

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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October 2017

Acknowledgments

Funding for this plan was provided by the U.S. Fish & Wildlife Service, Coastal Program. Additional funding to support the Xerces Society's western monarch conservation efforts comes from Xerces Society members, as well as the Alice C. Tyler Perpetual Trust, the Bay and Paul Foundations, CS Fund, the Disney Conservation Fund, the Edward Gorey Charitable Trust, Endangered Species Chocolate, the Hind Foundation, Monarch Joint Venture, and the Turner Foundation, Inc.

Thanks go to Tim Hyland of California Department of Parks and Recreation and Chris Lynch for their review of the plan; John Dayton for sharing his insights about the site; Mia Monroe for her long-term commitment to western monarch count efforts; and Western Monarch Thanksgiving Count volunteers for collecting data at overwintering sites for over 20 years.

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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

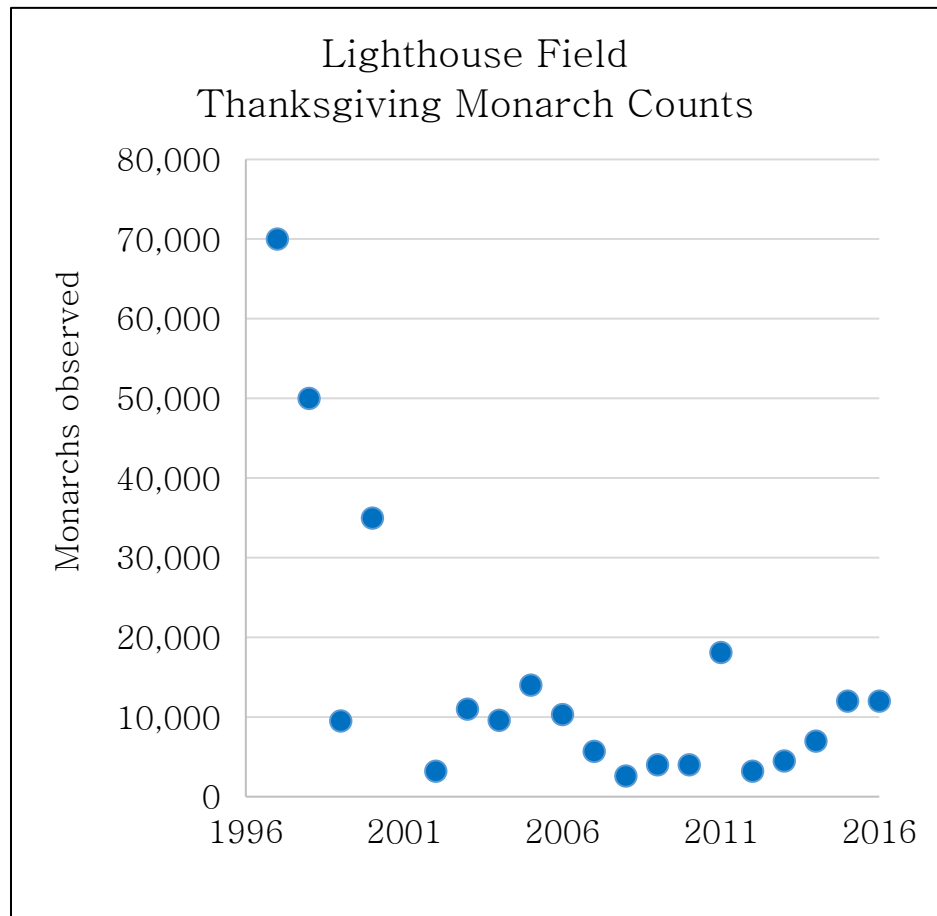


Table & Figure 1. Lighthouse Field Western Monarch Thanksgiving Count Monarch Counts.

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



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

(*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.

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.

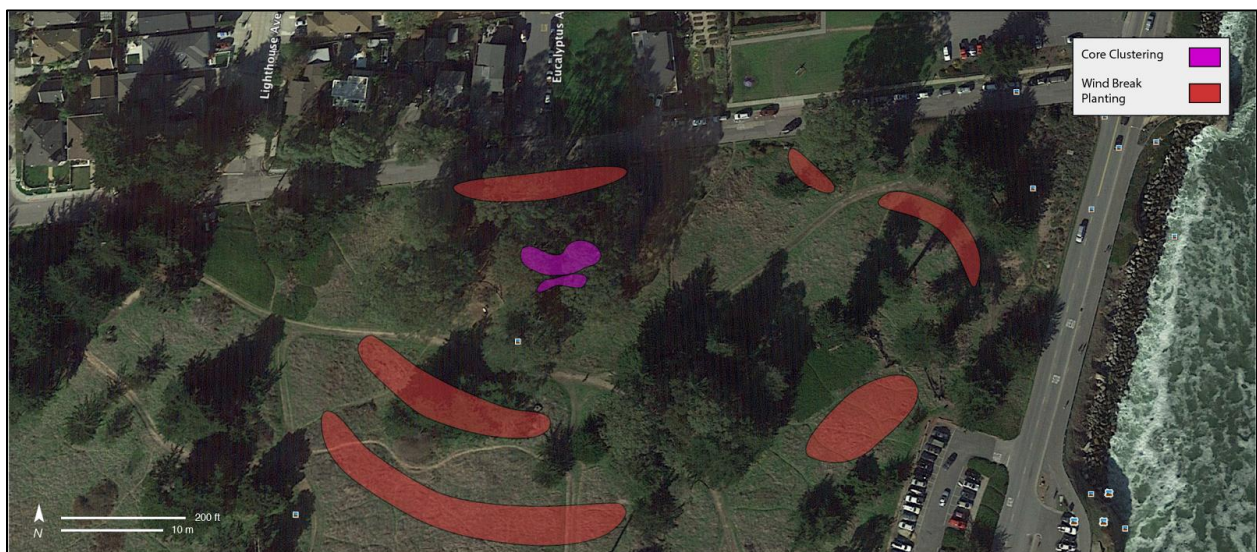


Picture 1. Tree topping and removal of blue gum eucalyptus trees within the cluster area has created a wind tunnel which negatively impacts clustering monarchs during storm events.

✓ **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 fast 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.	
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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.

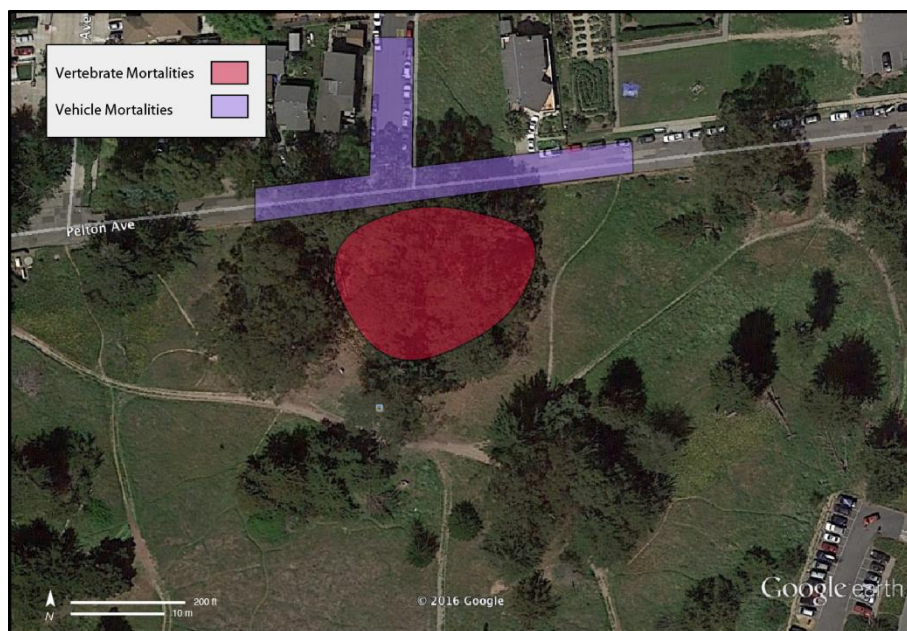
Road mortalities were associated with warm wet windy conditions when WSW winds created a wind tunnel in the northwest portion of the cluster area (Map 2), blowing monarchs to the NNE towards the adjacent surface streets including Pelton Avenue. During these conditions, butterflies often landed on pavement 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 m² area include late-flowering butterfly nectar resources listed in Appendix V. In 2016 and early 2017, Groundswell expanded restoration to include an additional 450 m² planting of late-flowering plants in a triangular plot southeast of the grove and in a 930 m² 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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