2012 Monitoring for the Pacific Pocket Mouse on the CNLM Dana Point Preserve (S033) Orange County, California

Funded by LAG Grant #1182116

Prepared for

Center for Natural Lands Management

Contact:
Lee Ann Carranza, Preserve Manager
34558 Scenic Drive
Dana Point, California 92629

Prepared by

Shana Dodd
4367 Coronado
San Diego, California 92107

William B. Miller
U.S. Fish and Wildlife Service
6010 Hidden Valley Road
Carlsbad, California 92011

Phil Brylski
61 Acacia Tree Lane
Irvine, California 92612

Figures prepared by CNLM
Lee Ann Carranza

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1. INTRODUCTION

Since acquiring the Dana Point Preserve (Preserve), the Center for Natural Lands Management (CNLM) has worked closely with the U.S. Fish and Wildlife Service (FWS) to develop a monitoring strategy for the Pacific pocket mouse (PPM; *Perognathus longimembris pacificus*) population on the Preserve. The need for monitoring to document population trends and to identify threats and management needs is identified in the PPM Recovery Plan (FWS 1998) as a necessary component of management plans that are needed for each of the extant PPM populations. In recognition of the characteristic low individual detectability of PPM, small population sizes that have historically been documented at Dana Point, and limited funding availability for monitoring, CNLM piloted a proportion area occupied (PAO) monitoring approach at Dana Point in 2008 and 2009 (*sensu* MacKenzie et al. 2006), focused on documenting PPM habitat use within historically occupied portions of the Preserve. While not specifically designed to estimate abundance, this method was successful at documenting 30 and 82 unique PPM in 2008 and 2009, respectively; population sizes not seen since the population's rediscovery (Brylski et al 2008, 2009). In 2009, exploratory surveys outside the area of historic occupancy also revealed that PPM are beginning to colonize the former Marguerita Roadbed and degraded habitat areas to the north of the road that are being restored as part of the Dana Point Preserve.

This report presents the results of monitoring the Preserve's PPM population in 2012 using Local Assistance Grant (LAG) funding from the California Department of Fish and Game (CDFG) under agreement P1182116. The survey was carried out from May 1-11, 2012. The 2012 survey utilized the same PAO methodology that was piloted in 2008 and 2009.

2. METHODS

The 2012 study area is the entire 29.4-acre CNLM Dana Point Preserve, including the former Marguerita Roadbed, and both north and south of the former Marguerita Roadbed. The area north of the road was not included in the grid overlay that was developed for the monitoring efforts in 2008 and 2009 because few PPM had ever been detected in that area. In October 2008 Marguerita Road was abandoned, its asphalt removed and restoration of the former roadbed was initiated. This reduced the degree of fragmentation within the Preserve and brought the core area of documented PPM occupancy into more effective contact with habitat being restored north of the former roadbed. In 2009, the area north of the road was surveyed for PPM along 12 transects, which led to the capture of two unique PPM. Based on the documented occurrence of PPM north of the former Marguerita Roadbed, CNLM decided to expand the grid-based survey methodology to this area, effectively expanding the PPM monitoring effort to the cover the entire CNLM Preserve.

The expanded 2012 sample frame contained 127 grid cells of which 74 were randomly selected for sampling. The original sample frame covering the area south of Marguerita Roadbed, from which 2008 and 2009 habitat use and abundance estimates are based, included 96 grid cells. However, field work in 2012 revealed that two of these grid cells (G2 and J12) are unsafe to access, so they were removed from the sample pool for this and future monitoring efforts. Thus, the expanded and modified 2012 sample frame includes 94 of the previously delineated grid cells south of Marguerita Roadbed, and 33 new grid cells within the former roadbed and area north of Marguerita Roadbed. In other respects, the survey effort in 2012 was functionally the same as the 2008 effort. The grid selection process occurred as follows:

- Among 127 grid cells within the sampling frame, 74 cells (58%) were randomly chosen for sampling. This was done by assigning all 127 grid cells a random number and choosing the grid cell with the lowest random value as the starting location for a systematic checkerboard sample design. The checkerboard design was chosen to optimize spatial coverage on the site by maximizing the

dispersion of sampled grid cells. The remaining grid cells were randomly chosen from the pool of cells that were not selected for sampling as part of the checkerboard.

- The 74 grid cells were divided into two sets of 37 to accommodate two 5 night sample sessions. It was decided by CNLM in consultation with USFWS that the two sessions would be divided geographically, with one set of 37 all in the northern area of the Preserve and the other set of 37 in the southern area of the Preserve. A coin toss determined the northern area would be surveyed first.

Session 1 trapping occurred May 1 thru May 6, 2012 and consisted of the northern half of the Preserve and included the following grid cells: AA10, AA12, BB11, A11, A13, B6, B7, B8, B10, B12, B14, B16, B18, C3, C5, C7, C9, C11, C13, C15, C16, C17, C18, D4, D6, D8, D10, D11, D12, D14, D16, D18, E9, E11, E13, E17 and E18. A total of 1,665 trap-nights were completed during this session. Session 2 occurred May 6 thru May 11, 2012 and consisted of the southern half of the Preserve and included the following grid cells: E3, E5, E7, F2, F4, F6, F8, F10, F12, F14, G1, G3, G4, G5, G7, G9, G10, G11, G13, H4, H6, H8, H10, H12, I3, I4, I5, I6, I7, I9, I11, I13, J4, J6 J7, J8, and J9. A total of 1,665 trap-nights were also completed during this session. Figure 1, *PPM Trapping Results, 2012*, shows the grid cells that were trapped. Sixteen of these grid cells were newly surveyed this year (not surveyed in 2008 and 2009).

Mark Recapture Data Analysis.
The data on species other than PPM is included in the summary of animal captures but was not included as part of the formal statistical analysis. PPM data was analyzed using Program MARK (White and Burnham 1999), (http://welcome.warnercnr.colostate.edu/~gwhite/mark/mark.htm) an online statistical software program developed for the analysis of capture-recapture data. Program MARK was used to estimate PPM abundance and the proportion of habitat that is used by PPM on the Preserve.

For estimation of both abundance and habitat use, midnight and morning trapping data was pooled and treated as a single trapping occasion. For estimation of PPM abundance, we used the Closed Captures function and applied the Huggins closed capture statistical models (Huggins 1989; Huggins 1991) to mark-recapture data collected for individual animals. These models estimate closed population size (N) from initial capture (p) and recapture (c) probabilities. Several alternative models attributing variation in detection probabilities to the factors of sex (male or female), time (i.e., night of capture), behavior (first capture or recapture), and combinations of each (e.g., time and behavior) were formulated within the design matrix and applied to the mark-recapture data. Models that did not obtain stable parameter estimates (e.g., obtained a standard error of zero) were removed from the candidate model set and results from the remaining models were compared with the null model, which assumes there is no variation in capture probability (Otis et al. 1978). Comparisons to determine which models were best supported by the data were made using Akaike's information criterion with a small sample size correction (AICc) (Burnham and Anderson 2002).

For estimation of habitat use, we used the Occupancy Estimation function in Program MARK and applied the single season, single species model (MacKenzie et al. 2002, MacKenzie et al. 2006) to data collected at each sampled grid cell or "site." This analysis pools individual animal capture records within each site by capture occasion to estimate the proportion of sites occupied or used (Ψ) by the target species, and the probability of detecting that species at a site on a given occasion [p(i)]. This data was analyzed using single season model formulations that modeled a constant capture probability among survey occasions, and that modeled occasion specific (e.g. nightly, weekly) capture probabilities. Model comparisons were also made using Akaike's information criterion with a small sample size correction (AICc) (Burnham and Anderson 2002).

3. RESULTS

The weather during the two five day sessions was characterized by mild nightly temperatures (60 to 65°F), clear to overcast skies, and low winds (0-5 mph). There was no precipitation during the surveys, but two mornings were very wet due to the heavy marine layer typical of Dana Point. Appendix 1 summarizes the weather data for the two survey sessions. It is worth noting that on May 6, 2012, the closest lunar perigee of the year coincided with a full moon.

Small Mammals Captured.

The survey yielded 700 captures of six rodent species (Table 1). All PPM were released immediately at the site of capture unharmed. There was mortality of eight desert woodrat and one California vole capture (the animals were caught in the partially closed entrance door to the trap). Such a high mortality of desert woodrat was unexpected and should be considered in future trapping efforts.

PPM accounted for 24% of all captures, making it the 3rd most commonly captured species. The western harvest mouse was the most common species captured (42%), followed by the desert woodrat (26%). There were substantial differences between sessions 1 and 2 with respect to captures of PPM (30% versus 17%), western harvest mouse (52% versus 31%), and desert woodrat (10% versus 45%).

Table 1. Summary of Small Mammal Captures

	Species*						
	PPM	**REME**	**NEBR**	**MICA**	**PEMA**	**PEFR**	
							Total
Session 1	110	193	35	29	0	1	368
% session 1	30	52	10	8	0	0	100
Session 2	58	104	148	21	1	0	332
% session 2	17	31	45	6	0	0	100
Totals	168	297	183	50	1	1	700
% of total	24	42	26	7	0	0	100

PPM, Pacific pocket mouse (*Perognathus longimembris pacificus*);
REME, western harvest mouse (*Reithrodontomys megalotis*),
NEBR, desert woodrat (*Neotoma bryanti*),
MICA, California vole (*Microtis californicus*),
PEFR, cactus mouse (*Peromyscus fraterculus*),
PEMA , deer mouse (*Peromyscus maniculatus*)

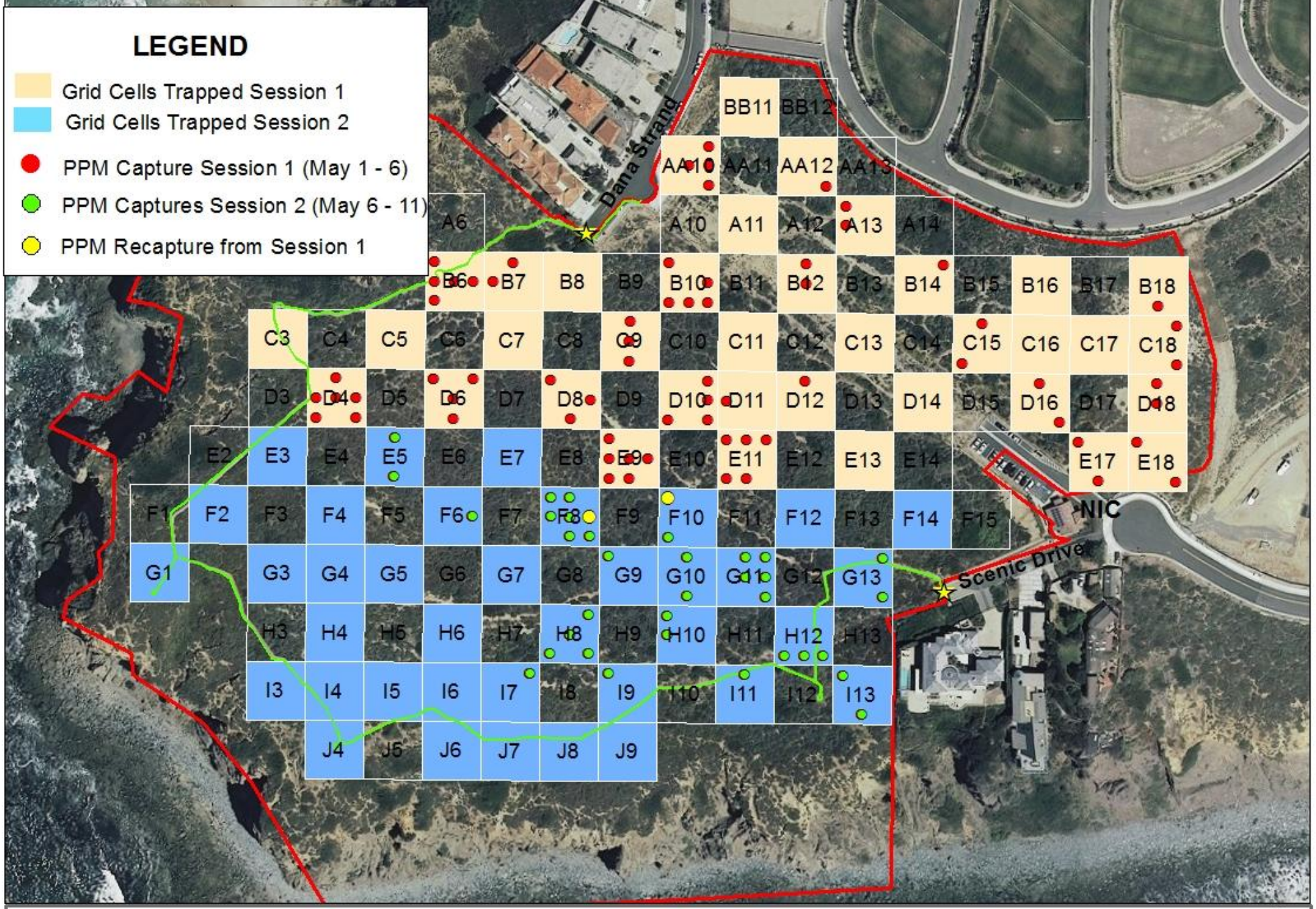

Figure 1: *PPM Trapping Results 2012*
Dana Point Preserve (S033)
Orange County, California

0 15 30 60 90 120
Meters

Center for Natural Lands Management

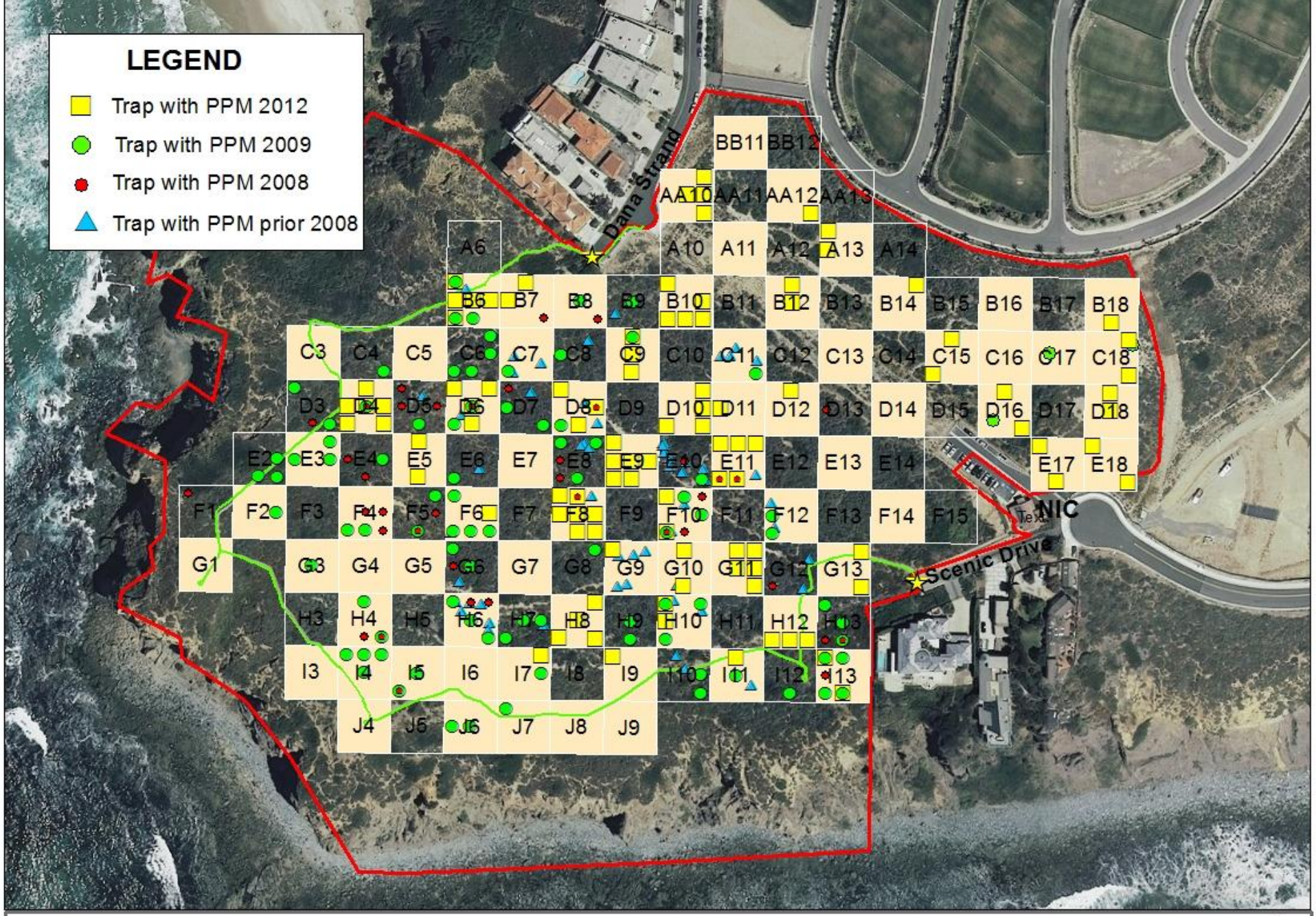

Figure 2: *PPM Trapping Results 2008, 2009 & 2012*
Dana Point Preserve (S033)
Orange County, California

PPM Captures and Abundance.
Four noteworthy results with respect to PPM were: (1) the number of unique PPM captures decreased from 82 (in 2009) to 57 individuals (in 2012) despite a similar trap effort (3,362 trap-nights in 2009 vs. 3,330 trap-nights in 2012, (2) PPM were captured in their highest numbers ever in the habitat north of the former Marguerita Roadbed, (3) South of the former Marguerita Roadbed, PPM were captured in 11 new cells in 2012 where they had not been recorded in the past, and (4) PPM were not captured in 14 cells in 2012 where they had been captured in 2009.

Table 2 summarizes the PPM capture results for the two sessions. Appendix 3 summarizes the sex, age, reproductive condition, weight of the captured PPM for the two sessions and distances moved by recaptured individuals. Appendix 4 lists the trap locations for each PPM capture.

Table 2. Summary of PPM Captures

	Total captures	Unique Individuals	Occupied Grid Cells
Session 1 (northern grids)	110	37	24
Session 2 (southern grids)	58	20	15
Total	**168**	**57**	**39**

Cumulatively, over the two 5-night trapping sessions, the 2012 survey yielded 168 captures of 57 unique PPM (Table 2). During the first session implemented on the northern half of the Preserve, a total of 37 unique adult PPM were captured comprised of 14 females and 23 males. Closed Capture analysis of Session 1 data found there was considerable model selection uncertainty, with several competing models receiving near equal support by the data (i.e., Delta AICc values of 2 or less) (Table 3). Models that received strong support included models that attribute variation in PPM detectability to all of the factors tested, including time, sex, and behavior. Due to model selection uncertainty, model averaging was used to calculate parameter estimates (Table 4). Overall, based upon point estimates, the strongest apparent pattern in detectability was a high first capture probability on the first night of the survey (e.g., p_1 female = 0.598, 95% Confidence Interval 0.32 to 0.824), followed by a gradual decline in detectability observed over the 5-night trapping session. There is also some suggestion that females were slightly more detectable than males. The point abundance estimate for females was 14.64 (95% C.I. 9.09-20.18) and males was 24.76 (95% C.I. 10.23-39.29), which is near equivalent to the number of unique individuals of each sex that were captured.

Table 3. Comparison of Closed Capture Models for North Grid Cells

Model	Model Type	AICc	Delta AICc	AICc Weights	Model Likelihood	Number of Parameters
p(t)= c(t)	Time	253.9848	0	0.26749	1	5
p(g+t) = c(g+t)	Time, Sex	254.6855	0.7007	0.18843	0.7044	6
p(.), c(.)	Behavior	254.869	0.8842	0.17191	0.6427	2
p(g+t),c(g+t)+b	Time, Behavior, Sex (additive)	255.5746	1.5898	0.1208	0.4516	7
p(.) = c(.)	Null	255.6302	1.6454	0.11749	0.4392	1
p(g)=c(g)	Null, Sex	256.291	2.3062	0.08443	0.3156	2
p(g), c(g)	Behavior, Sex	257.479	3.4942	0.04662	0.1743	4
p(g*t) = c(g*t)	Time, Sex (interaction)	263.0851	9.1003	0.00283	0.0106	10

Table 4. North Grid Cells Model Averaged Detectability and Abundance Estimates					
Parameter	Group	Estimate	SE	LCI	UCI
First capture probability, Night 1	Female	0.598	0.141	0.320	0.824
First capture probability, Night 2	Female	0.562	0.192	0.218	0.856
First capture probability, Night 3	Female	0.443	0.178	0.162	0.766
First capture probability, Night 4	Female	0.442	0.179	0.160	0.767
First capture probability, Night 5	Female	0.428	0.180	0.150	0.760
First capture probability, Night 1	Male	0.554	0.142	0.288	0.793
First capture probability, Night 2	Male	0.520	0.181	0.207	0.818
First capture probability, Night 3	Male	0.406	0.166	0.150	0.725
First capture probability, Night 4	Male	0.405	0.167	0.149	0.726
First capture probability, Night 5	Male	0.391	0.169	0.138	0.721
Recapture probability, Night 2	Female	0.569	0.119	0.339	0.773
Recapture probability, Night 3	Female	0.445	0.086	0.288	0.614
Recapture probability, Night 4	Female	0.443	0.086	0.286	0.611
Recapture probability, Night 5	Female	0.427	0.090	0.266	0.605
Recapture probability, Night 2	Male	0.528	0.106	0.326	0.720
Recapture probability, Night 3	Male	0.402	0.079	0.261	0.563
Recapture probability, Night 4	Male	0.400	0.080	0.258	0.562
Recapture probability, Night 5	Male	0.385	0.086	0.236	0.560
Abundance	Female	14.638	2.829	9.093	20.184
Abundance	Male	24.757	7.412	10.228	39.285

During the second session implemented on the southern half of the Preserve, 23 individual PPM were captured, including 3 animals originally captured on the northern half of the Preserve during session 1, and 20 animals that were unique to session 2. This indicates that there was some overlap in the effective trapping area of the northern and southern sample areas. The 23 captured individuals were comprised of 10 adult females and 13 adult males. Similar to session 1, the Closed Capture analysis for session 2 found some model selection uncertainty with the top supported models during this session including the null model, the null model with independent capture probabilities for males and females, and a behavior model (Table 5). These models indicate that first capture and recapture probabilities remained fairly constant over the 5-night trapping session, with estimates (e.g., p_1 female = 0.42, 95% C.I. 0.27-0.57) being most similar to the lower values estimated at the end of session 1. Estimated differences in detectability among males and females and between first capture and recapture probabilities were negligible (Table 6). The abundance estimate for females was 10.73 (95% C.I. 8.75-12.71) and males was 14.08 (95% C.I. 11.56-16.59), which again is near equivalent to the number of unique individuals of each sex that were captured during this session.

Table 5. Comparison of Closed Capture Models for South Grid Cells						
Model	Model Type	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par
p(.) = c(.)	Null	156.3474	0	0.52398	1	1
p(g) = c(g)	Null, Sex	158.1204	1.773	0.21593	0.4121	2
p(.), c(.)	Behavior	158.2994	1.952	0.19745	0.3768	2
p(g), c(g)	Behavior, Sex	162.163	5.8156	0.02861	0.0546	4
p(t) = c(t)	Time	163.1969	6.8495	0.01706	0.0326	5
p(g+t) = c(g+t)	Time, Sex (additive)	164.8339	8.4865	0.00752	0.0144	6
p(t), c(t)}+b	Time, Behavior (additive)	165.0637	8.7163	0.00671	0.0128	6
p(g+t), c(g+t)}+b	Time, Behavior, Sex (additive)	167.0655	10.7181	0.00247	0.0047	7
p(g*t) = c(g*t)	Time, Sex (interaction)	171.4567	15.1093	0.00027	0.0005	10

Table 6: South Grid Cells Model Averaged Detectability and Abundance Estimates					
Parameter	Group	Estimate	SE	LCI	UCI
First capture probability, Night 1	Female	0.415	0.078	0.274	0.570
First capture probability, Night 2	Female	0.417	0.080	0.274	0.577
First capture probability, Night 3	Female	0.416	0.079	0.273	0.575
First capture probability, Night 4	Female	0.416	0.081	0.270	0.578
First capture probability, Night 5	Female	0.421	0.086	0.267	0.592
First capture probability, Night 1	Male	0.401	0.076	0.266	0.554
First capture probability, Night 2	Male	0.404	0.078	0.265	0.561
First capture probability, Night 3	Male	0.403	0.077	0.264	0.559
First capture probability, Night 4	Male	0.403	0.079	0.262	0.562
First capture probability, Night 5	Male	0.408	0.083	0.260	0.576
Recapture probability, Night 2	Female	0.411	0.071	0.282	0.553
Recapture probability, Night 3	Female	0.407	0.066	0.287	0.539
Recapture probability, Night 4	Female	0.407	0.065	0.288	0.538
Recapture probability, Night 5	Female	0.407	0.066	0.287	0.539
Recapture probability, Night 2	Male	0.393	0.062	0.279	0.519
Recapture probability, Night 3	Male	0.391	0.062	0.279	0.516
Recapture probability, Night 4	Male	0.391	0.062	0.279	0.517
Recapture probability, Night 5	Male	0.396	0.066	0.276	0.530
Abundance	Female	10.730	1.010	8.751	12.710
Abundance	Male	14.076	1.284	11.559	16.592

Grid Cell Detections.
Combined across the two sessions, 168 PPM captures were recorded within 39 of the 74 grid cells surveyed, yielding a naïve habitat use estimate of 53% (i.e., without correcting for imperfect detection probability). Statistical analysis of the grid cell capture data found support for two single season habitat use models, one that held the detection probability (p) to be constant over the 10 nights of trapping, and one that modeled distinct detection probabilities for each 5-night trapping session implemented on the northern and southern portions of the Preserve, respectively (see Table 7). Model averaged parameter estimates suggest that, within a grid cell, PPM were slightly easier to detect during the first trapping session implemented on the northern grid cells relative to the second session implemented to the south. However, detection probabilities during both sessions were reasonably high, with the informed habitat use estimate of 54% (95 % confidence interval, 43-66%) almost equivalent to the naïve estimate uncorrected for detection probability.

Table 7. Comparison of 2012 Habitat Use Models for the Dana Point Preserve

Model	Model Type	AICc	Delta AICc	AICc Weights	Model Likelihood	Num. Par
{p(.), psi(.)}	Constant p	374.1243	0	0.59867	1	2
{p(session1, session2), psi(.)}	Session specific p	374.9256	0.8013	0.40104	0.6699	3
{p(t), psi(.)}	Full time dependence, nightly p	389.4278	15.3035	0.00028	0.0005	11

Table 8. 2012 Model Averaged Capture Probability and Habitat Use Estimates

Parameter	Estimate	SE	LCI	UCI
p 1	0.533	0.045	0.445	0.619
p 2	0.533	0.045	0.445	0.619
p 3	0.533	0.045	0.445	0.618
p 4	0.533	0.045	0.445	0.618
p 5	0.533	0.045	0.445	0.618
p 6	0.495	0.060	0.380	0.610
p 7	0.495	0.060	0.380	0.610
p 8	0.495	0.060	0.380	0.610
p 9	0.495	0.060	0.380	0.610
p 10	0.495	0.060	0.379	0.610
Ψ	0.543	0.060	0.425	0.657

Spatially, a majority of the grid cell detections (24 of 39) were observed during session 1 performed on the northern half of the Preserve. This imbalance in detections is reflected in fine scale habitat use estimates for each half of the Preserve. About 64 percent (95% C.I. 44-79 %) of habitat in the northern half of the Preserve and 45 percent of habitat (95% C.I. 28-64%) within the southern half of the Preserve was estimated to be used by PPM at the time of sampling.

PPM were captured in 12 of the 19 new grid cells sampled along the former Marguerita Roadbed and to the north, and in 27 of the 55 grids cells sampled south of the former Marguerita Roadbed. Figure 1, *PPM Trapping Results 2012*, shows the distribution of these captures.

For comparison with habitat use estimates from 2008 and 2009 we performed a similar analysis using just the 2012 data collected from grid cells within the former survey frame (i.e. grid cells south of Marguerita Roadbed). This reduced the sample size from 74 grid cells to 55 grid cells. Model comparisons from this analysis found the strongest support for a model with distinct detection probabilities during the two survey sessions. The 2012 model averaged habitat use estimate for the area south of Marguerita Roadbed was 52 percent (95% C.I. 38-65%), with session 1 and session 2 detection probabilities estimated to be 70 percent (95% C.I. 56-81%) and 47 percent (95% C.I. 34-61%), respectively.

Age Structure, Sex Ratio, Reproductive Conditions, and Individual Movements.
All of the PPM captured during the two sessions were considered to be adults. No juveniles or young of the year were captured. Thus, sampling during the first ten days of May appears to have preceded the emergence of young of the year; which is our goal for comparing population estimates among years. The sex ratio for all unique PPM was skewed toward males (33M:24F) for both sessions combined, but statistically the sample size is too small to conclude there were significantly more males than females. However, the difference in numbers of males and females is within the range of ratios observed in the past on the Preserve. Of the 37 PPM captured during session 1, the sex ratio was 23M:14F; and of the 20 unique PPM captured during session 2, the sex ratio was 10M:10F. Both sexes were reproductive at the time of sampling with most males observed to be scrotal or semi scrotal and many females observed to be pregnant and/or had distended mammae.

Of the 57 unique PPM captured in the study area, 14 were captured only once and the remaining 43 individuals were captured two or more times[1]. The average number of times individuals were recaptured was 3.58 (range 2-8).

The mean distance between recaptures was 15.4 meters (including the three recapture of individuals in Session 2 that were first captured in Session 1), nearly double the average movement of 8.4 meters found in 2009. The maximum distance moved was also calculated by summing the distances among all consecutive recaptures per unique individual. The maximum distance moved in 2012 was 154 meters. The distances moved between captures of the same individual are plotted in Figure 3, *PPM Individual Movements, 2012*.

4. DISCUSSION

PPM Status on the CNLM Preserve.

Similar to prior monitoring efforts, staffing of the 2012 survey effort required that two trapping sessions be performed to visit the number of grid cells chosen for sampling across the Preserve. During prior efforts the grid cells selected for each session were chosen entirely at random to avoid confounding spatial patterns in habitat use with temporal trends in detectability. However, this precluded our ability to sum abundance estimates from the two trapping sessions because interdigitation of the sample areas for each trapping session resulted in the recapture of individual PPM in adjoining grid cells sampled during alternate sessions. Thus, the abundance estimates were not spatially independent.

Although the 2012 effort employed the same sized grid cells previously chosen as the basis for population and habitat use monitoring (24 meters x 24 meters), it differed from prior efforts in two respects. First, the sample frame was expanded to include the former Marguerita Roadbed and restored habitat to the north. This resulted in the addition of 33 grid cells to the sample frame, for a total pool of 127 grid cells

[1] This includes 3 recaptures of individuals first captured in Session 1 and recaptured in Session 2.

that were available for sampling in 2012 and going forward. Second, sampling during the two trapping sessions was modified to a stratified random sample design that spatially divided the Preserve into discrete northern and southern survey areas. These survey areas were respectively surveyed during the two sessions to improve spatial inference and surveyor efficiency.

Cumulatively, the 2012 survey yielded 57 unique PPM across the northern and southern portions of the CNLM Preserve, including the capture of individuals in many of the new cells established north of the former Marguerita Roadbed. Of the 57 PPM, 3 individuals were captured during both trapping sessions, indicating there remains some overlap of the effective trapping areas during the two sessions, with around 5 percent of the animals captured in common among the divided sample areas. Nevertheless, division of the Preserve into two discrete sample areas does appear to have appreciably reduced the degree of overlap of the effective trapping areas for the two sessions. In comparison, in 2009, 14 of 80 animals (18%) were captured in common among the two trapping sessions.

Ignoring overlap of the effective trapping areas among the 2012 trapping sessions, addition of the point estimates for population size suggest around 64 PPM were present and available for capture in May of 2012. If one assumes that this estimate has a 5 percent positive bias based on the number of animals captured in common among the two sessions, then an adjusted abundance point estimate would be around 61 individuals for the Preserve, or just 4 animals more than were captured during the monitoring effort.

Due to the aforementioned problem summing 2008 and 2009 session level population estimates, and the use of less systematic sampling methods within Marguerita Road and the habitat to the north during those years, one cannot directly compare the 2012 abundance estimates with results from prior years. However, based on the capture of 30 and 82 unique individuals within the Preserve in 2008 and 2009, respectively, it appears likely that the 2011-2012 overwinter population of PPM was intermediate in size relative to the two most recent trapping efforts. It is also the second highest number of PPM to ever be documented at Dana Point.

Because PPM have been observed to undergo dramatic annual population fluctuations, the 2012 population estimate does not in itself provide an indication of population trend. Possibly of greater importance for management is the suggestion from the session level abundance point estimates that PPM are persisting in higher densities in the northern portion of the Preserve relative to the southern portion of the Preserve. Because the northern area has recently been exposed to a greater level of habitat disturbance, associated with the removal of Marguerita Road and implementation of habitat restoration, this suggests that the PPM population within the southern portion of the Preserve may have potential to benefit from some habitat manipulation.

Comparison of 2012 with Previous Years (2008/2009)

Small Mammals Captured.

Relative to the cumulative capture total of all small mammal species within the Preserve, the percentage of PPM captures in 2012 (24%) was down from 2009 (28%) but higher than in 2008 (15%) (Table 9). Comparatively, western harvest mouse capture totals were down in 2009 (21%) and increased dramatically in 2012 (42%). California vole captures were the highest ever recorded with 7 captures within the Preserve in 2012. No non-native rodents (house mouse and Norway rats) were captured in 2012. Provided that spikes or declines in captures of these species are indicative of underlying changes in abundance, this data is important to track as an indication that the habitat is improving in quality for these species and potentially shifting away from PPM suitability.

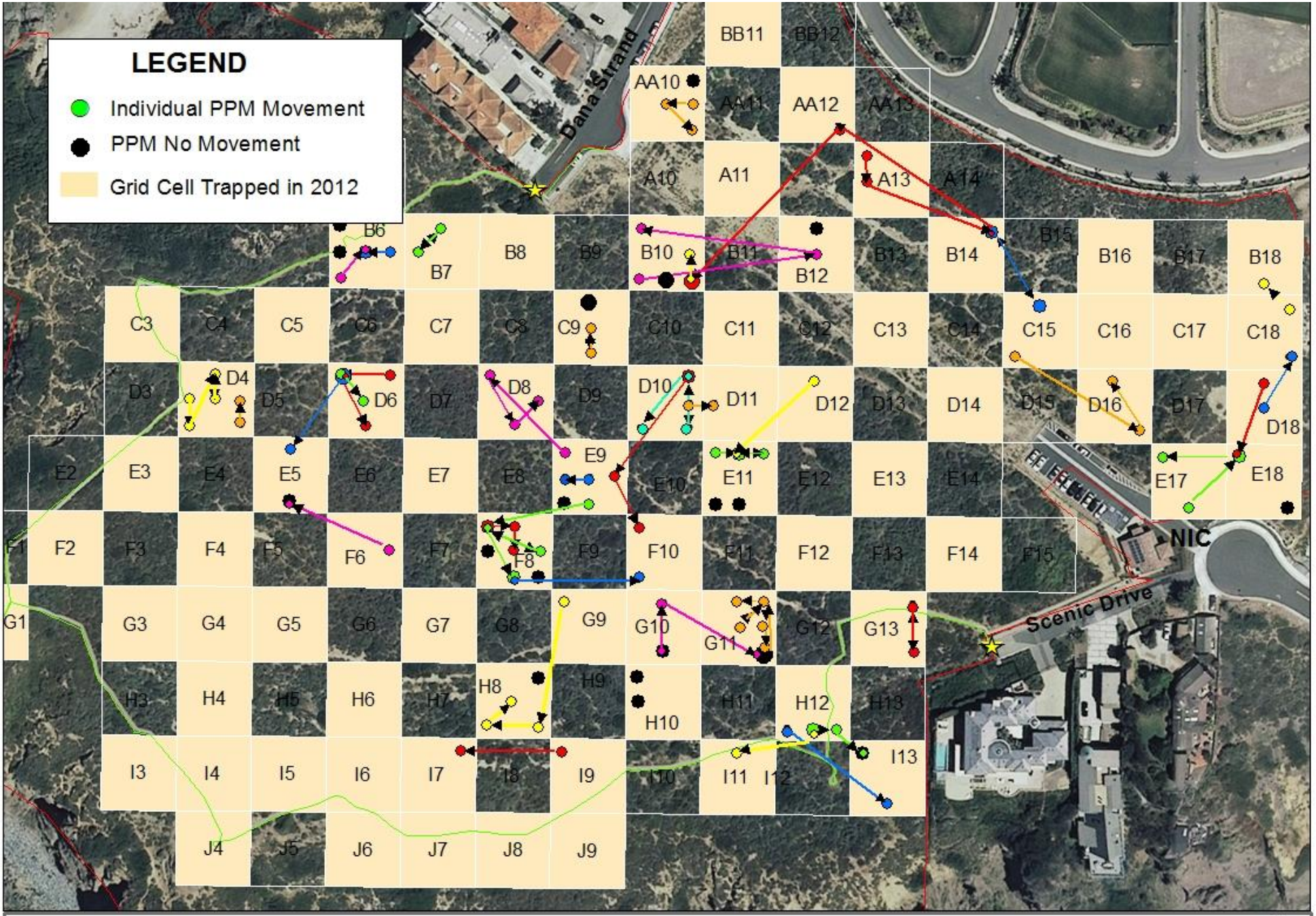

Figure 3: *PPM Individual Movement 2012*
Dana Point Preserve (S033)
Orange County, California

Center for Natural Lands Management

Table 9. Summary of Capture Percentages between 2008, 2009, and 2012								
	Species							
	PPM	**REME**	**NEBR**	**MICA**	**PEMA**	**PEFR**	**MUMU**	**RANO**
2008	15	43	34	2	5	0	1	1
2009	28	21	50	0	0	0	0	0
2012	24	42	26	7	0	0	0	0

PPM, Pacific pocket mouse (*Perognathus longimembris pacificus*);
REME, western harvest mouse (*Reithrodontomys megalotis*),
NEBR, desert woodrat (*Neotoma bryanti*),
MICA, California vole (*Microtis californicus*),
PEFR, cactus mouse (*Peromyscus fraterculus*),
PEMA, cactus mouse (*Peromyscus maniculatus*);
MUMU, house mouse (*Mus musculus*);
RANO, Norway rat (*Rattus norvegicus*)

PPM Habitat Use.
In 2012, the PPM habitat use estimate for the entire Preserve was 54 percent (95% confidence interval, 43-66%). In 2009, before proportion area occupied methods were expanded to include the former Marguerita Roadbed and areas north, the habitat use estimate was 74 percent (95% confidence interval, 60- 84%).

For direct comparison with 2009 results, we used data from only those grid cells within the 2009 survey frame and calculated habitat use to be 52 percent (95% confidence interval, 38- 65 %). Thus, the 95 percent confidence intervals for 2012 habitat use across the entire Preserve and within just the 2009 survey frame overlap the confidence interval for the 2009 estimate, but the point estimates suggest habitat use was down appreciably in 2012 relative to 2009.

Spatially, the pattern of PPM captures within the Preserve in 2012 was remarkable, with 27 captures of 11 individuals recorded within the former Marguerita Roadbed and areas to the north. Historically, just one PPM is reported to have been trapped in this area in the late 1990's, when the road was still in place and the adjoining habitat to the north was degraded by walking trails and public use. Following restriction of public access, removal of Marguerita Road and initiation of coastal sage restoration in this vicinity, exploratory trapping surveys recorded no individuals in this area in 2008 and 3 captures of 2 individuals in 2009. In 2011, a tracking tube study utilizing similar proportion area occupied methods to the present study indicated that PPM were beginning to colonize much of the habitat in this area, but this effort did not study the relationship between the PPM activity observed via the tracking tubes and PPM density. Thus, the 2012 results confirm that a number of PPM have colonized and are utilizing habitat in the former roadbed and habitat to the north of Marguerita Road indicating that the suitability of habitat in this area has improved for PPM, likely as a result of decreased fragmentation and changes in other habitat attributes such as vegetative cover and soil conditions.

One unanticipated result is the difference in the point estimates for habitat use in the northern (64 percent: 95% C.I. 44-79 %) and southern halves (45 percent: 95% C.I. 28-64%) of the Preserve. Combined with the expansion of PPM habitat use within the former roadbed and areas north, this may indicate that the PPM distribution has shifted within the Preserve.

A noteworthy PPM contraction on the site appears to have occurred in the southwestern edge of the Preserve (Figure 2). In 2012, no PPM were captured on this southwestern edge where they have been previously trapped (on grid cells: E3, F2, F4, G3, G6, H4, H6, H7, I4, I5, J6 and J7). It is not known why PPM were not detected within this area of the grid. One explanation is that the habitat is becoming less suitable for PPM (either has always been less suitable or is changing to less suitable). However, open

sandy soil persists throughout the area. Another explanation is that it is just normal population expansions and contraction across a population.

At first glance, it appeared the habitat may now be favoring woodrats since the 2012 survey had 148 woodrat captures during session 2 (the southern portion of the Preserve) and only 35 woodrat captures during session 1 (the northern portion of the Preserve). However, in 2009 woodrat captures were at an all time high across the Preserve (265 total captures) at the same time as PPM were at an all time high. Also, if woodrat numbers are compared only on those southern grid cells trapped in both 2012 and 2009 (grid cells: E3, F2, F4, G3, H4, H6, I4, I5, J6, J7) the woodrat capture numbers are similar with 57 in 2012 and 53 in 2009. Clearly some areas do favor woodrats such as the J grid cells where 51 woodrat captures occurred (J4, J6, J7, J8, and J9).

These and other questions about the small mammal population dynamics on the Preserve will be easier to track population trends from monitoring, if future trapping is implemented with the same methodology employed in 2012.

Sustaining PPM Numbers on the CNLM Preserve.

Population expansions and contractions are natural in small mammal populations and can be explained largely by food abundance and other environmental factors. Habitat management measures are a good strategy to promote use of the Preserve in areas PPM are not using. Previous vegetation thinning, habitat restoration, duff removal, invasive plant species removal completed on the Preserve over the past 15 years may have increased the over-all habitat suitability and population growth. For example, PPM numbers are at an all time high in the northern portion of the Preserve along the old road bed and habitat north where the vegetation was restored; and in areas where non-native plant species have been removed (around H13 and I13).

One example of a potential habitat restoration opportunity is the pocket of habitat which includes grid cells E12, E13, E14, F13, F14, and F15. PPM have never been active in this area despite the seemingly high quality soils. The sage scrub in this area is very tall (over 2 meter high in most places), very little herbaceous cover, and with a lot of woody duff/debris. Possibly if the vegetation was thinned and the duff removed, then the PPM population could expand into this section of the Preserve.

Along with habitat management, monitoring overall species activities on the Preserve could detect unusual and/or potentially damaging increases or decreases of certain species. For example, the California vole was captured in its highest number ever on the preserve. In 2008, this species was captured on 2 grid cells and in 2009, on only one grid cell. However, in 2012 the California vole was captured on 19 grid cells throughout the Preserve. This should be monitored because although the vole is a native species it is usually associated with dense grasslands with water availability. This increase may indicate an overall habitat shift on the Preserve.

Future monitoring should also address the potential challenges the public access trail on the Preserve has on habitat conditions. Any management/monitoring plans should insure that habitat conditions for the PPM are not degraded or destroyed by the recreation on the site. Hopefully, the efforts of the 2008, 2009, and 2012 monitoring studies on the Preserve will serve as a baseline so that future monitoring can be executed similarly and the PPM population can be tracked consistently over the short and long term.

5. REFERENCES

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Appendix 1. Weather data during the two trapping sessions

Session 1	**Weather Conditions for night and morning trap check**
Night 1 (5/1-5/2/12)	57-61°F, 100% cloud cover, light breezes, wet morning
Night 2 (5/2-5/3/12)	57-60°F, high haze to 100% cloud cover, heavy morning drizzle
Night 3 (5/3-5/4/12)	55-60°F, clear and calm to 100% cloud cover, dry morning
Night 4 (5/4-5/5/12)	59-63°F, clear with very bright almost full moon to 90% cloud cover
Night 5 (5/5-5/6/12)	58-65°F, clear with full moon to 100% cloud cover
Session 2	
Night 1 (5/6-5/7/12)	55-61°F, 100% cloud cover, light breezes
Night 2 (5/7-5/8/12)	58-65°F, 100% cloud cover, calm
Night 3 (5/8-5/9/12)	59-62°F, 100% cloud cover, calm
Night 4 (5/9-5/10/12)	60-62°F, 100% cloud cover, light breezes
Night 5 (5/10-5/11/12)	60-61°F, 100% cloud cover, light breezes

Appendix 2. Small mammal captures by cell

	Species						
	PPM	**REME**	**NEBR**	**MICA**	**PEMA**	**PEFR**	**Totals**
Session 1							
Cell							
AA10	5	3	1	0	0	0	9
AA12	1	11	0	0	0	0	3
BB11	0	11	0	5	0	0	16
A11	0	9	0	0	0	0	9
A13	2	8	0	1	0	0	11
B6	7	5	3	0	0	0	15
B7	7	3	2	0	0	0	12
B8	0	11	3	0	0	0	14
B10	11	6	3	2	0	0	22
B12	2	1	0	0	0	0	3
B14	2	4	0	0	0	0	6
B16	0	2	0	1	0	0	3
B18	2	3	0	0	0	0	5
C3	0	8	1	0	0	0	9
C5	0	2	5	0	0	0	7
C7	0	2	0	2	0	0	4
C9	5	6	5	0	0	0	16
C11	0	4	0	2	0	0	6
C13	0	3	0	0	0	0	3
C15	3	5	0	1	0	1	10
C16	0	5	0	0	0	0	5
C17	0	2	0	0	0	0	2
C18	2	2	0	0	0	0	4
D4	10	15	0	0	0	0	25
D6	10	5	2	0	0	0	17
D8	3	6	0	1	0	0	10
D10	6	5	1	0	0	0	12
D11	1	5	0	1	0	0	7
D12	1	5	2	3	0	0	11
D14	0	2	0	0	0	0	2
D16	2	1	0	0	0	0	3
D18	2	0	0	0	0	0	2
E9	10	9	5	9	0	0	33
E11	9	7	0	1	0	0	17
E13	0	9	2	0	0	0	11
E17	3	3	0	0	0	0	6
E18	4	5	0	0	0	0	9
TOTAL	**110**	**193**	**35**	**29**	**0**	**1**	**368**

Species legend:
PPM, Pacific pocket mouse (*Perognathus longimembris pacificus*)
REME, harvest mouse (*Reithrodontomys megalotis*)
NEBR, woodrat (*Neotoma bryanti intermedia*)
MICA, California vole (*Microtus californicus*)
PEMA, deer mouse (*Peromyscus maniculatus*)
PEFR, cactus mouse (*Peromyscus fraterulus*)

Appendix 2. Summary of small mammal captures (continued)

	Species						
	PPM	**REME**	**NEBR**	**MICA**	**PEMA**	**PEFR**	**Totals**
Session 2							
Cell							
E3	0	4	7	0	0	0	11
E5	5	6	1	0	0	0	12
E7	0	7	0	1	0	0	8
F2	0	0	15	0	0	0	15
F4	0	1	1	0	0	0	2
F6	1	2	1	0	0	0	4
F8	11	4	0	0	0	0	15
F10	2	3	0	0	0	0	5
F12	0	11	0	0	0	0	11
F14	0	4	6	1	0	0	11
G1	0	0	11	0	0	0	11
G3	0	2	8	1	0	0	11
G4	0	2	0	1	0	0	3
G5	0	2	0	0	0	0	2
G7	0	4	1	0	0	0	5
G9	1	3	0	0	0	0	4
G10	4	4	0	0	0	0	8
G11	11	0	0	0	0	0	11
G13	3	6	1	2	0	0	12
H4	0	1	1	1	0	0	3
H6	0	2	0	1	0	0	3
H8	7	0	5	3	0	0	15
H10	2	2	5	0	0	0	9
H12	4	2	2	0	0	0	8
I3	0	6	5	3	0	0	14
I4	0	3	2	0	0	0	5
I5	0	9	2	0	1	0	12
I6	0	0	3	4	0	0	7
I7	1	3	1	2	0	0	7
I9	2	0	3	0	0	0	5
I11	1	2	9	0	0	0	12
I13	3	2	7	0	0	0	12
J4	0	2	5	0	0	0	7
J6	0	1	8	0	0	0	9
J7	0	0	11	0	0	0	11
J8	0	2	10	1	0	0	13
J9	0	2	17	0	0	0	19
TOTAL	**58**	**104**	**148**	**21**	**0**	**1**	**332**

Species legend:
PPM, Pacific pocket mouse (*Perognathus longimembris pacificus*)
REME, harvest mouse (*Reithrodontomys megalotis*)
NEBR, woodrat (*Neotoma bryanti intermedia*)
MICA, California vole (*Microtus californicus*)
PEMA, deer mouse (*Peromyscus maniculatus*)
PEFR, cactus mouse (*Peromyscus fraterulus*)

Appendix 3. Characteristics of Individual PPM

PPM Individual Characteristics					
PPM #*	**Sex**	**Age**	**Weight (grams)**	**Reproductive Condition**	**Movement (meters) Max Distance Moved/ Average Distance Moved**
1	M	A	7.0	Non-scrotal	46.6m / 15.5m
2	F	A	7.25	Distended mammae	11.3m / 5.7m
3	M	A	7.25	Semi-scrotal	56.8m / 28.4m
4	M	A	7.5	Semi-scrotal	154.8m / 38.7m
5	F	A	8.5	Pregnant?	19.3m / 6.4m
6	F	A	7.5	Pregnant, distended mammae	0m
7	M	A	7.5	Semi-scrotal	113.2m / 56.6m
8	F	A	6.0	Just finished estrous	8.0m / 4.0m
9	F	A	8.5	Pregnant	22.6m / 3.8m
10	F	A	6.5	NR	0m
11	M	A	9.0	Scrotal	Trapped only once
12	M	A	8.0	Scrotal	33.9m / 11.3m
13	M	A	7.0	Semi-scrotal	28.4 m / 28.4m
14	M	A	9.0	Scrotal	49.8m / 7.1m
15	M	A	8.0	Scrotal	70.2m / 17.6m
16	F	A	8.0	Bloody anus	24.0 m / 4.5m
17	M	A	8.0	Semi-scrotal	Trapped only once
18	M	A	--	Semi-scrotal	Trapped only once
19	M	A	--	Non-scrotal	80.3m / 40.2m
20	F	A	--	NR	Trapped only once
21	M	A	--	Non-scrotal	33.9m / 33.9m
22	F	A	--	Pregnant?	11.3m / 2.8m
23	M	A	--	Non-scrotal	8.0m / 8.0m
24	F	A	--	Pregnant?	8.0m / 4.0m
25	M	A	--	Scrotal	57.8m / 28.9m
26	F	A	--	Distended mammae	0m
27	M	A	--	Semi-scrotal	25.3m / 25.3m
28	M	A	--	Non-scrotal	11.3m / 11.3m
29	F	A	--	NR	Trapped only once
30	M	A	--	Non-scrotal	54.6m / 18.4m
31	F	A	--	NR	8.0m / 8.0m
32	M	A	--	Non-scrotal	0m
33	M	A	--	Semi-scrotal	Trapped only once
34	M	A	--	Semi-scrotal	86.4m / 21.6m
35	M	A	--	Non-scrotal	17.8m / 17.8m
36	M	A	--	NR	Trapped only once
37	F	A	--	NR	Trapped only once
38	F	A	--	Pregnant?	Trapped only once
39	F	A	--	NR	78.5m / 13.1m
40	F	A	--	NR	16.0m / 8.0 m
41	M	A	--	Scrotal	35.8m / 11.9m
42	M	A	--	Semi-scrotal	40.0m / 40.0m
43	F	A	--	Distended mammae	62.6m / 8.9m
44	M	A	--	NR	Trapped only once
45	M	A	--	Scrotal	32.0m / 16.0m
46	F	A	--	Early pregnancy, mammae not distended	0m
47	M	A	--	Non-scrotal	22.0m / 11.0m
48	F	A	--	Distended mammae	40.0m / 40.0m
49	M	A	--	Scrotal	Trapped only once
50	M	A	--	Semi-scrotal	32.0m / 16.0m
51	M	A	--	Semi-scrotal	0m

Appendix 3. Characteristics of Individual PPM (Continued)

52	M	A	--	Semi-scrotal	51.8m / 25.9m
53	F	A	--	Pregnant	Trapped only once
54	F	A	--	Not pregnant	Trapped only once
55	F	A	--	NR	Trapped only once
56	F	A	--	Lactating	25.3m / 25.3m
57	M	A	--	Non-scrotal	0m
	24F; 33M	**57A**			**Mean distance moved, 15.4 m (both sessions)**

Legend
* PPM were marked and given a number in the order of capture.
Sex: M, male; F, female.
Age: A, adult; YOY, young of the year (includes juveniles and subadults)
--Weights weren't recorded after the first day due to inconsistency of scales and wind variability
NR-Nothing Recorded

Appendix 4. Summary of PPM Capture Locations – Session 1

PPM #	Night 1	Morn 1	Night 2	Morn 2	Night 3	Morn 3	Night 4	Morn 4	Night 5	Morn 5
1	E17-S	E17-S	\	E18-NW	\	E17-NW	\	\	\	\
2	C18-NE	\	\	B18-S	\	B18-S	\	\	\	\
3	C15-N	B14-NE	\	C15-N	\	\	\	\	\	\
4	A13-NW	A13-W	B14-NE	AA12-SE	\	\	B10-SE	\	\	\
5	AA10-E	AA10-C	AA10-SE	\	\	\	\	\	AA10-SE	\
6	B10-SE	\	B10-SE	B10-SE	B10-SE	\	\	B10-SE	B10-SE	B10-E
7	B10-SW	\	\	\	\	B12-C	B10-NW	\	\	\
8	B6-E	\	\	\	B6-E	\	\	\	B6-C	\
9	B7-W	B7-W	B7-W	\	B7-N	B7-W	B7-W	B7-W	\	\
10	B6-W	\	\	\	\	\	\	\	\	\
11	C9-S	\	\	C9-C	\	\	\	C9-S	C9-C	\
12	D6-NE	\	D6-NW	D6-NW	\	\	\	\	\	D6-S
13	D6-NW	\	\	\	\	\	\	\	\	\
14	D4-W	D4-SW	D4-N	D4-N	D4-C	D4-C	\	\	D4-N	D4-C
15	E9-NW	\	E9-NW	\	D8-NW	\	D8-S	\	\	D8-E
16	E11-NW	E11-N	\	E11-N	E11-NE	E11-N	E11-N	\	\	\
17	E11-S	\	\	\	\	\	\	\	\	\
18		AA10-NE	\	\	\	\	\	\	\	\
19		C15-SW	\	D16-SE	\	\	D16-N	\	\	\
20		B10-S	\	\	\	\	\	\	\	\
21		D12-N	E11-N	\	\	\	\	\	\	\
22		D6-NW	\	D6-NW	D6-NW	\	D6-NW	\	\	D6-C
23		D4-SE	\	\	D4-E	\	\	\	\	\
24		E9-C	\	E9-C	\	\	E9-W	\	\	\
25			D10-NE	E9-E	\	\	\	\	\	\
26			E9-SW	\	\	\	E9-SW	E9-SW	\	\
27				D18-N	\	\	E18-NW	\	\	\
28				B6-SW	\	\	\	\	\	B6-C
29				C9-N	\	\	\	\	\	\
30				D10-NE	\	D10-SE	D10-NE	\	\	D10-SW
31				D10-E	\	\	\	\	\	D11-W
32					E18-SE	\	\	E18-SE	\	\
33					B12-N	\	\	\	\	\
34						E9-S	\	\	\	\
35								D18-C	\	C18-SE
36										B6-NW
37										E11-SW

Appendix 4 continued. Summary of PPM Capture Locations – Session 2

PPM #	Night 1	Morn 1	Night 2	Morn 2	Night 3	Morn 3	Night 4	Morn 4	Night 5	Morn 5
38	I13-NW	\	\	\	\	\	\	\	\	\
39	G9-NW	H8-SE	H8SW	\	\	H8-SW	H8-SW	H8-SW	\	H8-C
40	F8-NW	\	\	F8-N	\	\	\	\	F8-C	\
25 (recap)	F10-NW	\	\	\	\	\	\	\	\	\
41		F6-E	\	\	\	E5-S	\	E5-S	\	E5-S
42		F8-S	\	\	\	\	\	F10-SW	\	\
43		G11-NE	\	G11-C	G11-NE	G11-NE	G11-E	G11-SE	G11-NE	G11-N
44		H8-NE	\	\	\	\	\	\	\	\
45		I9-NW	\	I9-NW	\	\	\	I7-NE	\	\
34 (recap)			F8-NW	F8-E	\	\	\	F8-NW	F8-S	\
46			G10-S	\	\	\	\	G10-S	\	\
47			H12-S	\	\	H12-SE	\	\	\	I13-NW
48			H12-SW	\	\	\	\	\	I13-S	\
49				E5-S	\	\	\	\	\	\
50				G13-SE	\	\	\	\	G13-NE	G13-SE
51				G11-SE	\	\	\	\	\	G11-SE
52				G10-S	G10-N	\	\	\	G11-SE	\
53						F8-W	\	\	\	\
54						H10-W	\	\	\	\
55						H10-NW	\	\	\	\
56						H12-S	\	I11-N	\	\
13 (recap)							E5-N	\	\	\
57									F8-SE	F8-SE