving positive public engagement with the site	Modify fencing and add additional signage. Develop a docent program. Plan a campaign to engage neighbors and schools.	Hold a monarch neighborhood outreach and park clean-up event.	Have a docent or staff presence.

V. Monarch Cluster and Habitat Monitoring

Monitoring monarch cluster location and abundance: Monitoring overwintering monarchs' use of the site will be crucial to assessing the effectiveness of this site management plan and to adapting habitat restoration and enhancement techniques as needed. Volunteers and biologists monitor the overwintering clusters at Lighthouse Field as well as other local overwintering sites and collect important data as part of the Xerces Western Monarch Thanksgiving Count and New Year's Count. However, additional monitoring at Lighthouse Field (ideally every two weeks from October through March) for a minimum of one year after major management actions have been taken is important to track how monarchs respond to changes in grove conditions. Recording monarch clusters' size and location will help refine the current understanding of monarchs' use of the site and can directly inform management actions in future years. For example, if monarchs shift away from a once-used area after the removal or planting of a tree, planting replacement trees or trimming existing trees may be needed to restore microhabitat conditions. Standard protocols and data sheets for monitoring monarch clusters (Monarch Counts) are available at www.westernmonarchcount.org and attached in Appendix III. Physically marking cluster trees with flagging tape or tree tags as well as tracking trees with GPS will be useful for monitoring within site and between year movements.

Monitoring monarch habitat: Annual monitoring of the grove's suitability for monarchs should be conducted to identify potential grove issues as soon as possible. Any additional threats or conservation issues (e.g., new tree fall) should be added to the management records and incorporated into the management plan. This will help managers plan future management actions (at

both short-and long-term time scales) and obtain funding as needed. Standard protocols and data sheets for assessing grove health (Habitat Assessments) are available at www.westernmonarchcount.org and attached in Appendix III.

	Action area	First year	Every 3-5 years	Every year
Monitoring	Monarch monitoring	Monitor clusters' size & location every 2 weeks from Oct-Mar.	Monitor site for monarchs' response to management actions.	Count clustering monarchs during the Thanksgiving & New Year's count periods. Conduct a habitat assessment.

VI. Monitoring and Management Action Master Timeline

	Action area	First year	Every 3-5 years	Every year
Monitoring	Monarch monitoring	Monitor clusters' size & location every 2 weeks from Oct-Mar.	Monitor site for monarchs' response to management actions.	Count clustering monarchs during the Thanksgiving & New Year's count periods. Conduct a habitat assessment.
Management	Strategic tree planting and forest management	Plant additional trees in the north, southwest, and eastern windbreaks (and irrigate as needed). Remove woody debris from cluster area. Remove woody debris from cluster area. Chip and spread on footpaths.	Plant additional saplings if needed. Thin trees and limbs in windbreaks as needed to avoid overcrowding and to maintain canopy openings near cluster area.	Assess hazard trees and consult with a monarch expert & arborist if action is needed.
	Reducing monarch mortality	Evaluate predator species & develop predator mitigation plan. Remove brush piles and improve trash management.		Document the extent and cause of large mortality events if observed.

	Increasing native nectar resource availability	Incorporate native nectar species into plantings. Evaluate monarch utilization of restoration planting to inform future species selection.	Continue to plant additional nectar resources as needed.	
Public Engagement	**Improving positive public engagement with the site**	Modify fencing and add additional signage. Develop a docent program. Plan a campaign to engage neighbors and schools.	Hold a monarch neighborhood outreach and park clean-up event.	Have a docent or staff presence.

VII. Plan Implementation

Before implementation: Before planting trees in the windbreaks, a site-specific planting plan (including maps) should be developed for the wind breaks and grove area specifying the location and spacing as well as the species and size of tree selected. Eucalyptus saplings selected for replanting within the site should be physically marked using flagging tape. In addition, applicable approval and permits from California State Parks and other relevant entities should be obtained.

Current partners: Current partners of this site management plan for overwintering monarchs at Lighthouse Field include Tim Hyland of California State Parks as manager of the site, Samantha Marcum of USFWS as funder and coordinator of work, Xerces Society staff as overwintering monarch and habitat knowledge source, and Groundswell for community and education-based ecological enhancement and monitoring. John Dayton and Chris Lynch, knowledgeable local biologists, were also solicited in the development of this plan and provided feedback. Groundswell, Xerces Society, and U.S. Fish & Wildlife will partner to implement this plan in close consultation with State Parks through funding from U.S. Fish & Wildlife (for implementation 2017-2018) and the National Fish & Wildlife Foundation (for implementation & monitoring 2017-2019). In the future, plan implementation will benefit from expanded engagement and partnerships with others interested in this site such as the City of Santa Cruz, Gateway School, and Natural Bridges State Beach.

Model plan: It is the authors' aim that this site management plan for Lighthouse Field will help inform site management plan development at other overwintering sites. This plan was developed through the partnership of multiple groups and knowledgeable individuals who each contributed different skills in monitoring the site and developing this plan. Records and documentation of decision-making regarding the implementation and adaptive management of this site management plan may be valuable models for other overwintering land managers in the future.

Additional research and monitoring: This plan was developed using the best available science about overwintering monarchs' behavior and habitat needs. However, there are still many knowledge gaps about fine-scale monarch overwintering microclimate habitat requirements and more detailed studies of Lighthouse Field and other overwintering groves could be useful to inform additional future management actions. Data collection could be focused to create a detailed profile of the groves' canopy structure, light availability, and/or wind patterns to determine which areas of the grove will benefit from additional planting or thinning of trees. These studies are typically conducted over an entire overwintering season and require detailed measurements completed through frequent site visits and deployment of monitoring equipment which was outside the scope of this plan. Any additional studies on habitat use at this site should be incorporated into this overwintering site management plan.

VIII. Appendices (please see attached)

Appendix I: Collated site records of Lighthouse Field State Beach from the Xerces Western Monarch Overwintering Sites Database (2017)

Appendix II: Copy of the Leong 2002 study/site management plan for Lighthouse Field State Beach

Appendix III: Copies of the monarch count and habitat assessment datasheets and protocols used in the WMTC

Appendix IV: Xerces Society California Coast Monarch Nectar Plant List

Appendix V: Groundswell Coastal Ecology List of Appropriate Native Plants for Butterfly Friendly Restoration at Lighthouse Field

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Appendix I. Lighthouse Field Site Report

Site Name: **Lighthouse Field, Santa Cruz**

Sensitive Data (yes if checked)? ☐

SiteID: **3000**

County: **Santa Cruz**

CNDDB #: 105

Aka:

Owner Name:	CA Dept. of Parks and Rec
Property Name:	Lighthouse Field State Beach
Primary Land Use:	State Park

Land Use Update:	5 /1 /2012
Ownership Update:	1/25/2011

Directions: LIGHTHOUSE FIELD STATE BEACH, SANTA CRUZ. The cluster trees are located near the interpretive sign.

Site Description:

Comment:

SITE CHARACTERISTICS (by date reported):

Source Code: SAK91F0002 **Source Year** 1991

Site Characteristics Date Reported: **xx/xx/1991**

Author First Name Walter

Author Last Name: Sakai

Aggregation Type Reported: Autumnal

Site Quality Reported: Good

Ecological Description: Eucalyptus and Monterey cypress remain from old plantings on an originally-treeless coastal terrace. Good site for a planting/recovery effort.

Aggregation Comments: Clusters form every fall, with small numbers occasionally overwintering (as in 1985 and 1994). Monarchs known from this site since the late 1800's

Cluster Tree Species

Scientific Name	Common Name
Cupressus macrocarpus	Monterey cypress
Eucalyptus spp.	eucalyptus species

Threats Comments:

Source Code: XER12U0001 **Source Year** 2012

Site Characteristics Date Reported: **11/16/2011**

Author First Name Carly

Author Last Name: Voight

Aggregation Type Reported: Overwintering

Site Quality Reported:

Ecological Description: Eucalyptus and Monterey cypress remain from old plantings on an originally-treeless coastal terrace. Good site for a planting/recovery effort.

Aggregation Comments: Clusters form every fall and large numbers persist throughout the winter.

Cluster Tree Species

Scientific Name	Common Name
Cupressus macrocarpus	Monterey cypress

Other Tree Species

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

Nectar Species

Scientific Name	Common Name
Eucalyptus globulus	Blue gum
Mesembryanthemum sp.	Ice plant

Site Threats

Threat Description
Old/aging trees
High visitation load

Landscape Threats

Threat Description
Roads/highways
High vehicle traffic area
Housing developments

Future Threats

Threat Description
Site might not offer enough wind protection in the future

Threats Comments:
This site might not offer enough wind protection. Additional wind break trees may need to be planted - a detailed habitat assessment should be conducted. There is a rope around the butterfly roost trees but this may not deter all visitors.

Source Code: XER16F0002 **Source Year** 2016

Site Characteristics Date Reported: **11/30/2015**

Author First Name See: Observor

Author Last Name: Xerces Society

Aggregation Type Reported:

Site Quality Reported:

Ecological Description: Nearby school gardens and residences, no nectar species in bloom.

Aggregation Comments:

Cluster Tree Species

Scientific Name	Common Name
Cupressus macrocarpus	Monterey cypress

Other Tree Species

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

Site Threats

Threat Description
Trimmed trees
Trees diseased from Eucalyptus leaf beetle
Old/aging trees

Landscape Threats

Threat Description
Roads/highways
Housing developments
Pavement

Future Threats

Threat Description
Site might not offer enough wind protection in the future

Threats Comments:

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.

01/07/17	10,214	Clustered in outer trees of grove of Monterey Cypress
12/09/16	10,425	
TC/TC/16	12,000	
11/21/2015	12,000	See email from Martha
TC/TC/2014	7,000	
TC/TC/2013	4,500	
TC/TC/2012	3,200	
TC/TC/2011	18,100	
TC/TC/2010	4,000	
TC/TC/2009	4,000	
TC/TC/2008	2,607	
TC/TC/2007	5,700	
TC/TC/2006	10,300	
TC/TC/2005	14,000	
TC/TC/2004	9,600	
TC/TC/2003	11,000	
TC/TC/2002	3,200	
11/23/2000	35,000	Secondary Source (date): 71
11/21/1999	9,500	Secondary Source (date): 71
12/06/1998	50,000	Secondary Source (date): 71
01/05/1998	60,000	
11/23/1997	70,000	Secondary Source (date): 71
11/23/1997	70,000	DELETE - DUPLICATE
01/09/1996	25,000	
01/xx/1995	0	
xx/xx/1994	1,000	
xx/xx/1993	0	
01/10/1991	2	no clusters found
xx/xx/1991	8,000	
12/10/1990	500	Most in small clusters of 50 or more.
11/10/1990	9,000	Approx. 8,000 seen clustered in the cypress; another 1,000 clustering in eucs.
10/15/1990	5,000	Approx. 5,000 seen clustering in the eucalyptus at this site.
02/10/1991	0	no butterflies or clusters seen.
	33	Total # observations reported:
	30	Total # observations with monarchs present (>0):

4_SourceReport_Test

Observation Data Source(s)

1991	Walter	Sakai	STATEWIDE SET OF FIELD SURVEY FORMS FOR MONARCH WINTERING SITES, SURVEYED IN WINTER 1990-91.
2014		Xerces Society	Summary of Thanksgiving Count data from 1997-2014
1991	Walter & William	Sakai & Calvert	Statewide Monarch Butterfly Management Plan for the State of California Dept. of Parks and Recreation - Final Report
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

Appendix II. Kingston Leong Lighthouse Field Study

Lighthouse Field State Beach
Monarch Butterfly Overwintering Site
First year study
Winter 2001-2002

Submitted by
Kingston L. H. Leong, Ph. D.

Submitted to City of Santa Cruz,
Department of Parks and Recreation
323 Church Street
Santa Cruz, CA 95060
August 1, 2002

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Introduction

In 1983, the long distance migration and mass winter aggregations of monarch butterflies (*Danaus plexippus* L.) were designated as a threatened phenomenon by the International Union of Conservation of Nature and Natural Resources (IUCN) and the World Wide Fund for Nature (WWF) (Wells et al., 1983; Pyle 1984). The dwindling numbers of suitable overwintering habitats were one of the reasons for the threatened status designation.

Efforts to preserve their mass winter aggregations have resulted in various measures to identify and preserve wintering sites in both Mexico and California. In Mexico, a special Biosphere Reserve for the Monarch Butterfly (REBMM) was established in 1986 to preserve and to reduce the loss of essential winter habitats of the monarch butterflies (Merino 1999, Alonso-Mejia and Alonso, 1999). The wintering habitats are still threatened due to continued logging and destruction of overwintering areas by the *campesino* (indigenous peoples). The Mexican government is currently trying to reduce the destruction of wintering sites by providing alternative sources of income for the *campensino* (e.g. tourism and raising of native deer).

In 1988, the California Legislator allocated a sum of $2,000,000 from a bond issue of $776 million for the acquisition of land on which monarchs overwinter along the Pacific coastline (Malcolm 1993). Although critical habitats have been purchased though this legislation (e.g. Escalona Gulch, Santa Cruz County), this legislation has not insured the preservation of the monarch's aggregation phenomenon because it does not account for the dynamic and changing nature of wintering sites. Wintering sites are suitable only for

a few decades and will eventually become unsuitable due to the normal maturation of the forested areas or to tree losses due to diseases (i.e., pine pitch canker), to insects (i.e., eucalyptus bark borer and the Lerp psyllids) and to urban development (e.g. Escalona Gulch, Santa Cruz County). Sakai and Calvert (1991) have reported overwintering butterflies in various tree species which include willow, laurel, alder, redwood, and palm, but were frequently found in larger populations in groves consisting of pure and mixed stands of eucalyptus and Monterey pine trees. Leong (1990) found no statistical differences among the microclimatic conditions associated with trees supporting winter aggregations of monarchs in groves consisting of pure pine, pure eucalyptus or the mixture of the two tree species. His findings suggest that overwintering monarch butterflies are attracted to the microclimatic conditions created by the forested areas and surrounding topography rather than to a particular tree species.

Wintering sites may be functionally classified as transitional or climax sites, based on their ability to maintain conditions conducive for winter aggregations (Leong et al. 2002). Transitional sites are those with ephemeral conditions and are generally used by overwintering butterflies early in the season. These sites are abandoned by the butterflies when conditions become unsuitable for aggregation, e.g. strong winds. Climax sites are those that provide suitable conditions throughout the season and may or may not support large numbers of overwintering butterflies.

The key to the preservation and maintenance of the monarch's winter aggregations along the California coastline is not only to identify and to preserve (protect) by purchasing critical wintering sites, but also to actively manage the tree groves so that conditions ideal for winter aggregations are perpetuated (Leong et al. 2002). The primary

objective, therefore, is to maintain or to restore conditions that favor winter aggregations of monarch butterflies. Suitable conditions may be achieved or maintained through grove enhancement activities such as plantings of seedlings, and selective limb or whole tree removal. Leong (1999) demonstrated that overwintering sites are resources that can be managed for the butterflies when he purposely modified a degraded grove to restore conditions for winter aggregations. He found that overwintering monarch butterflies returned to the grove when conditions were restored.

The objectives of this study were; (1) to establish a baseline information of the seasonal environmental conditions of Lighthouse Field State Beach overwintering site; (2) to identify the overwintering monarch's sphere of biological activities (areas used for roosting, sunning, foraging for water or nectar and for mating); (3) to determine seasonal population variation and location of winter aggregations within the grove proper for one winter season (October 2001 to February 2002); and (4) to develop the bases for long term habitat management for this winter site.

Materials and Methods

A. Study site and sampling areas. Lighthouse Field State Beach winter habitat is located in Santa Cruz County (36°57'15" N; 122°01'33" W) and is a relatively flat open grassy field, with patches of Monterey cypress trees (*Cupressus macrocarpa*), mixture of bluegum eucalyptus (*Eucalyptus globulus*) and Monterey cypress trees, willow (*Salix* sp), and additional species such as palm and walnut trees. The main aggregation grove (MAG) is a mixed stand of Monterey cypress and Bluegum eucalyptus trees, approximately 150 meters west of the junction of West Cliff Drive and Pelton Avenue (Figure 1).

Starting 30 meters west of the MGA and along the southern edge of Pelton Avenue, five sampling rows were established. Row A1 was located at southern edge of Pelton Avenue and rows B1 to E1 extended into Lighthouse Field State Beach, 30 meters apart, in a north to south orientation (Figure 1). With the exception of the last inner row, each row, going from west to east, had 7 sampling areas, 30 meters apart (Figure 1). The last row (E) had only 5 sampling areas. The location of each sampling site within Lighthouse Field State Beach was identified by imbedding an 18 in (45.7 cm) reinforcement bar into the ground and capping the exposed end with a plastic pink cap. The location of each site was also recorded as GPS coordinates by James Keller, GIS coordinator, City of Santa Cruz, Santa Cruz, CA 95060.

B. Aggregation area. During each sampling date, the location and the number of trees supporting winter aggregations, the number of butterflies on each tree, and the height of

Figure 1. Outline of the main aggregation grove (MAG) and surrounding vegetation showing the five sampling rows, A to E. Each row was 30 m apart and extended into Lighthouse Field State Beach in a north-south orientation. Except for row E, each row had 7 sampling areas, 30 m apart. Row E had 5 sampling areas.

the butterflies' clusters were recorded to determine population size and variation and clustering pattern (tree use) within the MGA during the season. The number of monarch butterflies within clusters was determined by counting the number of individual butterflies in a given area and multiplying that value by the total area occupied by the cluster. The heights of the butterflies' winter aggregations were determined by a range opti-altimeter. The microclimatic conditions associated with the winter aggregations were determined by recording the values of the same 5 environmental parameters described for the sampling areas. Measurements were taken directly below trees supporting the monarch's winter aggregations. The aforementioned data were taken during the early morning hours between 0730 and 0800 PST.

C. **Sphere of biological activity.** During clear winter days with temperatures of ≥55°C, the butterflies leave their clusters to forage for water or nectar, sun or find mates. To determine their sphere of biological activities from their aggregation trees, sample radii of 30, 60 and 90 meters were established in Lighthouse Field State Beach and adjacent areas such as residential yards and church properties. Because of the past concerns of monarch butterflies foraging for water or nectar, sun or find mates on the church properties, the 90 m survey radius was modified to include the lawn areas along Pelton Avenue and West Cliff Drive (up to the Statue). Beyond 90 meters, the biological activity of butterflies was confined to Lighthouse Field State Beach. Observational records on the number of butterflies, their location, and type of activity were taken at 2 hr intervals, starting at 0800 hr and terminating at 1400 hr, PST. During each interval, the 30 m radius sample took between 30 to 40 min to complete while the 60 m and 90 m radii

took between 15 to 40 min to complete depending upon the number of butterflies encountered.

D. Environmental data. At each sampling area, the following parameters were measured: (1) wet and dry bulb temperatures, using a Taylor-Syeron sling psychrometer, for temperature and vapor pressure deficit determination; (2) solar radiation, with a Kahlsicon radiation balance meter; (3) light intensity, with an illumination meter; (4) the highest wind velocity during a minute interval, with a Kestrel 3000 pocket weather meter; (5) wind direction using a Silva ranger compass. The environmental data were collected twice monthly between 0730 to 1000 PST starting in the last week of October, 2001 to the third week of February, 2002.

Results and Discussion

A. Seasonal population abundance and intra-grove location of the monarch's aggregations. Overwintering butterflies were present at Lighthouse Field State Beach winter site at the time this project began (October 25). Their aggregations were observed on foliage of two Monterey cypress and two eucalyptus trees. The initial population numbers, based on visual estimate, were 3,300. Subsequent population census showed that their numbers increased to peak abundance of 6,000 butterflies by December 11, maintained a population of ≈5,000 butterflies through January and began to decline significantly by the first week of February (Figure 2, Table 1). By the second week of February, only 600 butterflies remained and most butterflies that remained were males. In contrast, neighboring Natural Bridges winter site had ≈3,000 butterflies that began to leave by December and by the last week of December, no winter aggregations were observed within the grove.

Earlier studies concerning overwintering butterflies of California suggest that female monarch butterflies were the first to leave the wintering sites and disproportionately higher numbers of male than female were common towards the end of the season (Leong et al. 1995, Frey et al. 1998). The monarch butterflies at Lighthouse Field State Beach began their "spring" migration a week earlier than other, more southern central coast winter sites (personal observations). Similar early population declines for Natural Bridges was noted during winter season 1991-1992 and for Pacific Grove during winter season 1993-1994 (Leong & Frey 1991; Leong 1994). According to John Dayton (personal communication), spring migration occurs earlier in Santa Cruz County than

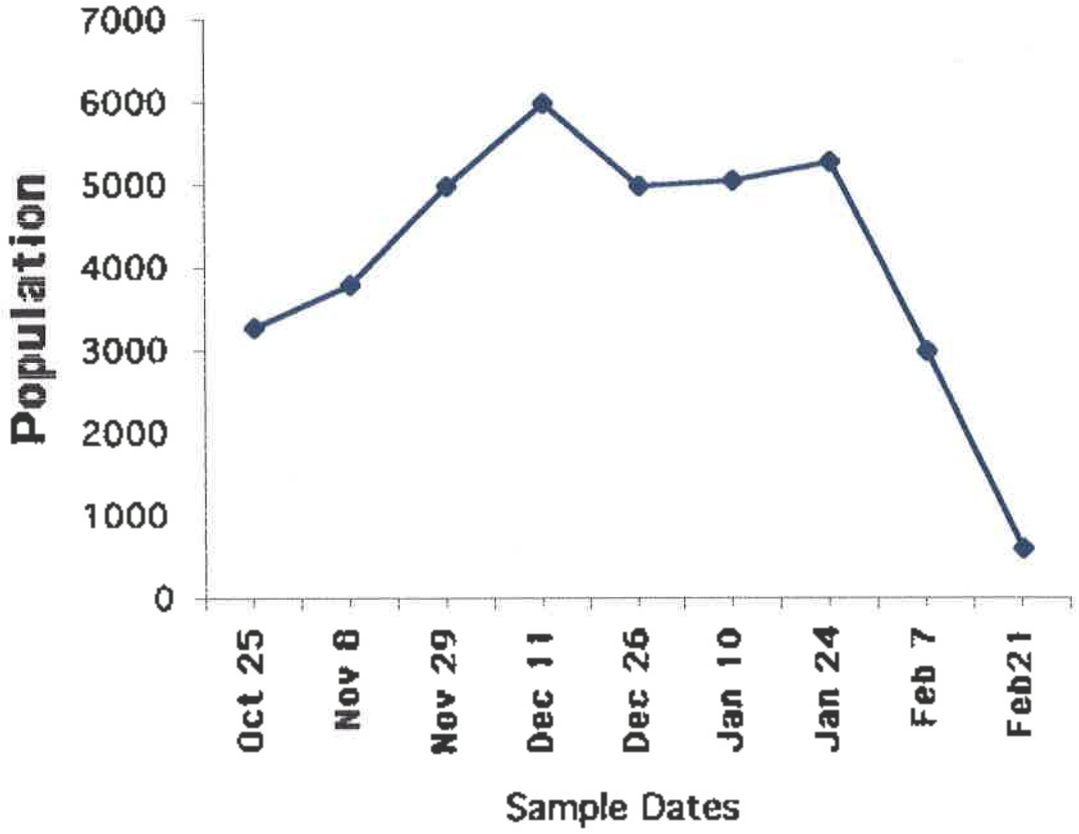

Figure 2. The population numbers of monarch butterflies overwintering at Lighthouse Field State Beach, Santa Cruz, California recorded during winter season 2001-2002.

Table 1. The number of trees supporting butterfly clusters, average cluster height, population and the average environmental variables recorded during the 9 surveys (winter season 2001-2002).

Date	No. trees	Height (ft)	Population	Temperature (°C)	VPD (mm Hg)	RH (%)	Light intensity (ft can)	Solar Radiation (ca; cm^{-2} m^{-1})	Max Wind (m/sec)
Oct 25	4	18.5±2.5	3300	58.5 ±0.5	0.28±0.03	56.5±5.5	63.0±10.6	0.03±0.0	1.1±0.1
Nov 8	3	23.3±4.4	3800	52.7 ± 0.7	0.26±0.01	71.7±2.7	44.0±1.0	0.02±0.0	1.2±0.1
Nov 19	1	28.0±0.0	5000	50.0 ± 0.0	0.36 ±0.00	100 ±0.0	20.0±0.0	0.01±0.0	0.3±0.0
Dec 11	1	25.0±0.0	6000	40.7 ± 0.7	0.23±0.02	85.0±0.0	31.0±9.5	0.01±0.0	0.6±0.3
Dec 26	1	21.5±6.5	5000	51.5 ±0.5	0.33±0.02	87.5±6.5	12.5±2.5	0.01±0.0	0.7±0.0
Jan 10	1	22.5±2.5	5050	46.3 ± 0.3	0.29±0.00	86.0±0.0	35.0±2.8	0.01±0.0	0.7±0.2
Jan 24	2	17.5±2.5	5300	47.0 ± 0.0	0.23±0.00	72.0±0.0	113.3±23.3	0.02±0.0	0.5±0.0
Feb 7	3	20.0±2.0	3000	50.0 ± 0.0	0.36±0.00	100±0.0	30.7±0.7	0.03±0.0	0.8±0.1
Feb 21	3	27.5±2.5	600	52.0 ± 0.0	0.36 ±0.00	94.0±0.0	83.3±3.3	0.03±0.0	1.1±0.2
Ave	2.1	18.2±2.8	3368	50.1±1.0	0.29±0.0	80.5±3.2	52.1±1.0	0.02±0.0	0.87±0.1

in other overwintering populations in the central coast. Monarchs of the southern central coast generally begin their spring migration by the third week of February.

The winter aggregations of monarch butterflies were found on more trees at the beginning and the ending of the season (Table 1). During the October 25 and November 8 surveys, for example, the butterflies clustered on 4 and 3 trees, respectively; from November 19 to January 10, the butterflies aggregated just on one cypress tree; on January 24 on two and on February 7 and 24, on three trees. This expansion, contraction and expansion on the number of trees supporting butterfly clusters during the winter season were similar to those recorded for previous studied central coast wintering sites (Leong 1990, Leong & Frey 1991, Leong 1994) and seem to be associated with the available solar radiation. The butterflies clustered on more trees when solar radiation was >0.01 cal cm^{-2} m^{-1} and only on one when solar radiation was 0.01 cal cm^{-2} m^{-1} (Table 1).

The heights at which the monarch butterflies clustered ranged from 17.5 ft ± 2.5 SE to 27.5 ft ± 2.5 SE (mean 18.2 ft ± 2.8 SE), but were not statistically different. At these heights, the neighboring foliage of eucalyptus trees on east, north and west of the clusters sheltered the roosting butterflies from gusty winds. The cypress foliage on which they formed their winter aggregations provided minimal protection from winds from the south. This minimal foliage protection, however, also allowed greater penetration of filtered sunlight.

B. Biological activity of monarch butterflies. Since monarch butterflies are poikelothermic organisms (i.e., their body temperature varies with the temperature of their surroundings; cold blooded), the initiation of their daily activities depends upon exposure to filtered sunlight (radiant energy) and ambient temperatures of ≥55°C to

increase their internal body temperatures to flight threshold (Masters 1993). Once flight threshold temperatures are achieved, they are able to leave their clusters, to fly, to sun on foliage, to hydrate on water or nectar or to find mates.

With the exception of the February 21 survey, the morning temperatures at 0800 hr were below flight threshold, and no butterfly activity was recorded for this observational period. The field notes are presented in Appendix A.

For the first 5 of 9 surveys (October through December), the butterflies did not venture more than 40 meters from the cluster trees and confined their activities mainly within Lighthouse Field State Beach (Figures 3 to 7). The majority of the butterflies were observed within or near the main aggregation grove (MAG) sunning on foliage of eucalyptus and Monterey cypress trees. A few were observed feeding on eucalyptus flowers or were on the ground imbibing morning dew on grasses and moist soil. On the October 25 and on December 11 surveys, some butterflies were observed outside of Lighthouse Field State Beach. On the October 25 survey, three were observed feeding on flowers in a residential yard located at the junction of Pelton and Phelan Road and 25 were observed along Pelton Avenue, approximately 35 meters northeast of the MAG, sunning on foliage of eucalyptus trees (Figure 3). One butterfly was observed in the Gateway School garden ovipositing on golden flower milkweed (*Asclepias currassavica*). On the December 11 survey, one butterfly was observed in the Gateway School garden feeding on the yellow flowers of bur clover (*Medicago polymorpha*).

The January surveys recorded greater numbers of butterflies sunning, flying, and seeking nectar and mates. They were observed sunning on foliage of trees of the MAG

Figure 3. Monarch biological activities recorded during October 25 between 1000 hr and1600 hr. The orange color on the trees represents butterflies either sunning or imbibing nectar. The spherical orange circles are butterflies imbibing morning dew grass or moist soil.

Figure 4. Monarch biological activities recorded during November 8, 2001 between 1000 hr and1600 hr. The orange color on the trees represents butterflies imbibing nectar while the yellow represents butterflies roosting or sunning on foliage. The spherical orange circles are butterflies imbibing morning dew on grass or moist soil.

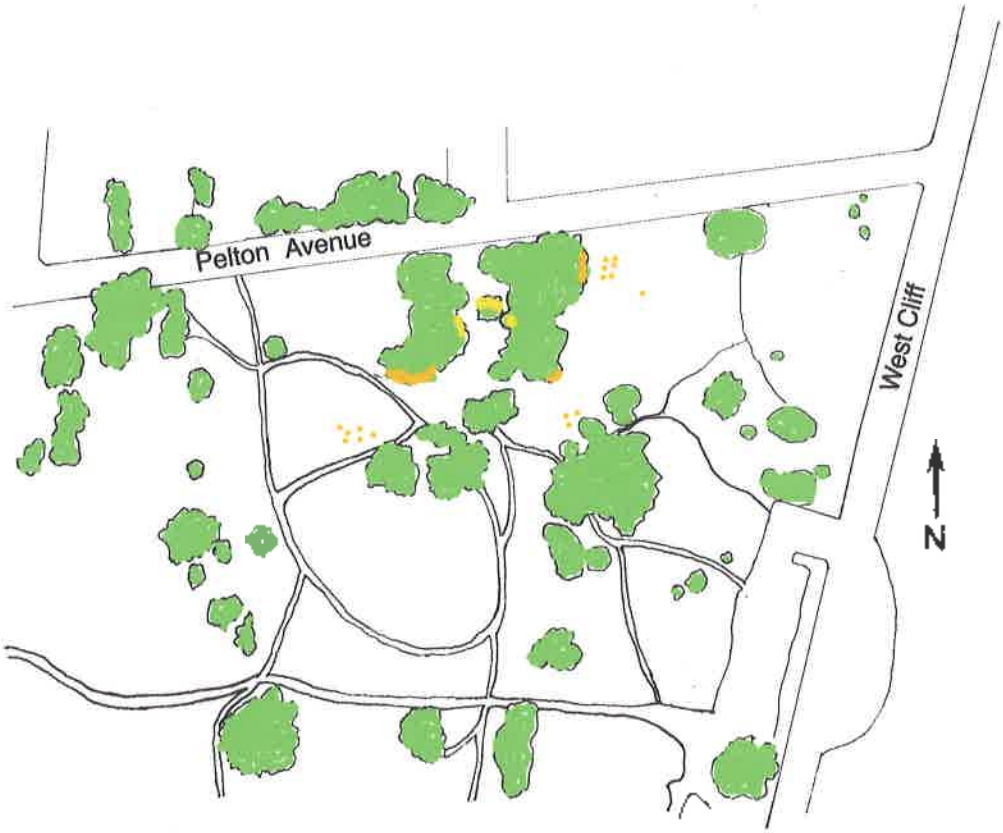

Figure 5. Monarch biological activities recorded during November 19, 2001 between 1000 hr and1600 hr. The orange color on the trees represents butterflies imbibing nectar while the yellow represents butterflies roosting or sunning on foliage. The spherical orange circles are butterflies imbibing morning dew on grass or moist soil.

Figure 6. Monarch biological activities recorded during December 11, 2001 between 1000 hr and1600 hr. The orange color on the trees represents butterflies imbibing nectar while the yellow represents butterflies roosting or sunning on foliage. The spherical orange circles are butterflies imbibing morning dew on grass or moist soil.

Figure 7. Monarch biological activities recorded during December 26, 2001 between 1000 hr and1600 hr. The orange color on the trees represents butterflies imbibing nectar while the yellow represents butterflies roosting or sunning on foliage. The spherical orange circles are butterflies imbibing morning dew on grass or moist soil.

as well as on foliage of cypress trees approximately 45 meters south of the roosting area (Between row C and D, columns 1, 2,and 3, Figures 8 & 9). Although eucalyptus blossoms were abundant on trees located southeast of the clustering area, near sample site D3, the butterflies fed only on eucalyptus flowers of MAG trees because these flowers were in full sunlight while the former were in the shade. Previous field investigations have revealed that monarch butterflies seek nectar or moisture in sunlit areas and seldom in shaded areas (unpublished observational data). At 1400 hr, the butterflies were observed imbibing dew on grasses and moist soil ≥30 meters west, south and east of the MAG. Although large numbers of butterflies were active within Lighthouse Field State Beach from 1000 hr to 1400 hr, no butterflies were observed north of the MAG, from the junction of Phelan – Pelton to Pelton-West Cliff Drive. Some mated pairs were observed on the ground under roosting trees and on the ground just below the trees of the MAG with south facing foliage.

The February 7 survey recorded no butterfly activity due to rainy and stormy conditions (Figure 10). Although only ≈600 butterflies remained on the February 21 survey, the butterflies were more active and were sunning, flying, feeding (morning dew and nectar) and mating by 0800 hr and as far as 60 meters south of the MAG. By 1200 hr, the butterflies extended their flying, sunning and foraging for moisture or nectar activities beyond the row E sampling sites (>120 meters). The butterflies were observed feeding on wild mustard (*Brassica* spp.) and on wild radish (*Raphanus sativa*) flowers that were growing ubiquitously in the open areas of Lighthouse Field State Beach (Figure 11). Two butterflies were observed north of the aggregation area, in the Gateway School garden, feeding on bur clover flowers.

Figure 8. Monarch biological activities recorded during January 10, 2002 between 1000 hr and1600 hr. The orange color on the trees represents butterflies imbibing nectar while the yellow represents butterflies roosting or sunning on foliage. The red circles represent mating pairs. The spherical orange circles are butterflies imbibing morning dew on grass or moist soil.

Figure 9. Monarch biological activities recorded during January 24, 2002 between 1000 hr and1600 hr. The orange color on the trees represents butterflies imbibing nectar while the yellow represents butterflies roosting or sunning on foliage. The red circles represent mating pairs. The spherical orange circles are butterflies imbibing morning dew on grass or moist soil.

Figure 10. The butterflies remain in their clusters the entire observational period (0800 hr to1600 hr) on of February 7 survey due to rainy and stormy conditions.

Figure 11. The February 21 survey was unlike other surveys; the butterflies were active by 0800 hrs when they were observed sunning, mating and imbibing on moisture and nectar. They also foraged widely and at greater distances within and outside of Lighthouse Field State Beach.

By the 1400 hr observational period, the number of butterflies sunning, flying, mating and foraging for nectar or water decreased significantly and some butterflies returned to the MAG where they began to reform clusters on the cypress trees.

The composite roosting, sunning, feeding, and mating areas recorded during the 9 surveys (October 25, 2001 to February 21, 2002) defines the sphere of biological activities of the monarch butterflies at the Lighthouse Field State Beach wintering site for the 2001-2002 season (Figure 12). As depicted, most of the areas used by the monarch butterflies for their biological activities were confined to Lighthouse Field State Beach. Less than 2% of the active butterflies were found north of Lighthouse Field State Beach in neighboring properties such as the Oblates of Saint Joseph properties (Church, Gateway School) and residential areas.

C. Environmental conditions of Lighthouse Field State Beach wintering site. Since this study represents just one season's data and the beginning of a long-term management program for the Lighthouse Field State Beach wintering site, no detailed analyses were made on the seasonal variation of the environmental parameters at each sample site. The data, however, are presented as Appendix B in this report for future reference.

This past season was relatively mild, with only one winter storm that brought winds strong enough to blow the roosting butterflies on to Pelton Avenue. The storm occurred in the second week of November and during the early morning hours. Consequently, no data were obtained as to the direction and velocities of the storm winds. According to a resident living near Lighthouse Field State Beach, the storm winds were strong enough to

Figure 12. The composite roosting, sunning, feeding, and mating areas recorded during the 9 surveys (October 25, 2001 to February 21, 2002) clearly defines the sphere of biological activities of the monarch butterflies at Lighthouse Field State Beach wintering site.

dislodge the butterflies and to blow many of them on to Pelton Avenue. After the storm, the resident transferred many of the downed butterflies off of Pelton Avenue.

Leong (1999) reported the effects of storm winds to roosting butterflies. When monarch butterfly clusters were exposed to storm winds ≥ 2.0 m/sec, the butterflies were either blown from their clusters or shaken from the branch on which they aggregated. If ambient temperatures were above flight threshold (≥55°F), the dislodged butterflies would fly and reform their aggregation on more wind-protected foliage within the grove. If ambient temperatures were below flight threshold, the dislodged butterflies would be blown to the ground and remain there until the ambient temperatures reached flight threshold.

Based on the aerial vegetation map of Lighthouse Field State Beach winter site, trees southwest of the MAG are sparsely distributed and offer little protection from southwest storm winds. In addition to poor wind protection, winds from the southwest would be "funneled" to the clustering area because the row of Monterey cypress trees just south of the MAG form a natural wind corridor (Figure 13). It is not surprising, therefore, that winter storm winds blow butterflies on to Pelton Avenue.

Other than the November storm, this past winter season had few storms with disruptive winds. Most survey days were mild and winds ≥ 2 m/sec were infrequent and came either from the south or northeast (Figure 14). These winds, however, were effectively buffered by trees of the MAG or by the group of "wind corridor" Monterey cypress trees just south of the MAB.

The average temperatures, light intensity and solar radiation values showed a general decrease through most of the season and a slight increase towards the end of the

Figure 13. Natural wind corridor (indicated by the mustard color) formed by Monterey cypress trees south of the main aggregation grove.

Figure 14. Winds ≥ 2 m/sec during most visitations were infrequent and were from the south or northeast. These winds were effectively buffered by the MAG trees or by the Monterey cypress trees south of the aggregation area.

overwintering period (Table 1).

The values reflect the ending of the autumnal equinox, through the winter solstice and part of the early phase of the vernal equinox. Subsequently, the height of the sun in the sky seems to influence the clustering pattern within the grove. As day length decreased, so did the amount of solar radiant energy. The butterfly's winter aggregations were found on more than one tree when solar radiant energy was ≥0.02 cal cm^{-2} m^{-1} but only one tree when solar radiant energy was 0.01 cal cm^{-2} m^{-1} between 0730-0900 hrs.

The low relative humidity during the first two site visitations was also associated with minimal amounts of morning dew present in Lighthouse Field State Beach. During this period, several butterflies would sun and seek moisture outside of Lighthouse Field State Beach in neighboring watered lawn and flowering plants (Figures 3 & 6). From December 27 to February 7, the butterflies were found only within Lighthouse Field State Beach where morning dew was abundant in the sunlit field south and east of the aggregation area until 1400 hrs. Since the sun's angle was low during the winter solstice, much of the areas north of Pelton Avenue (including Gateway school and the neighboring church property) was shaded by the tall trees growing along the northeastern border of Lighthouse Field State Beach. As discussed earlier, monarch butterflies feed only in sunlit areas and seldom in shaded areas.

Towards the end of the season with the increasing sun's height in the sky, day length and temperatures, the butterflies were active by 0800 hrs and by 1000 hrs they were dispersed throughout Lighthouse Field State Beach. A few individuals were observed north of the MAG, feeding on clover flowers in Gateway School garden and moisture on

the lawn of the church property as these areas were no longer shaded gateway property and adjacent church lawn.

The environmental parameters associated with trees supporting butterfly clusters at Lighthouse Field State Beach were similar to those recorded for the Pacific Grove, Pismo North Beach and Morro Bay wintering sites during winter season 1993-1994 (Table 2). The grove tree composition for the Lighthouse Field State Beach wintering site was eucalyptus-cypress, for Pacific Grove eucalyptus-Monterey pine and for Pismo North Beach and Morro Bay, eucalyptus. The similar microclimatic conditions associated with winter groves of different tree species composition support the theory that overwintering butterflies seek specific conditions of winter groves rather than specific tree species.

Table 2. Comparison of the 6 environmental variables associated with trees supporting butterfly clusters at Lighthouse Field to three central coast wintering sites (Pacific Grove, Pismo North Beach and Morro Bay).

Location	Temperature (°C)	VPD (mm Hg)	RH (%)	Light intensity (ft can)	Solar radiation (cal cm^{-2} m^{-1})	Maximum wind (m/sec)
Lighthouse Field (2001-2002)	50.1 ± 1.0	0.29 ±0.0	80.5 ± 3.2	52.1 ± 1.0	0.02 ± 0.0	0.87 ± 0.1
Pacific Grove (1993-1994)	55.6 ± 1.1	0.37 ± 0.0	84.7 ± 1.2	94.2 ± 20.0	0.13±0.0	0.9 ± 0.1
Pismo NB (1993-1994)	51.2 ± 0.6	0.29 ± 0.0	76.8 ± 1.8	57.1 ± 8.6	0.08 ± 0.0	0.7 ± 0.1
Morro Bay (1993-1994)	54.7 ± 0.7	0.28 ± 0.0	66.0 ± 3.2	48.5 ±14.1	0.06 ± 0.02	1.0 ± 0.2

Summary

Approximately 4,000 to 6,000 monarch butterflies overwintered at Lighthouse Field State Beach the entire season, arriving in late October and leaving by February. In contrast, the neighboring Natural Bridges winter site had ≈3,000 butterflies that did not remain the entire winter season and were absent by the last week of December. It appears that Lighthouse Field State Beach wintering site is evolving into a stable climax site while Natural Bridges wintering site seems to be degrading into a transitional one. The decline of Natural Bridges may be attributed to the loss of Monterey pine trees due to the pine pitch canker disease and the loss of Red gum eucalyptus foliage (*E. camaldulensis*) due to the Lerp psyllid.

Within the main aggregation grove of Lighthouse Field State Beach, the butterflies formed their winter aggregations mainly on Monterey cypress foliage at an average height of 22.2 ft ±1.2 SE. At this height, the aggregations were sheltered from gusty winds approaching from the west, north and east by surrounding eucalyptus trees. The butterflies, however, were minimally protected on the south and are susceptible to southwest winds due to the natural wind corridor formed by Monterey cypress trees growing south of the main aggregation grove.

The butterflies clustered in an area of the grove that offered microclimatic conditions conducive for winter aggregations (Leong 1990, Leong et al. 1991) and were similar to those recorded at other wintering sites (Table 2). These conditions were maintained throughout the season and at the Lighthouse Field State Beach wintering site and subsequently the butterflies to remained at the grove the entire season.

The seasonal pattern of biological activities reflected an oval sphere of distribution that extended deep into Lighthouse Field State Beach where they foraged for nectar or water, sunned, soared, or found mates. Less than 2% of the active butterflies were observed north of the MAG (i.e., resident, Gateway School, and church properties) during the winter season.

Although winds 2 m/sec were recorded during surveys, they were infrequent and were coming from the southeast and northeast of Lighthouse Field State Beach. The trees comprising the MAG and the group of Monterey cypress trees south of the aggregation area effectively buffered these wind gusts. Tree densities southwest of the MAG offered little protection against storm winds from the southwest and the group of Monterey cypress trees south of the MAG compounded the problem by forming a corridor that funneled winds to the trees supporting butterfly clusters (Figures 15).

Figure 15. Southwest winds maybe funneled to the cluster trees due to the natural wind corridor formed by the group of the Monterey cypress trees south of the aggregation area.

Management of Lighthouse Field State Beach winter habitat

For the past few winter seasons, the butterflies have used the Lighthouse Field State Beach habitat as a climax wintering site. The management of the Lighthouse Field State Beach wintering site should encompass incremental objectives or goals.

A. Goal 1. The first goal is to protect the main aggregation grove from southwest storm winds. As discussed earlier, the trees southwest of the MAG were sparsely distributed and offered very little wind protection. Spaces between established trees in this region should be inter-planted with tree species that would effectively buffer storm winds as well as allow filtered sunlight to reach the aggregation area (Figure 16).

Lighthouse Field State Beach has two dominant tree species, bluegum eucalyptus and Monterey cypress, that can be used to enhance the habitat. Both species, however, have advantages and disadvantages. The advantages of using bluegum eucalyptus trees are their ability to grow rapidly, to buffer winds, to provide source of nectar for overwintering butterflies and to produce new growth when cut. This tree species, however, has obvious liabilities such as production of allelopathic chemicals, production of litter prone to fire and limbs known to break or fall during stormy conditions. Monterey cypress trees produce stiff branches with dense foliage that effectively buffer storm winds, but their rate of growth is slower than eucalyptus, their dense thick foliage tends to screen out much of the essential filtered sunlight, do not regenerate new growth readily and like eucalyptus, their tree limbs are susceptible to breakage during storm conditions. Perhaps the solution involves the inter-plantings of a mixture of bluegum

Figure 16. Suggested new seedling plantings of Monterey cypress or eucalyptus or a mixture of the two tree species to buffer future southwest winds.

eucalyptus and Monterey cypress trees in a pattern that would take advantage of their positive attributes and minimize their negatives.

To reduce the funneling of the winds into the aggregation arena, the Monterey cypress closest to the MAG (Figure 17) should either be removed or modified through selective tree trimming to reduce or eliminate the wind "corridor". Plantings of two or more rows of Monterey cypress and/or eucalyptus seedlings between D2 an D3 should be established before removing or modifying the Monterey cypress wind corridor (Figure 16).

B. Goal 2. The second goal is to relocate the aggregation arena further south into Lighthouse Field State Beach so butterflies dislodged from their clusters during winter storms would fall within the habitat rather than on to Pelton Avenue (Figure 17). Although disruptive, very few (<1%) monarch butterflies are killed directly by being blown onto the ground (unpublished field data). A greater danger to the butterflies is passing cars that may kill them while they lay on Pelton Avenue.

The relocation of the cluster arena further south involves new plantings of Monterey cypress or eucalyptus seedlings ≈20 feet south of the present aggregation trees (Figure 17). In addition, selective trimming of the Monterey cypress trees south of the MAG may be necessary to allow penetration of filtered winter sunlight into the cluster arena. The degree of selective thinning to the Monterey cypress south of the MAG will depend upon the amount of filtered sunlight penetrating onto the new "target" cluster trees during critical morning and afternoon hours. Morning sunlight is necessary to increase the butterflies' body temperatures for their winter activities and the afternoon

Figure 17. Suggested location of new trees for winter aggregations and the group of Monterey cypress that needs to be modified to reduce the wind corridor effect.

sunlight is needed for their re-aggregation activities. Unlike the southern central coast, ambient temperatures do not warm to 55°C until 0930 hr to 1000 hr during much of the winter season. Consequently, the new cluster trees should be exposed to filtered sunlight between the hours of 0900 hr. to 1000hr and again between 1300 hr and 1430 hr to reform their clusters. This past winter season, the butterflies began to reform their winter aggregations by 1330 hr at Lighthouse Field State Beach. The amount of filtered sunlight that the new "target" trees are exposed ti during the critical morning and afternoon hours should be documented during the winter season. Implementation of selective trimming of tree limbs could be accomplished during the season if such modification would not be detrimental to the butterflies. The advantage of selective tree trimming during the season is the actual exposure of the new cluster arena to the winter sunlight.

C . Goal 3. The last and most important goal is the maintenance of the grove's suitability for winter aggregations. This goal may be accomplished through grove enhancement activities based on the monitoring of biological and environmental variables that influence their seasonal population size, duration of occupancy and aggregation pattern within the grove. The best indicator of the habitat's viability and health is the monarch butterfly. Consequently, the management of a winter grove should be based on the presence and activities of the overwintering monarch butterflies. These include:

1. **The decline in the seasonal numbers of overwintering butterflies.** Although population numbers vary depending upon the season, the population is a good measure of the habitat's suitability when compared to the historical population numbers for the site and the general population trends throughout the state of California. If the population shows a consistent decline for three consecutive

seasons while neighboring winter sites show an increase or similar numbers as the previous seasons, the microclimatic conditions of the habitat may be changing and should be evaluated. Based on the findings, grove enhancement activities such as new plantings to provide better wind protection or selective tree or limb removal to allow more filtered sunlight into the cluster arena could be implemented.

2. **The abandonment of the grove by the overwintering butterflies before the end of the winter season.** The winter season in California begins in late October and ends usually by mid February or early March. If a climax site is abandoned before February, the grove conditions should be evaluated to determine the reasons for the butterflies' early departure. Factors that may contribute to their early departure may include the loss of protection against gusty and storm winds, and the lack of sufficient sunlight on the cluster trees during critical morning and afternoon hours. As discussed earlier, afternoon sunlight is important for the butterflies to reform their winter aggregations.

3. **The reduction in the number of trees supporting clusters during late December and early January.** Winter aggregations of monarch butterflies are generally found on trees that offer protection from gusty winds and provide best access to filtered sunlight, particularly the amount of radiant energy. As discussed earlier, a greater number of trees support aggregations of monarch butterflies is more at the beginning (October and November) and towards the end of the season (February and March). During late December and early January, the sun's radiant energy is limiting due to the short day length and the lower

height of the sun in the sky. The butterflies during this period will form winter aggregations on certain wind protected trees that provide best exposure to sunlight. If the winter aggregations are concentrated just to one tree, then it maybe be assumed that the "bubble" of suitable conditions for winter aggregations is small or limiting. The key to the expansion of this "bubble" (carrying capacity) is to increase the number of wind sheltered exposed to filtered sunlight during the critical hours.

4. **The effect of storm winds to overwintering butterflies.** Winter storms that have the most negative impact to overwintering butterflies are those that encroach the grove from the south. Reason? Monarch butterflies tend to form their winter aggregations on trees located on the southern edge of a grove and often next to a clearing or open area. Their southern location provides shelter from the prevailing gusty winds, but also allows the roosting butterflies optimum exposures to filtered winter sunlight. Often, however, there is a fine line between the butterflies' access to winter sunlight and the protection from southern storm winds. Trees that can effectively buffer storm winds generally have dense, sturdy foliage but can also block or limit penetration of sunlight to roosting butterflies.

5. **Butterflies foraging for nectar or water outside the winter habitat.** Overwintering butterflies need to imbibe water to survive. These butterflies are physiologically different from the summer generation in that they are in reproductive diapause, long lived and have large amount of fat reserves. The fat reserves allow the butterflies to survive the winter without the need of nectar sources, but they do require water to metabolize their body lipids. Butterflies that

overwinter in the high mountains of Mexico depend primarily on these fat reserves to survive the winter months because their winter habitat lacks of sufficient winter flowering plants to support the large populations of monarch butterflies (> 200 million). In California, overwintering populations have the luxury of winter flowering plants to supplement their diet, but they still depend primarily upon their fat reserve for their winter survival. Consequently, most overwintering sites in California are associated with an abundance of morning dew, close proximity of a pond, stream or the presence of winter flowering plants.

At Lighthouse Field State Beach, morning dew is present in abundance through most of the winter season except during months of October and most of November. During this period, the butterflies may seek moisture in neighboring irrigated residential yards. To minimize the butterflies' foraging activities outside of Lighthouse Field State Beach during these dry months, the sunlit fields east and south of their aggregation area (MAG) could be irrigated with a sprinkler system between the hours of 0730 and 0800 hrs. Moisture on grass and soil would then be available to the butterflies when ambient temperatures reach and exceed flight threshold. Irrigation of open sunlit fields is important because the butterfly will seek moisture and nectar only in areas that are in sunlight.

6. **Limiting public access to the aggregation trees.** Two major concerns with public access to the winter groves are: (1) objects thrown (e.g., stones or sticks) at the butterflies while they are in clusters; and (2) deaths caused by stepping on the butterflies while they lay on the ground due to low temperatures (< 55°C) or to mating activities. Possible solutions to minimize the danger to the butterflies

are the establishment of: (1) a rail fence around the trees supporting butterfly clusters; (2) gravel trails leading to and away from the main aggregation trees; and (3) signage to explain the need to preserve the monarch's endangered phenomenon (mass aggregations) and ways to avoid or handle the butterflies on the ground.

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Appendix A (Field notes of monarch's winter activities)

Field notes on the monarch's winter activities during winter 2001-2002 at Lighthouse Field State Beach Overwintering Site.

October 25, 2001

Time	total	Activity	Number of Butterflies
12 pm	211	sunning	201 in grove 2 Gateway & church
		flower	3 in residential yard (junction of Pelton and Phelan Rd)
		sunning	25 on eucalyptus (35 m NE of MAG)
2 pm	0	0	0

Strong winds from N280W (4.2 m/sec) and S240E (2.7 m/sec).

November 8, 2001

Time	Total	Activity	Number of Butterflies
8 am	0		0
10 am	474	sunning	467
		feeding on flower	5
		field	2
12 pm	3	sunning	0
		feeding on flower	0
		field	3

November 19, 2001

Time	Total	Activity	Number of Butterflies
8 am	0		0
10 am	18	sunning	0
		flowers	15
		field	3
12 pm	1,660	sunning	1651
		flowers	3
		field	6
2 pm	152	sunning	135
		flowers	2
		field	15

December 11, 2001

Time	Total	Activity	Number of Butterflies
8 am	0		0
10 am	3	sunning	0
		flower	0
		field	3
12 pm	147	sunning	125
		flower	15
		field	6
		Gateway	1
2 pm	313	sunning	310
		flower	3
		field	0

December 26, 2001

Time	Total	Activity	Number of Butterflies
8 am	0		0
10 am	20	sunning	12
		flower	1
		field	0
		flying	7
12 pm	282	sunning	258
		flower	16
		field	8
2 pm	113	sunning	3
		flower	0
		field	0
		flying	110

January 10, 2002

Time	Total	Activity	Number of Butterflies
8 am	0		0
10 am	44	sunning	27
		flower	4
		field	13
12 pm	498	sunning	372
		flower	35
		flield	38
		mating	3
		flying	50
1 pm			
outer (C & D) region			
	269	sunning	42
		flower	10
		field	17
		flying	200
2 pm	2380	sunning	1917
		flower	146
		field	39
		flying	278
outer (C & D) region			
	285	sunning	281
		field	4

January 24, 2002

Time	Total	Activity	Number of Butterflies
8 am	0		0
10 am	6	sunning	2
		flower	2
		field	2
12 pm	146	sunning	120
		flower	5
		field	21
outer (C & D) rows			
	8	sunning	3
		field	5
2 pm	1549	sunning	1448
		flower	60
		field	41
outer (C & D) rows			
	12	sunning	6
		flower	0
		field	2
		flying	4

February 7 (rain out)

Time	Total	Activity	Number of Butterflies
8 am	0		0
10 am	0		0
12 pm	0		0

terminated due to increasing rain.

February 21

Time	Total	Activity	Number of Butterflies
8 am	60	sunning	25
		flower	7
		field	26
		mating	2
outer (C & D) rows			
	311	sunning	176
		flower	0
		field	76
		flying	53
		mating	6
10 am	118	sunning	72
		flower	16
		field	28
		mating	2
outer (C, D & E) rows			
	91	sunning	50
		flower	0
		field	9
		flying	28
		mating	4
12 pm	52	sunning	32
		flower	9
		field	10
		mating	1

February 21, 2002

12 pm			
outer (C, D & E) rows			
	41	sunning	6
		flower	0
		field	12
		mating	1
		flying	20
		field	2 Gateway
beyond row E			
	23	sunning	0
		flower	0
		field	4
		flying	19
2 pm	97	sunning	60
		flower	13
		field	3
		mating	1
		flying	20
outer (C, D & E) rows			
	41	sunning	2
		flower	0
		field	5
		flying	32
		mating	2
beyond row E			
	14	sunning	0
		flower	0
		field	3
		flying	11

Appendix B (Environmental variable values at sample sites)

Environmental variables collected at each sample station

DATE	SITE	WB	DB	VPD	RH	LI	SR	MAXWIND	WINDDI REC
10/25/01	A1	52	57	0.334	71	80	0.02	1.2	N90E
10/25/01	A2	52	57	0.334	71	80	0.02	1.1	N50E
10/25/01	A3	51	59	0.287	56	90	0.03	<0.3	N50E
10/25/01	A4	55	64	0.334	56	400	0.5	0.2	N20E
10/25/01	A5	55	63	0.322	60	130	0.06	0.6	N20E
10/25/01	A6	53	63	0.287	50	100	0.02	0.8	N20E
10/25/01	A7	53	63	0.287	50	130	0.02	1	S120E
10/25/01	B1	59	72	0.36	45	140	0.07	1.4	S240W
10/25/01	B2	59	65	0.448	70	100	0.03	1.1	S240W
10/25/01	B3	59	64	0.448	74	110	0.04	1	S100E
10/25/01	B4	55	66	0.31	48	420	0.56	0.3	S140E
10/25/01	B5	55	66	0.31	48	420	0.52	0.2	S140E
10/25/01	B6	55	66	0.31	48	580	0.43	1.5	S140E
10/25/01	B7	53	63	0.287	50	500	0.45	0.3	S120E
10/25/01	C1	59	72	0.417	45	600	0.86	1.2	S140E
10/25/01	C2	55	67	0.298	45	40	0.01	1	S160E
10/25/01	C3	54	65	0.289	48	600	0.71	0.5	S160E
10/25/01	C4	55	66	0.289	48	80	0.02	2.1	S160E
10/25/01	C5	55	63	0.347	60	130	0.04	0.3	N320W
10/25/01	C6	55	63	0.347	60	130	0.04	0.3	N320W
10/25/01	C7	53	63	0.287	50	600	0.47	0.8	S160E
10/25/01	D1	58	71	0.334	45	600	0.8	1.6	S140E
10/25/01	D2	58	71	0.334	45	600	0.82	1.5	S160E
10/25/01	D3	56	68	0.31	46	600	0.87	1	S165E
10/25/01	D4	53	66	0.256	40	60	0.05	0.2	S160E
10/25/01	D5	57	66	0.36	57	520	0.64	1.5	S160E
10/25/01	D6	57	63	0.402	69	120	0.05	0.4	S130E
10/25/01	D7	57	63	0.402	69	500	0.62	1.1	S160E
10/25/01	E1	58	71	0.334	45	680	0.75	2.2	S160E
10/25/01	E2	58	71	0.334	45	670	0.76	2.3	S160E
10/25/01	E3	54	65	0.298	48	130	0.05	1.3	N60E
10/25/01	E4	56	68	0.31	46	520	72	1	S160E
10/25/01	E5	55	68	0.287	46	520	0.7	0.6	S160E

DATE	SITE	WB	DB	VPD	RH	LI	SR	MAXWIND	WINDDIREC
11/8/01	A1	46	57	0.187	40	90	0.01	0.7	N30E
11/8/01	A2	47	52	0.256	69	80	0.03	1.1	N30E
11/8/01	A3	47	52	0.256	69	90	0.03	1	N30E
11/8/01	A4	45	57	0.164	35	200	0.15	1	N30E
11/8/01	A5	47	57	0.211	45	320	0.24	0.7	N30E
11/8/01	A6	47	54	0.247	59	100	0.04	0.5	N30E
11/8/01	A7	49	59	0.237	47	150	0.05	0.3	S140?
11/8/01	B1	52	57	0.334	71	400	0.37	0.8	N350W
11/8/01	B2	50	57	0.277	61	90	0.02	0.5	N70E
11/8/01	B3	51	57	0.31	66	60	0.03	1.1	N70E
11/8/01	B4	50	57	0.277	61	260	0.4	0.6	S120E
11/8/01	B5	51	58	0.298	61	320	0.32	0.7	N80E
11/8/01	B6	51	58	0.298	61	38	0.38	1.7	N80E
11/8/01	B7	50	57	0.277	61	400	43	0	??
11/8/01	C1	50	57	0.277	61	150	0.03	0.9	N350W
11/8/01	C2	52	57	0.334	71	60	0.02	0.5	N350W
11/8/01	C3	52	57	0.334	71	150	0.02	0.8	N50W
11/8/01	C4	52	57	0.334	71	100	0.05	0.8	N63E
11/8/01	C5	54	61	0.334	63	480	0.42	1.4	N288W
11/8/01	C6	52	60	0.298	58	210	0.07	0.7	N360W
11/8/01	C7	52	60	0.298	58	100	0.57	0.2	N350W
11/8/01	D1	56	64	0.36	60	480	0.73	1.8	S103E
11/8/01	D2	55	63	0.347	59	520	0.71	1	S103E
11/8/01	D3	55	62	0.36	64	500	0.6	0.7	S103E
11/8/01	D4	55	62	0.36	64	90	0.03	1	S103E
11/8/01	D5	55	62	0.36	64	500	0.7	1.3	S143E
11/8/01	D6	55	62	0.36	64	420	0.3	1.3	S98E
11/8/01	D7	55	63	0.347	60	520	0.41	1	N350W
11/8/01	E1	56	64	0.36	60	400	0.09	1.3	S98E
11/8/01	E2	56	64	0.36	60	500	0.67	0.9	N60E
11/8/01	E3	56	64	0.36	60	500	0.51	1	S130E
11/8/01	E4	56	64	0.36	60	520	0.53	0.3	N60E
11/8/01	E5	56	64	0.36	60	520	0.54	0.5	S130E

DATE	SITE	WB	DB	VPD	RH	LI	SR	MAXWIND	WINDDIREC
11/19/01	A1	50	50	0.36	100	70	0.02	0.3	N270W
11/19/01	A2	50	50	0.36	100	70	0.01	1.1	N364E
11/19/01	A3	51	51	0.373	100	50	0.01	1.2	N364E
11/19/01	A4	51	51	0.373	100	80	0.6	N364E	
11/19/01	A5	51	51	0.37	100	1400	0.03	1.7	N343W
11/19/01	A6	51	52	0.36	94	70	0.01	0.6	N320W
11/19/01	A7	51	52	0.36	94	100	0.03	1.5	N290W
11/19/01	B1	53	54	0.387	94	310	0.2	<0.3	N270W
11/19/01	B2	51	52	0.36	94	100	0.03	0.7	N270W
11/19/01	B3	51	52	0.36	94	70	0.02	<0.3	?
11/19/01	B4	51	52	0.36	94	150	0.5	<0.3	?
11/19/01	B5	51	52	0.36	94	130	0.04	<0.3	?
11/19/01	B6	51	52	0.36	94	110	0.03	<0.3	N320W
11/19/01	B7	51	52	0.36	94	120	0.04	<0.03	N290W
11/19/01	C1	53	54	0.387	94	50	0.04	<0.3	N320W
11/19/01	C2	53	54	0.387	94	90	0.01	0.6	S260W
11/19/01	C3	53	54	0.387	94	110	0.03	0.7	S260W
11/19/01	C4	52	53	0.373	94	100	0.05	1.2	S260W
11/19/01	C5	53	54	0.387	94	400	0.24	<0.3	?
11/19/01	C6	53	54	0.387	94	160	0.05	0.4	N280W
11/19/01	C7	53	54	0.387	94	380	0.3	<0.3	N280W
11/19/01	D1	55	56	0.432	94	420	0.42	2.2	N280W
11/19/01	D2	55	56	0.432	94	420	0.4	1.4	N280W
11/19/01	D3	53	55	0.373	88	190	0.1	1.2	N200W
11/19/01	D4	53	54	0.387	94	80	0.03	0.6	N300W
11/19/01	D5	55	57	0.417	88	390	0.3	<0.3	?
11/19/01	D6	55	57	0.417	88	400	0.36	0.5	S210W
11/19/01	D7	55	57	0.417	88	360	0.51	0.7	S210W
11/19/01	E1	55	57	0.417	88	320	0.23	0.9	N280W
11/19/01	E2	55	57	0.417	88	410	0.26	2.4	S250W
11/19/01	E3	55	57	0.417	88	300	0.1	1.5	N290W
11/19/01	E4	55	57	0.417	88	410	0.37	1.6	N290W
11/19/01	E5	55	57	0.417	88	230	0.15	0.6	N290W

DATE	SITE	WB	DB	VPD	RH	LI	SR	MAXWIND	WINDDIREC
12/11/01	A1	39	40	0.228	92	42	0.01	0.6	N354W
12/11/01	A2	39	40	0.228	92	42	0.01	0.7	N108E
12/11/01	A3	39	40	0.228	92	48	0.01	0.6	N360W
12/11/01	A4	39	40	0.228	92	90	0.01	0	?
12/11/01	A5	39	40	0.228	92	90	0.01	0.8	N280W
12/11/01	A6	39	40	0.228	92	90	0.01	0.5	N280W
12/11/01	A7	39	40	0.228	92	100	0.01	0.8	N18E
12/11/01	B1	39	40	0.228	92	120	0.02	0.7	N330W
12/11/01	B2	40	42	0.228	85	120	0.04	0.7	N20E
12/11/01	B3	40	42	0.228	85	50	0.01	0.9	N40E
12/11/01	B4	40	42	0.228	85	180	0.07	0.6	N320W
12/11/01	B5	40	42	0.228	85	110	0.04	0.6	S120E
12/11/01	B6	39	40	0.228	92	140	0.03	0	?
12/11/01	B7	39	40	0.228	92	100	0.03	<0.3	N289W
12/11/01	C1	44	48	0.247	73	140	0.03	0.6	N330W
12/11/01	C2	40	42	0.203	85	100	0.03	0.3	N330W
12/11/01	C3	41	43	0.237	85	100	0.03	0	?
12/11/01	C4	42	44	0.247	85	320	0.23	0.7	N40E
12/11/01	C5	43	44	0.247	93	380	0.34	0.3	N300W
12/11/01	C6	43	45	0.256	86	300	0.21	0.8	N300W
12/11/01	C7	43	45	0.256	86	380	0.2	0.6	N300W
12/11/01	D1	44	47	0.256	79	380	0.38	0.6	S250W
12/11/01	D2	44	47	0.256	79	180	0.23	0.5	S250W
12/11/01	D3	44	47	0.256	79	140	0.05	0	?
12/11/01	D4	45	49	0.256	73	80	0.04	0	?
12/11/01	D5	45	49	0.256	73	400	0.4	1.1	N330W
12/11/01	D6	44	48	0.256	73	400	0.25	0	?
12/11/01	D7	44	47	0.277	79	320	0.4	1.1	N330W
12/11/01	E1	44	47	0.277	79	200	0.13	1.1	N330W
12/11/01	E2	44	47	0.277	79	420	0.4	0	?
12/11/01	E3	45	46	0.287	93	150	0.04	1.1	N330W
12/11/01	E4	45	48	0.266	76	400	0.4	1.2	N330W
12/11/01	E5	45	48	0.266	76	400	0.48	0	?

DATE	SITE	WB	DB	VPD	RH	LI	SR	MAXWIND	WINDDIREC
12/26/01	A1	50	52	0.334	87	30	0.01	70	N40E
12/26/01	A2	49	52	0.298	81	24	0.01	<0.3	N40E
12/26/01	A3	49	52	0.298	81	30	0.01	0.4	N40E
12/26/01	A4	49	52	0.298	81	40	0.01	<0.3	N40E
12/26/01	A5	49	51	0.322	87	48	0.02	0.4	N40E
12/26/01	A6	49	51	0.322	87	32	0	<0.3	N40E
12/26/01	A7	49	51	0.332	87	50	0.01	<0.3	N40E
12/26/01	B1	49	52	0.31	81	100	0.02	0.9	N10E
12/26/01	B2	49	51	0.322	87	80	0.02	1	N10E
12/26/01	B3	50	52	0.334	87	36	0.01	0.9	N30E
12/26/01	B4	50	52	0.334	87	80	0.01	0.9	N300W
12/26/01	B5	50	52	0.334	87	90	0.02	0.3	N40E
12/26/01	B6	50	52	0.334	87	75	0.02	0.3	N40E
12/26/01	B7	50	52	0.334	87	80	0.02	0.3	N40E
12/26/01	C1	50	52	0.334	87	130	0.02	0.4	N10E
12/26/01	C2	50	52	0.334	87	130	0.03	0.5	N360W
12/26/01	C3	49	51	0.322	87	120	0.02	0.5	N360W
12/26/01	C4	49	51	0.322	87	130	0.04	<0.3	?
12/26/01	C5	50	51	0.347	94	150	0.04	0.6	N320W
12/26/01	C6	50	51	0.347	94	280	0.04	0.6	N30E
12/26/01	C7	50	51	0.347	94	170	0.05	<0.3	?
12/26/01	D1	50	52	0.334	87	250	0.1	0.7	N40E
12/26/01	D2	50	52	0.334	87	230	0.1	1.3	N40E
12/26/01	D3	50	52	0.334	87	130	0.04	0.6	N60E
12/26/01	D4	50	51	0.347	94	0.01	0.6	N60E	
12/26/01	D5	50	51	0.347	94	180	0.08	0.8	N350W
12/26/01	D6	50	52	0.334	87	160	0.05	0.7	N10E
12/26/01	D7	50	52	0.334	87	170	0.04	0.05	N10E
12/26/01	E1	50	52	0.334	87	300	0.13	<0.3	?
12/26/01	E2	51	53	0.347	87	300	0.13	<0.3	?
12/26/01	E3	51	53	0.347	87	240	0.1	<0.3	?
12/26/01	E4	51	53	0.347	87	0.1	0.5	N30E	
12/26/01	E5	52	54	0.36	0.36	260	0.17	0.8	N30E

DATE	SITE	WB	DB	VPD	RH	LI	SR	MAXWIND	WINDDIREC
1/10/02	A1	45	46	0.287	93	70	0.01	1	N260W
1/10/02	A2	45	46	0.287	93	70	0.01	1	N260W
1/10/02	A3	44	45	0.266	93	80	0.02	0.6	N260W
1/10/02	A4	44	45	0.277	93	100	0.01	0.7	S240W
1/10/02	A5	44	44	0.287	100	100	0.03	0.4	N20E
1/10/02	A6	44	45	0.277	93	120	0.01	0.3	N20E
1/10/02	A7	44	45	0.277	93	110	0.02	0.3	N260W
1/10/02	B1	46	47	0.298	93	170	0.06	1	N10E
1/10/02	B2	46	47	0.298	93	70	0.02	0.6	N358W
1/10/02	B3	46	47	0.298	93	60	0.02	0.3	?
1/10/02	B4	47	48	0.31	93	300	0.21	0.3	?
1/10/02	B5	46	47	0.298	93	150	0.03	0.3	?
1/10/02	B6	46	47	0.298	93	170	0.03	0.3	S220W
1/10/02	B7	45	46	0.87	93	150	0.03	0.4	N308W
1/10/02	C1	47	48	0.31	93	320	0.1	0.6	N10E
1/10/02	C2	47	48	0.31	93	100	0.03	0.3	?
1/10/02	C3	47	48	0.31	93	320	0.13	0.7	N10E
1/10/02	C4	46	47	0.298	93	80	0.04	0.6	N10E
1/10/02	C5	47	48	0.31	93	380	0.25	1.2	N320W
1/10/02	C6	47	48	0.31	93	130	0.02	0.7	N320W
1/10/02	C7	48	50	0.31	87	310	0.2	0.6	N320W
1/10/02	D1	49	51	0.322	87	480	0.37	0.9	N340W
1/10/02	D2	49	50	0.334	93	400	0.32	0.9	N356W
1/10/02	D3	47	49	0.322	86	120	0.5	0.6	N10E
1/10/02	D4	47	49	0.322	86	50	0.3	0.6	N10E
1/10/02	D5	48	50	0.31	87	420	0.28	1.1	N10E
1/10/02	D6	49	50	0.334	93	320	0.12	0.5	N40E
1/10/02	D7	49	50	0.334	93	310	0.25	1.1	N40E
1/10/02	E1	51	52	0.36	94	460	0.3	1.3	N310W
1/10/02	E2	51	52	0.36	94	520	0.37	1.2	N310W
1/10/02	E3	49	51	0.322	94	220	0.1	0.3	?
1/10/02	E4	51	52	0.36	94	520	0.51	0.3	N310W
1/10/02	E5	52	55	0.36	82	540	0.44	0.7	N10E

DATE	SITE	WB	DB	VPD	RH	LI	SR	MAXWIND	WINDDIREC
1/24/02	A1	44	47	0.256	79	150	0.04	0.7	N30E
1/24/02	A2	42	46	0.219	72	100	0.03	0.7	N15E
1/24/02	A3	43	46	0.247	79	100	0.03	0.6	n30e
1/24/02	A4	43	47	0.228	72	500	0.6	0.3	?
1/24/02	A5	42	46	0.266	72	150	0.06	0.6	N320W
1/24/02	A6	41	45	0.277	71	400	0.05	0.6	N60E
1/24/02	A7	42	46	0.266	72	150	0.04	1.9	N60E
1/24/02	B1	44	48	0.247	73	560	0.44	1.1	N30E
1/24/02	B2	42	46	0.219	72	70	0.04	1.9	N30E
1/24/02	B3	43	47	0.228	72	220	0.06	0.22	N320W
1/24/02	B4	43	47	0.228	72	400	0.13	1.4	N320W
1/24/02	B5	42	46	0.219	72	200	0.05	0.8	N320W
1/24/02	B6	42	46	0.219	72	180	0.35	1.3	N60E
1/24/02	B7	43	46	0.247	79	440	0.6	0.3	N30E
1/24/02	C1	40	42	0.228	85	380	0.33	0.6	N30E
1/24/02	C2	40	41	0.237	92	100	0	0.9	N30E
1/24/02	C3	40	44	0.203	71	112	0.04	0.8	N30E
1/24/02	C4	40	43	0.211	77	120	0.05	0.9	N30E
1/24/02	C5	43	46	0.247	77	510	0.5	1.3	N60E
1/24/02	C6	42	46	0.219	71	210	0.36	1.1	N60E
1/24/02	C7	43	46	0.247	71	480	0.08	1.4	N403
1/24/02	D1	40	42	0.228	85	320	0.14	0.4	N30E
1/24/02	D2	39	41	0.211	84	280	0.3	1.3	N30E
1/24/02	D3	38	41	0.195	76	100	0.02	0.5	N30E
1/24/02	D4	38	41	0.195	76	34	0.02	0.4	N10E
1/24/02	D5	38	40	0.203	83	200	0.5	1.3	N20E
1/24/02	D6	38	40	0.203	83	210	0.04	1.2	N10E
1/24/02	D7	39	41	0.211	84	240	0.2	1.1	N320W
1/24/02	E1	36	38	0.187	83	18	0.01	1	N340W
1/24/02	E2	36	37	0.203	91	100	0.01	2	N70E
1/24/02	E3	35	36	0.195	91	90	0.08	0.3	?
1/24/02	E4	36	37	0.203	91	280	0.18	0.6	N30E
1/24/02	35	36	37	0.203	91	280	0.18	0.6	N40E

DATE	SITE	WB	DB	VPD	RH	LI	SR	MAXWIND	WINDDIREC
2/7/07	A1	51	51	0.373	100	29	0.01	0.3	?
2/7/07	A2	50	50	0.36	100	28	0.05	0.3	N280W
2/7/07	A3	50	50	0.36	100	32	0.02	0.5	N70E
2/7/07	A4	50	50	0.36	100	38	0.01	0.5	N20E
2/7/07	A5	50	50	0.36	100	40	0.03	0.3	?
2/7/07	A6	50	50	0.36	100	30	0.01	0.2	N20E
2/7/07	A7	50	50	0.36	100	40	0.01	0.8	S40E
2/7/07	B1	50	50	0.36	100	80	0.05	0.3	?
2/7/07	B2	50	50	0.36	100	48	0.01	0.7	S140E
2/7/07	B3	50	50	0.36	100	30	0.01	0.8	S140E
2/7/07	B4	50	50	0.36	100	58	0.02	2.4	S140E
2/7/07	B5	50	50	0.36	100	60	0.05	1	S140E
2/7/07	B6	50	50	0.36	100	48	0.02	1.5	S140E
2/7/07	B7	50	50	0.36	100	40	0.02	0.9	N70E
2/7/07	C1	50	50	0.36	100	100	0.06	0.9	N60E
2/7/07	C2	50	50	0.36	100	120	0.06	0.3	?
2/7/07	C3	50	50	0.36	100	100	0.03	1.1	N60E
2/7/07	C4	50	50	0.36	100	32	0.01	1	S120E
2/7/07	C5	50	50	0.36	100	30	0.06	0.7	S120E
2/7/07	C6	50	50	0.36	100	70	0.05	1.6	S120E
2/7/07	C7	50	50	0.36	100	130	0.04	1.6	S120E
2/7/07	D1	50	50	0.36	100	190	0.08	1.2	N20E
2/7/07	D2	50	50	0.36	100	170	0.07	0.7	N80E
2/7/07	D3	50	50	0.36	100	150	0.05	0.7	N80E
2/7/07	D4	50	50	0.36	100	50	0.02	2	N80E
2/7/07	D5	50	50	0.36	100	170	0.07	1.4	S180E
2/7/07	D6	50	50	0.36	100	130	0.03	1.4	N50E
2/7/07	D7	50	50	0.36	100	120	0.06	1.5	S120E
2/7/07	E1	50	50	0.36	100	180	0.07	1.3	N70E
2/7/07	E2	50	50	0.36	100	180	0.07	0.8	N70E
2/7/07	E3	50	50	0.36	100	150	0.06	1.1	S150E
2/7/07	E4	50	50	0.36	100	100	0.05	1.5	N40E
2/7/07	E5	50	50	0.36	100	120	0.03	0.8	N40E

DATE	SITE	WB	DB	VPD	RH	LI	SR	MAXWIND	WINDDIREC
2/21/02	A1	51	52	0.36	94	80	0.02	0.5	N70E
2/21/02	A2	51	52	0.36	94	70	0.03	1	N70E
2/21/02	A3	51	52	0.36	94	80	0.01	0.9	N70E
2/21/02	A4	51	52	0.36	94	150	0.06	0.3	N70E
2/21/02	A5	51	52	0.36	94	100	0.04	0.3	N70E
2/21/02	A6	51	52	0.36	94	80	0.03	0.3	N70E
2/21/02	A7	51	52	0.36	94	70	0.02	0.6	N70E
2/21/02	B1	53	55	0.373	94	70	0.02	0.7	N70E
2/21/02	B2	53	54	0.387	94	80	0.03	0.9	N30E
2/21/02	B3	53	54	0.387	94	30	0.02	0.3	?
2/21/02	B4	53	54	0.387	94	80	0.13	1	N30E
2/21/02	B5	53	54	0.387	94	100	0.06	1.3	S140E
2/21/02	B6	53	54	0.387	94	100	0.08	1.7	N70E
2/21/02	B7	51	52	0.36	94	60	0.04	0.5	N290W
2/21/02	C1	55	56	0.417	94	320	0.17	0.8	N30E
2/21/02	C2	55	56	0.417	94	180	0.04	1.2	N70E
2/21/02	C3	54	56	0.402	88	100	0.06	0.3	?
2/21/02	C4	54	56	0.402	88	120	0.05	1.7	N70E
2/21/02	C5	54	56	0.402	88	150	0.05	0.6	N70E
2/21/02	C6	54	56	0.402	88	110	0.03	0.6	N320W
2/21/02	C7	57	58	0.448	94	320	0.52	0.6	S140E
2/21/02	D1	58	62	0.432	79	120	0.63	0.3	?
2/21/02	D2	56	58	0.417	88	420	0.5	2.1	N603
2/21/02	D3	56	58	0.417	88	180	0.29	0.9	N60E
2/21/02	D4	56	58	0.417	88	40	0.04	0.8	N60E
2/21/02	D5	57	60	0.432	83	320	0.44	1.3	N70E
2/21/02	D6	57	60	0.432	83	90	0.12	1.3	N70E
2/21/02	D7	57	60	0.432	83	320	0.56	1.5	N360W
2/21/02	E1	58	62	0.432	79	120	0.7	0.3	?
2/21/02	E2	60	63	0.482	84	400	0.54	0.5	N320W
2/21/02	E3	60	63	0.482	84	200	0.05	0.3	?
2/21/02	E4	62	65	0.555	85	120	0.05	0.7	N70E
2/21/02	E5	62	65	0.555	85	420	0.6	0.7	N70E

Appendix III. Monarch Cluster Count Datasheet,
Habitat Assessment Form & Protocol

Western Monarch Count
Site Specific Data Sheet: Monarch Count

Date _____ Site Name _____ Site ID #_____

Observers _____

Count Start Time _____ to _____ Total Count Time (minutes) _____

Weather: Cloud/Fog Cover_____% Precip: none, drizzle, rain, downpour

Wind (mph or m/s or bft) _____ Wind Direction _____ Temp (^{o}F or C) _____

# Monarchs Clustered	Tree Species	Cluster Height (m)
Total Clustered:		

# of Sunners:	*Tally every butterfly of each type that you see in the site. More space on reverse.*
# of Fliers:	
# of Loners	
# of Grounders:	
Grand Total: *(sum of all clustered butterflies plus sunners, fliers, loners, grounders.)*	

These should be included in the grand total above. Please provide tag numbers if applicable.	
# of Tagged Monarchs	
# of Mating Monarchs	

# Monarchs Clustered	Tree Species	Cluster Height (m)

Please add any counts on this page to the total tally on page 1.

Please return this data sheet to:
wmtc@xerces.org
The Xerces Society, 628 NE Broadway, Suite 200, Portland, OR 97232

Western Monarch Overwintering Habitat Assessment (Long Form)
Instructions and Definitions

Thank you for your interest in collecting monarch overwintering habitat data. The information that you collect is important as it will enable us to assess threats to sites and, if used regularly, to document changes over time. In addition, the data may inform overwintering site restoration and management.

1. Fill out the data sheet to the best of your ability. Feel free to skip sections, but please note why the section was skipped (not enough time, did not have the necessary equipment, were not sure). If you are unsure, no information is better than inaccurate information. The majority of the items listed on the data form are self explanatory. Below is additional information for items that require further explaination.

2. **Site ID** is the number assigned to the site from the Xerces Society's Monarch Overwintering Database. If you do not know the site identification number, leave this line blank.

3. **Property Owner** can include public agencies such as the U.S. National Forest Service or California Department of Parks and Recreation, private landowners such as home owners or business owners, or non-profit organizations. If the property owner is a private landowner but you do not know the company or the person's name, please write private landowner.

4. **Current land use** is the primary human use of a specific land area. Some examples include state, county, or national parks; state or national forests; golf courses; residential areas; commercial areas; industrial areas; agricultural fields; or other land uses.

5. **Site Location/Directions**: Please be as specific as possible. Be sure to include relevant information such as town names, highway or street names, river or stream names, and distances.

6. **GPS data**: If you have access to a GPS unit or a smart phone with GPS capabilities, please provide GPS coordinates of the site as well as the accuracy of the GPS unit and the datum (i.e. NAD27, NAD83, WGS84) that the data is collected in. If you do not have access to a GPS unit, skip this section.

7. **Microclimate Data**: If you have access to a Kestrel pocket weather meter, please use this device to collect the data. Be sure to collect the data in metric units (i.e. Celsius, meters per second). If you do not have access to this device, please skip the relative humidity and dewpoint data fields and use an outdoor weather thermometer to record the temperature data.

8. **Topography Data**: To measure aspect (which is the direction in which a slope is oriented), record the cardinal direction (N, NE, E, SE, S, SW, W, NW) that the slope is facing at the site. If you have access to a clinometer, a compass with a clinometer, or a rangefinder, use this to record slope. If you do not, record an ocular slope estimate by estimating the incline at the site relative to the terrain around you. For example, if the horizon of the ground appears flat, then you would record that the site has a 0% slope.

9. **Community Structure**: Record an ocular estimate of the percentage each forest structure layer (i.e. tree, shrub, herbaceous layer) occupies. For example, tree cover is measured by projecting an imaginary shape encompassing the crown of the tree onto the ground (think shading). Densly growing trees would be 80-100% cover, whereas very

sparsely growing trees generally would be 20% or less cover. Shrub cover includes woody species that do not reach tree height. Herbaceous cover comprises flowers, grasses, or other plants that are not woody. Leaf litter cover is the percentage of dead material such as leaves, branches, and tree bark that covers the ground. Bare soil cover includes all exposed soil not covered by plants or dead material. Consider each layer on its own. The total for all layers combined can be greater than 100%.

10. **Photopoints**: If you are able, take a photograph or multipule photographs of the site. Record a description, to the best of your ability, on the camerapoint (where you are standing to take the photograph) and the photopoint (the direction in which you are taking the photograph). GPS points and cardinal directions (N, NE, etc) are helpful if you have access to a GPS unit and/or a compass. If you have sufficient time, it is best to position the camerapoint location a few feet from the main monarch cluster tree and take photopoints in every cardinal direction (N, NE, E, SE, S, SW, W, NW). Email or send the photos to The Xerces Society along with this form.

11. **Overall Site Sketch**: Draw as much information as you can including monarch cluster trees, trees within the grove in which monarchs are not roosting, buildings, trails, streams/rivers, adjacent roads or highways, signs, areas with nectar plants, and open areas.

12. **Please return completed habitat assessment forms to wmtc@xerces.org or The Xerces Society, 628 NE Broadway St, Suite 200, Portland, OR.**

Monarch Overwintering Habitat Assessment Equipment List

Data sheets
Clipboard (helpful but not required)
Pen or pencil
Binoculars (to monitor monarchs)
Kestrel pocket weather meter or outdoor weather thermometer
GPS unit or smart phone w/ GPS capability (optional)
Clinometer or rangefinder or compass with a clinometer (optional)
Plant Identification/Field Guide Book (optional)
Camera (optional)
Compass (optional)

Monarchs Observed ___Yes ___No

Western Monarch Overwintering Habitat Assessment (Long Form)

Please fill out as much information on this form as you can, but feel free to skip any sections for which you do not have the right equipment or you are uncertain about the question. Any information you are able to provide is valuable! Refer to the *Instructions and Definitions* on page 5 for additional information about how to fill out this data sheet.

Date _____ Site Name _____Site ID # _____
County _____ Property Owner _____
Observers _____Start Time _____ End Time _____
Current Land Use (i.e. State, County or National Park; State or National Forest; Golf Course; or Residential Area)
_____

Location Information
Site Location/Directions_____
_____

Please provide GPS coordinates of the grove's boundaries. If the grove is an odd-shaped polygon, please provide additional GPS points as needed or as a shapefile/kmz utilizing ArcGIS or Google Earth.
GPS Point of Grove's Northern corner: _____N _____W Accuracy (ft): _____
GPS Point of Grove's Eastern corner: _____N _____W Accuracy (ft): _____
GPS Point of Grove's Western corner: _____N _____W Accuracy (ft): _____
GPS Point of Grove's Southern corner: _____N _____W Accuracy (ft): _____

GPS Point of Cluster tree #1: _____N _____W Accuracy (ft): _____
GPS Point of Cluster tree #2: _____ N _____W Accuracy (ft): ____

Datum of GPS Unit: __ NAD27 __ NAD83 __ WGS84 __ Unknown __
Other, please specify (e.g., recreational GPS): _____

Weather
Cloud/Fog Cover: ____ %
Precipitation: __ None __ Drizzle __ Rain __ Downpour

Topography
Aspect: __ N __ NE __ E __ SE __ S __ SW __ W __NW
Slope: _____ % (The data was collected: __ with a clinometer /rangefinder or __ by ocular estimate)

Microclimate INSIDE Overwintering Grove
Temperature (°F or C): _____
Relative Humidity: _____

Dewpoint: _____
Wind: _____ (mph or m/s or bft)
Wind Direction: __ N __ NE __ E __ SE __ S __ SW __ W __NW

Wind OUTSIDE Overwintering Grove
Wind: _____ (please circle: mph or m/s or Bft)
Wind Direction (direction wind is coming FROM): __ N __ NE __ E __ SE __ S __ SW __ W __NW

Wind Protection
Is there a buffer between predominant and storm winds and the cluster trees? Yes / No
Please describe the tree arrangement (including tree species) _____
_____
_____

Light
Do the cluster trees get morning sunlight Yes / No

Fresh Water Source
Fresh Water Source Present at the Site: __ stream/river __ lake/pond __ abundant dew __ other __ none
About how many meters is the fresh water source from the monarch cluster trees? _____

Community Structure (total can be >100% for all layers combined)
Tree cover ____% Shrub cover ____% Herbaceous cover ____% Leaf litter layer ____%
Bare soil cover ____%

Nectar Species In Bloom
(Rate the amount per species: A= abundant; M= moderate; S= scarce)
__ no nectar species in bloom

Native Species:	Native Species (cont.):	Non-native Species (cont.):
__Narrow leaf milkweed (*Asclepias fascicularis*)	__ Red alder (*Alnus rubra*)	__ German ivy (*Senecio mikanioides*)
__ Mule fat/seep willow (*Baccharis glutinosa*)	__ Aster (*Aster* sp.)	__ Passionflower vine (*Passiflora* sp.)
__ Coyote brush (*Baccharis pilularis*)	__ Redclaw (*Escallonia* sp.)	__ Bull thistle (*Cirsium vulgare*)
__ Arroyo willow (*Salix lasiolepis*)	Other: _____	__ Wild radish (*Raphanus sativus*)
__ Other willow (*Salix* sp.)	_____	__ English daisy (*Bellis perennis*)
__ Monkeyflower (*Mimulus* sp.)	_____	__ White nightshade (*Solanum nodiflorum*)
__ Morning glory (*Calystegia* sp.)		__ Ice plant (*Mesembryanthemum* sp.)
__ Miner's lettuce (*Montia perfoliata*)	Non-native Species:	__ Field bindweed (*Convolvulus arvensis*)
__ Dune groundsel/ragwort (*Senecio blochmaniae*)	__ Blue gum (*Eucalyptus globulus*)	__ Chrysanthemum (*Chrysanthemum* sp.)
__ Mock heather (*Ericameria ericoides*)	__ Red gum (*Eucalyptus camaldulensis*)	__ Klamath weed/tansy mustard (*Senecio* sp.)
__ Crisp dune mint (*Monardella crispa*)	__ Black mustard (*Brassica nigra*)	__ Lily-of-the-Nile (*Agapanthus africanus*)
__ California blackberry (*Rubus ursinus*)	__ Unknown or other mustard (*Brassica* sp.)	__ Sweet fennel (*Foeniculum vulgare*)
	__ Common dandelion (*Taraxacum officinale*)	__ Bottlebrush (*Callistemon* sp.)
	__ Ox-eye daisy (*Chrysanthemum*	__ Lantana (*Lantana* sp.)
		__ Lemon (*Citrus limon*)

__ Morro manzanita (*Arctostaphylos morroensis*) __ Bottle brush (*Ceanothus thyrsiflorus*) __ Western goldenrod (*Euthamia occidentalis*)	*leucanthemum*) __ Periwinkle (*Vinca major*) __ Butterfly bush (*Buddleia* sp.) __ English ivy (*Hedera helix*)	__ Pride of madeira (*Echium fastuosum*) Other: _____ _____ _____ _____

How many meters is the closest nectar source from the monarch cluster trees? _____

Did you observe monarchs feeding on nectar? ___ Yes ___ No

If yes, which species? _____

Monarch Cluster Trees

Record the species that monarchs are actively clustering on. A cluster is considered 3 or more adjacent monarch butterflies with closed wings:

__ Blue gum (*Eucalyptus globulus*) __ Red river gum (*Eucalyptus camaldulensis*) __ Unknown or other Eucalyptus species (*Eucalyptus spp.*) __ Monterey pine (*Pinus radiata*) __ Unknown or other pine (Pinus spp.) __ Monterey cypress *(Cupressus macrocarpa*)	__ Coastal redwood (*Sequoia sempervirens*) __ Coast live oak *(Quercus agrifolia*) __ Western sycamore (*Platanus racemosa*) __ Willow (*Salix spp*.) __ Acacias (*Acacia spp*.) Other: _____

Tree Species Composition

Other tree species present at the site that monarchs are not clustering on:

__ Blue gum (*Eucalyptus globulus*) __ Red river gum (*Eucalyptus camaldulensis*) __ Unknown or other Eucalyptus species (*Eucalyptus spp.*) __ Monterey pine (*Pinus radiata*) __ Unknown or other pine (Pinus spp.) __ Monterey cypress *(Cupressus macrocarpa*)	__ Coastal redwood (*Sequoia sempervirens*) __ Coast live oak *(Quercus agrifolia*) __ Western sycamore (*Platanus racemosa*) __ Willow (*Salix spp*.) __ Acacias (*Acacia spp*.) Other: _____

Visible Disturbances within the Overwintering Site

__ Cut trees __ Trimmed trees __ Possibly too dense of trees (i.e. too much shade) __ Trees diseased from pitch canker __ Trees diseased from Eucalyptus leaf beetle __ Trees diseased from Eucalyptus lerp psyllid __ Trees diseased from Eucalyptus longhorn borer __ Trees diseased from unknown source __ Dead/dying trees from non- disease source __ Old/aging trees __ High visitation load __ Erosion	__ Cattle grazing __ Pesticide/herbicide use at site (observed) __ Pesticide/herbicide use at site (likely) __ Fire destroyed a portion of site __ Construction __ Buildings __ Pavement __ Parking lot __ Mowing/plowing of nectar plants __ Railroad tracks __ Extensive trails __ Road (within the site) Other: _____

__ Campsite __ Picnic area	_____

Visible Disturbances in the Landscape (Outside of the Overwintering Site)

__ Roads/Highways __ High vehicle traffic area __ Housing Developments __ Shopping Malls/Restaurants __ Pavement	__ Parking lot __ Pesticide/herbicide use in landscape (observed) __ Pesticide/herbicide use in landscape (likely) __ Construction Other: _____

Possible Future Threats

__ High possibility that overwintering trees will be cut __ Site might become too dense/shady in the future __ Site might not offer enough wind protection in the future __ Proposed housing development	__ Proposed expansion of facilities or buildings within the site Other: _____ _____

Is the site protected by staff/docent presence? ___ Yes ___ No

Describe the disturbances/threats in greater detail, if possible. (For example, if you observed dead/dying trees or cut trees at the site, how many did you observe and how important are these trees to the site? If the site is affected by erosion, what is the cause of the erosion?) _____

_____

_____

_____

Photopoints

Camerapoint Description: _____

_____

Photopoint #1 Description: _____

_____

Photopoint #2 Description: _____

_____

Notes

_____

_____

_____

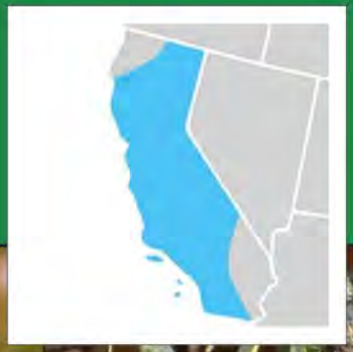
Overall Site Sketch *(here or on the back of the datasheet)*

Appendix IV. Xerces California Coast Nectar Plant List

also available online:
https://xerces.org/sites/default/files/publications/19-046_01_MonarchNectarPlants_California_web-3pg.pdf

MONARCH NECTAR PLANTS

California



Left to right: Monarch butterflies on rabbitbush, Pacific aster, and clustered together on eucalyptus in a California overwintering site.

California is one of the most floristically biodiverse regions in the world, supporting unique plant communities such as prairie grasslands, chaparral, giant sequoia groves, and Joshua tree woodlands. The native plants that make up these communities in turn support an incredible array of insects and other animals, including the monarch butterfly. During spring and summer, monarchs leave hundreds of overwintering sites along the California coast and fan out across the western landscape to breed and lay eggs on milkweed (*Asclepias* spp.), the monarch's host plant. Several generations are likely produced during this time. In the fall, adults from throughout the western U.S. migrate back to overwintering sites in California and central Mexico, where they generally remain in reproductive diapause until the spring, when the cycle begins again.

Once, millions of monarchs overwintered along the Pacific coast of California and Baja, Mexico. By 2018, the population of western monarchs hit a record low of less than 29,000 butterflies, which represents a 99.4% decline since the 1980's. The significant problems afflicting western monarchs include habitat loss, pesticide use, and climate change. Because of the monarch's migratory life cycle, it is important to protect and restore habitat across their entire range. Adult monarchs depend on diverse nectar sources for food during all stages of the year, from spring and summer breeding to fall migration and overwintering. Caterpillars, on the other hand, are completely dependent on their milkweed host plants. Inadequate milkweed or nectar plant food sources at any point may impact the number of monarchs that successfully arrive at overwintering sites in the fall.

Providing milkweeds and other nectar-rich flowers that bloom where and when monarchs need them is one of the most significant actions you can take to support monarch butterfly populations. This guide features native California plants that have documented monarch visitation, bloom during the times of year when monarchs are present and are commercially available... This list is not exhaustive, but focuses on the plants that appear to be the most important for western monarchs. The list also includes moisture requirements, so that you can choose plants to create a drought-tolerant monarch garden, if needed. These species are well-suited for wildflower gardens, urban greenspaces, and farm field borders. Beyond supporting monarchs, many of these plants attract other nectar- and/or pollen-seeking butterflies, bees, moths, and hummingbirds. For a list of native plants that host butterflies and moths specific to your zip code see www.nwf.org/nativeplantfinder. The species in this guide will be adaptable to growing conditions across most of the state, but may be less suitable for planting in the High Sierras, Modoc Plateau, and Eastern Interior Desert regions. Please consult Calflora (www.calflora.org) for details on species' distributions in your specific area.

MONARCH JOINT VENTURE

XERCES SOCIETY for Invertebrate Conservation

GARDEN FOR WILDLIFE

Bloom		Common Name	Scientific Name	Flower Color	Max. Height	Water Needs
		Forbs			(Feet)	Low, Med., or High
Spring to Summer	1	Nettleleaf giant hyssop	*Agastache urticifolia*	Purple/red	2	L
	2	Yarrow	*Achillea millefolium*	White	3	L
Spring to Fall	3	Coastal sand verbena	*Abronia latifolia*	Yellow	1	L
	4	Gumplant	*Grindelia camporum*	Yellow	4	L–H
	5	Milkweed	*Asclepias* spp.	Pink/white/purple	2–4	L/M
	6	Oregon gumweed	*Grindelia stricta*	Yellow	5	H
	7	Western vervain	*Verbena lasiostachys*	Purple	3	L
Summer	8	Coyote mint	*Monardella villosa*	Pink/purple	2	L
	9	Indian hemp	*Apocynum cannabinum*	White/pink	6	M/H
	10	Mountain monardella	*Monardella odoratissima*	White/purple	1	L
	11	Pacific aster	*Symphyotrichum chilense*	Yellow/violet	4	L
Summer to Fall	12	Goldenrod	*Solidago* spp.	Yellow	3	L
	13	Smooth beggartick	*Bidens laevis*	Yellow	3	H
	14	Sunflowers	*Helianthus* spp.	Yellow	5–8	M
	15	Western goldentop	*Euthamia occidentalis*	Yellow	6	H
Winter to Spring	16	Bluedicks	*Dichelostemma capitatum*	Purple	3	L
Winter to Summer	17	Seaside fleabane	*Erigeron glaucus*	Purple	2	L
		Shrubs and Trees				
Year-round	18	Coyotebrush, mulesfat, desertbroom	*Baccharis* spp.	White/yellow/pink	6–10	L
Spring to Summer	19	Black sage	*Salvia mellifera*	Blue/purple	6	L
	20	Desert sage	*Salvia dorrii*	Purple	4	L
Summer to Fall	21	Common buttonbush	*Cephalanthus occidentalis*	White	6	H
	22	Rabbitbrush, goldenbush, mock heather	*Ericameria* spp.	Yellow	4–8	L
Winter to Spring	23	Manzanita	*Arctostaphylos* spp.	Pink/white	1–30	L/M
	24	Willow	*Salix* spp.	White	20–50	H

Notes

PLEASE NOTE: *In general, milkweed should not be planted within 5 miles of the coast north of Santa Barbara, nor within 1 mile of the coast from Santa Barbara south. These areas are generally outside of milkweed's historical range and planting milkweed too close to overwintering sites may interfere with monarch migration and overwintering behavior.*

This list was produced by the Xerces® Society. www.xerces.org.

XERCES SOCIETY for Invertebrate Conservation

All species perennials, unless otherwise noted. Monarchs can be found year-round in California.

Establishes better from transplant than seed. Tolerates clay soil and wet or dry conditions.

Tolerates clay soil and wet or dry conditions. Attractive to many insects.

Tolerates salt spray and prefers sandy soils. Can bloom year-round.

Tolerates clay soil and wet or dry conditions.

Monarch caterpillar host plant. *Likely entire genus is attractive to monarchs.*

Wetland / riparian.

Good butterfly plant. Tolerates seasonal flooding, sand and clay. Can be used for erosion control.

Requires good drainage.

Poisonous to humans, pets and livestock.

Does best at mid to high elevations. Attracts many species of butterflies.

Tolerates clay soils and wet or dry conditions. *Likely entire genus is attractive to monarchs.*

Important late-season forage for bees, butterflies, wasps, beetles, and more. *Likely entire genus is attractive to monarchs.*

Prefers wet areas and can be used in bioswales. Attracts beneficial insects and butterflies in the fall.

Excellent butterfly nectar plant. Attractive to many insects. *Likely entire genus is attractive to monarchs.*

Wetland-riparian. *Likely entire genus is attractive to monarchs.*

Attracts bees, butterflies, and hummingbirds. An early spring bloomer.

A great butterfly plant.

Easy to grow and attractive to many insects. *Likely entire genus is attractive to monarchs.*

Important butterfly and hummingbird plant. Quail eat the seeds.

Very drought tolerant.

Fragrant, showy flowers that attract butterflies.

Great late season nectar source for bees and butterflies. Very drought tolerant. *Likely entire genus is attractive to monarchs.*

Some species/varieties are very drought tolerant. *Likely entire genus is attractive to monarchs.*

Tolerates sand and seasonal flooding. Important wildlife plant. *Likely entire genus is attractive to monarchs.*

Planting for Success

Monarch nectar and host plants often do best in open, sunny sites. You can attract more monarchs by planting flowers in single species clumps and choosing a variety of plants that have overlapping and sequential bloom periods. Monarchs can be present year-round in California, so you may want to provide nectar plants for migrating and breeding monarchs from spring through fall, as well as milkweeds in the spring and summer.

Why Plant Native?

Although monarchs use a variety of nectar plant species, including exotic invasives such as ice plant and cape ivy, we recommend planting native species. Native plants are often more beneficial to ecosystems, are adapted to local soils and climates, and help promote biological diversity. They can also be easier to maintain in the landscape, once established.

Tropical milkweed (*Asclepias curassavica*) is a non-native plant that is widely available in nurseries. This milkweed can persist year-round in mild climates, allowing monarchs to breed throughout the winter rather than going into diapause. Tropical milkweed may foster higher loads of a monarch parasite called OE (*Ophryocystis elektroscirrha*), which negatively impacts monarch health. **In general, milkweed should not be planted within 5 miles of the coast north of Santa Barbara, nor within 1 mile of the coast from Santa Barbara south. These areas are generally outside of milkweed's historical range and planting milkweed too close to overwintering sites may interfere with monarch migration and overwintering behavior.** Because of these implications, we recommend planting native milkweeds in areas where they historically occurred. You can read more about OE in this Monarch Joint Venture fact sheet: http://monarchjointventure.org/images/uploads/documents/Oe_fact_sheet.pdf.

Protect Monarchs from Insecticides

Both insecticides and herbicides can be harmful to monarchs. Herbicides can reduce floral resources and host plants. Although dependent on timing, rate, and method of application, most insecticides have the potential to poison or kill monarchs and other pollinators. Systemic insecticides, including neonicotinoids, have received significant attention for their potential role in pollinator declines (imidacloprid, dinotefuran, clothianidin, and thiamethoxam are examples of systemic insecticides now found in various farm and garden products). Because plants absorb systemic insecticides as they grow, the chemicals become distributed throughout all plant tissues, including the leaves and nectar. New research has shown that some neonicotinoids are toxic to monarch caterpillars that are poisoned as they feed on leaf tissue of treated plants. You can help protect monarchs by avoiding the use of these and other insecticides. Before purchasing plants from nurseries and garden centers, be sure to ask whether they have been treated with systemic insecticides. To read more about threats to pollinators from pesticides, please visit: www.xerces.org/pesticides.

Additional Resources

Gardening for Butterflies **by The Xerces Society**

www.xerces.org/books

Attracting Birds, Butterflies, and Other Backyard Wildlife

http://bit.ly/1Xhxfgu

From the Xerces Society

- ***Conservation Status and Ecology of the Monarch Butterfly in the U.S.:*** xerces.org/us-monarch-consv-report
- ***Guide to Milkweeds and Monarchs in the Western U.S.:*** xerces.org/western-us-monarch-guide
- ***Guide to California Native Milkweeds:*** xerces.org/ca-mw-guide
- **Milkweed Seed Finder:** xerces.org/milkweed-seed-finder

Websites

- **The Xerces Society:** www.xerces.org/monarchs
- **Monarch Joint Venture:** www.monarchjointventure.org/resources
- **Natural Resources Conservation Service:** www.nrcs.usda.gov/monarchs
- **National Wildlife Federation:** www.nwf.org/butterflies

Citizen Science Efforts in California

- **Xerces Society Western Monarch Thanksgiving Count:** www.westernmonarchcount.org
- **Xerces Society & USFWS Milkweed and Monarch Survey:** www.xerces.org/milkweedsurvey
- **Journey North:** www.learner.org/jnorth/monarch
- **Monarch Larva Monitoring Project:** www.mlmp.org
- **Project Monarch Health:** www.monarchparasites.org

Data Sources

Nectaring data and observations, background information, and other contributions to this publication were taken from the published literature and generously provided by multiple researchers, gardeners, partners, and biologists. For the full list of data sources, please see the Monarch Nectar Guides page on our website (www.xerces.org/monarch-nectar-plants).

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