

Central Coast Monarch Butterfly Project Report

**Ventana Wilderness Society's
Big Sur Ornithology Lab**

Winter 2001-2002

By (*in alphabetical order*):

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ABSTRACT

We observed monarch butterflies (*Danaus plexippus*) at seven winter roost sites on the central California coast in Monterey County during the winter of 2001-2002. We estimated numbers of monarch butterflies weekly at all sites, documenting arrival and departure dates, cluster aspect and height, weather, and the availability of nectar and water. Three sites showed characteristics of climax sites, maintaining large numbers of monarch butterflies throughout the season. The other four sites showed characteristics of transitional sites, with numbers of monarch butterflies declining to zero early in the season or midway through the season. At the climax site with the greatest number of monarch butterflies (Pacific Grove Monarch Sanctuary), we observed a shift in tree use from non-native Blue Gum Eucalyptus (*Eucalyptus globulus*) to the native Monterey Cypress (*Cupressus macrocarpa*) in December, during the peak of the winter storm season. At all climax sites, we observed a general dispersal from previously used trees to various tree species and shrubs in mid-February. Results from this study suggest that the central coast of California is an important overwintering region for western populations of monarch butterflies. Long-term monitoring of these overwintering populations is warranted, and further study of monarch butterflies' need for tree species relative to microclimate is necessary to further confirm our findings of seasonal variation in use of tree species over the course of the winter at specific sites.

INTRODUCTION

The western population of monarch butterflies (*Danaus plexippus*) migrates to specific areas along the Pacific coasts of California and Mexico each fall. In California, monarch butterflies are known to have specific overwintering microclimate requirements, including appropriate roosting trees such as native Monterey Pine (*Pinus radiata*) and Monterey Cypress (*Cupressus macrocarpa*) (Nagano and Lane 1985). Extensive land development, logging, and poor land management in the last century have reduced the number of native tree stands that support overwintering monarch butterflies in California (Brower et. al. 2000).

The population dynamics of monarch butterflies that overwinter on the central California coast are not well documented. Currently, it is believed that many monarch

butterfly populations overwinter in isolated stands of non-native Eucalyptus trees (*Eucalyptus spp.*), making the butterflies vulnerable to land management plans that mandate the removal of non-native tree species (Brower and Malcolm 1989). Given that monarch butterfly overwintering habitat along the central California coast has been substantially altered, it is urgently important to collect baseline data on current monarch butterfly roost sites in order to make scientifically sound habitat management recommendations. In the winter of 2001-2002, we conducted a pilot study to gather baseline data on overwintering monarch butterflies and their habitats in Monterey County. Our main objectives were 1) to locate, monitor, and describe climax and transitional roosting sites¹ along the California coast from Pacific Grove to Pacific Valley; 2) to design a long-term monitoring study to better obtain estimates of monarch butterfly population densities, fluctuations, and movements; and 3) to design and implement a tagging study to gain information on monarch butterfly spring migration routes.

METHODS

Site selection.—We identified potential study sites in Monterey County, California by searching the Natural Diversity Database maintained by the California Department of Fish and Game, for historic monarch butterfly winter roosting sites. We then conducted field surveys of monarch butterflies at these sites from Pacific Grove south to Plaskett Creek. We observed substantial numbers of monarch butterflies at seven locations: Pacific Grove Monarch Sanctuary, Point Lobos State Reserve, Palo Colorado Canyon, Andrew Molera State Park, a site on private property, Prewitt Creek, and Plaskett Creek Campground, which we selected as our study sites (Figure 1 and Table 1).

Cluster estimations.—We estimated the number of monarch butterflies in a small area of a cluster and then extrapolated this count to arrive at a total count for the entire cluster as demonstrated by David Marriott of The Monarch Program (based out of San Diego, California). We recorded the average of the total counts of all observers. In December we received additional training from California Polytechnic Institute Ecologist, Dennis Frey, Ph.D. During this training session, we tested the accuracy of our cluster estimates by

¹ Leong (1991) defined climax sites as sites that maintain a stable monarch butterfly population throughout the winter season. In contrast, transitional sites function as a stopover for migrating monarch butterflies on their way to their climax overwintering site.

estimating the number of monarch butterflies in a cluster, then trapping the butterflies in the cluster, and then comparing our estimates with the true numbers. Each biologist gauged his/her individual accuracy rate, corrected for his/her individual bias, and calibrated with all observers. We practiced and implemented these techniques throughout the season to ensure that all observers were calibrated in their estimates.

Site Surveys.—We surveyed Pacific Grove Monarch Sanctuary and the private property site one day per week from the last week of November to the first week of March; we surveyed Point Lobos State Reserve, Palo Colorado Canyon, Andrew Molera State Park, Prewitt Creek, and Plaskett Creek Campground one day per week from the last week of November to the last week of February. Surveys were conducted in the mornings while temperatures were low (usually below 13°C) and monarch butterflies were still clustered. We did not survey during heavy precipitation because visibility was poor. We recorded the following survey data at each site using a standard data form (Appendix 1): date, site, observers, pre-count time start and end, count time start and end, presence of nectar and water sources, and observations of tagged or mating monarch butterflies. Weather data included: sky, percent cloud cover, wind speed and direction, temperature, precipitation, and percent fog. Sky was indexed from 0-8 by the following criteria: (0) Clear or few clouds, (1) Scattered clouds, (2) Mostly cloudy, (3) Overcast, (4) Fog or smoke, (5) Drizzle, (8) Showers. Wind was estimated using the Beaufort's wind scale (Appendix 2). For every tree that had roosting monarch butterflies, we recorded the number of monarch butterflies, tree species, tree identification number, and the aspect and height of clusters. We also counted and recorded separately the number of monarch butterflies on the wing and on the ground.

We recorded aspect as the range of directions that butterflies were roosting from the base of the tree (e.g., NE – S). These ranges were converted to presence or absence of butterflies at eight cardinal directions (N, NE, E, SE, S, SW, W, and NW). For each tree that had butterflies, the number of butterflies present was evenly distributed throughout the range of directions in order to weight aspects for cluster size.

Tagging.—In the first week of March we captured and tagged monarch butterflies from 0700 to 0900 at Plaskett Creek. Tags were self adhesive, round stickers supplied by Watson Label Products. Each tag had a serial number that identified each individual monarch butterfly and a phone number to report recovery.

We captured monarch butterflies using a butterfly net on a long pole. For every captured monarch butterfly, we placed a tag on its right wing and we recorded sex, wing wear, lipid stores, and mated status (Appendix 3). We identified the sex of each individual by the presence or absence of a pheromone spot on the center of the hindwing (spot present = male, spot absent = female) and by the presence or absence of claspers located on the sides of the abdomen (claspers present = male, claspers absent = female). We scored wing wear of each individual from 0 to 4 based on the number of wings that had nicks (no damaged wings = 0, one damaged wing = 1, etc.). We scored the lipid stores from 1 to 3 by examining the plumpness of the abdomen (extremely emaciated = 1, moderate abdomen girth = 2, and extremely plump = 3). Finally, for each female we assigned mated status from 0 to 2 based on abdominal palpation (no detectable spermatophore = 0, small or questionable spermatophore = 1, and large and readily detectable spermatophore = 2).

RESULTS

Climax Sites

Pacific Grove Monarch Sanctuary. An estimated 14,712 monarch butterflies were present at Pacific Grove Monarch Sanctuary on the initial survey date of 29 November 2001 (Figure 2). Weekly estimates averaged 20,943 monarch butterflies during the months of December 2001 and January 2002. The maximum weekly estimate was 29,105 monarch butterflies recorded on 8 January 2002. Weekly estimates declined during February 2002 (weekly average 13,233 monarch butterflies) and, by March 2002, most of the monarch butterflies had dispersed. The final estimate, which was recorded on 5 March 2002, was 2,358 monarch butterflies.

Blue Gum Eucalyptus, Monterey Cypress, and Monterey Pine were the predominant tree species at Pacific Grove Monarch Sanctuary. Monarch butterfly presence on these trees shifted over the course of the winter from mainly Monterey Pine and Blue Gum Eucalyptus early in the season to mainly Monterey Cypress later in the season (Figure 3). Through 31 December 2001, 89% of the total estimated number of monarch butterflies were observed roosting on Monterey Pines (50% of the total) or Blue Gum Eucalyptus trees (39% of the total); the remainder of the total estimated monarch butterflies were observed roosting on Monterey Cypress trees (10.5% of the total) or small shrubs (0.5% of the total). In contrast,

during January 2002 and February 2002, 90% of the total estimated number of monarch butterflies was observed roosting on Monterey Cypress trees, and the remaining 10% were observed roosting on Monterey Pine and Blue Gum Eucalyptus trees.

Private Property Site. An estimated 10,313 monarch butterflies were present at the private property site on the initial survey date of 26 November 2001 (Figure 2). Weekly estimates averaged 12,891 monarch butterflies during the months of December 2001 and January 2002. The maximum weekly estimate was 20,031 monarch butterflies recorded on 15 January 2001. Weekly estimates declined during February 2002 (weekly average 3,470 monarch butterflies) and, by March 2002, most of the monarch butterflies had dispersed. The final estimate, which was recorded on 5 March 2002, was three monarch butterflies.

Coast Redwood, Blue Gum Eucalyptus, Monterey Cypress, and Monterey Pine were the predominant tree species at the private property site. Essentially all monarch butterflies at the private property site roosted on a single Coast Redwood tree through 28 January 2002 (Figure 4). In contrast, during February 2002, 54% of the total estimated number of monarch butterflies was observed roosting on Blue Gum Eucalyptus, Monterey Pine, and Monterey Cypress trees, and the remaining 46% were roosting on a single Coast Redwood tree.

Plaskett Creek Campground. An estimated 91 monarch butterflies were present at Plaskett Creek on the initial survey date of 29 November 2001 (Figure 2). Weekly estimates averaged 1,886 monarch butterflies during the months of December 2001 and January 2002. The maximum weekly estimate was 2,317 monarch butterflies recorded on 8 January 2001. Weekly estimates declined during February 2002 (weekly average 237 monarch butterflies); the final estimate, which was recorded on 26 February 2002, was two monarch butterflies.

Blue Gum Eucalyptus, Monterey Cypress, and Monterey Pine were the predominant tree species at Plaskett Creek. Monarch butterflies were observed roosting only on Monterey Pine trees, except on 11 February 2002 when 78% of monarch butterflies were observed on Arroyo Willow (*Salix lasiolepis*) (Figure 5).

Transitional Sites

Point Lobos State Reserve. An estimated 960 monarch butterflies were present at Point Lobos State Reserve on the initial survey date of 26 November 2001 (Figure 6). Weekly estimates averaged 1,174 monarch butterflies during the month of December 2001

and declined to 424 monarch butterflies during the month of January and 19 monarch butterflies during the month of February 2002. The maximum weekly estimate was 1,496 monarch butterflies recorded on 12 December 2001. The final estimate, which was recorded on 26 February 2002, was 25 monarch butterflies.

Monterey Pine was the predominant tree species at the grove at Point Lobos State Reserve and was the only tree species used by monarch butterflies.

Palo Colorado Canyon. An estimated 300 monarch butterflies were present at Palo Colorado Canyon on the initial survey date of 26 November 2001 (Figure 6). Weekly estimates averaged 136 monarch butterflies during the first two weeks of December 2001 and declined to 117 monarch butterflies during the month of January and 9 monarch butterflies during the month of February 2002. The maximum weekly estimate was 300 monarch butterflies recorded on 26 November 2001. The final estimate, which was recorded on 26 February 2002, was 19 monarch butterflies.

Blue Gum Eucalyptus was the predominant tree species at the grove at Palo Colorado Canyon and was the only tree species used by monarch butterflies.

Andrew Molera State Park. An estimated 4,470 monarch butterflies were present at Andrew Molera State Park on the initial survey date of 26 November 2001 (Figure 6). Weekly estimates averaged 1,639 monarch butterflies during the month of December 2001 and declined to 7 monarch butterflies during the month of January and 5 monarch butterflies during the month of February 2002. The maximum weekly estimate was 4,470 monarch butterflies recorded on 26 November 2001. The final estimate, which was recorded on 26 February 2002, was six monarch butterflies.

Blue Gum Eucalyptus was the predominant tree species at the grove at Andrew Molera State Park and was the only tree species used by monarch butterflies.

Prewitt Creek. An estimated 370 monarch butterflies were present at Prewitt Creek on the initial survey date of 20 November 2001 (Figure 6). Weekly estimates averaged 289 monarch butterflies during the first two weeks of December 2001 and declined to 69 monarch butterflies during the month of January and 10 monarch butterflies during the month of February 2002. The maximum weekly estimate was 370 monarch butterflies recorded on 20 November 2001. The final estimate, which was recorded on 26 February 2002, was zero monarch butterflies.

Blue Gum Eucalyptus was the predominant tree species present at the grove at Prewitt Creek and was the only tree species used by monarch butterflies.

Cluster Aspect and Height

Monarch butterfly clusters were observed at all cardinal directions (N, NE, E, SE, S, SW, W, NW), with the majority of clustering monarch butterflies (73.6%) observed at E, SE, or S aspects (Figure 7). All sites showed this trend, with small variations. At Pacific Grove Monarch Sanctuary, most clustering monarch butterflies (41%) were observed on the south aspect of roost trees. This southern distribution was mirrored at Andrew Molera State Park (65%), Point Lobos (42%) and Palo Colorado Canyon (56%). An east aspect was predominant at the private property site (49%) and Prewitt Creek (85%). At Plaskett Creek Campground most clustering monarch butterflies (41%) were observed on the southeast aspect of roost trees. Averaged across all sites, we observed monarch butterflies clustered at heights between 9 meters and 13 meters from ground level.

Weather

Precipitation data for Monterey County were collected from the U.S. National Oceanic and Atmospheric Administration. From October to November, precipitation increased from 5.08 mm to 74.93 mm, followed by a sharp increase to 159.26 mm in December. For the duration of the season from January through March, the precipitation remained fairly steady averaging 38 mm. (Figure 8).

Wind was predominately out of the north, northwest, and northeast (collectively accounting for 60% of the wind direction) throughout the season, except for the last two weeks in December when winds were mainly out of the south (Figure 7).

Tagged Monarch Butterflies

On 15 February 2002, we captured and tagged 40 monarch butterflies at Plaskett Creek Campground. The majority of captured monarch butterflies (90%) were males. Wing damage scores ranged from 0 to 4, with an average of 1 (one wing damaged). Abdomen plumpness scores ranged from 1 to 3, with an average of 1.5 (less than moderate girth). No spermatophore was detected in any female.

DISCUSSION

Of our seven survey sites, Pacific Grove Monarch Sanctuary, the private property site, and Plaskett Creek Campground appeared to be climax roosting sites for overwintering monarch butterflies. Pacific Grove Monarch Sanctuary and the private property site maintained large numbers of monarch butterflies throughout the winter from late November until the beginning of March. Plaskett Creek Campground also showed a stable number of roosting monarch butterflies throughout the winter season; however, this site supported a much smaller population of monarch butterflies compared with the large numbers observed at Pacific Grove Monarch Sanctuary and the private property site (Figure 2). These findings suggest that Plaskett Creek Campground is a relatively small climax roosting site. The remaining four survey sites (Point Lobos State Reserve, Palo Colorado Canyon, Andrew Molera State Park, and Prewitt Creek) likely served a transitional function for migrating monarch butterflies that were moving toward their main winter roosts. The initial high numbers of roosting individuals declined rapidly by mid- to late-December and remained very low until the end of February. The sharp decline in the number of roosting monarch butterflies in late December at the transitional sites coincided with winter storms (Figure 8) that included hail, downpours, and strong winds. In contrast, the climax sites maintained large wintering populations during this period of severe weather.

These findings indicate that the climax roosts on the central California coast in Monterey County may offer overwintering monarch butterflies protection from severe winter weather conditions. In his study of environmental parameters at two climax wintering sites in San Luis Obispo County, California, Leong (1990) observed that monarch butterflies clustered in areas that offered exposure to filtered sunlight and shelter from gusty intermittent winds. The monarch butterflies moved readily among trees at each site, and their movements seemed to be associated with wind direction and velocity. Leong (1990) concluded that avoidance of wind appeared to be the key environmental factor that affected roosting behavior. In our study, roosting monarch butterflies clustered predominately at south, southeast, and east aspects, likely because of winds that were predominately from the north (Figure 7). Further study is needed to verify that monarch butterflies moved from transitional sites to climax sites on the central California coast in Monterey County, and to

verify that this transition was prompted by the lack of protection from wind and other abiotic micro-environmental factors. Thus, we recommend that long-term monitoring of overwintering sites on the central California coast be augmented by the collection of site-specific microclimate data, including wind speed and direction, temperature, precipitation, and sunlight intensity throughout each overwintering season.

The monarch butterflies' choice of, and movement among, the various tree species at the three climax locations suggests that Eucalyptus trees may not be critical habitat as previously assumed (Figure 9). At Pacific Grove Monarch Sanctuary, the private property site, and Plaskett Creek Campground the butterflies had a choice between the non-native Blue Gum Eucalyptus and native trees such as Monterey Cypress, Monterey Pine, and Coast Redwood. The monarch butterflies were observed roosting with an equal possibility on Eucalyptus and native tree species during the early winter period, from November until the beginning of December. This was also the case at the end of the season, beginning with the dispersal period from mid-February. However, during the middle of the winter season from January to mid-February the monarch butterflies roosted almost exclusively in native tree species at Pacific Grove Monarch Sanctuary and the private property site (Monterey Cypress and Coast Redwood, respectively). Historic records from the last decade showed that previously, large numbers of monarch butterflies roosted in the Eucalyptus grove at the Plaskett Creek Campground. During our study, however, no monarch butterflies were observed in the Eucalyptus trees; all monarch butterflies roosted in the native Monterey Pines. The transitional sites at Palo Colorado Canyon, Andrew Molera State Park, and Prewitt Creek consisted only of pure Eucalyptus groves and thus did not offer a choice of different roost tree species to the monarch butterflies.

Leong (1991) studied abiotic micro-environmental factors (light intensity, solar radiation, wind velocity, and vapor pressure) at two central California coast climax sites. One site was a grove of native Monterey Pine. The other was a grove of non-native Eucalyptus species. A non-overwintering grove of Eucalyptus species was studied for comparison. Month by month (November to February) comparisons of the measured parameters showed no statistically significant difference between the two climax sites. The climax sites had lower light intensities, solar radiation, and wind velocities, and higher vapor pressure deficit compared with the non-overwintering grove (except for December). Using

multivariate analysis to characterize suitable and unsuitable cluster areas within the two climax sites revealed that the microclimate of cluster trees was greatly influenced by the trees surrounding the roosting areas. Similarly, the microclimate habitat study by Weiss et al. (1990) using hemispherical photography of forest canopy structure at 33 climax and transitional sites near Santa Barbara, California indicated that the surrounding trees of the monarch butterfly roost groves served a protective function against extreme weather conditions. Frey et al. (1992) studied clustering patterns at the same two central California coast climax sites studied by Leong et al. (1991). They found that 1) patterns of tree use were similar at both sites, and 2) fewer trees supported clusters of monarch butterflies as the season progressed (i.e., “consolidation”).

Further study is needed to determine if native tree species offer more adequate conditions than Eucalyptus for overwintering monarch butterflies. In the meantime, if land managers remove trees, such as non-native Eucalyptus, at overwintering sites, they should consult empirical microclimate data prior to the removal because the microclimate composition desired by the wintering monarch butterflies could be negatively affected. Finally, to gain information on spring migration routes, we recommend tagging several thousand individuals at the three climax sites prior to spring dispersal. During our pilot study, the numbers of clustering monarch butterflies started to decrease rapidly by late January, indicating the beginning of spring movements.

ACKNOWLEDGMENTS

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Table 1. Study sites and surveys on the coast of Monterey County, California during winter 2001-2002.

Site Name	Site Location	Predominant Tree Species	Survey Period	Number of Surveys
Pacific Grove Monarch Sanctuary	3.0 km N ^a	Blue Gum Eucalyptus Monterey Cypress Monterey Pine	11/29/01 – 3/5/02	14
Point Lobos State Reserve	7.0 km S ^b	Monterey Pine	11/26/01 – 2/26/02	13
Palo Colorado Canyon	16.0 km S	Blue Gum Eucalyptus	11/26/01 – 2/26/02	13
Andrew Molera State Park	34.0 km S	Blue Gum Eucalyptus	11/26/01 – 2/26/02	13
Private Property	50.0 – 60.0 km S	Blue Gum Eucalyptus Coast Redwood Monterey Cypress Monterey Pine	11/26/01 – 3/5/02	14
Prewitt Creek	60.0 km S	Blue Gum Eucalyptus	11/29/01 – 2/26/02	13
Plaskett Creek Campground	60.5 km S	Blue Gum Eucalyptus Monterey Cypress Monterey Pine	11/29/01 – 2/26/02	13

^a North of Carmel River

^b South of Carmel River

Figure 1. Locations of seven study sites on the coast of Monterey County, California surveyed winter 2001-2002.

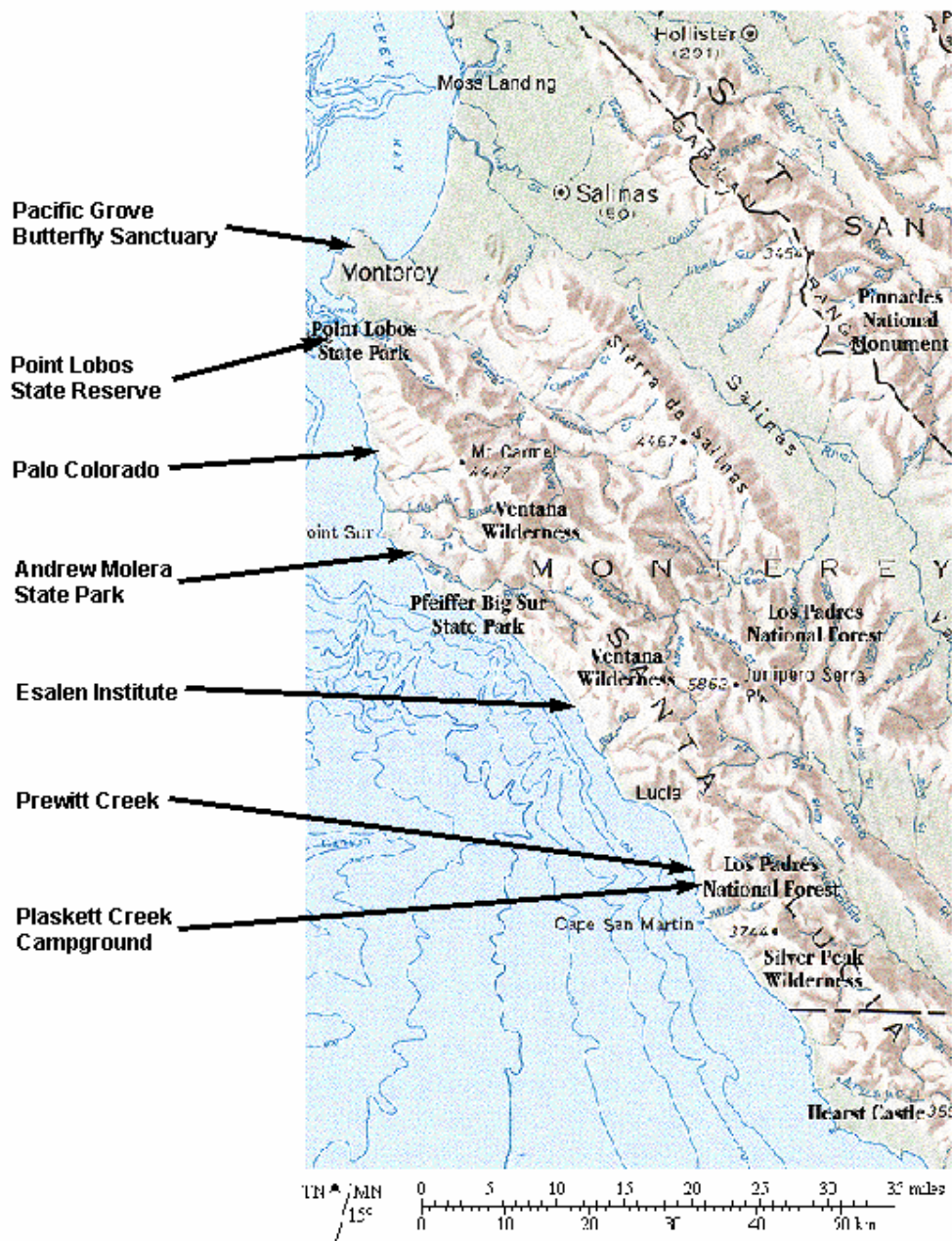


Figure 2. Weekly estimates of overwintering monarch butterflies at three climax sites in Monterey County, California during winter 2001-2002.

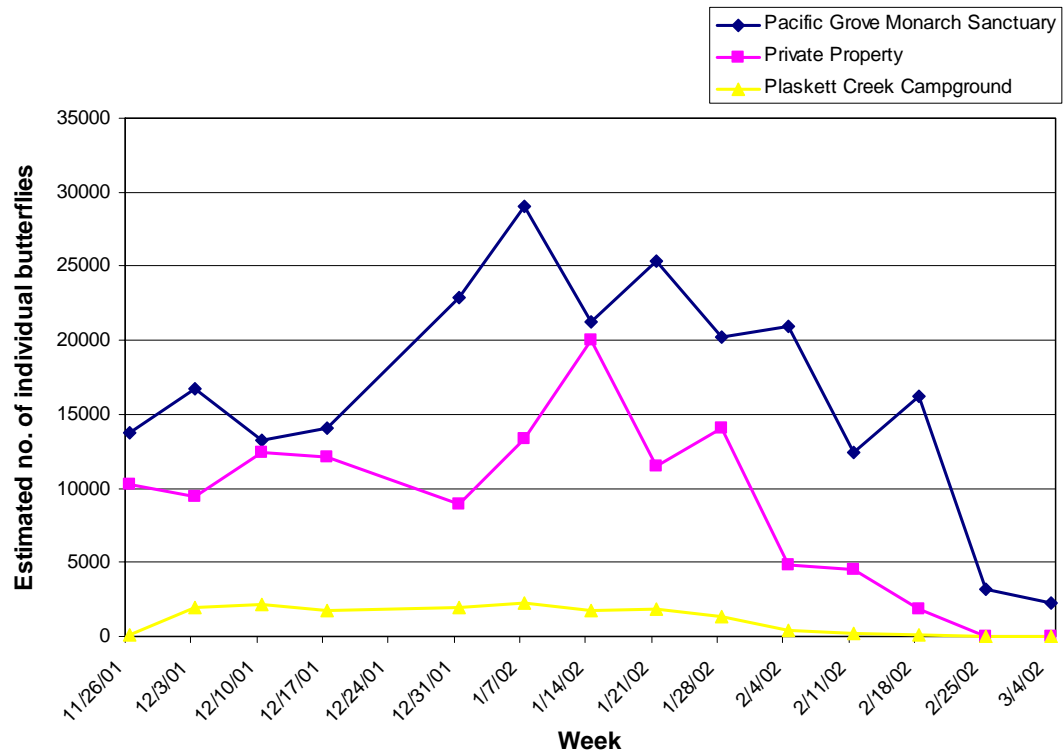


Figure 3. Estimated number of monarch butterflies using different tree species at Pacific Grove Monarch Sanctuary during winter 2001-2002.

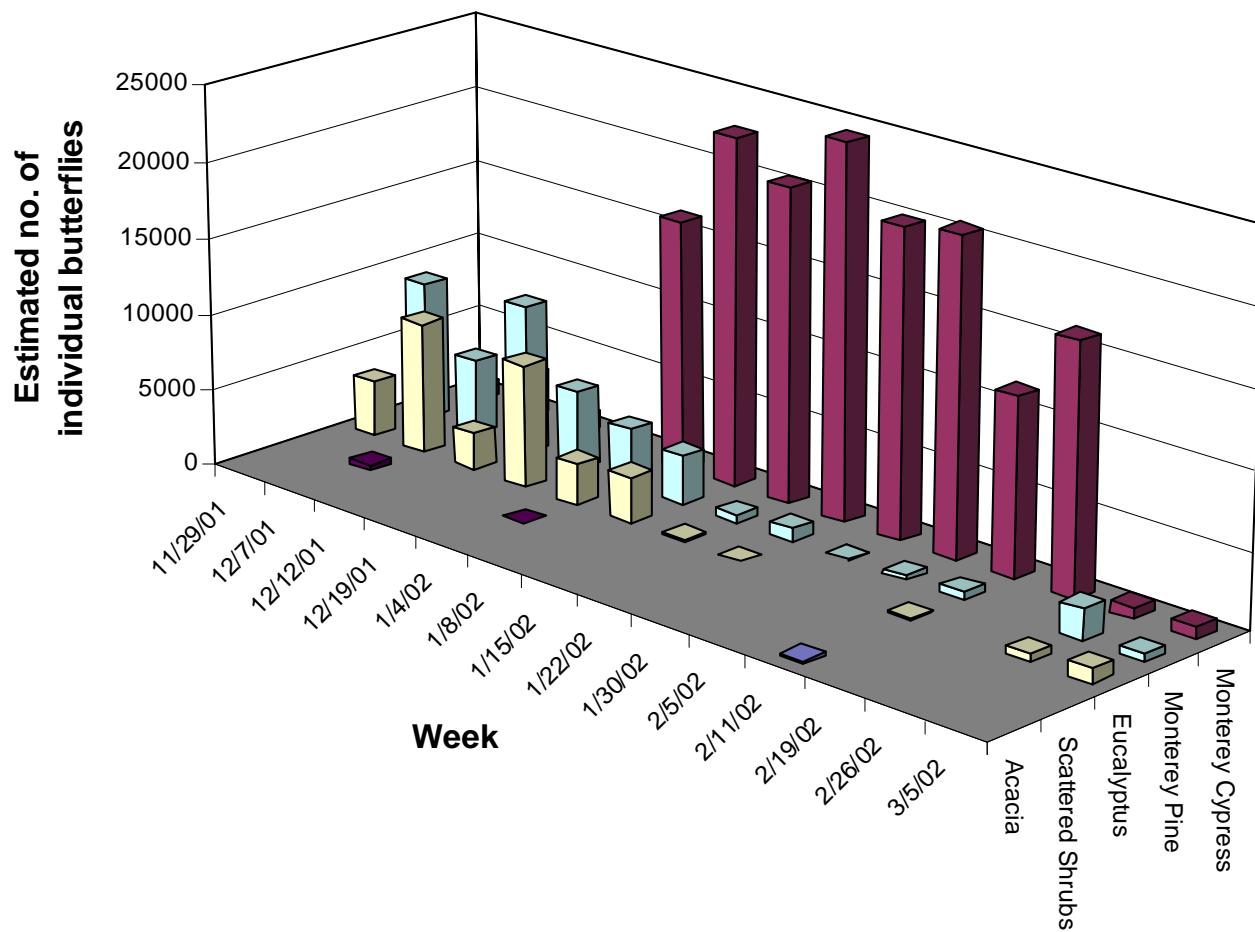


Figure 4. Estimated number of monarch butterflies using different tree species at the private property site during winter 2001-2002.

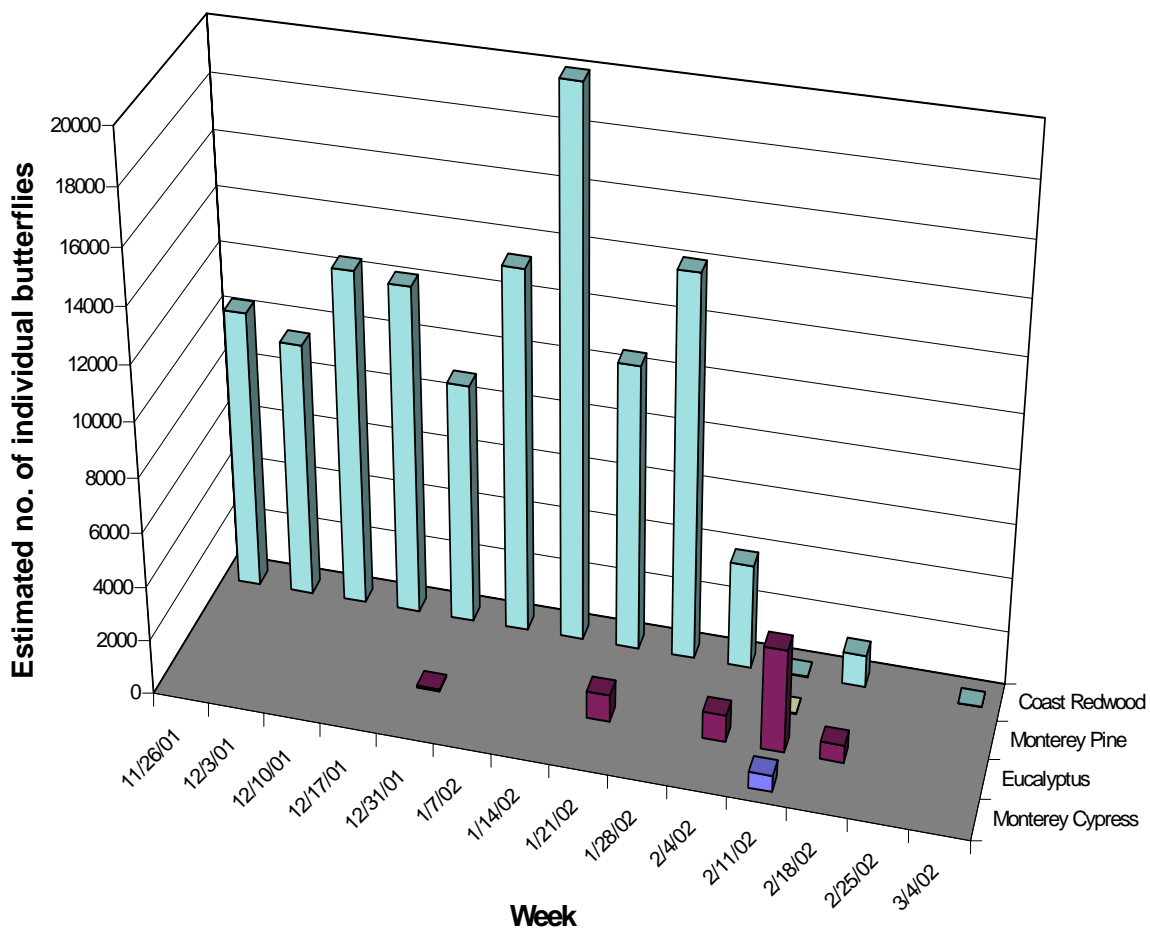


Figure 5. Estimated number of monarch butterflies using different tree species at Plaskett Creek Campground during winter 2001-2002.

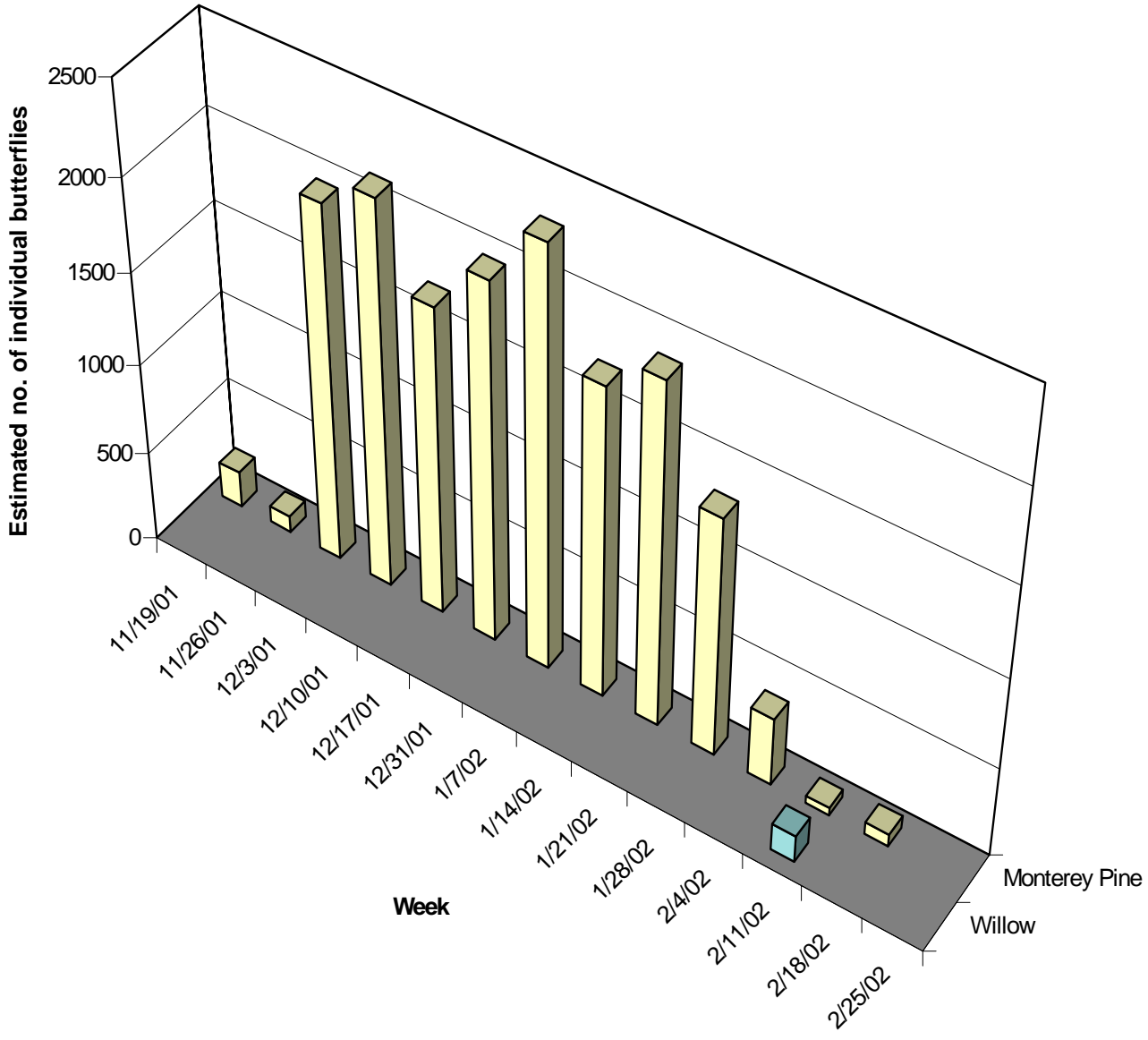


Figure 6. Weekly estimates of overwintering monarch butterflies at four transitional sites in Monterey County, California during winter 2001-2002.

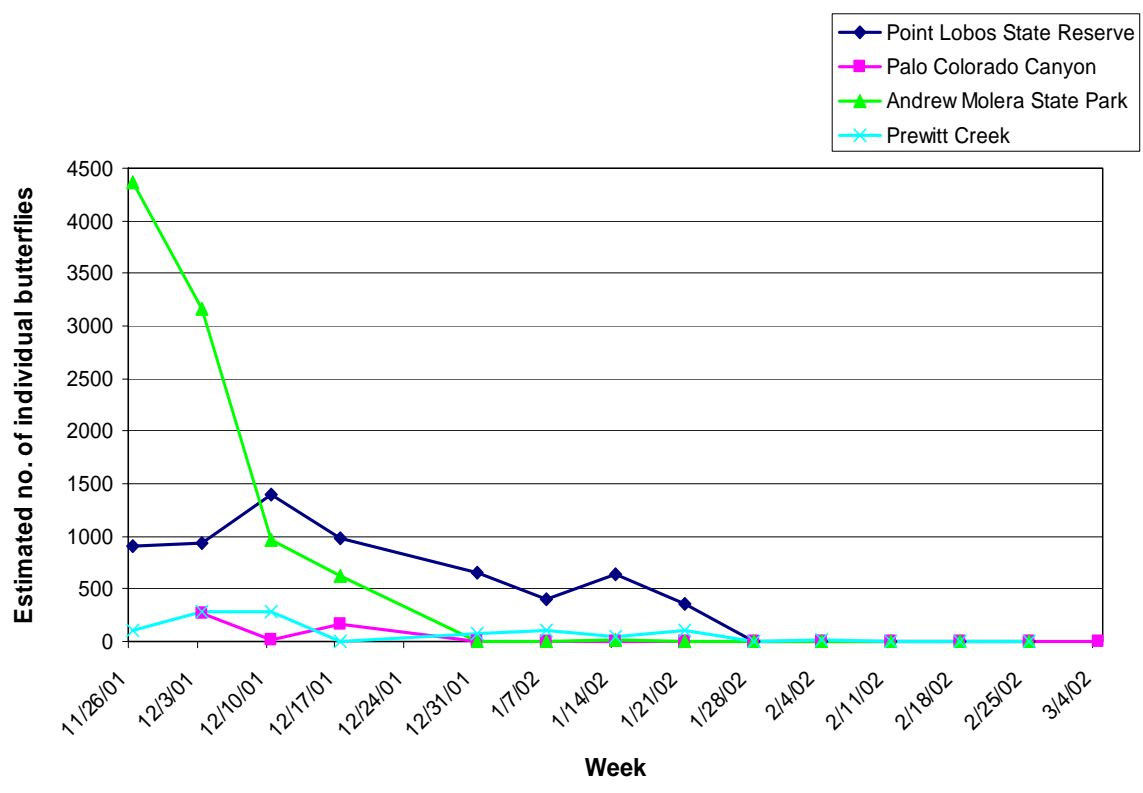


Figure 7. Distribution of clustering monarch butterflies in roost trees relative to aspect and wind direction at seven overwintering sites combined in Monterey County, California during winter 2001-2002.

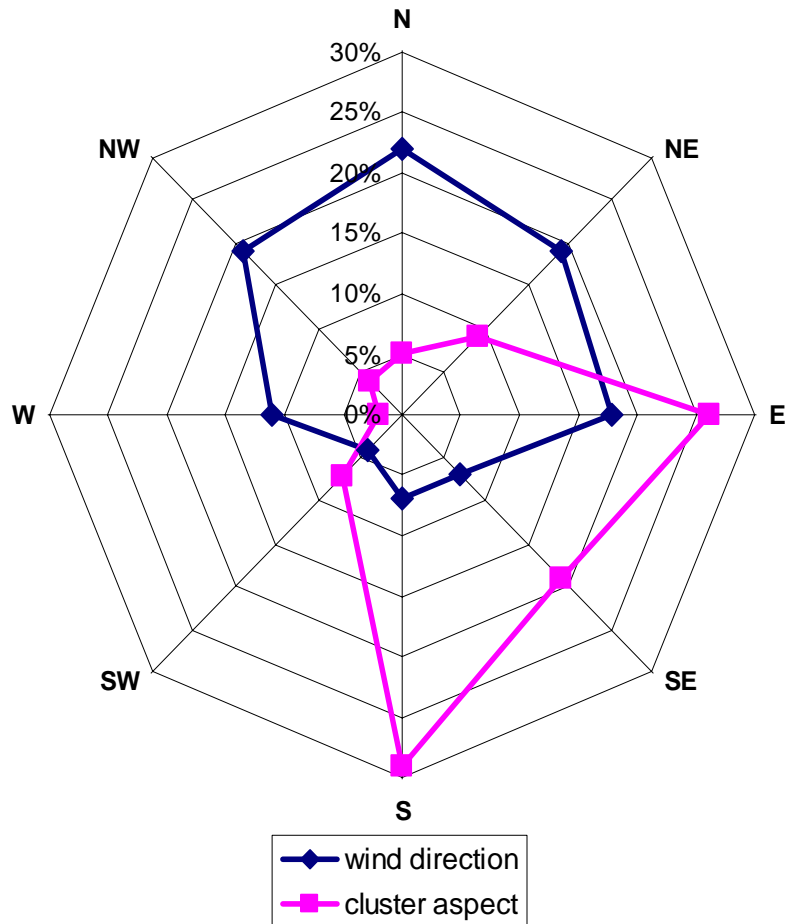


Figure 8. Precipitation by month in Monterey County, California during winter 2001-2002.

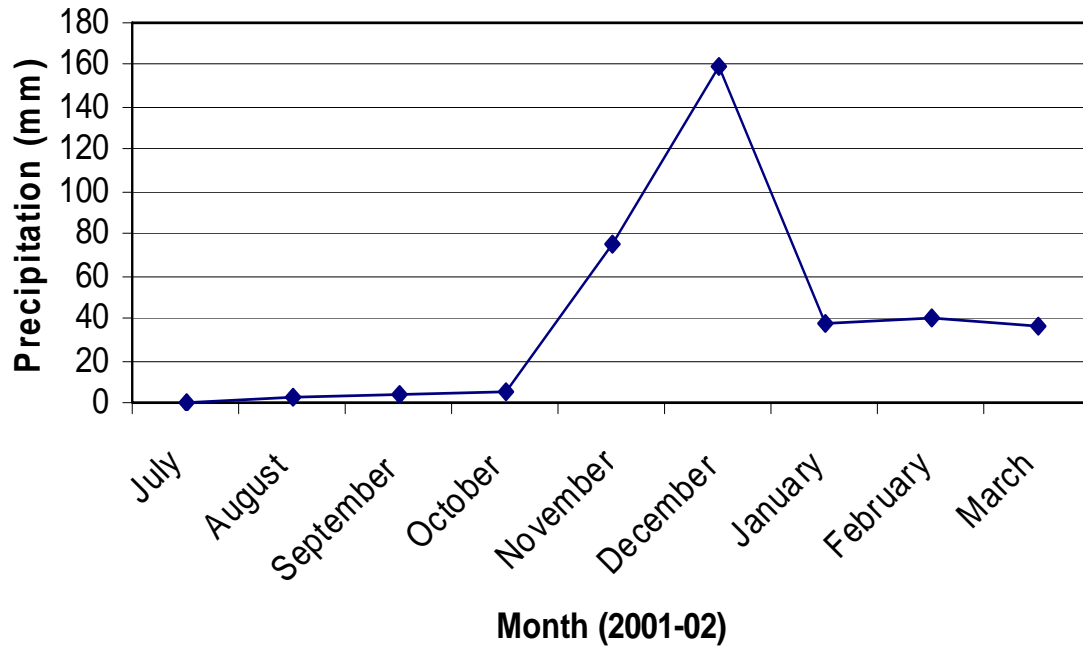
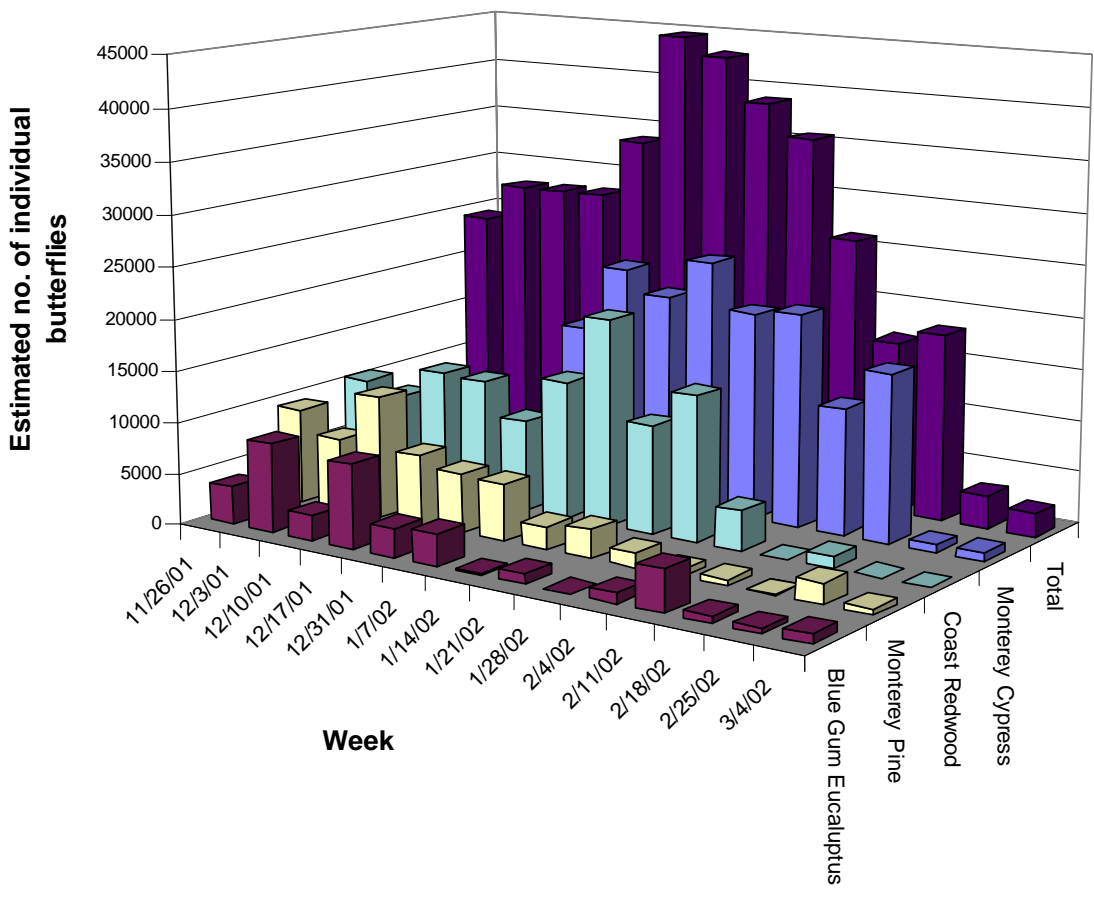


Figure 9. Estimated number of monarch butterflies using different tree species at three climax sites (Pacific Grove Monarch Sanctuary, the private property site, and Plaskett Creek Campground) determined by weekly surveys in Monterey County, California during winter 2001-2002.



Appendix 2. Weather and Tree Codes

Temp: in Celsius degrees

Sky:

- 0 = Clear, few clouds**
- 1 = Partly cloudy, scattered**
- 2 = Mostly cloudy, broken**
- 3 = Overcast**
- 4 = Fog or smoke**
- 5 = Drizzle**
- 8 = Showers**

Wind (Beaufort Scale):

<u>Beaufort #</u>	<u>mph</u>	<u>Indicators</u>
0	< 1	Smoke rises vertically
1	1 - 3	Smoke drifts
2	4 - 7	Wind felt on face, leaves rustle intermittently
3	8 - 12	Leaves in constant motion
4	13 - 18	Dust raised, branches moving
5	19 - 24	Small trees sway
6	>25	Large branches sway
7		Whole trees sway

Tree Species Codes:

EUSP	Blue Gum Eucalyptus	<i>Eucalyptus spp.</i>
PIRA	Monterey Pine	<i>Pinus radiata</i>
SESE	Coast Redwood	<i>Sequoia sempervirens</i>
CYMA	Monterey Cypress	<i>Cypressus macrocarpa</i>
QUAG	Coast Live Oak	<i>Quercus agrifolia</i>

