Analysis of Butterfly Survey Data and Methodology from San Bruno Mountain Habitat Conservation Plan (1982–2000).

2. Survey Methodology

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Technical Report No. 2

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Cover Photo:
Mission blue butterfly at San Bruno Mountain, March 2003 (T. Longcore)

Preferred Citation:
Longcore, T. 2004. *Analysis of Butterfly Survey Data and Methodology from San Bruno Mountain Habitat Conservation Plan (1982–2000). 2. Survey Methodology*. University of Southern California GIS Research Laboratory and Center for Sustainable Cities, Los Angeles, California.

Introduction

The butterfly monitoring scheme for the San Bruno Mountain Habitat Conservation Plan from 1982 to 2000 was plagued with a number of methodological difficulties. These included a haphazard rather than random survey design, no repeatability between years, and varying geographic coverage. While some information can be extracted from the "wandering surveys" conducted on San Bruno Mountain, a more rigorous survey design is necessary to allow managers to draw statistically significant inferences about the status of the butterflies and their responses to management actions. Indeed, since 1998, standardized transects have been established to monitor butterflies at San Bruno Mountain.

This report discusses the factors that should be considered in the further development of a new monitoring protocol. While it provides as detailed guidance as possible, the ultimate survey design must incorporate the considerations of those who will implement the surveys. Feasibility on paper does not always translate well to the field.

This report draws on the analysis of mission blue butterfly and Callippe silverspot butterfly survey data completed by USC. It adds to that analysis a quantitative description of the flight period of each butterfly, derived from survey data collected 1982-2000.

Survey Methodologies

The survey methodology for both butterfly species should be revised to meet the conditions necessary for statistical inference across the whole study area. The surveys should assess the relative population size from year to year, as well as the distribution of occupancy. Based on Longcore et al. (2003) I recommend a combination of fixed transects and presence surveys, both using the 250 m grid system developed to analyzed the "wandering transects" (Figure 1).

Fixed transects

The purpose of fixed transects (i.e., "Pollard walks", Pollard 1977) is to provide a repeatable measure to draw inference about the overall population size in any given year, and to describe the abundance curve of the butterflies within any given season to aid in analysis of presence data. The transects cannot be placed simply in the locations with the most butterflies because of the phenomenon of regression to the mean. Rather their locations must be chosen randomly from the universe to which inference is to be made. Because the survey methodology intends to draw inference about the entire San Bruno Mountain Habitat Conservation Plan area, the first inclination is to select fixed transect sites randomly from all cells. It may be reasonable, however, to assume that locations within the Habitat Conservation Plan area that have not supported butterflies for the past 20 years are unlikely to support them in the future, and even if butterflies were introduced, they would not behave differently than other previously occupied area. If this assumption is acceptable, then fixed transects can be chosen randomly from the universe of cells that have been occupied in the past by each or both butterflies, which would avoid the frustrating possibility of conducting fixed transects at locations unoccupied by the butterfly.

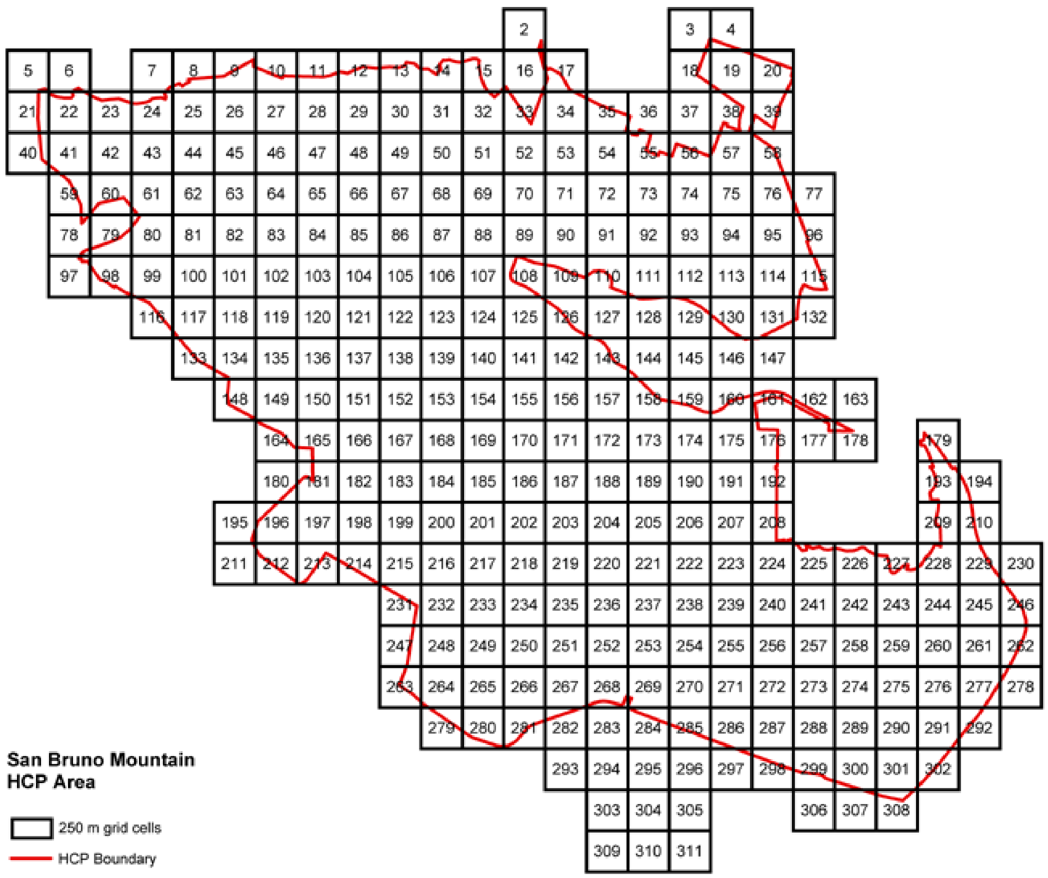

Figure 1. Numbered grid for analysis of butterfly survey data, San Bruno Mountain HCP.

The next questions are the number of fixed transects, their length, and frequency of survey. These interrelated issues are influenced by the availability of resources. It is imperative for population estimation techniques that fixed transects be conducted at least every ten days during the flight season of each butterfly. Further, they should be sufficiently long within each cell to fully survey that cell (>250 m). The layout of the survey within the cell should follow the guidelines established by Thomas (Thomas 1983) so that the transect is not a sample of the habitat within the cell, but rather a complete survey. The number of these transects then depends on a power analysis in which one must assume the amount of variation between sites. Effectively this variation should be low, and relatively few (e.g., 5) fixed transects are required relative to the total number of cells (310).

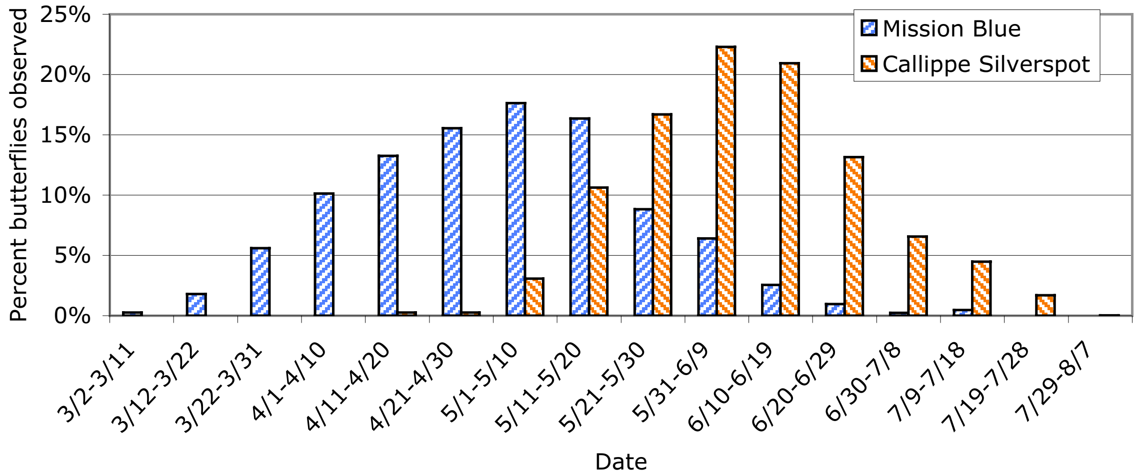

Figure 2. Distribution of adult mission blue butterfly and Callippe silverspot butterfly observations by date, 1982-2000.

The flight season of mission blue butterfly and Callippe silverspot butterfly combined almost always falls within a 140 day window from March 12 to July 28. Most years the combined season will be shorter. As a practical matter, abundance transects will take at a maximum 14 visits during this period.

Presence Surveys

The number of fixed transects must also be balanced against the desire to have spatial and temporal resolution of trends in occupancy, which require a different type of survey. Presence surveys must be spread throughout the flight season of the butterfly species, according to the characteristics of the species (Zonneveld et al. 2003). The number of surveys, the size of the population to be detected, and probability of encountering a butterfly are interrelated. With fewer surveys, the probability of encountering a small population decreases. More surveys or more butterflies always increase the probability of encounter, and a demand for greater probability of encounter requires either a larger population to detect or more surveys. For any survey methodology, one must decide two of the variables to determine the third. For example, if only four surveys are possible financially and a 95% confidence of locating a population is desired, only populations of a certain size (e.g., 10 individuals) will be detected with that confidence. Analysis of these tradeoffs are necessary to devise a survey methodology; once data are collected, complete analysis of them can calculate the actual detection probability, taking into account many factors that determine visibility of the species (MacKenzie et al. 2003).

Drawing on analysis of other butterfly species (Zonneveld et al. 2003), I suggest three surveys, spaced optimally, to evaluate cells for presence. Counts need not be conducted on such visits, only presence or absence recorded. All three visits must be made, even if presence is already established, to allow for application of the best available trend analysis algorithms (MacKenzie et al. 2003). Three surveys should be adequate to detect populations of five or more visible butterflies within a cell 90% of the time (see Figure 3, Zonneveld et al. 2003). Subsequent analysis will determine the actual detection probability.

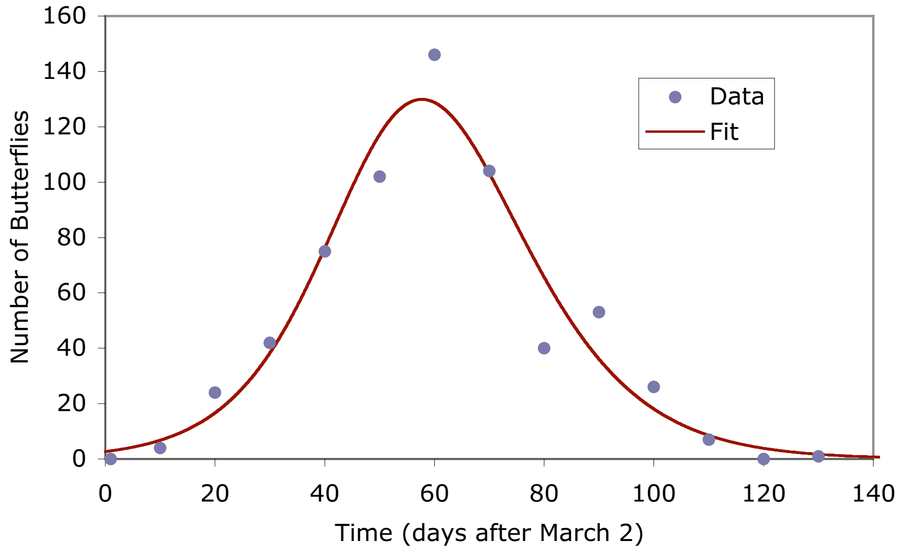

Figure 3. Fit by INCA of Zonneveld model to observed abundance curve of mission blue butterfly by ten-day increments at all locations across San Bruno Mountain, 1990.

The question then arises of how to time the surveys to maximize the chance of encountering each species during presence surveys. Zonneveld et al. (2003) provide guidance for this question, and a table to identify the optimal spacing of five survey days based on known flight period characteristics. These characteristics are the death rate of the butterfly (alpha, α), the spread of emergence of the butterfly within years (beta, β), and the variation (s.d.) in date of peak emergence (mu, μ) over time. I produced estimates of these values by aggregating survey data from each year of wandering transect data (1982–2000) at SBM into ten-day periods, and fitting the Zonneveld model to the abundance curve with INCA (INsect Count Analyzer) (Zonneveld 1991; Longcore et al. 2003). This can only be expected to provide a very rough estimate, because the use of aggregate data from nonreplicated transects violates assumptions of the model. Nevertheless, the model fit these aggregate data for many years for both species (e.g., Figure 3) with the use of prior information to constrain the death rate. I used the results of these analyses to assign each of the variables to low, moderate, or high categories as defined by Zonneveld et al. (2003).

Table 1. Estimated flight period characteristics of mission blue butterfly and Callippe silverspot butterfly at San Bruno Mountain, 1982–2000.

	Mean death rate (α)	Mean dispersion of eclosion (β)	Mean date of peak eclosion (μ)	Variation in peak eclosion (s.d. μ)
Callippe silverspot	0.16 (moderate)	5.8 (moderate)	June 4	14.7 (high)
Mission blue	0.15 (moderate)	8.9 (high)	April 20	10.7 (moderate)

These results provide an indication for the general range of these flight period values for each species, but should be interpreted with consideration of the numerous assumptions violated in the application of the model deriving them. The estimates are consistent with observable patterns in the flight period of the two species. For example, the flight season for mission blue butterfly is generally spread out over a greater period, while Callippe silverspot butterfly has a more distinct peak in most years — this qualitative observation is confirmed by the higher beta value for mission blue.

Based on these estimates of flight period characteristics and Table 1 in Zonnveld et al. (2003), surveys for mission blue should be conducted all approximately five days following the average peak emergence. For Callippe silverspot, the same analysis suggests surveying three times, ten days before peak emergence, five days after, and twenty days after.

Implementation of this general advice must be done in the field, with consideration of appropriate weather conditions to survey. Ideally, the presence surveys for mission blue butterfly should be conducted during an intensive period during the end of April and the beginning of May. Presence surveys for Callippe silverspot should be conducted during the last week of May, second week of June, and end of June (Table 2).

Cost and Feasibility

Combining the survey scheme for both species would allow surveys during the overlapping portion of the flight season to be used to record information about both species. In doing so, it is possible that certain sites will be chosen for surveys that have never supported one or the other species. This has certain benefits, because by selecting presence survey sites by random from the cells occupied at one time by either species allows for inference to these cells as well.

The total hours required for abundance surveys for both species (fixed transects) is 14 visits times 5–10 sites times an average of 1.5 hours per survey, or 210 hours. At an average cost of $50/hour for permitted surveyors, the cost would be $5,250–10,500.

Presence surveys should take approximately one hour on average per cell, including travel time. Equal effort should be expending for each species, with three visits per cell. Presence surveys should be conducted separately for each species following the timing suggested above. Because the survey scheme should provide information about specific habitat areas to guide management, the return interval for surveying cells should be relatively short (2-3 years). A three year return interval for mission blue butterfly (218 cells) would require 73 cells surveyed per year at a cost of $10,950, and for Callippe silverspot butterfly (165 cells), 55 cells per year at a cost of $8,250. The cost of abundance and presence surveys together would be $24,450–29,700, not including data analysis and report preparation.

Table 2. Suggested frequency and dates for fixed transects (abundance surveys) and cell surveys (presence surveys) for mission blue butterfly (MB) and Callippe silverspot butterfly (CS).

Date	Abundance Survey	Presence Survey
3/12–3/22	MB	
3/23–3/31	MB	
4/1–4/10	MB	
4/11–4/20	MB	
4/21–4/30	MB	MB (3 intensive)
5/1–5/10	MB	
5/11–5/20	MB, CS	
5/21–5/30	MB, CS	CS
5/31–6/9	MB, CS	
6/10—6/19	MB, CS	CS
6/20–6/29	MB, CS	CS
6/30–7/8	CS	
7/9–7/18	CS	
7/19–7/28	CS	

Thus, for approximately $30,000 per year a survey scheme could be implemented that would allow for comparison of population sizes across years and permit statistical inference about the status and trends of these two butterfly species. This estimate depends on the actual time required for each type of survey and the actual cost of hiring surveyors. It should provide, however, a framework for discussion.

The cost estimate does not include the cost of setting up the grid of cells on San Bruno Mountain. This initial effort will be costly, and require a substantial off-season effort with a Geographic Positioning System unit to identify the corners of each cell. This effort would identify cells that cannot or should not be surveyed for some reason, providing information to adjust the survey design.

Well-trained volunteers could contribute significantly to the proposed survey effort. The presence surveys could be assigned to volunteers once the cell system was established, and a volunteer could be responsible for conducting six appropriately timed visits to one or many cells each year. Such volunteers should be permitted by the U.S. Fish and Wildlife Service. Given the enormous effort expended by volunteers on behalf of San Bruno Mountain over the years, such integration of volunteers into the survey protocol may be possible.

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