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Assessment and proposed management activities Monarch Grove Sanctuary and George Washington Park for 2021

The following recommendations and assessments are based on site visits and consultations with City Arborist Albert Weisfuss and Caleb Schneider in fall 2020 and spring 2021. They are presented in the context of the 2011 Management Plan (Weiss 2011) and subsequent consultations with City staff and residents, including annual recommendations from 2014-2019 (Weiss 2014-2020). The recommendations are based on previous scientific work, professional judgment, input from stakeholders in Pacific Grove, and field assessments. They attempt to carefully balance monarch habitat needs, hazard reduction, and forest health, based on both short-term and long-term perspectives.

In 2020, City Arborist Albert Weisfuss completed a detailed report with his recommendations, and those were considered in the 2020 report (Weisfuss 2020). The assessments and recommendations (with a few noted exceptions) are a solid foundation for guiding management, and the input of a professional arborist is essential especially on matters of tree health and species suitability.

Background data on monarch numbers at Monarch Grove Sanctuary (Xerces Society Thanksgiving Counts and New Year's Counts) provide context of the entire California monarch population. Butterfly monitoring data from the Pacific Grove Museum since 2013 document habitat suitability and monarch use patterns relative to weather and time of season. This reporting on monarch abundance and distribution provides a long-term accessible record for the local community.

The major elements of this report are:

1. Explanation of potential causes of the western monarch population collapse to the point where no over wintering butterflies occupied Monarch Grove Sanctuary in 2020-2021.
2. A graphical view and description of the output of the new Ambient Weather station in the Sanctuary
3. A brief review of management actions completed in 2020
4. Discussion of and proposals on opportunities for a new management plan.
5. A repeat and update of the long-term management considerations from previous reports, where still relevant.

No monarchs overwintered in Pacific Grove in 2020-2021

The overwhelming reality of the 2020-21 overwintering seasons in California is a population crash to less than 2,000 butterflies at the overwintering sites during the Thanksgiving Counts (Table 1). None were observed in Pacific Grove.

The causes of this crash, a 99+% decline from the most recent peak of ~300,000 monarchs in 2015 and 2016, are complicated and multifaceted. The following is an account of the declines, based on published information(see Literature Cited) and discussions with monarch experts. The exact mix of causes remains uncertain; the narrative here should be viewed as hypotheses rather than absolute fact.

The Western Monarch Population as a whole

The long-term decline from the 1980s and 1990s has been described and analyzed elsewhere (Crone et al. 2019, Crone and Schultz 2021, Espeset et al. 2016, James and Kappen 2021, Pelton et al. 2019, Schultz et al. 2017). The loss of breeding habitat in the Central Valley, changes in pesticide composition, weather fluctuations, and losses of overwintering sites are among the important causes. From 1999 to 2016, the California population fluctuated between ~60,000 and ~500,000, with a geometric mean size of 200,000 (Table 1). Notable lows included 86,000 in 2007, and 58,000 in 2009, coinciding with relative drought conditions across the West. But the population weathered the 2012-2015 drought, and recovered to ~300,000 in 2015 and 2016, and declined to 190,000 in 2017 (a very wet year). There are no simple relationships between annual precipitation and monarch numbers.

In 2018, the population declined sharply to ~30,000 butterflies, a record decline. A leading hypothesis for this decline was a record warm February 2018 with coastal high temperatures greater than 70^{O}F, which stimulated monarchs to break diapause and leave the overwintering sites. The record warmth was followed by the return of winter with a vengeance in March (extended rains, some freezing nights, snow down to 1000 ft). Such winter weather immobilizes and can directly kill adult monarchs, especially away from the mild coastal zone, and cold also delays the emergence of milkweeds. The phenological gap between monarch emigration and milkweed emergence has been

identified as a key bottleneck, and the temperature signal at the coast does not perfectly correlate with the temperature signal inland.

Much of the spring 2018 generation was lost, and the subsequent generations were not able to make it up the rest of the season. No monarchs made it to Washington State in 2018. Only 30,000 returned to California that fall.

In 2019, the overwintering population declined by ~30% to 22,000, a relative change well within the historical range of variability. But again, no monarchs reached the Pacific Northwest that year.

The 2020 season was a disaster. February 2020 was warm, and followed by a cool rainy March (but not as severe as 2018). August and September 2020 brought on record heat-monarch larvae cooked to death in the Santa Barbara area (115^{O}F or higher, and hotter closer to the ground with little shade). The heat extended across nearly all the breeding range in California. An example of the record heat is the average temperature for Monterey County as a whole in August and September (Figure 2). Four million+ acres of fires directly took out some of the breeding habitat in the South Coast Ranges that produce monarchs that migrate to Pacific Grove (Yang et al. 2016). The weeks of smoke, which is harmful to insects, came just as the monarchs were initiating the migration. Then there was a hard freeze in some inland areas, for example 22^{O}F in Paso Robles in early November (Dan Meade pers. comm.). The monarchs had not yet flown to the coast because of warm temperatures in October. The extreme fluctuations in temperature and rainfall have been termed “weather whiplash,” and appear to be a feature of the rapidly changing climate.

The mild fall and early winter weather also allowed breeding to continue - reproductive diapause is not hardwired in by photoperiod. Monarchs have been breeding year-round in SoCal for more than a decade, and in 2020 winter breeding was observed in the Bay Area and other mild coastal climates (Crone and Schultz 2021, James and Kappen 2021). Even the native milkweeds, especially showy milkweed, did not senesce and the widespread availability of tropical milkweed means that hostplant resources are available in urban areas throughout the winter. The presence of non-diapausing resident monarchs in coastal areas could have intercepted migratory butterflies and short-circuited diapause.

In addition, the widespread use of mobile and persistent neonicotinoid pesticides has produced toxic host plants and nectar in the Central Valley, even in non-agricultural settings such as wildlife refuges (Fordyce et al. 2020). Much of the migration beyond the Coast Ranges needs to cross the Central Valley (and other heavily agricultural areas like the Salinas Valley) twice. These areas act as population sinks.

In summary, the collapse of the migratory western monarch population in 2020 was likely driven by weather whiplash and record heat waves (both symptoms of climate

change), exacerbated by continuing toxification of breeding habitat in agricultural regions. However, any assertions and conclusions are conditional on deeper analyses and consideration of the entire western monarch migration.

Pacific Grove in California Context

The numbers of monarchs at Pacific Grove primarily reflect the ups and downs of the overall California population ($r^2 = 0.82$), with some variations among years (Table 1). MGS has served as one of the major overwintering sites in California, accounting for an average of 7% (range 1% to 14%) of the Thanksgiving Counts since 1999. Its rank among all CA sites ranged from 1st (2006) to 17th (2009), and MGS is almost always in the top 10 sites. For Monterey County (from 2001 on), MGS accounted for an average of 37% (range 17% to 58%) of the county population.

Previous annual reports in this series describe the behavior of the overwintering population at MGS through the season, and will not be repeated here. In general, monarchs seek wind-sheltered but sunny sites. They "crowdsource the microclimate" - taking flight when conditions are too warm or too cool, too sunny or too shady, and especially too windy. They tend to land where other monarchs are clustered, because the best indicator of good conditions for monarchs is the presence of other butterflies. The butterfly clusters move around according to the weather and time of year; wind shelter is often the proximal cause of shifts. They often cluster just outside MGS to the south; and they use a mixture of tree species that varies from week to week and year to year.

The seasonal course of monarch numbers for 2013-2020 is shown in Figure 3. Monarchs arrive in October, and typically reach peak numbers in late-November – December. Emigration and mortality reduce numbers for the remainder of the season, with a final exodus by mid-February. The details of each season are described in previous reports.

Importantly, over the period 2017-2019, the decrease in numbers from November (Thanksgiving Counts) to January (New Year's Count) has been similar to or less than the decreases observed at other sites in Monterey and Santa Cruz Counties (Table 2). This observation indicates that monarchs find the habitat suitable for the entire season. The only time that MGS has been totally abandoned mid-season was in December 1995, when a record windstorm swept through coastal California with hurricane force winds.

Habitat Management and Restoration

This section provides a brief history of management plans and actions over the past 25 years. More complete accounts can be found in the 2011 Assessment and Management plan and in subsequent annual reports.

In the 1990s and 2000's, monarchs primarily clustered along the southern boundary, often on the neighbor's pine tree. They would move into the Sanctuary proper to escape southerly storm winds, but returned to the southern boundary when winds swung

around to the NW. Based on the 1998 assessment and management plan (Weiss 1998), a shelterbelt of blue gum eucalyptus was planted in 1999 to protect the site against NW winds.

Following the planting of the shelterbelt, little was done in the grove. Attempts to plant a second row of eucalyptus to reinforce the southern boundary, as recommended in the 1998 plan, failed because trees were pulled up. The many dead and dying pines (from old age and pitch canker) were not removed, despite a recommendation in the same report. In 2005, a dead branch fell and killed a woman, and the grove was closed to the public for the remainder of the season. Following the overwintering season, the dead trees were taken down, and many wildlife snags were retained. Several more hazard trees were removed in 2007-2008, but following consultations.

In fall 2009, several large branches on the southern boundary were cut, without consultation, because they posed a hazard to the neighbors. These branches included favored monarch cluster sites. This action coincided with the (then) record low point of the California population, and only 900 monarchs overwintered in Pacific Grove. The situation stimulated the development of a new management plan, completed in 2011.

In fall 2011, potted trees were brought into the grove and placed in the SE corner near where the branches had been cut, to create some temporary wind shelter. Based on the new management plan, in 2012 several of these trees were planted in an additional row of eucalyptus just north of the southern boundary trees, at 10-15 ft spacing.

By 2012, the 1999 shelterbelt trees had grown tall enough (50-60') to provide wind shelter in conjunction with nearby pines and cypress, and monarchs moved into the interior of the grove and remained there for the remainder of the season, clustering on pines and cypress trees that receive more insolation than surrounding branches (see below for a discussion of shading).

In spring 2013, potted trees that had been brought into the grove as a temporary wind shelter were planted in the ground, creating a dense stand of small trees in the southeast corner of the grove. It was a period of conflicts over grove management.

In recent years, most hazard trees have been removed, and management actions have been relatively minor.

Ambient Weather Station

A weather station was installed on the southern fence within the historical cluster area in that zone. With the absence of monarchs, it is not possible to describe monarch reactions to the changing weather, but it is possible to describe the weather measured at this point. And it gives some indication of habitat suitability at this micro site. The graphical output for August 1, 2020, through March 31, 2021, are shown in Figure 4.

Temperatures were generally mild during the period. Heat spikes in August (T_{max} 90+^{O}F), September, and October (85+^{O}F) stand out. Notably, during the typical overwintering season, T_{max} exceeded 65^{O}F for short periods in November and December, and almost a week in mid-January (with 2 days >72^{O}F.). Temperatures <40 ^{O}F were infrequent. The lowest temperature recorded was ~35 ^{O}F on January 19.

Wind gusts greater than 10 mph were recorded on 4 days in November, 4 days in December, 6 days in January, and 6 days in February. The gusts came from many directions, sometimes from the NNW (early November) or from the S (late January during the one strong storm). The Ambient site has variable wind shelter from different directions.

Peak solar radiation values were typical, ranging from 800 w/m^2 in August to <300 w/m^2 in December. Extremely cloudy periods were short, with the longest period in late January at the time of the strong storm.

Precipitation was intermittent, with the maximum storm total of 3.28" in late January. The amount of rainfall in 2020-2021 was not sufficient to saturate the soils, and high drought stress is expected in summer-fall 2021. Some relief may be provided by coastal fog.

The Ambient Weather Station is a welcome addition to Monarch Grove Sanctuary. It characterizes the conditions at one point in a complex environment, albeit in an area where monarchs have clustered in the past. Conditions here can be related to weather measured at nearby or long-term stations (especially Monterey Airport, Hopkins Marine Station, and others) which have the longest records. Wind exposure of the weather station site from different directions could be quantified with hemispherical photography.

Spatial patterns across MGS are important for understanding monarch use. Wind exposure and solar radiation can be quantified by hemispherical photography, as done in the 2011 report. Several methods are explored below in more detail.

Management Actions in 2020

Many of the minor actions recommended for 2020 were carried out.

Some small dead trees were removed.

The major action in fall 2020 was plantings of boxed Monterey cypress that had been brought into MGS in 2019. Many cypress trees were planted in the open area south of the main entrance and kiosk, where 1 or 2 trees were recommended as cluster trees. More cypresses were planted south of the main trail. Cypresses were also planted to the

east of the nectar beds. Some bottlebrush and eucalyptus trees were also planted (Photos 1-4). Some toyon and ceanothus were planted and caged.

No new low-growing native nectar plants were established along the trail through the nectar beds. Suggested management of the existing nectar plants by selective pruning was not observed by April 2021.

These new tree plantings have not been mapped as of May 2021, so a complete inventory is not available. The plantings produce an impetus for a new map of MGS as discussed below.

Recommended Actions for 2021

The 2011 Assessment and Management plan is now 10 years old. Conditions have changed enough that development of an updated plan is desirable. Some key steps are suggested here.

Produce a New Base Map of Monarch Grove Sanctuary

Managing MGS is an exercise in landscape architecture, with the goal of maintaining wind shelter from all directions, but allowing sufficient light in the interior so that monarchs can choose a mix of sunny, dappled, and shaded spots within the forest. Also, management of hazard trees and tracking of new plantings and subsequent growth are desirable so that a record of actions is maintained, and precise plans for each year can be laid out and executed as planned.

The foundation of a long-term management plan is an accurate map of the Sanctuary, including property boundaries, tree locations, tree species, tree diameter at breast height (DBH), tree height, and tree health. In addition, new plantings, understory plants, trails, and other features should be added on an annual basis.

In 2010, a working map of MGS was produced for the 2011 Assessment and Management Plan (Figures 5 and 6). The 2011 map used triangulation with tapes to lay down a 10 m grid, and trees were mapped out within those grids to within 1-2 meters. Hemispherical photographs were taken at each 10 x 10m point. Attempts to tie the grid to surveyed property lines were stymied by poor GPS accuracy within the forest, and distortions of horizontal distances by topography. Therefore, the working map is not georeferenced and has its own local coordinate system. This map has served since 2011 for management, but is now out of date because of tree mortality and new plantings.

Rather than update the current map, it is recommended that a new map be produced with surveying equipment such as a Total Station, and be tied into the parcel map, digital elevation model (DEM), and other base data for Pacific Grove. GPS is not accurate enough within the denser parts of the grove. A surveying class project by CSUMB may be an economical way to complete this work.

Remapping all the trees is an opportunity to reassess their health, requiring the city arborist to be involved. Drought stress will be severe in 2021, and special note should be made of drought symptoms where visible.

Repeat hemispherical photography
Nearly exact relocation of photopoints is possible through triangulation from the SE fence corner, even without a formally surveyed base map. Some photographs were reshot in 2018 but never fully analyzed. Either this year (2021) or next year (2022) a subset of photos should be retaken so that the change in conditions from 2011 and 2018 can be quantified.

Methods for interpolating wind and light have improved since the 1998 and 2011 reports, and can be redone in such a manner as to directly compare sites through time and understand the effects of canopy changes through time.

LiDAR
LiDAR (Light Detection and Ranging) is a state-of-the-art method for quantifying the 3-dimensional structure of vegetation at fine scales. A laser scanner is used from either above (airborne) or below (ground-based). The reflections are timed to calculate distance, and a "point" cloud of reflections is produced. There are software packages, including ARCGIS Pro, that can analyze and display the point cloud and describe vertical structures in detail.

Projects at other monarch sites (in Sonoma County) has developed some methods for quantifying wind and solar radiation at the outer canopy surface, using ARCGIS Pro and Wind Ninja software.

LiDAR data can be collected from airplanes, drones, or from ground-based scanners. A LiDAR flight over Pacific Grove was completed in 2018, with resolution of 5.68 pts/square meter and is available at:
https://portal.opentopography.org/usgsDataset?dsid=CA_FEMA_Z4_B1_2018

The point density is lower than that used in Sonoma County (9-12 points/square meter), and is sufficient to capture many canopy features. But it is not adequate to fully map the middlestory and understory. One advantage is that it is possible to map the surrounding urban forest areas.

It is possible to contract for drone LiDAR that can produce a map of several acres at high point densities of >30 points/square meter. Laguna Drones in Los Gatos can provide services for $5-10,000 depending on the amount of processing. This would produce the best up to date map and capture nearly full understory structure.

Ground-based LiDAR is feasible, but requires accurate ground locations, and would be difficult to deploy on private property outside MGS. No vendors are known at this time.

Airborne LiDAR could also cover George Washington Park and provide base data for a management plan there,

Wind mapping
Kingston Leong (1990, 1991) has developed a method for mapping wind on a grid using hand-held wind meters. The meters are held for a short period (2 minutes or more) and the mean, max, and min windspeed recorded. These measurements are done under a variety of wind directions, and can be correlated with monarch occupancy at fine scales. Monarchs tend to leave sites when ground-level winds exceed ~5 mph (2 m/s).

This wind mapping procedure could be executed by students from CSUMB, or volunteers in Pacific Grove. The wind attenuation from outside conditions can be correlated with Wind Site Factors (WSF) from hemispherical photography, which would allow for better inference of wind exposure. A well calibrated wind attenuation model would be of great use across all monarch sites. LiDAR data could also be correlated with measured wind.

Assessing New Plantings
The numerous newly planted cypress and eucalyptus will eventually greatly change the canopy structure and microclimate in the grove. While providing additional wind shelter is an important goal, it is important to remember that it is possible to have too dense a canopy that does not let in enough light for monarchs. This careful balance must be maintained (see below).

It is standard practice to overplant trees to account for mortality, and eventually thin them to an acceptable density. The spreading structure of Monterey cypress can deeply shade a site for decades, until the lower branches drop and open the understory.

At this point, it is important to evaluate the eventual growth of these new trees and plan accordingly so that they are not overcrowded and competing with one another, and do not provide excessive shade in key parts of the grove.

Tree health
As mentioned above, the health of each tree and prospects should be documented. In 2021, the extreme drought conditions make it imperative that drought stress symptoms be carefully noted.

In particular, the redwoods along the western boundary have not been preforming well, especially during droughts. The weakest of these trees should be removed in phases and replaced with cypress or pines to maintain wind shelter. Some of the older tall pines are in poor shape, and may pose hazards to people, structures, and other trees. Prompt attention to hazard trees with “targets” should they fall is an essential annual activity.

Evaluation of Shade Limitations

While wind shelter is paramount, monarchs often seek sunny habitats for clustering. The consistent use of the sunny southern boundary trees and adjacent trees to the south reflect this preference. But the high southerly wind exposure in those sites means that monarchs move north into the interior of the grove where southerly wind exposure is lower.

But, in the wind-sheltered interior of the grove, shade may be limiting use by monarchs. The large eucalyptus on the southern boundary cast shade deep into the grove, and additional pines and cypress north of the path add to the shading.

The 2011 Assessment and Management Plan has insolation maps copied here (Figure 7). These maps show that there are some higher insolation sites in the interior – note the small halos within the deep blue areas near the center of the grove - which are where monarchs tend to cluster on pines (Photo 5) when they move into the interior. Repeat photography of these sites would establish if the canopy has grown and filled enough to cast more shade.

Shade can also limit access to nectar. The nectar beds are just west and north of the outline of the former building (removed in 2011). The southern portions of the nectar beds are deeply shaded for much of the winter, and are inaccessible except when high air temperatures allow monarch flight in shady habitat. The northern section of the nectar bed area is the best area for season-long nectar access. In the longer term, the growth of trees to the south and west of the nectar beds could increase shade limitations. Again, reshooting hemispherical photographs could quantify any differences in shade patterns.

A thorough evaluation of shade limitations, and potential ameliorations through selective pruning or even removal of trees to decrease deep shade should be conducted. Of course, maintaining wind shelter is essential. Modification of hemispherical photographs can provide a first order estimate of effects on both sunlight and wind. If LiDAR is available, then a similar modification of the canopy can be simulated by deleting potions of the point cloud.

Any such modification of the canopy by opening will require rigorous documentation and a cautious approach, given the sensitivity of the site and the Pacific Grove community.

Long-term Management Considerations (repeated from 2020 with some modifications)

Management of Monarch Grove Sanctuary is a long-term process. This section looks ahead to anticipated changes and issues over the next decades, so that current management recommendations can be put into context. Much of this section is reiterated from previous reports, with a few updates.

1) **NW Windbreak**: The 1999 blue gum plantings are now 60-70' tall and provide critical NW wind shelter and allow monarchs to remain in the interior of the grove following storms that drive them from the wind-exposed southern boundary. *These eucalyptus trees are the anchor of a multi-species windbreak, and are absolutely necessary to maintain long-term windbreak functions* because pines may succumb to pitch canker and cypress will lose lower branches. The mid-story of pines and cypress currently contributes to windbreak function, as the foliage on the blue gums is concentrated in the upper canopy.
2) **Eucalyptus threat?**: The ground along narrow zone below the NW windbreak eucalyptus is being affected by leaf and litter fall, but less than 0.1 acres are affected. The comments on page 2 in the 2020 arborist report ("potential catastrophic effects") greatly exaggerate the threat to native forest, especially since the eucalyptus will not be allowed to spread, and the litter deposits can be occasionally raked up. The remainder of the interior and northern reaches is available for native forest management.
3) **Southern Boundary:** The 2011 blue gum plantings inside the southern boundary, authorized by the City, have grown to heights of 25-30' and are beginning to provide additional wind shelter. Monarchs clustered on some of these trees in November and December 2019, with a peak of 53 (~15% of the population) on December 5 (see 2020 report). As these trees continue to grow, eventually monarchs can cluster in a wind sheltered dappled light environment as envisioned in the 2011 Assessment and Management plan. These trees will provide redundancy for the large southern windbreak trees, and will eventually replace them decades from now. These trees are in a difficult environment for rapid growth, with shade and root competition from the large southern boundary trees, so they will continue to grow relatively slowly, but will be healthy. Planting some additional trees, *Callistemon viminalis* and *Eucalyptus ficifolia* as recommended by the arborist report in key locations would fill gaps, diversify the windbreak, and provide a multi-age structure.
4) **SE Corner**: The densely planted blue gums (2013) in the SE corner are showing signs of overcrowding (some were planted 3' apart), with poor growth relative to more widely spaced trees. There has been a consistent recommendation over the years to thin these trees back to a more appropriate density, but it has never been implemented. The Weisfuss 2020 arborist report also recommends thinning these trees. Thinning will increase the health of the remaining trees, and their canopies will expand to fill in the available space. Several of them are now dead, and should be removed. These trees will continue to grow poorly in

crowded conditions and eventually self-thin, and they are competing with several of the authorized plantings from 2011.

5) **Wind gaps**: Farther west on the southern boundary, there are several larger gaps that should be filled. The arborist report recommends *Callistemon viminalis* and *Eucalyptus ficifolia* to diversify the windbreak and provide mid-story and low windbreaks. Cypresses are not recommended along the southern boundary because of sprawling growth form. Trees were panted int his gap in 2020 (Photo 2).
6) **Pines:** Pines continue to succumb to pitch canker, and despite some wet years in 2017 and 2019, drought effects are still being expressed in some trees. The dry year in 2020 and very dry year in 2021 promise more drought stress. Continued plantings to maintain a substantial pine component in the grove is important, but pines still cannot be counted upon to provide long-term overstory. Pine plantings need to be protected from browsing and getting knocked over by deer. Removal of pines heavily infested with pitch canker can slow, but not stop the spread of this disease.
7) **Previous cypress plantings**: Many of the cypress planted over the last two decades are in their period of rapid growth and will provide significant wind shelter in coming years and decades. The cypress along with blue gums will provide the backbone of the grove, given the uncertainties of pine survival in the long run. Some densely planted cypress stands have been thinned in recent years to encourage more rapid growth of remaining trees, and continued selective thinning is recommended in several spots.
8) **New Plantings 2020** More than 20 potted Monterey cypress were brought into the Sanctuary as temporary windbreaks in 2019. These trees have been planted in several parts of the grove. *The locations of these trees should be recorded on the new base map*. The cypresses are overplanted as discussed above, and eventually should be thinned once it is apparent which trees are strongest. If they are not appropriately thinned, the individual trees will be stressed and grow poorly. The spreading canopy of Monterey cypress can become too dense for monarchs, especially when tree crowns interlock. Special care should be taken to balance wind shelter and shade.
9) **Oaks**: Understory live oaks are scattered among the pines and cypress, and more plantings could fill in understory in select parts of the grove and provide good native habitat. Oaks can eventually provide low and mid-story windbreaks.
10) **Native forest management**: Overall, there are many sections of the Sanctuary where management for native forest is appropriate, with an emphasis on overstory pines. The northern reaches, beyond the NW windbreak is a prime example. The old pines have died or fallen, leaving wildlife snags and an open canopy. In addition to oaks, native shrubs (toyon and ceanothus are present, but a large palette of native shrubs is available) can contribute to understory structure. Non-native cover like the calla lilies can be removed in phases, and native forest floor forbs could be introduced in parts of the Sanctuary. All native plantings need to be protected from deer browsing. Some control of the dense

annual grass cover is needed while understory is establishing, and annual grasses will always be a component of the forest floor.

11) **Irrigation:** Maintaining the irrigation system for tree establishment and for watering during droughts, as well as developing a rigorous irrigation management plan overseen by City staff and implemented by volunteers, is critical. But irrigation should only be provided for the first year (unless severe drought occurs in the second year). The irrigation management has greatly improved over the last year, according to volunteers (Photo 6).
12) **Nectar:** Attractive fall blooming nectar plants help to retain arriving butterflies early in October and November. *Nectar plants in sunny areas can be used far more frequently than those in the shade and sunny areas are at a premium.* Yellow Buddleia and tree daisy are the most attractive species in the beds, and replacement of some of the other species in the beds (i.e. the mallow) should be considered. The sunny edges along the trail are perfect for planting native nectar species for fall nectar. Away from the nectar beds, butterflies nectar on the flowering red gum when it occasionally blooms in the fall. Use of bottlebrush was noted every year. Later in the season, early-blooming *Prunus* has provided winter-spring nectar in addition to the blooming blue gums. As mentioned above, a thorough evaluation of present and future shade limitations is desirable.

George Washington Park

George Washington Park (GWP) is ready for a more detailed site restoration and management plan. Observations and recommendations (largely repeated from previous years) include:

1) This is a unique site for California monarchs; it is one of the few remaining Monterey pine/live oak habitats for monarchs.
2) GWP has been used intermittently by monarchs, a few individuals can be found there every year at some point, but major clusters were observed only in 2003, 2004, and 2006 (Table 1). In 2006, there were more than 10,000 monarchs at GWP and very few at Monarch Grove Sanctuary. Since then, there has been only one year (2011 with 61 observed) with monarchs at Thanksgiving, none were observed from 2012 to 2019. Individual monarchs have been observed here during other times of the overwintering season.
3) The historic cluster sites in GWP are losing sufficient wind shelter for monarchs, and additional senescence of mature trees threatens this important component of habitat suitability. In particular, the largest pine at the historical overwintering site died several years ago, but there are several mid-story pines that are in positions to replace this tree over coming decades. Losses of forest cover to the south and west through overstory tree mortality is reducing wind shelter.
4) Removal of dead standing trees is recommended where they have stationary targets, especially around the edge of GWP. Dead trees that may fall across trails in the interior should be evaluated on a case-by-case basis. Trees can be left as safe wildlife snags where appropriate, but a more naturalistic topping should be considered.
5) Reduction of accumulated deadfall by CALFIRE in 2014, 2015, and 2016 removed large piles of downed tree debris. This is important preparation for eventual site restoration. Some branch and log piles have been retained and downed logs are used to redirect foot traffic to fewer trails.
6) Plantings of pine seedlings to the SW of the historical cluster site, similar to the plantings at the southern end of GWP, should commence.
7) Live oak plantings can provide the under- and middle-story necessary for wind shelter in a mature pine forest.
8) Similarly, ceanothus and toyon can provide understory structure.
9) Operations on the perimeter of the park are the priority, to maintain safety from falling dead trees on adjacent roads, and to create a fire buffer.
10) The full impact of the recent and ongoing drought will continue to be expressed. Trees may take one or two years to die after major drought stress and high rainfall season like 2016-2017 and 2018-2019 may not allow for recovery once drought stress has weakened trees.
11) Establishment of a designated trail system and decommissioning of meandering paths impacting root systems of the trees is occurring. Ingrowth of poison oak is effectively shutting some social trails.

12) Now that there have been reductions in downed trees and debris, and the full impact of the drought on mature trees will become apparent, the long-term suitability of George Washington Park for monarchs should be assessed, using a combination of hemispherical photography, LiDAR and other suggested methods.
13) An assessment of pitch canker and tree health is especially important in GWP.
14) Once assessments are done, a long-term planting scheme (pines, oaks, and native understory shrubs) should be developed and implemented. The key elements of such a planting scheme should be to provide eventual replacements for canopy trees, create and maintain a mid-story of oaks and pines, and maintain wind shelter from all directions around defined canopy gaps.

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Table 1. Monarch Butterfly Thanksgiving Counts Xerces Society Monarch Grove Sanctuary (MGS) George Washington Park (GWP), Monterey County, and California Totals. *MGS was the only site counted that year.

Year	MGS	GWP	CA Total	Monterey Co.	MGS % CA	MGS % Monterey	MGS CA Rank
1997	45,000		1,235,490	45,000	4%	100%*	10 (tie)
1998	35,000		564,349	41,000	6%	85%	5
1999	25,000		267,574	25,000	9%	100%*	3 (tie)
2000	20,000	0	390,057	20,000	5%	100%*	6 (tie)
2001	14,960		209,570	31,203	7%	48%	4
2002	4,700		99,353	11,593	5%	41%	5 (tie)
2003	22,802	2,750	254,378	68,979	9%	33%	2
2004	10,867	4,325	205,085	54,481	5%	20%	4 (tie)
2005	12,199	2	218,679	37,540	6%	32%	4
2006	28,746	11,795	221,058	59,957	13%	48%	1
2007	8,181	2	86,437	15,426	9%	53%	3
2008	17,866	0	131,889	31,063	14%	58%	2
2009	793	0	58,468	4,735	1%	17%	17
2010	4,968	0	143,204	8,634	3%	58%	4
2011	12,265	61	222,525	27,788	6%	44%	4
2012	10,790	0	144,812	29,048	7%	37%	4 (tie)
2013	13,420	1	211,275	35,772	6%	38%	3 (tie)
2014	18,128	0	234,731	55,879	8%	32%	3
2015	11,472	0	292,888	27,787	4%	41%	3 (tie)
2016	17,100	0	298,464	64,804	6%	26%	3
2017	7,350	0	192,629	35,657	4%	21%	8
2018	705	0	28,429	2,758	2.5%	26%	15
2019	642	0	21,944	2,792	2.9%	25%	8
2020	0	0	1,914	58	0	0	--

Table 2. Comparisons of Thanksgiving (NOV) with New Years (JAN) counts at Northern California sites that had butterflies at Thanksgiving Counts.

SITE ID	SITE NAME	COUNTY	NOV 2020	JAN 2021	Ratio 2020	NOV 2019	JAN 2020	Ratio 2020	NOV 2018	JAN 2019	Ratio 2019
3000	Lighthouse Field, Santa Cruz	Santa Cruz	50	13	26%	3402	2600	76%	1802	1933	107%
2998	Natural Bridges State Beach	Santa Cruz	550	550	100%	1997	25	1%	1120	765	68%
2920	Private Property near Big Sur	Monterey	-	-	-	1750	50	3%	819	29	4%
2833	San Leandro Golf Course	Alameda	-	-	-	702	252	36%	192	5	3%
2935	Butterfly Grove Sanctuary	Monterey	0	0	-	642	316	49%	705	685	97%
2983	Moran Lake, Moran Lake	Santa Cruz	50	30	60%	400	30	8%	1373	346	25%
3248	Deer Flat Ranch	Monterey	40	47	117%	369	244	66%	163	270	166%
2912	Alder Rd.,	Marin	100	53	53%	200	0	0%	1256	62	5%
2832	Chuck Corica Golf Course	Alameda	19	11	58%	177	0	0%	177	-----	-----
3010	Ocean View and Marine Drive	Santa Cruz	-	-	-	167	54	32%	167	-----	-----
3227	Juniper & Kale, Bolinas	Marin	18	12	66%	113	12	11%	200	0	0%

Figure 1. Relationship between total California monarch numbers and MGS numbers, Xerces Thanksgiving Counts

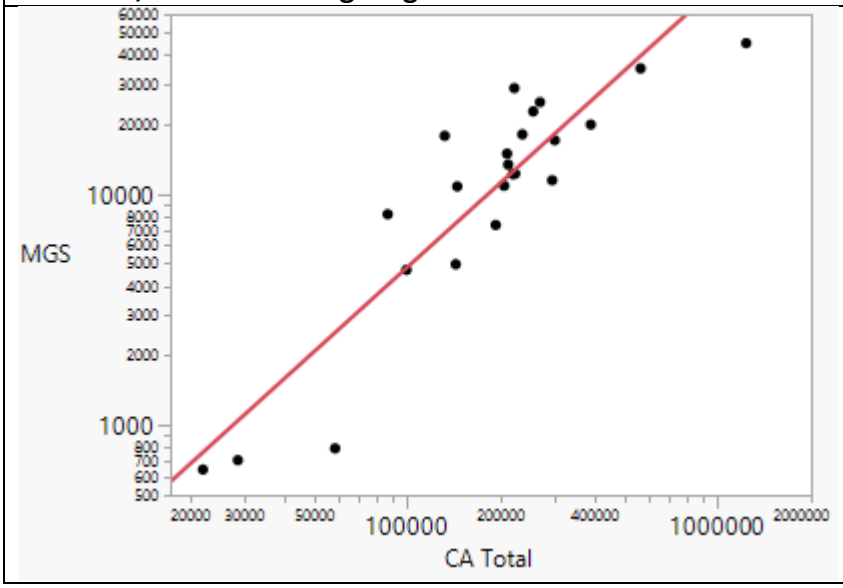


Figure 2. Monthly Mean Temperature for Monterey County, August-November 2020. From Westmap (https://cefa.dri.edu/Westmap/Westmap_home.php)

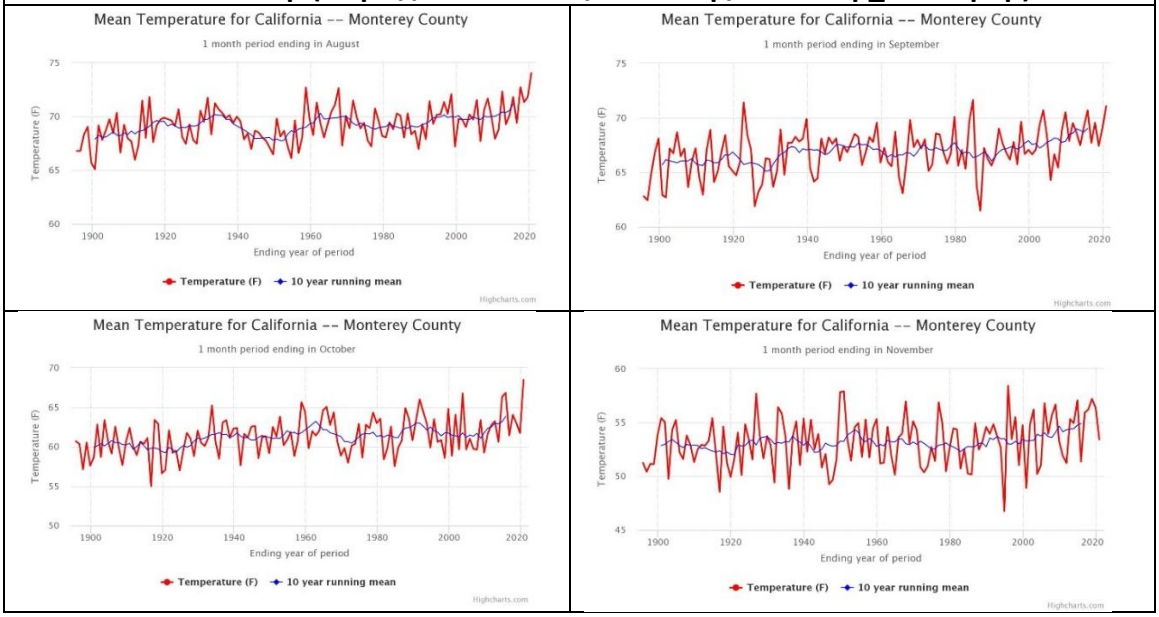


Figure 3a. Monarch numbers through seasons. Data from Pacific Grove Museum

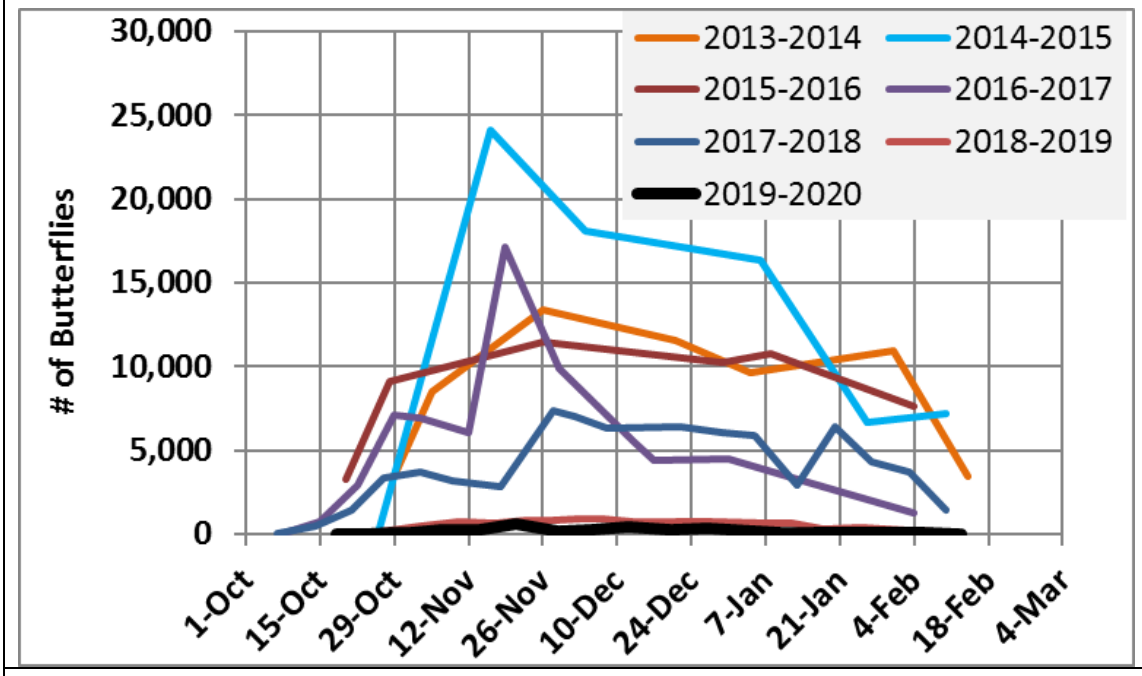


Figure 3b. Monarch numbers through 2018-19 and 2019-2020 seasons

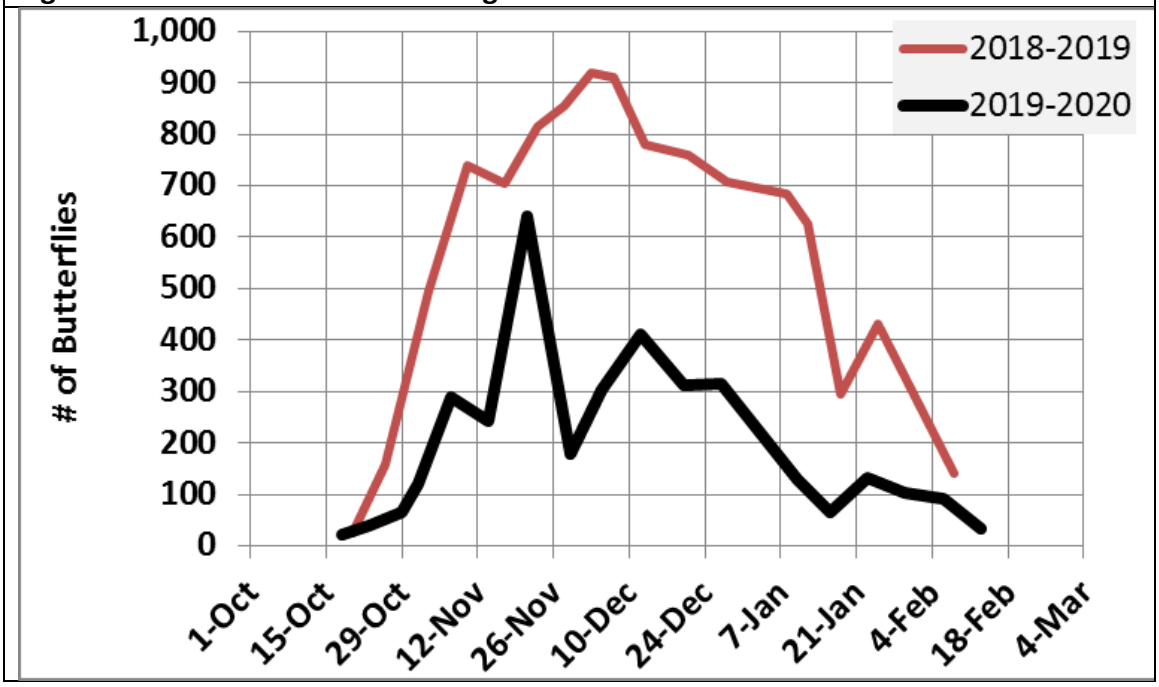


Figure 4. Graphical output from Ambient Weather station

Figure 5. Monarch Occupied Trees (Green Triangles) 2012-2014, Grid in meters

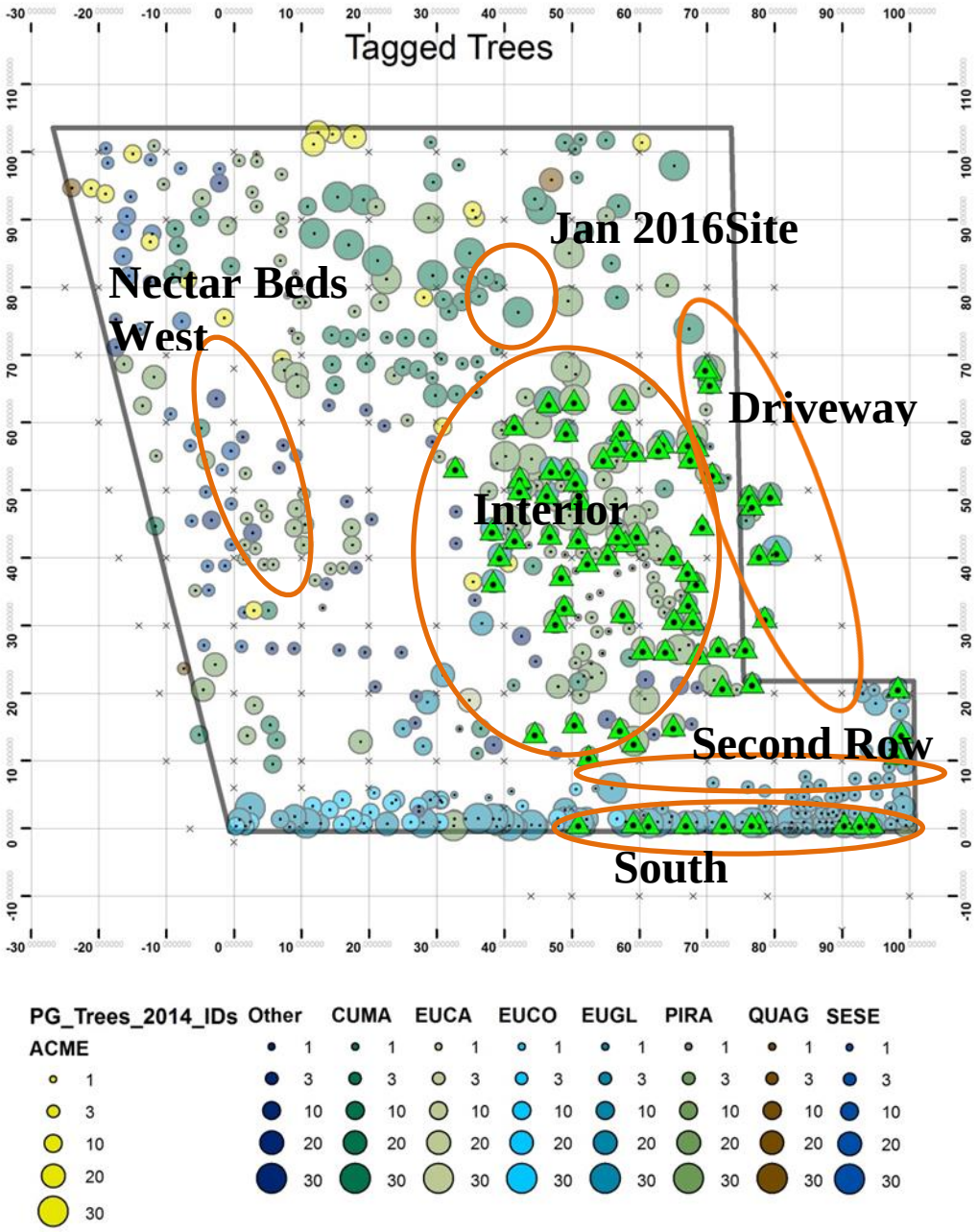


Figure 6. Management Zones. Grid in Meters

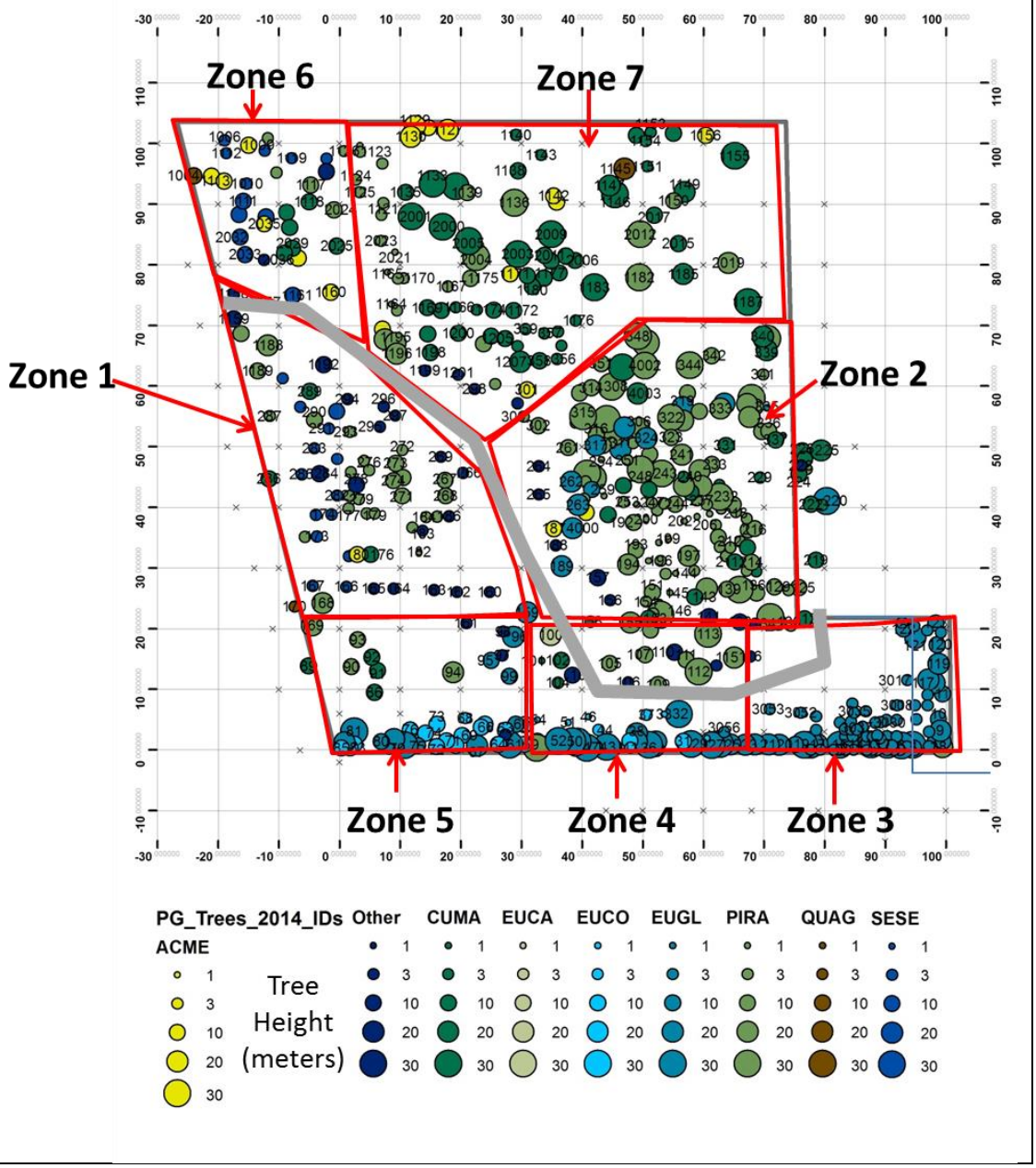
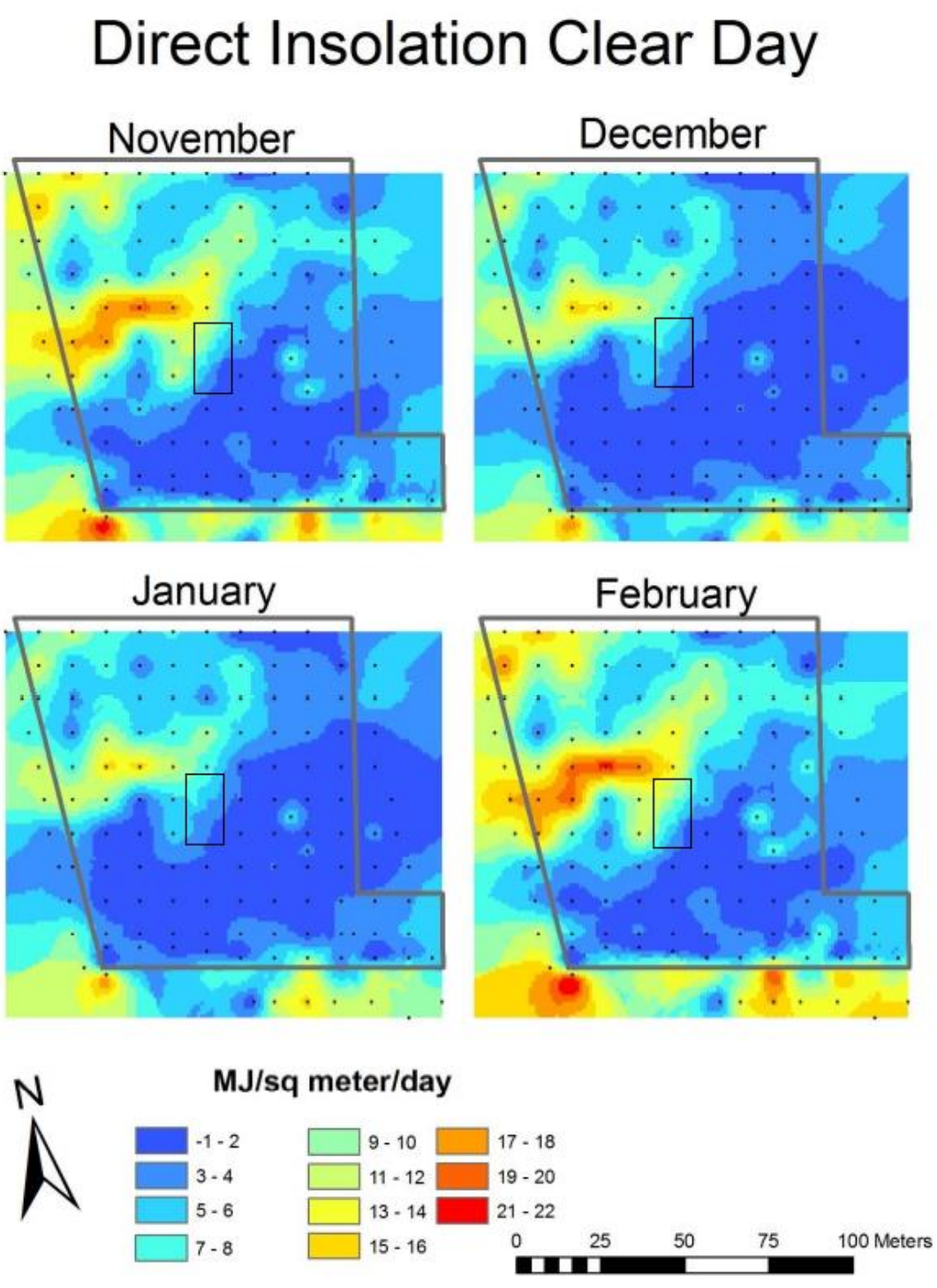


Figure 7. Insolation maps from 2011 report. Note the small halos in the interior east of the outline of the old building footprint, and the high insolation areas NW of the building where the nectar beds are now planted.



Photos

Photo 1. Monterey cypress planted in 2020 in SE corner

Photo 2. Ceanothus and cypress planted in gap along south boundary

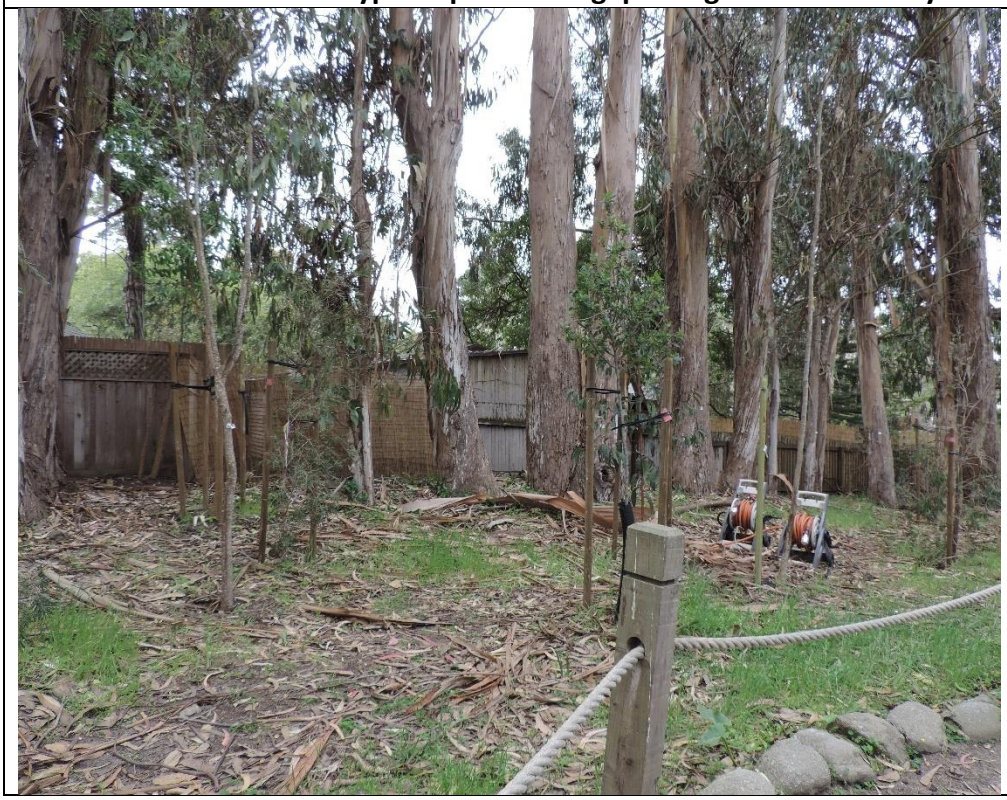


Photo 3. Cypress planted just south of kiosk in SE corner

Photo 4. Cypress east of nectar beds

Photo 5. Monarchs on pine in interior of forest, December 2014

Photo 6. Irrigation documentation