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# FINAL REPORT FOR 2010 PALOS VERDES BLUE BUTTERFLY ADULT SURVEYS ON DEFENSE FUEL SUPPORT POINT SAN PEDRO, CALIFORNIA

**COOPERATIVE AGREEMENT NUMBER:**
**N62473-08-LT-R0011**

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**FINAL REPORT**
**FOR**
**2010 PALOS VERDES BLUE BUTTERFLY ADULT SURVEYS**
**ON**
**DEFENSE FUEL SUPPORT POINT**
**SAN PEDRO, CALIFORNIA**

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## Executive Summary


Surveys for adult Palos Verdes blue butterfly at the Defense Fuel Support Point (DFSP), San Pedro, were completed along a standardized transect that has been surveyed since 1994. Estimates of total population size and other population attributes were calculated using established formulas and software. The distribution of butterflies was analyzed and a population viability model estimated extinction risk based on population characteristics derived from all annual surveys. The status for Palos Verdes blue butterfly at DFSP in 2010 is as follows.

- The estimate of the wild adult population along the transect is 47, which is in the bottom 25% of yearly population estimates.
- The probability of extinction calculated is 100%, which would occur on average in 160 years.
- The number of transect segments where the butterfly was present in the prior year but not present in the current year was the second greatest on record.
- The distribution of the species on the property has contracted since the mid-1990s when surveys were initiated, commensurate with the maturation of coastal sage scrub vegetation.

Based on these results, the following management actions are strongly recommended.

- Begin a regular program of targeted disturbance to clear vegetation and allow development of early successional habitat near existing Palos Verdes blue butterfly habitat.
- Continue to establish new populations of the species, either at DFSP or elsewhere, to decrease risk of extinction.
- Continue to maintain a captive population to allow for reintroduction if an extended drought limits butterfly distribution at DFSP.

# 1 Introduction

The federally endangered Palos Verdes blue butterfly (*Glaucopsyche lygdamus palosverdesensis*) was discovered at the Defense Fuel Support Point (Figure 1; see also Supplemental Figures 1 and 2) in 1994 after ten years of presumed extinction (Mattoni 1994). Since that time, surveyors have monitored the adult population of butterflies along a fixed transect each year (Mattoni and Longcore 2002, Osborne 2002, Longcore and Mattoni 2003, 2005, Longcore 2007a, b, 2008, Longcore et al. 2010). Each year the results increase information about a range of attributes for the species and allow for refined estimates of population viability and population trends. This report describes the transect, results of the transect, and updates analysis of population parameters and viability.

In 1994, Mattoni established a transect that included the obvious larger stands of larval foodplant at DFSP at that time (Mattoni 1994). This standard transect was subsequently extended several times in following years to include areas where butterflies were later found (Mattoni and Longcore 2002). The 15 years of annual counts provide data to assess trends in the butterfly's patterns of distribution and abundance on the transect. Below we present results of surveys from 1994 to 2010 and include an estimate of the adult population using a standardized algorithm developed for this purpose. Furthermore, we analyze the trends in occupancy within the habitats that the different segments of the transect traverse. Finally, we update a population viability analysis for the species at DFSP using parameters derived from the transect count.

# 2 Methods

## 2.1 Transect Counts

Surveyor Rick Rogers counted butterflies on Pollard transect walks (Figure 2) throughout the flight period of the butterfly (Pollard 1977, Pollard and Yates 1983). For purposes of population estimation, regular walks along a standard transect have been shown to be superior to the other survey methods that also do not involve handling butterfly individuals (Royer et al. 1998). Mark-recapture methods of population estimation are not completed on this endangered species because of the damage done to small butterflies by marking and handling (Singer and Wedlake 1981, Morton 1982). Walks were initiated on February 24, before the first sighting of Palos Verdes blue butterflies in the spring.

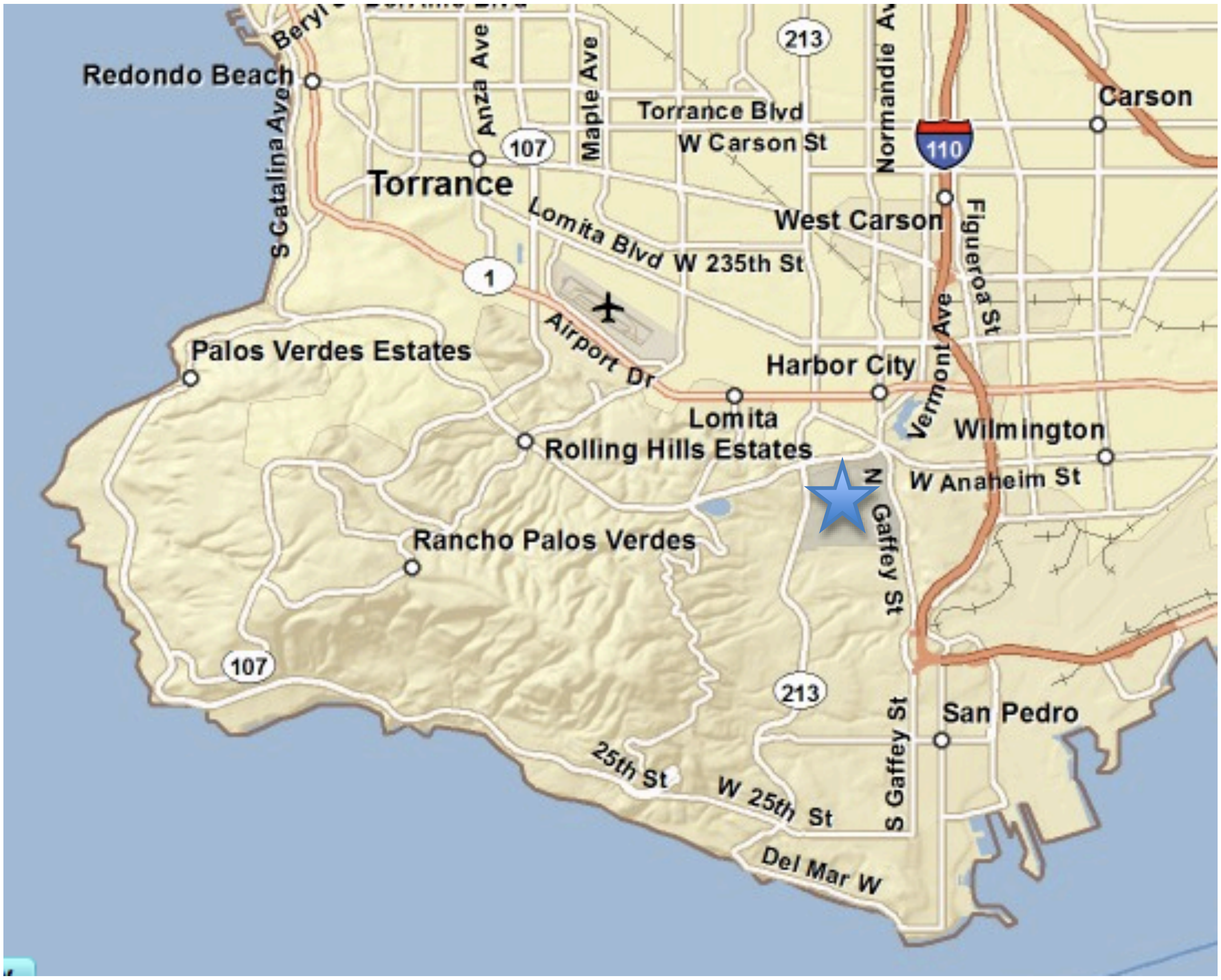


**Figure 1. Location of Defense Fuel Support Point, San Pedro in southwestern Los Angeles.**

The transect is ~3.2 km long (Figure 2), which is divided into segments based on habitat characteristics. The transect remains the same as instituted in 1994, with segments 5-3 and 9 added in 1996, segment 10 added in 1997, segment 11 added in 1999, and segment 5-4 added in 2005. When established, the transect included all areas where Palos Verdes blue butterfly had been observed and along corridors between habitat patches. We learned from a base-wide survey in 2006 that additional areas are occupied by the butterfly but not included on the transect (Longcore 2007a). All butterfly surveys, years 2005 to present, have been conducted under the USFWS 10(a) recovery permit of Ken H. Osborne, number TE837760.

## *2.2 Population Estimates*

We estimate total adult population size ($N_t$) with the formula

$$N_t = \sum_{i=1}^{n} \frac{x_i d_i}{LSR}$$

where $N_t$ is total population size, $n$ is number days of observations, $x_i$ is the number of individuals on the $i$th day of observation, $d_i$ is the number of days from the $i$th survey to the $i$th + 1 survey, $L$ is the average adult lifespan of each individual (9.3 days), $R$ is the average sex ratio observed (70% males), and $S$ is the assumed search efficiency (40%) (Mattoni et al. 2001). This technique is a modification of the estimate of brood size proposed by Watt et al. (1977).

We also used the software program INCA (INsect Count Analyzer; downloaded at http://www.urbanwildlands.org/INCA/) to analyze the count data for 1994 through 2009 (Zonneveld 1991, Longcore et al. 2003). For some years solutions failed to converge with the data alone, so we provided prior information about the flight period by constraining the distribution of the death rate based on results from previous years (see INCA documentation for details). This model fits a curve to the transect numbers by estimating four parameters: day of peak emergence, spread of emergence, longevity, and total population size (Zonneveld 1991, Longcore et al. 2003). The statistical model underlying this method is not particularly robust to calculation of population size and longevity when the peak number of butterflies observed in a day on the surveys is less than 25, but other parameters can be estimated robustly (Gross et al. 2007). Because the peak number of Palos Verdes blue butterflies at DFSP is usually lower than 25, population and longevity results from this method should be interpreted with caution.

Butterfly abundance varies widely with environmental conditions, most notably weather (Pollard 1988). Large increases and decreases in population are therefore expected and make the detection of trends difficult. The geographic area occupied by a species makes a somewhat greater predictor of population stability and, indeed, occupancy forms the basis of mathematical models of persistence of butterflies in metapopulations (Hanski 1999). Establishing occupancy is confounded by butterfly abundance. During a year when butterflies are not common, no butterflies may be seen at a site because of rarity, not because the butterfly has become extinct. With constant effort, detection of occupancy increases with population size (Zonneveld et al. 2003).

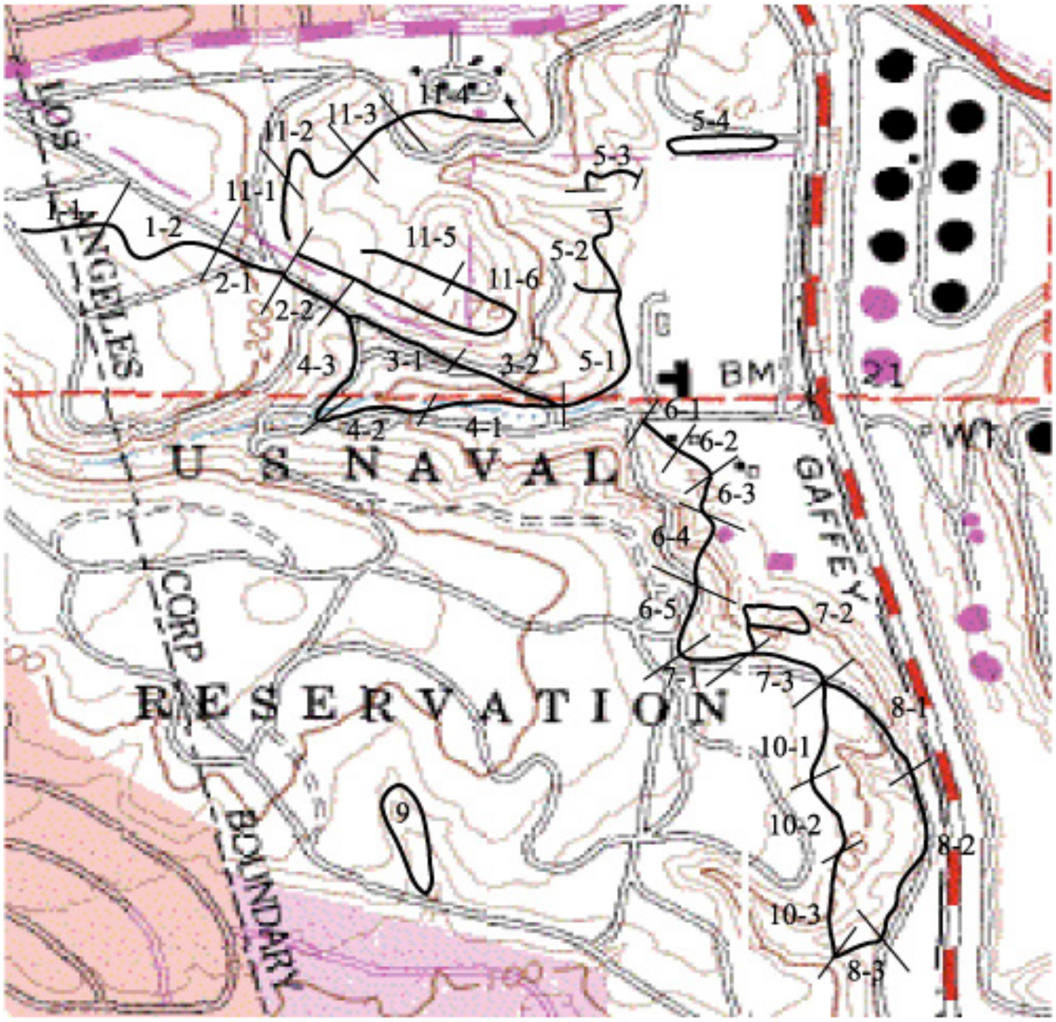


**Figure 2.** Location of Palos Verdes blue butterfly transect at DFSP (segments 1–10) and Palos Verdes housing (segment 11), as found on the Torrance, California 7.5' USGS quadrangle.

### *2.3 Occupancy Analysis*

We tested for trends in occupancy of Palos Verdes blue butterfly by constructing a multiple logistic regression, in which the independent continuous variables were year and estimated population size and the dependent categorical variable was presence or absence of butterflies along each transect segment. While the dependent variable may exhibit some degree of spatial autocorrelation, the well-documented asynchronous fluctuation of abundance among transect segments suggests that these responses are statistically independent (Mattoni and Longcore 2002). To identify the geographic distribution of trends in occupancy, we then completed logistic regressions for each transect segment with year as the independent variable and butterfly presence as the dependent variable.

### *2.4 Population Viability Analysis*

We implemented a population viability analysis for Palos Verdes blue butterfly at DFSP (Morris et al. 1999). This method uses the total population size each year to calculate the average growth rate ($\lambda$) and its variance ($\sigma^2$), and assumes that surveys of the species have recorded the normal variability in population growth rates that can be exhibited by the population. The method then uses a statistical model known as diffusion approximation (Dennis et al. 1991) to estimate the probability of extinction under user-designated conditions (i.e., initial population size and extinction threshold). We used the total population size for each year as estimated from transect surveys for 1994–2008. Because the species may undergo multiple year diapause, we set the extinction threshold at 1. Even if population size in any given year is extremely low, pupae remain in the ground that have not eclosed and can "rescue" the population during the next year. This was illustrated by the dramatic rebound in population in 2004, following an all-time low of 30 adult butterflies in 2003. If the pupae could not undergo multi-year diapause the extinction threshold would be higher because the number of butterflies flying each year would be all of the individuals extant, not a proportion of the total.

### *2.5 Climatic Models*

Finally we obtained climatic data from the nearest station (Long Beach) and ran a multiple regression analysis to relate the estimated population size to precipitation and temperature. We evaluated a series of candidate models, using total larval year rainfall (September through May of previous season), larval year spring rainfall (March through May of previous season), larval year winter rainfall (September through March of previous season), mean maximum temperature during previous flight season (March and April), and estimated population during previous flight season. Models were evaluated with Akaike's Information Criterion (AIC). These variables were chosen for model construction because of the observed relationship between rainfall and availability of larval foodplant. Rainfall during winter and spring were tested separately because rain during the flight season (spring) could adversely affect adults. Mean maximum temperature during the flight period was used to identify the possible influence of heat stress on adults.

## 3 Results

### *3.1 Population Estimates*

Surveys were conducted on 16 days between February 24 and April 16 (Table 1).

**Table 1. Survey conditions and observations for Palos Verdes blue butterfly at Defense Fuel Support Point and adjacent housing area. Weather conditions recorded on site except April 2 from weatherunderground.com (Torrance, CA).**

| Date | Male PVB | Female PVB | Temp ºF (start/finish) | Wind Speed mph (start/finish) | Percent Cloudy (start/finish) |
|---|---|---|---|---|---|
| February 23 | 0 | 0 | 65/75 | 0/0 | 0/0 |
| February 25 | 0 | 0 | 65/68 | 1–3/1–3 | 5/5 |
| March 2 | 0 | 0 | 64/68 | 1–2/1–2 | 75/50 |
| March 4 | 0 | 0 | 65/67 | 3–5/2–3 | 0/0 |
| March 10 | 1 | 0 | 62/68 | 5–10/2–4 | 80/5 |
| March 12 | 2 | 0 | 65/68 | 1–2/3–4 | 0/0 |
| March 15 | 3 | 0 | 68/70 | 1–3/3–5 | 0/0 |
| March 19 | 3 | 1 | 67/69 | 5–10/5–10 | 0/0 |
| March 22 | 3 | 1 | 70/71 | 1–4/1–2 | 80/80 |
| March 26 | 5 | 2 | 71/73 | 1–2/1–2 | 0/0 |
| March 29 | 3 | 2 | 74/74 | 1–3/1–3 | 0/0 |
| April 2 | 1 | 3 | 60/64 | 5/15 | 40/20 |
| April 5 | 1 | 2 | 65/68 | 2–4/2–4 | 25/0 |
| April 10 | 0 | 2 | 64/69 | 2–3/2–4 | 80/75 |
| April 13 | 0 | 0 | 67/70 | 1–3/1–4 | 0/0 |
| April 16 | 0 | 0 | 70/75 | 0–3/1–3 | 0/0 |

The population estimate of 47 adults for 2010 was in the bottom quarter of years surveyed (Table 2). Flight period (i.e., the number of days between the first and last observation) continues to be predicted by estimated population size ($r^2$=0.35, $F_{1,15}$=8.26, $P$=0.01). The length of the season can be estimated as 28.8 days plus 11.5 days for each 100 butterflies in the population, simply because of the added probability of observing an early or late individual with increased population size (Figure 3).

**Table 2.** Abundance and phenology of Palos Verdes blue butterfly at DFSP and Palos Verdes housing, 1994–2008.

| *Year* | *First Observed* | *Last Observed* | *Flight Period (days)* | *Daily Maximum* | *Estimated Population* |
|---|---|---|---|---|---|
| 1994 | March 12 | April 8 | 30 | 14 | 69 |
| 1995 | February 28 | March 26 | 27 | 29 | 105 |
| 1996 | March 1 | May 5 | 67 | 30 | 247 |
| 1997 | February 23 | April 7 | 50 | 12 | 109 |
| 1998 | February 28 | April 8 | 50 | 23 | 199 |
| 1999 | February 24 | May 4 | 77 | 14 | 209 |
| 2000 | March 13 | April 26 | 45 | 25 | 132 |
| 2001 | March 12 | April 27 | 46 | 13 | 139 |
| 2002 | February 21 | April 19 | 47 | 23 | 243 |
| 2003 | February 21 | March 28 | 35 | 3 | 30 |
| 2004* | March 6 | April 14 | 39 | 43 | 282 |
| 2005 | February 28 | April 5 | 36 | 31 | 204 |
| 2006 | February 23 | April 30 | 73 | 13 | 219 |
| 2007 | February 26 | April 12 | 46 | 27 | 211 |
| 2008 | March 4 | April 7 | 34 | 7 | 45 |
| 2009 | February 27 | May 1 | 67 | 28 | 214 |
| 2010 | March 10 | April 10 | 32 | 7 | 47 |

*Transect followed from map by two observers working together (G. Pratt/C. Pierce). All other transects by R. Mattoni (2003), K. Osborne (2002), or R. Rogers (1994–2001, 2005–2010).

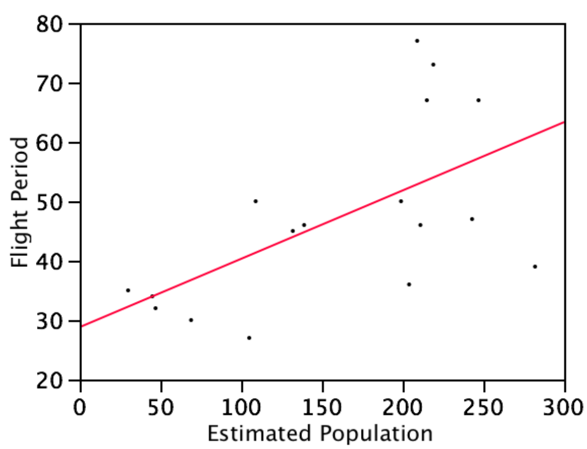


**Figure 3.** Influence of population size on observed flight periods for Palos Verdes blue butterfly, 1994–2010, defined as number of days between first and last observation.

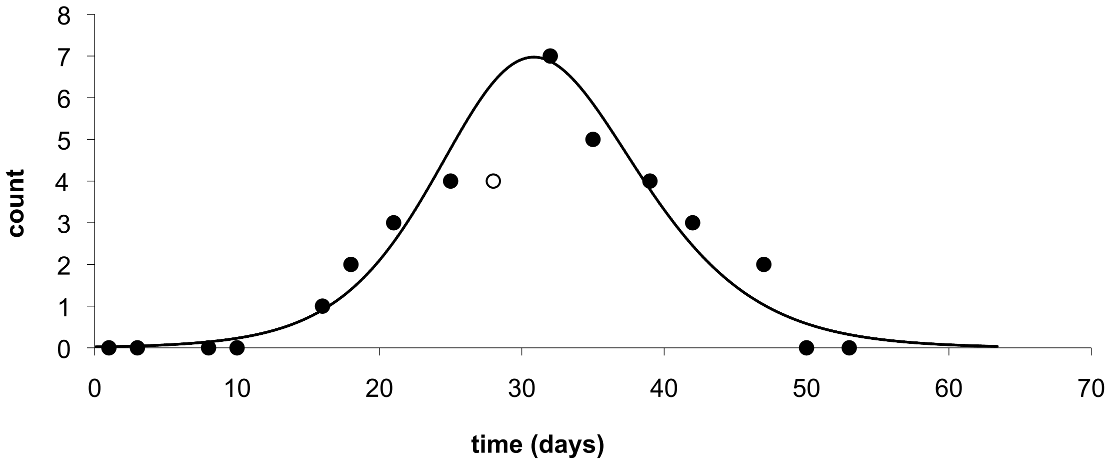


**Figure 4.** Raw data from transect counts with curve fit by INCA, 2010. The open circle represents a count on a cloudy day (80% cover) that was omitted to allow the curve to be fitted to the data. The start of surveys (time = 0) was February 23, 2010.

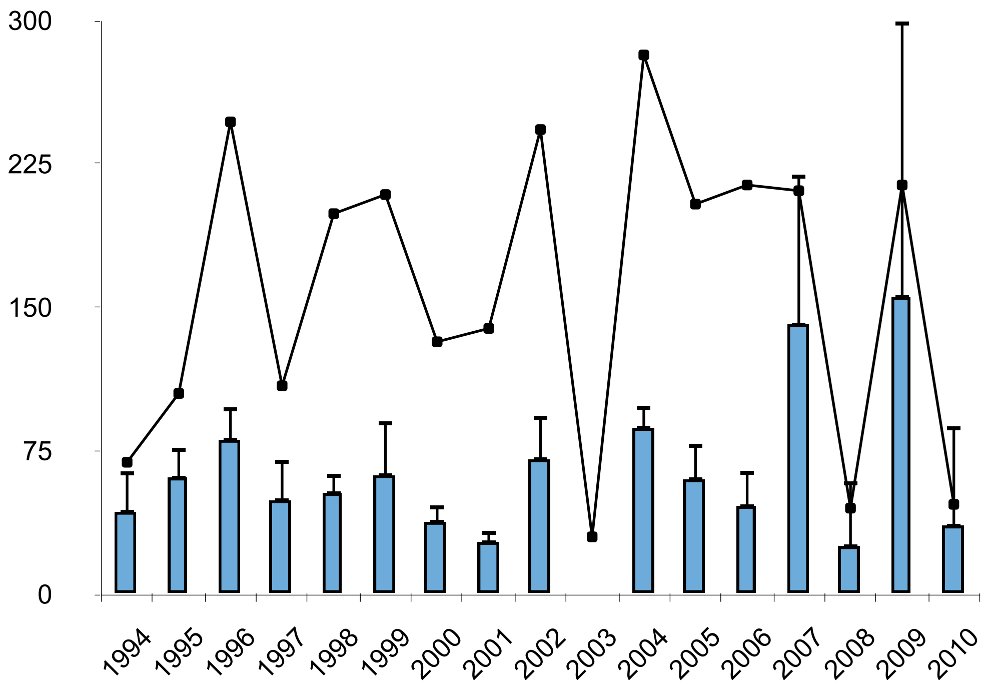


**Figure 5.** Solid line: population of Palos Verdes blue butterfly at DFSP, 1994–2010, estimated by Mattoni et al. (2003) method. Bars: estimated population of Palos Verdes blue butterfly at DFSP, 1994–2010, calculated by Zonneveld (1991) method from transect counts. This index is not adjusted for sex ratio or search

efficiency. Error bars + 1 S.D. Too few butterflies were observed in 2003 to produce an estimate so no bar for the Zonneveld method is given for 2003.

During 16 years of monitoring, the estimated population of Palos Verdes blue butterfly has fluctuated without a statistically significant trend (Figure 5). No trend is evident based on overall abundance alone. Similar results are obtained with the Zonneveld method (Figure 5), which also shows the population fluctuating without a trend.

### *3.2 Patterns of Occupancy*

The multiple logistic regression of Palos Verdes blue butterfly presence by year and by estimated population shows no significant change in the number of transect segments occupied over time, but a significant increase in the number of transect segments occupied when total population estimates are large ($\chi^2$=10.71; $P$ =0.001). This result shows that butterflies are concentrated in fewer locations along the transect when numbers are low. Although the explanatory power of these regressions is modest, they are consistent with the known properties of butterfly surveys and the habitat dynamics at DFSP. Larger population sizes will result in observation of butterflies on more transects simply because of increased ease in detecting them. Significant negative trends in occupancy at segments, as documented further in a segment-by-segment analysis, is a result of habitat succession along the transect segments.

Logistic regressions for each transect segment separately show that of the 14 significant ($p<0.10$) trends, 10 were negative (Table 3). Those sites showing negative trend over time are sites that were occupied when the butterfly was rediscovered in 1994, or were revegetated shortly thereafter (2-2, 3-1, 4-1, 5-1). One site with a significant positive trend is segment 9, which was restored more recently and the butterfly introduced (Mattoni et al. 2002). The other positive trend is on the adjacent housing area, where segment 11-6 has shown an increase. Segments 7-2 and 5-4 continue to support butterflies every year, although segment 5-4 has only been surveyed since 2005.

**Table 3.** Status of Palos Verdes blue butterfly by transect segment, 1994–2010: present (black), not detected (white), not surveyed (grey). Trends by logistic regression reported with chi-squared probability (P), with only trends significant at ($P < 0.1$) reported. Segments 6 and 7 were split into subsegments in 2002.

| Segment | 94 | 95 | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | Trend | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-1 | | | | | | | | | | | | | | | | | | | |
| 1-2 | | | | | | | | | | | | | | | | | | | |
| 2-1 | | | | | | | | | | | | | | | | | | | |
| 2-2 | | | | | | | | | | | | | | | | | | | |
| 3-1 | | | | | | | | | | | | | | | | | | – | 0.001 |
| 3-2 | | | | | | | | | | | | | | | | | | – | 0.006 |
| 4-1 | | | | | | | | | | | | | | | | | | – | 0.007 |
| 4-2 | | | | | | | | | | | | | | | | | | | |
| 4-3 | | | | | | | | | | | | | | | | | | | |
| 5-1 | | | | | | | | | | | | | | | | | | | |
| 5-2 | | | | | | | | | | | | | | | | | | + | 0.08 |
| 5-3 | | | | | | | | | | | | | | | | | | | |
| 5-4 | | | | | | | | | | | | | | | | | | – | 0.02 |
| 6 | | | | | | | | | | | | | | | | | | | |
| 6-1 | | | | | | | | | | | | | | | | | | | |
| 6-2 | | | | | | | | | | | | | | | | | | | |
| 6-3 | | | | | | | | | | | | | | | | | | | |
| 6-4 | | | | | | | | | | | | | | | | | | | |
| 6-5 | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | |
| 7-1 | | | | | | | | | | | | | | | | | | | |
| 7-2 | | | | | | | | | | | | | | | | | | – | 0.01 |
| 7-3 | | | | | | | | | | | | | | | | | | | |
| 8-1 | | | | | | | | | | | | | | | | | | | |
| 8-2 | | | | | | | | | | | | | | | | | | – | 0.01 |
| 8-3 | | | | | | | | | | | | | | | | | | – | 0.08 |
| 9 | | | | | | | | | | | | | | | | | | + | 0.06 |
| 10-1 | | | | | | | | | | | | | | | | | | – | 0.02 |
| 10-2 | | | | | | | | | | | | | | | | | | – | 0.07 |
| 10-3 | | | | | | | | | | | | | | | | | | | |
| 11-1 | | | | | | | | | | | | | | | | | | | |
| 11-2 | | | | | | | | | | | | | | | | | | – | 0.08 |
| 11-3 | | | | | | | | | | | | | | | | | | + | 0.05 |
| 11-4 | | | | | | | | | | | | | | | | | | | |
| 11-5 | | | | | | | | | | | | | | | | | | | |
| 11-6 | | | | | | | | | | | | | | | | | | + | 0.08 |

**Table 4.** Results of population viability analysis after each season 2003–2008.

| *Year* | *Probability of Extinction* | *Years to Extinction (for extinction scenarios)* |
|---|---|---|
| 2003 | 100% | 37 |
| 2004 | 24% | 40 |
| 2005 | 36% | 53 |
| 2006 | 33% | 56 |
| 2007 | 35% | 62 |
| 2008 | 100% | 125 |
| 2009 | 43% | 71 |
| 2010 | 100% | 165 |

### *3.3 Population Viability Analysis*

The population viability analysis produced a probability of extinction of 100% with the average time to extinction 165 years (Table 4). This analysis is sensitive to the number of butterflies observed during the season, so "good" years result in estimates of lower extinction risk, perhaps more so than is biologically warranted. Similar analyses have been completed for Fender's blue butterfly (*Icaricia icarioides fenderi*) with eight years of population data (Schultz and Hammond 2003) for Oregon silverpot by Crone et al. (2007). The population growth rate and its variance for Palos Verdes blue are within the range of values found for individual populations of Fender's blue butterfly. Schultz and Hammond (2003) demonstrated that extinction risk decreased more with additional populations than with increasing populations at existing sites. Consequently, off-site release of Palos Verdes blue butterflies from the captive population should, if found to be successful, reduce overall extinction risk substantially.

### *3.4 Climate Influence on Observed Population*

The models that best described estimated population size all included precipitation measures (Table 5). Flight season temperature and previous year's population were not included in any of the best models. The best model was the natural log of total larval year rainfall (Table 5; Estimated Population = 1.06 + 73.00 * ln(Larval Year Rainfall)). Larval year rainfall alone was positively associated with butterfly population size, but the relationship is much stronger when rainfall is log-transformed. This can be interpreted as meaning that a moderately wet year is good, but there is no marginal benefit of an extremely wet year. Because the sample size is still relatively small (n = 16), these results must be interpreted with caution.

**Table 5.** Regression models predicting estimated population size.

| Variables | $R^2$ | P | AIC |
|---|---|---|---|
| Ln (Larval Year Rainfall) | 0.46 | 0.003 | 182.40 |
| Ln(Larval Winter Rainfall) | 0.35 | 0.01 | 185.32 |
| Ln(Larval Spring Rainfall) | 0.06 | 0.38 | 191.29 |

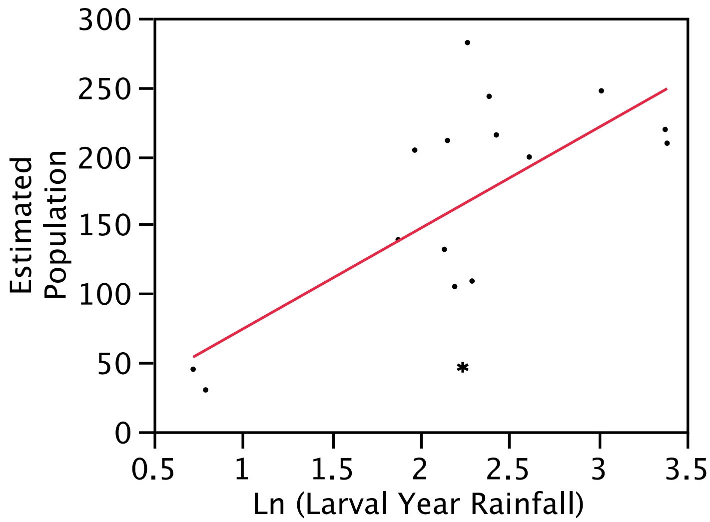


**Figure 6.** Estimated population of Palos Verdes blue butterfly at DFSP by log-transformed rainfall during larval year. The 2010 year, indicated by a star, is an outlier.

The 2010 year is an outlier in the relationship between precipitation and population size (Figure 6). Even though the 2009 larval year had sufficient rainfall to be associated with a good flight of butterflies in 2010, this did not occur.

## 4 Discussion

Our methodology of estimated total population size remains preferable to other methods. Pickens (2007) recently suggested the use of maximum daily count as an index for butterfly abundance. For Karner blue butterfly he showed that maximum daily count correlated highly with a variant of the Watt et al. method that we employ (Pearson's correlation; r = 0.70 and 0.89 for two different sites; both numbers log-transformed). The same correlation for our data was significant, but with r = 0.74. Based on these results, we will continue to report both the estimated total population and the maximum daily count as indicators of population trends.

The adult Palos Verdes blue butterfly population in 2010 was below average for the past several years, but the trend of contraction of range within the installation has continued. Our understanding that larval year rainfall explains a large portion of annual variation in observed numbers (approximately 50%; Longcore et al. 2010) remains intact, but 2010 was an outlier to this relationship. The likely explanation for this lies in the die-off of deerweed recorded in 2009 during basewide foodplant surveys (Longcore et al. 2010). The extent of mortality of deerweed foodplants, combined with succession from more open to more closed scrub habitats, seems to have lead to a situation where adequate rainfall was available, but not enough foodplant was alive to take advantage of it. This decoupling of rainfall with butterfly numbers is troubling because it suggests an ongoing degradation of the foodplant resources, which are unlikely to recover without intervention.

We have for many years made the observation that disturbance would need to be used as a management tool to keep the early successional host plant of Palos Verdes blue butterfly abundant (Osborne 2002, Longcore 2007a, b). Plans are currently in place to initiate a disturbance experiment to open up habitat areas for the early successional foodplants. These survey results provide added evidence that this effort remains necessary.


**Figure 7.** Comparison of vegetation cover at DFSP in 1994 (left) and 2009 (right). The development of more mature coastal sage scrub vegetation is seen in a number of locations, for example (a) where a large disturbed area has been replaced by closed canopy *Eriogonum fasciculatum* (encircled by transect segments 3 and 4, shown in blue), and (b) where disturbance associated with installation of a drainage system has become much more closed (transect segment 7-2). This area consistently was occupied by Palos Verdes blue butterfly until 2010 when it was absent.

Newly available aerial photographs from Google Earth illustrate the successional development that has taken place at DFSP since the butterfly was discovered in 1994 (Figure 7). A comparison of photographs from these two dates shows succession and closure of canopy in a large area in the central valley of the installation during this period, as well as succession in other locations that had supported the butterfly during the 1990s in this area (transect segments 3 and 4).

It is now evident that there are areas that were restored to support the butterfly, did so successfully for a number of years, and now no longer support it. Transect segment 9 shows this pattern, as does transect segment 5-4. Palos Verdes blue has been absent from transect 9 for two years, after being found there for seven years straight. Transect 5-4 had been restored to coastal sage scrub as a mitigation and supported the butterfly 2006 (when surveys were initiated) to 2009 but not in 2010. In 2009, the only habitat was seen in a small area that had been disturbed, perhaps by users of the baseball field adjacent to it. Little recruitment of deerweed was observed outside this patch. Areas shown as disturbed in 1994 (Google Earth photographs), corresponding to transect segments 3-1, 3-2, and 4-1 and the area encompassed by them, have undergone dramatic successional change to nearly pure *Eriogonum* and near exclusion of *Lotus*, with marked decline of the butterfly in these areas (Table 3).

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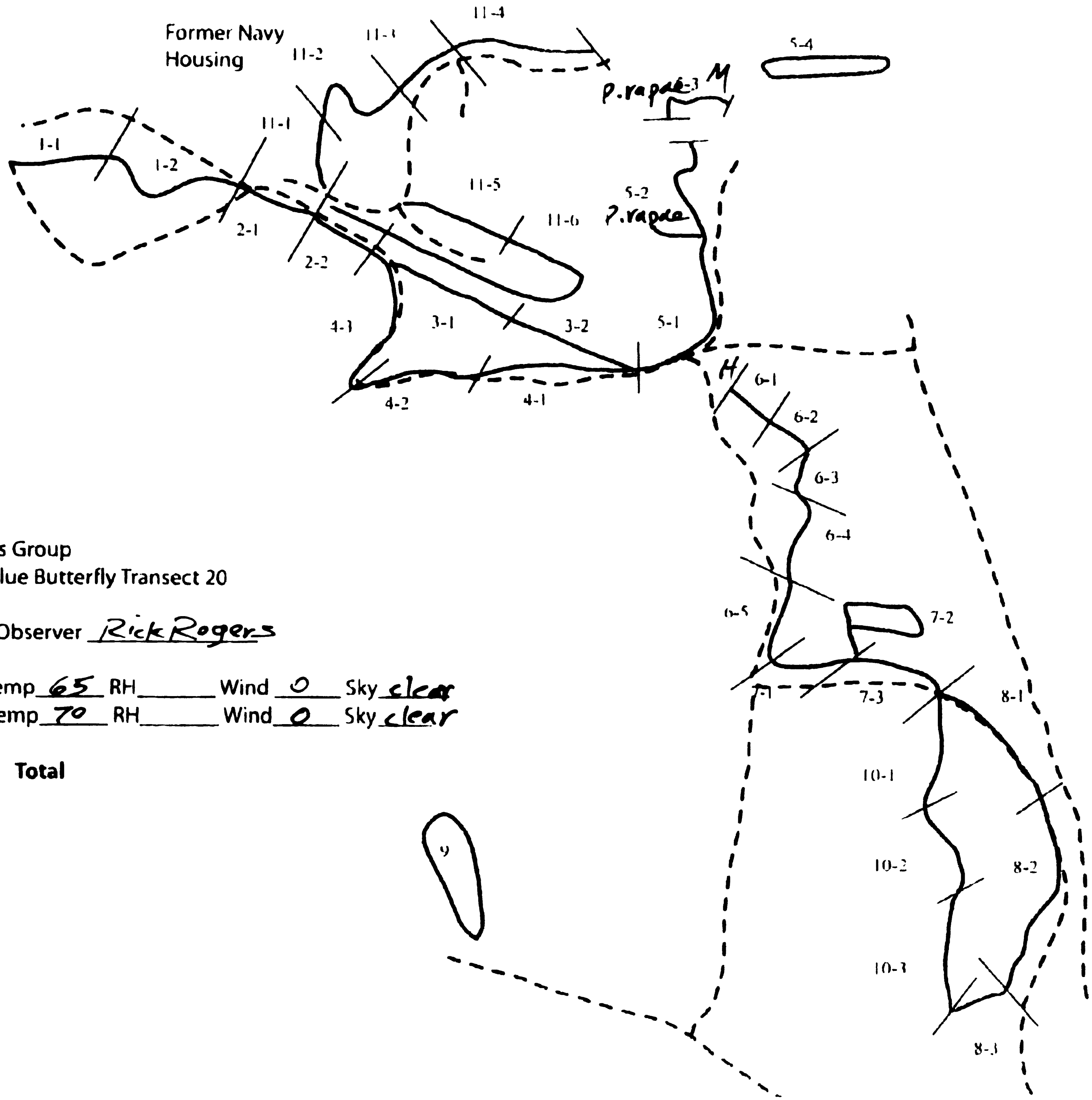
## Appendix: Survey Data Sheets

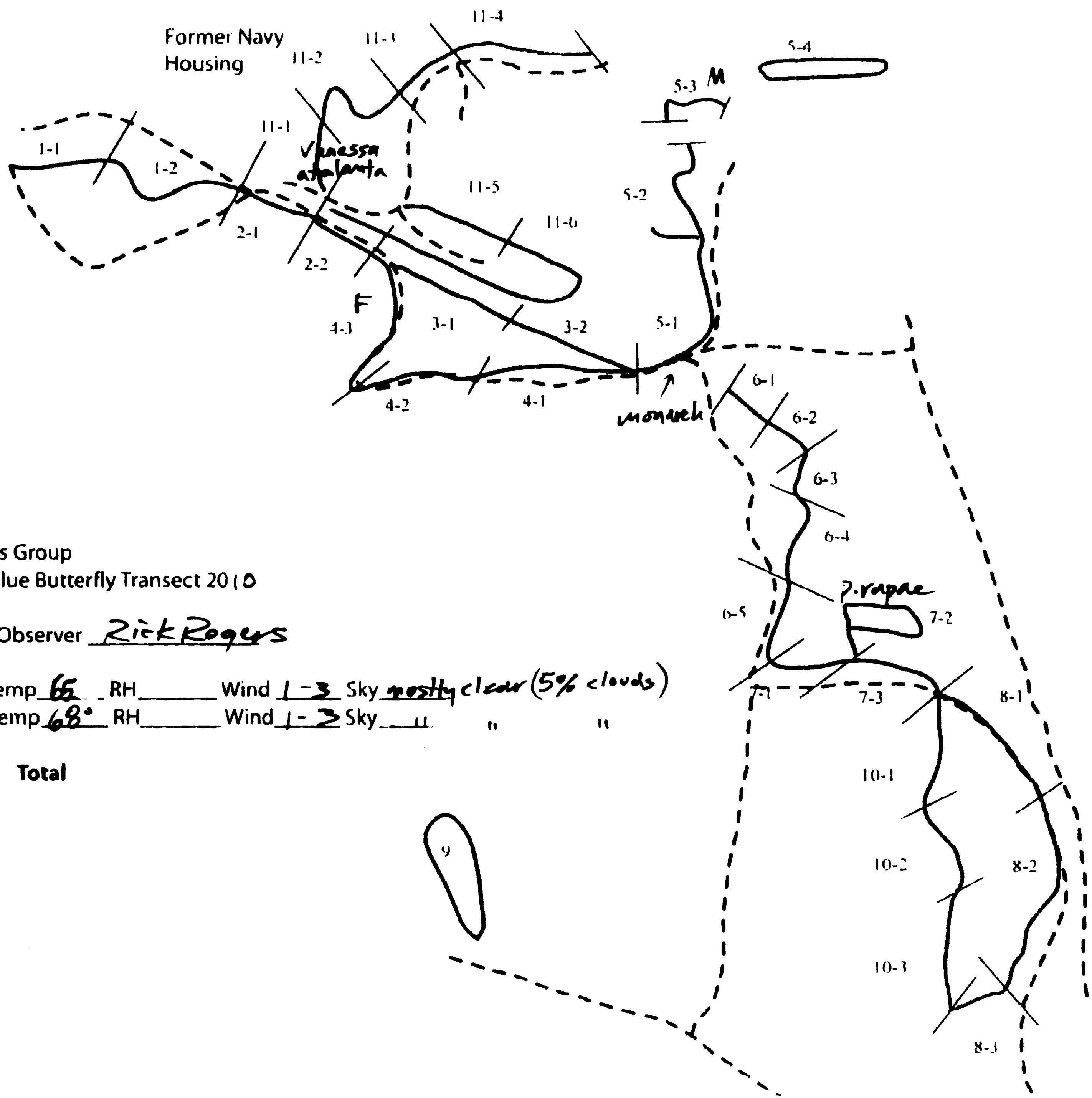



The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 20

Date Feb. 23, '10 Observer Rick Rogers

Time start 10:45 Temp 65 RH______ Wind 0 Sky clear
Time finish 12:45 Temp 70 RH______ Wind 0 Sky clear

| **Legend** | | **Total** |
|---|---|---|
| ♀♂ | *G. lygdamus* | |
| *F* | *E. funeralis* | |
| *M* | *L. marina* | |
| *G* | *C. perplexa* | |
| *H* | *S. melinus* | |
| *B* | *B. diegoensis* | |

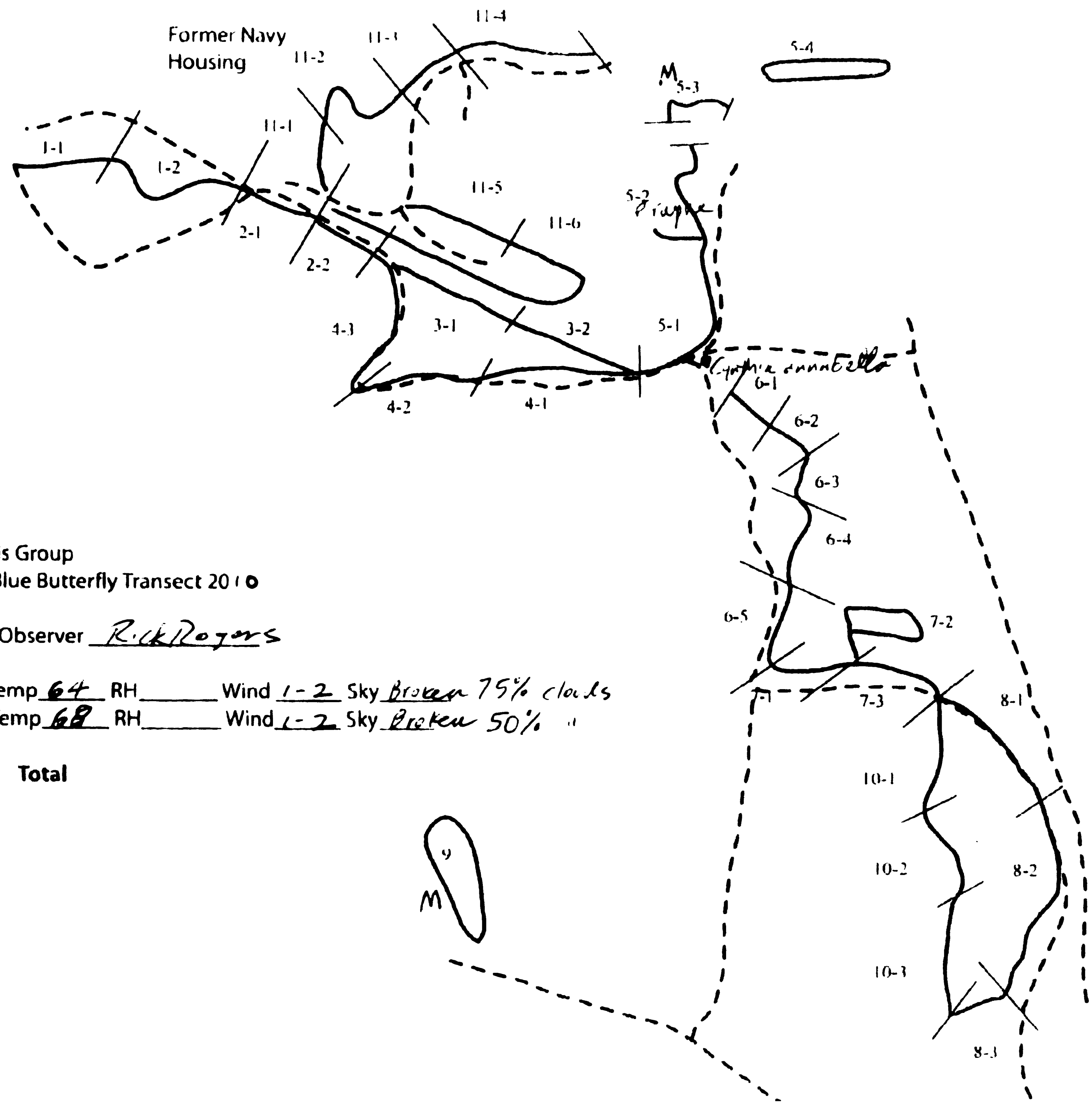



The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

Date Feb. 25 '10 Observer Rick Rogers

Time start 11:30 Temp 65 RH______ Wind 1-3 Sky mostly clear (5% clouds)
Time finish 1:30 Temp 68° RH______ Wind 1-3 Sky " " "

| Legend | | Total |
|---|---|---|
| ♀♂ | *G. lygdamus* | |
| F | *E. funeralis* | |
| M | *L. marina* | |
| G | *C. perplexa* | |
| H | *S. melinus* | |
| B | *B. diegoensis* | |

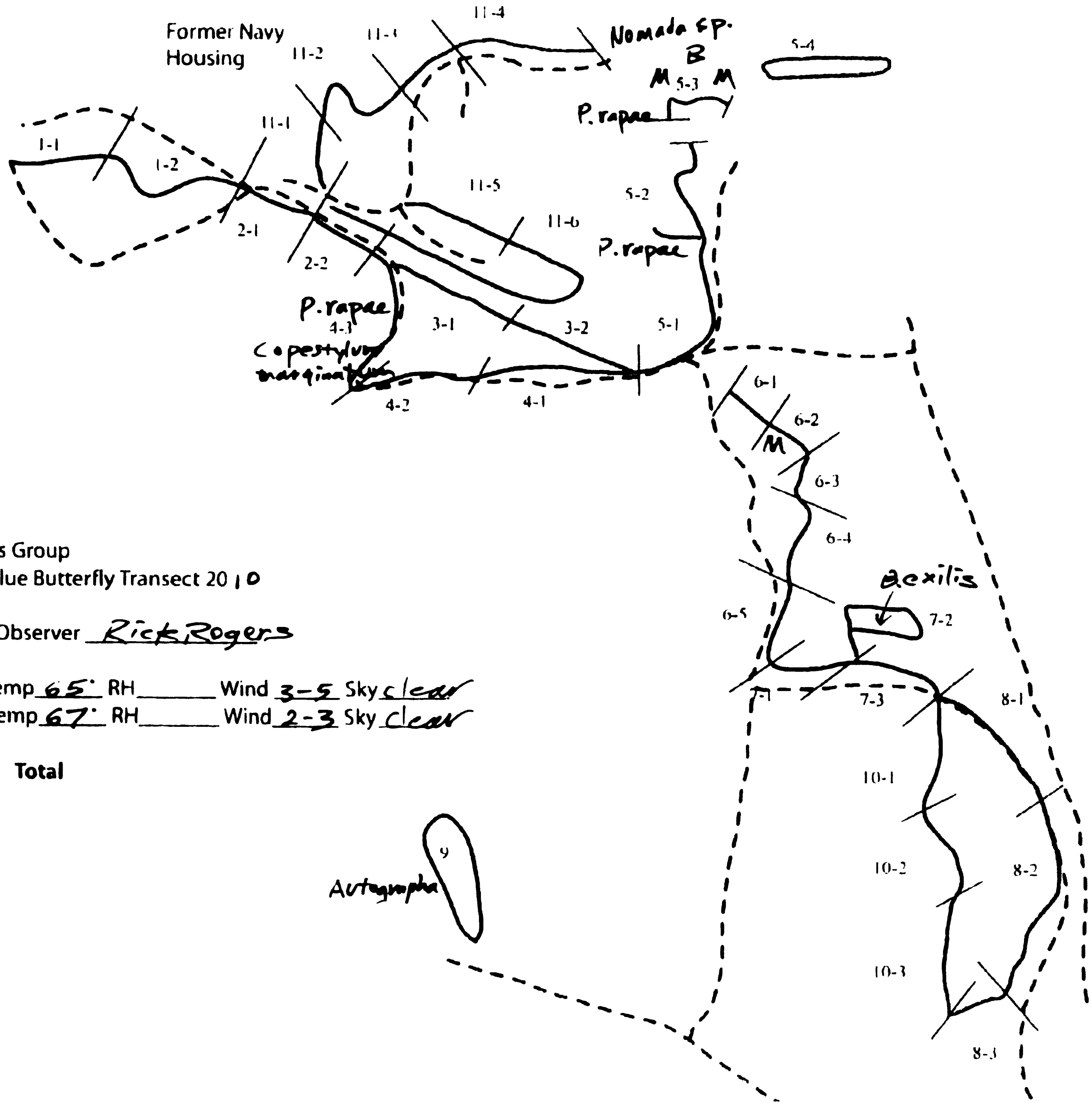



The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

Date Mar 2, 2010 Observer Rick Rogers

Time start 11:00 Temp 64 RH ______ Wind 1-2 Sky Broken 75% clouds
Time finish 1:00 Temp 68 RH ______ Wind 1-2 Sky Broken 50% "

| Legend | | Total |
|---|---|---|
| ♀♂ | *G. lygdamus* | |
| F | *E. funeralis* | |
| M | *L. marina* | |
| G | *C. perplexa* | |
| H | *S. melinus* | |
| B | *B. diegoensis* | |

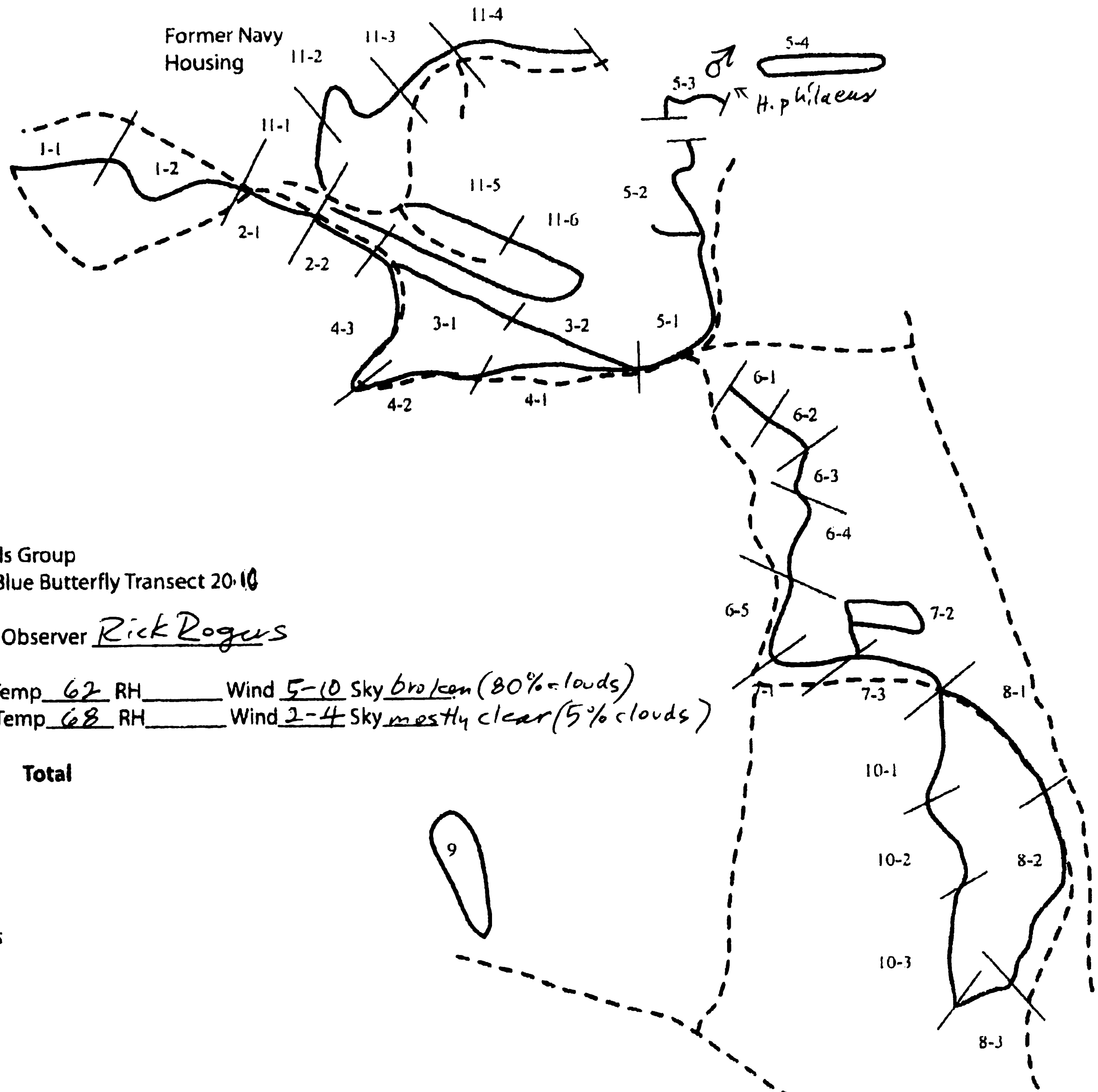



The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

Date Mar 4, '10 Observer Rick Rogers

Time start 11:30 Temp 65° RH______ Wind 3-5 Sky clear
Time finish 1:30 Temp 67° RH______ Wind 2-3 Sky clear

| **Legend** | | **Total** |
|---|---|---|
| ♀♂ | *G. lygdamus* | |
| F | *E. funeralis* | |
| M | *L. marina* | |
| G | *C. perplexa* | |
| H | *S. melinus* | |
| B | *B. diegoensis* | |




The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

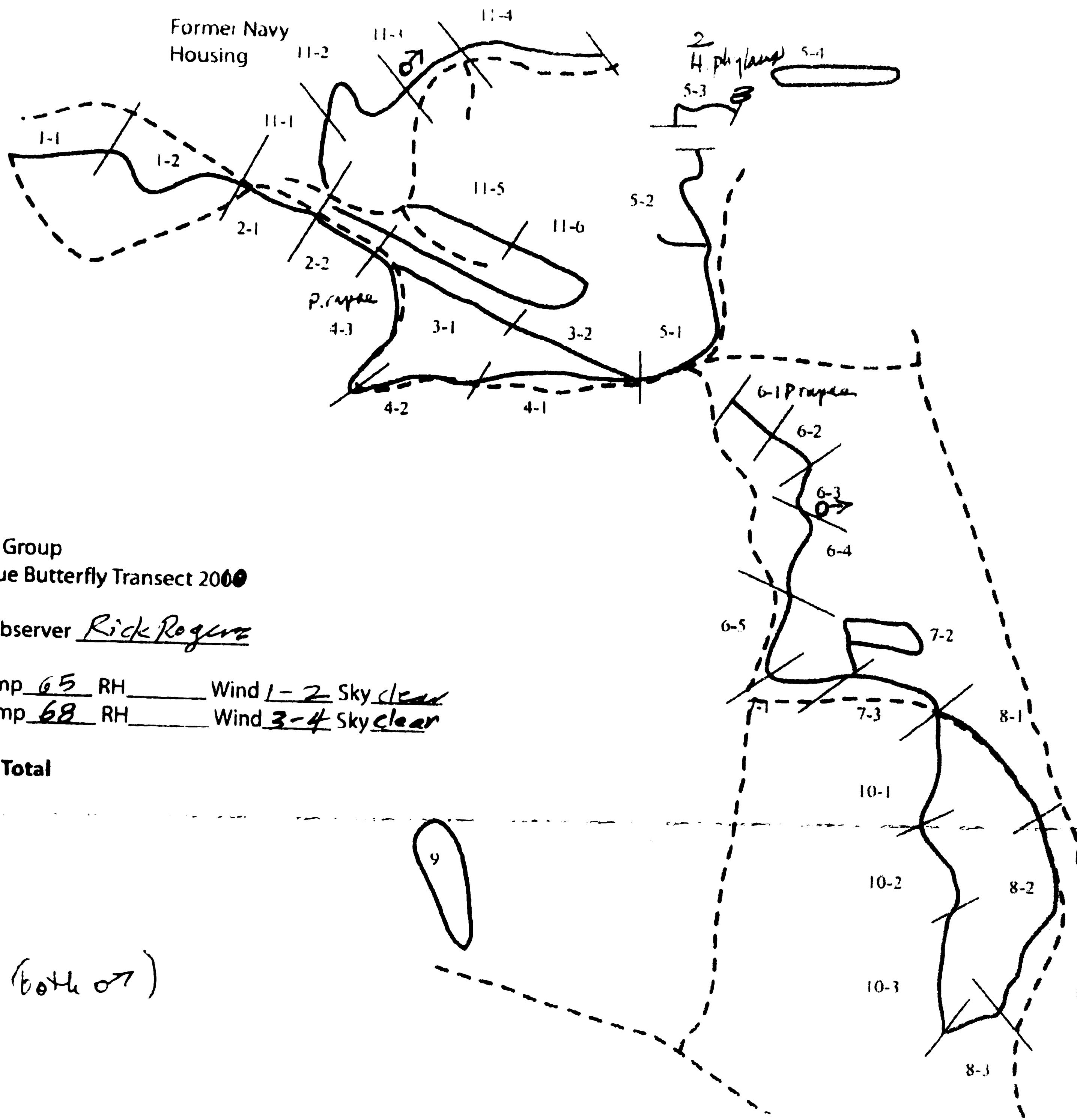
Date mar10, 2010 Observer Rick Rogers

Time start 11:30 Temp 62 RH______ Wind 5-10 Sky broken (80% clouds)
Time finish 1:30 Temp 68 RH______ Wind 2-4 Sky mostly clear (5% clouds)

**Legend** **Total**

♀♂ *G. lygdamus*
F *E. funeralis*
M *L. marina*
G *C. perplexa*
H *S. melinus*
B *B. diegoensis*

(1 PVB)
♂




The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

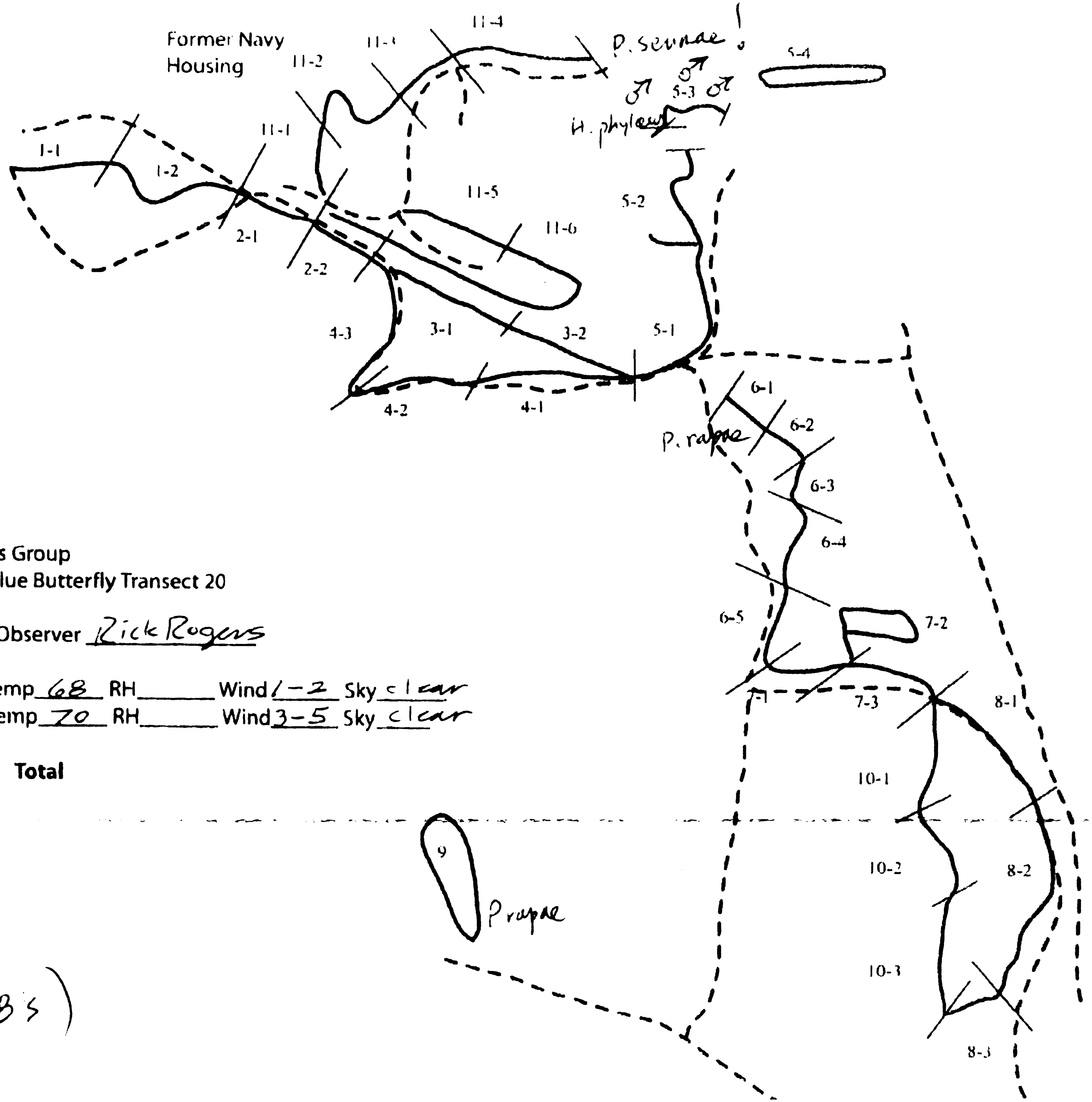
Date Mar 12, 2010 Observer Rick Rogers

Time start 11:30 Temp 65 RH_______ Wind 1-2 Sky clear
Time finish 1:30 Temp 68 RH_______ Wind 3-4 Sky clear

**Legend** **Total**

| | |
|---|---|
| ♀♂ | *G. lygdamus* |
| F | *E. funeralis* |
| M | *L. marina* |
| G | *C. perplexa* |
| H | *S. melinus* |
| B | *B. diegoensis* |

2 PVB's (both ♂)



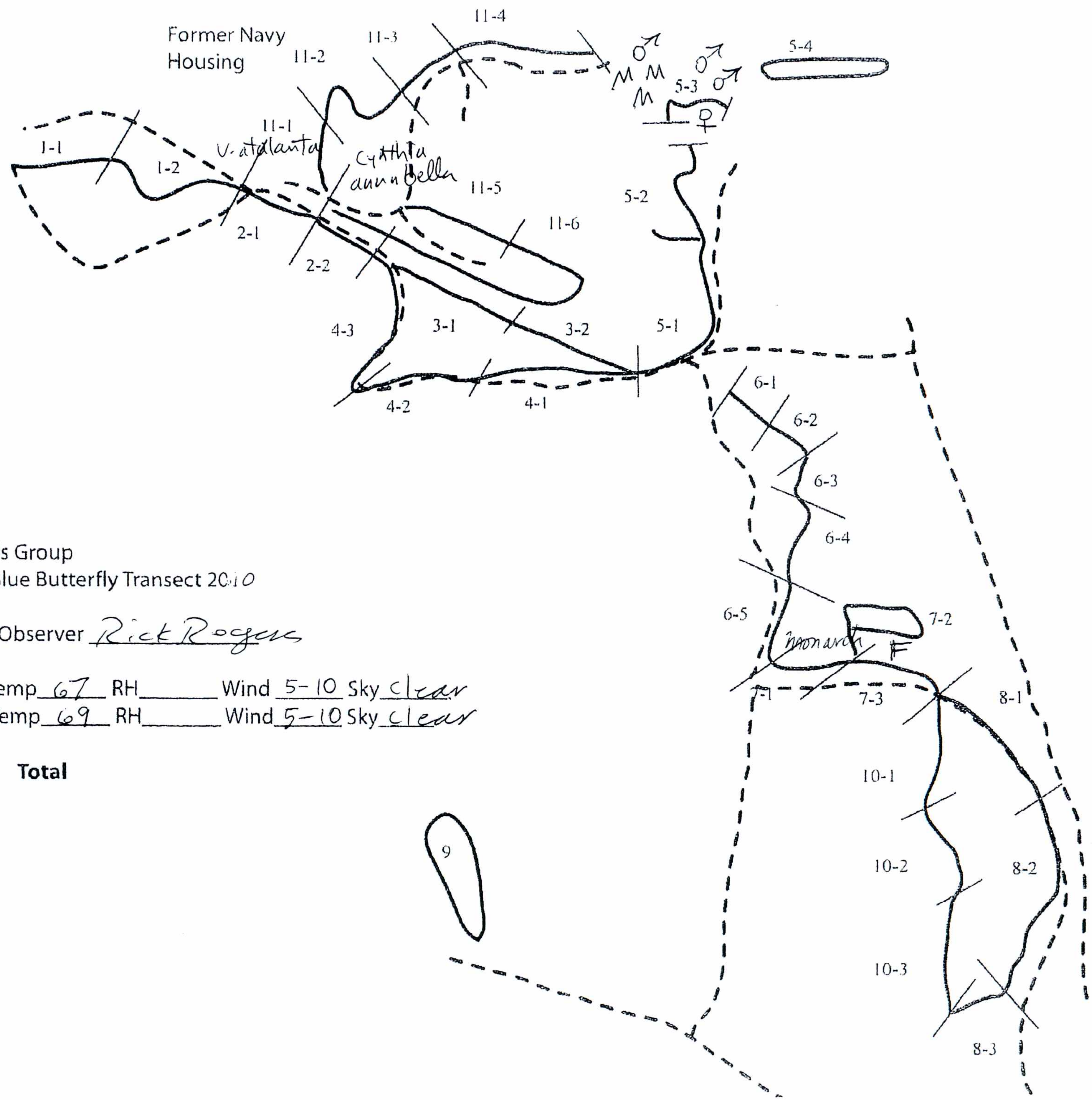

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 20

Date Mar 15, '10 Observer Rick Rogers

Time start 11:00 Temp 68 RH______ Wind 1-2 Sky clear
Time finish 1:00 Temp 70 RH______ Wind 3-5 Sky clear

| **Legend** | | **Total** |
|---|---|---|
| ♀♂ | *G. lygdamus* | |
| F | *E. funeralis* | |
| M | *L. marina* | |
| G | *C. perplexa* | |
| H | *S. melinus* | |
| B | *B. diegoensis* | |

(3 ♂ PVB's)



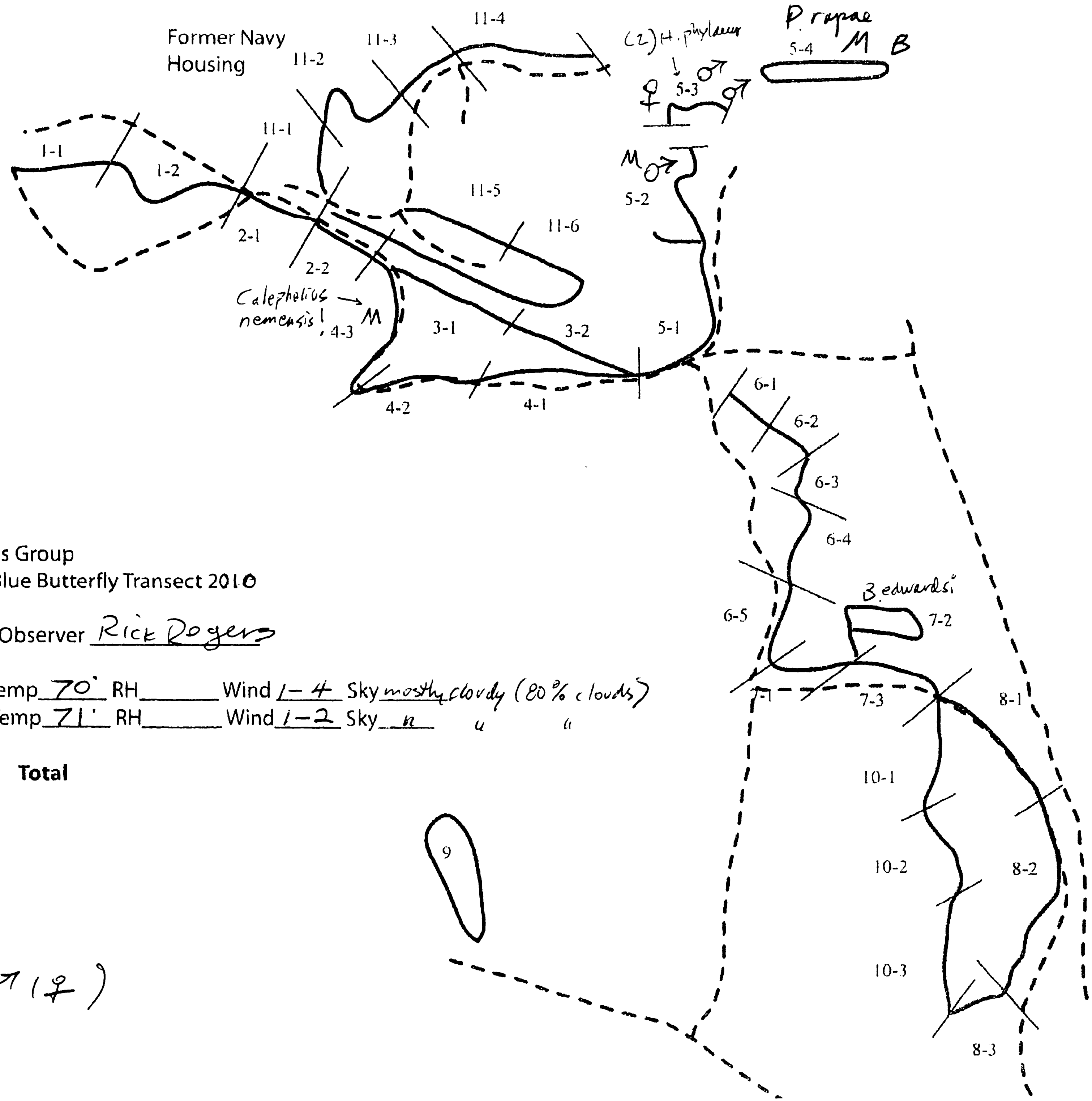

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

Date Mar 19, 2010 Observer Rick Rogers

Time start 11:45 Temp 67 RH______ Wind 5-10 Sky clear
Time finish 1:45 Temp 69 RH______ Wind 5-10 Sky clear

| **Legend** | | **Total** |
|---|---|---|
| ♀♂ | *G. lygdamus* | |
| F | *E. funeralis* | |
| M | *L. marina* | |
| G | *C. perplexa* | |
| H | *S. melinus* | |
| B | *B. diegoensis* | |

PVB 3♂ 1♀



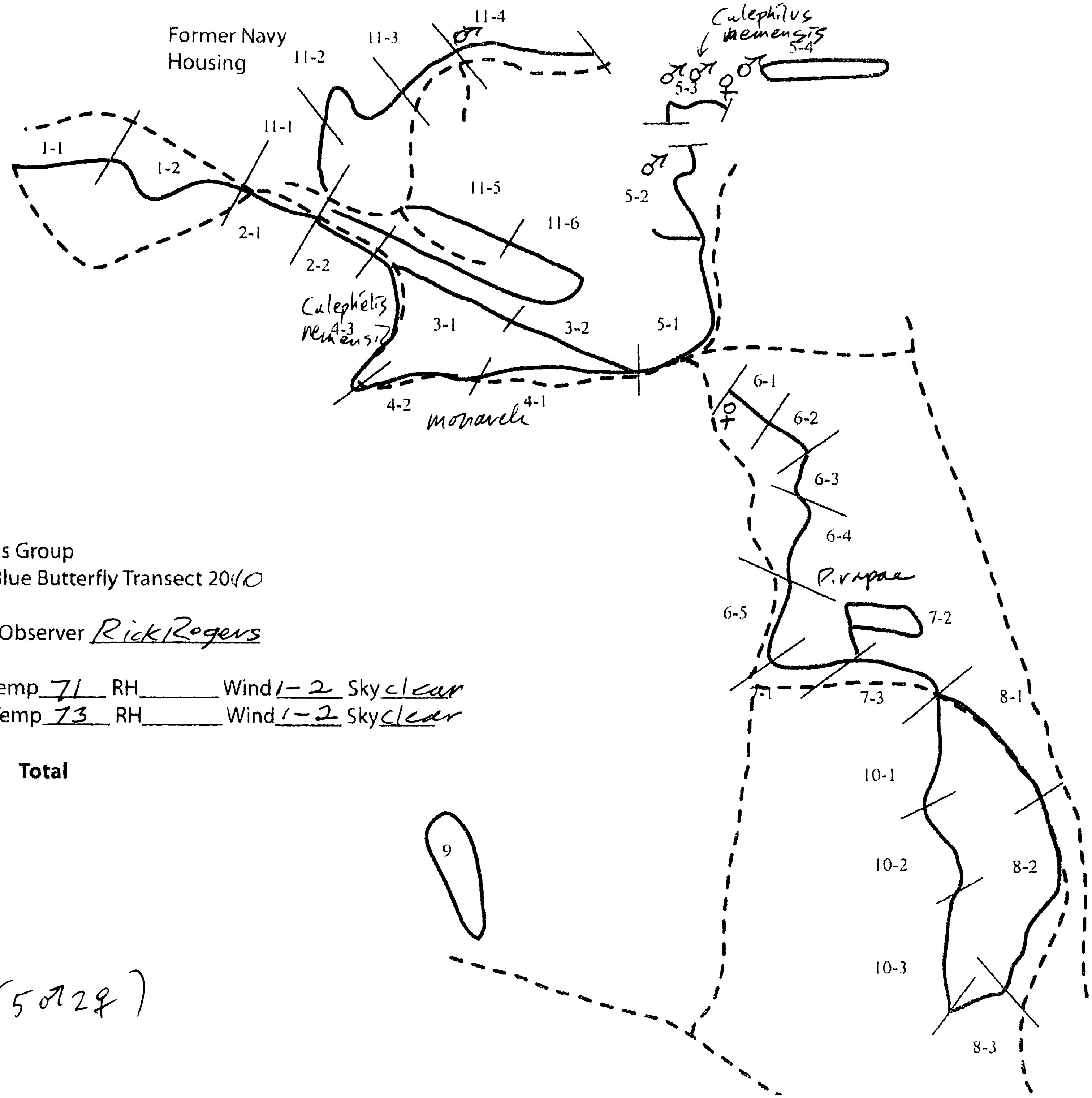

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

Date Mar 22, 2010 Observer Rick Rogers

Time start 11:45 Temp 70° RH______ Wind 1-4 Sky mostly cloudy (80% clouds)
Time finish 12:45 Temp 71° RH______ Wind 1-2 Sky " " "

| **Legend** | | **Total** |
|---|---|---|
| ♀♂ | *G. lygdamus* | |
| F | *E. funeralis* | |
| M | *L. marina* | |
| G | *C. perplexa* | |
| H | *S. melinus* | |
| B | *B. diegoensis* | |

4 PVB's (3♂ 1♀)




The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

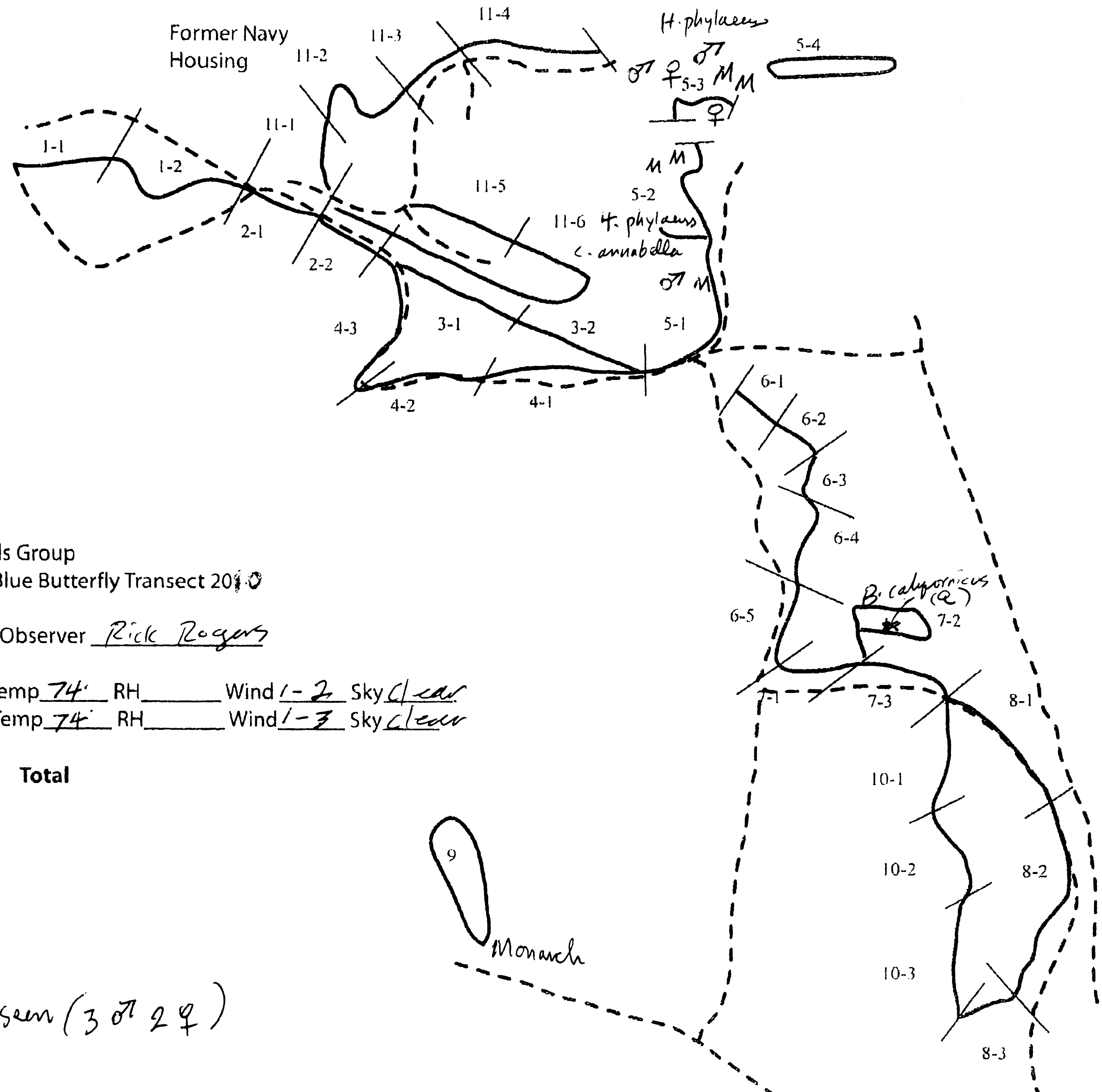
Date Mar 26 2010 Observer Rick Rogers

Time start 11:30 Temp 71 RH_____ Wind 1-2 Sky clear
Time finish 1:30 Temp 73 RH_____ Wind 1-2 Sky clear

**Legend** **Total**

| | | |
|---|---|---|
| ♀♂ | *G. lygdamus* | |
| F | *E. funeralis* | |
| M | *L. marina* | |
| G | *C. perplexa* | |
| H | *S. melinus* | |
| B | *B. diegoensis* | |

7 PVB's (5♂ 2♀)



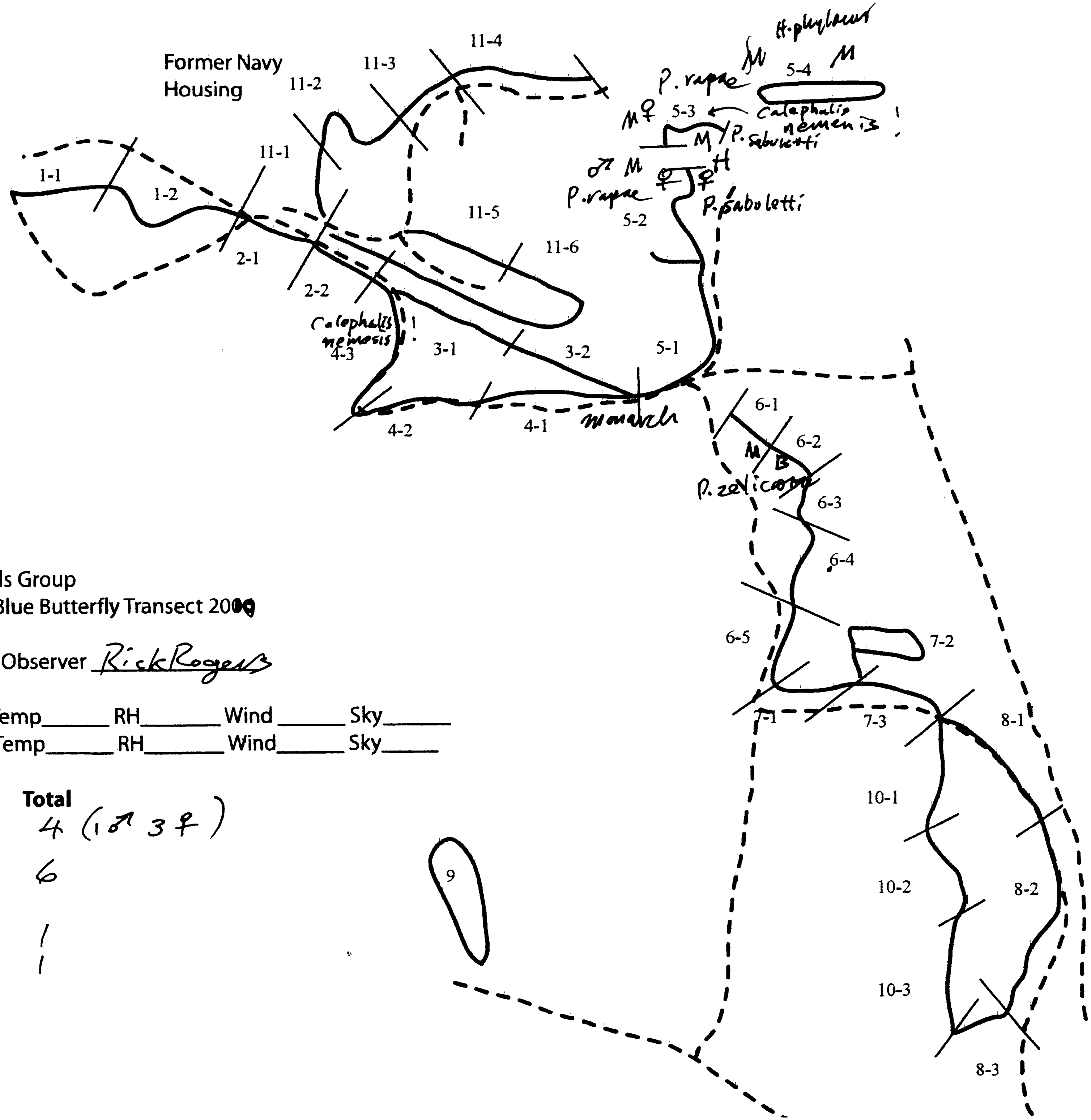

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

Date Mar 29, '10 Observer Rick Rogers

Time start 11:30 Temp 74° RH______ Wind 1-2 Sky Clear
Time finish 1:30 Temp 74° RH______ Wind 1-3 Sky Clear

| **Legend** | | **Total** |
|---|---|---|
| ♀♂ | *G. lygdamus* | |
| F | *E. funeralis* | |
| M | *L. marina* | |
| G | *C. perplexa* | |
| H | *S. melinus* | |
| B | *B. diegoensis* | |

5 PVB's seen (3♂ 2♀)

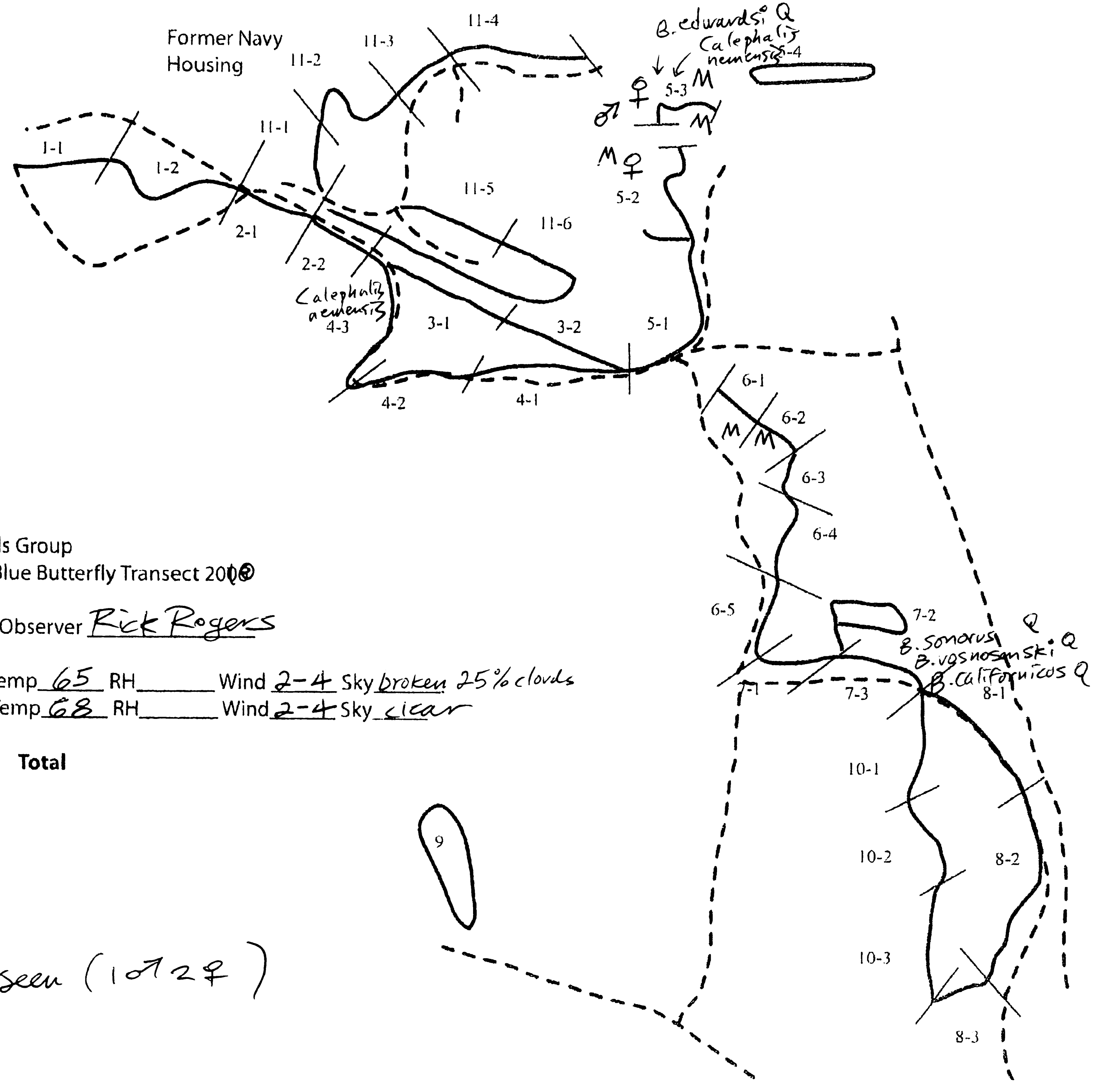



The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

Date April 2, 2010 Observer Rick Rogers

Time start ______ Temp______ RH_______ Wind ______ Sky______
Time finish______ Temp______ RH_______ Wind______ Sky_____

| **Legend** | | **Total** |
| --- | --- | --- |
| ♀♂ | *G. lygdamus* | 4 (1♂ 3♀) |
| *F* | *E. funeralis* | |
| *M* | *L. marina* | 6 |
| *G* | *C. perplexa* | |
| *H* | *S. melinus* | 1 |
| *B* | *B. diegoensis* | 1 |



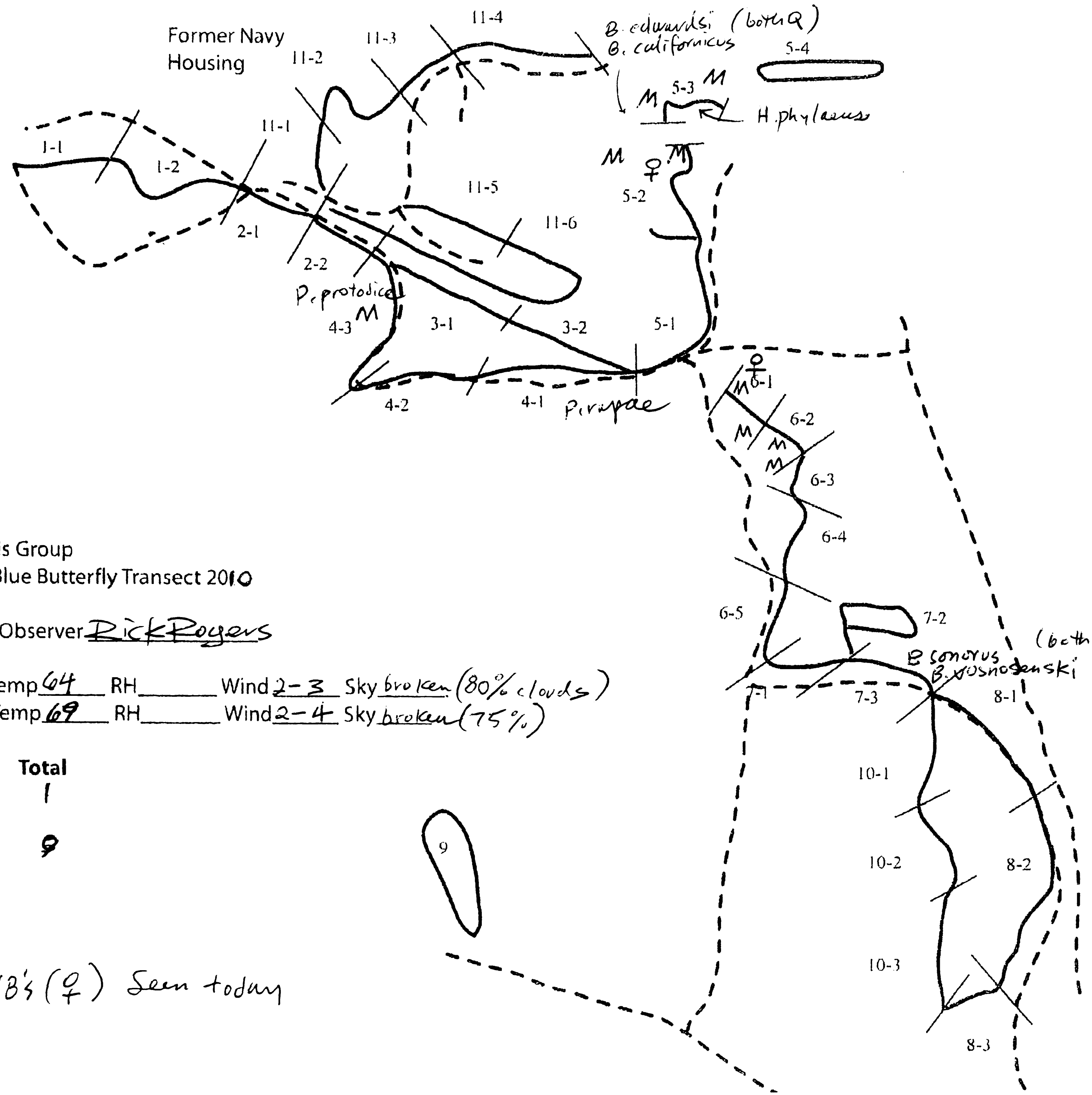

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

Date April 5, 2010 Observer Rick Rogers

Time start 11:30 Temp 65 RH_______ Wind 2-4 Sky broken 25% clouds
Time finish 1:30 Temp 68 RH_______ Wind 2-4 Sky clear

| **Legend** | | **Total** |
|---|---|---|
| ♀♂ | *G. lygdamus* | |
| F | *E. funeralis* | |
| M | *L. marina* | |
| G | *C. perplexa* | |
| H | *S. melinus* | |
| B | *B. diegoensis* | |

3 PVB's seen (1♂ 2♀)



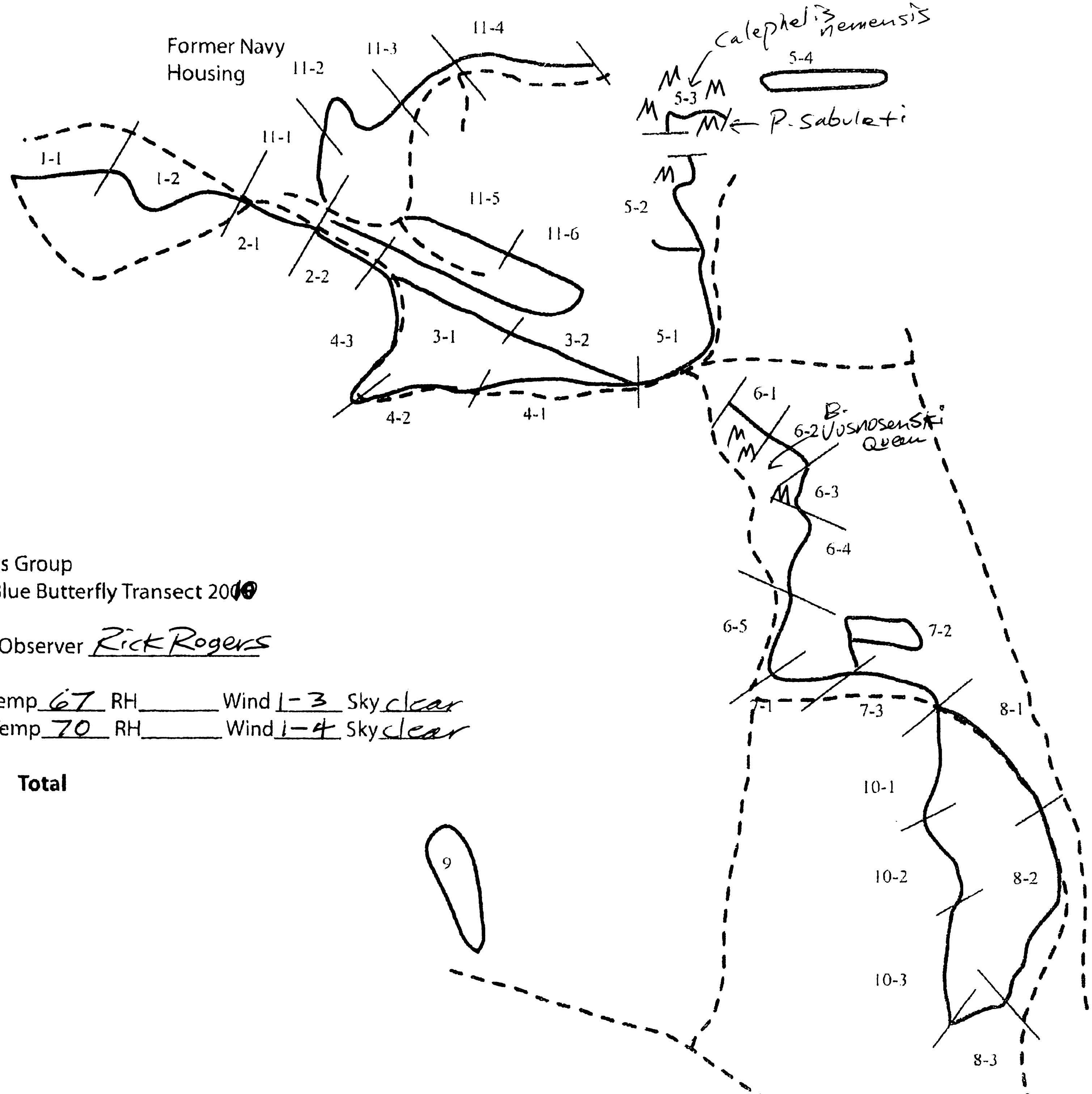

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

Date April 10, 2010 Observer Rick Rogers

Time start 11:30 Temp 64 RH_______ Wind 2-3 Sky broken (80% clouds)
Time finish 1:30 Temp 69 RH_______ Wind 2-4 Sky broken (75%)

| Legend | | Total |
| --- | --- | --- |
| ♀♂ | *G. lygdamus* | 1 |
| F | *E. funeralis* | |
| M | *L. marina* | 9 |
| G | *C. perplexa* | |
| H | *S. melinus* | |
| B | *B. diegoensis* | |

2 PVB's (♀) Seen today

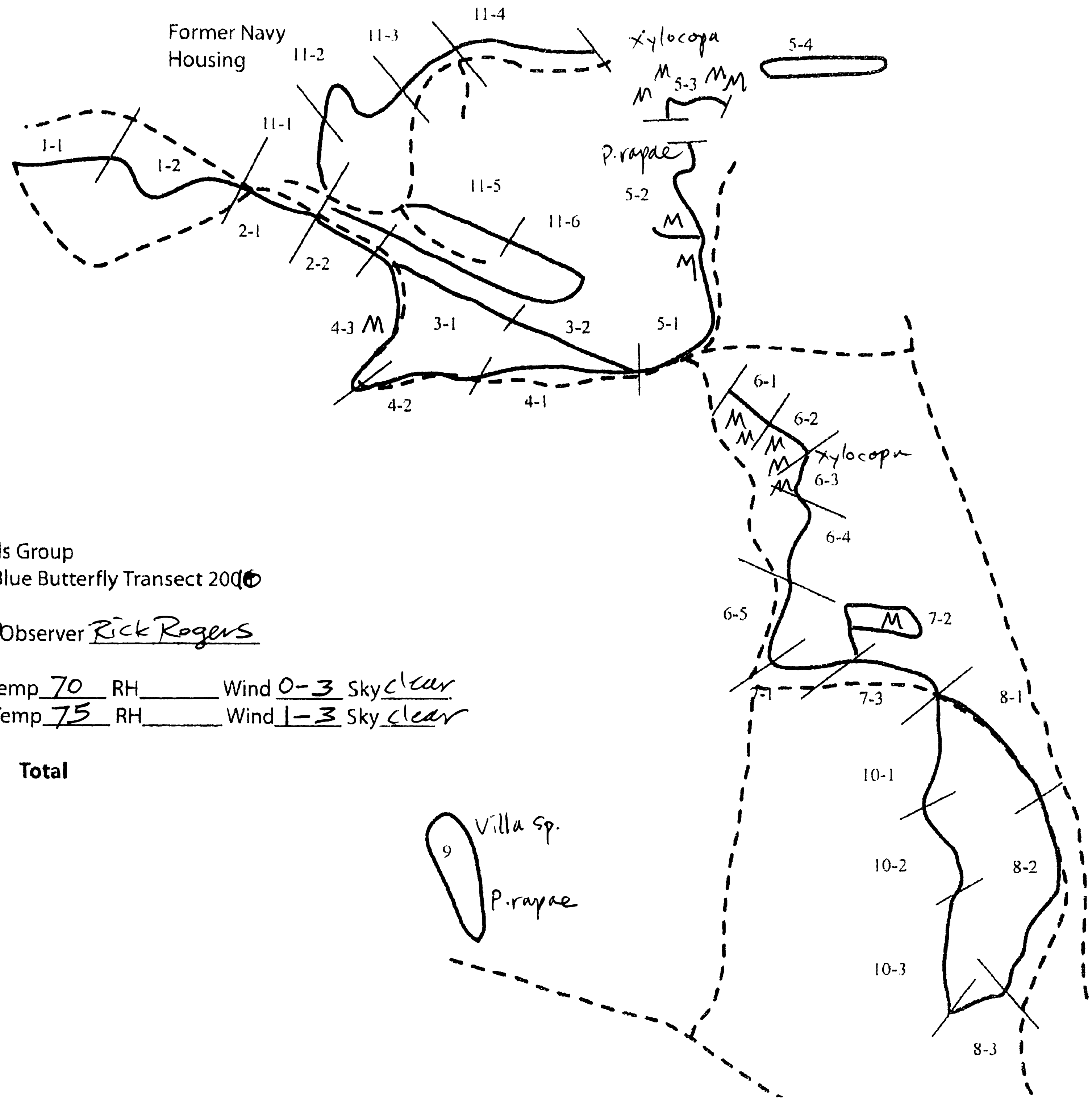



The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

Date April 13, 2010 Observer Rick Rogers

Time start 11:30 Temp 67 RH_______ Wind 1-3 Sky clear
Time finish 1:30 Temp 70 RH_______ Wind 1-4 Sky clear

| **Legend** | | **Total** |
|---|---|---|
| ♀♂ | *G. lygdamus* | |
| *F* | *E. funeralis* | |
| *M* | *L. marina* | |
| *G* | *C. perplexa* | |
| *H* | *S. melinus* | |
| *B* | *B. diegoensis* | |

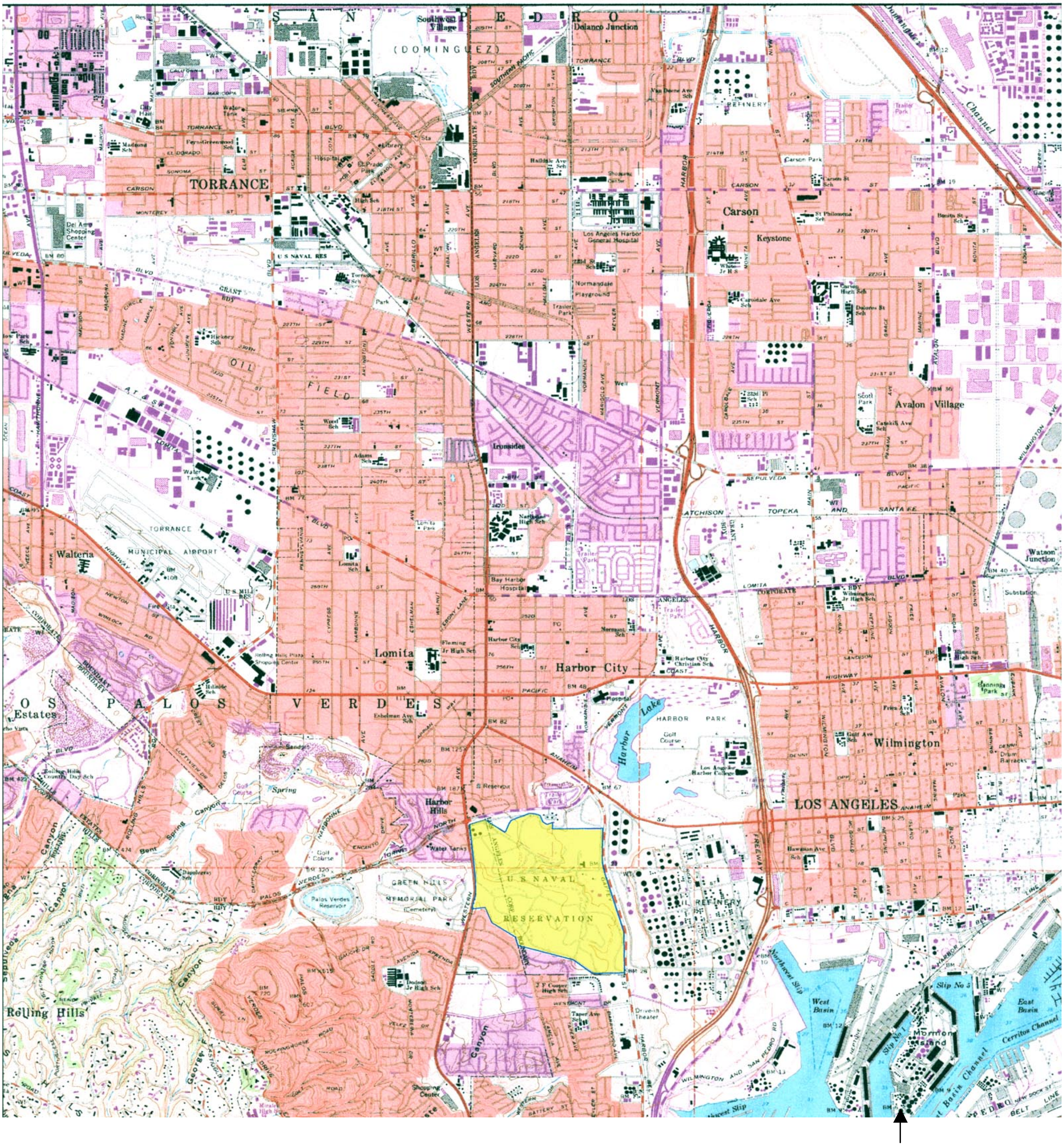



The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2010

Date April 16, 2010 Observer Rick Rogers

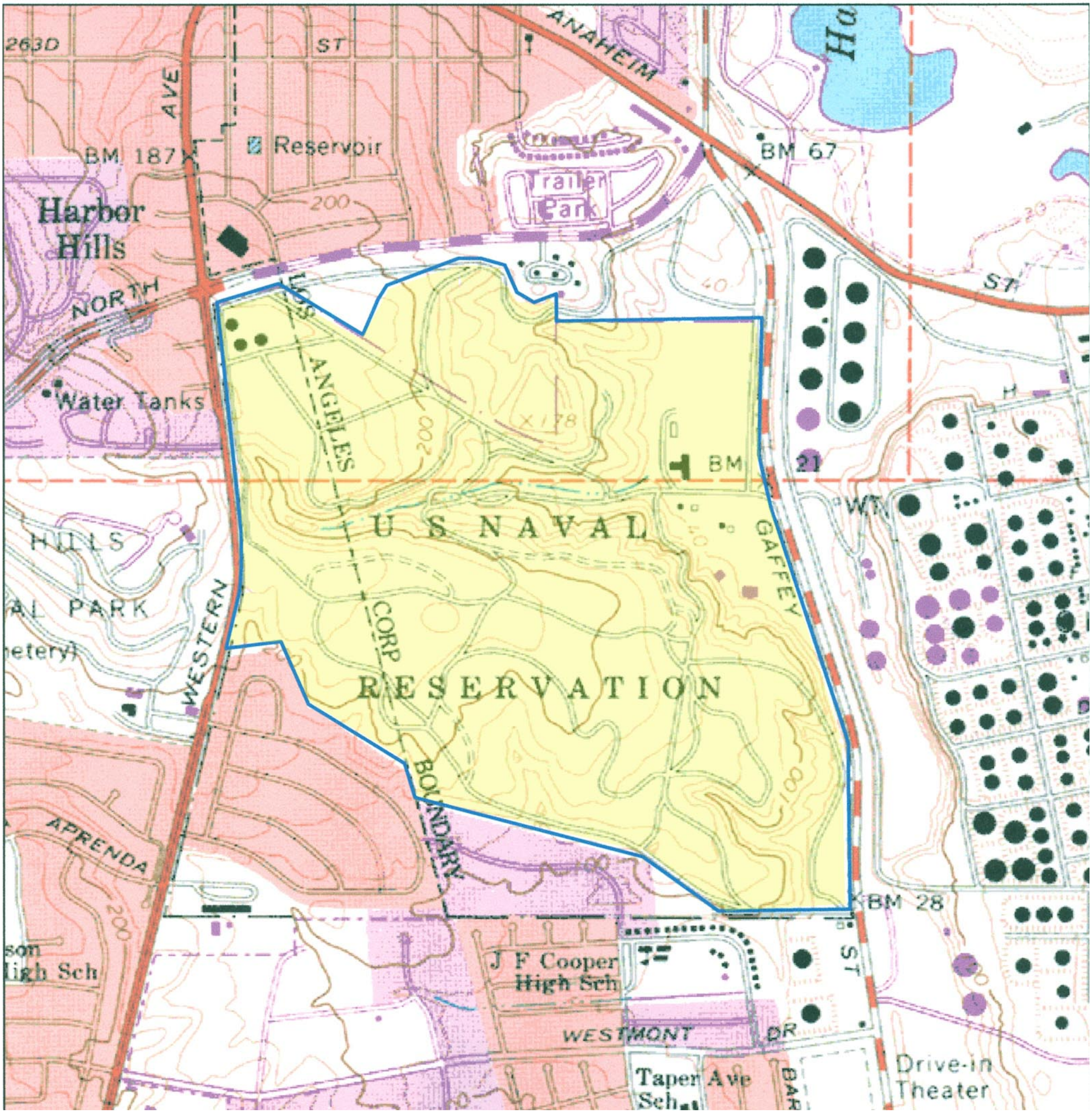
Time start 12:00 Temp 70 RH______ Wind 0-3 Sky clear
Time finish 2:00 Temp 75 RH______ Wind 1-3 Sky clear

| **Legend** | | **Total** |
|---|---|---|
| ♀♂ | *G. lygdamus* | |
| F | *E. funeralis* | |
| M | *L. marina* | |
| G | *C. perplexa* | |
| H | *S. melinus* | |
| B | *B. diegoensis* | |




1 mile N

**Supplemental Figure 1.** General vicinity of survey site, Torrance, California USGS 7.5' quadrangle at 50%. The DFSP and associated survey areas are outlined in blue and highlighted in yellow.




——= 100 meters N

**Supplemental Figure 2.** General vicinity of survey site, Torrance, California USGS 7.5' quadrangle at 200%. The DFSP and associated survey areas are outlined in blue and highlighted in yellow.