Monarch Grove Sanctuary Restoration Program

First year study, winter 1993-1994

Pacific Grove, California

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Introduction

Although monarch butterflies are not an endangered species, their winter migration and aggregation are considered to be threatened phenomena (Wells et al. 1983). In California, suitable overwintering habitats, in native trees and in eucalyptus groves, are being lost due to urban development, grove senescence and diseases (Australian eucalyptus borer, Phoracantha semipunctata (Froggatt), and pitch pine canker, Fusarium subglutinans (Wallenweb. & Reinking)). Efforts are being made to preserve their winter aggregations by: (1) identifying groves along the California coastline that have winter aggregations, (2) requiring an environmental evaluation of a winter site slated for development, and if necessary, recommend mitigating measures to preserve portions or all of the habitat, and (3) purchasing habitats deemed critical for the overwintering butterflies. The preservation of part or all of a winter habitat, however, will not insure the monarch's winter aggregation as a permanent phenomenon for future generations to experience and enjoy. A winter grove is a complex and ever changing ecosystem. The butterflies overwinter in groves at a particular stage of maturation that provide the microclimatic conditions suitable for overwintering (Leong 1990, Leong et al. 1991). Grove suitability at a particular site may last for two decades or more, but eventually the trees reach a stage of maturity that no longer provides the conditions necessary for overwintering. Mature grove trees, for example, tend to have few lower branches to: (1) provide lower limbs for winter aggregation, (2) offer wind protection, (3) provide optimum exposure to filtered sunlight and (4) create microclimatic conditions necessary for winter aggregation. When a grove reaches this stage of maturity, the butterflies may seek other suitable areas within a grove or

migrate to another grove. If they are unsuccessful, they may form temporary clusters on trees that offer little protection against severe conditions and may not survive the winter.

A long term habitat (grove) management program is the key to preservation of the monarch's winter aggregation in California. Unfortunately, there is little scientific information available on which to base a habitat management program that ensures the continued health of the habitat. A unique program is currently being undertaken by the city of Pacific Grove to restore an overwintering site. This project is the first of its kind in California, and if successful, will serve as a model for future habitat restoration program and management. Because trees take time to grow, the restoration project will take a minimum of 15 to 20 years to reach fruition.

This proposed study will provide answers to many questions that are now lacking and which are necessary for long term overwintering habitat management at a specific, protected site. Questions such as (1) can a permanent overwintering site be restored, and if so, (2) how long will it take for the newly planted trees to create the microclimatic conditions that are attractive to overwintering butterflies, (3) what is the life expectancy of grove trees before they reach a stage of growth that no longer provide the conditions necessary for winter aggregation, and (4) what are the major environmental (i.e. wind storms) and biological (i.e. predation) factors that adversely affect overwintering butterflies. These and perhaps other questions may be answered once this habitat restoration project is implemented.

Objectives of this initial study are: (1) to document, through one complete overwintering season, the environmental conditions of the habitat before habitat restoration is implemented; (2) to identify the direction of high winds entering the grove and the maximum wind velocities of major winter

storms; (3) to determine the seasonal abundance of overwintering butterflies; (4) to locate the main aggregation area of the habitat and to describe the movement of the butterfly's winter aggregations among the trees within the grove; and (5) to recommend a possible grove configuration for habitat restoration. Follow up studies at 5, 10 and 20 years would not only document the changes in the grove microclimatic conditions as it reaches fruition, but also allow periodic evaluations of the grove and perhaps make the necessary adjustments (i.e. plantings of more border trees in a particular area to buffer strong winter winds) to improve the habitat.

Methods and Materials

The Monarch Grove Sanctuary (36°35"N latitude, 121°50" W longitude) is a 2.7 acre (1.09 hectare) "L-" or "flag" shaped parcel, located between Grove Acre Avenue on the west and Ridge road on the east, in Pacific Grove, California. The grove has a maximum elevation of 56 feet (17.07 meter) along Ridge road and slopes to the west to a minimum elevation of 27 feet (8.23 meter) along Grove Acre Avenue. The dominant vegetation is mature Monterey pine trees, many with few to no lower branches. A row of trees growing along its southern border consist mainly of eucalyptus and a few Monterey pine trees.

The sanctuary was divided into 18 sampling stations (fig 1), approximately 30 meters apart (excepting sites along Grove Acre Avenue). At each sample station, the following environmental parameters were measured: (1) lowest and highest wind velocities during a 10 second interval, with a thermoanemometer; (2) wind direction, using a compass; (3) wet and dry bulb temperatures with a sling psychometer; (4) Solar radiation, with a radiation balance meter; and (5) light intensity, with an illumination meter. The environmental data were collected twice monthly between 0800 and 1200 PST during November, December, January, and February and once monthly in October and March.

The trees on which the butterflies formed winter aggregation were individually identified by a numbered label attached to their trunks. During each site visits, the same five environmental parameters were measured at the base of each tree supporting butterfly clusters, as well as (1) a visual population estimate of the aggregation, (2) the maximum and minimum height of the clusters, and (3) their orientation and spread of the aggregation

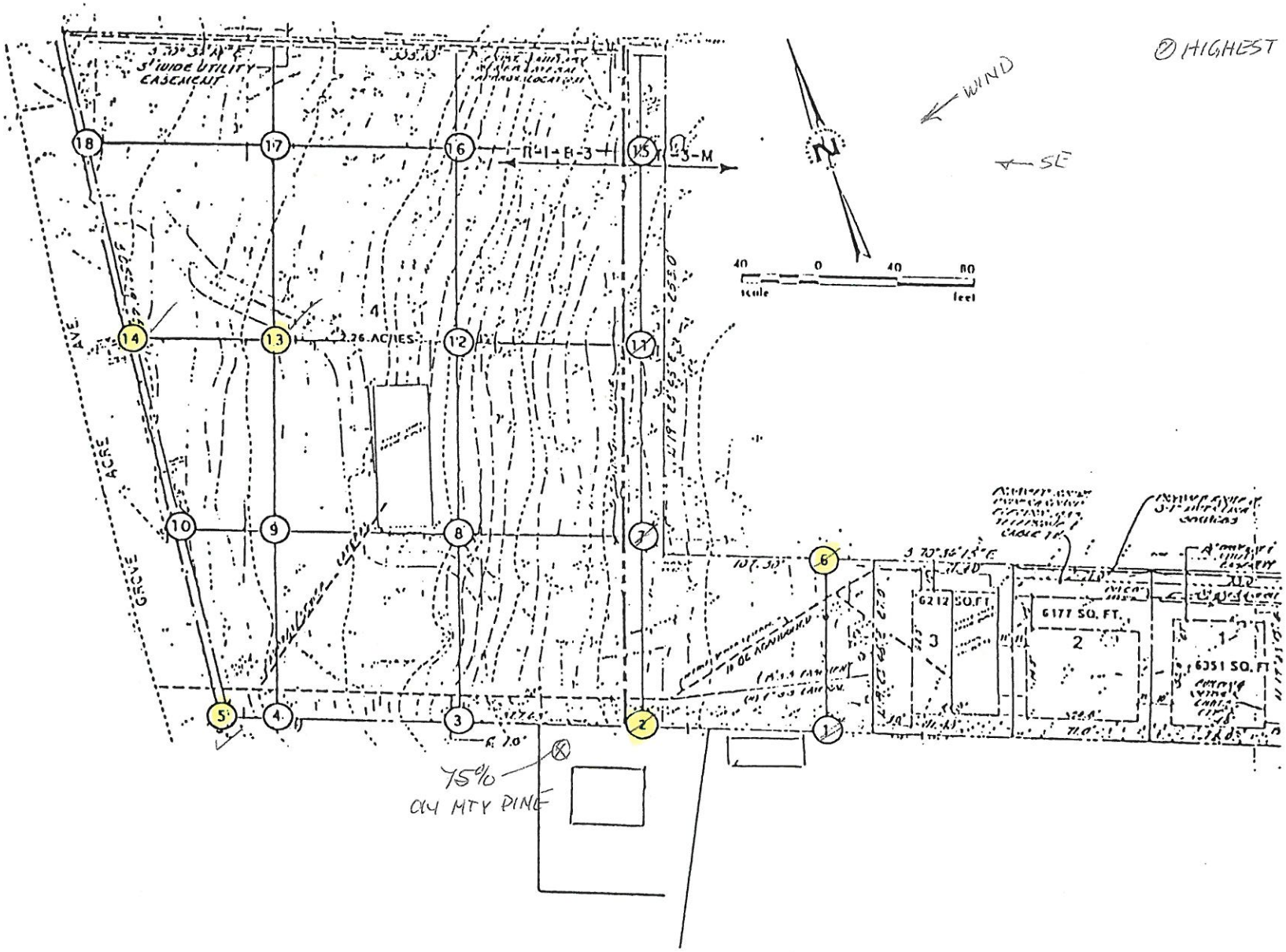

Figure 1. Monarch Grove Sanctuary showing the 18 sample stations, approximately 30 meters apart.

on the tree. Visual population estimates were made by counting the number of butterflies in a given area and multiplying this value by the total area occupied by the cluster on a tree. The cluster orientation (left and right edges) on a tree was determined using a compass, a technique described by Frey et al. (1992). In addition, the directions of the wind and sunlight angle into the grove were also measured using a compass.

In addition, 24-hr environmental conditions were monitored with an On-site Weather Logger (OWL) system, developed by Dr. Tracy Allen of EME systems, 2229 5th Street, Berkeley, CA 94710. It was placed on a eucalyptus tree located on the grove's southern border, adjacent to Gunter and Mary El Bode's property to record (1) wind velocity and direction, (2) solar radiation, (3) temperature and (4) relative humidity. The decision to place the an On-site Weather Logger at this location was because it was the area where the butterflies had formed winter aggregations during the past two winter seasons.

Results and Discussion

Grove environmental conditions: The microclimatic conditions (seasonal averages) of the Monarch Grove Sanctuary indicate that the habitat is basically, shady, very moist and windy (Table 1, appendices 1). Solar radiant energy and light intensity were highest in sample stations 2, 5, 6, 13 and 14 having average values of greater than 0.10 cal cm^{-2} m^{-1} and approximately 4,500.2 ft. can. Most of these sample stations were in open nonforested areas of Monarch Grove Sanctuary. Sample stations along the grove's eastern border (1,2, 6, 7, 11, and 15; appendices 1), also representing the grove's highest elevation, had the highest maximum wind values. The high winds, therefore, approached the grove mainly from the east, either from the north or south. The highest wind velocities were from the southeast (8 December; sample station 7, recording 4.8 m/sec winds, appendices 1) and seem to be related to approaching winter storms from that direction. Sample stations 5, 13 and 14 located on the lower western slop of the grove and represented an open, wind sheltered area of the habitat.

The grove's northern and western borders were sheltered from eastern winds because of their lower elevation and to some degree by the vegetation growing along the upper slope. A dense stand of Monterey pine and acacia trees growing in the northern section of the habitat effectively buffered much of the northwest winds. Sample stations within the northern section (16, 17, and 18) reflect a shady, wind sheltered area (Table 1, appendices 1).

The ambient moisture of Monarch Grove Sanctuary was very high (79.6 to 84.3 RH; 330 to 350 mm Hg VPD) and uniform throughout the habitat. This high moisture may be attributed to the dense morning fog conditions, typical

Table 1. Seasonal averages of 5 environmental variables measured at 18 sample stations within Monarch Grove Sanctuary, Pacific Grove, California during winter 1993-1994 (Light intensity values should be multiplied by 100).

SITE	SOLAR RADI (cal cm^{-2} m^{-1})	LIGHT (ft. can)	MAXWIND (m s^{-1})	MINWIND (m s^{-1})	WET BULB (°C)	DRY BULB (°C)	VPD (mm Hg)	RH
1	**0.08 ±0.05**	**20.6 ±2.6**	**1.5 ±0.2**	**1.0 ±0.1**	**50.2 ±1.9**	**53.0 ±2.0**	**0.340 ±0.02**	**83.0 ±3.0**
2	**0.10 ±0.04**	**45.2 ±16.2**	**1.8 ±0.3**	**1.5 ±0.3**	**50.2 ±2.0**	**52.9 ±2.0**	**0.340 ±0.03**	**83.6 ±2.7**
3	**0.05 ±0.01**	**31.2 ±5.4**	**1.9 ±0.2**	**1.5 ±0.2**	**50.0 ±1.9**	**53.2 ±2.1**	**0.330 ±0.03**	**80.6 ±2.8**
4	0.05 ±0.01	32.4 ±6.5	1.4 ±0.3	0.8 ±0.2	49.8 ±2.0	52.9 ±2.4	0.330 ±0.03	81.2 ±3.0
5	0.12 ±0.08	78.9 ±46.2	1.1 ±0.2	0.7 ±0.2	49.8 ±2.0	53.0 ±2.4	0.330 ±0.03	80.8 ±3.2
6	0.11 ±0.03	67.8 ±19.3	1.4 ±0.2	0.8 ±0.1	50.3 ±2.0	53.1 ±2.1	0.340 ±0.03	82.7 ±2.6
7	**0.06 ±0.01**	**40.2 ±8.6**	**1.8 ±0.5**	**0.9 ±0.2**	**50.3 ±1.9**	**52.8 ±2.0**	**0.340 ±0.02**	**85.6 ±3.0**
8	0.06 ±0.01	51.0 ±9.0	1.2 ±0.2	0.7 ±0.2	50.2 ±2.0	53.1 ±2.1	0.330 ±0.08	82.4 ±3.7
9	0.07 ±0.02	63.3 ±21.0	1.2 ±0.2	0.6 ±0.2	50.0 ±2.0	53.3 ±2.4	0.320 ±0.02	80.7 ±3.9
10	0.04 ±0.01	50.1 ±20.9	1.1 ±0.2	0.6 ±0.2	50.2 ±2.0	53.3 ±2.4	0.330 ±0.02	81.2 ±3.8
11	**0.06 ±0.03**	**56.1 ±20.6**	**1.8 ±0.4**	**1.0 ±0.2**	**50.4 ±2.0**	**53.0 ±2.0**	**0.340 ±0.02**	**84.3 ±2.6**
12	0.04 ±0.01	32.0 ±6.3	1.4 ±0.3	1.0 ±0.2	50.7 ±2.0	54.0 ±2.3	0.340 ±0.03	79.8 ±3.8
13	0.19 ±0.09	126.6 ±51.4	0.8 ±0.2	0.3 ±0.1	51.1 ±2.1	54.4 ±2.5	0.350 ±0.03	81.1 ±3.8
14	0.12 ±0.05	97.7 ±27.3	0.9 ±0.2	0.4 ±0.1	51.0 ±2.1	54.2 ±2.5	0.340 ±0.02	81.8 ±4.0
15	**0.03 ±0.01**	**26.4 ±3.3**	**1.7 ±0.3**	**1.1 ±0.2**	**51.0 ±2.0**	**54.1 ±2.4**	**0.350 ±0.02**	**82.2 ±4.0**
16	0.04 ±0.01	28.2 ±5.4	1.0 ±0.2	0.5 ±0.1	50.7 ±2.0	53.3 ±2.3	0.350 ±0.02	83.2 ±3.3
17	0.04 ±0.01	28.4 ±3.7	1.1 ±0.3	0.5 ±0.2	50.4 ±2.0	53.9 ±2.3	0.340 ±0.02	79.6 ±3.6
18	0.04 ±0.01	25.0 ±3.4	1.0 ±0.3	0.5 ±0.2	50.6 ±2.1	53.3 ±2.3	0.350 ±0.02	83.3 ±3.5

of Pacific Grove, and the copious amount of morning dew that is commonly deposited on plant and grass leaves .

The 24-hr environmental monitoring system recorded data only from September 19, 1993 to October 6, 1993 (Appendices 2) due to a faulty unit. Unfortunately, the problem was not discovered until the end of the season and consequently, the strength, direction and frequency of winter storm winds could not be documented. During the interval in which the On-site Weather Logger was functioning, however, the data indicate that the grove received the maximum radiant energy between 1300 and 1400 hrs and the major winds were from northeast.

Overwintering population and environmental conditions. The monarch butterflies formed winter aggregations on eucalyptus and Monterey pine trees located along the grove's southern border and in adjacent residential lots (fig 2). The butterflies clustered on a total of 14 different trees (fig 2) during the course of the winter season and their movement seems to be related to the direction and strength winds through the grove (fig 3). Although they clustered on different trees, the Monterey pine tree (no. 27) located within Gunter and Mary El Bode's property had winter aggregations during 75 % of the site visits and often supported the largest butterfly clusters (Table 2). This tree was situated just north of the Bode's residential home and was in a wind sheltered area. The butterflies also clustered on the trees growing along the southern border, but their location were more variable than those of tree 27 (figs 3). Interestingly, the two Monterey pines (no. 20 and 28) among the row of eucalyptus border trees had clusters during 38% of site visits.

Since visual population estimates were not initiated until 19 November, the early population build-up period (late September and October) and

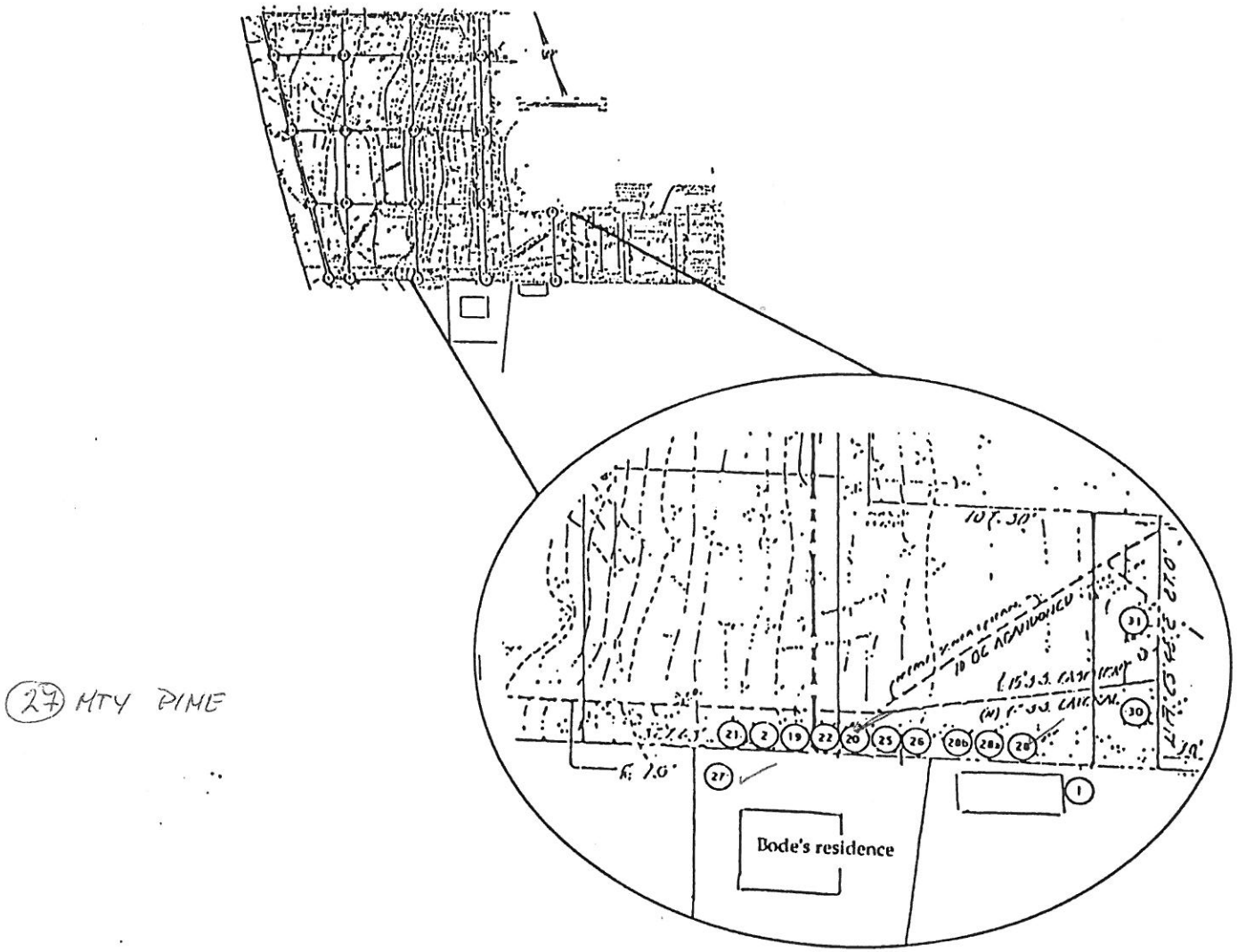

Figure 2. The aggregation area showing the locations of 14 trees on which overwintering butterflies formed winter aggregations during winter 1993-1994.

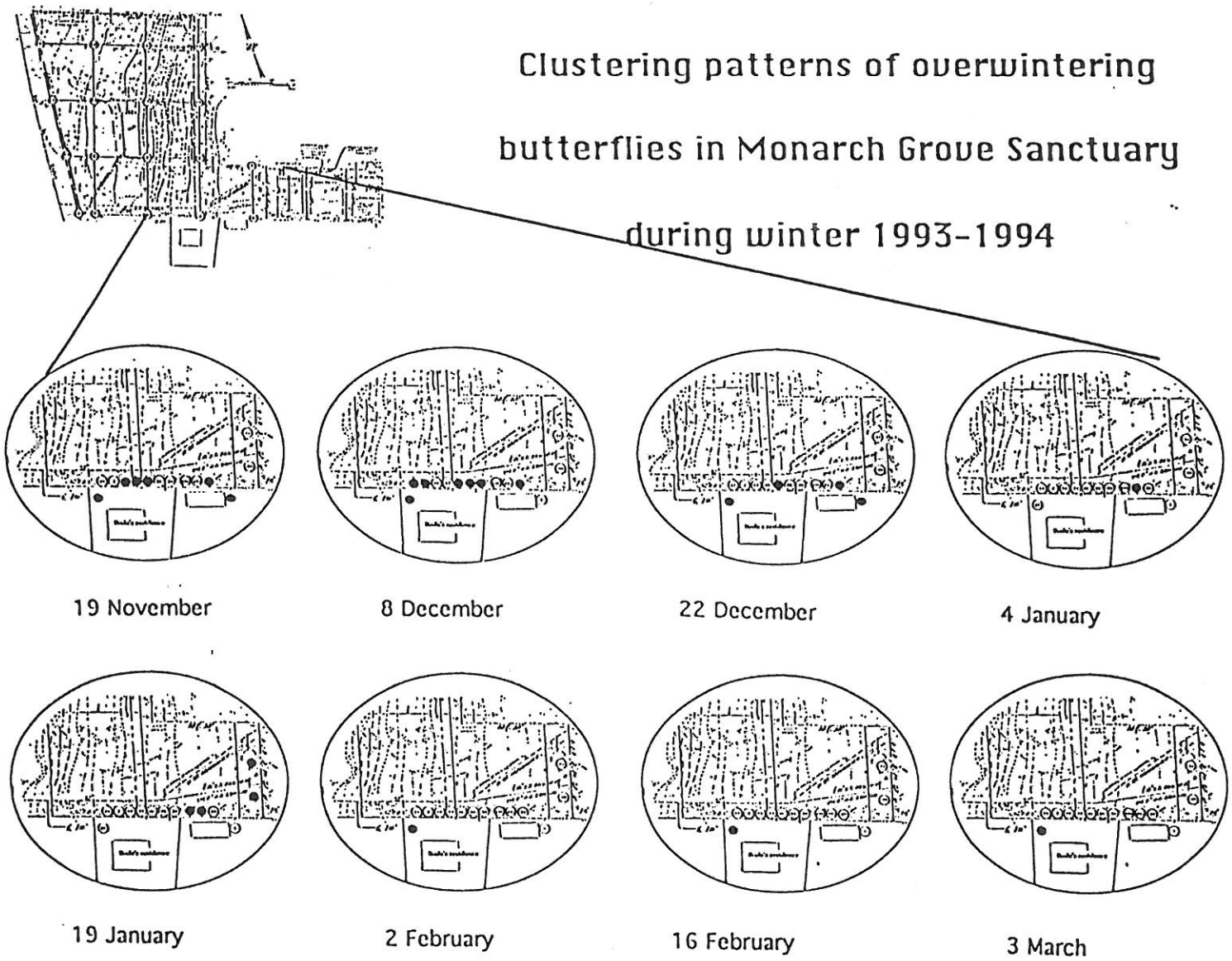

Figure 3. Clustering patterns of overwintering butterflies (black dots) showing their locations during each site visits during winter 1993-1994.

Table 2. Environmental and biological parameters associated with Monarch Grove Sanctuary cluster trees during winter 1993-1994. Light intensity values should be multiplied by 100.

tree/date	SOLAR RAD	LIGHT	MAXWIND	MINWIND	WET BULB	DRY BULB	VPD	RH	WD	LCA	RCA	HCL	LCL		POP
1-Nov-19	0.02	16	0.6	0.3	49	50	0.334	93	60	•	•				400
20-Nov-19	0.51	333	0.3	0.2	50	54	0.31	76	60	196	224				1200
22-Nov-19	0.5	332	0.3	0.2	50	54	0.31	76	60	176	200				150
19-Nov-19	0.5	264	0.6	0.3	51	55	0.334	76	60	166	208				500
27-Nov-19	0.11	100	1.3	0.3	50	53	0.322	81	60	196	174				2000
28-Nov-19	0.1	96	0.7	0.3	50	54	0.31	76	60	226	236				2800
AVERAGE	0.29	190.17	0.63	0.27	50.00	53.33	0.32	79.67	60.00	192.00	208.40			Total	7050
20-Dec-08	0.05	30	1.5	0.4	57	59	0.417	89	98	210	230				1500
27-Dec-08	0.06	46	0.5	0.3	58	61	0.448	84	240	120	160				4000
28-Dec-08	0.02	16	0.7	0.4	56	59	0.465	94	96	210	230				600
2-Dec-08	0.3	261	0.8	0.2	58	61	0.448	84	248	234	234				58
29-Dec-08	0.3	268	0.8	0.2	58	61	0.448	84	248	212	220				1000
25-Dec-08	0.03	47	0.5	0.7	58	61	0.448	84	170	340	50				300
26-Dec-08	0.03	49	0.8	0.3	58	61	0.448	84	170	342	•				100
AVERAGE	0.11	102.43	0.80	0.36	57.86	60.43	0.446	86.14	181.71	238.29	187.33			Total	7558
22-Dec-22	0.03	72	0.5	0.3	38	39	0.219	92	186	180	212	32	24		2500
27-Dec-22	0.03	22	0.6	0.2	38	39	0.219	92	52	124	140	32	28		5100
AVERAGE	0.03	47.00	0.55	0.25	38.00	39.00	0.219	92	119	152	176	32	26	Total	7500
28A/JAN4	0.02	17	0.5	0.4	53	54	0.387	94	92	200	246	36	21		8000
28A/JAN19	0	17	1.3	1.1	50	53	0.322	81	96	180	362	34	26		3000
28B/JAN19	0.03	20	2.5	1.5	51	54	0.334	82	118	350	88	39	34		300
30-Jan-19	0.01	17	1.5	1.3	50	54	0.31	76	106	310	360	41	33		500
31-Jan-19	0.02	18	2.5	1.7	51	54	0.334	82	136	268	286	45	45		70
AVERAGE	0.02	18.00	1.95	1.40	50.50	53.75	0.325	80.25	114	277	274	40	35	Total	3870
27-Feb-02	0.04	27	0.7	0.2	43	47	0.228	72	70	128	154	29	22	Total	400
27-Feb-16	0.04	20	0.6	0.2	50	54	0.31	76	126	162	120	29	22	Total	400
27/3MARPG	0.04	20	0.6	0.2	53	54	0.373	94	126	162	120			Total	30

SOLAR RADI = SOLAR RADIATION; CAL CM-2 M-1
LIGHT = FT. CA
MAXWIND= MAXIMUM WIND VELOCITY; M/SEC
MINWIND= LOWEST WIND VELOCITY; M/SEC
WET BULB= WET BULB TEMPERATURE; °F
DRY BULB= DRY BULB TEMPERATURE; °F
VPD= VAPOR PRESSURE DEFICIT; MM HG
WD= WIND DIRECTION; °
LCA= LEFT CLUSTER ANGLE
RCA=RIGHT CLUSTER ANGLE
RH= RELATIVE HUMIDITY
HCL= HIGHEST CLUSTER LEVEL; FT
LCL= LOWEST CLUSTER LEVEL; FT
POPULATION

clustering patterns among the grove trees were not documented. There were approximately 7,000 butterflies overwintering in Monarch Grove Sanctuary and their numbers remained at this relative abundance through early January (Table 2). By late January, the population had declined to 3,870, to 400 by February, and to 30 by March. The maintenance of stable overwintering population though December and mid-January was similar to data from overwintering populations at Pismo North Beach and Morro Bay wintering sites. The decrease in population levels, at least at these San Luis Obispo County wintering sites, occurred in late February and was associated with spring dispersal, after a short period of intense mating activity.

The butterflies generally cluster on a tree opposite to the prevailing winds and on foliage where they can receive the best exposure to filtered sunlight. Occasionally, the butterflies would cluster on the windward side of the tree if wind velocities were < 2 m/sec. It has been my observations that winds greater than 2 m/sec would dislodge the butterflies from their roost (unpublished data). The horizontal spread of the butterfly's aggregation on the tree was from the south to east, but they may exhibit a south to west distribution, if prevailing winds are greater than 2 m/sec and from the northeast (Table 2).

The butterflies clustered as high as 34.7 ft ±1.6 and as low as 27.36 ft ±2.2 (Table 2).

The microclimate associated with cluster trees of Monarch Grove Sanctuary had similar wind velocities (maximum and minimum), solar radiation and light intensities as other winter sites located in San Luis County (Pismo Beach and Morro Bay; Table 3). They did differ, however, in temperature, vapor pressure deficit and relative humidity. The Monarch

Table 3. Comparisons of 8 environmental variables among cluster trees from three winter sites: Pacific Grove, Pismo North Beach, and Morro Bay during winter 1993-1994 (Light intensity values should be multipled by 100).

Location	N	SOLAR RADI (cal cm^{-2} m^{-1})	LIGHT (ft can)	MAXWIND (m/sec)	MINWIND (m/sec)	WET BULB (°C)	DRY BULB (°C)	VPD[a] (mm Hg)	RH
Pacific Grove	30	0.13 ±0.03	94.2 ±20.0	0.9 ±0.1	0.5 ±0.1	52.9[b] ±1.1	55.6[b] ±1.1	0.37[b] ±0.01	84.7[c] ±1.23
Pismo North Beach	71	0.08 ±0.01	57.1 ± 8.6	0.7 ±0.1	0.4 ±0.1	47.5[a] ±0.5	51.2[a] ±0.6	0.29[a] ±0.0	76.8[b] ±1.85
Morro Bay	19	0.06 ±0.02	48.5 ±14.1	1.0 ±0.2	0.5 ± 0.1	48.8[a] ±0.7	54.7[b] ±0.8	0.28[a] ±0.01	66.0[a] ±3.15

means within a column with different letters are significantly different ($p=\ll 0.01$)

Grove Sanctuary was colder and wetter than either of the San Luis winter sites.

Reasons for optimism for the habitat restoration of MSG. This project undertaken by the city of Pacific Grove has a good chance of being successful and would serve as a model for future habitat restoration programs in the state of California. The reasons for my optimism are due to three attributes of Monarch Grove Sanctuary. First, Monarch Grove Sanctuary and the surrounding areas have been a wintering site for the monarch butterflies since the late 1800s. We presently do not know the actual navigational mechanism used by the migrating butterflies to guide them to coastal California. Theories include the use of magnetic field, sun angle, or wind currents. Unlike birds, the monarch's long distance migration behavior is innate, since individuals that arrive in the fall are not the same butterflies that emigrated the previous spring. Whatever the mechanism, Monarch Grove Sanctuary is part of their "ancestral" migratory route. Once they arrive along the California coastline, the butterflies probably seek out groves that possesses particular microclimatic conditions suitable for overwintering. Second, parts of Monarch Grove Sanctuary are still suitable and being used by the overwintering butterflies. Although the current state of the habitat is poor, primarily consisting of mature Monterey pine trees, approximately 7,000 monarch butterflies were able to survive (overwinter) in "small pockets" of the grove the entire winter season (1993-1994). Lastly, the high ambient moisture of the habitat provided the much needed water, in the form of morning dew, for rehydration. Overwintering monarch butterflies store large amounts of body fat and survive the overwintering period mainly on their fat reserves. They, however, need to rehydrate occasionally on water or

nectar to replace lost body fluids. A common feature of many permanent overwintering sites in California is their association with sources of water (i.e. pond, stream, morning dew or winter flowering plants). An added advantage of a habitat with high ambient moisture is the resulting protection against desiccation, a major problem of most insects. Butterflies overwintering in Monarch Grove Sanctuary, as a result high ambient moisture, may not need to rehydrate as frequently as those overwintering in more southern sites as those located in San Luis Obispo county where there is less dew.

Possible Grove configuration for habitat revegetation plan. Winter aggregates of monarch butterflies are usually found on trees located on the southern section of the grove and where they can receive exposure to filtered sunlight and protection from gusty winds (Leong 1990, Leong et al. 1991, Frey et al. 1992). For the past two winter seasons, I have noticed three activities of overwintering butterflies that center around sunlight (unpublished data): (1) daily activity--individuals in clusters exposed to morning sun (approximately 0800 hr; sun angle 130° SE) were able to increase their body temperatures quicker and were able to sun, rehydrate or mate earlier than butterflies in clusters not exposed to sunlight; (2) reforming of clusters--the butterflies would return to the grove, after the day's activity, to reformed clusters or join individuals in clusters on trees whose foliage was exposed to the afternoon sun(≈01300 -01500 hrs; sun angle ≈230° SW); and (3) rehydration on water or nectar--butterflies would rehydrate on water or feed on flower nectar in areas that are in direct sunlight but only rarely in shady areas.

Any habitat restoration program, therefore, should have three primary objectives:

(1) to provide a wind sheltered area for clustering;

(2) to provide roosting trees with optimum exposure to filtered sunlight; and

(3) to provide open sunlit areas for feeding (nectar), rehydrating and mating.

To incorporate these objectives for the restoration of the Monarch Sanctuary Grove, the focal point for the aggregation area should be in the grove's southeastern section to take advantage of the winter sun and its highest elevation topography. Tree plantings should be strategically grown around a modified "U" or a "V" shaped open area, with the open end of the "U" or V" facing the southern border trees, angled such that the left most edge of the "U" oriented at least 130° SE and the right edge at 230° SW (fig. 4). In my opinion a southern oriented grove with a modified "U" open area would allow the overwintering butterflies to cluster on trees within the inner perimeter or on trees just behind this perimeter, that offer shelter from gusty winds and yet provide optimum access to winter sunlight from 0800 to 1500 hrs. The trees in front of the "U" (southern border trees which may need to be selectively thinned and trimmed) will act as a buffer wind zone for some south winds, but more importantly, would filter the sunlight coming into the "U" open area. Trees growing along the eastern, northern and western borders of the open "U" area should be dense enough to buffer winds and to create the sheltered inner zone. Particularly attention should be given to plantings along the eastern border, since major winds, including winter storms, approach the grove from this direction.

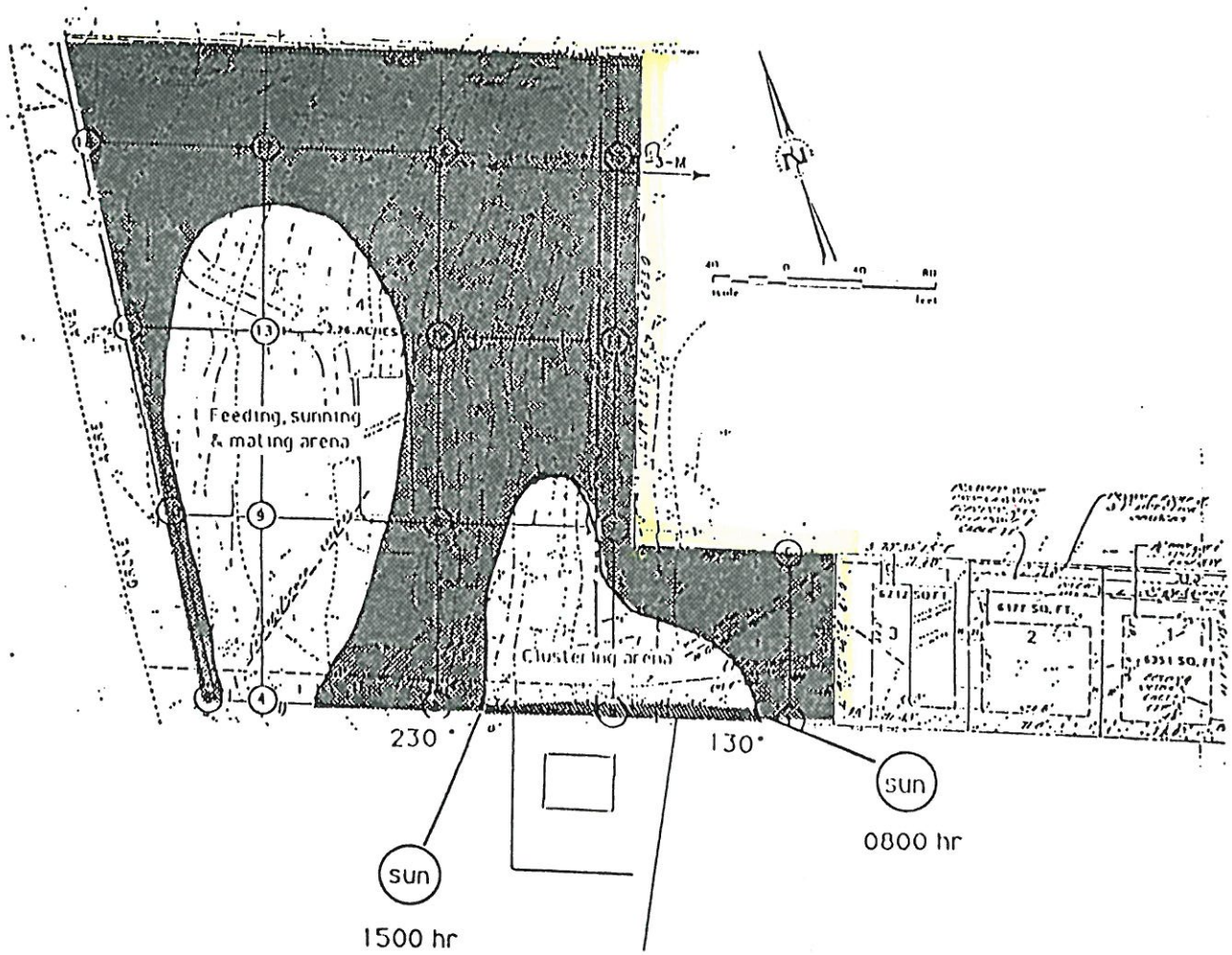

Figure 4. Proposed habitat restoration design for Monarch Grove Sanctuary showing the wind sheltered arena for clustering, the large open arena for feeding, sunning and mating activities, the proposed forested areas (shaded) of the grove and the angle of the morning and afternoon sun.

An open sunlit grassy area (fig. 4), west and northwest of the proposed aggregation area, with intraplantings of nectar flowing plants, would provide a region within the habitat where the butterflies could rehydrate, sun and mate.

Tree species used for habitat restoration. In California, overwintering monarch butterflies are found in groves consisting mainly of blue gum eucalyptus (Eucalyptus globulus Labill.) and Monterey pine trees (Pinus radiata Don) or a mixture of the two species. Groves made up of these tree species type of microclimatic conditions necessary for overwintering butterflies. A habitat restoration program needs to consider these tree species and perhaps other tree species, such as Monterey cypress (Cupressus macrocarpa Gord.), to replace trees within the habitat that have fallen due to wind storms, diseases, or senescence, or to add to an area to enhance a wind buffer zone within a habitat. Each tree species has definite advantages and disadvantages and the two most common tree species used as winter habitats are discussed below:

Blue gum eucalyptus (E. globulus) is a fast growing tree that produces abundant foliage supported by sturdy branches. It is capable of buffering strong winds quite effectively and provides ample branches for the roosting butterflies. It has remarkable regenerative powers and readily produces new growth when trimmed. Because of these characteristics, eucalyptus is an ideal species for grove management and modifications. Eighty one percent of the groves containing overwintering butterflies consist of eucalyptus trees, predominately blue gum (Sakai and Calvert 1991). The disadvantages of blue gum are: (1) its an invasive species and will generally out compete many native vegetation; (2) its litter contains chemicals that suppress the growth of

other vegetation, and their branches are prone to break during wind storms; (3) it is a nonnative species, and (4) it is susceptible to the eucalyptus bark beetle, a insect pest capable of killing eucalyptus trees, especially those under stress conditions (weaken by drought).

Like eucalyptus, Monterey pine (P. radiata) is fast growing and accounts for 16.4% of the overwintering groves within California (Sakai and Calvert 1991). In addition to its fast growing characteristics, it produces dense foliages that can effectively buffer strong winds. It is not as prone to limb losses during winter storms. Monterey pine is a species native to Pacific Grove. The disadvantages of Monterey pine trees are: (1) under crowded conditions, they lose their lower branches and subsequently, their wind buffering effectiveness, (2) if trimmed, they do not regenerate new foliage as readily as eucalyptus; and (3) susceptible to a fungal disease, pine pitch canker, known to kill Monterey pine trees (Correll et al. 1991).

Grove management care and considerations:

(1) Diseased trees with outward symptoms of pitch pine canker or infestation of bark beetles should be removed immediately from the grove and destroyed by burning.

(2) Eucalyptus trees should be watered during drought years to minimize stress and subsequently, their susceptibility to the eucalyptus pine borer.

(3) Monterey pine seedlings used for habitat restoration and tree replacement should be from various sources (parent trees) to prevent genetic uniformity and possible of large tree losses due the pitch pine canker disease.

(4) Grove trees should be periodically evaluated and trimmed or replaced if deemed necessary for the health of the overwintering grove.

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