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10 September 2018

Re: Proposed management activities Monarch Grove Sanctuary and George Washington Park September 2018

The following recommendations and assessments are based on site visits and consultations with City Arborist Albert Weisfuss in summer 2018. They are addressed in the context of the 2011 Management Plan and subsequent consultations with City staff and residents, including annual recommendations from 2014-2017. The recommendations are based on previous scientific work, professional judgment, and detailed field assessments. They carefully balance monarch habitat needs, hazard reduction, and forest health, based on both short-term and long-term perspectives.

Background data on Monarch Grove Sanctuary (Xerces Society Thanksgiving Counts) provide context of the entire California monarch population. Also, we have also incorporated butterfly monitoring data from the Pacific Grove Museum since 2013 to document habitat suitability and monarch use patterns relative to weather and time of season. This reporting on monarch abundance and distribution will constitute a long-term accessible record for the local community.

Summary of recommended actions (see page 4 for detailed exposition)
Minimal on the ground actions are recommended this year

1. Removal of dead and dying pines near nectar beds
2. Thinning of cypress in dense stand north of nectar beds
3. Protecting and replanting sapling pines that have been knocked over

All other recommendations are for planning for future actions in 2019 and beyond.

Recent History

Monarch Grove Sanctuary (MGS) continues to support one of the largest overwintering aggregations in California (Table 1). The ultimate size of the MGS aggregation is dependent on range-wide breeding success the previous summer, and the ability of the site to attract butterflies in the fall and provide suitable temperature, light, and wind conditions through the fall and winter. Since 1998, MGS supported between 1% and 14% of the Thanksgiving Count estimates for the entire state. From 2001 on, MGS supported between 17% and 58% of the Monterey County population.

From 1997 to 2008, the Sanctuary supported between 4,700 and 45,000 butterflies (Table 1). The severe drop in 2009 to 800 butterflies reflected a sharp decline rangewide from 220,000 to 55,000, likely driven by a three year drought across the Western United States. The low numbers at MGS in 2009-2010 also followed hazard branch trimming (summer 2009) along the southern boundary where monarchs had clustered in most years. The relative contributions of low overall California numbers and branch trimming to the sharp decline compared to other aggregations are difficult to quantify. MGS had supported as few as 20% of the Monterey County population (in 2004) compared with 17% in 2009.

Numbers and ranking recovered in 2010 and 2011 with the end of the drought. In fall 2010, potted trees were placed along the southern edge to fill in low wind gaps. Adventitious branches filled the mid-level gaps created by the trimming, and wind shelter improved on the southern boundary. Importantly, the blue gum trees planted in 1999 achieved heights (50-60') and crown volume that provided critical NW wind shelter, as envisioned in the 1998 management plan. In 2011-2012, butterflies moved from the southern edge into the grove interior for much of the season. Since then they have regularly used those interior trees for substantial parts of many seasons.

Current Monitoring Results

Creekside staff mapped the location of trees that have been tagged by monitoring crews from the Museum (Figure 1) green triangles. Note the two distinct areas for monarch clustering; the southern and far southeast boundary and the Monterey Pine on the adjacent property (*southern boundary and neighbors yards* [208, 210, and 212 Ridge Road]), and the interior stretching from the hotel driveway to 30-40 m west into the grove (*interior*). These maps were combined with the monitoring database collected by the Museum paint a dynamic picture of monarch distribution and abundance in the Sanctuary for 2013-2017. In 2016-2017 and 2017-2018 a simplified map as used by monitors to document monarch distributions. Discussions of the 2013-2017 seasons are in Appendix A.

The numbers of monarchs within seasons have been collated by the since 2013-14 by the Pacific Grove Museum of Natural History (Figure 3a). The general pattern for each season is a rise in numbers in October/early November, a peak in late-November and December, and a decline through the remainder of the season. The overall movements of butterflies between the southern boundary and interior can be tracked as a measure of

habitat suitability and response to weather. Wind data from Monterey Airport provide context for local shifts in distribution.

2017-2018 season summary
The 2017-2018 season was quite mild for long stretches (Figure 2). Wind events (max speed > 20 mph) are noted for October 20, November 16, November 27, January 9, and January 24. The largest rainfall events were on November 27 (0.81") January 2 (0.66") and January 9 (2.61"). December was quite dry (0.03" total).

In fall 2017, butterflies arrived as usual in October with 42 observed on October 7, rising to 3,353 by October 29, and hit peak numbers of 7,350 on November 28 (Figure 2). Numbers held at ~ 6,000 through January 5, then dipped temporarily to 2,947 on January 13 following the large storm and wind event, but recovered to 6,450 by January 20. The windstorm (max wind = 24 mph) apparently scattered the butterflies, but they regrouped soon thereafter. Then with warmer weather, numbers declined to 1,411 by February 10, the last monitoring date of the year before the monarchs left the site during record warmth in mid-February.

The monarch distribution was quite dynamic in 2017-2018. In mid-October, butterflies clustered along the southern boundary, and on the cypress above the hotel driveway. They remained on the southern boundary, with some in the interior, into mid-November. From late-November through early-February, they were primarily clustering just outside the Sanctuary at 208 and 210 Ridge Road on cypress and pine.

Use of tree species varied through the season according to availability in different areas (Figure 3b). From October through December 2, butterflies primarily used eucalyptus and pine along the southern boundary and interior. From December 8 through December 30, they were primarily on cypress on adjoining properties, but some shifted to a eucalyptus on January 5. They then primarily used cypress and pines through the rest of the season.

The use of tree species was similar to that in 2016-2017 (Figure 3c). Eucalyptus and pines were favored in October and early November, then cypress was favored from mid-November to the end of the season.

Long-term Management Considerations
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.

1) The 1999 blue gum plantings are working as anticipated, growing to 40-60' tall and providing NW wind shelter and allowing monarchs to stay in the interior of the grove following storms. These trees will continue to function for many decades as part of a multi-species windbreak that includes pines and cypress.
2) The 2011 blue gum plantings inside the southern boundary have grown to heights of 20-25' and are beginning to provide additional wind shelter at low heights.

These trees will eventually reach heights where monarchs can cluster in a wind sheltered dappled light environment – some early season clustering has been observed on the taller trees. These trees will provide redundancy for the large southern windbreak trees, and will eventually replace them decades from now.

3) The densely planted blue gums (2013) in the SE corner are showing signs of overcrowding, with poor growth relative to more widely spaced trees. Incremental thinning of these in the near future (not in 2018) should be seriously considered. Remaining trees will fill out the canopy quickly.
4) Pines continue to succumb to pitch canker, and drought effects are still being expressed. 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. Removal of pines heavily infested with pitch canker can slow, but not stop the spread.
5) Many of the cypress planted over the last decade 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 on pine survival in the long run. Some densely planted cypress stands should be thinned.
6) Understory live oaks could fill in select parts of the grove and provide good native habitat. Understory native shrubs (toyon and ceanothus in particular) and forest floor forbs could be introduced in parts of the Sanctuary, but need to be protected from deer browsing.
7) Maintaining the irrigation system for tree establishment and for watering during droughts, as well as developing a rigorous irrigation management plan implemented by City staff, is critical.
8) Continued provision of attractive fall blooming nectar plants will help retain arriving butterflies early in October and November. All nectar plants should be in sunny areas if they are to be effectively used. Yellow Buddleia is the most attractive of all the species planted in the beds, and replacement of some of the other species in the beds should be considered. Away from the nectar beds, butterflies nectar on the flowering red gum when it is blooming in the fall. Use of bottlebrush was noted every year. Early-blooming *Prunus* has provided winter-spring nectar in addition to the blooming blue gums.

Management Recommendations for 2018

Monarch Grove Sanctuary

Several issues in forest and habitat management at Monarch Grove Sanctuary were identified in the field, and are keyed to zones identified in Figure 4. There are relatively few actions recommended which are summarized immediately below. A more in depth discussion of various issues follows

1. No hazard trees were identified, so no action is necessary.
2. Removal of the completely dead pine near the nectar plots (red oval Photo 1)
3. Removal of the nearly dead pine between the nectar beds and Grove Acre Ave (orange oval Photo 1).

4. Thinning of a few Monterey cypress trees (planted in the mid-2000s) to allow for better growth of remaining trees in the area north of the nectar beds. Individual trees will be identified in the field with the City arborist (Photo 2).
5. Consideration of staking, exclosures, and replanting needs/options for recently planted Monterey pines that have been knocked over (Photo 3).
6. Planning for a few additional cypress plantings in key spots, to provide back-up for pines.
7. Evaluation of the crowded blue gums in the SE corner and consideration of selected removal of poorly performing individuals (Photo 4).
8. Evaluation of needs for further plantings of *Eucalyptus* (not necessarily blue gums) in the second row to fill in gaps along the southern boundary
9. Planning for plantings of live-oaks (preferably from acorns and with adequate protection) in the northern reaches of the Sanctuary and other selected sites to provide eventual understory in the wind shelterbelt, as well as wildlife habitat.

Detailed discussion and observations

1) **Zone 1 Removal of dead pines with pitch canker (Photo1):** Near Grove Acre Avenue, a dead Monterey pine and a nearly dead pine should be removed in 2018 (Photo1). Additional pines should be planted in this zone and receive irrigation, along with continued monitoring of the remaining trees.
2) **Zone 1 and 6 redwood management:** The redwood trees have clearly not worked. They are water-stressed, most are growing poorly and have dead tops and branches. Redwoods are not well suited for Pacific Grove close to the ocean because of salt spray. Irrigation has not kept up with tree demand. We recommend phasing out the redwoods over a few years and planting cypress and pine as replacements. There is sufficient wind shelter in this area that removal of the short redwoods will not diminish the butterfly habitat.
3) **Zone 1 Cypress growth:** The rapidly growing cypress in Zone 1 will provide greater wind shelter in several years and replace the pines that have died, as well as providing an alternative to the redwoods. In general, many of the cypress across MGS planted in the late 1990s and 2000's are hitting peak growth and will provide canopy functions well into the future.
4) **Zone 2 Understory Pines (Photo3)**: The recently planted pines in this zone were knocked over after reaching several feet in height. We recommend that they be replanted with cages to protect them
5) **Zone 3 Blue gum plantings (2011) status:** City-authorized plantings of blue gums were carefully planned to fill in gaps in wind protection, be appropriately spaced, and their rapid growth and health is essential to the long-term habitat suitability of the Sanctuary. A minimum of 10-15 feet (3-4.5 m) between trees is necessary for tree health and rapid growth in the long-term. These trees are now ~20-25' tall (Photo 5), and occasionally support clustering monarchs early in the fall.
6) **Zone 3 Dense blue gum plantings (2013) status (Photo 4):** Additional blue gums (formerly potted) were planted much too densely in 2013 (Photo 4). Crowding serves to slow growth and create unhealthy individual trees. We have

recommended each year that these trees thinned back closer to the originally planned configuration. A number of these trees were removed (mainly dead ones), but are still too closely planted. Some trees were planted too shallow and may be structurally deficient.

7) **Zone 3 Potted Trees:** The remaining potted trees can be moved around to fill gaps, but are too root bound to planted.
8) **Zone 3 Mulch Management:** Surface blue gum duff was raked from around the small trees in 2015. This duff is important mulch to retain limited water, and such raking should be discouraged in the future. The duff also provides structure for monarchs to climb away from the ground of they are dislodged.
9) **Zone 2 Acacia management (Photo 6):** An acacia with much dead foliage is noted along the western edge of Zone 2, and some removal of dead branches is appropriate. But, the dense fine branches are filling an important gap for SW wind shelter for the interior cluster sites, and removal of all of these dead branches at once should be delayed until established trees and new plantings can fill the gap. There is an acacia growing in the corner of a nectar bed (left in photo) and a pine sapling that can fill this gap in coming years.
10) **Zone 2 Oak plantings:** In Zone 2, live oaks should be planted just east of the trail to create low windbreak. Provision of irrigation for the first few years should be a priority.
11) **Zone 7 Cypress thinning:** In the interior of Zone 2, several young cypresses failed to establish straight trunks and were removed. An additional 2-3 cypresses are recommended for removal to thin the stand. The remaining cypress plantings are dense enough to fill in for these removed trees. Final selection of trees to be removed will be made in the field by the City Arborist.
12) **Zone 7 Replanting pines and oaks next to snags:** In Zone 7, there are opportunities to replant pines alongside the many wildlife snags in the open area, to re-establish forest cover. These snags were dead or hazardous Monterey pines that were removed and left to act as a habitat / granary snags. Natural re-forestation is non-existent in Zone 2. Oaks would be a suitable understory in this area. While the canopy is open overhead, this site does not receive much direct light during the overwintering season because of tall canopy to the south. Provision of drip irrigation for the initial plantings increases chances for success.
13) **Zone 3 South fence line trees:** The trees planted next to the fence will eventually damage the fence as they grow in girth (Photo 5). No immediate actions are suggested other than removing dead trees, but monitoring the situation is important. At some point in the future (several decades) realignment of the fence will be necessary.
14) **Zone 4 Closing south edge gap:** On the south edge of Zone 4, there is a substantial low canopy gap that should be filled in by planting a nursery raised blue gum or red gum.
15) **Zone 5 no action:** No actions are suggested for Zone 5 at this time.
16) **Zone 6 NW corner:** The dead redwoods and ceanothus (Photo 9) should be removed. In addition, a couple of acacias are largely dead and should be removed (Photo 11).

17) **Nectar beds:** It is clear that the yellow Buddleia is a favored fall nectar source. The bushes are getting quite large, and accumulating dead foliage and branches in their interiors. We suggest that half of these bushes be trimmed in spring 2017, to allow for refreshed growth, and the other half be trimmed back in 2018. There are species that have been tested that are not favored, so replacement of some of the other species with Buddleia should be considered. The bottle brush and red gums do provide alternatives to Buddleia. Continued experimentation with fall blooming species should be continued in at least one of the beds. Appropriate irrigation management – not overwatering – is essential for the nectar beds.
18) **Understory plantings:** Toyon and blue blossom ceanothus are two species that can thrive in the grove and provide native understory. Plantings of these two species need to be caged for several years to protect against deer browsing, but once established can live for decades.
19) **Irrigation system**: Maintaining and operating the irrigation system for establishing trees, and avoiding over-watering and under-watering is an important management action. The reliable early survival of new plantings is dependent on appropriate irrigation, but trees should be weaned off irrigation after a few years once firmly established
20) **Adaptive Management:** This year (2018) is the fifth year where the deliberate adaptive management cycle has been undertaken. The cycle starts with a site visit in summer to assess the grove, a written report presented to the BNRC, and a public tour of the Sanctuary soon thereafter (sponsored by Public Works). Work is completed in September prior to seasonal restrictions. Public input is sought at appropriate times and through official channels.
21) **Management of trees at the Butterfly Grove Inn:** The City and the new owners of the hotel need to maintain cordial relations and coordinate actions in this sensitive area. Balancing safety, tree health, and maintenance of wind shelter can be difficult
22) **Southern Neighbors:** South of the Sanctuary, trees in the neighbors' yards provide cluster sites (the pine near the shed and several cypress), and additional wind shelter. In 2017-2018, a pines and cypress at 210 and 212 Ridge Road were heavily used by monarchs. While beyond the direct control of the City, maintenance of these trees by the neighbors is important. Outreach by the City is important to find out plans and anticipate changes. Management of hazards over these yards should be done on a case by case basis. But, management actions within the Sanctuary itself are designed to eventually make it more self-contained and less reliant on neighboring property owners.
23) **Squirrel disruption of monarch clusters:** A non-native Eastern fox squirrel was noted disrupting monarch clusters in 2016 and 2017, and may actually be responsible for some of the within season reduction in numbers, as well as changes in distribution. Should this squirrel make a re-appearance in fall 2018, various non-lethal methods (trapping, hazing) might be attempted. Lethal trapping might also be considered if live-trapping fails.

George Washington Park

George Washington Park (GWP) is ready for a more detailed site restoration and management plan. Observations and recommendations 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 2017. 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 has died, 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 assuming that sufficient rain falls in fall-early winter 2018-19.
7) 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.
8) The full impact of the recent drought will continue to be expressed. Trees may take one or two years to die after major drought stress and a single high rainfall season like 2016-2017 may not provide much relief.
9) 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.
10) 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, with methods similar to those employed at Monarch Grove Sanctuary.
11) An assessment of pitch canker and tree health is especially important
12) 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.

Table 1. Monarch Butterfly Thanksgiving Counts Xerces Society
Monarch Grove Sanctuary (MGS) George Washington Park (GWP), Pacific Grove and California Totals

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

Table 2. Comparisons of Thanksgiving (NOV) with New Years (JAN) counts at Northern California sites. Red indicates a virtual abandonment of the site, orange indicates a substantial decline, yellow a small decline, and blue an increase.

ID	SITE NAME	COUNTY	NOV	JAN	JAN/NOV
2920	Private Property near Big Sur	Monterey	19,741	3,780	19%
2912	Alder Rd., vortex (Larch, Ocean St)	Marin	12,360	10,000	81%
3000	Lighthouse Field, Santa Cruz	Santa Cruz	12,000	13,533	113%
2998	Natural Bridges State Beach, Santa Cruz	Santa Cruz	9,000	0	0%
2833	San Leandro Golf Course, San Leandro	Alameda	7,817	248	3%
2935	**Butterfly Grove Sanctuary,**	**Monterey**	**7,350**	**6,050**	**82%**
2983	Moran Lake, Moran Lake	Santa Cruz	5,400	8,094	150%
2924	Andrew Molera State Park	Monterey	5,100	130	3%
3227	Juniper & Kale, Bolinas	Marin	4,310	0	0%
2831	Ardenwood Historical Farm, Fremont	Alameda	2,075	1,255	60%
3192	CH1 Private Site	Monterey	1,100	250	23%
2832	Bay Farm Island	Alameda	985	1,532	156%
2830	Albany Hill, Albany	Alameda	768	200	26%
2899	Purple Gate, Bolinas	Marin	625	0	0%
2898	BPUD Sewer Ponds, Bolinas	Marin	410	0	0%
2841	Point Pinole, Point Pinole	Contra Costa	268	0	0%
2903	Chapman Ravine, Stinson Beach	Marin	210	0	0%
2923	Sycamore Canyon, Big Sur	Monterey	200	1	1%
2836	Skywest Mall	Alameda	163	0	0%
2927	Del Monte Road	Monterey	142	0	0%

Figure 1. Monarch Occupied Trees (Green Triangles) 2012-2014, Grid in meters

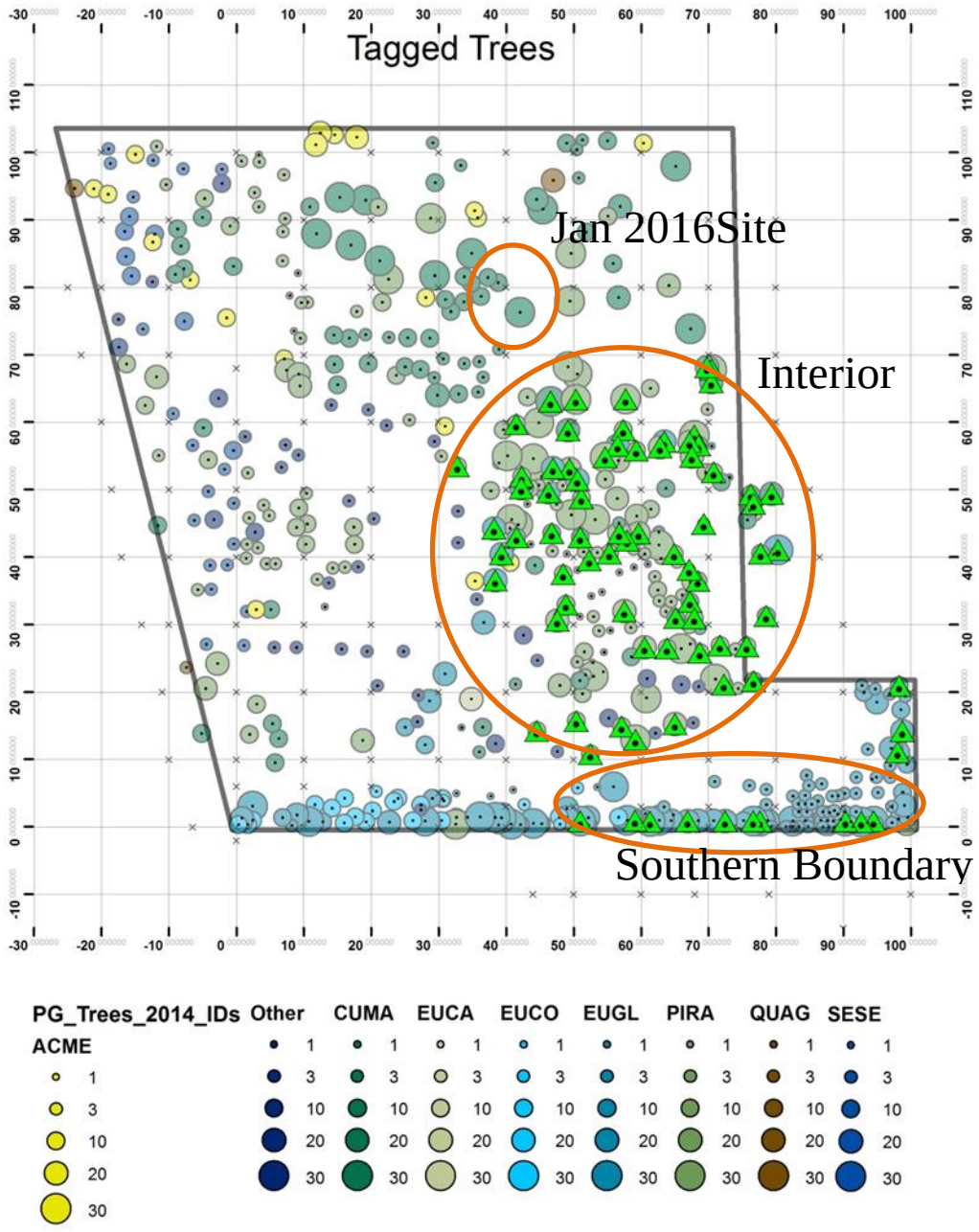

Figure 2. Daily Maximum Wind Data from Monterey Airport No data were available for a period in December.

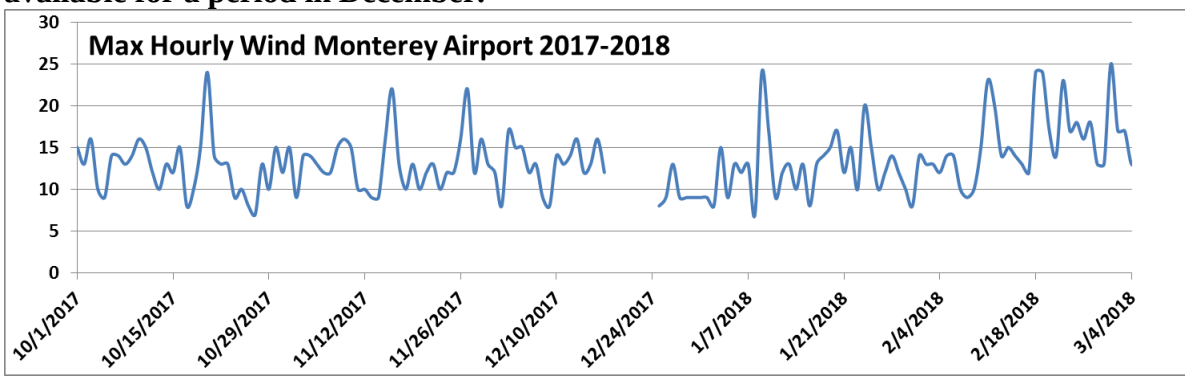

Figure 3a. Monarch numbers through season. Data from Pacific Grove Museum

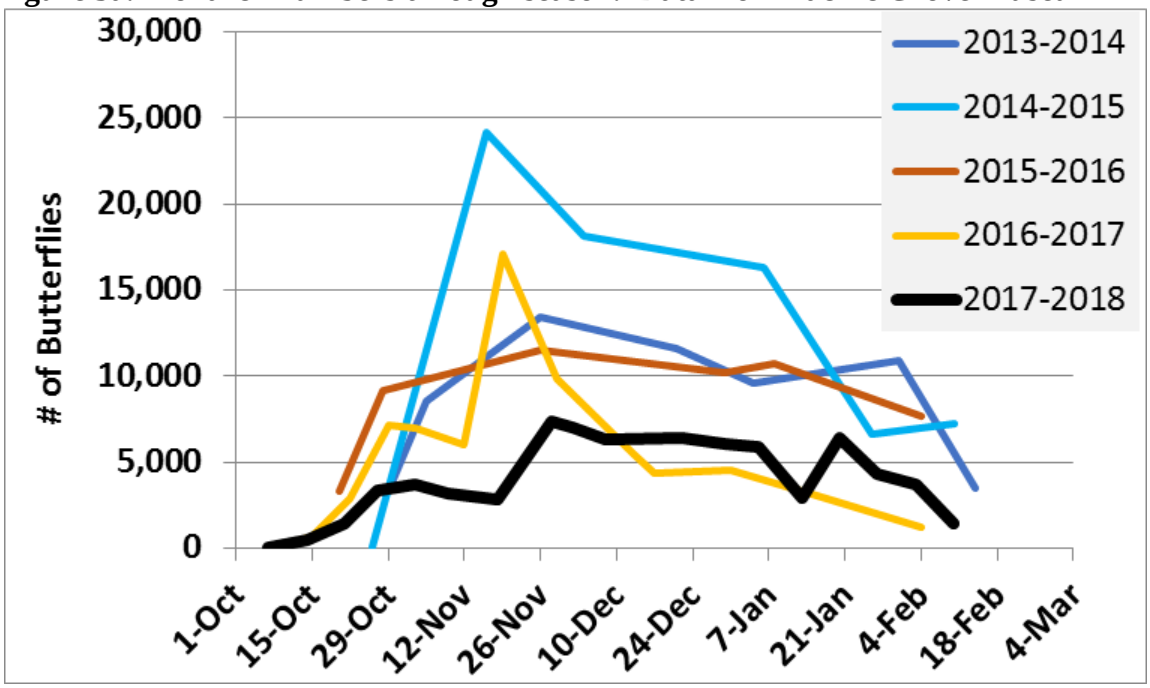

Figure 3b. Tree species usage by date 2017-2018

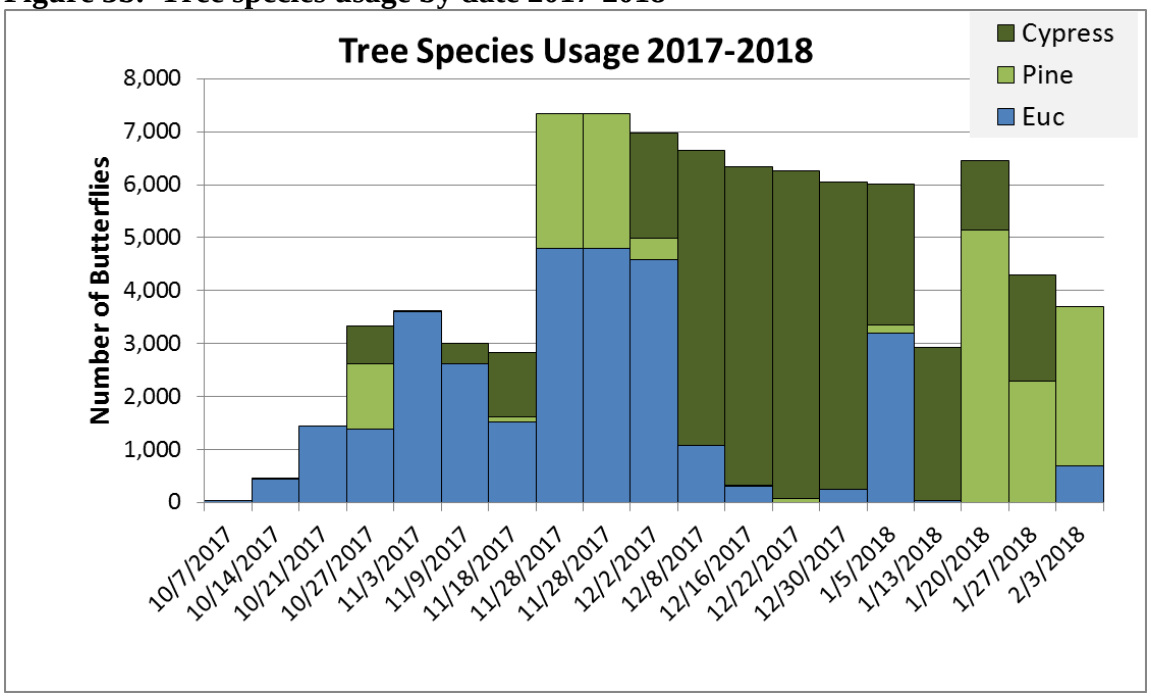

Figure 3c. Tree species usage by date 2016-2017

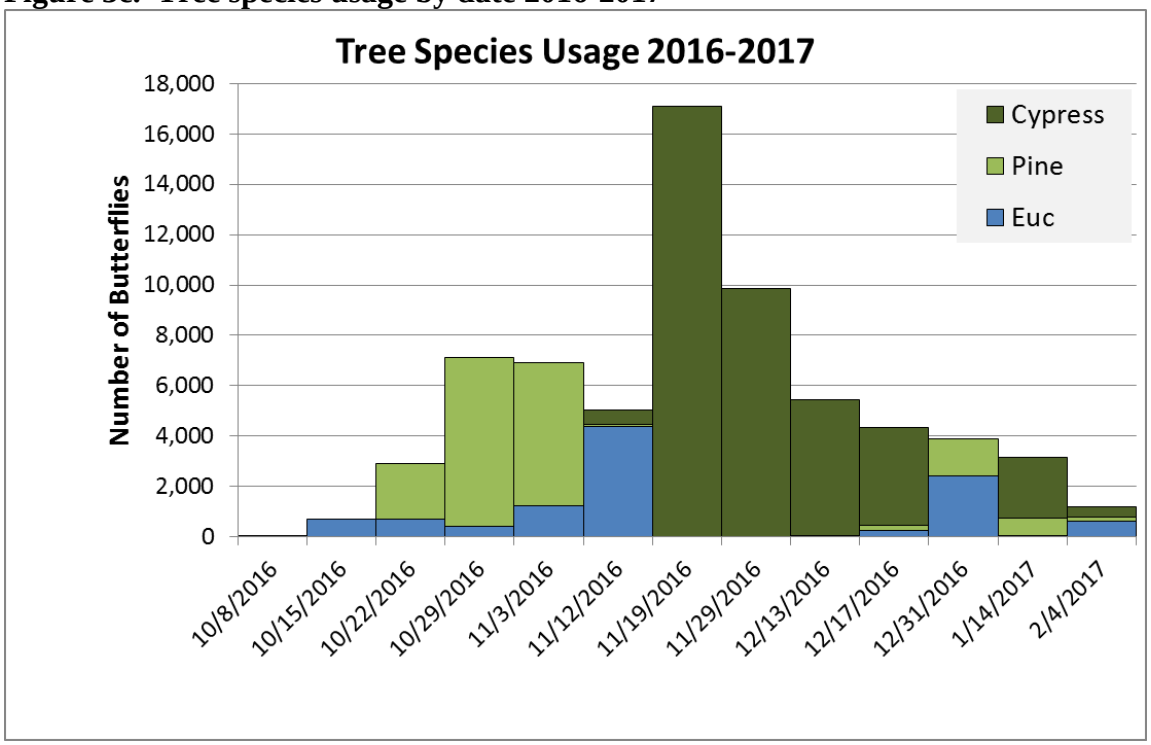

Figure 4. Management Zones. Grid in Meters

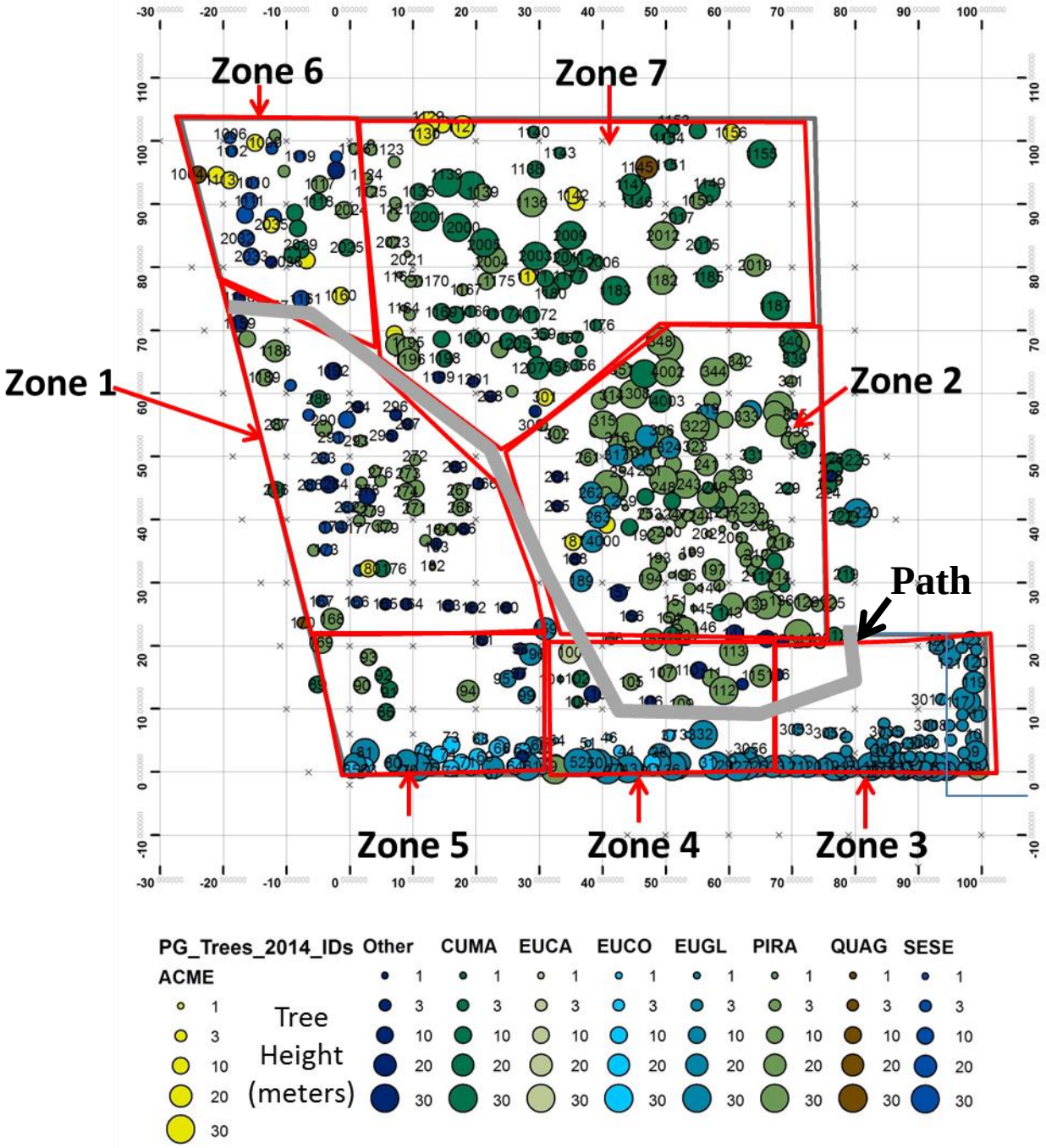

Photo 1 Zone 1 dead and dying pines, pitch canker

Photo 2 Dense cypress stand to be thinned

Photo 3 Knocked over pines Zone 2

Photo 4 Densely planted blue gums Zone 3 SE corner

Photo 5 Blue gum in second row along south boundary 25' tall

Photo 6 Acacias SE of nectar beds, sapling pine

Appendix A.

2013-2016 season summaries
Thanksgiving counts of 10,790 in 2012, 13,420 in 2013, and 18,128 in 2014, 11,472 in 2015, indicate that the Sanctuary continued to attract large numbers of butterflies that remained through the overwintering season.

In 2012-2013, the butterflies largely moved onto pines and cypresses in the interior of the grove following strong storms in November and December 2012. The interior habitat provided suitable light and wind conditions through the remainder of the season. The 1999 blue gum trees grew to 40-60' tall and provide critical NW wind shelter as part of a multi-species windbreak. Viewing opportunities were provided from the hotel driveway.

In 2013-2014, butterfly numbers peaked in late-November at 13,500 and remained at ~10-11,000 through early February, with a sharp drop in mid-February to <5,000 as they dispersed to the breeding grounds. Butterflies remained at the southern boundary through early January 2014. The strongest wind events during this period were in early December (max speeds 21-22 mph, gusts of 28-31 mph). By January 27, 2014, they had moved into the interior of the grove and were clustered on pines and cypress. There was a wind event on January 11 (max speed 16 mph, gusts to 28 mph). By February 14, butterflies had moved back to the southern boundary on Eucalyptus prior to dispersing away to breeding rounds.

In 2014-2015, numbers declined from 24,000 in mid-November to 16,000-18,000 from December through early January and persisted through strong storms in November-December. The decline to 6,000-7,000 by late January through February 10 represents dispersal to breeding grounds during a record warm January. Butterflies started clustering on the southern boundary, but by early December, following strong storms (max winds 25 mph, gusts 40-65 mph) they moved to the interior and remained there through February 10. Apparently the interior conditions were suitable during the warm relatively calm January (one wind event with 30 mph gusts), and butterflies did not move back to the southern boundary. The butterflies that remained in the grove persisted through another high wind event in early February (32-37 mph gusts).

In 2015-2016, butterflies arrived as usual in October and hit peak number quite similar to 2013-2014 (11,000, Figure 2). Numbers remained steady into late-January, and dropped in February as butterflies left the grove. A warm dry February led to dispersal to breeding grounds by the end of the month. Butterflies started clustering in October-November in the western and southern part of the grove, and by December had moved to the interior of the grove following several wind events (40 mph gusts), with the strongest gusts of the season (50 mph) in December (Figure 3). In early January, Dr. Weiss observed monarchs clustering on a tall Monterey cypress about 25 m off the northern boundary, well north of the typical interior cluster sites (Figure 1). They moved back into the interior and hotel driveway later that month.

These observations from 2013-2017 indicate that Monarch Grove Sanctuary continues to provide enough wind shelter and varied light conditions to support a large monarch aggregation early in the season, and maintain substantial numbers of butterflies through the remainder of the winter. There is sufficient wind shelter for the interior of the grove for butterflies to remain there following storms, and sufficient light that they can take flight as needed. The major wind directions that produce the highest sustained winds are SE-SW and W-NW (Figure 3) and the grove is now much better protected, especially from W-NW than in previous decades because of the growth of the 1999-planted Eucalyptus trees. 2016-17 provided a real test of wind shelter given the large number of storms and high wind events.

Figure A1. Daily Wind Data from Monterey Airport

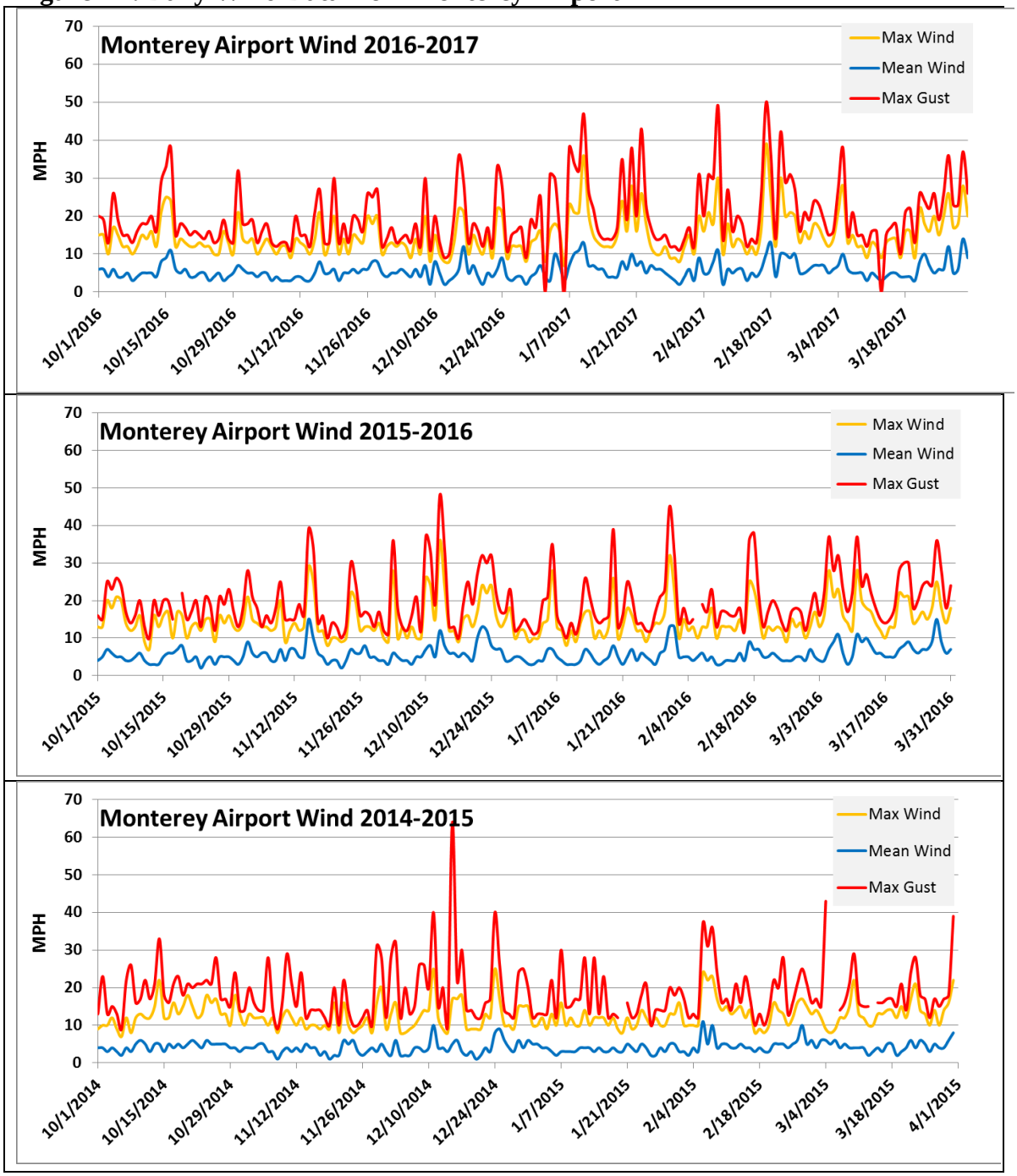

Figure A1 (Continued). Maximum wind and wind direction Monterey Airport