THE URBAN WILDLANDS GROUP, INC.
P.O. Box 24020, Los Angeles, California 90024-0020, Tel (310) 247-9719

FINAL REPORT
FOR
2009 PALOS VERDES BLUE BUTTERFLY ADULT SURVEYS
ON
DEFENSE FUEL SUPPORT POINT
SAN PEDRO, CALIFORNIA

COOPERATIVE AGREEMENT NUMBER:
N62473-08-LT-R0011

February 22, 2010

Contracting Officer:
Linda Protocollo
Naval Facilities Engineering Command (NAVFAC), Southwest
1220 Pacific Highway
San Diego, CA 92132-5190
Tel: (619) 532-1159, Fax: (619) 532-1155
Email: Linda.protocollo@navy.mil

Agreement Representative:
Albert Owen, Ph.D.
Natural Resources Specialist
Naval Facilities Engineering Command (NAVFAC), Southwest
1220 Pacific Highway, Building 131
San Diego, CA 92132-5190
Tel: (619) 532-3775, Fax: (619) 532-1195
Email: albert.owen@navy.mil

DRAFT REPORT
FOR
2009 PALOS VERDES BLUE BUTTERFLY ADULT SURVEYS
ON
DEFENSE FUEL SUPPORT POINT
SAN PEDRO, CALIFORNIA

Prepared By:
Travis Longcore, Ph.D.
The Urban Wildlands Group
P.O. Box 24020
Los Angeles, CA 90024-0020

Ken H. Osborne, M.S.
Osborne Biological Consulting
6675 Avenue Juan Diaz
Riverside, CA 92509-6242

Ann Dalkey, M.S.
Palos Verdes Peninsula Land Trust
916 Silver Spur Road #207
Rolling Hills Estates, CA 90274-3826

Prepared For:
Albert Owen, Ph.D.
Natural Resources Specialist
Naval Facilities Engineering Command (NAVFAC), Southwest
1220 Pacific Highway, Building 128
San Diego, CA 92132-5190

February 225, 2010

Recommended Citation:
Longcore, T., K. H. Osborne, and A. Dalkey. 2010. Draft Report for 2009 Palos Verdes Blue Butterfly Adult Surveys on Defense Fuel Support Point, San Pedro, California. Los Angeles: The Urban Wildlands Group (Defense Logistics Agency Agreement # N62473-08-LT-R0011).

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. A basewide survey for all butterflies and larval hostplant was completed in 2006 and repeated in 2009. The status for Palos Verdes blue butterfly at DFSP in 2009 is as follows.

- The estimate of the wild adult population along the transect is 214, which is in the top 25% of yearly population estimates.
- The probability of extinction calculated is 43%, which would occur on average in 71 years. This is a greatly improved prognosis from 2008, but illustrates that the species is still in demographic peril.
- The survey of larval foodplant showed dramatic declines from 2006, presumably as a result of senescence and succession to mature coastal sage scrub.
- The basewide distribution of the species contracted considerable since 2006 with no butterflies observed in the southern part of the property where they were once found.

Based on these results, the following management actions should be considered.

- Undertake 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) 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, Longcore and Mattoni 2003, 2005, Longcore 2007a, b). 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. In 2006 a basewide survey was initiated to document distribution off the established transect and to track hostplant distribution. This survey was repeated in 2009. This report describes the transect, results of the transect and basewide surveys in 2009, 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 2009 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 18, 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 TE837760-6.

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 ith day of observation, d_i is the number of days from the ith survey to the ith + 1 survey, L is the average 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).

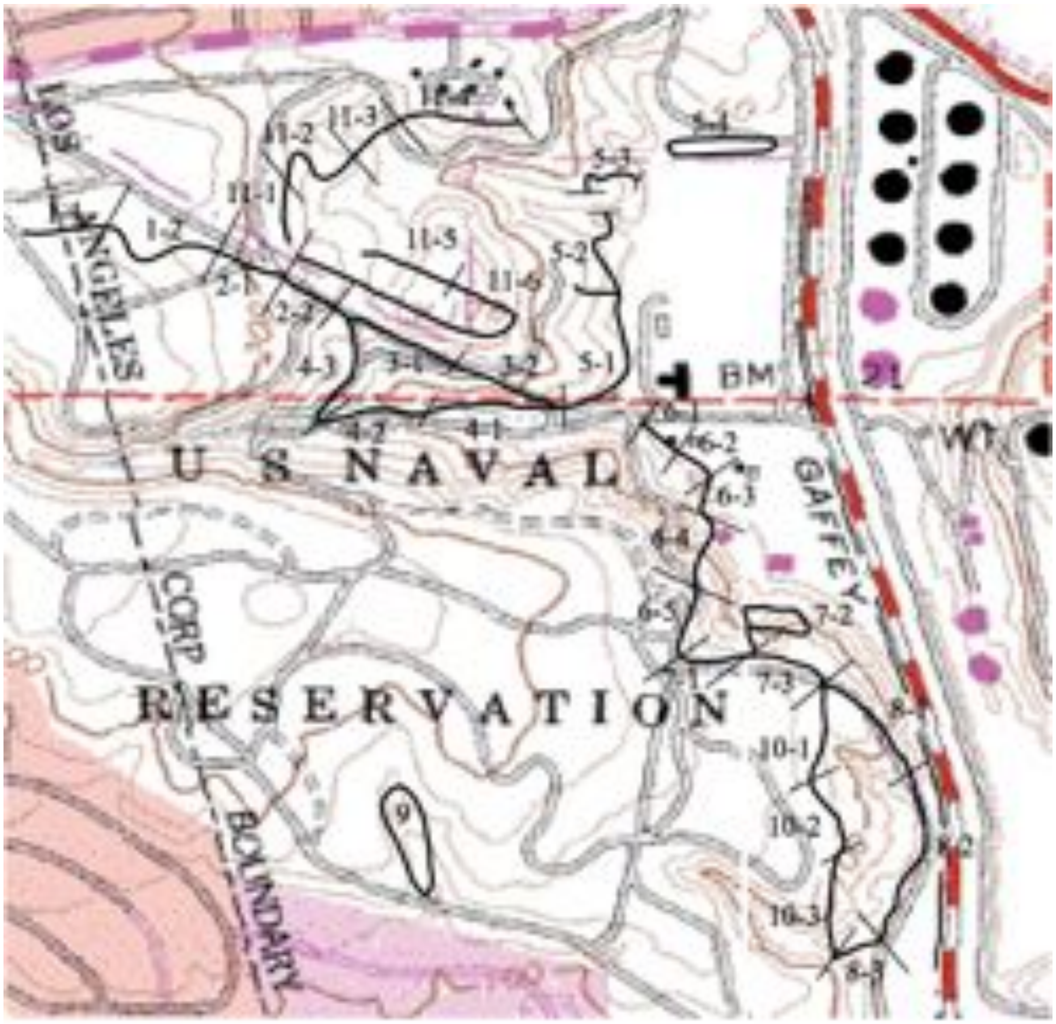


Figure 2. Location of Palos Verdes blue butterfly transect at DFSP (segments 1–10) and Palos Verdes housing (segment 11).

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 (λ) and its variance (σ^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.

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.

2.6 Basewide Survey

To better detect Palos Verdes blue butterflies colonizing new habitats at DFSP, we conducted surveys for presence in all available habitats. This effort involved two parts: a base-wide survey for the larval hostplants for the species and a subsequent set of surveys for adults.

For both surveys we divided the property into 46 polygons that follow discernable landmarks on the ground. Maps of each polygon with 1-m aerial photographs were then used in the field during surveys for foodplant and butterflies. Surveys were conducted by Ken Osborne with trainee

Ann Dalkey in addition to the regular transects conducted by Rick Rogers.

Before the flight season we surveyed each polygon for presence of deerweed (*Lotus scoparius*) and locoweed (*Astragalus trichopodus*). Surveyors drew polygons on the survey map to show the extent of areas with foodplant and recorded the percent foodplant cover within those polygons and the total percent cover within the polygon. Field maps were then digitized and compared with results from 2006 using a Geographic Information System (ArcMap 9.2).

All polygons were surveyed for butterflies. Sixteen polygons are covered by the regular transect and therefore were already being surveyed by Rick Rogers. The other polygons were surveyed by Osborne and Dalkey. Three surveys were conducted of each polygon during the peak of the flight season (i.e., the three weeks around March 15). Surveyors recorded the location of all adult butterflies. Polygons were surveyed in random order to avoid systematic biases of surveying early or late in the day.

3 Results

3.1 Population Estimates

A release of 80 adult butterflies was conducted along the transect (segment 5-3) in the spring of 2009. We consequently omitted surveys for 10 days following that release (the average lifespan of an imago) to avoid confusing the index with the captive stock. Any progeny would of course be counted in 2010. The resulting 2009 population estimate of 214 adults was in the top quarter of years surveyed (Table 1). Flight period (i.e., the number of days between the first and last observation) continues to be predicted by estimated population size (r^2=0.33, $F_{1,14}$=6.84, P=0.02). The length of the season can be estimated as 28.8 days plus 11.7 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 1. 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

*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, 2005–2009).

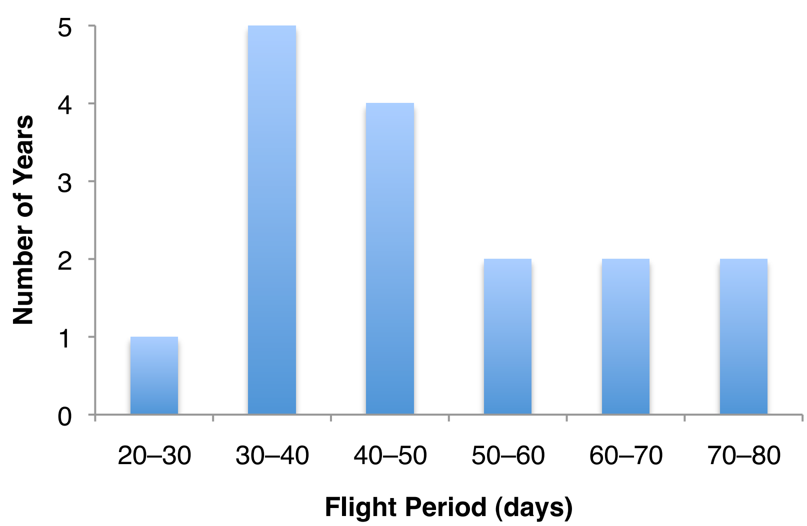


Figure 3. Length of flight periods for Palos Verdes blue butterfly, 1994–2009, defined as number of days between first and last observation.

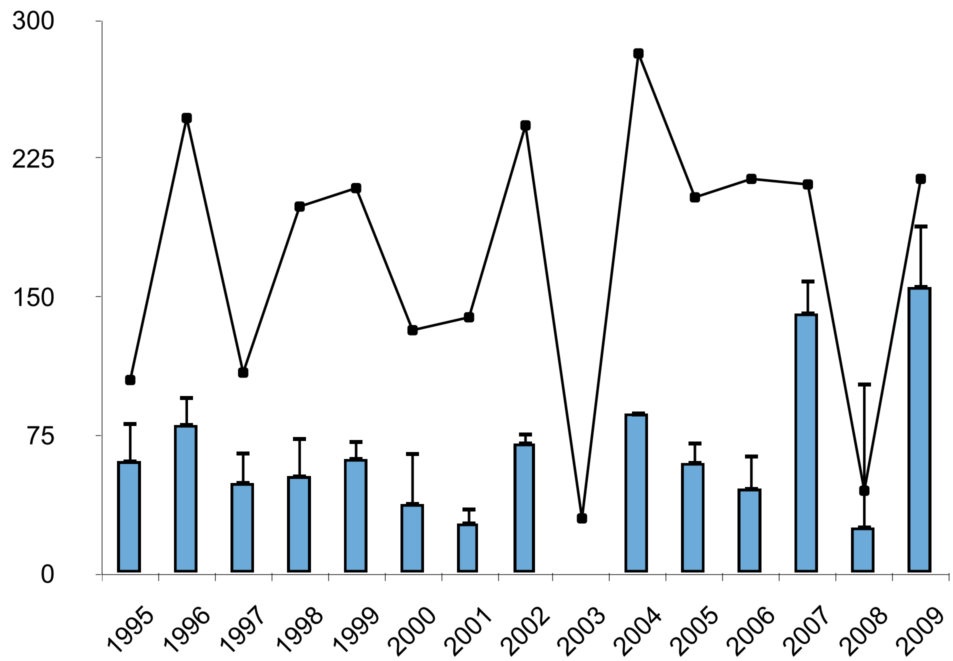


Figure 4. Solid line: population of Palos Verdes blue butterfly at DFSP, 1994–2009, estimated by Mattoni et al. (2003) method. Bars: estimated population of Palos Verdes blue butterfly at DFSP, 1994–2009, calculated by Zonneveld (1991) method from transect counts. This index is not adjusted for sex ratio 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 15 years of monitoring, the estimated population of Palos Verdes blue butterfly has fluctuated without a statistically significant trend (Figure 4). No trend is evident based on overall abundance alone. Similar results are obtained with the Zonneveld method (Figure 4), which also shows the population fluctuating without a trend.

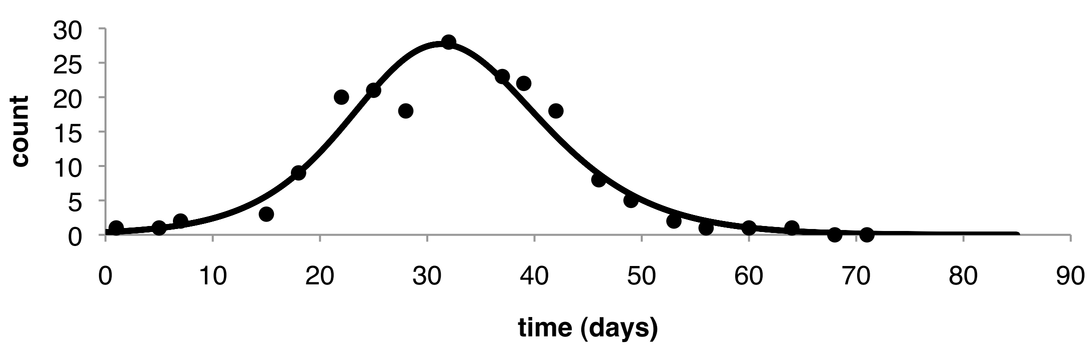


Figure 5. Raw data from transect counts with curve fit by INCA, 2009.

Table 2. Status and trends of Palos Verdes blue butterfly occupancy by transect segment at Defense Fuel Support Point, San Pedro as of 2009. Status indicates presence (+) or absence (–) in 2009. Trend indicates stable (0), positive (+), or negative (–) trend in occupancy from logistic regression with chi-squared probability (P). Significance values of 0.1 and lower reported.

Segment	*2009 Status*	*Trend*	*P*
1-1	–	–	*ns*
1-2	–	+	*ns*
2-1	–	n/a	always absent
2-2	+	–	*ns*
3-1	+	–	0.002
3-2	–	–	0.02
4-1	+	–	0.02
4-2	–	–	*ns*
4-3	–	–	*ns*
5-1	+	–	*ns*
5-2	+	+	*ns*
5-3	+	+	*ns*
5-4	+	n/a	present since 2005
6-1	+	+	*ns*
6-2	+	+	*ns*
6-3	–	0	*ns*
6-4	+	+	*ns*
6-5	–	0	*ns*
7-1	+	+	*ns*
7-2	+	n/a	always present
7-3	+	+	*ns*
8-1	+	–	*ns*
8-2	–	–	0.01
8-3	–	–	*ns*
9	–	+	0.06
10-1	–	–	0.02
10-2	–	–	0.08
10-3	–	+	*ns*
11-1	–	–	*ns*
11-2	+	–	0.08
11-3	+	+	*ns*
11-4	–	–	*ns*
11-5	+	+	*ns*
11-6	+	+	0.02

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 (χ^2=6.94; P =0.01). 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 nine significant ($p<0.10$) trends, seven were negative (Table 2). 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. 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

3.3 Population Viability Analysis

The population viability analysis produced a probability of extinction of 43% with the average time to extinction 71 years (Table 3). 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 4). 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 4; Estimated Population = 8.0779 + 72.548 * ln(Larval Year Rainfall)). In this model winter and spring rainfall were positive, while total larval year rainfall had a negative effect on population. 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 = 15), these results must be interpreted with caution.

Table 4. Multiple regression models predicting estimated population size.

Variables	R^2	P	AIC
Ln (Larval Year Rainfall)	0.54	0.002	166.23
Larval Year Rainfall	0.32	0.03	172.96
Larval Winter Rainfall	0.22	0.05	173.96
Larval Spring Rainfall + Larval Fall Rainfall + Larval Year Rainfall	0.56	0.02	174.68
Larval Spring Rainfall	0.17	0.12	175.79

3.5 Basewide Surveys

The foodplant distribution maps were updated for 2009 (Figure 6). The surveys found that the density of deerweed declined precipitously during 2006–2009 (Figure 7). Of the 46 polygons, we observed declines in the proportion of deerweed cover in patches mapped in 40 of them. Some of these patches lost 75% to 100% of all deerweed. By means of comparison, only 9 polygons contained deerweed patches that increased in coverage, and these only by modest amounts with two notable exceptions (polygons 24 and 8). Please note that polygon 1 is only indicated as occupied by virtue of vagrant individuals from the restored cut slope to the north of the baseball field, which is outside the mapped area.

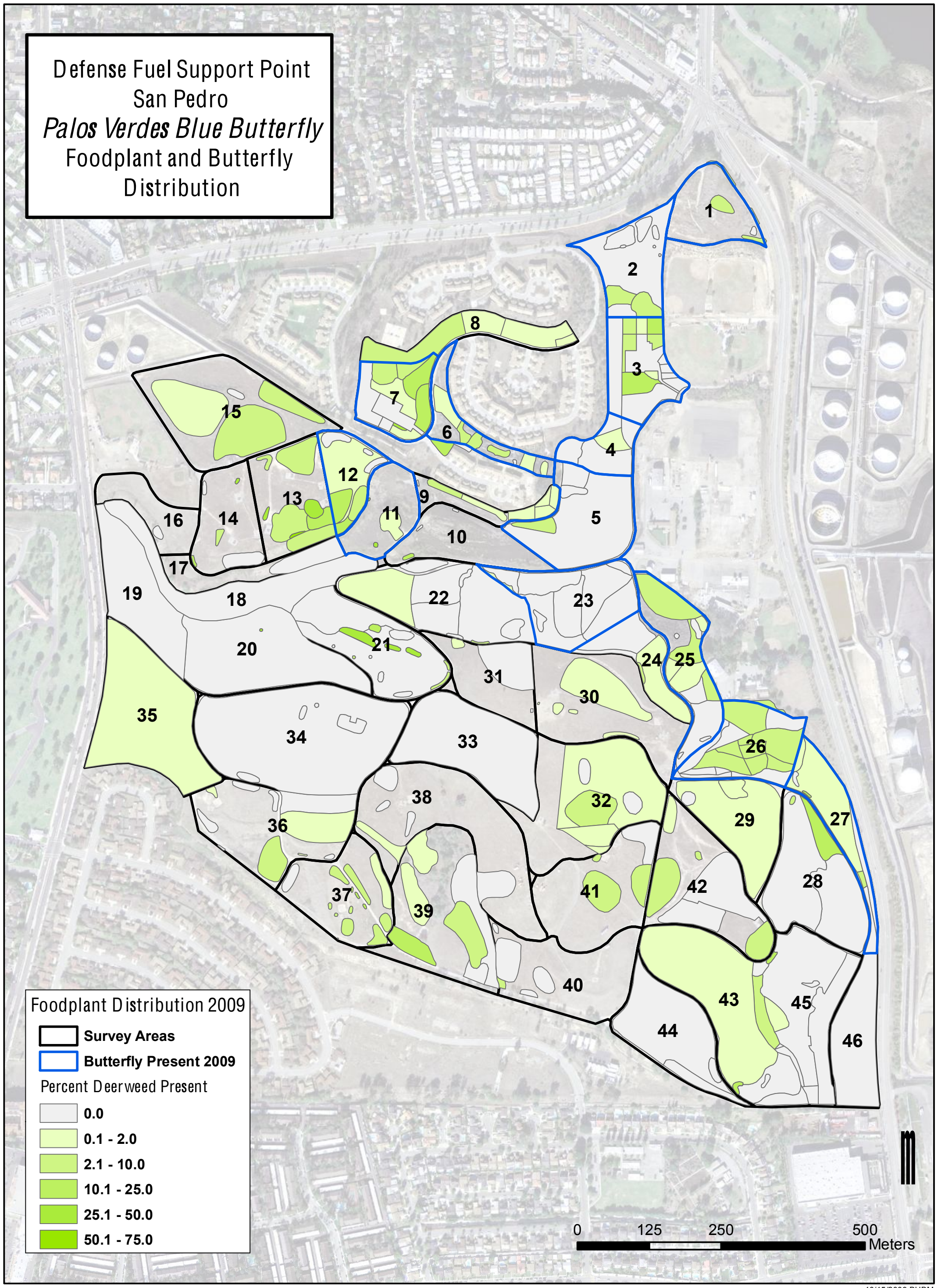


Figure 6. Distribution and density of deerweed (*Lotus scoparius*) at DFSP in 2009. Palos Verdes blue butterflies were observed in polygons outlined in blue. Polygon 1 is listed as occupied only by virtue of vagrant individuals from the cut slope immediately to the south.

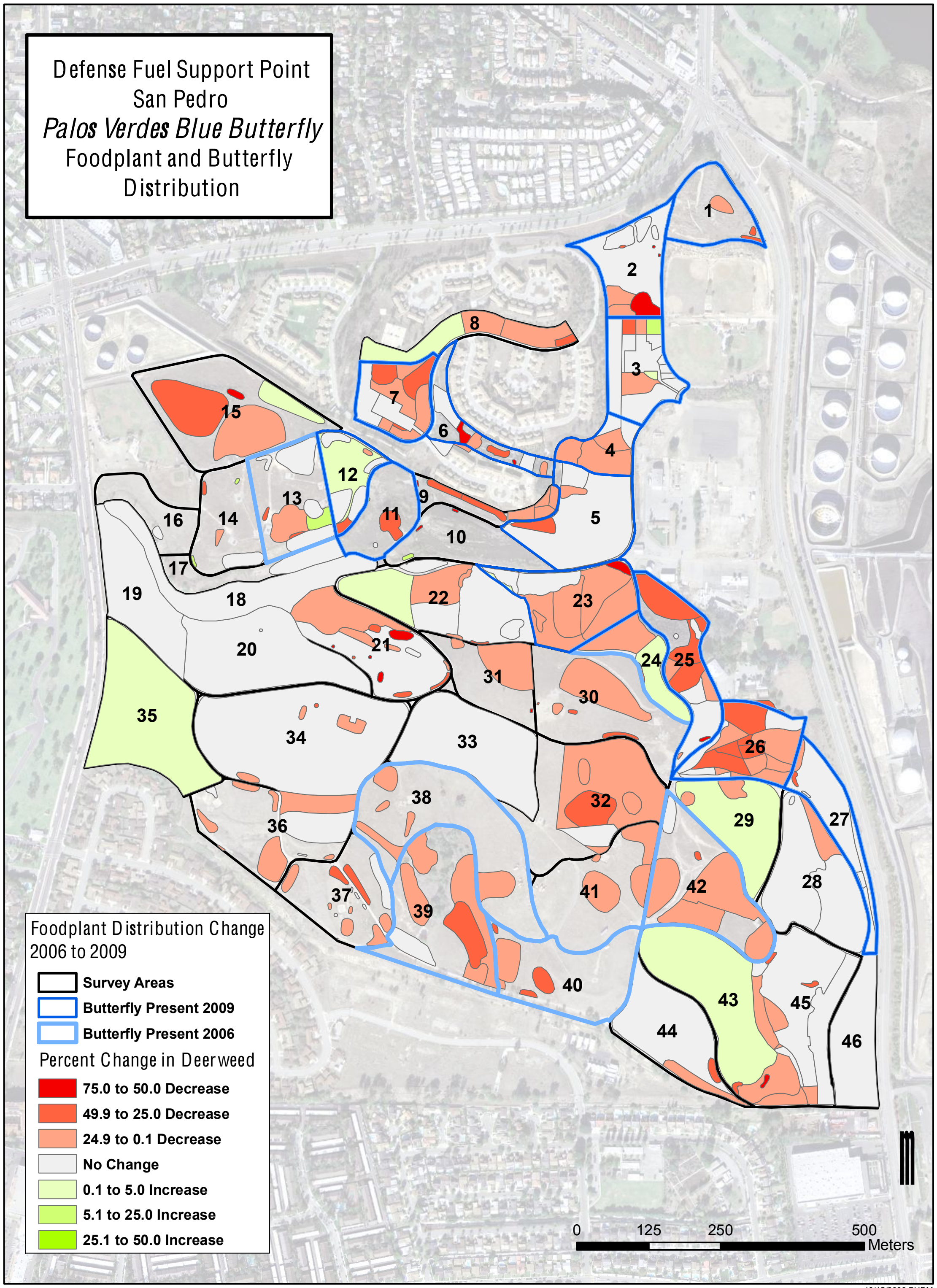


Figure 7. Change in cover of deerweed (*Lotus scoparius*) from 2006 to 2009. Presence of Palos Verdes blue butterflies on surveys in 2006 and 2009 also indicated.

Photodocumentation of previously robust deerweed patches showed many dead and senescent individuals. Dead plants are easy to discern in the field because they take on a grayish color and lack the red to green coloring of the main stems (Figure 8). One particularly dramatic example of the die-off of deerweed was in the covered disposal site at the former Navy Housing (polygon 7). Butterflies were once observed in numbers at this site, but the 2009 survey showed very little living deerweed and few butterflies (Figure 9). In comparison, areas with some disturbance, such as the slope above the softball fields just south of polygon 1 has a dense stand of deerweed and an abundance of new recruits, which were conspicuously absent in other areas (Figure 10).

Figure 8. Photograph (KHO) of deerweed on the upper southern DFSP comparing dead and alive. Living (left), dead (right).

Figure 9. Photograph (KHO) of deerweed stand at the old Navy Housing area, northwest of DFSP. This location previously supported numerous PVB found on an annual basis. Butterfly much reduced now at this area.

Figure 10. Photograph (KHO) of deerweed stand at the baseball fields on disturbed slope north of DFSP. Note abundance of new recruits.

4 Discussion

The adult Palos Verdes blue butterfly population in 2009 was at levels average for the past several years, but the trend of contraction of range within the installation has continued. We now understand more fully that larval year rainfall explains a large portion of annual variation in observed numbers (approximately 50%), and also have evidence that the foodplant resources have declined dramatically since 2006.

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). The patterns of decreased occupancy along the transect in 2009 underscore again the need for ongoing management to enhance habitat for the butterfly. The surveys continue to indicate that occupied, suitable habitat can become unsuitable over time. The mechanism for this is the replacement of early successional habitat with abundant foodplant, with later successional habitat dominated by larger species. At DFSP, restored and enhanced habitats have been occupied by the butterfly and indeed have become important population centers (Segment 9), only to have the foodplant decline and butterfly numbers dwindle.

In a subsequent document, we will propose intentional disturbance of ruderal patches at DFSP to ensure regeneration of suitable foodplant patches. Sites with deerweed persisting for many years seem to have poorly developed soils. For example, transect segment 7-2 is found on an slope that was graded for the installation of a series of concrete drainage channels before the 1994 discovery of the butterfly. This exposed a compacted sandy outcrop that has been ideal deerweed habitat. This is consistent with a low-nutrient environment with poor soil development that is ideal for pioneers species such as deerweed.

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 $r = 0.72$. Based on these results, we will continue to report both the estimated total population and the maximum daily count as indicators of population trends.

5 Bibliography

Crone, E. E., D. Pickering, and C. B. Schultz. 2007. Can captive rearing promote recovery of endangered butterflies? An assessment in the face of uncertainty. Biological Conservation 139: 103–112.

Dennis, B., P. L. Munholland, and J. M. Scott. 1991. Estimation of growth and extinction parameters for endangered species. Ecological Monographs 61: 115–144.

Gross, K., E. J. Kalendra, B. R. Hudgens, and N. M. Haddad. 2007. Robustness and uncertainty in estimates of butterfly abundance from transect counts. Population Ecology 49: 191–200.

Hanski, I. 1999. Metapopulation dynamics. Oxford University Press, Oxford.

Longcore, T. 2007a. Final report for 2006 Palos Verdes Blue Butterfly adult surveys on Defense Fuel Support Point, San Pedro, California (Defense Logistics Agency Agreement # N68711-06-LT-R0011), pp. 1–13. The Urban Wildlands Group Los Angeles.

Longcore, T. 2007b. Final report for 2007 Palos Verdes blue butterfly adult surveys on Defense Fuel Support Point, San Pedro, California. Defense Logistics Agency Agreement #N68711-07-LT-R0011. The Urban Wildlands Group, Los Angeles.

Longcore, T., and R. Mattoni. 2003. Final report for Palos Verdes blue butterfly year 2003 adult surveys on Defense Fuel Support Point, San Pedro, California. The Urban Wildlands Group (Defense Logistics Agency Agreement # N68711-03-LT-C3003), Los Angeles.

Longcore, T., and R. Mattoni. 2005. Final report for 2005 Palos Verdes blue butterfly adult surveys on Defense Fuel Support Point, San Pedro, California, pp. 1–11. The Urban Wildlands Group (Defense Logistics Agency Agreement # N68711-05-LT-A0012), Los Angeles.

Longcore, T., R. Mattoni, C. Zonneveld, and J. Bruggeman. 2003. INsect Count Analyzer: a tool to assess responses of butterflies to habitat restoration. Ecological Restoration 21: 60–61.

Mattoni, R., and T. Longcore. 2002. Census results for Palos Verdes blue butterfly and associated species, 1994–2001, pp. 2-10. *In* R. Mattoni [ed.], Status and trends: habitat restoration and the endangered Palos Verdes blue butterfly at the Defense Fuel Support Point, San Pedro, California, 1994–2001. The Urban Wildlands Group, Los Angeles.

Mattoni, R., T. Longcore, C. Zonneveld, and V. Novotny. 2001. Analysis of transect counts to monitor population size in endangered insects: the case of the El Segundo blue butterfly, Euphilotes bernardino allyni. Journal of Insect Conservation 5: 197–206.

Mattoni, R., M. Vergeer, J. George, and Y. Marlin. 2002. Release of captive reared Palos Verdes blue butterfly: manipulative field experiments, pp. 2-10. *In* R. Mattoni [ed.], Status and trends: habitat restoration and the endangered Palos Verdes blue butterfly at the Defense Fuel Support Point, San Pedro, California, 1994–2001. The Urban Wildlands Group, Los Angeles.

Mattoni, R. H. T. 1994. Rediscovery of the endangered Palos Verdes blue butterfly, *Glaucopsyche lygdamus palosverdesensis* Perkins and Emmel (Lycaenidae). Journal of Research on the Lepidoptera 31: 180–194.

Morris, W., D. Doak, M. Groom, P. Kareiva, J. Fierberg, L. Gerber, P. Murphy, and D. Thomson. 1999. A practical handbook for population viability analysis. The Nature Conservancy, Arlington, Virginia.

Morton, A. C. 1982. The effects of marking and capture on recapture frequencies of butterflies. Oecologia 53: 105–110.

Osborne, K. H. 2002. Population monitoring for the Palos Verdes blue on the Defense Fuel Support Point, San Pedro, California: year 2002 survey results, Riverside, California.

Pickens, B. A. 2007. Understanding the population dynamics of a rare, polyvoltine butterfly. Journal of Zoology 273: 229–236.

Pollard, E. 1977. A method for assessing change in the abundance of butterflies. Biological Conservation 12: 115–132.

Pollard, E. 1988. Temperature, rainfall and butterfly numbers. Journal of Applied Ecology 25: 819–828.

Pollard, E., and T. J. Yates. 1983. Monitoring butterflies for ecology and conservation. Chapman & Hall, London.

Royer, R. A., J. E. Austin, and W. E. Newton. 1998. Checklist and "Pollard walk" butterfly survey methods on public lands. American Midland Naturalist 140: 358–371.

Schultz, C. B., and P. W. Hammond. 2003. Using population viability analysis to develop recovery criteria for endangered insects: case study of the Fender's blue butterfly. Conservation Biology 17: 1372–1385.

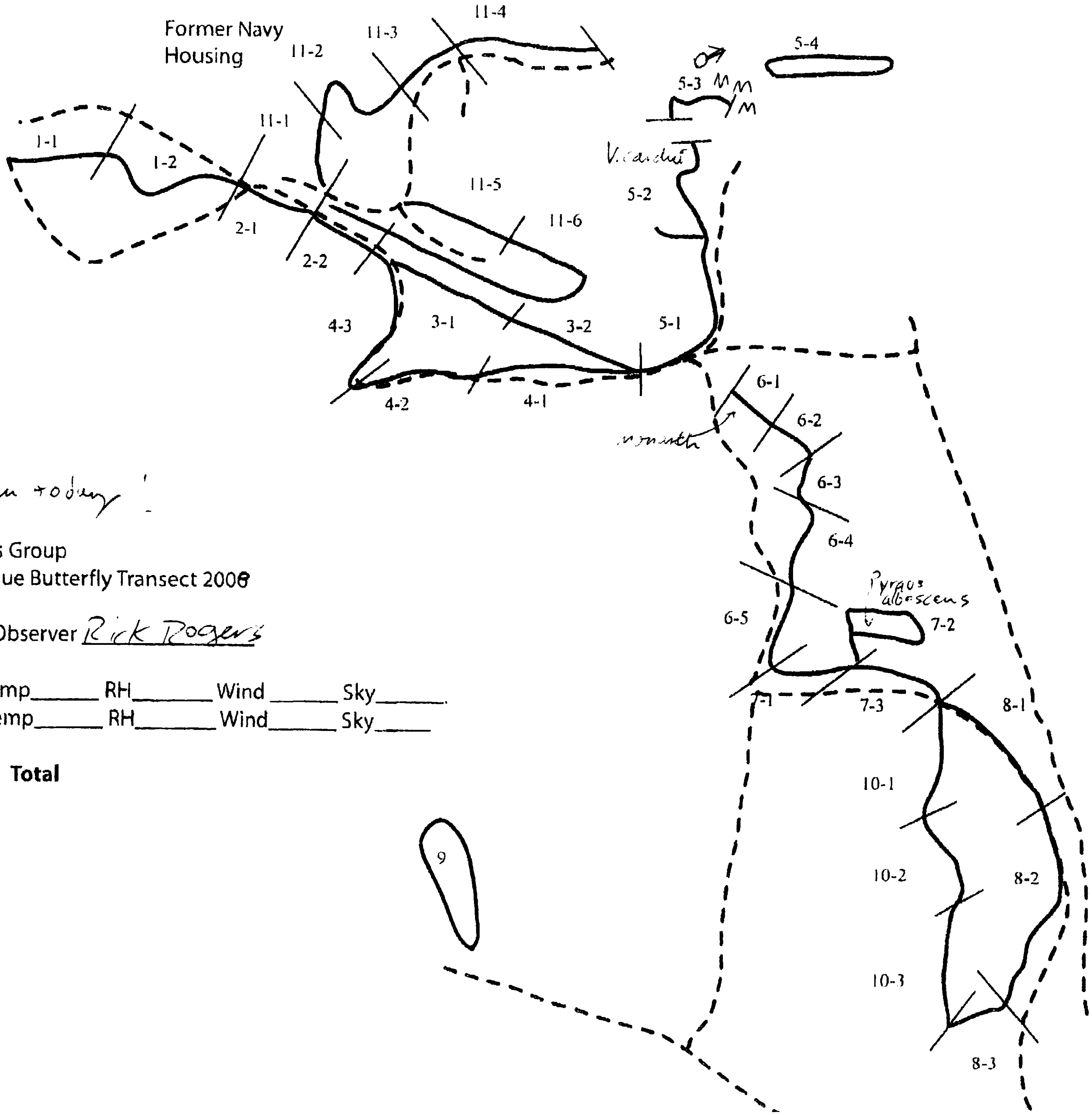
Singer, M. C., and P. Wedlake. 1981. Capture does affect probability of recapture in a butterfly species. Ecological Entomology 6: 215–216.

Watt, W. B., F. S. Chew, L. R. G. Snyder, A. G. Watt, and D. E. Rothschild. 1977. Population structures of Pierid butterflies I. Numbers and movements of some montane Colias species. Oecologia 27: 1–22.

Zonneveld, C. 1991. Estimating death rates from transect counts. Ecological Entomology 16: 115–121.

Zonneveld, C., T. Longcore, and C. Mulder. 2003. Optimal schemes to detect presence of insect species. Conservation Biology 17: 476–487.

Appendix: Survey Data Sheets



! ♂ PVB seen today !

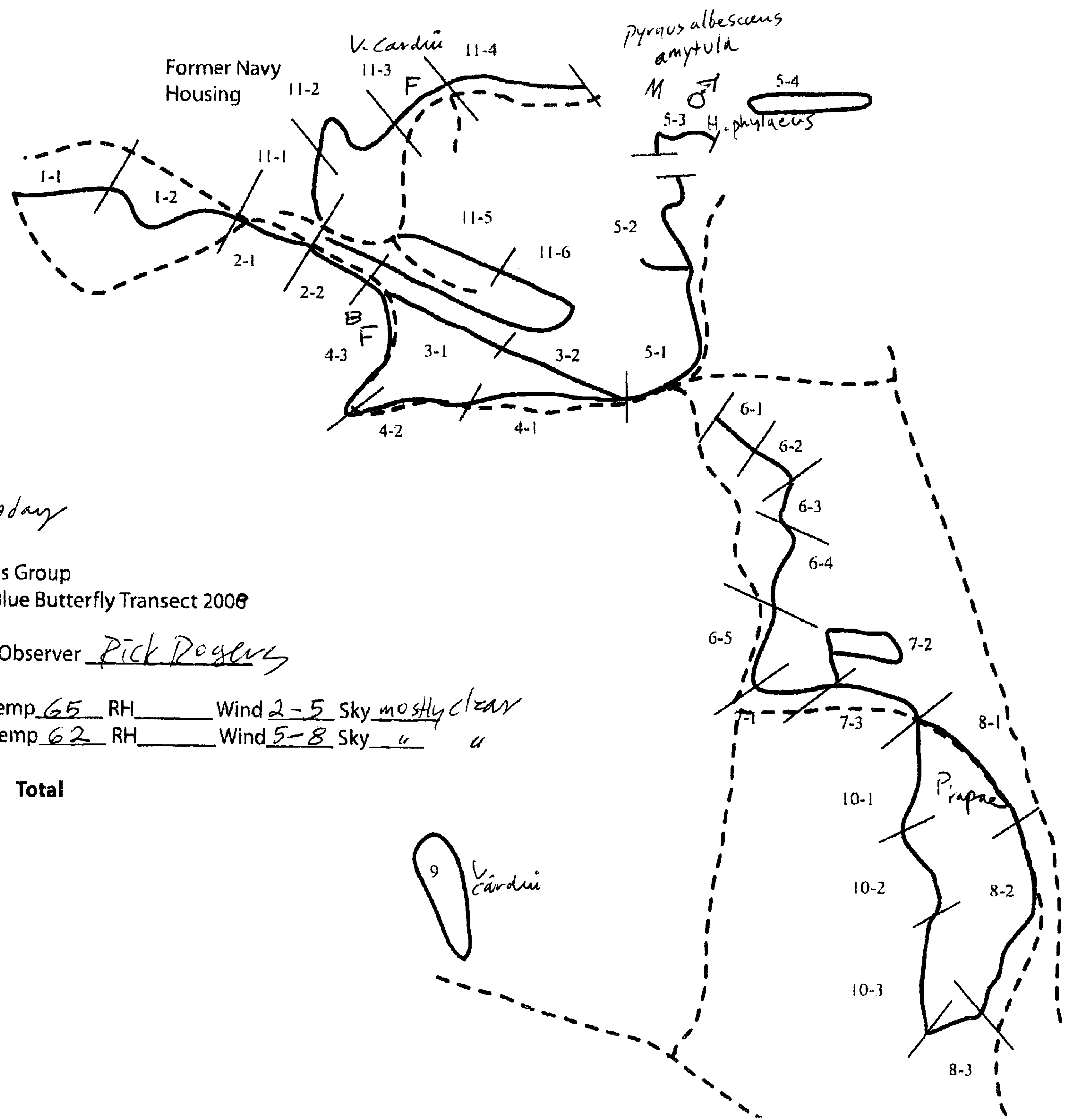
The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2009

Date Feb 27 '09 Observer Rick Rogers

Time start 12:00 Temp______ RH_______ Wind ______ Sky______
Time finish 2:00 Temp______ RH_______ Wind______ Sky_____

Legend **Total**

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



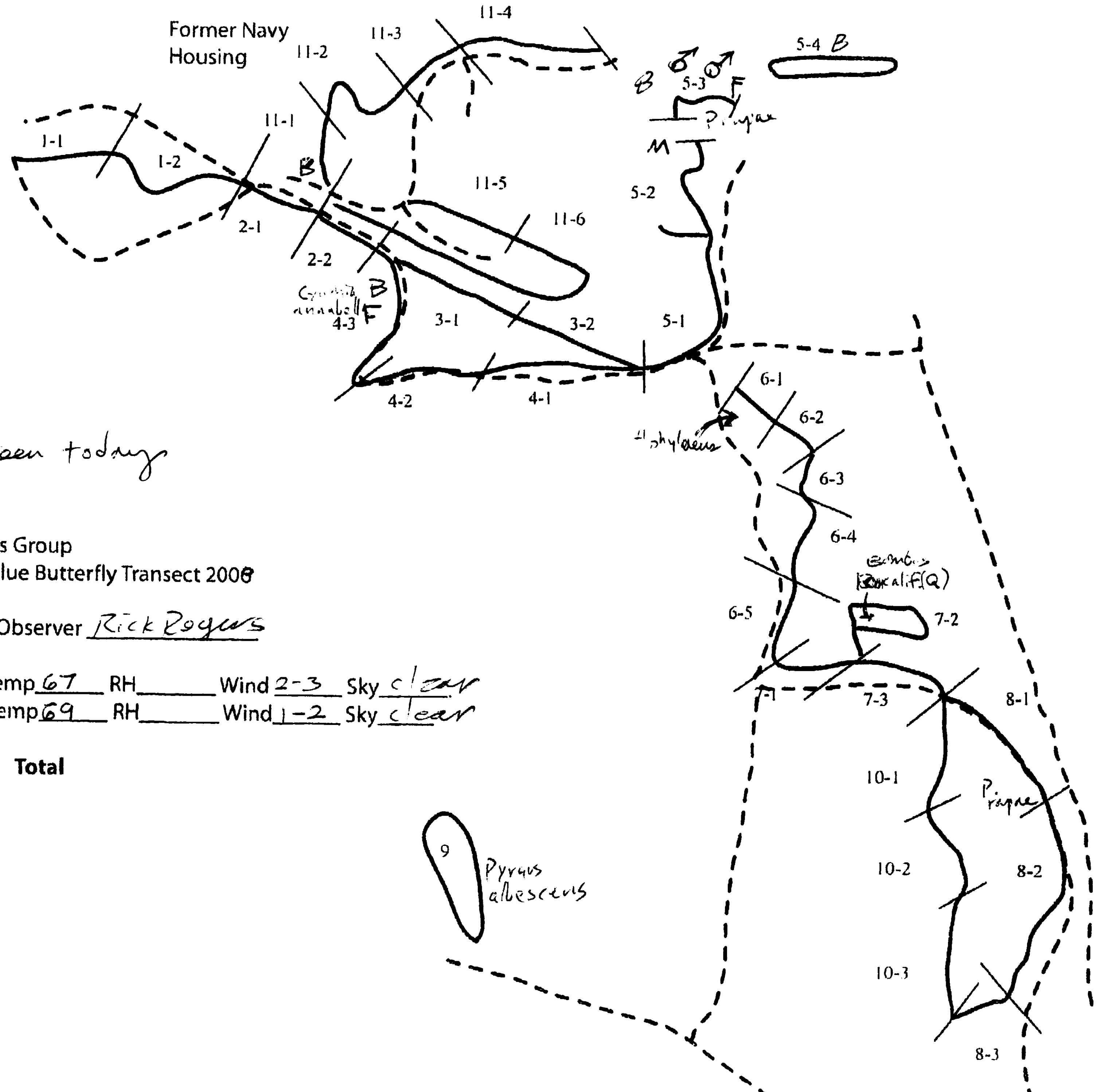
1 ♂ seen today

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2008

Date Mar 3, 09 Observer Rick Rogers

Time start 11:00 Temp 65 RH______ Wind 2-5 Sky mostly clear
Time finish 1:30 Temp 62 RH______ Wind 5-8 Sky " "

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



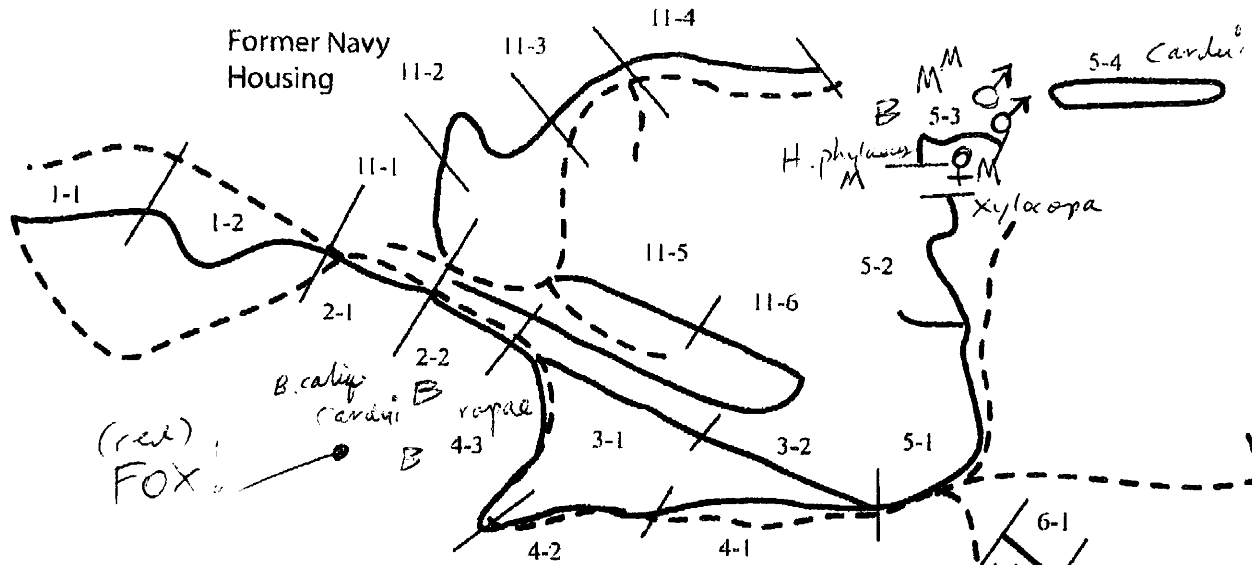
2 ♂ PVB's seen today

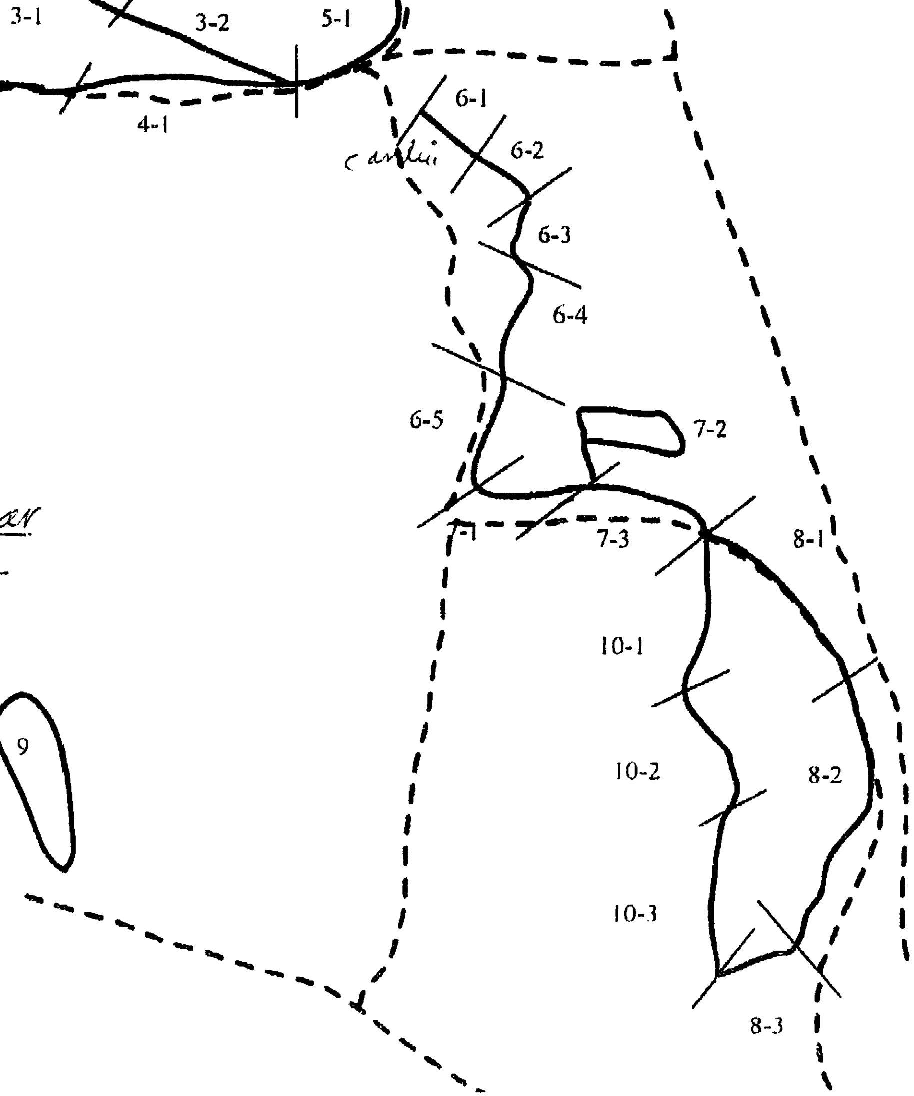
The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2008

Date Mar 5, 2009 Observer Rick Rogers

Time start 11:00 Temp 67 RH______ Wind 2-3 Sky clear
Time finish 1:00 Temp 69 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*	





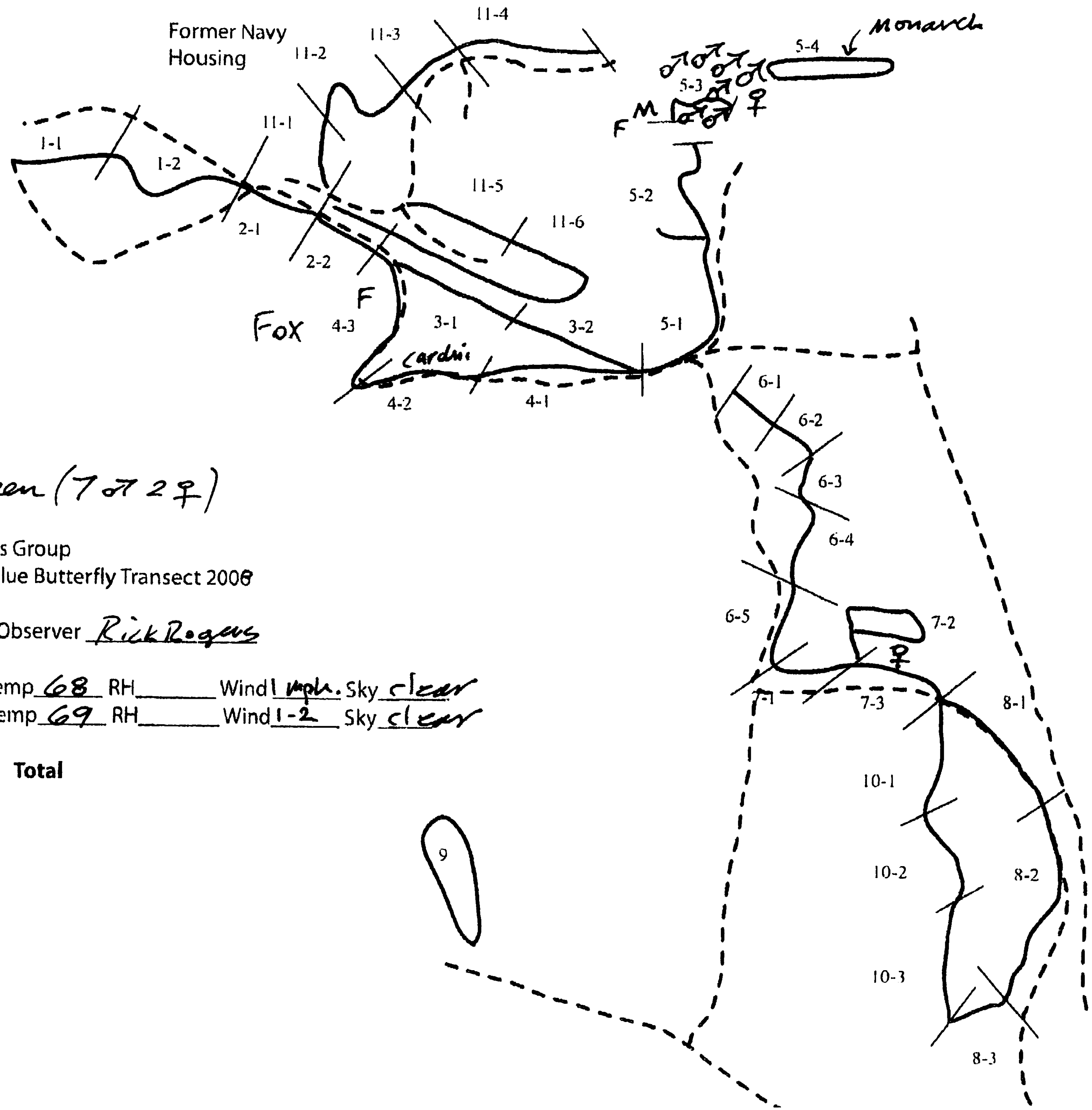
3 PVB's today 2♂ 1♀

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2008

Date Mar 13, 09 Observer Rick Rogers

Time start 11:00 Temp 68 RH____ Wind 3-4 Sky clear
Time finish 1:00 Temp____ RH____ Wind____ Sky____

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



9 PVB's seen (7 ♂ 2 ♀)

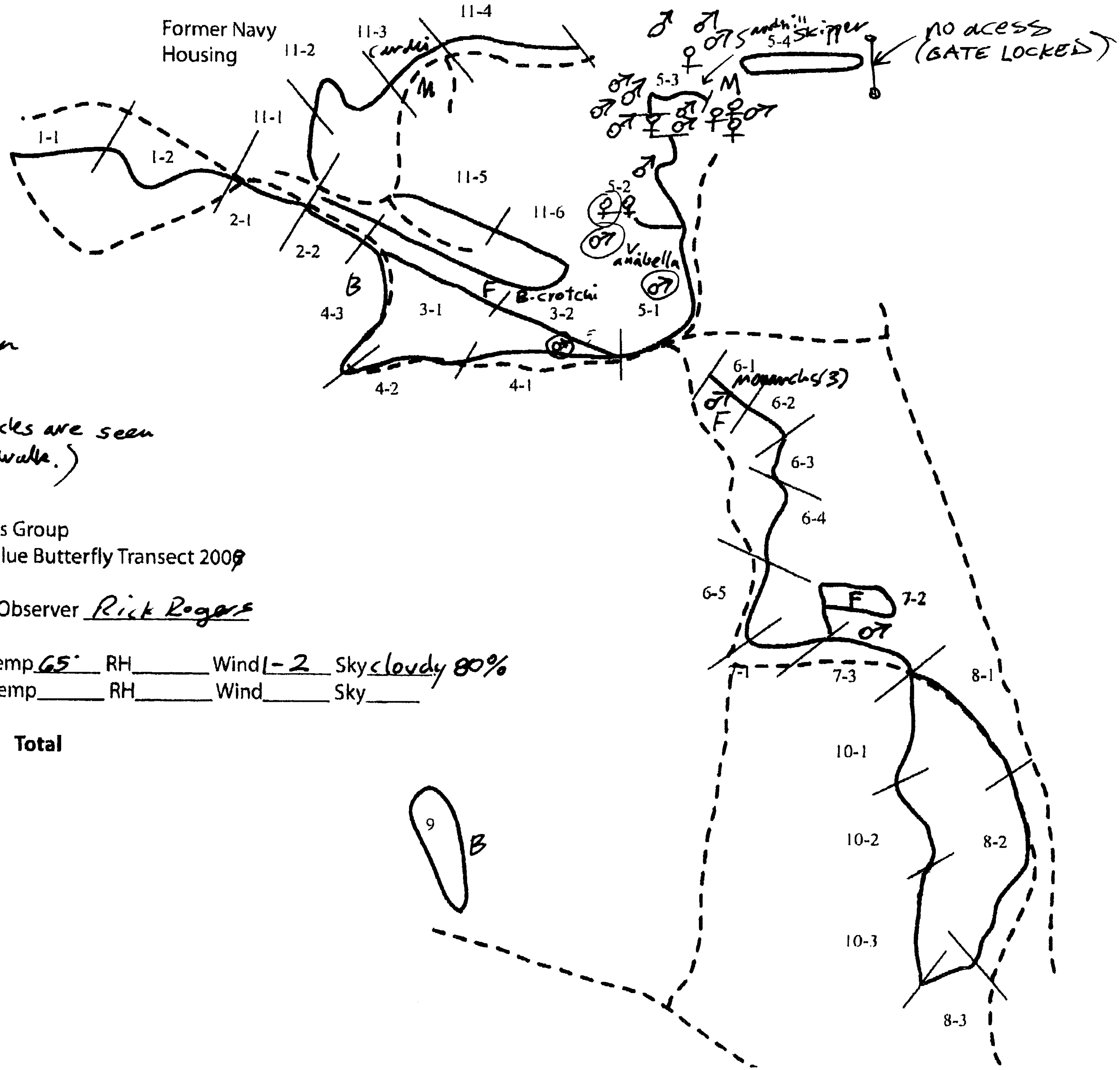
The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2009

Date mar 16, '09 Observer Rick Rogers

Time start 11:00 Temp 68 RH______ Wind 1 mph. Sky clear
Time finish 1:30 Temp 69 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*



19 PVB's seen

(signs within circles are seen after regular walk.)

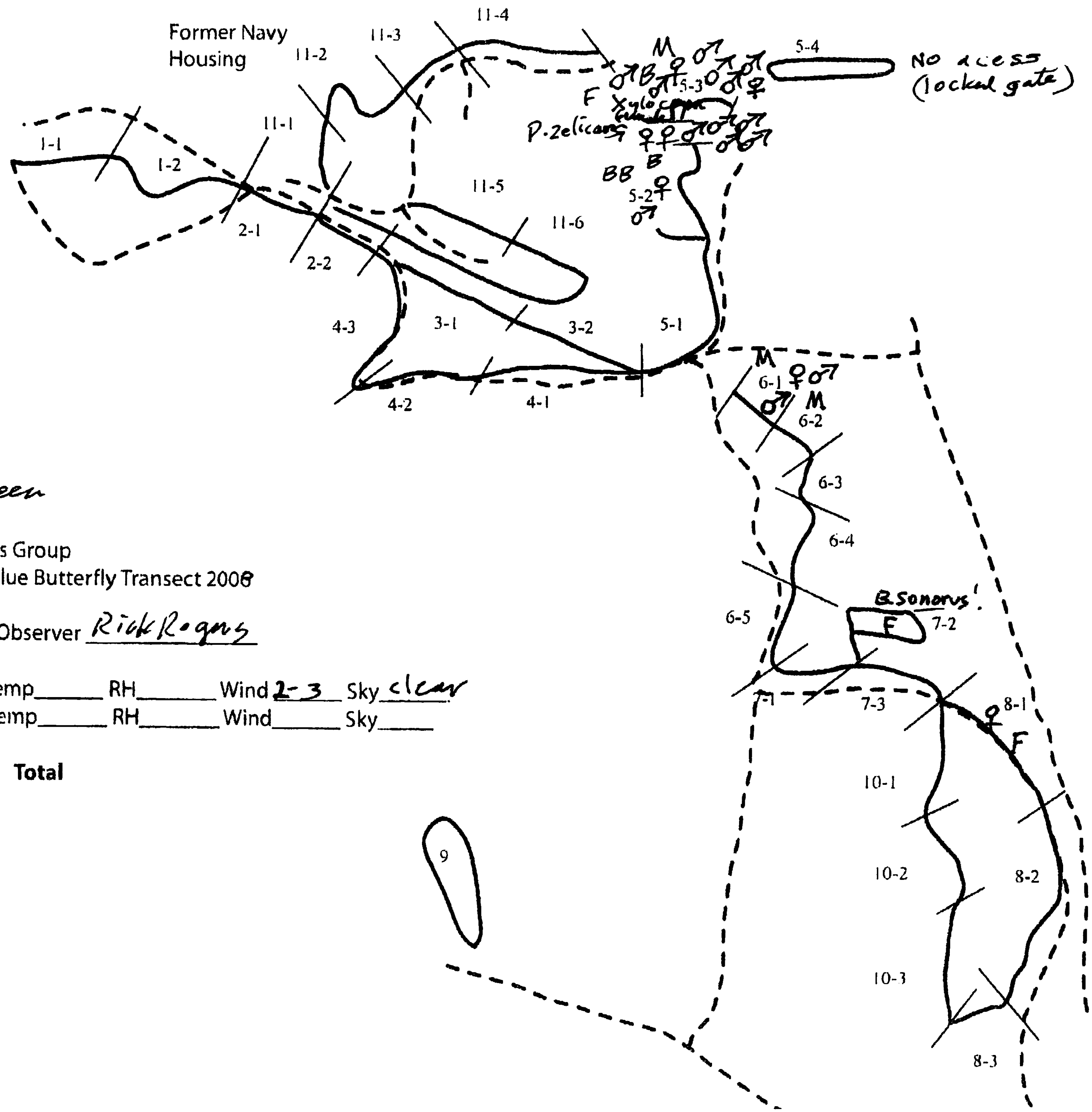
The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2009

Date Mar. 20, 09 Observer Rick Rogers

Time start 11:00 Temp 65° RH_____ Wind 1-2 Sky cloudy 80%
Time finish 1:00 Temp_____ RH_____ Wind_____ Sky_____

Legend **Total**

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



21 PVB's seen

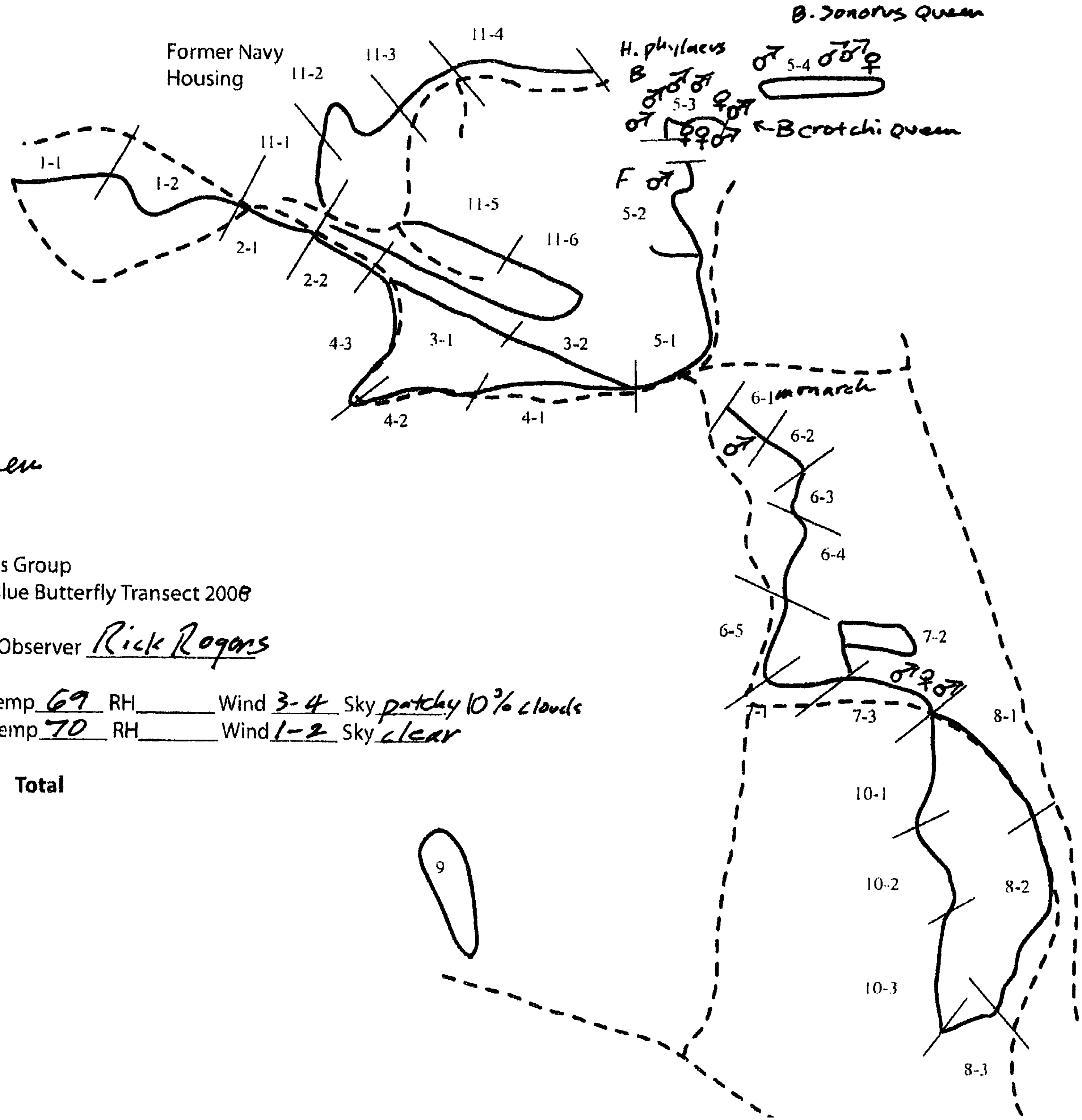
The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2008

Date Mar. 23, 09 Observer Rick Rogers

Time start ______ Temp______ RH______ Wind 2-3 Sky clear
Time finish______ Temp______ RH______ Wind______ Sky_____

Legend **Total**

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



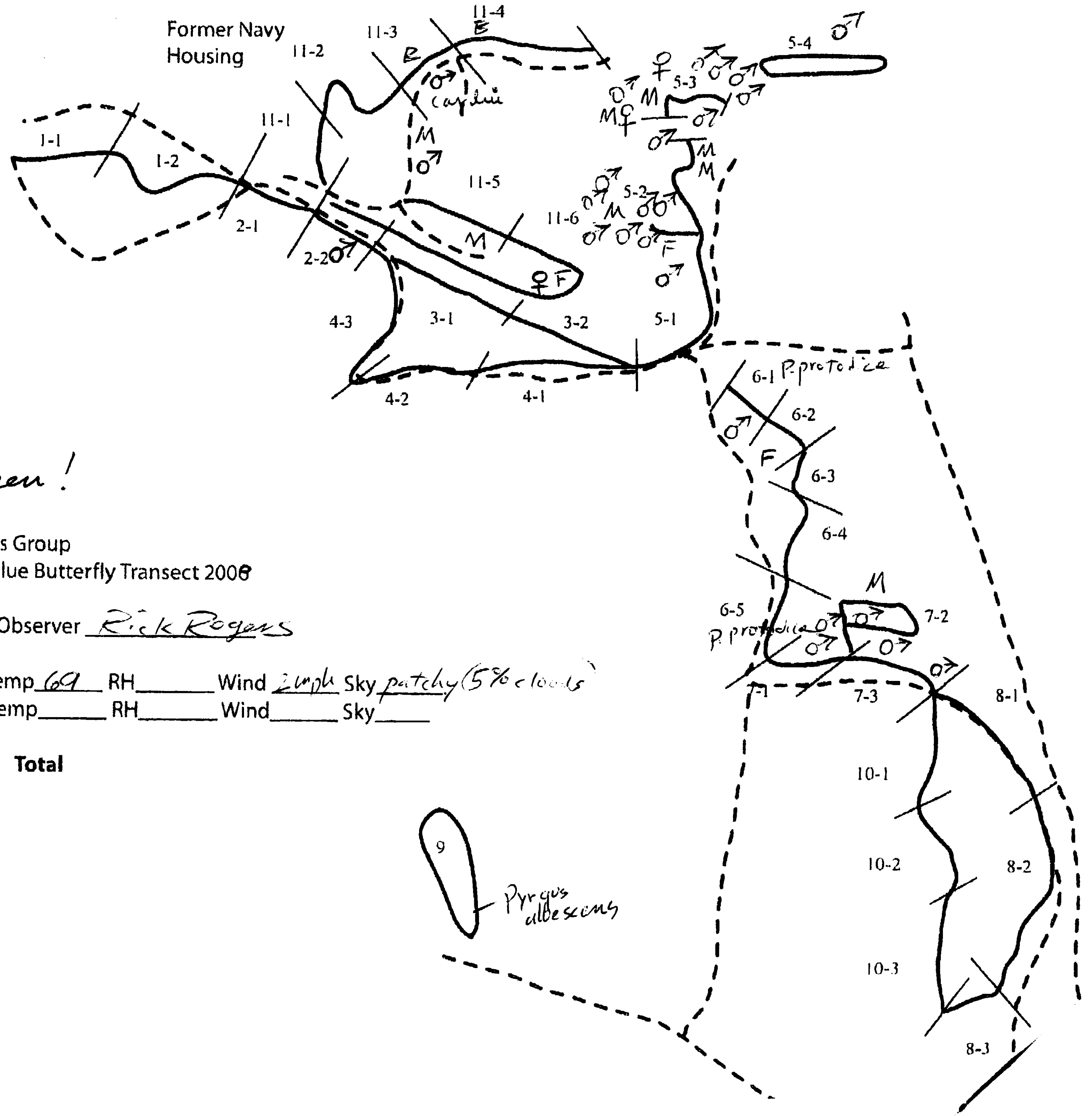
18 PVB's seen

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2008

Date Mar 26, 09 Observer Rick Rogers

Time start 11:00 Temp 69 RH ______ Wind 3-4 Sky patchy 10% clouds
Time finish 1:00 Temp 70 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*	



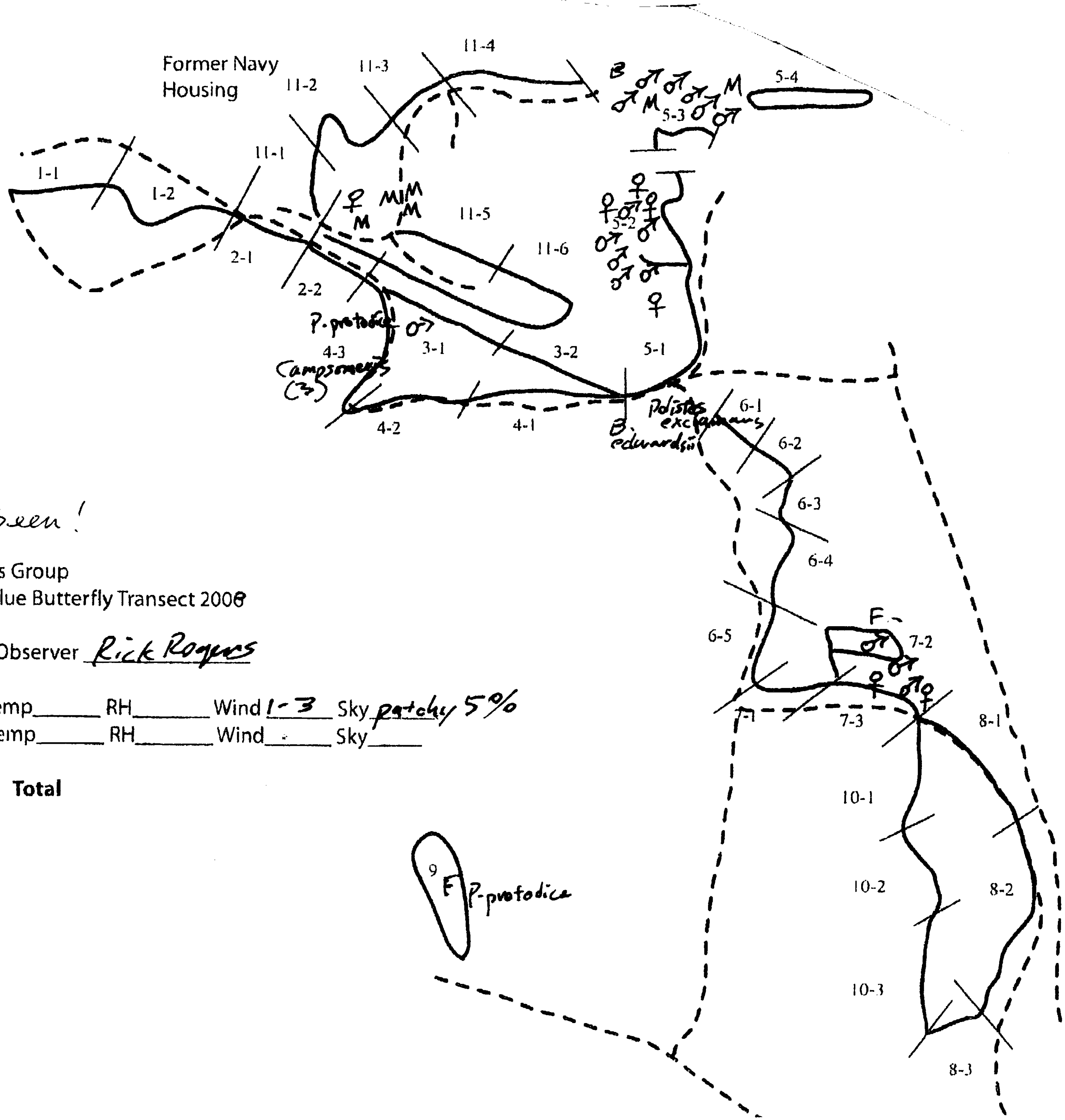
28 PVB's Seen!

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2008

Date Mar 30, 07 Observer Rick Rogers

Time start 10:30 Temp 69 RH_______ Wind 2 mph Sky patchy (5% clouds)
Time finish 12:30 Temp_______ RH_______ Wind_______ Sky_____

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



23 PVB's seen!

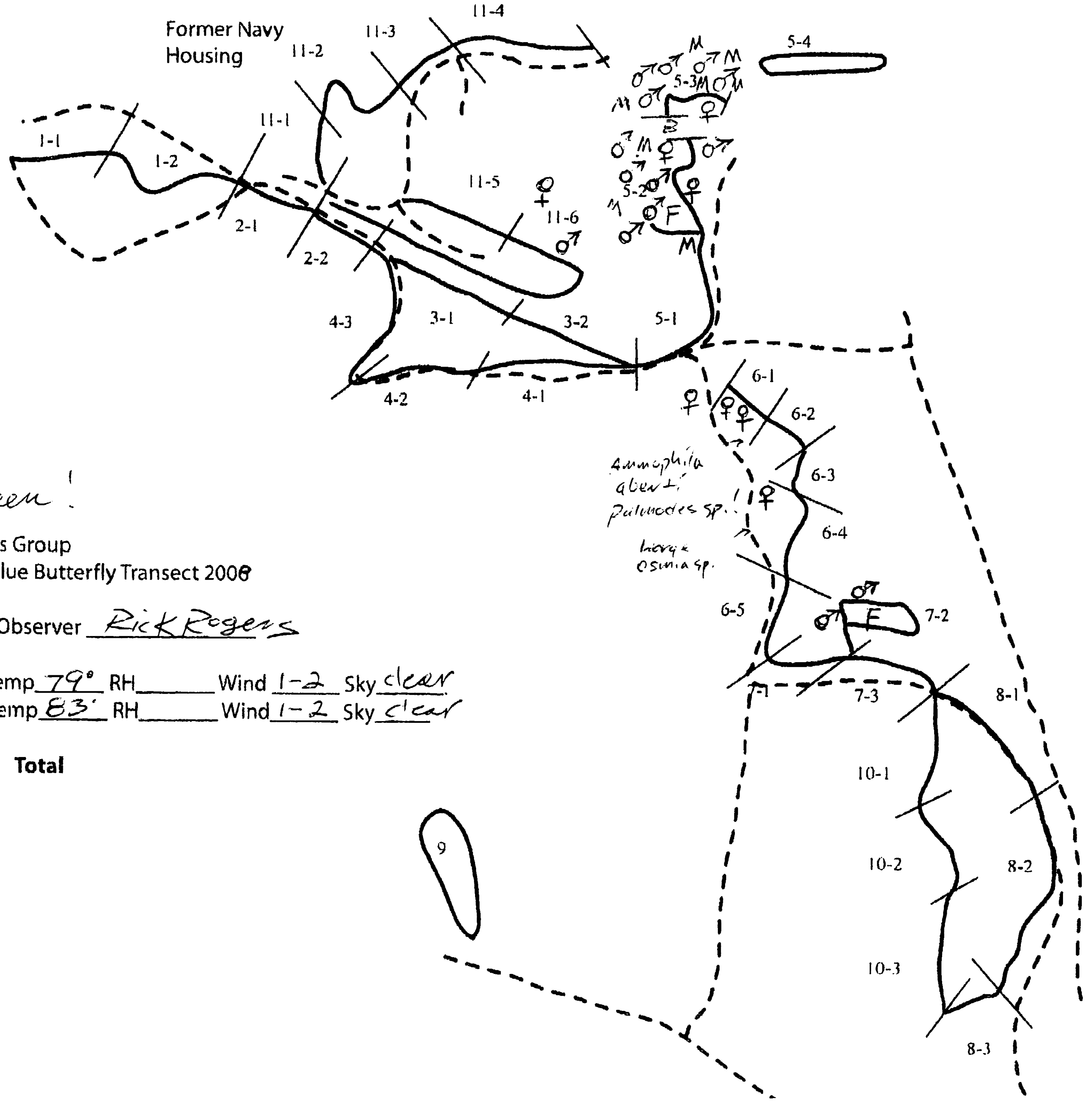
The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2008

Date April 4, 09 Observer Rick Rogers

Time start 11:15 Temp______ RH______ Wind 1-3 Sky patchy 5%
Time finish______ Temp______ RH______ Wind______ Sky______

Legend **Total**

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



22 PVB's seen!

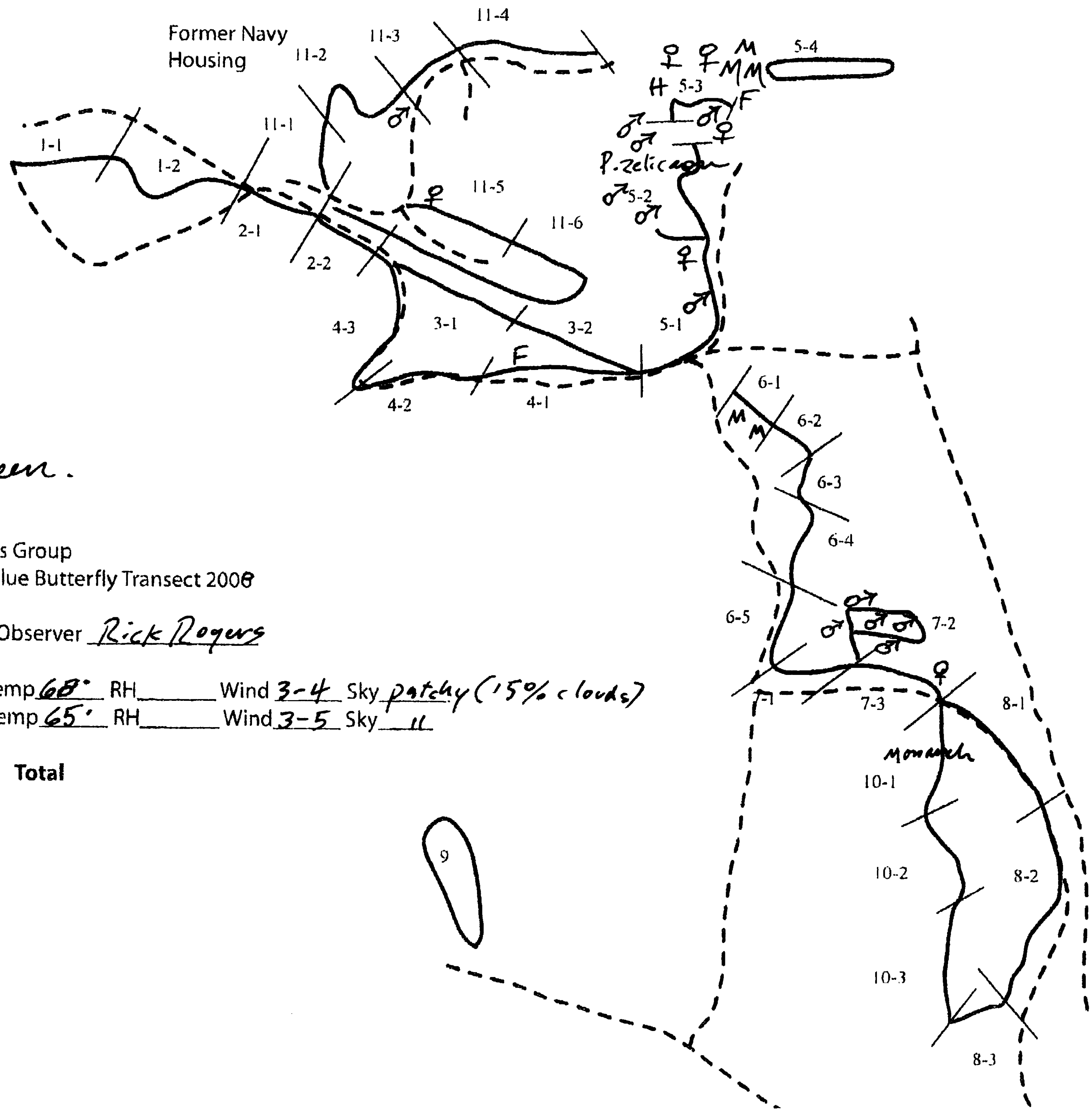
The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2009

Date April 6, 09 Observer Rick Rogers

Time start 11:30 Temp 79° RH______ Wind 1-2 Sky clear
Time finish 1:30 Temp 83° 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*



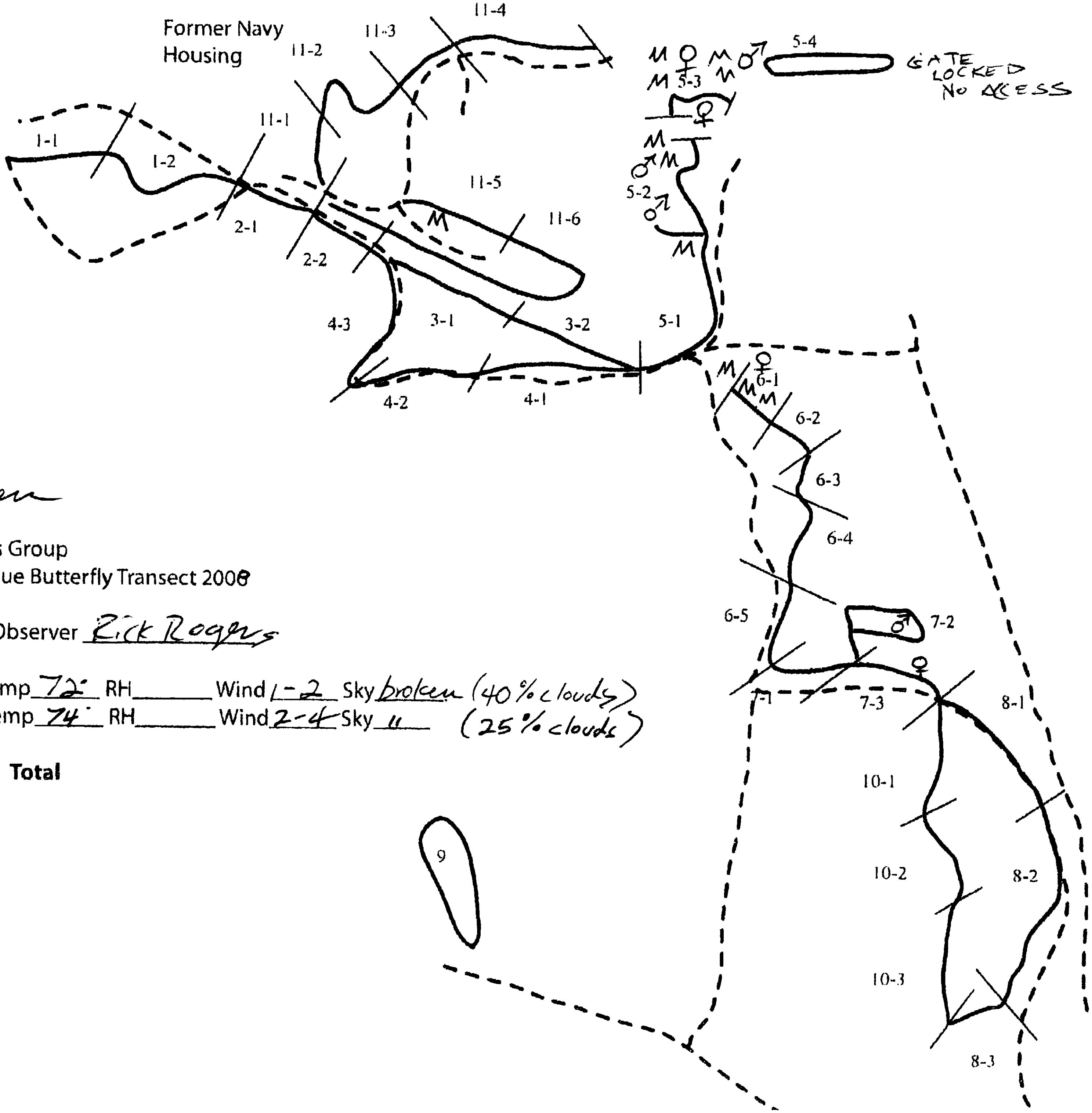
18 PVB's seen.

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2008

Date April 9, 09 Observer Rick Rogers

Time start 11:30 Temp 68° RH______ Wind 3-4 Sky patchy (15% clouds)
Time finish 1:30 Temp 65° RH______ Wind 3-5 Sky "

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



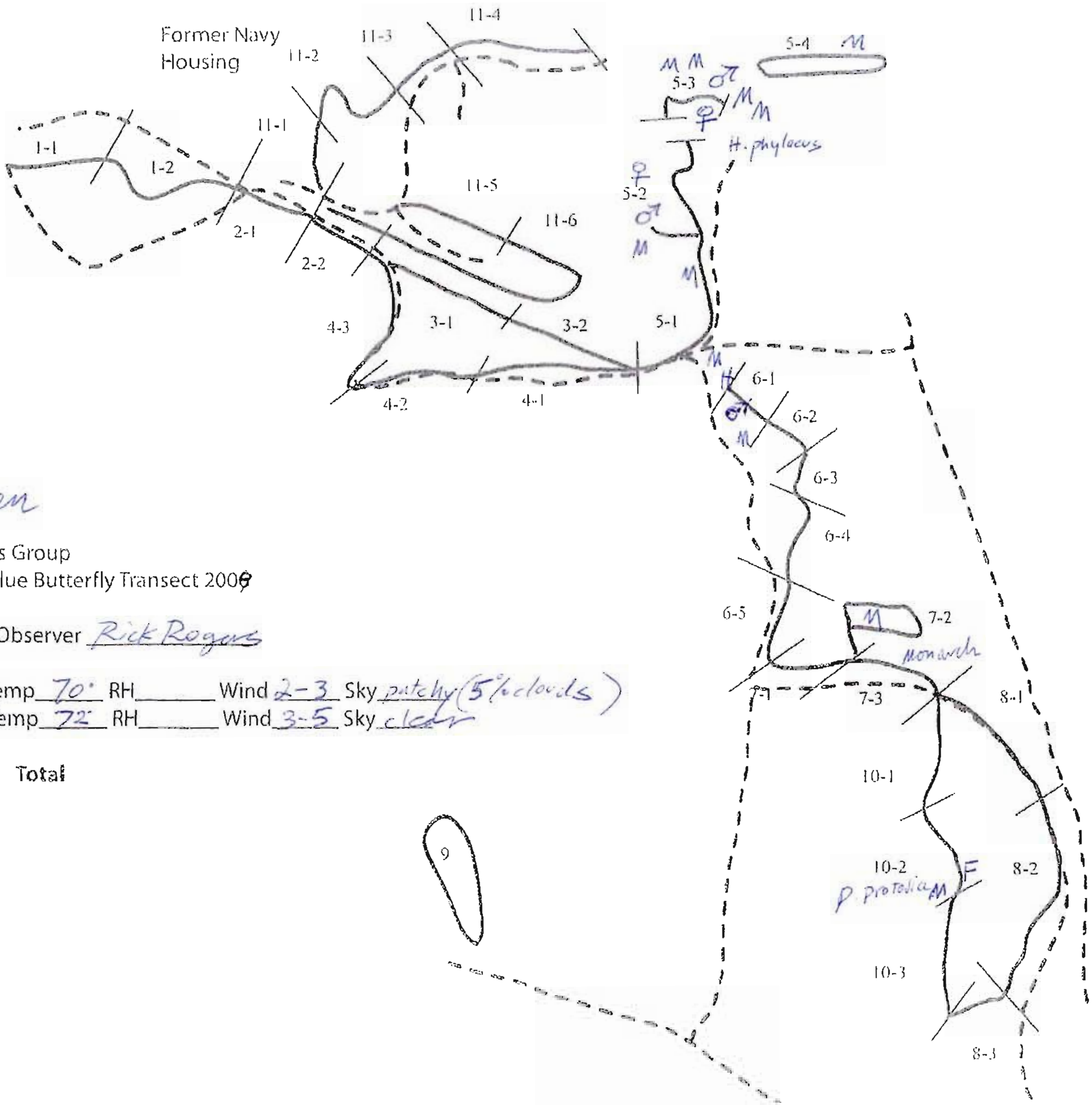
8 PVB's seen

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2008

Date April 13, 09 Observer Rick Rogers

Time start 11:30 Temp 72° RH_____ Wind 1-2 Sky broken (40% clouds)
Time finish 1:30 Temp 74° RH_____ Wind 2-4 Sky " (25% clouds)

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



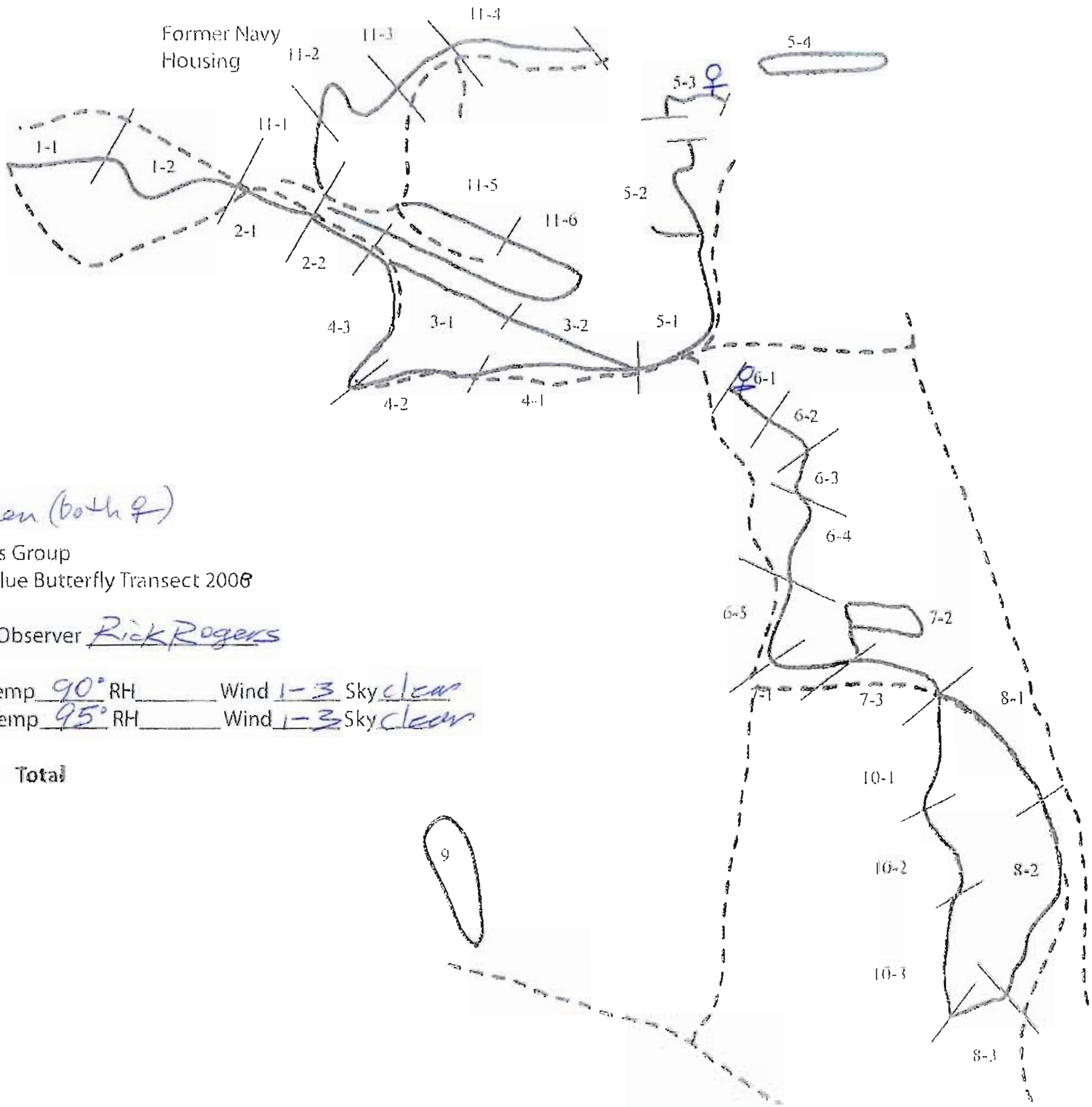
5 PVB's seen

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2009

Date April 16, 09 Observer Rick Rogers

Time start 11:15 Temp 70° RH_______ Wind 2-3 Sky patchy (5% clouds)
Time finish 1:15 Temp 72° 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*	



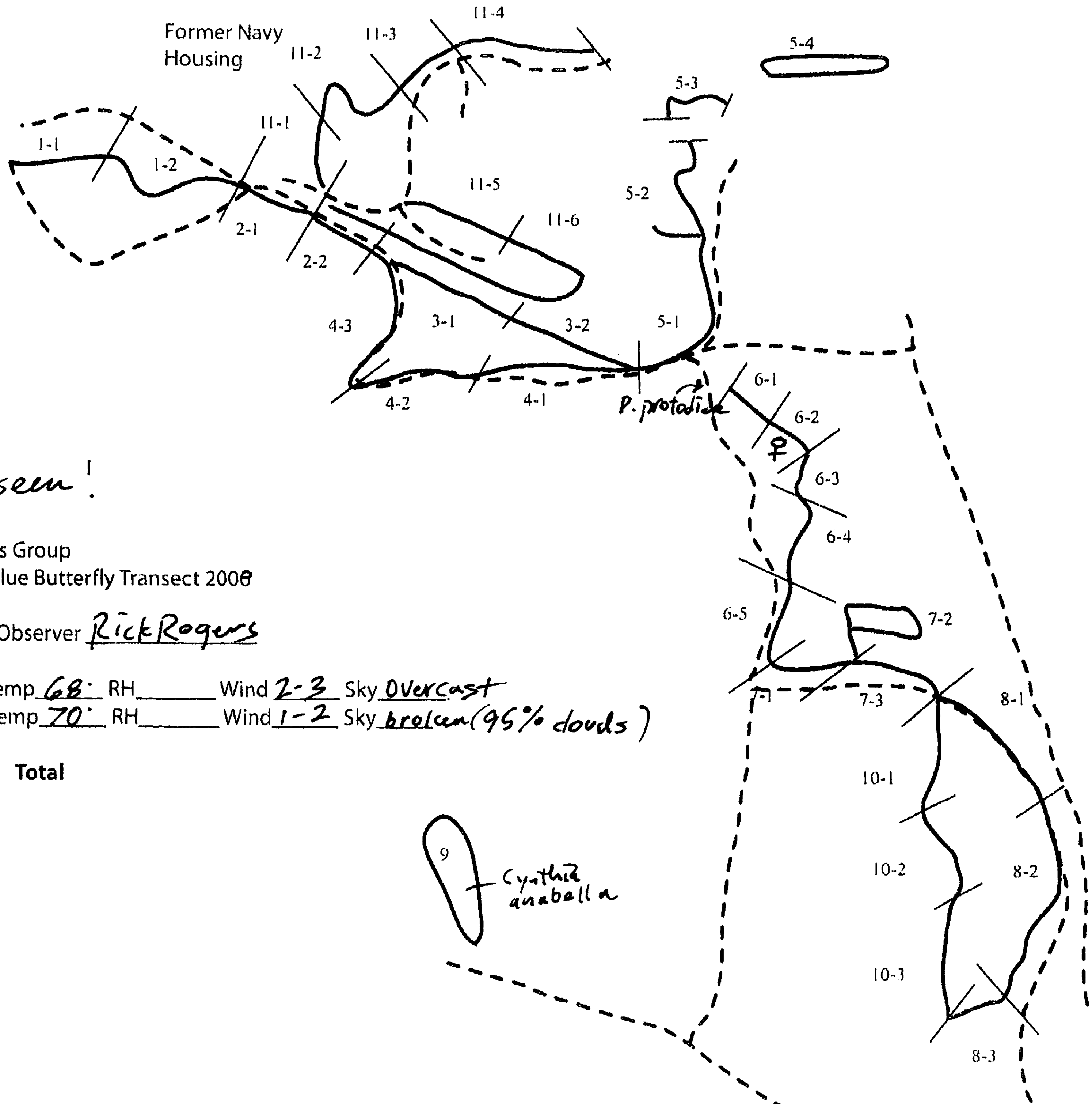
2 PVB's seen (both ♀)

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2008

Date April 20, 09 Observer Rick Rogers

Time start 11:00 Temp 90° RH______ Wind 1-3 Sky clear
Time finish 1:00 Temp 95° 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*	



~~[illegible]~~ 1 PVB ♀ seen!

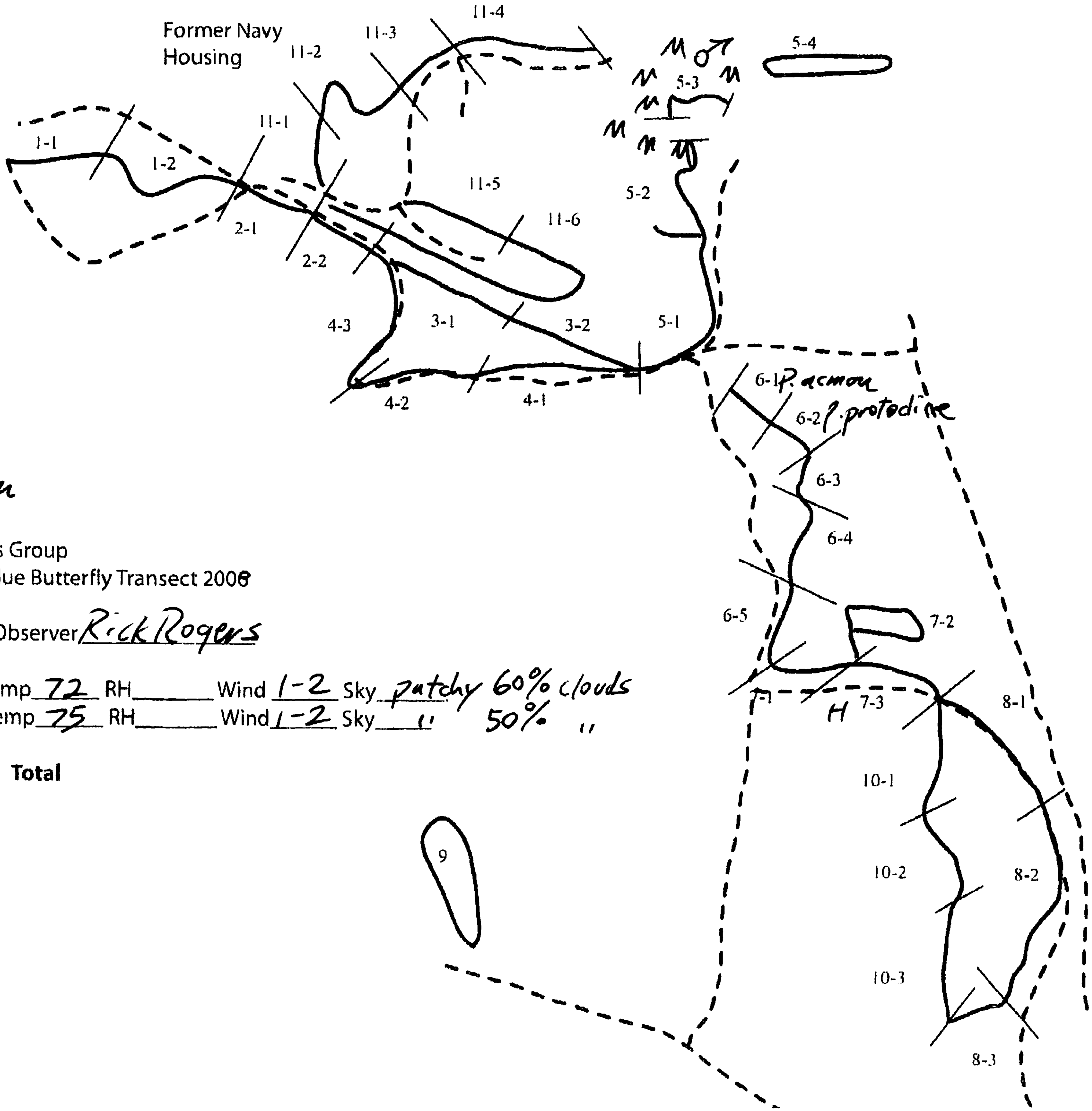
The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2009

Date April 23, 09 Observer Rick Rogers

Time start 11:00 Temp 68° RH ______ Wind 2-3 Sky Overcast
Time finish 1:00 Temp 70° RH ______ Wind 1-2 Sky broken (95% clouds)

Legend **Total**

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



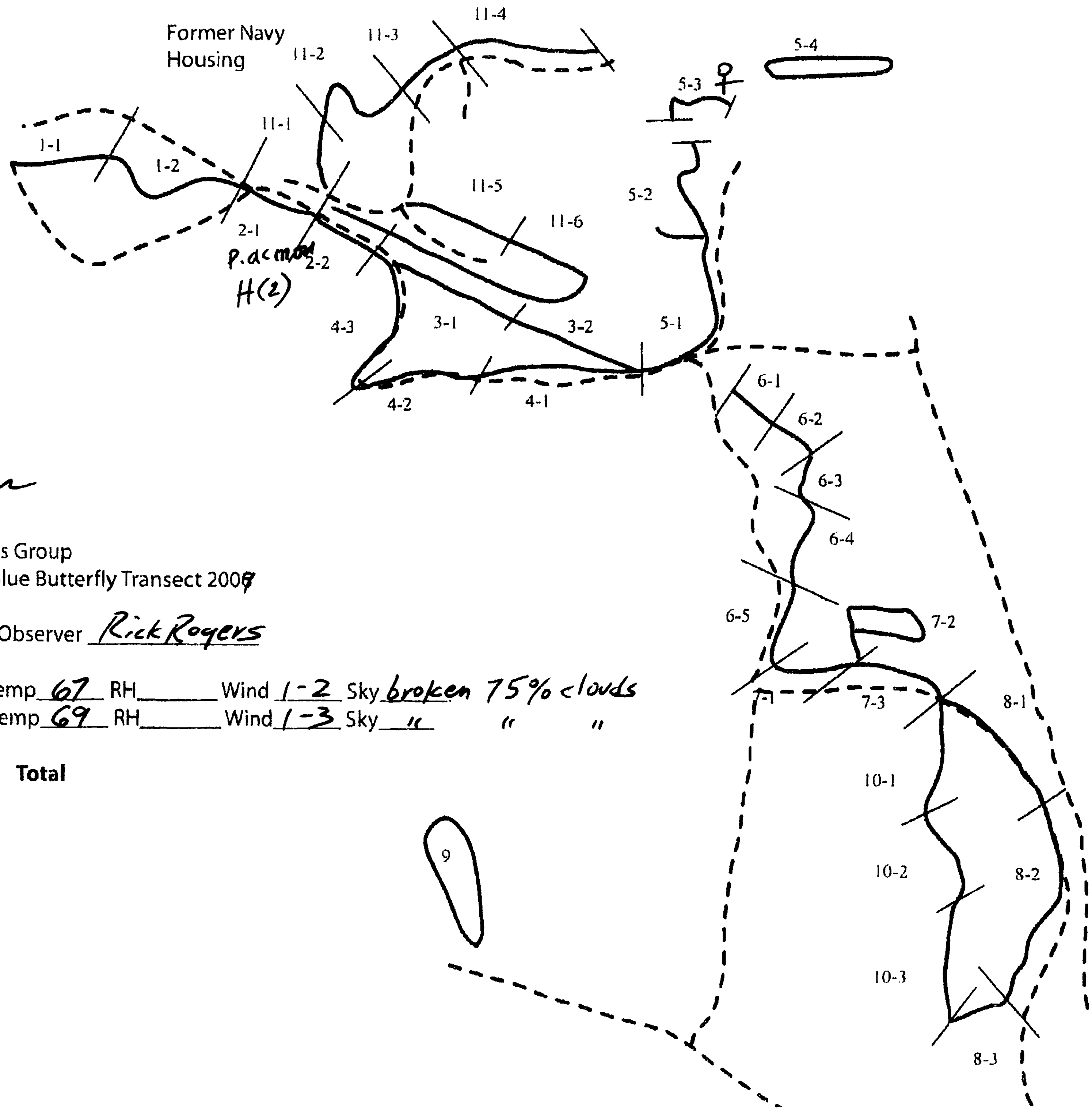
1 PVB seen

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2008

Date 4/27/09 Observer Rick Rogers

Time start 11:00 Temp 72 RH______ Wind 1-2 Sky patchy 60% clouds
Time finish 1:00 Temp 75 RH______ Wind 1-2 Sky " 50% "

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



1 PVB seen

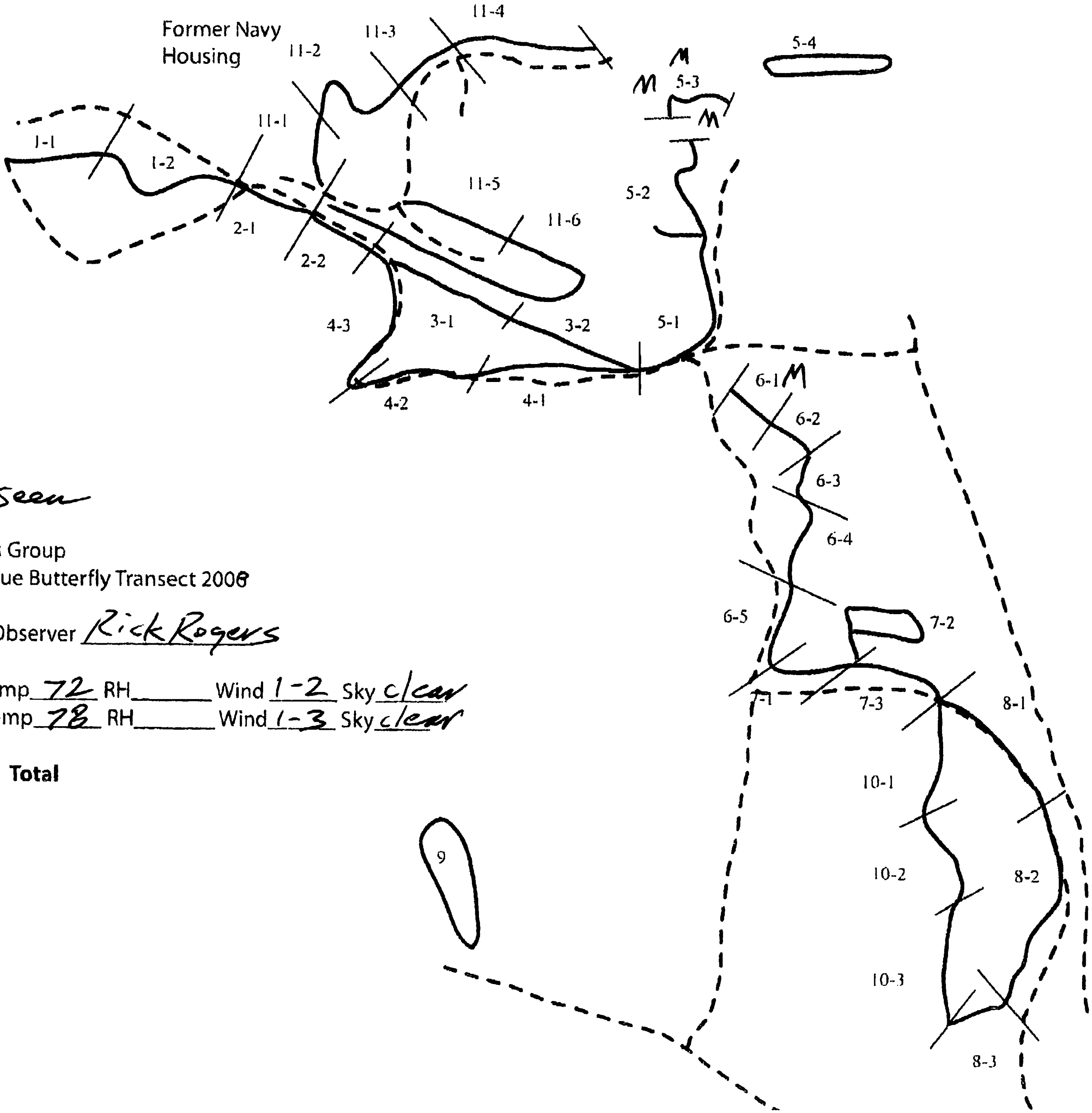
The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2009

Date May 1, 09 Observer Rick Rogers

Time start 11:00 Temp 67 RH______ Wind 1-2 Sky broken 75% clouds
Time finish 1:00 Temp 69 RH______ Wind 1-3 Sky " " "

Legend **Total**

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



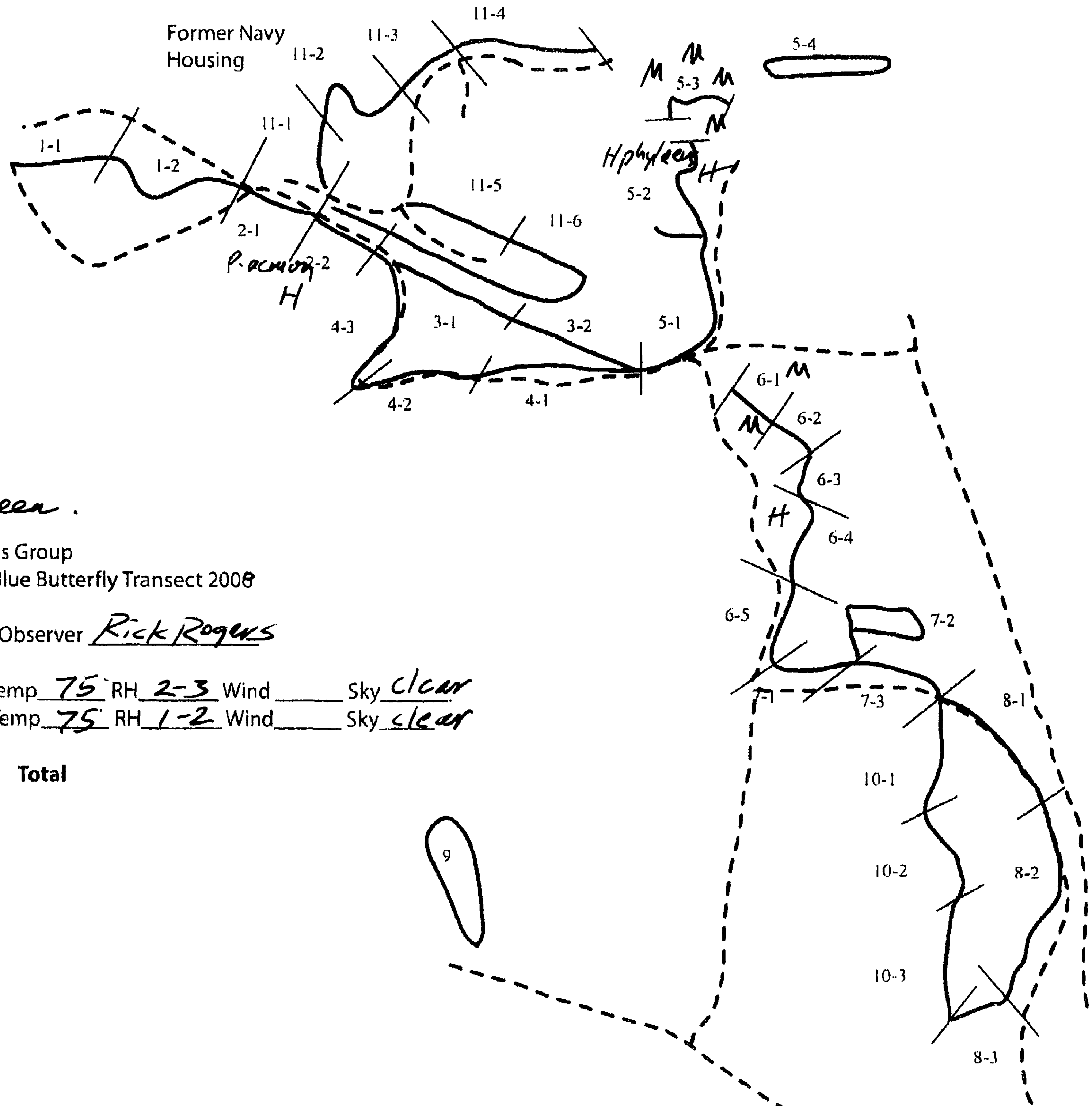
No PVB's seen

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2009

Date May 5, 09 Observer Rick Rogers

Time start 12:00 Temp 72 RH______ Wind 1-2 Sky clear
Time finish 2:00 Temp 78 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*	



No PVB's seen.

The Urban Wildlands Group
DFSP Palos Verdes Blue Butterfly Transect 2008

Date *May 8, 09* Observer *Rick Rogers*

Time start *11:00* Temp *75* RH *2-3* Wind ______ Sky *clear*
Time finish *1:00* Temp *75* RH *1-2* Wind ______ Sky *clear*

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