



2013 – 2014
Monarch Overwintering Season Report

Summary of population trends in Central California's
Monterey County overwintering sites

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I. Project Background

The Monarch butterfly (*Danausplexippus*) makes its famed migration in two unique Eastern and Western partitions in the United States. Considered an ‘Endangered Phenomenon’ (Malcolm 1993), the migratory ecology of these insects has attracted intensive study and, increasingly, public awareness and advocacy. As natural habitat becomes fragmented and subject to human impacts across monarch home and migratory ranges, close monitoring of population fluctuations and trends becomes a vital tool in the conservation of the butterflies and their migratory behavior. Data on favored overwintering sites and microclimate variation, as well as butterfly behavior in relation to landscape modification and broader climatic trends can lend insight into the causes and consequences of population fluctuations. In addition, local efforts contribute to long-term datasets, the importance of which has been widely recognized for identification of correlative and causal relationships over ecological and evolutionary time (Franklin 1989).

The need to monitor monarchs across multiple years and overwintering sites has generated unique alliances between academic institutions, not-for-profit organizations, private donors, and the public. The importance of such efforts has been recognized both domestically and regionally; recently, the three countries that host to monarchs in various stages of their life cycle and migration – Canada, the United States, and Mexico – put forth the North American Monarch Conservation Plan, a document outlining current status of the species, causes of local and continental decline, and directives for research and conservation. Among their suggestions, monitoring of monarch population abundance and habitat quality is closely followed by recommendations of outreach and public awareness – two objectives that are highly complementary in communities near to overwintering sites or flyways.

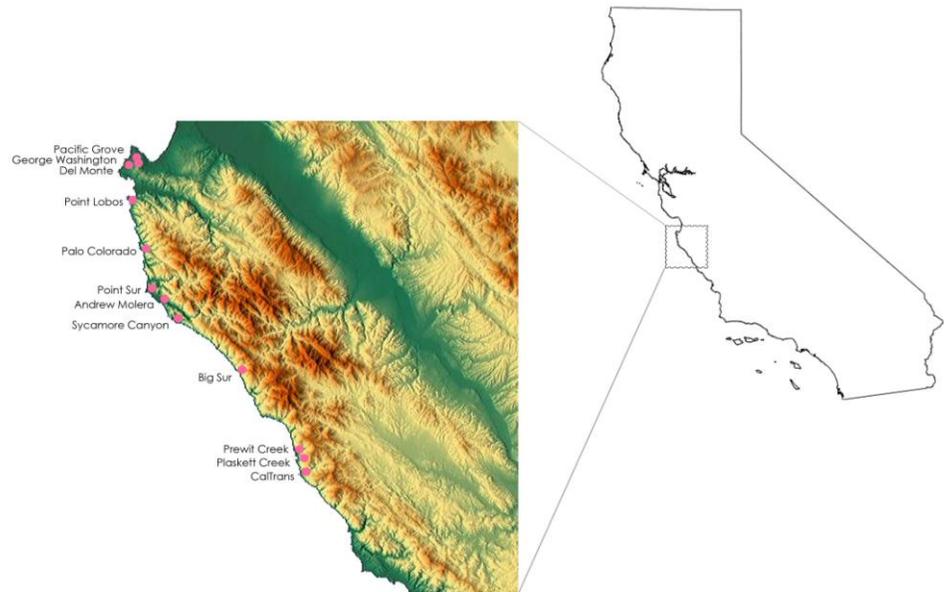
The Pacific Grove Museum of Natural History (PGMNH) is one such institution uniting the public with the process and importance of data collection through its citizen science education program. Volunteers from the community are trained in standard techniques to count monarchs, observe their behavior, and assess habitat and climate. These citizen scientists then report their findings to a central database, whose results are analyzed upon conclusion of the overwintering season. In addition to collecting census data, local students are given the opportunity to complete independent research projects with the insects and present their findings at local conferences or within the Museum.

In the current report, data from the 2013-2014 overwintering season is presented. Trends in Central California’s Monterey County monarch populations are explored, and ideas for future work suggested.

II. Methods

Citizen Scientist Recruitment and Training

- Museum exhibition (*Monarchs Come Home*) and Pacific Grove Sanctuary placards provide general information about monarch butterfly ecology in the area. As part of the Museum's Citizen Science education program, volunteers assisted with monarch population monitoring events. Volunteers were recruited from the general public, college students at California State University, at Monterey Bay and middle and high school students throughout Monterey County."
- Interested volunteers participated in a hands-on training for data collection. Skills learned included estimation of butterfly cluster size and height, categorization of non-clustering behavior (nectaring, mating, flying, sunning), observation of mortality, identification of host trees, and general habitat assessment. Volunteers also learned how to use instruments for climatic measurements (temperature, cloud cover, wind speed/direction).
- Volunteers were assigned, in pairs, to visit 12 overwintering sites located throughout Monterey County. Sites were visited bi-weekly. Sites without butterflies were visited through mid-overwintering season to observe late arrivals, and then dropped from scheduled census.



Data Analysis

- Data are visualized as time series records (abundance through time) for each overwintering site. Variation in overall abundance, trends through time, and trends across years are discussed.

III. 2013-2014 Overwintering Season Trends

Monarch Abundance 11 Site Snapshot, 2013-2014 Overwintering Season

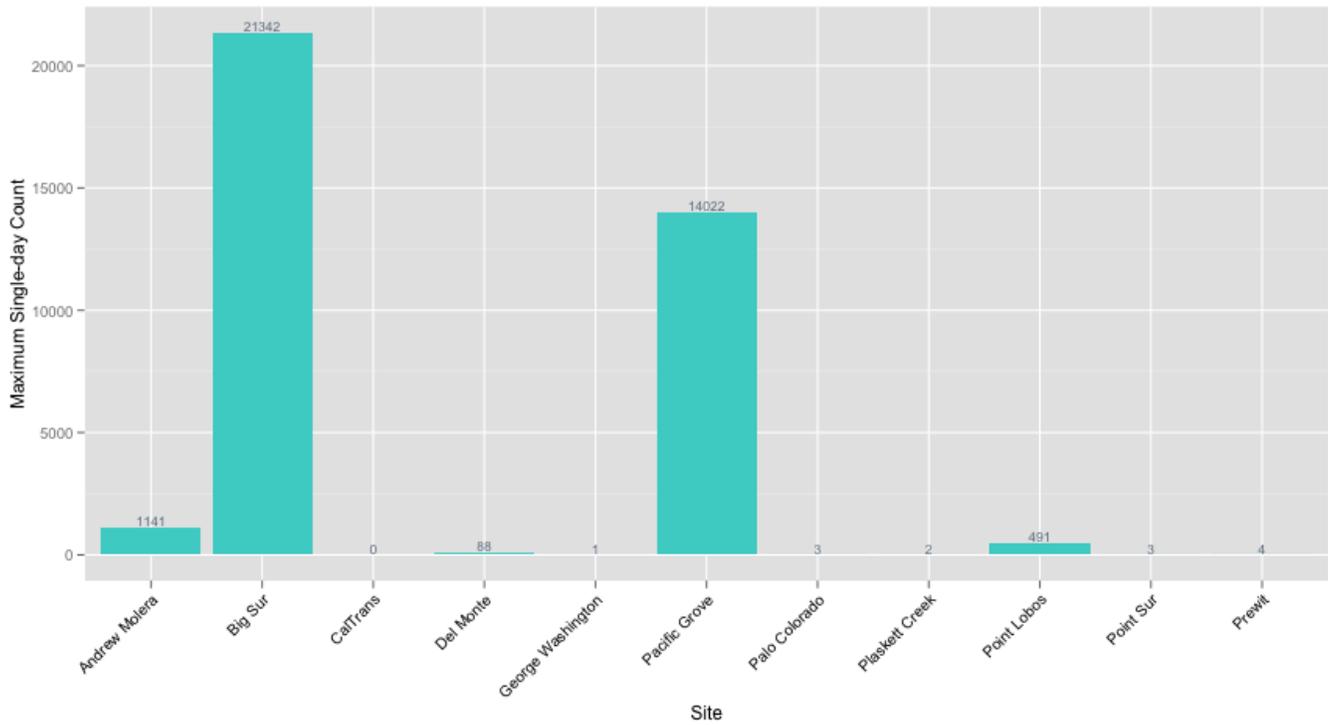


Figure 1. Maximum single-day counts of monarch butterflies at each site. Extensive variation in abundance is clear. At peak census, ‘Private Property: Big Sur’ hosted >21,000 butterflies; in contrast, sites such as CalTrans, George Washington, Palo Colorado, Plaskett Creek, Point Sur, and Prewitt hosted only a handful of individuals – and those potentially en route to other locations.

Site Populations through Time

The following figures show abundances of monarch butterflies through time at sites with consistent populations: Andrew Molera, 'Private Property: Big Sur', Del Monte, Pacific Grove, and Point Lobos. Note that y-axis scales vary by site.

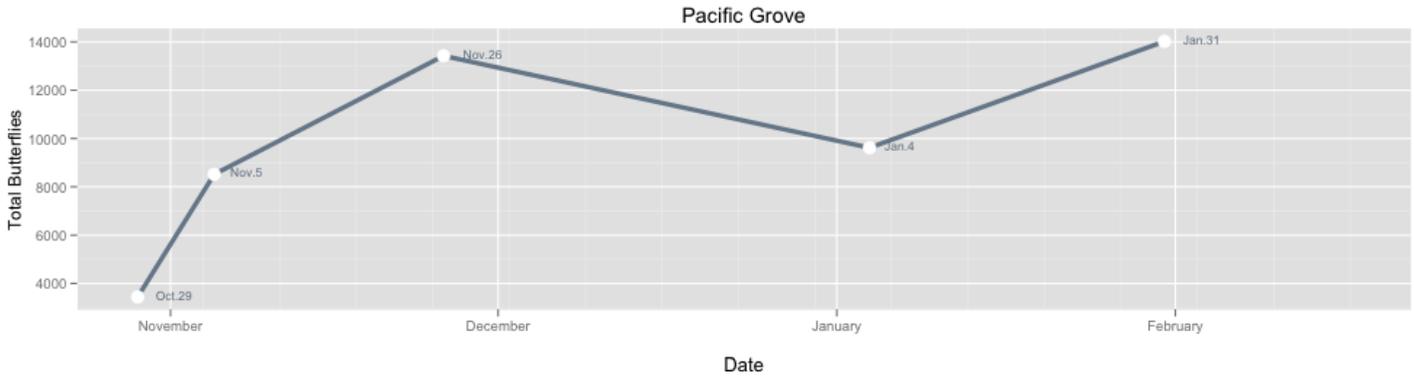


Figure 2. Pacific Grove

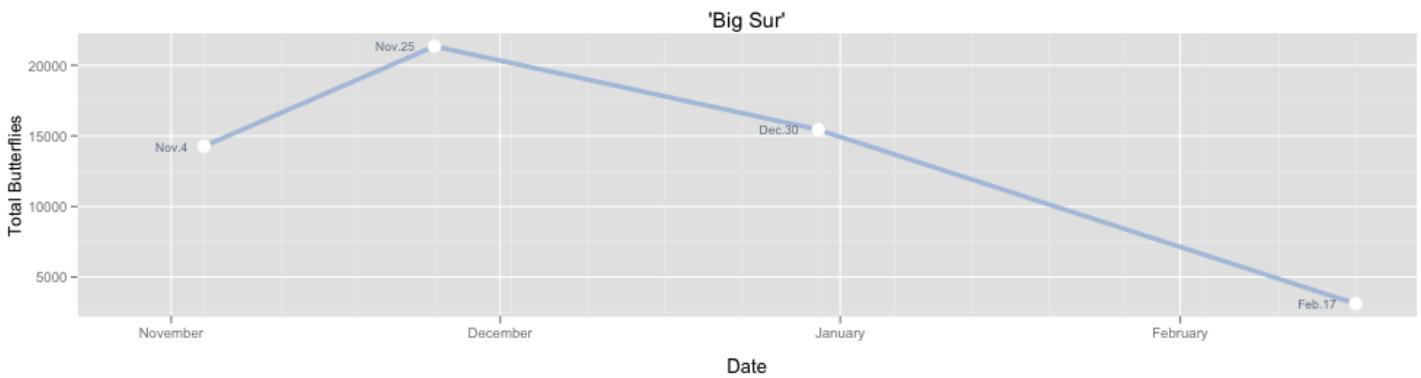


Figure 3. 'Private Property: Big Sur'

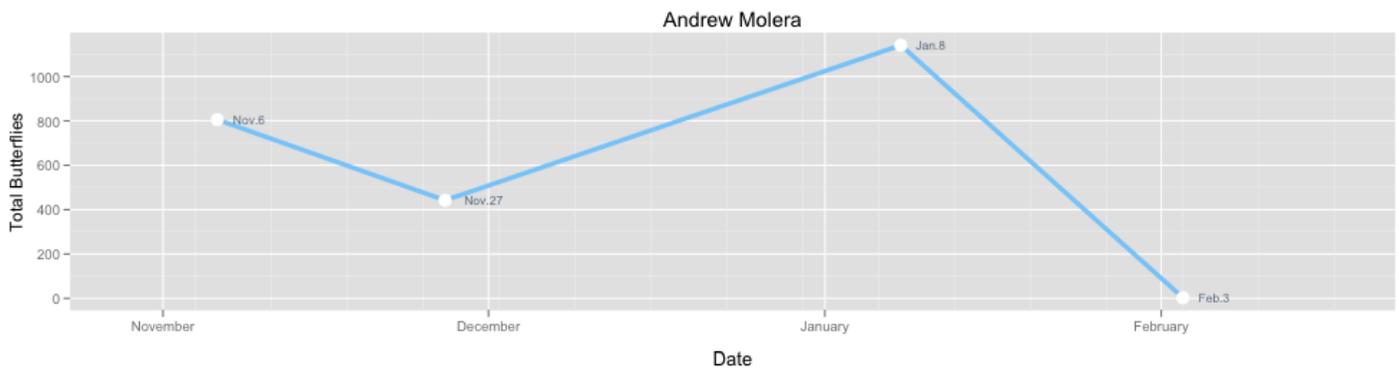


Figure 4. Andrew Molera

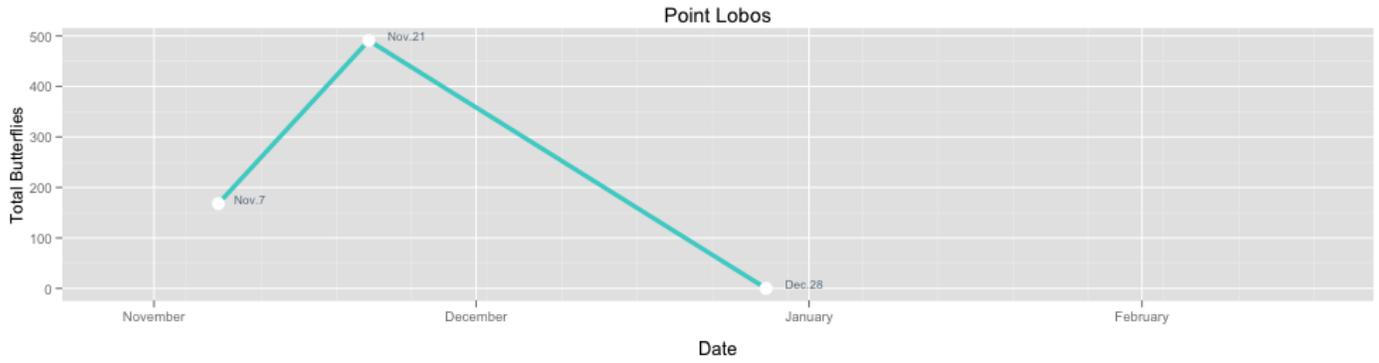


Figure 5. Point Lobos

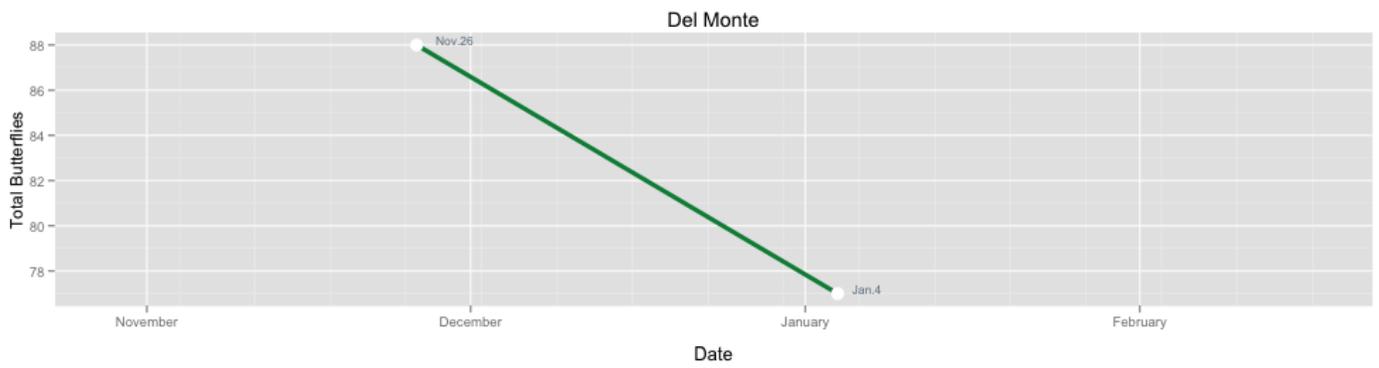


Figure 6. Del Monte

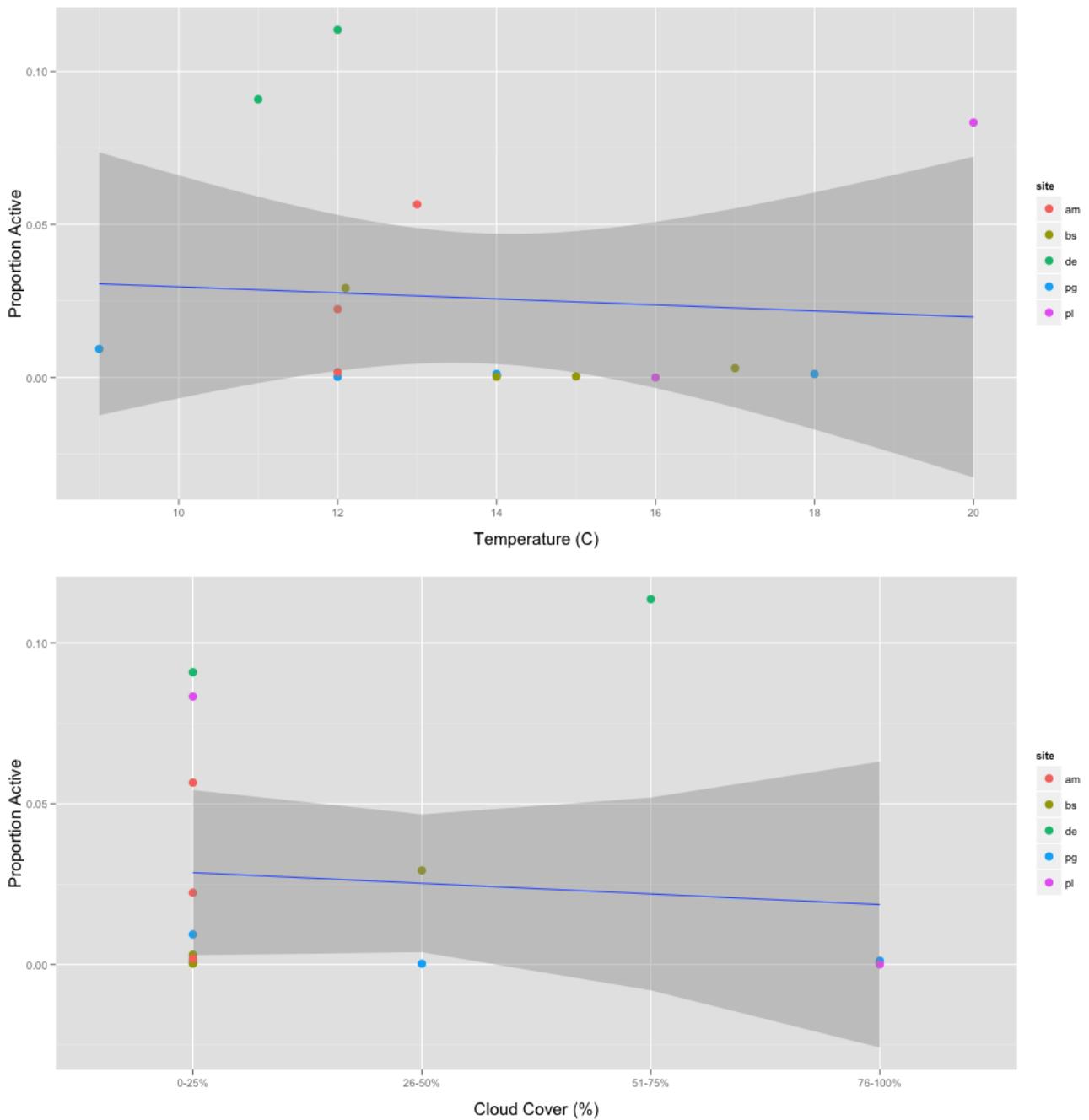


Figure 7. Relationship between proportion of active butterflies and site temperature (top) and cloud cover (bottom) across sites (includes only sites with > 20 butterflies through time). Color indicates site. Surprisingly, these data show no relationship between either climate variable and butterfly activity level across sites (Temperature : $R^2 = 0.005$; Cloud Cover: $R^2 = 0.011$).

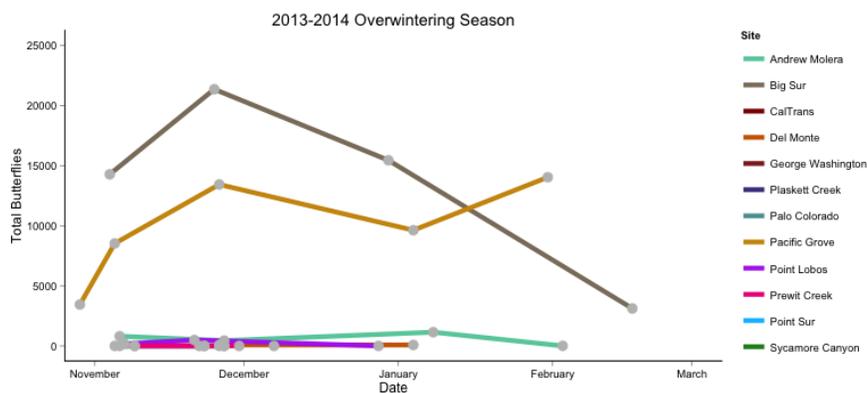
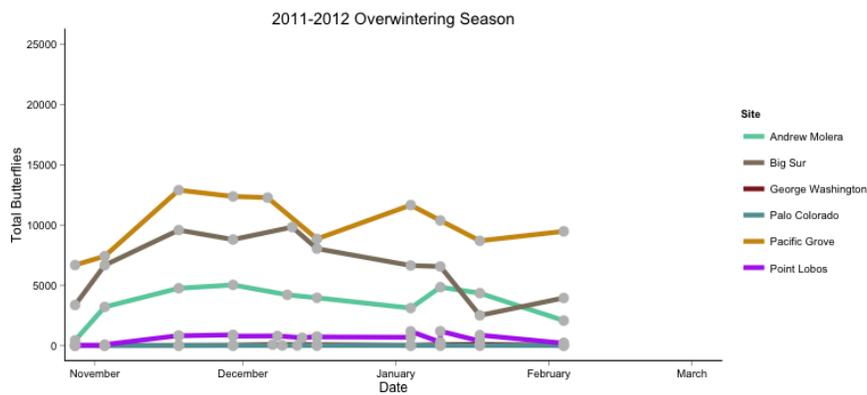
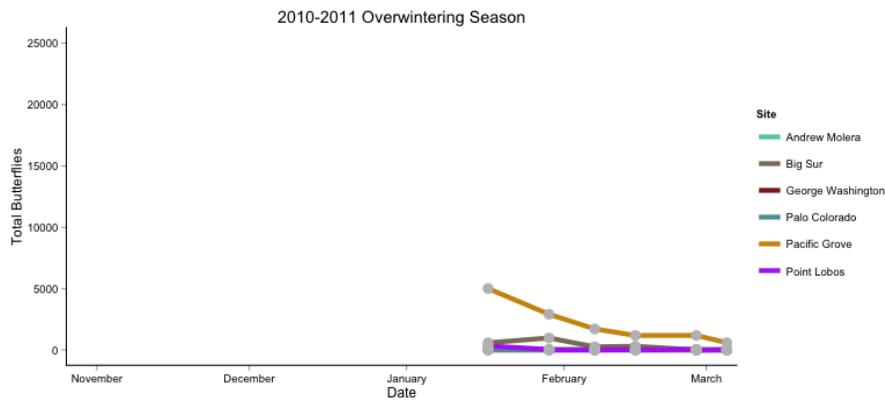


Figure 8. Monarch population counts by year, across overwintering sites. Although sampling effort varied by year, some patterns may be observed across years. In both 2011-2012 and 2013-2014, Pacific Grove’s site and a Private Property in Big Sur hosted the largest populations of overwintering butterflies. Andrew Molera appears more variable in its butterfly population, though it maintained the next-largest population. Other monitoring sites hosted comparatively small numbers of individuals.

IV. Conclusions

Population trends by site

Overall abundances of overwintering monarchs varied greatly by site. ‘Private Property: Big Sur’ hosted the largest overwintering population by far, with a minimum of ~4,500 butterflies recorded at the end of the season (late February) and a maximum of 20,000 at the peak (late November). The Pacific Grove Sanctuary housed the second-largest population with 4,000 (late October) to 14,000 (late January) butterflies. No other sites approached these two in population size; Andrew Molera hosted a maximum population of ~1,100 butterflies in early January, Point Lobos ~500 in late November, and Del Monte ~90 in late November.

Generalizing population trends through time was difficult due to high variation across sites. While ‘Private Property: Big Sur’ exhibited a clear climb to peak abundance in late November and then steady decrease, Pacific Grove and Andrew Molera experienced stronger fluctuations in abundance. The clearest generalization to be made from these data appears to be a peak in overwintering butterfly populations in late November at most sites.

Unexpectedly, there appears to be little correlation between microclimate and butterfly activity across sites. Neither temperature nor cloud cover were correlated with the proportion of butterflies outside of the cluster (a summed category that includes fliers, sunners, loners, grounders, and mating individuals). A lack of correlation may be due to predominance of early morning monitoring, when insect activity tends to be minimal.

Across overwintering seasons, the greatest numbers of monarchs were counted in 2013-2014 with peak population estimations of >20,000 at Private Property: Big Sur and ~15,000 at Pacific Grove. In 2011-2012, the same sites hosted a maximum of ~10,000 – 13,000 butterflies. Spatial distribution of butterflies across sites was also more concentrated this past year, with very few observed in sites other than Private Property: Big Sur and Pacific Grove.

Implications

The strong dissimilarity in butterfly abundance across sites suggests high variability in site suitability and/or preference by monarchs. These data suggest that ‘Private Property: Big Sur’, ‘Pacific Grove’, and ‘Andrew Molera’ were of disproportionate importance as overwintering sites for monarchs in 2013-2014. Both ‘Private Property: Big Sur’ and Pacific Grove have substantial human activity and modification of the surrounding landscape; in contrast, Andrew Molera and Point Lobos are within conservation areas. It is tempting to conclude that natural areas are of lesser importance to these butterfly populations; however, without a larger set of sites and consideration of past human activity, these patterns remain purely correlative.

V. Future Directions

Understanding the cause of variability in butterfly abundance across sites relates strongly to central questions of monarch butterfly ecology: why are some sites preferred? What makes an overwintering site of better or poorer quality? How does human proximity or modification of the landscape influence monarch abundance, behavior, and trends through time at overwintering sites?

Our ability to answer these questions is greatly aided by long-term census studies such as the one presented here. Suggestions for future research and incorporation of additional methods include:

- 1) **How consistent are the relative ‘popularities’ of these overwintering sites across years?** *Method:* collect census data from the same sites across multiple years; compare relative abundances through time.
- 2) **How correlated are fluctuations in monarch abundances across sites** – i.e., are regional factors, such as climate, influencing overwintering populations of monarchs in parallel ways or are local conditions more predictive of changes? *Method:* use broader climate data – i.e. from WorldClim or similar database – to examine correlations between non-local climate patterns and butterfly abundance and activity in each site.
- 3) **How do butterfly behavior and mortality vary by site?** *Method:* Continue to collect data on butterfly behavior. Potentially design a more rigorous survey for dead individuals. In addition, collect site data on biotic interactions, such as prevalence of the protozoan parasite *Ophryocystis elektroscirrha*.
- 4) **What is the scale of movement during the overwintering season;** that is, do individuals visit multiple overwintering sites, or do they remain in the same population until Spring departure? *Method:* mark / recapture throughout the overwintering season within and between sites.
- 5) **What are the population dynamics at low-abundance sites?** *Method:* observe behavior of butterflies at sites such as George Washington, Palo Colorado, PlaskettCreek, Point Sur, and Prewit. Are butterflies staying at these sites for multiple days? For how long do they stay before departing, or perishing?
- 6) **How does butterfly condition (vigor) vary by site?** *Method:* collect data on butterfly mass (non-destructive) or lipid content (destructive) to test hypotheses of variation in site quality for overwintering monarchs.

7) What are the most effective measures for improving overwintering sites for monarchs? *Method:* assess the effect of increasing nectar availability on butterfly behavior and condition. Although increasing abundance of nectar resources seems beneficial, studies suggest that such landscape modification may cause monarchs to increase their activity to the detriment of their lipid stores (Alonso-Mejía et al. 1997). The importance of understanding effects of this type of habitat modification cannot be overstated.

8) How do the trends observed in these sites compare or relate to others in California? *Method:* utilize databases such as the NDDB (California Fish and Game's Natural Diversity DataBase), which contains data on >300 overwintering sites for monarchs in California. While most are unlikely to be monitored at the level of PGMNH's efforts, situating our findings within a larger data set would lend more power to recognize broader trends and unique phenomena.

VI. Works Cited

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