Microclimate parameters associated with three overwintering monarch butterfly habitats in central California: a two year study

Project Report 2004

Winters
2002-03
2003-04

Study Sites:
Andrew Molera State Park (Stands A and B)
Point Lobos State Reserve

Ventana Wilderness Society's
Big Sur Ornithology Lab

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INTRODUCTION

The western population of monarch butterflies *(Danaus plexippus)* migrates to specific overwintering habitats along the Pacific coasts of California and Mexico each fall. A suitable overwintering habitat comprises a relatively dense grove of trees with understory, located near water and nectar sources and protected from the wind by topographic landforms or trees (Sakai and Calvert 1991). An overwintering grove acts as a protective "humidity lens" to ameliorate climatic extremes of temperature and moisture occurring outside the grove (Sakai and Calvert 1991).

Managing overwintering monarch butterfly habitat requires an understanding of microclimate conditions needed by butterflies. Microclimate conditions supporting monarch butterfly populations along the central coast of California are not well documented. Past studies reported that monarch butterflies seek trees with exposure to filtered sunlight and shelter from gusty intermittent winds (Leong 1990, Leong et al. 1991, Sakai and Calvert 1991). Monarch butterflies appear to orient themselves to various different aspects during the winter months in response to the direction of winds through the grove (Leong 1990, Hamilton et al. 2002, Frey et al. 2003).

Two groves at Andrew Molera State Park and one grove at Point Lobos State Reserve have been recognized as historic monarch butterfly overwintering habitats in Monterey County in the Natural Diversity Database maintained by the California Department of Fish and Game. Prior to the surveys conducted by Hamilton et al. (2002) beginning in winter 2001-02, monarch butterfly population estimates at these locations had been intermittent and anecdotal.

At Andrew Molera State Park, the earliest reports of monarch butterfly population estimates date back to John Lane's field notes from 1982, when he observed butterflies clustered over the trail adjacent to the Cooper Cabin (hereafter referred to as Stand A) (Appendix A). Whether or not the butterflies were roosting at that time in the western grove across the small drainage (hereafter referred to as Stand B) is not known. In winter 1990-91, Sakai and Calvert (1991) observed the majority of butterflies roosting in Stand B. More recent reports have described monarch butterflies roosting primarily in Stand A (Sakai 2001, Hamilton et al. 2002, Frey et al. 2003, Frey et al. 2004).

At Point Lobos State Reserve, the earliest recorded observations of overwintering monarch butterflies date back to the establishment of the reserve when docents began

keeping log books of natural history observations. The majority of observations to-date documents the butterflies using the warmer protected areas on the southeast side of Whaler's Knoll (Appendix B) (Hamilton et al. 2002, Frey et al. 2003, Frey et al. 2004).

In the winters of 2002-03 and 2003-04, we conducted a pilot study to gather baseline data on microclimate variables in the overwintering habitats at Andrew Molera State Park (Stands A and B) and Point Lobos State Reserve in Monterey County. Our main objectives were to establish a long-term monitoring study for 1) comparing microclimate characteristics among monarch butterfly overwintering groves and 2) investigating the relationship between microclimate and relative numbers of overwintering monarch butterflies within the groves.

METHODS

Study sites.—In 2002 and 2003 we installed data-loggers and weather equipment at two locations in Andrew Molera State Park (Appendix A) and at one location in Point Lobos State Reserve (Appendix B). Andrew Molera State Park (Molera) is located 34 km south of the Carmel River, Monterey County. Blue gum eucalyptus (*Eucalyptus globulus*) is the predominant tree species at both Stand A and Stand B and was the only tree species used by monarch butterflies. Point Lobos State Reserve (Point Lobos) is located 7 km south of the Carmel River, Monterey County. Monterey pine (*Pinus radiata*) is the predominant tree species at the grove and was the only tree species used by monarch butterflies.

At each location, we placed a weather station on the northwestern fringe of the "amphitheatre" opening where a significant number of butterflies had clustered in the winter of 2001-02 (Hamilton et al. 2002). However these locations did not exactly match the areas where the butterflies clustered in the winter of 2003-04 (Frey et al. 2004). In 2003-04, butterflies clustered near the Molera Stand A weather station, but not near the Stand B weather station. At Point Lobos, the majority of clustering butterflies were about 75 meters west of the weather station. Due to vandalism of Molera Stand A, we moved the rain gauge and temperature/relative humidity (RH) meter approximately 3 meters west into a patch of poison oak (*Toxicodendron diversilobum*) to discourage further tampering. Each station was elevated off the ground approximately 0.5 to 1.5 m. For the purposes of this monitoring report, we included analyses from microclimate parameters collected from 7 November 2003 to 4 March 2004, the period of time when large numbers of monarch butterflies overwintered on the central coast.

Data management.—Using a HOBO shuttle and cable, we routinely transferred weather data from the data loggers to our office desktop computer using Boxcar Pro 4.0 software. From Boxcar, we imported the data into an Excel spread sheet we designed specifically for managing microclimate data. On a regular basis we monitored equipment, downloaded weather data, maintained the database, and ensured that all equipment functioned properly. After 10 March 2004 we removed and safely stored all weather equipment to prevent vandalism.

Sunlight intensity.—We measured light intensity using the HOBO Light Intensity Logger. Every 30 min the HOBO logged light intensity in lumens per square meter.

Temperature, relative humidity, and dew point.—We measured temperature, relative humidity, and dew point using a HOBO Pro Series Weatherproof Logger protected by a rain shield. Temperature was logged every 30 min in degrees Celsius, relative humidity was logged every 30 min in percent, and dew point was logged every 30 min in degrees Celsius.

Precipitation.—We measured precipitation using a Rainwise III Rain Gauge connected to a HOBO Event Rainfall Logger. The rain gauge collected precipitation using a funnel that dripped water into a "tipping bucket". Each time the bucket tipped, an "event" that equated to 0.02710 cm precipitation was logged.

Monarch butterfly censusing.—In addition to recording microclimate data, we also conducted a weekly census of overwintering monarch butterflies at each of the three locations throughout the overwintering period (7 November 2003 to 4 March 2004) (Frey et al. 2004). For the purposes of this report, we documented the presence or absence of clustered monarch butterflies.

Statistical analyses.—We used one-way ANOVA (Ott 1993) to investigate differences in sunlight intensity, temperature, relative humidity, and dew point at each of the three study sites. Statistical significance was assumed at a level of $P < 0.05$.

RESULTS

Light intensity differed significantly between the two groves at Molera and the grove at Point Lobos (df = 2, $F = 18.99$, $P < 0.0001$). Stand B at Molera received the least amount of light, Stand A received a medium amount of light, and the Stand at Point Lobos received the most light (Table 1; Figure 1).

Temperature differed significantly between the two groves at Molera and the grove at Point Lobos (df = 2, $F = 40.26$, $P < 0.0001$). Stand A at Molera had the lowest mean temperature, Stand B at Molera had slightly higher temperatures, and the Stand at Point Lobos had the highest recorded temperatures (Table 1; Figure 2). Even though mean temperatures were different, temperatures tracked similarly among the sites. Point Lobos consistently had the highest temperatures when exposed to sunlight and the lowest troughs during the night. Otherwise, all three sites tracked temperature surprisingly closely, as shown in Figure 3 during the week of greatest storm activity from 31 December 2003 to 8 January 2004.

Relative humidity differed significantly between the two groves at Molera and the grove at Point Lobos (df = 2, $F = 639.36$, $P < 0.0001$). Stand A at Molera had the lowest relative humidity, followed by greater relative humidity at Point Lobos and Stand B, respectively (Table 1; Figure 4).

Dew point significantly differed between the two groves at Molera and the grove at Point Lobos (df = 2, $F = 791.32$, $P < 0.0001$). Stand A at Molera had much lower dew point than Stand B and Point Lobos, respectively (Table 1; Figure 5).

Precipitation also differed among the three study sites. However, due to various technical difficulties, the rain gauges at each of the weather stations did not record precipitation for the entire 119-day overwintering period from 7 November, 2003 to 4 March 2004. At Point Lobos, precipitation was only recorded for 57 days, at Molera Stand A precipitation was recorded for 71 days, and at Stand B, 115 days. Because of the disparate recording times, we compared precipitation among stations when all three stations recorded precipitation simultaneously, 8 January to 4 March 2004 (Figure 6). Stand A at Molera and Point Lobos received substantially more precipitation over the winter (19.54 cm and 18.81 cm, respectively) than Stand B at Molera (5.42 cm).

During the overwintering period, 7 November, 2003 to 4 March, 2004, numbers of overwintering butterflies varied greatly among the three study sites. We consistently observed clusters of overwintering butterflies at Molera Stand A and Point Lobos; weekly population estimates ranged from 290 to 16,133 butterflies at Molera Stand A and 158 to 7,661 butterflies at Point Lobos. We observed butterflies at Stand B at Molera on only two occasions, 454 butterflies on 15 October 2003 and 1,618 butterflies on 10 December 2003.

Both of these counts were higher than counts from the previous two winters (Hamilton et al. 2002, Frey et al. 2003, Frey et al. 2004).

DISCUSSION

Microclimate parameters measured from 7 November 2003 to 4 March 2004 varied significantly among the three study sites. Point Lobos averaged the highest light intensity, temperature, and dew point (Table 1, Figure 3). In contrast, Stand A at Molera averaged the lowest temperature, relative humidity, and dew point (Table 1). Stand B at Molera averaged medium ranges for temperature and dew point, and the lowest light intensity and highest relative humidity (Table 1). These different microclimate conditions likely affected the number of overwintering butterflies observed at each of the three sites. However, long-term monitoring of microclimate parameters and overwintering butterflies is needed to clearly understand relationships between microclimate conditions and their effect on overwintering butterflies.

Monarch butterflies clustered in the greatest aggregations in Stand A at Molera, in lower numbers at Point Lobos, and were virtually absent (except for two occasions) in Stand B at Molera. Preliminary results suggest that microclimate conditions that support overwintering monarch butterflies are more favorable in Stand A at Molera and in Point Lobos compared to conditions in Stand B at Molera. Comparatively, Stand B averaged lower light intensity and lower relative humidity than the other sites. Stand B is much more structurally dense and lacks the "amphitheatre" opening where butterfly clusters are most commonly located. Opening up Stand B with management practices (e.g., felling large branches in the center) would likely allow for more sunlight to enter the grove and could potentially create conditions favorable for overwintering butterflies.

Last winter (2003-04) at population peak which occurred during the week of 1 December 2003, we estimated 71,566 butterflies present at eight[3] overwintering sites in Monterey County (Frey et al. 2004). This population peak was more than 5 times greater than the previous winter's (2002-03) peak of 13,083 butterflies estimated during the week of 9 December 2002. The peak of 45,362 butterflies in winter 2001-02 which occurred during the week of 7 January 2002 was more than 3 times greater than that in 2002-03 but 37%

[3] Monarch Grove Sanctuary, George Washington Park, Point Lobos State Reserve, Palo Colorado Canyon, Andrew Molera State Park, Private Property Site, Prewitt Creek, Plaskett Creek Campground.

lower than that in winter 2003-04. Such differences among years in the overall number of overwintering butterflies is probably a function of annual macroclimate variation. The population dip in winter 2002-03 may be attributed to unseasonably drier and milder conditions in the preceding summer and fall, which may have reduced the availability of milkweed (*Asclepias* spp.), the host plant of the monarch butterfly (Sakai *pers. comm*). When comparing annual fluctuations of butterflies in conjunction with overwintering microclimate parameters, it is important to take macroclimate fluctuations into account.

Past studies reported that overwintering butterflies did not cluster on trees subjected to sun exposure and bright illumination (Brower et al. 1998, Leong 1990, Leong et al. 1991). Frey et al. (1992) found that on any given day, approximately 80% of the clusters were found in the shaded or indirectly lighted parts of a tree. Chaplin and Wells (1982) surmised that because metabolic rate in butterflies is a function of body temperature, prolonged exposure to direct light could result in suboptimal rate of body fat utilization. However, clustering butterflies were consistently found on southern exposures of trees throughout the overwintering period (Frey et al. 1992, Hamilton et al. 2002, Frey et al. 2003). Frey et al. (1992) suggested that roosting on the southern exposure of trees represents a compromise solution, whereby the butterflies are situated in a portion of the grove that is shaded and protected by wind, but also are provided brief opportunities for radiant thermoregulation, allowing for movement on days near or below the flight threshold (13.8 °C). Given the results of these past studies and our preliminary results suggesting greater sunlight exposure in Stand B at Molera could be advantageous, we suggest continuing this microclimate study over several years, in conjunction with butterfly surveys and any habitat management or improvement that is undertaken.

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Table 1. Microclimate parameters compared during winter 2003-04 between the two groves at Andrew Molera State Park (Stand A and Stand B) and the grove at Point Lobos State Reserve, Monterey County, California.

Stand	Light intensity (Lumens/sq. m)		Temperature (°C)		Relative humidity (%)		Dew point (°C)	
	μ	SE	μ	SE	μ	SE	μ	SE
Molera A	0.32	0.03	10.64	0.04	74.49	0.34	4.75	0.11
Molera B	0.19	0.03	10.72	0.04	86.12	0.21	8.14	0.05
Point Lobos	0.45	0.03	11.18	0.05	85.71	0.21	8.49	0.04

μ = mean
SE = standard error of the mean

Figure 1. Light intensity compared during the winter 2003-04 between the two groves at Andrew Molera State Park (Stand A and Stand B) and the grove at Point Lobos State Reserve, Monterey County, California.

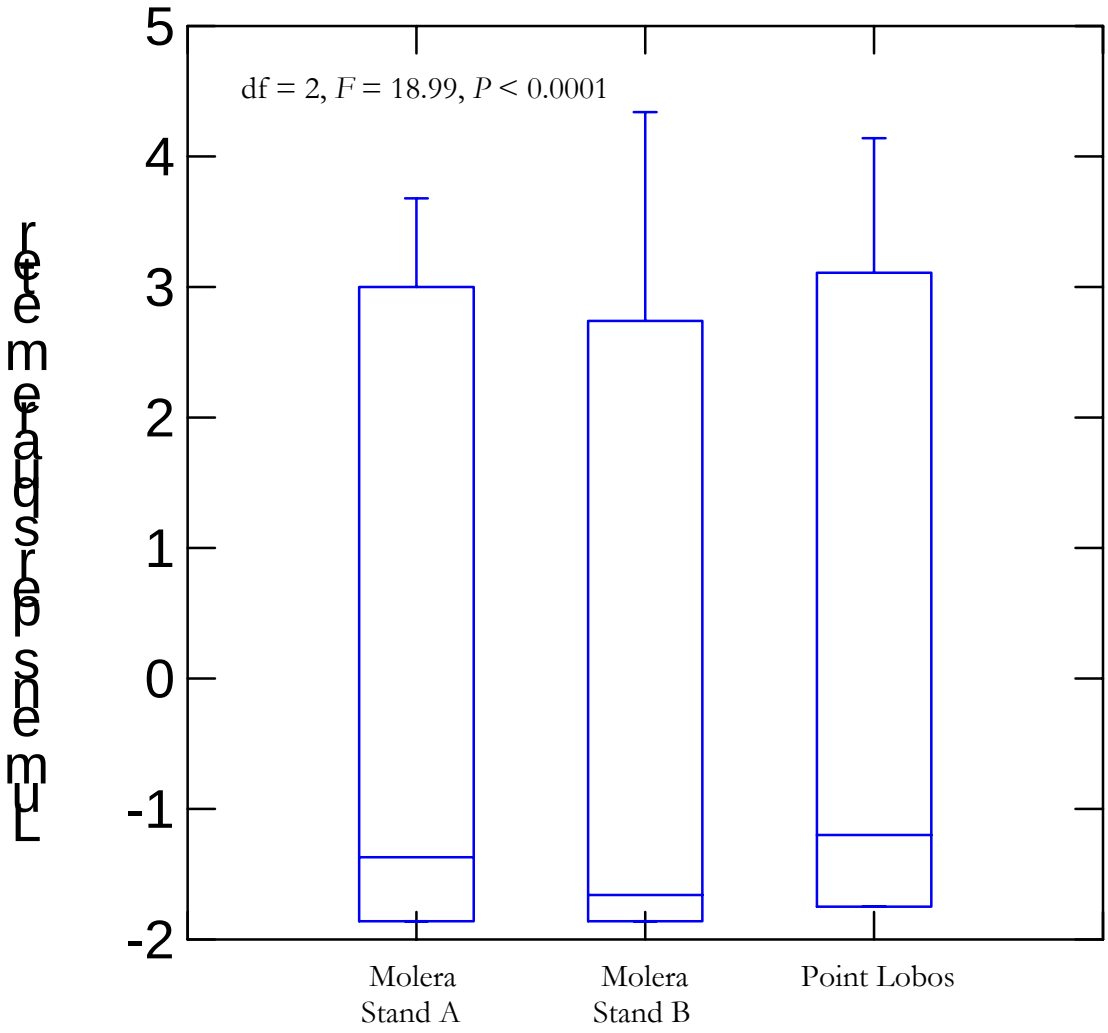


Figure 2. Temperature compared during the winter 2003-04 between the two groves at Andrew Molera State Park (Stand A and Stand B) and the grove at Point Lobos State Reserve, Monterey County, California.

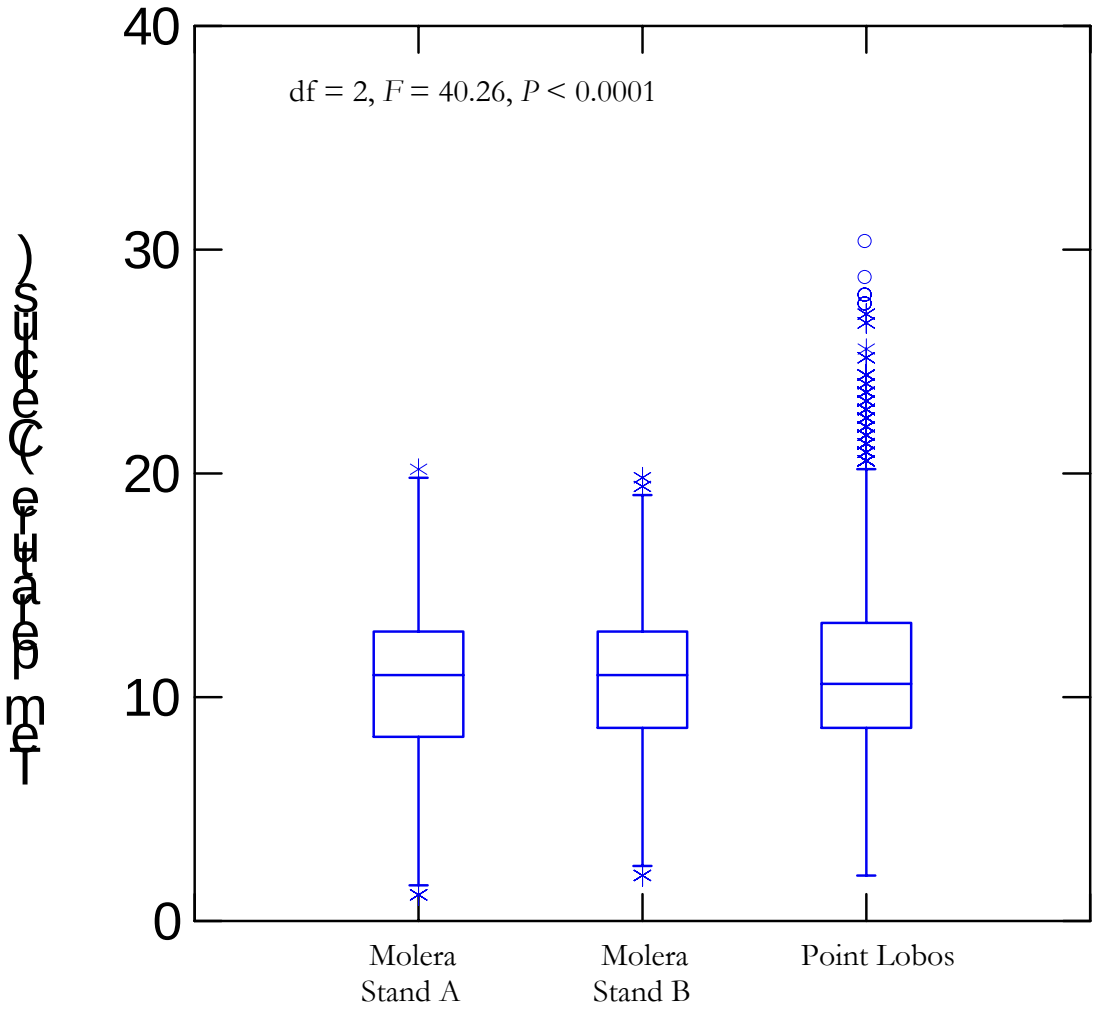


Figure 3. Temperature compared between the two groves at Andrew Molera State Park (Stand A and Stand B) and the grove at Point Lobos State Reserve, Monterey County, California on a temporal scale from 31 December 2003 to 8 January 2004.

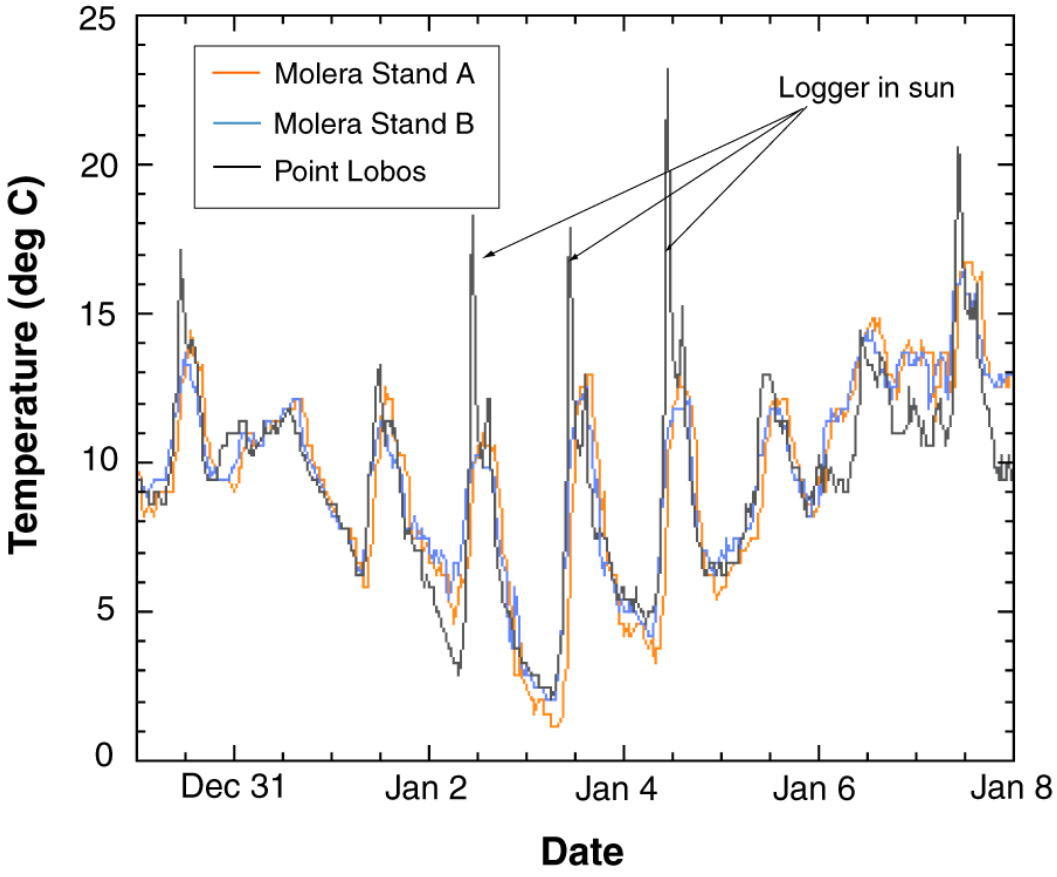


Figure 4. Relative humidity compared during the winter 2003-04 between the two groves at Andrew Molera State Park (Stand A and Stand B) and the grove at Point Lobos State Reserve, Monterey County, California.

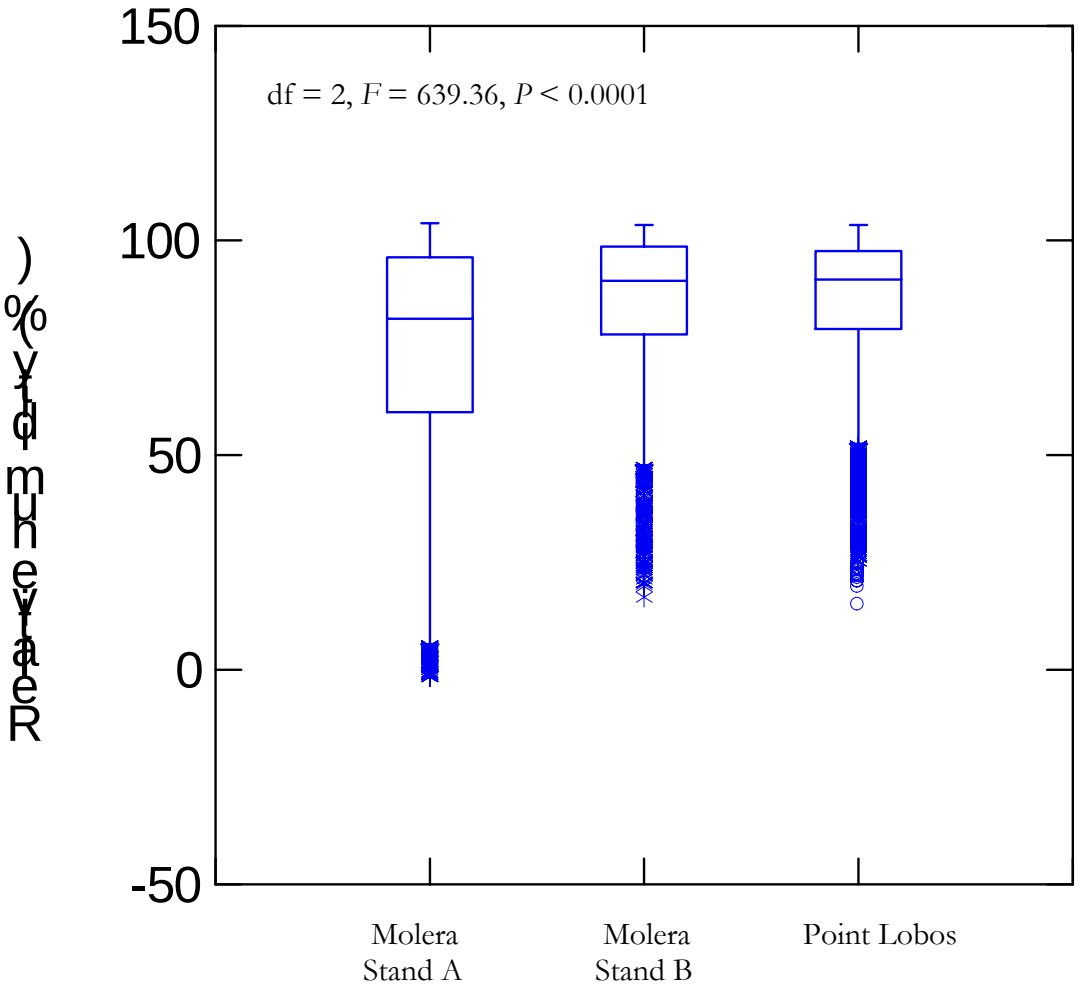


Figure 5. Dew point compared during the winter 2003-04 between the two groves at Andrew Molera State Park (Stand A and Stand B) and the grove at Point Lobos State Reserve, Monterey County, California.

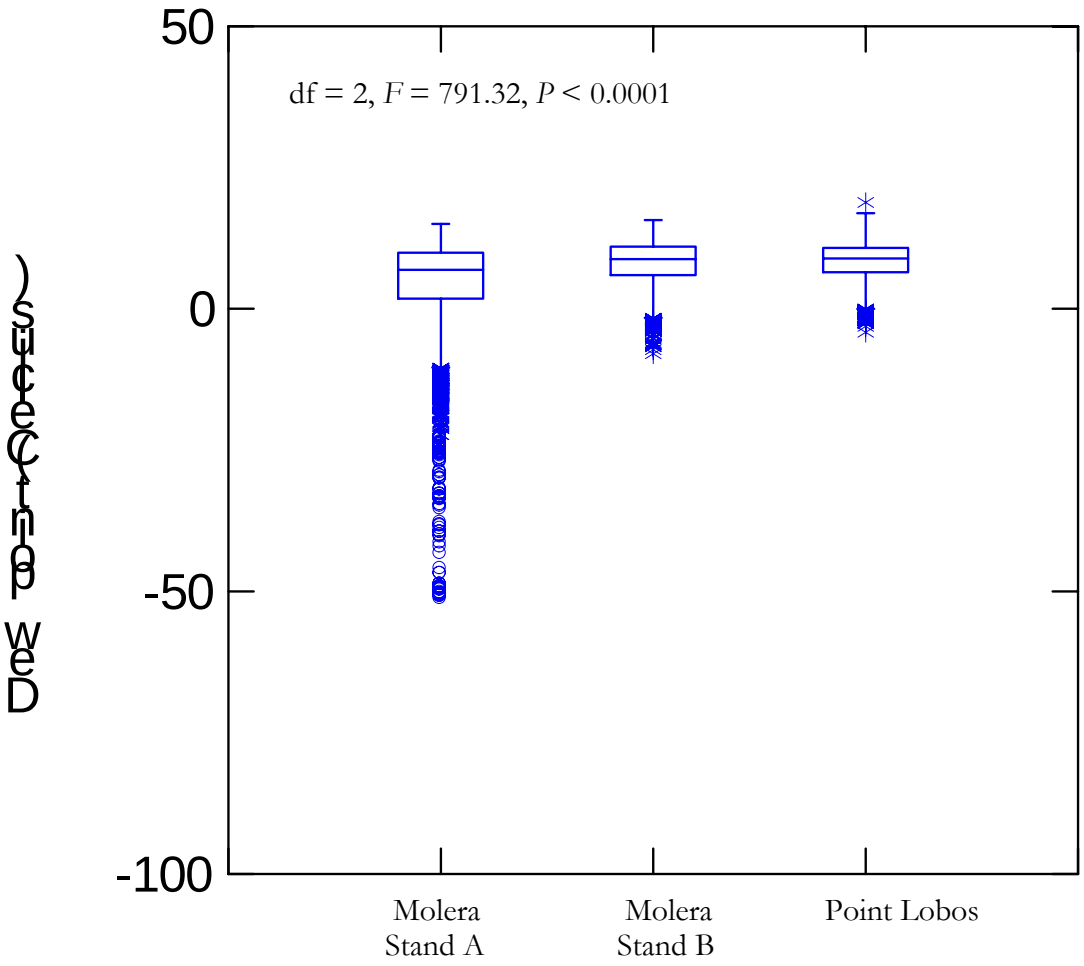


Figure 6. Cumulative precipitation compared from 8 January to 4 March 2004 at the two groves at Andrew Molera State Park (Stand A and Stand B) and the grove at Point Lobos State Reserve, Monterey County, California.

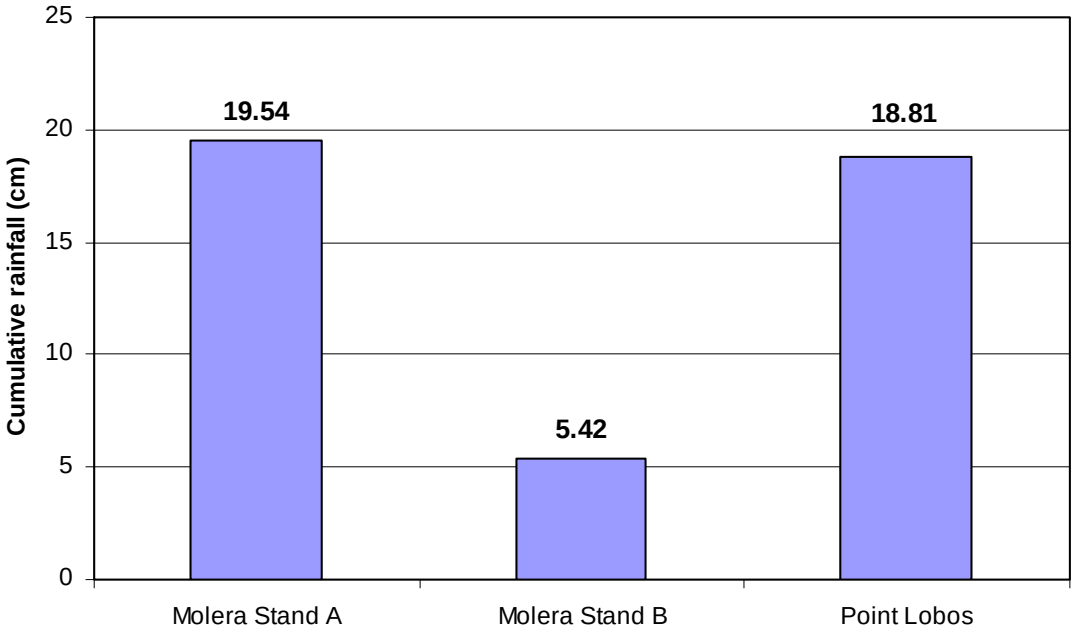
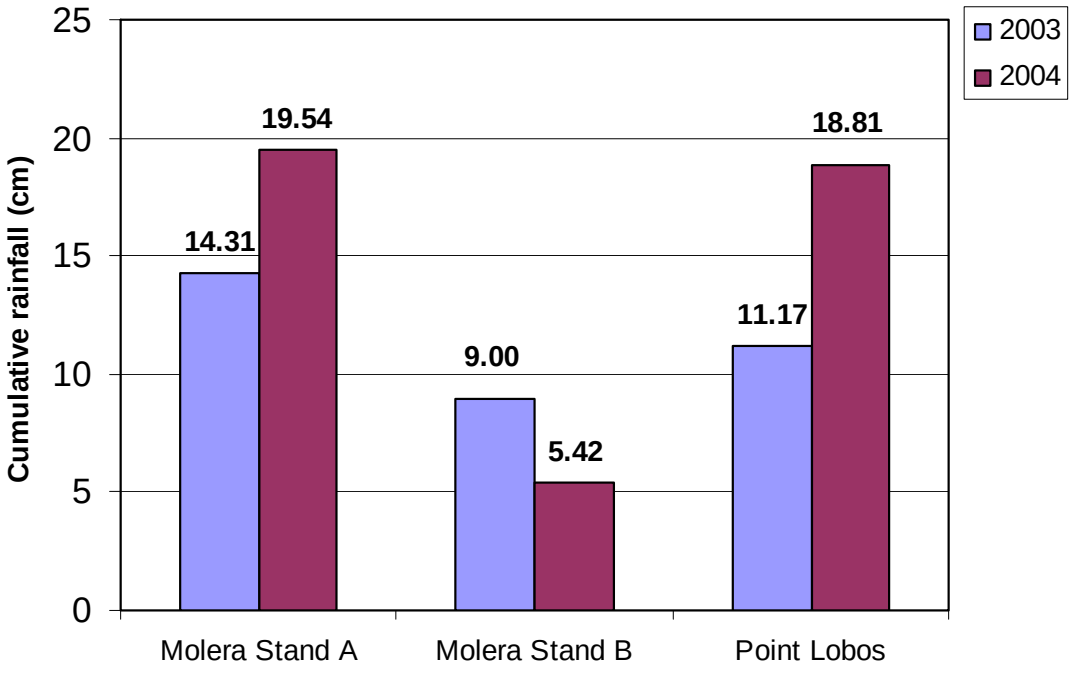
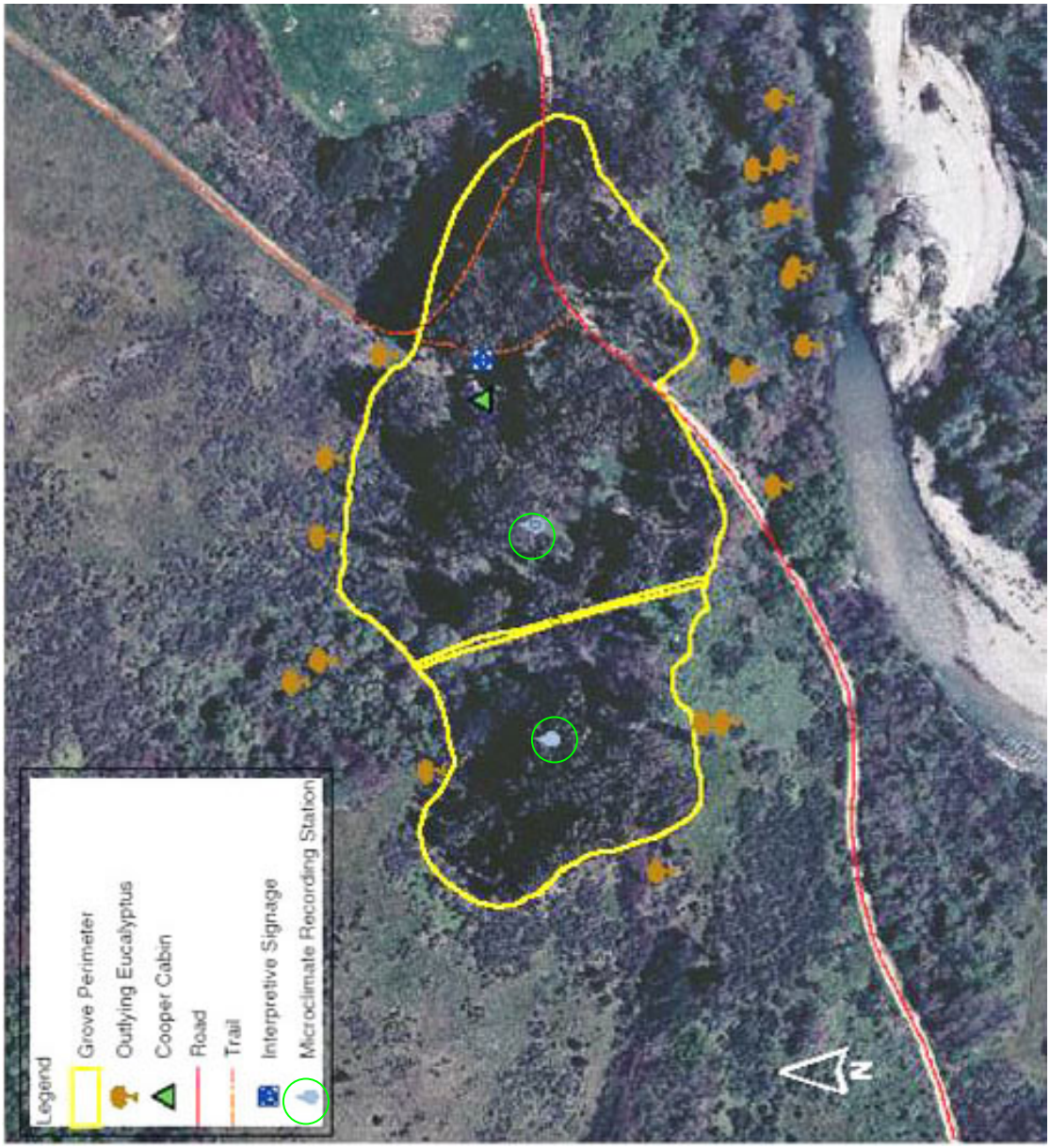


Figure 7. Cumulative precipitation compared from 8 January to 4 March 2003 and 2004 at the two groves at Andrew Molera State Park (Stand A and Stand B) and the grove at Point Lobos State Reserve, Monterey County, California.



Appendix A. Study sites: Stand A and Stand B at Andrew Molera State Park, Monterey County, California.



Appendix B. Study Site: Point Lobos State Reserve, Monterey County, California.