Western Ecological Research Center

Pacific Pocket Mouse Monitoring Plan for Marine Corps Base Camp Pendleton: Short Term Studies and Long Term Goals.

Prepared for:
Wildlife Management Branch
AC/S Environmental Security
Marine Corps Base Camp Pendleton

U.S. Department of the Interior
U.S. Geological Survey

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Pacific Pocket Mouse Monitoring Plan for MCB Camp Pendleton: Short Term Studies and Long Term Goals

Prepared by C.S. Brehme and R.N. Fisher, U.S. Geological Survey, Western Ecological Research Center in collaboration with a multi-agency expert scientific panel: Burnham, K., Meserve, P., Spencer, W., Miller, W., Pavelka, M., and D. Deutschman.

Executive Summary:

The U.S. Geological Survey Western Ecological Research Center (USGS), representatives from Marine Corps Base Camp Pendleton (MCBCP) and a scientific review panel (all hereby referred to as the panel) researched literature on Pacific pocket mouse (*Perognathus longimembris pacificus*, PPM) ecology and previous monitoring efforts in order to construct a long term monitoring plan for PPM on MCBCP. A two day workshop was held in which many independent and agency scientists, consultants, and land managers gave additional input. The major consensuses are presented in this document. In general, the panel agreed upon a 'proportion area occupied' (PAO) spatial approach to monitoring the largest population within the Oscar One and Edson training areas. This approach may be used for the smaller San Mateo populations; however, it is suspected that if population sizes are very small, these areas may require a more intensive annual census. In addition, a portion of annual effort should go toward discovery of 'new' populations of PPM within suitable habitat less than 5 km from the coast. Finally, the panel agreed that the current accepted sampling technique of live-trapping is not ideal, as extensive data from FWS has revealed its limitations; low capture probabilities, high impact, high effort, and high cost. The panel would like to explore the feasibility of alternative methods.

In preparation for developing a comprehensive long term monitoring plan on MCBCP that will effectively track the status and trends in PPM, the panel agreed that several preliminary 'pilot' studies are warranted. These studies are designed to 1) immediately and comprehensively assess the status of North and South San Mateo PPM populations, 2) assess effectiveness of alternate sampling methodologies, and 3) assess initial occupancy estimates, sample unit size, statistical power and precision of a pilot PAO program in Oscar One. Since field work will be scheduled to occur in and around the months of May and June, when the Pacific pocket mice are most consistently active above ground, these studies are planned to take place over several years.

Summary of Proposed Studies and products for first 3-4 years:

Year 1 (2008): Completed

1. Comprehensive trapping coverage of North and South San Mateo population(s). Estimate gross population sizes and PAO. Produce map with all trap locations and PPM capture locations.
2. Collect covariate data at small and large spatial scales. Assess and validate covariate data and collection methods.

Year 2 (2009):

1. Sampling methodology study: Compare a number of active and passive sampling techniques for PPM. Choose the method with highest probability of detection, the lowest impact to species, lowest impact to habitat, and that is most cost efficient.
2. Density/activity indices will also be evaluated. If sample size is limited in 2009 studies, validation may continue into 2010 with PAO implementation.

Year 3 (2010):

1. Implement PAO in Oscar One/Edson using chosen methodology.
2. Implement PAO in North and South San Mateo (with 100% coverage if necessary).

Year 3-4 (2010-2011):

1. Assess initial PAO estimates, detection probabilities, density or activity index, and power to detect changes in occupied habitat. Determine number of survey plots, number of repeat visits required to estimate PAO with certain level of precision (TBD by data). Redefine study area, plot size, and 'trap' spacing as required by the data.
2. Revisit plans for North and South San Mateo subpopulations as warranted (sample boundaries, survey methodology, PAO and/or abundance, etc.)
3. Draft long term monitoring program for PPM on MCBCP.

Introduction:

This document is not a detailed monitoring plan, but describes key considerations and desired elements of a long term monitoring plan. These elements were generated by the U.S. Geological Survey (USGS), Marine Corps Base Camp Pendleton (MCBCP), and a scientific panel during and after a multi-agency workshop for development of a long term monitoring program for the Pacific pocket mouse (*Perognathus longimembris pacificus*, PPM). General consensus for these elements and some programmatic details are presented. At this workshop and subsequent communication with the panel, there was consensus that vital information gaps were important to address before the development of a detailed monitoring plan. Short term studies are summarized that aim to fill in these gaps. A timeline is proposed for these studies, as well as the creation and implementation of a long term monitoring program for PPM populations on MCBCP. Workshop informational materials and an accounting of all written comments made by the scientific panel, USGS, and MCBCP on versions of this document are provided in the two appendices.

Objectives:

Our objective is to develop a scientifically valid, effective, and cost-effective monitoring program for the Pacific pocket mouse (PPM) on Marine Corps Base Camp Pendleton (MCBCP). The monitoring program should document trends in the status of PPM on base and identify results criteria for management action.

PPM Monitoring Workshop

This protocol will be developed in collaboration with MCBCP, the USGS, and a six member Scientific Peer Review Panel. The panel members were chosen for their expertise in spatial and statistical monitoring design or PPM and heteromyid biology and ecology.

<u>Scientific Panel Members:</u>
Kenneth Burnham, Statistician, USGS/ Colorado State University
Douglas Deutschman, Statistician, San Diego State University
Peter Meserve, Ecologist, Northern Illinois University
William Miller, Biologist, US Fish and Wildlife Service
Mark Pavelka, Biologist, US Fish and Wildlife Service
Wayne Spencer, Ecologist, Conservation Biology Institute

A workshop was held from September 6-7, 2007 to discuss our current knowledge of PPM biology, ecology, historical survey and monitoring results, management needs and information gaps. The workshop was also attended by local PPM experts and land managers from many agencies including MCBCP, USFWS, CDFG, Center for Natural Lands

Management, San Diego Zoological Society (CRES), SD Natural History Museum, California Department of Parks and Recreation, among others.

The workshop process was as follows:

1. Reviewed and revised a conceptual model of current knowledge and understanding of PPM population structure, demographics, and stressors.
2. Reviewed what is known about the historic and current status of PPM on MCBCP. FWS presented results of extensive mark-recapture research.
3. Reviewed several current and/or proposed monitoring programs and sampling methods for PPM and other similar species.
4. Reached some consensus points on best overall strategy to monitor PPM population(s).
5. Discussed feasibility of various sampling strategies, density indices, and management scenarios.
6. Visited Camp Pendleton for firsthand look at PPM habitat in Oscar One, North San Mateo and South San Mateo.

Some Key Considerations:

After reviewing all historic and current knowledge of PPM life history and monitoring efforts, and receiving input from MCBCP, the scientific panel identified the following list of key considerations in the development of a long term monitoring plan for the Pacific Pocket mouse. The key considerations fall under two categories: programmatic and species life history.

Programmatic Considerations:

PPM Monitoring Program and the monitoring requirements committed to by the Marine Corps during the formal consultation on programmatic activities in upland ecosystems on MCBCP and other formal consultations should be linked, as appropriate (e.g. consultations for the Crucible Challenge Course and road upgrades in Oscar One).

Monitoring results should support and provide information of relevance to biological consultations but, based on the spatial detail that is of relevance to specific actions, it is acknowledged that basewide monitoring may not provide information that is sufficient for all biological consultations.

Monitoring indices should be consistent with consultation indices for PPM as appropriate.

Monitoring results should inform the Base and FWS when goals for PPM populations are not met and management action is necessary.

Program should incorporate Before and After/Control-Impact (BACI) study designs as needed to assess the effectiveness of management actions. However, the scientific panel confers that low numbers of PPM may result in low power to assess effects.

MCBCP Needs

The Base would like information on species distribution and some measure of status and trends.

The Base would like to understand more about PPM spatial distribution to better inform about current and future training and troop movement.

The Base are willing to try different methods of applied habitat management (example: soil/sand additions, vegetation clearing), even if they do not fit into rigorous statistical design, to further conservation and recovery of PPM.

Other:

Over the long term, program should assess if temporal trends in PPM status are similar across subpopulations (i.e. are the main drivers of PPM dynamics similar across populations or not?).

Discovery of new population(s) is a priority.

Species Life History Considerations:

PPM may be active above ground from late March to September or longer. Activity period varies by year, across populations, and within populations by sex and age structure.

Expect most animals to be active in late April, May and June.

PPM are patchily distributed across the landscape- drivers unknown

- tends to occur where sand and bare ground cover are high-
- PPM is granivorous, depending principally on forb and grass seed
- interspecific interactions may explain exclusion from some suitable habitats

PPM is nocturnal.

PPM home range radius ~30 to 50m. Short term average movements likely smaller (radius 5-10m?).

See Appendix 1 (Workshop materials) for larger treatment of species life history and stressors.

Note: Detailed behavioral ecology and translocation studies are currently occurring within Oscar One by Debra Shier, Conservation and Research for Endangered Species (CRES) that should significantly add to our knowledge of the life history of this species..

Lessons from Oscar One live-trapping studies: FWS:

Standard Sherman live-trapping with Grid Layout.

It would be extremely challenging and time intensive (at best) to get accurate estimates of annual abundance on which to make informed decisions.

- Abundance estimates can be highly variable and imprecise through time (high seasonal and annual variability). This is particularly true when PPM are at low densities.
- Capture probabilities can be highly variable through time and space (related to limited above ground activity and/or other unknown factor(s)).
- Capture probability may be heterogeneous among individuals in the population. Data suggests juveniles may have lower probability of capture in general.
- Detection of trends in abundance and other demographic parameters in populations is very challenging.
- Not all PPM appear to be active at the same time. During years of good reproduction, the above ground population appears to cycle among two or more cohorts that are variously dominant in spring/early summer and late summer/early fall (e.g. overwintering adults predominate in spring/early summer and young of the year predominate in late summer/early fall)- FWS data.

Difficult to distinguish juveniles (young of year) from adults. Pelage turns brown after 6-7 days (post weaning?).

- Difficult to measure recruitment.
- USFWS biologist examination of PPM skins and skulls at the San Diego Natural History Museum found 1-year toothwear patterns on “subadults”. This may compromise the ability to reliably distinguish between young of the year and 1st year adults.
- Contributes to variable abundance estimates within and among years

There is currently little known about variation in spatial distribution over time.

Long Term Monitoring Program:

After weighing key considerations and lessons learned from previous studies, the panel determined that a long term spatial occupancy monitoring scheme should provide a more stable metric than abundance for tracking long term trends in PPM populations. A more stable metric is desired in order to have the power to distinguish longer term trends over short term variation. This program should inform and be consistent with the Uplands Biological Consultation for the Base. Over time, this program should provide information to the Base and FWS that is useful for guiding training activities and troop movements as well as adaptive management of PPM. However, there are vital information gaps that hinder our ability to specify a detailed program at this time (identified in red below).

General Consensus for Long Term Monitoring Program

Spatial Monitoring Scheme- Proportion Area Occupied (PAO) approach with annual sampling will be explored for all subpopulations (Oscar One/ Edson, North San Mateo, South San Mateo). Annual PAO Index will be generated for each population and over all populations.

Because the San Mateo North and South populations are much smaller, these areas may require more intense sampling (i.e. 100% coverage) and additional efforts for estimating gross population sizes. (Information Gap- we do not know current status or distribution of these populations- see 2008 study section).

Program will be closely tied to management.

- Results should inform and be compared to population thresholds and triggers for management action in the Biological Assessment for the Uplands Consultation.
- Program will incorporate collection of habitat, biological, and environmental data at multiple scales to help assess drivers of PPM distribution and inform management.
- Will incorporate Before and After/Control and Impact (BACI) studies as needed to attempt to inform and assess effects of any management actions. (Low numbers of PPM may result in low power to assess effects).
    - Any need for more comprehensive sampling should be determined before implementation of actions.
    - Lack of power should not prevent implementation of management actions, particularly for making less suitable unoccupied habitat more suitable.
- Information on PPM spatial distribution will better inform MCBCP on better management decisions for current and future training and troop movement.
- Monitoring program results will not substitute for project specific actions on base (i.e. cannot interpret with 100% confidence that a non detection is equal to absence).

Adaptive Program- program will be reassessed after set period of time for power to detect changes in occupancy, sample size, detection probabilities, survey plot size, intensity, etc.

We will include some effort each year in attempting to discover 'new' populations of PPM. Because PPM are so scarce, discovery of a new population will be very significant for species conservation.

Program Specifics:

Sample (Inference) Area

Monitoring:

Initial sampling area will be defined as a minimum convex polygon around all known PPM occurrences within Oscar One/ Edson, South San Mateo, and North San Mateo with an added buffer that extends >=50m into adjacent suitable habitat.

Edson Range (adjacent to Oscar One) is very difficult to gain access to, especially for multiple days of trapping. Will include in monitoring program, however, may need to assess as a separate stratum/population for logistic considerations as well as differences in management.

Discovery:

Sampling area will be defined as suitable PPM habitat within 5km of coast (not confined to MCBCP). Suitability will be defined using soils and vegetation as described by Spencer et al. (2001). Area sampled may be defined by having suitability rankings of moderate, high, and very high.

Allocation of effort:

Monitoring: 90% of cost/effort

~75% of PAO plots will be permanent (i.e. Sampled every year) for greatest power to detect trends (exact % TBD following results of pilot studies and/or initial PAO efforts).

~25% of PAO plots will be randomly chosen each year to generate more detailed spatial coverage within PPM habitat over time. Will help inform management and habitat relationships (exact % TBD following results of pilot studies and/or initial PAO efforts).

Discovery: 10% of cost/effort

There will be an annual effort to discover new populations (~10% of program cost). Randomized surveys will be conducted in suitable PPM habitat within 5km of coast. Survey methodology to be consistent with chosen PAO methodology.

Sampling Method:

Use of a passive sampling method is preferable. The optimal method will have high probability of detecting PPM, low impact to PPM, and be reasonable in cost. This method may require validation over time by live-trapping a subset of plots annually. (Information Gap- Require preliminary studies to assess and validate. see 2009 study section).

Size of Sample plot/Grid:

Oscar One/Edson = $100m^2$ -$150m^2$ (TBD)

North and South San Mateo = $50m^2$ (TBD)

- The size of the plot is very important as it will directly affect occupancy (PAO) estimates. If sample plots are too large, PAO approaches 1.0, while sample plots that are too small will result in extremely low PAO estimates. MacKenzie et al. (2005) recommend a study design with a PAO target of between 0.20-0.80 in order to effectively model changes over time and assess predictive power of environmental covariates (see Figure 2).
- In order to assess the effects of different plot sizes on potential PAO for the MCBCP PPM populations, we overlaid sampling grids of several size plots (from 25 x 25m to 150 x 150m) over historic PPM capture locations for the Oscar One, South San Mateo, and North San Mateo populations. For each population and each size grid, we then calculated a naïve PAO estimate by defining a plot as occupied if it contained a historic capture point and unoccupied if it did not. Some plots are smaller than the defined plot size, because they were along the border of the sampling area. For the purposes of this exercise, plots that were >=50% of an entire plot were included in the analyses and those <50% were excluded.
- Historic captures may represent an overly high estimate of occupancy because the data represent PPM captures from many studies, trap nights, and years. They may also represent a low estimate of occupancy because the spatial area trapped varied and may not have been complete over the entire sampling area. However, these data give us an idea of potential PAO over given scenarios of sample plot sizes for each of these populations. (see Table 1 and Figures 3, 4 and 5).

Measures:

PPM

- Annual Monitoring Index= Proportion Area Occupied
- Relative index of abundance and/or activity (i.e. number of positive tracking cards per grid, number of unique PPM individuals captured, etc. (Information Gap- depends upon sampling technique chosen- will need to evaluate/validate - see 2008-9 study section).

- Some measure of reproductive success: Idea of high recruitment year vs. low recruitment year. May not be feasible due to identification issue above.

Environmental Covariates:

Data collection for testing hypotheses regarding PPM habitat suitability, species competition, and training/management activities. Data collection to be at both small and large spatial scales. (Smaller scale = 3m around each sampling node (trap, track plate, etc), Large scale = plot size (TBD)).

- *Presence of sandy patches? (Y/N with estimated proportion)
- *Vegetative cover (growth forms: herbs/forbs, grasses, shrubs, trees, open ground, leaf litter) (Visual estimates). Data may be taken at one or several height categories as in Dodd, Laabs, and Greene 1999.
- *Dominant plant species recorded for each growth form (species comprising >20% of cover for growth form).
- Slope (large scale only).
- Recent human disturbance (low (few footprints), moderate (many footprints/trampling), high (vehicle tracks/ heavy trampling and use)).
- Other rodent species detected.
- Soil descriptors
- Covariates* to be evaluated for observer variability.

Other possible covariate measures suggested to be evaluated for information gain, feasibility and cost.

- Ant species (or taxonomic groups) detected or noted. Would likely be temporally variable. Count ant mounds?
- Historic land use (old roads, grazing, agriculture, etc.- may not be reasonable- see MP comments-Appendix 2).
- Soil depth (ground penetrating radar or seismic refraction?)
- Soil permeability (infiltration rate).
- Soil hardness (penetrometer)
- Other soil measures (texture, % gravel, carbon, bulk density) large scale only- see KB comment (Appendix 2).

Note: Detailed behavioral ecology and translocation studies are currently occurring within Oscar One by Debra Shier, Conservation and Research for Endangered Species (CRES). The long term monitoring plan will consider and incorporate important findings from these studies toward sampling strategies and measures as appropriate

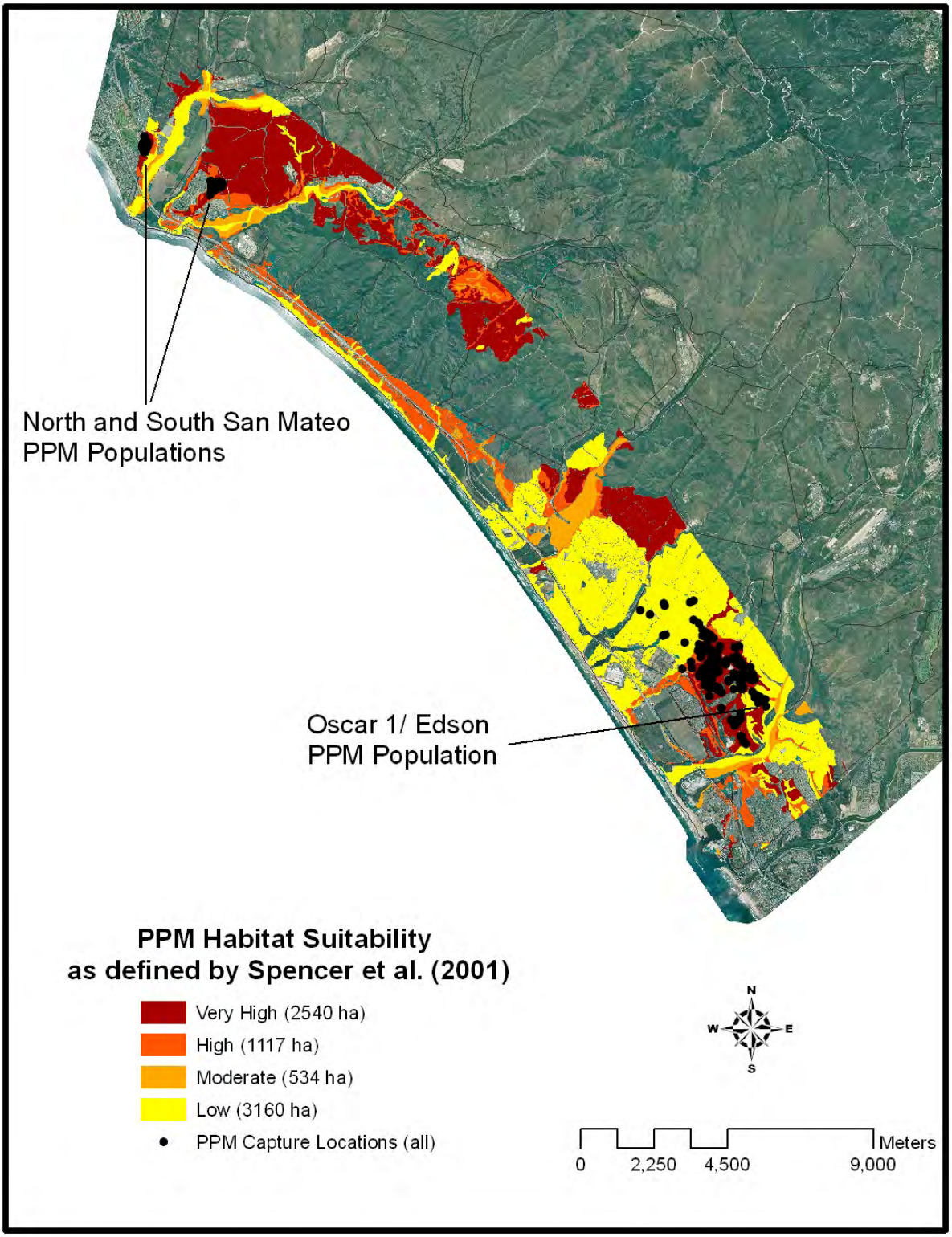

Figure 1. PPM habitat suitability map within MCB Camp Pendleton.

Suitability is shown within 5 kilometers of the coast within MCBCP. Note that this map may be revised due to new information or re-evaluation. Sampling may or may not be limited to MCBCP.

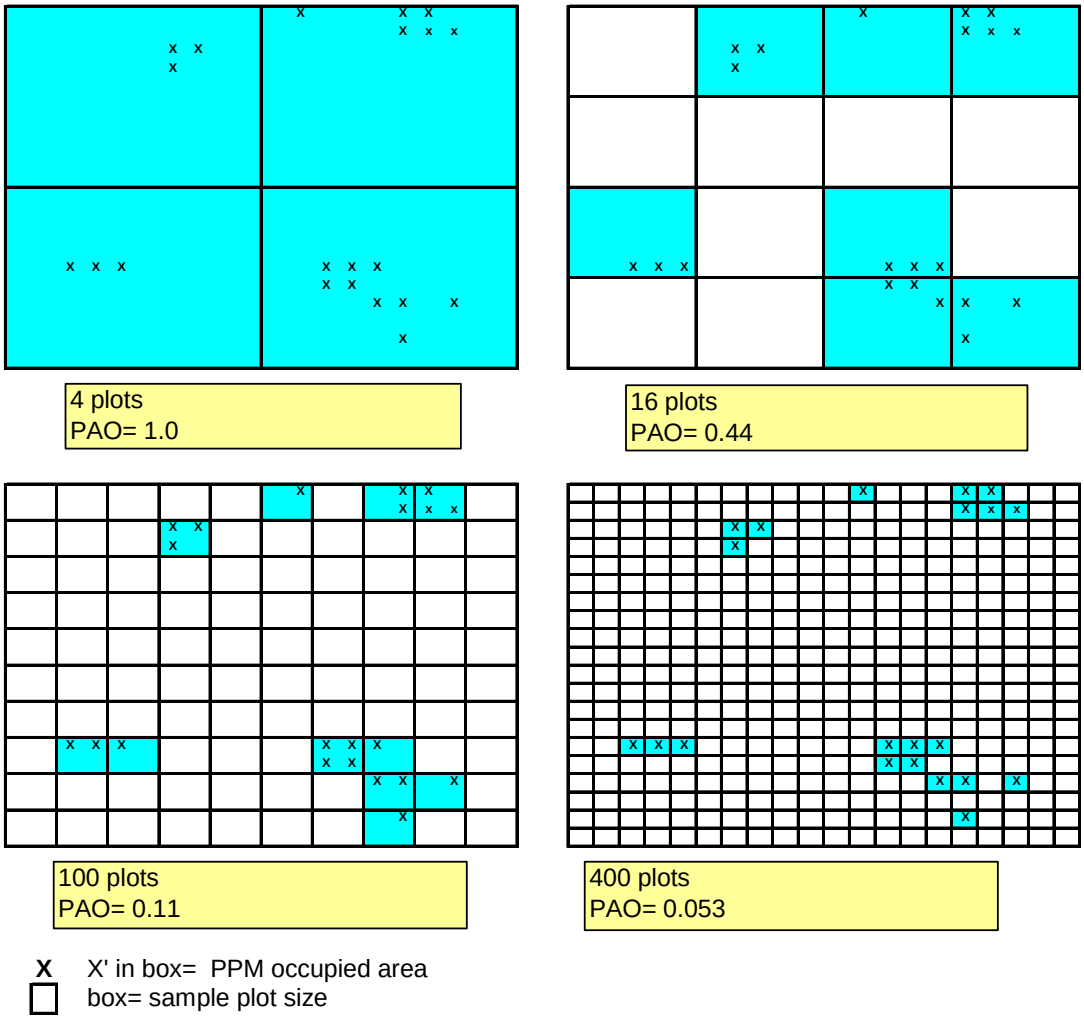

Figure 2. Example of Effect of Plot Size on Proportion Area Occupied.

We present here a simulated sampling area (represented by 4 large boxes) and simulated PPM locations within the sampling area (represented by the small dark grey boxes with an 'X'). The PPM locations remain the same for all four scenarios, but the size of the sample plot varies from very large (4 grids/plots per sample area) to very small (400 grids/plots per sample area). Occupied plots are shaded in blue. The impact of plot size on occupancy (PAO) estimates is shown.

Note that the probability of a random sample plot to be occupied by PPM is 1 (very high) in the 1st scenario and 0.04 (very low) in the 400 plot scenario. In the 1st scenario, if we sampled any random plot, we would expect it to be occupied. We would need to survey a very large area and there are few total plots to get an acceptably precise estimate. In contrast, if we sampled a subset of 20 random plots in the 400 plot scenario, we would expect only one to be occupied. This would translate into a lot of sampling effort with a low and imprecise PAO estimate. Both extremes would not be ideal for a long term monitoring program. In both cases, we would get little information on spatial patterns over time or effects of landscape, environmental, and other covariates on species distribution. Note that decreasing the sample area (for example by removing areas that would be less suitable) would also increase expected occupancy estimates. A balance of these is ideal with a target occupancy estimate of 0.2 to 0.8.

Table 1. Sample area and Grid size simulations of Oscar One, North San Mateo, and South San Mateo with corresponding effects on PAO estimates.

Sample areas were varied by adjusting width of buffer around minimum convex polygon of PPM captures. All historic PPM captures were used in these analyses through 2007 (except for FWS soil study points in Oscar One, not yet available). PAO estimates may be low, because complete trapping coverage has not been conducted in the past. They may be high, because they contain PPM capture records over multiple efforts and years. Those highlighted in yellow fall within or close to the recommended target PAO of 0.2 to 0.8 (MacKenzie et al. 2005).Adjusting sample area (by adding buffer or eliminating less suitable habitat) can also be used to affect expected PAO values.

Please note: Some plots are smaller than the defined grid size as they were along the border of the sampling area. For the purposes of this exercise, all grids that were >50% of the area of an entire grid were counted. Those that were <50% were not counted (even if they contained PPM historic point).

(Grid size ranges: 50-150m^2 (Oscar1/Edson) and 25-100m^2 (N&S San Mateo))

(sample area buffer width ranges from 0 to 150m)

Oscar 1/Edson

Defined Sample Area[a]	Area (ha)	Grid Size 150m # grids[c]	Grid Size 150m PAO[e]	Grid Size 100m # grids[c]	Grid Size 100m PAO[e]	Grid Size 50m # grids[c]	Grid Size 50m PAO[e]
MCP (0m)	729.1	323	0.29	734	0.16	2916	0.05
50m	791.0	347	0.30	799	0.16	3170	0.05
100m	854.6	383	0.27	852	0.15	3413	0.05
150m	919.7	406	0.25	921	0.13	3690	0.04
No of Grids Occupied[d]:		95(MCP),103		121(MCP),124		156(MCP),161	

North San Mateo

Defined Sample Area[a,b]	Area (ha)	Grid Size 100m # grids[c]	Grid Size 100m PAO[e]	Grid Size 50m # grids[c]	Grid Size 50m PAO[e]	Grid Size 25m # grids[c]	Grid Size 25m PAO[e]
MCP (0m)	5.6	5.0	0.80	22.0	0.45	90.0	0.27
50m	9.7	9.0	0.89	41.0	0.41	159.0	0.18
100m	14.4	16.0	0.63	59.0	0.31	238.0	0.12
150m	19.9	21.0	0.48	85.0	0.21	325.0	0.09
No of Grids Occupied[d]:		4(MCP),8,10		10(MCP),17,18		24(MCP), 29	

precision low for 100m grid

South San Mateo

Defined Sample Area[a,b]	Area (ha)	Grid Size 100m # grids[c]	Grid Size 100m PAO[e]	Grid Size 50m # grids[c]	Grid Size 50m PAO[e]	Grid Size 25m # grids[c]	Grid Size 25m PAO[e]
MCP (0m)	8.3	9.0	0.78	34.0	0.32	141.0	0.13
50m	15.3	20.0	0.60	67.0	0.24	259.0	0.09
100m	23.2	24.0	0.50	103.0	0.16	390.0	0.06
150m	31.3	33.0	0.36	132.0	0.12	557.0	0.04
No of Grids Occupied[d]:		7(MCP),12		11(MCP),16		19(MCP), 24	

precision low for 100m grid

[a]MCP = Minimum Convex Polygon around all known historic PPM captures
[b]Unsuitable habitat not included in buffers (as described in Spencer et al. 2001)
[c]Number of grids calculated by overlaying sample areas with different size grids (includes partial grids >~50%)
[d]Number of grids occupied by PPM calculated as number of grids intersecting all historic PPM captures
[e]PAO calculation = (no. of grids occupied/ total number of grids)
Grid size and buffer combinations with PAO estimates from 0.15 to 0.85 (recommended range= 0.2-0.8)
Options with no buffer shown for information purposes but not acceptable to panel

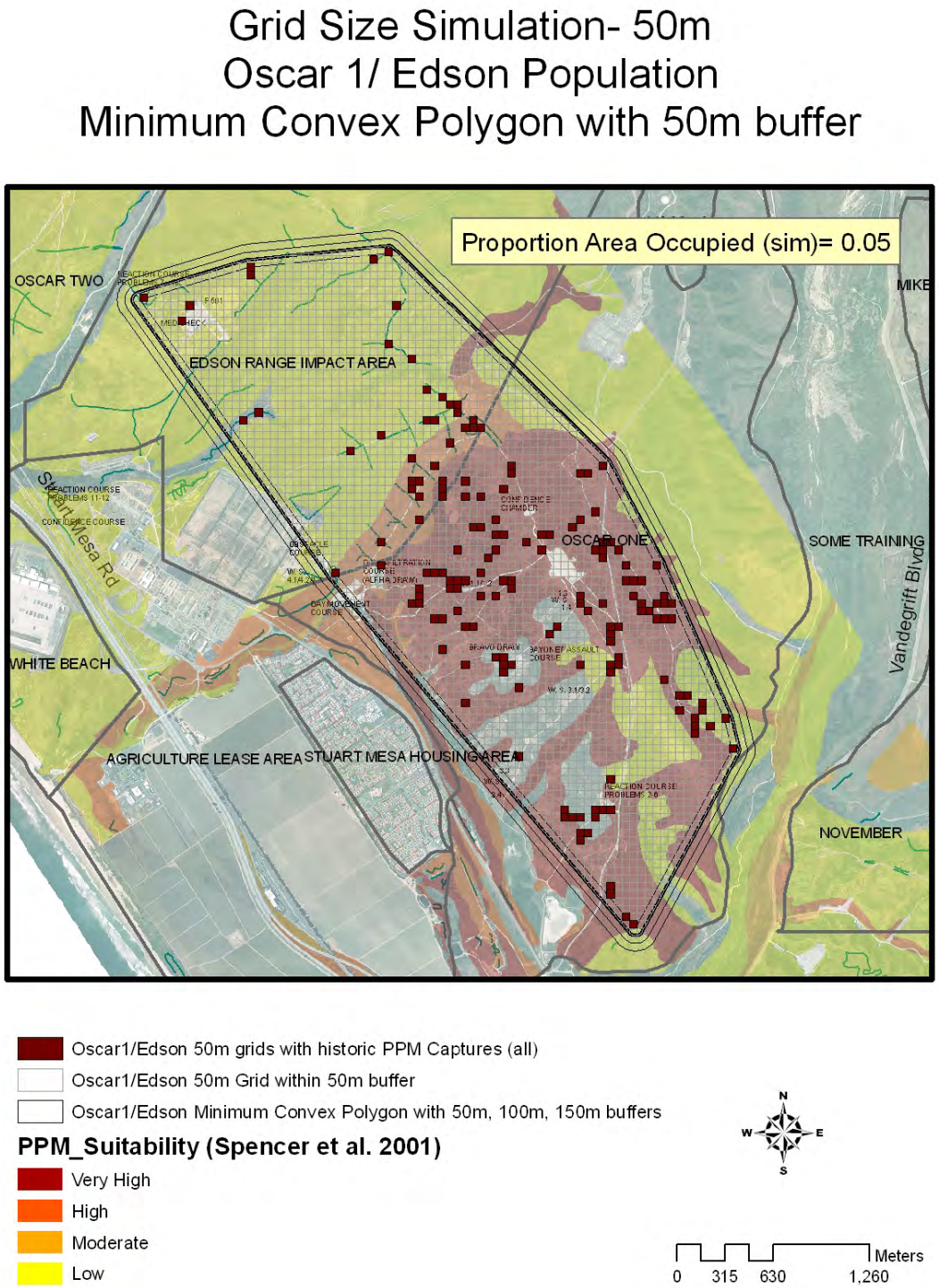

Figure 3. PAO simulation for Oscar One/Edson PPM population using 50m^2 grids.

All grids intersecting a historical PPM capture record are marked as "occupied". This gives an estimated proportion area occupied (PAO) of 0.05 within the sampling area defined by a minimum convex polygon around historic PPM captures and added 50m buffer. In this scenario, we might expect one in twenty randomly selected 50m^2 plots to be occupied by PPM. Reduction of sampling area could also serve to increase PAO estimates.

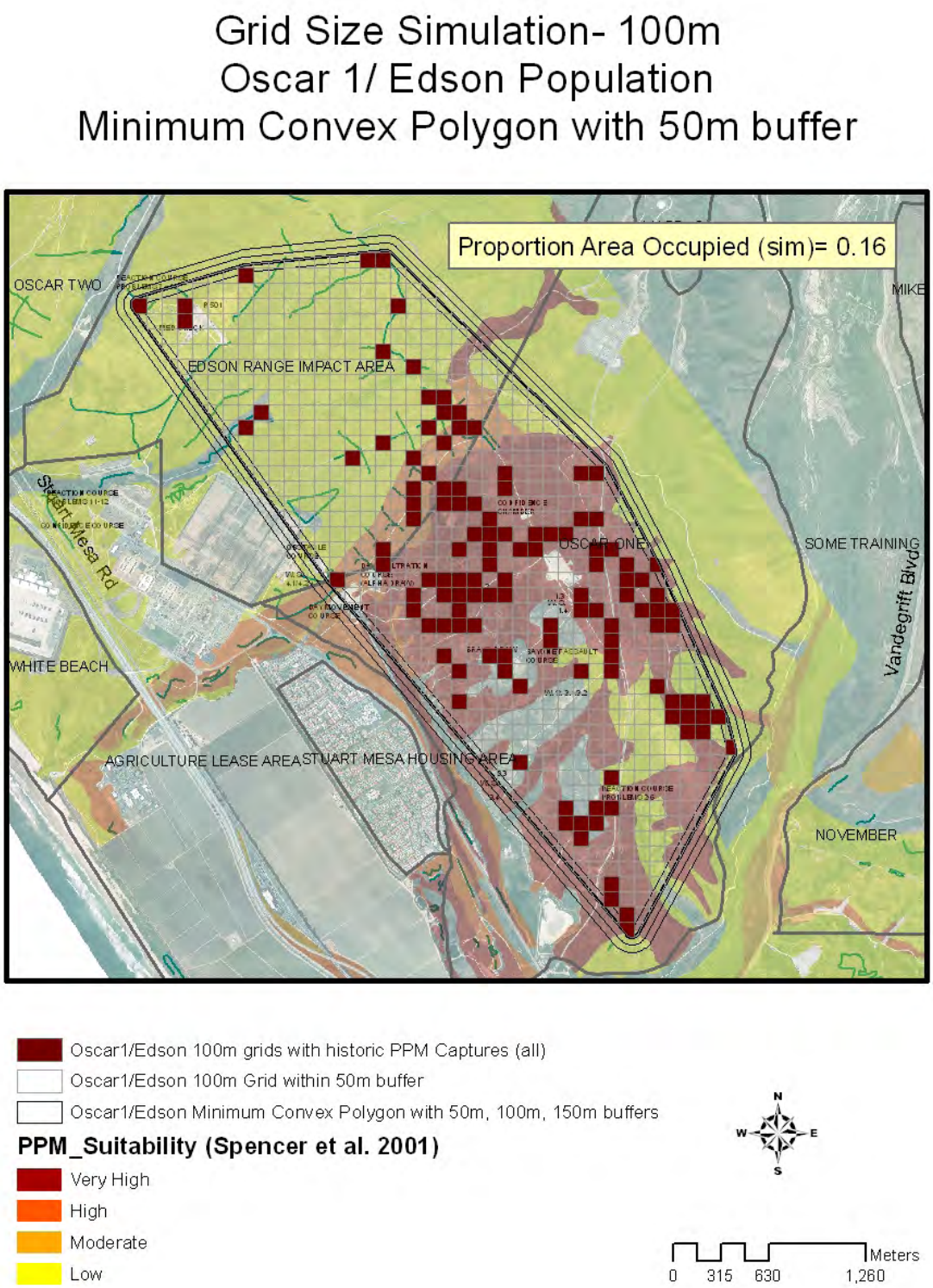

Figure 4. PAO simulation for Oscar One/Edson PPM population using 100m2 grids.

All grids intersecting a historical PPM capture record are marked as "occupied". This gives an estimated proportion area occupied (PAO) of 0.14 within the sampling area defined by a minimum convex polygon around historic PPM captures and an added 50m buffer within suitable habitat. In this scenario, we might expect three of twenty randomly selected $100m^2$ plots to be occupied by PPM. Reduction of sampling area could also serve to increase PAO estimates.

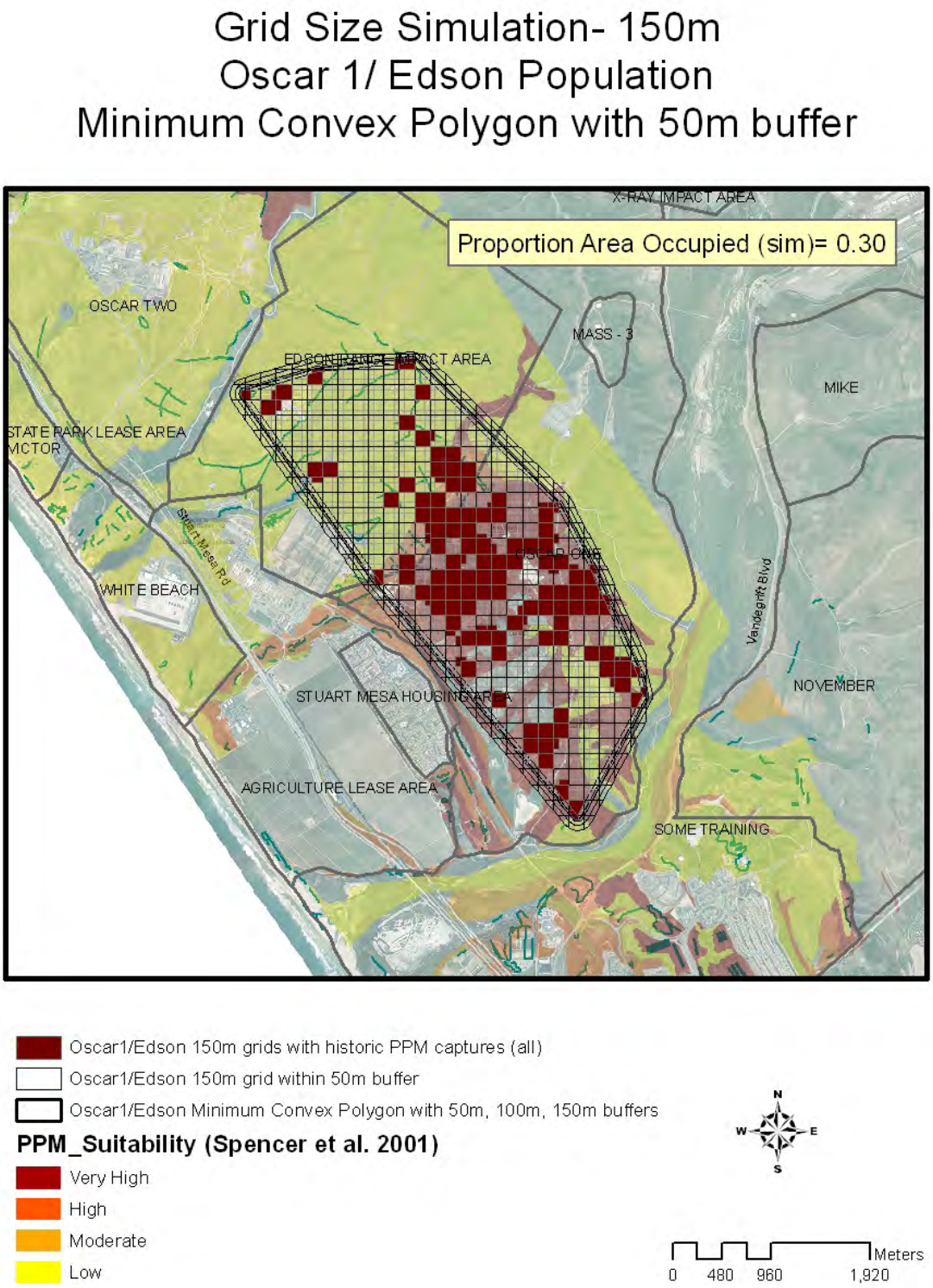

Figure 5. PAO simulation for Oscar One/Edson PPM population using 150m^2 grids.

All grids intersecting a historical PPM capture record are marked as "occupied". This gives an estimated proportion area occupied (PAO) of 0.14 within the sampling area defined by a minimum convex polygon around historic PPM captures and an added 50m buffer within suitable habitat. In this scenario, we might expect five of twenty randomly selected 100m^2 plots to be occupied by PPM.

Short term goals:

In this section, we propose several preliminary studies. The studies will generate information needed to draft a quality program. In 2008, we propose to assess the status of both the North and South San Mateo populations which have not been surveyed since 2003 and 2005, respectively. This will be important in determining if a more intense effort, perhaps involving a gross abundance estimate, is necessary to include in the long term monitoring program for these sites. In 2009, we propose to explore alternate sampling methodologies and assess each method for PPM detection probability, impact to species, and cost/effort. Sampling methodologies may be evaluated on PPM in Oscar One, North San Mateo, and/or South San Mateo or evaluated on a surrogate *Perognathus longimembris* subspecies and validated in Oscar One.

In 2010, the top sampling method will be employed for PAO monitoring in the Oscar One monitoring area. The San Mateo population(s) will also be comprehensively surveyed, if feasible, using the chosen sample method. Data from the 2010 pilot monitoring will then be used to assess initial PAO estimates, detection probabilities, density or activity index, and power to detect changes in occupied habitat. These results will be used to refine the study area, plot size, and 'trap' spacing, if needed. A long term study plan will be drafted in 2010-2011. The 2008 and 2009 studies are summarized below. More detailed study plans will be submitted separately prior to each years sampling.

2008 Preliminary Studies

Question 1: Are PPM still present in South and North San Mateo sites? If so, are there few or many?

Question 2: Can we collect meaningful small scale covariate data in a short amount of time that is precise enough to be reliable.

Q1: Live-trap to determine if PPM still present

- 100% coverage over previously mapped habitat (see Figures 5 and 6)
- Census. Get an idea if there are a few or many (5 vs. 50?)
- Trap for 3 nights/mornings between May 1 and June 30 (3X3X9" Sherman live-traps- on loan from FWS). Grids will be trapped for 4 nights if no PPM are captured across grids in the first 2 nights.
- 10m spacing between all traps with and extra 3 traps placed subjectively in each 50m2 grid. Extra traps placed to maximize detectability of PPM (near open sandy patches with shrub cover edge).
- Collect covariates for Grid (larger spatial scale)
- Collect covariates 3m radius around trap (smaller spatial scale)

Q2: Environmental Covariates:

Data collection for testing hypotheses regarding PPM habitat suitability, species competition, and training/management activities. Data collection to be at both small and large spatial scales. (Smaller scale = 3m around each trap location, Large scale = Plot size ($50m^2$).

Note: data collection must be very fast (example: one person setting 200 traps and collecting 5 minutes of data at each trap would take >16 hours).

- GPS coordinate
- Presence of sandy patches? (Y/N with estimated proportion).
- Vegetative cover (growth forms: herbs/forbs, grasses, shrubs, trees, open ground, leaf litter) (Visual estimates). Data recorded at <1m (Dodd, Laabs, and Greene 1999).
- Dominant plant species recorded for each growth form.
- Recent human disturbance (low (few footprints), moderate (many footprints/trampling), high (vehicle tracks/ heavy trampling and use)).
- Slope and aspect (large scale only).
- Other rodent species detected (trap results).

Analyses/ Products:

- Detection probability and Proportion Area Occupied estimates.
- Capture probability and simple closed population abundance estimate.
- Minimum number known alive (MKNA).
- Observer variability vs. total variability in covariate data.
- Are any covariates predictive of PPM occupation (both spatial scales)?

Non permanent marking technique- hair clipping. (note: up to 4 nights -hair clip okay, more nights would require toe clip or elastomer method (D. Shier, CRES))

Need FWS approval to use nonpermitted field person for baiting traps. All traps will be checked for sensitivity after placement of seed. CSB will train and regularly check for proper seed placement and trap sensitivity.

Other considerations:

Can we properly age animals in the field (i.e. young of year)? Pelage not good characteristic.

- toothwear/ premolars (impression paper, other)?
- Relative measurements of hind foot, body, ear, tail (ears and feet grow first, body and tail take longer to catch up)?
- Test of scat (Growth hormone or other?). Explore cost and feasibility.

No monitoring in Oscar One or Edson in 2008.

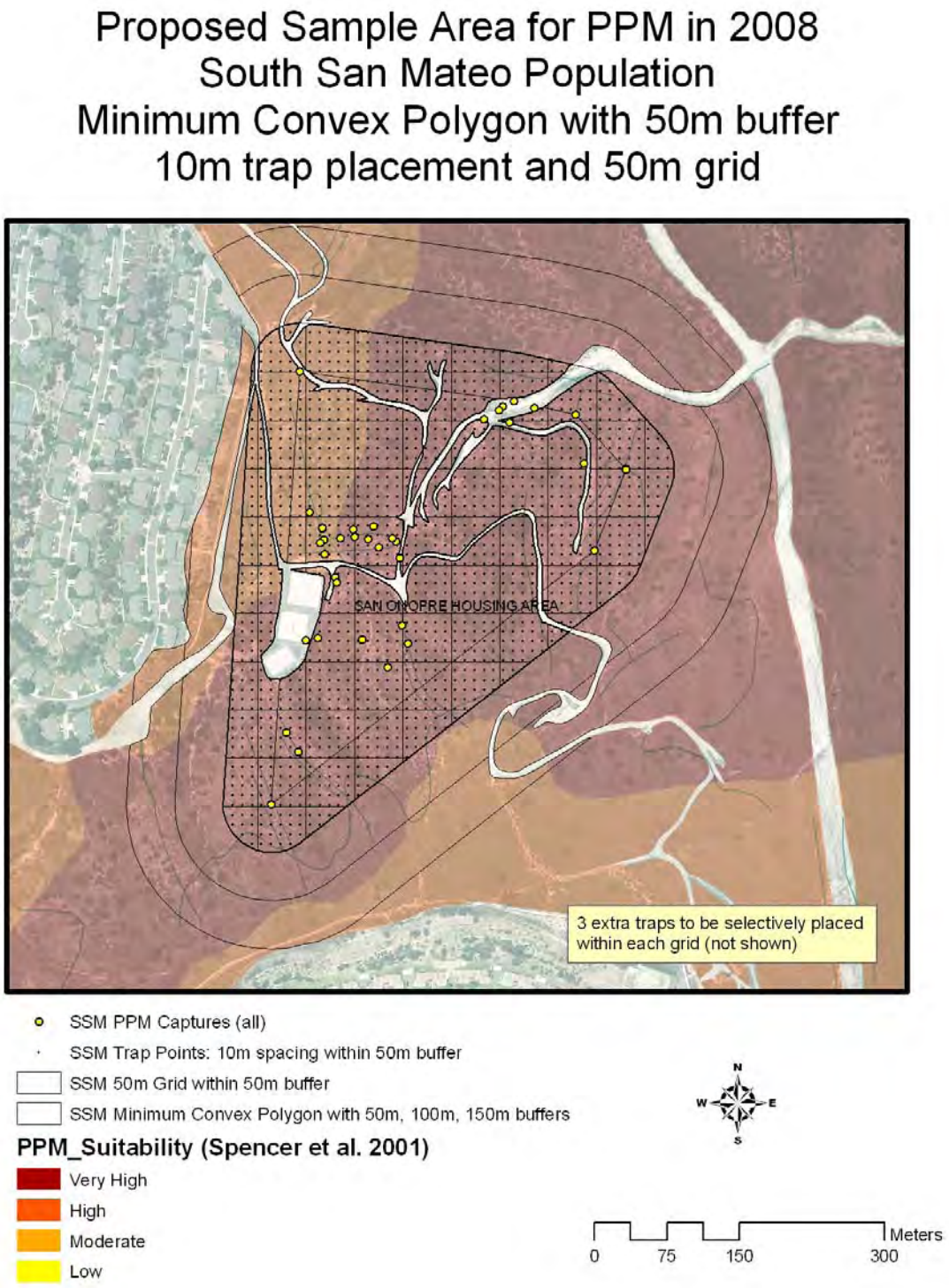

Figure 6. The proposed sampling area and trap placement for complete coverage of the South San Mateo PPM population in 2008.

Sampling area is defined by a minimum convex polygon around historic PPM captures and an added 50m buffer within adjacent suitable habitat. Traps will be placed 10m apart over the entire sampling area with an extra 3 traps placed in optimal habitat (near open sandy patches with shrub cover edge) within each 50m2 grid.

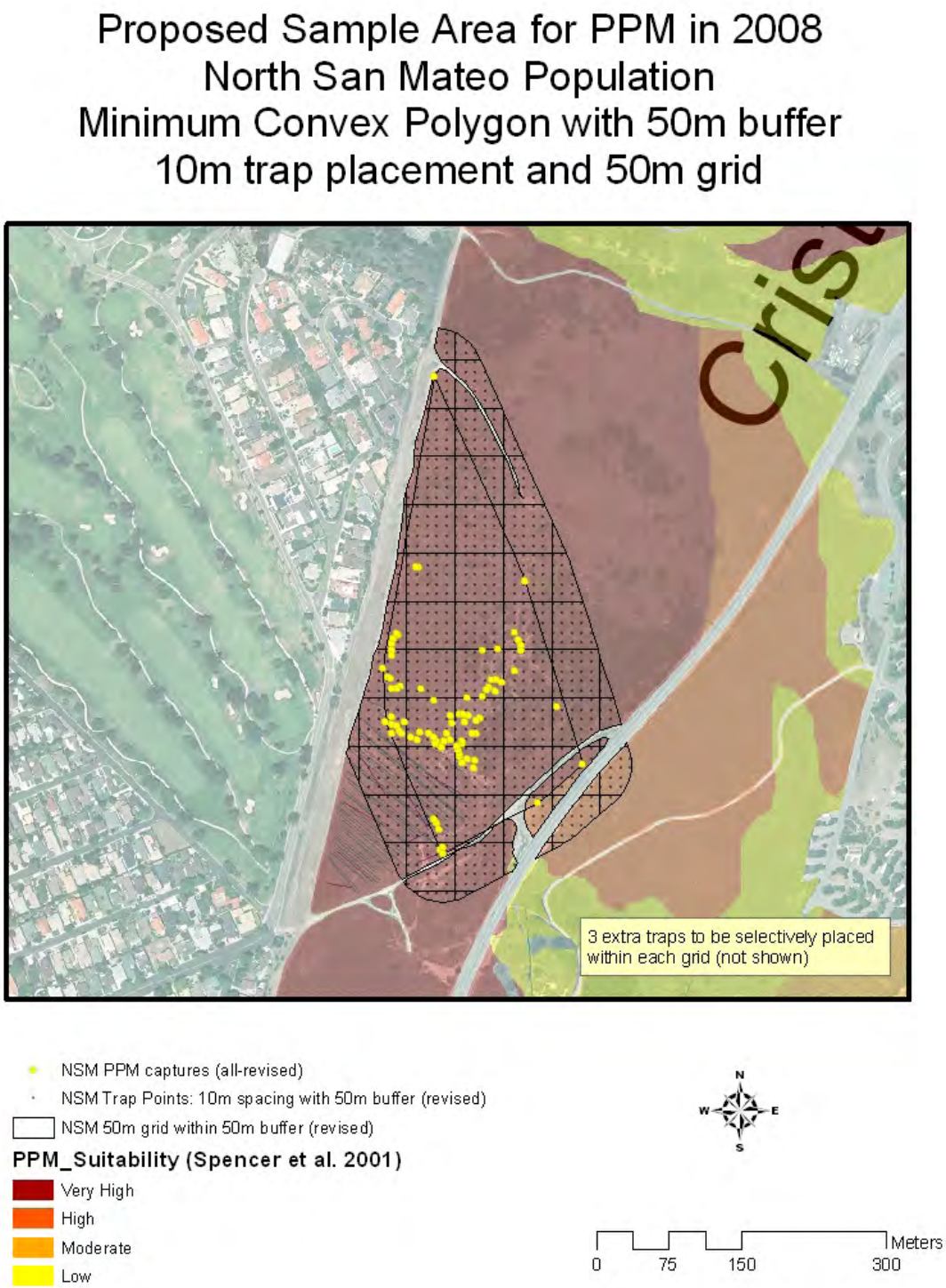

Figure 7. Proposed sampling area and trap placement for complete coverage of the North San Mateo PPM population in 2008.

Sampling area is defined by a minimum convex polygon around historic PPM captures and an added 50m buffer within adjacent suitable habitat. Traps will be placed 10m apart over the entire sampling area with an extra 3 traps placed in optimal habitat (near open sandy patches with shrub cover edge) within each 50m2 grid.

2009 Preliminary Studies

Question: What is the optimal sampling method for annual monitoring of PPM?

Evaluation Criteria and Analyses:

- accuracy
- detection probability
- impact to species
- impact to habitat
- cost

Compare the following potential sampling methods.

- Sherman Traps (2 sizes)
  - (2"X2.5"X6.5")
  - (3"X3.5"X9") Perforated vs. Non perforated.
- Tracking tubes
  - 1.5” diameter vs. 1.0” diameter (12” length)
- Scat collection- for all methods above to determine efficacy as detection technique.
- Dog detection of PPM scat and/or sand bathing areas (UW).

Supplemental Integral Studies:

- Supplemental: use video camera to view species behavioral response to different trap/track types.
- Supplemental: Develop and assess fecal assays for species, gender, hormones, and microsatellites (6-loci, UW). (i.e. potential to identify PPM individuals and reproductive condition with collection of scat).

Proposed Locations

1. Oscar One and South San Mateo in known PPM habitat. Possible North San Mateo. Materials and methods may also be supplied to Dana Point.

Time frame: May and June 2009. Possibly through mid-July if PPM are still active and more data is warranted.

Deliverables: Report with comparative analyses of methods. Recommendations of sampling methodology for long term monitoring program. Shapefile or Feature class with locations of surveys and PPM detections.

Detection probability, estimated PAO, and desired precision will be used to calculate number of samples and repeat visits for pilot monitoring in Oscar One/Edson in 2010.

Data will also be applied to assessment of North and South San Mateo sampling strategies.

APPENDIX 1: Pacific Pocket Mouse Long Term Monitoring Workshop Materials (Individually numbered pages 1-23).

Pacific Pocket Mouse Monitoring Workshop
Marine Corps Base Camp Pendleton

Date & Location: Thursday, Sept. 6: 9AM-5PM
Friday, Sept. 7 (Scientific Panel Only): 9AM-5PM
USGS, Western Ecological Research Center Conference Room
4165 Spruance Road, Suite 200
San Diego, CA 92101
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Scientific Panel Members:

Kenneth Burnham, Statistician, USGS/ Colorado State University
Douglas Deutschman, Statistician, San Diego State University
Peter Meserve, Ecologist, Northern Illinois University
William Miller, Biologist, US Fish and Wildlife Service
Mark Pavelka, Biologist, US Fish and Wildlife Service
Wayne Spencer, Ecologist, Conservation Biology Institute

Additional Participants:

Peter Beck, US Fish and Wildlife Service
Phil Brylski, Independent Scientist
Lee Ann Carranza, Center for Natural Lands Management
Shana Dodd, S.C. Dodd Biological Consulting
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Pacific Pocket Mouse Monitoring Workshop for MCB Camp Pendleton

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WORKSHOP AGENDA

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Day 1 (Thursday, September 6)

9:00-9:20AM Introductions
Order lunch

9:20-10:00AM Review workshop purpose and objectives, goals of monitoring program, and roles of workshop members.

10:00- 10:45AM Review maps of PPM occurrence (Figure 1, others).
Review and Refine PPM Background/Conceptual model (Figures 2 & 3).

10:45-11:00AM Break

11:00- 11:30 History of monitoring on Camp Pendleton (Oscar 1). May include discussion from workshop participants on other monitoring efforts.

11:30-12:30 Group discussion (suggested topics)

1. How does PPM function on the landscape? Population dynamics (Figure 4).
2. What basic methods are available for monitoring these types of populations? (Review table 1).
    a. What do we learn from each from these strategies (data output/ analysis)
    b. How do results tie into informed management recommendations/ actions?
3. What methods could be used to sample for PPM? Table 2. Discuss Pros and Cons.

12:30-1:30 Lunch

1:30-5:00 Group discussion (suggested topics, continued)

4. Create basic components for monitoring plan to minimally and most effectively track the status of PPM on Camp Pendleton. Fill out table: Sampling scheme, frequency, timing, responses/ data output, tie to management, covariates).
5. What criteria should be met to warrant management action and why.
6. What supplemental studies would you recommend for Camp Pendleton to learn more about PPM dynamics and/or methodologies to effectively manage PPM populations? Why?

Day 2 (Friday, September 7)
Scientific Panel Only

9:00AM-12:00PM Discussion and consensus on monitoring plan strategy for MCBCP.

Protocols
Sampling design
Need for initial studies and/or further analyses of existing data
Define potential habitat and locations for monitoring
Sampling frequency
Environmental, Habitat, and/or Demographic Variables to record
Analysis
Adaptive protocol? Review period
Criteria for Management action
Supplemental information needs

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1:00-4:00PM **Tour of MCB Camp Pendleton PPM Habitat**

****

4:00-5:00PM **Return to USGS office**

****

Workshop Purpose & Objectives

The purpose of this workshop is to develop a scientifically valid, effective, and cost-effective monitoring program for the Pacific pocket mouse (*Perognathus longimembris pacificus,* PPM) on Marine Corps Base Camp Pendleton (referred to as MCB Camp Pendleton & MCBCP). The monitoring program should document trends in the status of PPM on base and identify results criteria for management action. This protocol is to be developed using a Scientific Peer Review Panel, with additional participation of USFWS, CDFG, as well as other agencies and scientists.

About Camp Pendleton

Camp Pendleton occupies approximately 125,000 acres of largely undeveloped land, with more than 17 miles of coastline, in northwestern San Diego County. It is the Marine Corps' premier amphibious training Base and its only west coast amphibious assault training center. The primary mission for Marine Corps Base Camp Pendleton (MCBCP) is "to operate an amphibious training Base that promotes the combat readiness of operating forces by providing facilities, services, and support responsive to the needs of Marines, Sailors, and their families" (MCB Camp Pendleton Strategic Plan 2002). In addition, the base has committed to fulfill stewardship and regulatory requirements for the natural resources on base. This includes monitoring and management for the endangered Pacific pocket mouse as described in the MCBCP Integrated Natural Resources Management Plan (October 2001).

There are three known areas within the base that still harbor PPM populations. These are north San Mateo (~4.2 ha), south San Mateo (~15.0 ha), and north Santa Margarita (Oscar One and Edson Ranges, ~634 ha, Figure 1). Multiple trapping efforts have been conducted on base since the species was rediscovered on the Dana Point Headlands in 1993. Most have been to establish distributional data and limits of species occurrence. Extra studies were designed to understand PPM habitat and/or effects of management activities. Many were inconclusive due to low numbers of PPM captured or other reasons. The primary drivers of PPM distribution are unknown, but are thought to be primarily associated with the presence of open sandy patches within CSS or other vegetation containing grasses and forbs. The USFWS have also monitored abundance at two large grids within the Oscar One training area from 1997 to 1998 and 2003 to 2005. Location maps, monitoring results, and trends will be discussed during the workshop.

Roles of Workshop Members

Role of Scientific Peer Review Panel

The Scientific Peer Review Panel (SPRP) consists of scientists with a strong background in wildlife monitoring methodologies and statistics, small mammal ecology and/or PPM natural history. Although many of our scientists have knowledge in more than one subject area, the specific roles of each member of the panel are defined below. Prior to the workshop, the SPRP will review the relevant background literature provided to them by USGS. At the workshop, the SPRP will evaluate existing monitoring design(s) and decide upon a design to meet the program objectives. After the workshop, USGS will submit a draft of the monitoring protocol to the SPRP. The SPRP will then provide USGS with their review and comments of the draft.

Panel Member	Role
Kenneth Burnham	Monitoring Program Statistical Design
Douglas Deutschman	Monitoring Program Statistical Design
Peter Meserve	Small Mammal Community Ecology Expert
William Miller	Pacific Pocket Mouse Expert
Mark Pavelka	Pacific Pocket Mouse Expert
Wayne Spencer	Pacific Pocket Mouse Expert

Role of USGS

USGS is responsible for organizing the panel and workshop, providing any needed supportive data and/or statistical analyses, developing a protocol review system, managing of the process, and the completion of the draft and final monitoring protocol.

Role of Camp Pendleton

The Base representative and his designee will provide an oversight role to USGS and will be engaged in all meetings and correspondence.

Role of Additional Participants

We are fortunate to have additional workshop participants with significant PPM experience and expertise, as well as key representatives from regulatory agencies and land management agencies. Invited representatives and scientists from USGS, USFWS, CDFG, and other agencies will act in a support capacity to the Scientific Peer Review Panel during the workshop and are encouraged to join in the discussion. Representatives will be provided a draft of the monitoring protocol but are not required to submit their comments to USGS staff. The SPRP will have the final decision on the monitoring protocol recommendations for implementation on MCB Camp Pendleton.

PPM Background/ Conceptual Model

History

First described in 1898
Subspecies of the Little pocket mouse (*Perognathus longimembris*). One of 19 subspecies.
Historically rare and patchily distributed along coastal southern California (~10 known locations).
Populations found only within 4km of coast
Thought extinct until rediscovered on Dana Point in 1993
Federally listed as endangered on September 29, 1994
Discovered in 3 locations within Camp Pendleton in 1995 (North San Mateo, South San Mateo, North Santa Margarita)
Total occupied habitat <700 ha
Goal to establish 10 independently viable populations and >2000 ha occupied habitat within historic range (Recovery Plan 1998)

Species Life History & Stressors (Figure 2)

Some aspects of PPM life history and/or ecology have not been studied, but are inferred from studies of other subspecies of *Perognathus longimembris*. These are designated as (PELO) below.

General:

Physiologically adapted to warm and dry climates
Go into variable lengths of facultative torpor during winter & low resource conditions
Live up to 3-5 years in the wild & 8 years in captivity
Average survivorship unknown (higher than other rodents due to use of facultative torpor and lower reproductive output- other PELO 30% annual survival)
Abundance/presence variable over time and space.
Nocturnal
Nonsocial

Stressors (general):

- Lack of suitable habitat
- Low/no connectivity (dispersal corridors)
- Low food resources
- High predation pressure (owls, snakes, coyotes, foxes, feral cats, invasive ants)
- High Competitive pressure (other rodents, ants)
- Disease
- Low genetic variability

Habitat:

Typically found in or near sandy soils (>90-95%), but also found occasionally on loam & clay soils
Primarily open coastal sage scrub (Artemisia/ White sage) with a moderate amount of grass and forb understory. Also "coastal strand, coastal dunes & ruderal vegetation, "weedy" fields, grassy fields).
Reported percent shrub cover ranges from 0 to 79% (no consistent results, vegetation studies all done within PPM habitat), open ground 9-26%, not found in dense non-native grasslands. One study inferred positive response from clearing.
Thought to prefer some shrub or large forb cover vs. completely open habitat (PELO).

Stressors:

Dense ground cover (shrubs, brome grasses) may prohibit movement.
Little to no ground cover (Fires, clearing by heavy training, vehicles)
Hardened soils (due to trampling/heavy equipment/drought) affect burrowing ability/ energetics
Agriculture (prior & current)

Food habits:

Feeds primarily on grass seeds (*Bromus**, other) and forb seeds (*Heterotheca grandiflora*, Pluchea sericea, Hordeum murinum, Croton californicus*, Centaura melitensis, Corethrogyne filaginafolia, Gnapthalium sp., Calacadenia sp*., other).
(* found at all historic & currently occupied sites –D. Germano 1997)
Thought to get all or most of water from food (but regularly drink water in captivity)

Stressors:

Low seed production- drought years
Dense ground cover (shrubs, brome grasses) may reduce foraging efficiency.
Competition for seeds from other species (rodents, ants, birds)
Consumption of pesticides from rodent control programs.

Reproduction:

Typically breed once per year during April-June. Can breed 2X in high resource years and 0X in low resource years.
Females may reach reproductive age same year of birth (41 days old).
0-2 litters/season, 4-6 young/ litter, Gestate for ~23 days, Weaned at ~30 days, (PELO)

Stressors:

Drought. Reproductive output may be reduced or eliminated in drought years.
Affected by timing of rains (possibly due to resource type availability).
Low population densities result in decreased chance of finding mate, lower effective population size.

Home range/ Dispersal:

Relatively small home ranges reported (0.38- 1.1 ha, other PELO studies- desert)
Little known about age, timing, mechanisms of dispersal. Juveniles disperse (PELO).
Home range/movement estimates:

- Radius of 35-60m (other PELO studies- desert)
- Mean distance 30.3m (Range 7.3-82.6m) Dana Point 1997 (9 nights, 15 indiv)
- Mean distance 35.9m (Range 4.0-181.0m) Dana Point 1998 (12 nights, 19 indiv)
- Maximum distance 7.0m. Oscar One 1998 (24 nights, 70 animals, 10X 10 grids, Grid sizes 0.07 ha and 0.30 ha)

Oscar 1 2003-2005 (5-10 trap nights/session, 3-4 sessions/year, 20X30 grids, 1.4ha)

- 95% of movements <43m. within session.
- 95% of movements <57m within year
- 95% of movements <81m within among years

Stressors:

Lack of surrounding suitable habitat (natural/ unnatural) for dispersal to other suitable habitat patches.

Behaviors:

Seasonal activity- Facultative torpor during fall & winter & extreme weather or low resource conditions (food availability)
Activity period: 60-90 days typical – adults trappable longer in poor years (PELO)
Emergence from torpor –in spring (March-May) related to soil temperature, seed availability?
Submergence into torpor- late summer to late fall, reproduction complete, seeds stored
Activity patterns vary during active season (adult males emerge & submerge first, females second, juveniles 3rd (Figure 3, PELO).
Forage under cover of shrubs/ forbs (PELO).
Collects seeds in external cheek pouches.
Cache seeds (mostly larder hoarding in burrows).
Typically asocial.
Dust baths to maintain healthy pelage.
Burrow depth from 1-67cm reported (desert PELO).

Stressors:

Hardened soil or lack of loose soil may decrease burrowing efficiency or potential cache sites (seed storage).
Burrow collapse from vehicular activity or heavy training.
No loose soil for bathing (result is unhealthy pelage- parasites/ less effective insulation).
Loud noises may interfere with time spent foraging and predatory response (artillery fire, bombing, troop movement)
Artificial lights decrease foraging, foraging efficiency

Population growth & decline (potential causes)

Growth

Natural:

Increased resource availability: Greater seed output due to normal or high levels of rainfall.
Decrease of natural predators
Habitat gain: Open up previously closed vegetation (natural fires, scouring events, intense drought) or conversely increased cover on previously open vegetation.

Unnatural:

Increased resource availability: Invasive grasses/ herbaceous plants provide greater seed output.
Habitat gain: Open up previously closed vegetation (unnatural fires-infrequent burn intervals, bomb explosions, intense training activities, roads and firebreaks, shallow discing)
Road berms increase potential burrow sites in suitable & unsuitable habitat.

Decline

Natural:

Decreased resource availability (Decreased fitness, decreased reproductive success, starvation): drought, plant diseases & pests
Increased predation/ predator pressure (owls, foxes, coyotes, snakes, native fire ants).
Increased competition for food/habitat: (other rodents, ants, birds)
Habitat loss: Successional changes (late seral communities), complete overgrowth & invasion of non-native grasses.
Habitat loss: Complete loss of vegetation due to plant disease, drought
Diseases, high parasites load

Unnatural:

Habitat loss: Development (buildings, highways, roads), compaction of soils (troop & heavy equipment movements, bikers/hikers from nearby neighborhoods)
Habitat loss: Type conversion to thick non-native grasslands, frequent fires resulting in lack of cover)
Fragmentation/Isolation by infrastructure: Paved roads, buildings, housing developments.
Increased predation/ predator pressure (cats, dogs, Argentine ants)
Increased competition: non-native rodents (*Mus musculus?)*
Direct mortality: Crushed/injured by trampling/ fire/ road maintenance/ development of land/rodenticides.
Decreased resource availability: herbicides, non-native grass removal? (potentially)
Noise/explosions decrease habitat quality by decreasing efficiency of communications, anti-predator strategies, stress levels
Decreased foraging time and efficiency due to presence of artificial lights.
Disease transmission from exotic mammals.
Ingestion of poisons used to control unwanted rodent infestations (i.e., squirrels-plague)

Status and Trend

Distribution:

Historic: ~9 populations patchily distributed along coast from southern Los Angeles (Marina Del Rey & El Segundo) to Southern San Diego County (Tijuana estuary)

Current: ~ 4 populations in northern San Diego (MCB Camp Pendleton) and southern Orange County (Dana Point).

Population numbers and sizes:

"North Santa Margarita" (MCBCP: Oscar 1 & Edson Range)

- ~634 ha (1567 acres) unknown occupancy/patchily distributed (FWS estimate ~20%).
- Overall abundance not estimated. Uncorrected densities in grid locations within best habitat range from 6 -196/ha.

"South San Mateo" (MCBCP)

- ~15.0 ha (37 acres)
- maximum 19 animals captured/varied efforts

"North San Mateo" (MCBCP)

- ~4.2 ha (10.3 acres)
- PPM Captures range from 4-33 individuals (1995-1996, 2001)

"Dana Point" (CNLM)

- 8.9 ha preserve (22 acres)
- PPM Captures range from 2-36 individuals (1993-2002)

Grand total

- ~662 ha "habitat"
- % occupancy within unknown
- Overall abundance unknown

Annual variation:

Distribution: Unknown variation but presumed large (Dana Point/ Oscar 1 studies)

Abundance/ density: Large- 32 fold differences reported (includes juveniles).

- Juveniles and adults difficult to tell apart

Long Term Trends:

Overall trends may be largely unknown.

Expect large annual fluctuations in abundance as with other rodents/ heteromyids.

Camp Pendleton:

Monitoring:

Existing monitoring program: MCBCP from 2003-2005

Oscar 1 portion of “North Santa Margarita” population
2 live-trapping grids (“A” & “D”) on most densely populated homogenous areas
Grid size= 1.4 ha (3.4 acres); 600 traps ; 5m trap spacing
Run 4-10 nights, 4X per year (April through September)

Population numbers and sizes:

Grid A: 17 to 274 animals captured from 2003-5 (includes juveniles)
Grid D: 8 to 257 animals captured from 2003-5 (includes juveniles)

Capture probabilities:

(2004) Capture Probabilities were 0.16 to 0.79 (5m trap spacing- lowest in September)
Recapture probabilities higher-Trap happy?
Note: (1997/8) Capture Probabilities were 0.03 to 0.23 (10m trap spacing, lowest in September)

Trends (general):

Drop in abundance in 2005 compared to 2003 and 2004. Some variability among sites.
Times of peak population estimates vary within and among years.

Potential Management Actions

Reintroduction programs (Relocation to suitable habitat)
Vegetation manipulation (addition of shrubs to open habitat, removal from closed habitats (clearing may be effective/ inconclusive results from previous studies)
Seed supplementation in poor resource years
Reduction of artificial lights at night.
Control of feral pets.
Prevent any disturbance, degradation of current habitat (fence off).

References for Workshop Materials and Conceptual Model

Acknowledgements: Mark Pavelka and Will Miller provided us with extensive PPM literature and literature review information.

(* Supplied to Scientific Peer Review Panel)

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Note: Does not contain complete list of all PPM trapping reports.

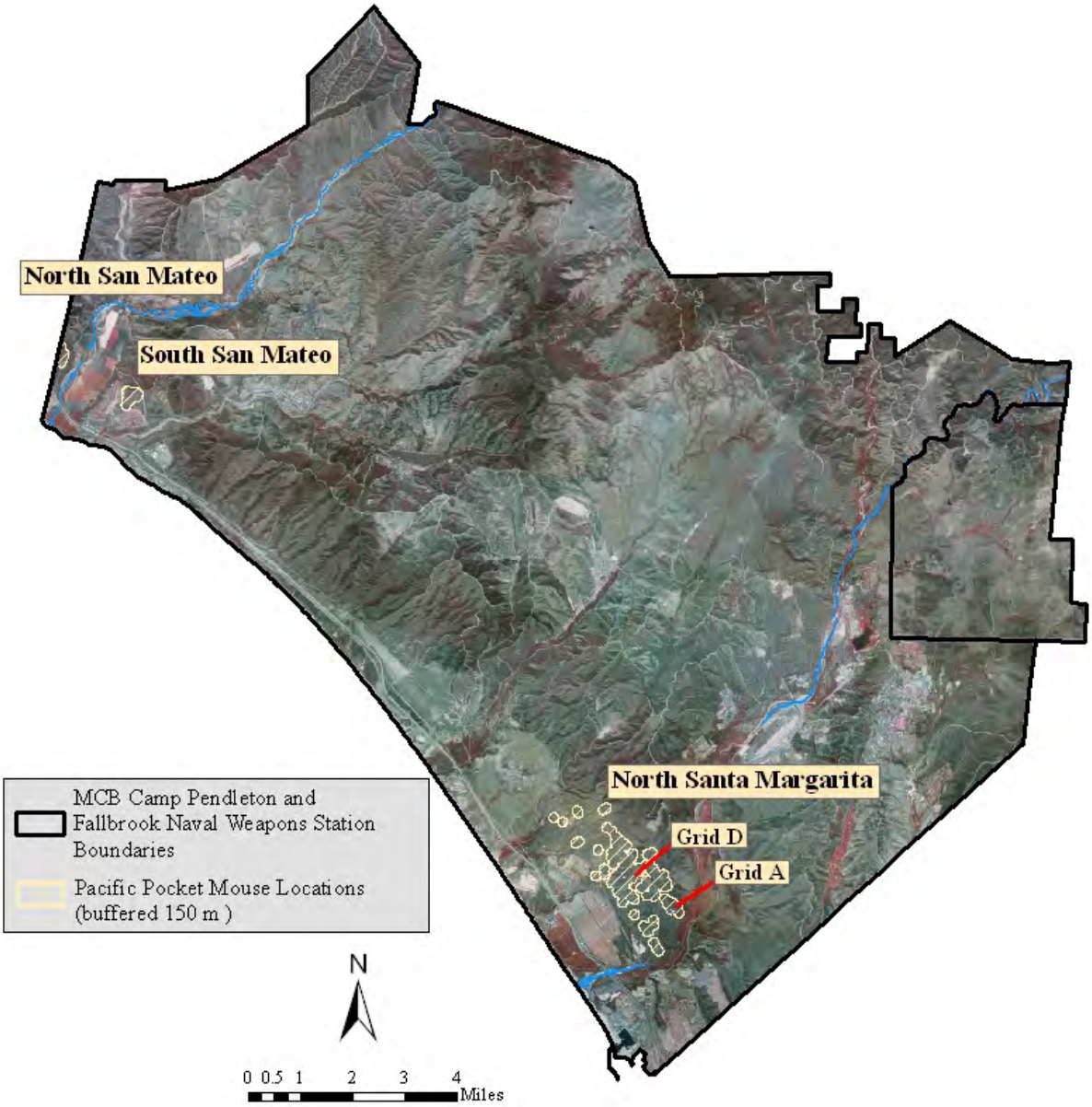
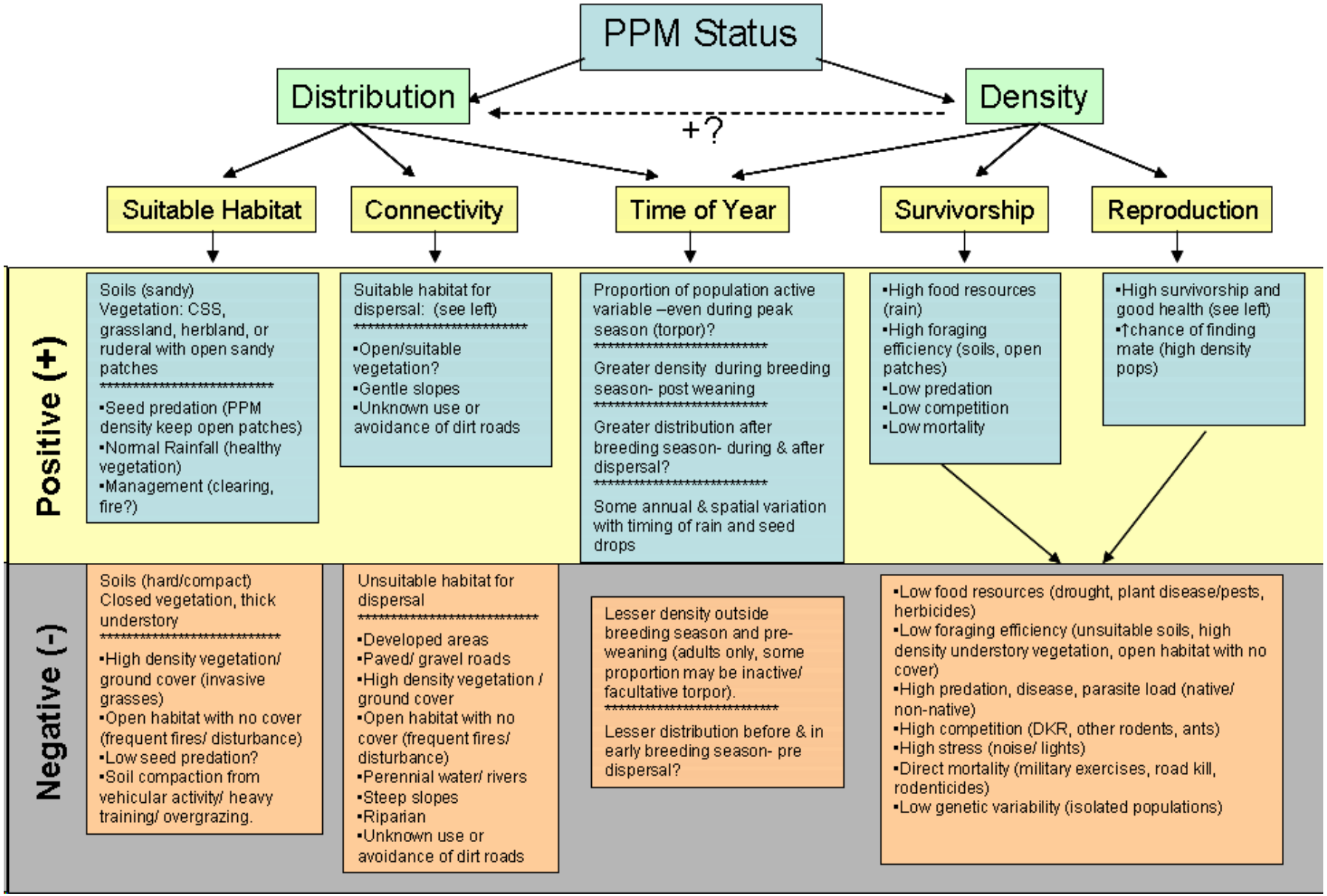


Figure 1. Map of PPM Habitat (documented locations with 150m buffer) and 1997, 1998, 2003-5 North Santa Margarita "Oscar 1" Monitoring Sites (Grid locations) on MCB Camp Pendleton.

PPM Conceptual Model



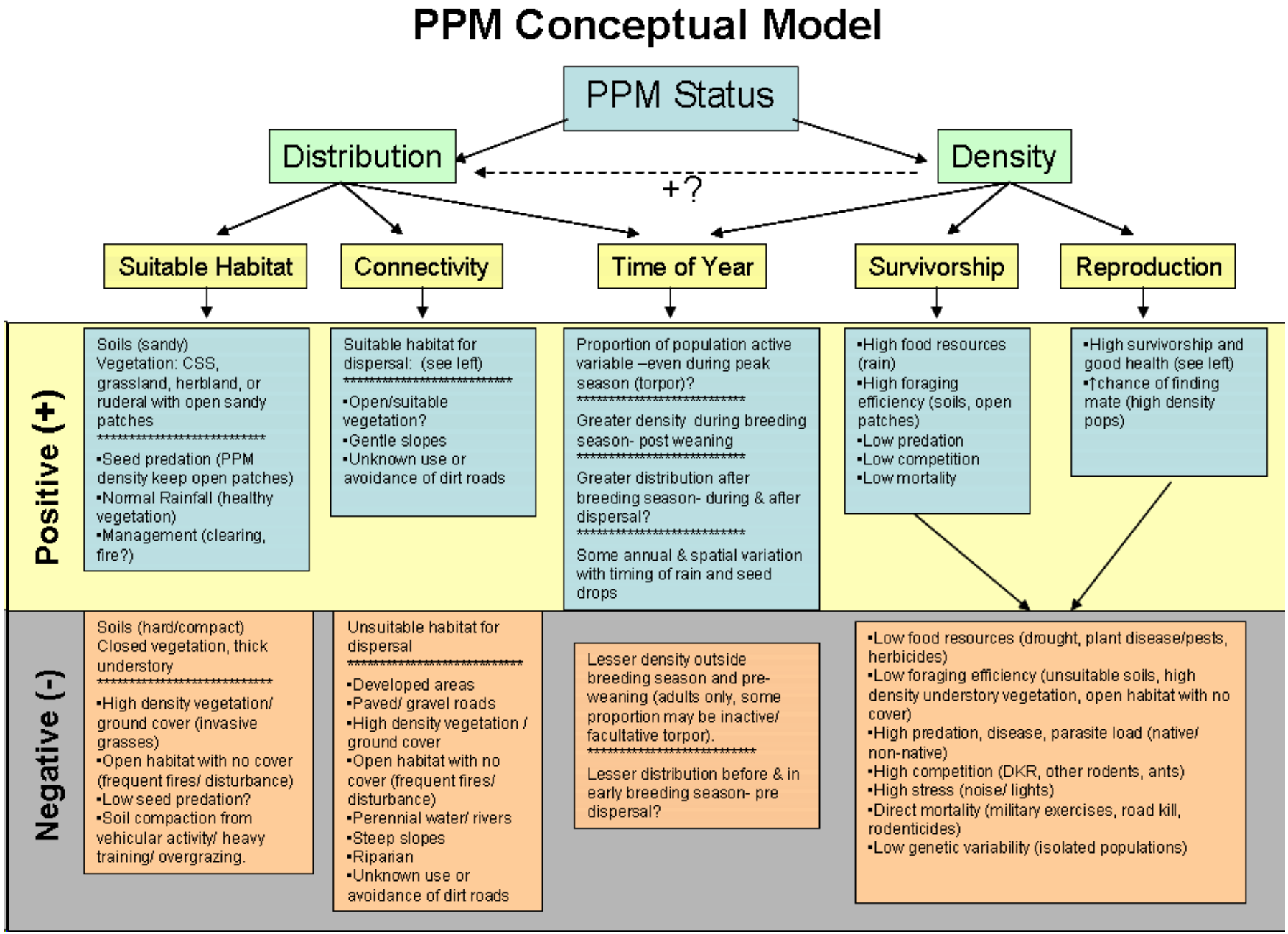
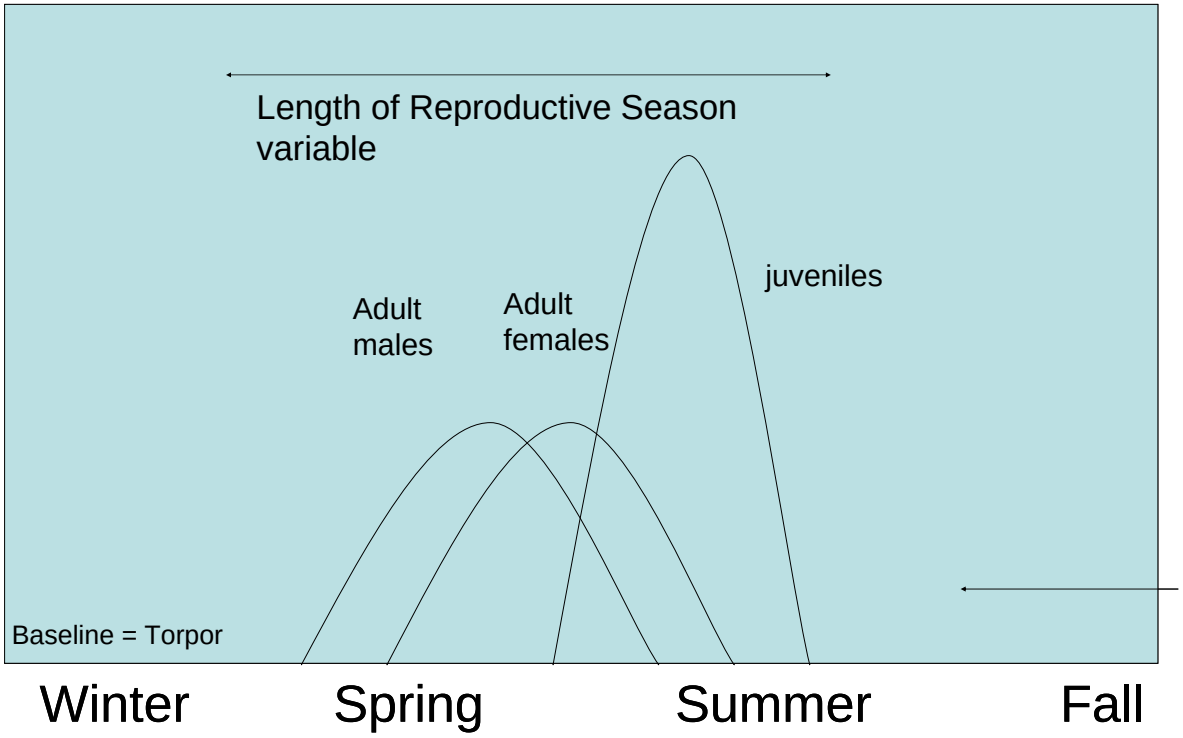


Figure 2. Proposed Conceptual Model for Pacific Pocket Mouse Population Dynamics.

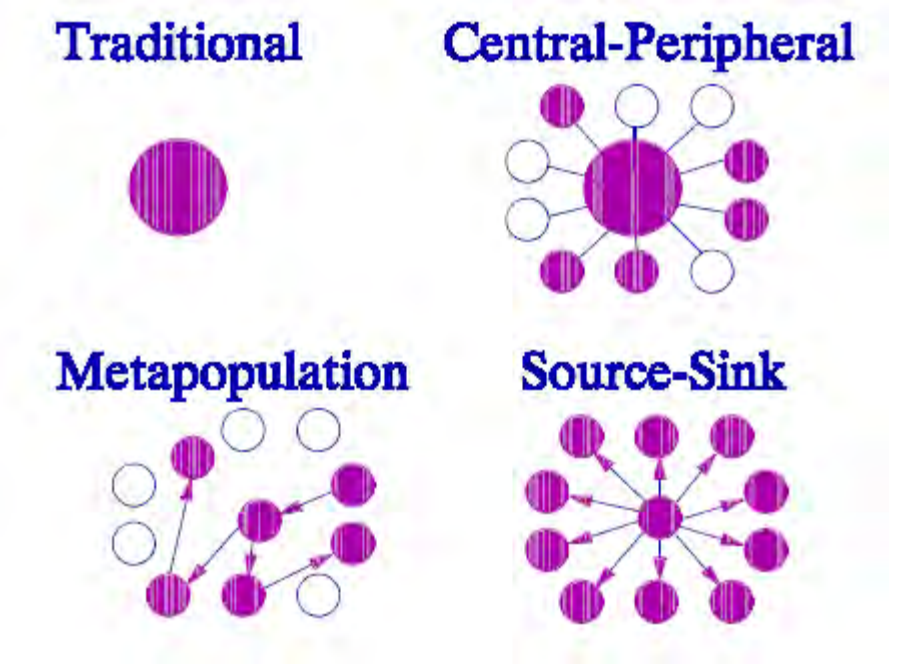
Status of PPM is the product of distribution and density. Positive effects (+) are depicted in the top row of blue boxes, while negative stressors (-) are depicted in bottom row of orange boxes.

Simple Conceptual Model:
Seasonal Variability in PPM Density/ Distribution



Reproductive cycles
(0-2 per year: average =1)
Gestation: 23 days
(ave: 5 young)
Weaned: 30 days
Maturity: 41 days

Figure 3. Conceptual Model for Pacific pocket mouse above ground activity patterns & population demography over time.



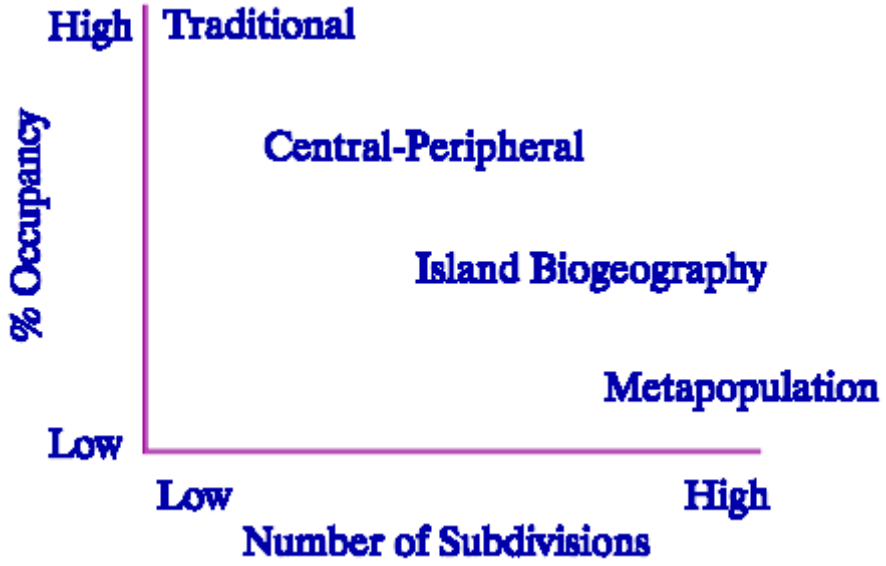


Figure 4. Spatial Population Models (see definitions on following page)

Spatial Population Models (Definitions for Figure 4)

Traditional- Nonspatial

Single homogeneous population.
Equilibrium -- population reaches a carrying capacity.
Extinction dependent on N.
Homogeneous environment/habitat -- no spatial heterogeneity.
Spatial-area of occupancy not related to abundance

Traditional- spatial

Spatial-area of occupancy increases/ decreases with abundance
Diffusion Equation

Metapopulation

Many local populations (>2, 10?).
Each local population has a given extinction probability.
Each local population has traditional dynamics
High probability of extinction generates "winking", no probability of extinction generates "fixed" populations.
Dispersal is responsible for re-colonization of vacant sites.

Mainland-island and source-sink spatial populations

Persistence depends on the existence of one or more extinction-resistant populations.
Example, the checkered white butterfly in Central Valley, California, as its source as riparian areas. Some patches have e = 0, other patches have e > 0.

Patchy populations

Dispersal between patches or subpopulations is so high that the system is effectively a single extinction-resistant population.
In this case m >> e.

Non-equilibrium metapopulations

local extinction occurs in the coarse of a species overall regional decline.
(This suggests a modified view of metapopulation dynamics in which local extinction is more an incidental occurrence than a central feature. A natural example of this phenomena are mammal populations in the sky island country of the south-west, where mammals were isolated on mountain top habitat during post-Pleistocene warming. A more frequent example is human-caused fragmentation of natural habitats.)

Taken from FW662 -- Wildlife Population Dynamics, Gary C. White, Colorado State Univ.
http://www.cnr.colostate.edu/class_info/fw662/web_docs/Lecture%208%20Spatially-structured%20populations.pdf

Table 1. Basic Approaches to Population Monitoring Schemes							
Program	Purpose	Methods	Frequency	Timing	Possible Response Variables	Some strengths	Some limitations (if population assumption incorrect)
PAO/ Patch Occupancy	Distribution	Survey for presence throughout potential habitat. Sampling schemes could vary.	Could Vary	Could vary	Prop. Area Occupied, Detection probabilities, Colonization/ Extinction, Relationship of covariates to Presence/Absence (i.e., habitat variables, other spp., stressors).	Powerful for tracking metapopulation dynamics: Strong relationships established between target species and habitat/stressor variables can directly relate to mgmt actions.	No information on abundance/ densities or demographic variables. Large number of sub-populations could "blink out" due to critically low abundance before management action is recommended. . Difficult to model when occupancy is low.
Abundance Monitoring	Population Abundance / Density	Survey for abundance at fixed locations within species habitat. Sampling schemes could vary.	Could Vary	Could vary	Estimate total abundance, Capture probabilities, reproductive success, survivorship, relationship of covariates to abundance (i.e. other spp. (competition), stressors).	Powerful for tracking increases and decreases in population size over predefined area. Potential to learn about fluctuations in abundance and demographic variables over time and perhaps in response to environmental/ climatic variables.	No information on distribution. Assume uniform abundance over predefined habitat boundaries. Could conclude species in trouble due to low numbers when location of high density may have only moved. Low power for analysis of habitat variables. Difficult to model when abundance is low.

Table 2. Potential and Current Sampling Methods for PPM

Purpose	Methods	Detection/ capture probability**	Some strengths	Some limitations
Presence/ Abundance	Live-trapping- box traps* (requires midnight and morning trap checks)	Averages: ~0.2-0.7 Varies within & among populations.	Proven. Direct abundance estimates. If frequent, gain information on demography.	High effort (requires midnight and morning trap checks). Capture probability unknown/ variable.
Presence/ Abundance	Live-trapping- pitfall traps (requires midnight and morning trap checks)	Unknown for PPM. Desert PELO very high.	Proven. Direct abundance estimates. If frequent, gain information on demography. Higher capture probability than box traps.	High effort (requires midnight and morning trap checks). Capture probability unknown. Requires digging in PPM habitat. Mortality may result from aggressive interactions of trapped individuals.
Presence/ Activity index	Track plates/ tubes	Unknown	Passive. Low cost- low effort.	Need to be proven sensitive enough to detect species. Print close to juvenile Chaetodipus? Probably Index of Activity not abundance?
Presence/ Abundance Index?	Search for sign (active burrows, scat, tracks)	Burrows plugged during inactive periods.	Low effort, proven method, passive.	May be difficult to positively identify. Absence confounded with inactivity. Need to trap to confirm presence Unknown # of burrow entrances per animal. Unknown # of active burrows plugged. Unknown accuracy in burrow ID.
Presence/ Abundance Index	Hair Snare/ Tube	Unknown	Passive Field effort. With genetics testing- could gain additional demographic info (presence, activity, abundance, demographics).	Time consuming laboratory effort? Possible safety concerns – snare may cause harm to such small animal. Genetics test development required (species ID & individual ID)– especially if used for abundance.
Presence	Infra red cameras	Unknown	Rel. low effort, passive.	Not proven- potential high initial cost for cameras/ film.
Abundance Index	Count burrows	Unknown. Less than 1.	Medium effort, passive.	Unknown # of burrow entrances per animal. Unknown # of active burrows plugged. Unknown accuracy in burrow ID. Unknown correlation with density.

*Only method currently in use for regular monitoring.
**All methods- detection probability varies by season & location- Highest in late spring/early summer

APPENDIX 2. Comments from MCBCP, Scientific Panel, and USGS on versions of this document (Individually numbered pages A-U).

PPM Monitoring for MCB Camp Pendleton: Post Workshop Notes

This is a compilation of workshop and panel input into several versions of this document:

Several versions sent to panel and MCBCP on 9/24/07, 3/17/08, and 3/31/2009

Comments received:
Eric Kershner [EK] 10/11/07, Roland Sosa [RS] 4/27/09
Doug Deutschman [DHD} 9/29/07
Ken Burnham [KB] 10/18/07, July 2008 (paper), 4/15/09
Peter Meserve [PM] 10/19/07, 4/11/08, 4/13/09
William Miller [WM] 1/14/08, 4/20/09
Mark Pavelka [MP] 1/14/08
Wayne Spencer [WS] 4/16/09

[CSB] Additional comments by CSB in red

I have summarized the workshop discussions regarding the monitoring plan in 3 main sections; 1) Key Considerations, 2) Goals for long-term monitoring program, and 3) Short term goals & studies for 2008. Issues that were agreed upon among the panel are in black. Outstanding issues and USGS comments are in red font. Please review & comment.

Thank you,'
Cheryl

Proposed changes to document that incorporate feedback are enclosed in boxes following original wording.

Comments on current version of document:

[KB] I have now read parts of the draft PPM Monitoring Plan you sent. I read, or looked at, the first 21 pages. I glanced at the two appendices but saw no reason to read them again give we have looked at them before and they are a record of what happened, so are not really subject to change. It is well written – there is nothing I would change; I have no comments or change suggestions, except maybe one. Page 7 refers to the Uplands Biological Consultation for the Base. I do not recall knowing what that is; should there be a reference to a document here, or any explanation of what this item is?
[PM] Let me look for the Paynie Pearson idea; it's not really very formal. The main thing is to search for most likely places to trap PPM rather than be limited to an arbitrary radius around a uniformly distanced sampling site. One problem might be that I am not sure what a PPM burrow looks like!!! I recall seeing very few burrows at all at Irvine.

As for the concept, I think that it could be searched under the term "hidey holes" since I vague recall a reference to the latter. I will do a search sometime soon. This whole idea came from a very humbling experience that I had trapping with Oliver (a.k. "Paynie") Pearson in southern Chile. In the late 1980's, we both started up a forested hillside looking for Rhyncholestes raphanurus (snout-nosed rat opossum) which Pearson had never seen alive. At a fork in the trail, Paynie went up one branch and set something like 10-15 traps at hidey holes and near rotten logs; I went up the other and set 50 traps every 10 m or so. In the morning he came back with 10 animals including several Rhyncholestes; I had 5 captures and no Rhyncholestes!!! 'nough said!
CSB- Yes- We definitely get better trap success where we subjectively look for sign/ suitable habitat & place traps there.
[WM] Please include as part of the record the following emails and any others that represent concepts that might otherwise be overlooked in the document : William Miller (WBM) to Cheryl Brehme (CB) 5-8-08, Ken Burnham (KB) to , CB 6-14-08, and WBM to KB 7-8-08. CSB- Added all as appendix 3
[RS] Have we come to a conclusion as to what we are going to call the PPM populations? I've been seeing Oscar One/Edson and I've been seeing Santa Margarita...do you know if there is a consensus on this?
I like Santa Margarita but know they have been historically called by training area- any votes?
[WS] I think this is a very good plan; about as good as possible given all the constraints and uncertainties. I like the adaptive nature and flexibility you've retained to improve methods with pilot studies.
San Mateo South site: Consider trapping beyond the MCP plus buffer area at select sites, especially along roads like the SDGE service roads to the north. If memory serves, there were sandy pockets scattered along some of the roads and trails at which we never captured PPM back in the 90s, but where I suspected PPM might colonize in some years. PPM may move along roads and inhabit sandy berms. I understand there has been grading over the years, and I don't know the current nature of the habitat there, but it's worth checking out.
CSB- Yes, I think we all believe that PPM extend well beyond current known occupied habitat (2008 results support this). Will need to determine how to best approach this- how to draw initial sample area, can change/expand as information is available, may need to be part of "discovery" at first.

Some Key Considerations:

1) PPM activity can be highly variable through time and space, making detection of abundance & other demographic trends in populations very difficult and time intensive (if not impossible!). MCBCP cannot continue to support cost and intensity of current program.

Alternatives:
1A) PPM activity and abundance can be highly variable through time (high seasonal & annual variability), making detection of abundance & other demographic trends in populations very challenging. There is currently little known about variation in spatial distribution over time.

1B) Task: Monitoring program should be scientifically justified, practical, and cost effective. Should be consistent with the existing Oscar One and pending Uplands consultation.

1C) Base would like information on species distribution and some measure of status and trends.

[EK] General comment: I need to reiterate that from the Base's perspective, we need to develop an efficient sampling technique that gives us 1) Distribution of the animals and 2) some form of indication of whether the numbers are increasing, decreasing, or remaining stable or some temporal time frame.

[DHD - I think this conclusion is premature. MCBCP has an obligation to monitor this species and has the right to demand that the monitoring be scientifically justified and cost effective. But, we should not be making sweeping statements like this just yet]
[KB] No comment
[PM] No comment
[WM] I am not sure I agree that tracking population trends is an impossible task but readily admit that tracking pop trends through time is extremely challenging. I think our primary challenge at the Oscar One grids was the population crash that occurred during our study which hampered the reliability of estimators during the portion of our study when population densities were low. Since low numbers are cause for greatest concern, the low precision at low numbers is vexing. With regards to the cost and intensity of monitoring that is warranted, I would like this decision to be made based on scientific principles and the conservation commitment made by the Base in relation to the existing Oscar One and pending Uplands consultation. Minimizing cost is an important goal but should not be the driving principle behind program design such that it forecloses consideration of what is needed to formulate a program that is scientifically defensible. If we have to back away from what is warranted then this decision should be made explicitly.
[WM2] As a general comment, references for the Marines, the Base, MCBCP etc should be consistent throughout the document. It is worthwhile to distinguish between the physical location of MCBCP and the Marines who are stewards of the land and who carry out biological consultations.
[WM2] SUGGESTED WORDING:1) "PPM Monitoring Program should be linked to monitoring requirements committed to by the Marine Corps during the formal consultation on programmatic activities in upland ecosystems on MCBCP and other formal consultations, as appropriate (e.g. consultations for the Crucible Challenge Course and road upgrades in Oscar One)".: Re: "Monitoring should inform the Base and FWS of reasonable and measurable goals for consultation". [CSB- removed per request} [WM] It is not clear what this is saying or if this statement is necessary The triggers for consultation are set forth in the implementing regulations for the ESA. This concept appears to be captured below. (2) Monitoring results should support and provide information of relevance to biological consultations but, based on the spatial detail that is of relevance to specific actions, it is acknowledged that basewide monitoring may not provide information that is sufficient for all biological consultations.
[CSB] Incorporated both sentences into document. 1) Changed "should be linked to"…"to should be linked".
[MP – Although the first statement seems plausible, it has not been confirmed by data. Our (FWS) 2003-2006 data from two trapping grids in Oscar-One indicates that PPM populations can fluctuate in abundance quite dramatically from year to year, especially in a downward direction. However, we do not have reliable data on the magnitude of spatial variance in trends of population abundance or other demographic parameters. Understanding spatial variance may be important to the allocation of effort (e.g., many small effort samples or few large effort samples) in the final design. Also, while I recognize the cost of any monitoring program needs to be reasonable, the available funding and existing monitoring commitments by MCBCP were not discussed at the workshop. The monitoring program should be based solely on scientific principles and proper funding sought to match the stated need. However, if the design is limited by specific constraints (e.g., cost) or must meet some specified minimum criteria (e.g., existing commitments) these should be stated clearly up front so that as alternative designs are considered or dismissed, the justification for any deviation from the best scientific principles can be acknowledged and any loss in information as a result estimated.
[PM2] I'd agree with Will that minimizing cost should not be the driving principle behind design considerations.

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2) PPM capture probabilities using Sherman traps can be highly variable through time and space (related to above ground activity and/or other?). FWS data in Oscar 1 also showed very low capture probabilities possible for large portion of population.

2A) PPM capture probabilities using Sherman traps can be highly variable through time and space (related to limited above ground activity and/or other unknown factor(s)).

2B) There is evidence that the probability of capturing PPM using Sherman traps is heterogenous among individuals in the population. Data suggests juveniles may have lower probability of capture in general (FWS data in Oscar 1 (2003-2005))

[EK] No comment
[DHD} No comment
[KB] No comment
[PM] No comment
[WM] Yes. We found support for heterogeneity as a factor governing detection probabilities. Though it is dangerous to generalize, it appears that a larger proportion of juveniles fall within the harder to detect category. Our data suggests that no. of unique animals captured (M t+1) is closest to our abundance estimates in April when juveniles are not present.
[MP – see Will's comments]

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3) Cannot estimate annual abundance using standard Sherman live-trapping methods with any accuracy. (i.e. FWS data in Oscar 1 with large grid in best habitat).

3A) It would be extremely challenging and time intensive (at best) to get accurate estimates of annual abundance using standard Sherman live-trapping methods on which to make informed decisions. This is particularly true when PPM are at low densities. FWS studies in Oscar 1 have shown that PPM abundance is highly variable and largely imprecise within each year (intensively trapping very large grid in best habitat).

[EK] No comment
[DHD - I would prefer to re-iterate that it is challenging to get precise estimates on which to make an informed decision]
[KB] No comment
[PM] No comment
[WM] Actually, using closed capture estimators we were able to estimate abundance with fairly small coefficients of variation (20% or less) during a number of sampling intervals. So this is not necessarily true. It would be more accurate to state that we cannot estimate abundance at low population densities with good accuracy. Our methods also employed considerable trapping effort (600 trap grids operated for 4-10 nights). At high pop densities we should be able to get away with smaller grids.
[MP – This statement may be an overstatement. Using closed-capture estimators we were successful at generating population size estimates with relatively tight confidence intervals for some trapping periods. In addition, we only tested one method – large 600 trap grids – thus we did not test other configurations of Sherman live traps (e.g., webs, multiple smaller grids) to support the broad dismissal of all Sherman live trapping methods for population abundance estimation. Abundance estimation (or use of Mt+1), based on trapping methods, may still be important at the smaller San Mateo sites where PAO or other approaches could be problematic.]
CSB- There is still the issue that abundance estimates differed greatly for each trapping period within a year. Which abundance estimate (i.e. which trapping period) would you use for an annual index?

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4) MCBCP would like to understand more about PPM spatial distribution to better inform about current and future training and troop movement.

[EK] No comment
[DHD} No comment
[KB] No comment
[PM] No comment
[WM]Okay but these actions should still be planned to maximize information gain (e.g. before/ after monitoring, control comparisons, etc.)
[MP – Monitoring for the purpose of assessing the net benefit of a management action should follow basic design principles (e.g., Before-After-Control-Impact; BACI) even if the number of animals is expected to be insufficient to support a statistical analysis. It is important to recognize that given the high variability in population size cited above and the lack of complete data on habitat affinity, habitat management actions could diminish habitat quality as well as increase it. As a result, as the population fluctuates in size (and PAO?) can we attribute any observed increase <u>or decrease</u> in PPM on the managed site directly to the management

action? Differentiating the effects of the management action will rely on a sound design, even if the numerical results are not statistically robust.
[CSB] I believe this statement is about informing troops of particular areas to avoid and possibly areas where PPM less likely to occur- as it relates to ongoing training/movement vs. any new proposed Base actions.
[RS] change- training movements and management activities to"Marine Corps training and management activities".

Low numbers of PPM may result in low power to assess effects of management actions

[EK] No comment
[DHD - same idea, combine]
[KB] No comment
[PM] No comment
[WM] No comment. [WM2] (Reword recommendation)However, the scientific panel acknowledges that this approach may have low power to assess effects if few PPM are encountered before impact.
CSB- Left wording as is- low power would be from few PPM before and after- if just before or after- would have high power- so left wording as is.
[MP] No comment

---

4) MCBCP would like to try different methods of applied habitat management (example: soil/sand additions, vegetation clearing), even if they do not fit into rigorous statistical design, to further conservation and recovery of PPM.
5)
Alternatives:
5A) MCBCP would like to try different methods of applied habitat management (example: soil/sand additions, vegetation clearing), even if they do not fit into rigorous statistical design, to further conservation and recovery of PPM.

5B) Program should incorporate study design to assess and inform. Low numbers of PPM may result in low power to assess effects of management actions

[EK] No comment
[DHD- Be very careful, if you can't track it rigorously, you cannot know it further conservation]
[KB] No comment. (2) Objective: Who is the management? FWS or MCBCP?
[PM] No comment
[WM] No comment
[MP] No comment
[CSB]: Perhaps try habitat mgmt to nearby unoccupied/less suitable areas & track through time.
[PM2] I like this idea too. If there are currently occupied areas, modifying them to resemble occupied areas (i.e., shrub vs. bare ground coverage) might be productive.

Other:
[KB] On page 1 it could be noted that the ppm is nocturnal. While we are not likely to forget this it is a key factor in design and or easy/difficulty of doing any direct monitoring of the animal (live capture of seeing it).
[PM] Concur with Ken that nocturnal activity is a major point; has anyone ever considered doing flourescent (or iridescent) tracking with this beast? Seems like it would give a better measure of activity/spatial range than live-trapping and enable more accurate scaling of grid size to real populations.
[KB] another big deal to me is that it is quite difficult to apply any sort of permanent, unique id "mark" to the animals. One really needs unique id for survival studies, but not necessarily for abundance monitoring.
[PM] Also concur with Ken about this difficulty of marking issue; I would have to think that with PIT tags getting smaller, this might still be the better way to go rather than clipping multiple toes--especially on a partially bipedal heteromyid. Also what about ear-notching?
[PM] PPM is very patchily distributed even in a habitat with high cover, and tends to occur where sand + bare ground cover are high--I suspect that interspecific interactions explain why it did not occur in ALL habitats with high sand and bare ground cover

[PM] PPM is very granivorous depending principally on forb and grass seed (which may explain why it occurs in some abundance at Oscar One where shrub cover was rather low).
[PM2] I'd like to reemphasize the potential utility of doing some activity studies on selected individuals. Dusting PPM with flourescent powder and use of black lights to retrace movements can be very informative for studying movements. Further, it would identify actively-used burrows for future reference.
[PM2] I guess PIT tags are still too large to place in PPM. If they are smaller, this is obviously the way to go to permanently marking individuals. Further, using loop sensors to detecting movement of PPM into or out of burrows could provide info on activity.

Additions:

6) PPM is nocturnal.
7) Need for marking- permanent or not permanent? hair clip okay? Debra Shier methodology
8) PPM are patchily distributed across the landscape. Access to open sandy patches thought to be important, however, habitat suitability at different spatial scales largely unknown?

May be active above ground from April to September or longer. Activity period varies by year, across populations, and within populations by sex and age structure. Expect most animals to be active in May & June. Would not expect to capture juveniles during this period. (D. Shier- this year some went down in June- others still active in Sept)

Alternative:

PPM may be active above ground from April to September or longer. Activity period varies by year, across populations, and within populations by sex and age structure. Expect most animals to be active in April, May & June. (D. Shier 2007- some PPM went down in June- others still active in Sept)

[EK] No comment
[DHD]- No comment
[KB] No comment
[PM] This annual activity period range seems to vary a lot. But May-June is definitely a period of maximum nos. Irvine pops had peak in April too--when animals were obviously emerging and actively seeking food, mates, etc.
[WM] In 2003 we detected juveniles starting around May 3rd. We did not detect juveniles during April trapping in 2004, 2005 or 2006. Our latest April trapping was in 2006 when we trapped up to April 25. However, drought conditions over '05-'06 appears to have reduced breeding activity considerably during Spring and Summer of '06 (i.e. Debra Shier only detected 4 juveniles throughout her trapping efforts from March to September 2007). During most years it is likely juveniles emerge sometime in late April early May. To avoid juveniles (i.e. sample just the overwinter adult population) an optimal trapping period is likely between April 10-20.
[MP – We captured juveniles in May of 2003, but not in April of 2004, 2005, or 2006. Additionally, Shier reported that adult males (based on reproductive activity?) were not trapped after June of 2007, suggesting they had already entered torpor and left the trappable population. Thus the activity period may vary from year to year and any monitoring program that seeks to capture only adults (e.g., pre-breeding survey) may need to be timed each year based on observed levels of activity from pilot data rather than a calendar. If a hard date must be selected, then early April is probably the most reliable time when adults can be presumed active and if juveniles are present, they would be most discernable from adults. Shier may have additional data based on her current monthly trapping efforts in Oscar-One designed to better define the phenology of PPM.]
CSB- April 10-20 window too small to conduct all monitoring activities. Maybe measuring stable adult population with confidence is not feasible? If we go out in April- risk not having all adults active.

Difficult to distinguish juveniles (young of year) from adults. Pelage brown after 6-7 days (post weaning?). How to know recruitment?

[EK] No comment
[DHD]- No comment
[KB] No comment

[PM] No comment
[WM] Recruitment m inferred from monitoring at least twice within the same location within a given year. The ideal timing for the two sampling periods might be April 10-20 and then anytime between June 20-July 10. One could then compare abundance estimates and make observations of reproductive status within the population, appearance of new animals, etc.
[WM] -----which normally would be characterized as "subadult" in appearance. However, USFWS biologist examination of PPM skins and skulls at the San Diego Natural History Museum found 1-year toothwear patterns on "subadult" skins. This may compromise the ability to reliably distinguish between young of the year and 1st year adults if locations are only trapped once or twice per year.
[WM] It may be difficult to accurately measure recruitment because not all PPM appear to be active at the same time. During years of good reproduction, the above ground population appears to cycle among two or more cohorts that are variously dominant in spring/early summer and late summer/early fall (e.g. overwintering adults predominate in spring/early summer and young of the year predominate in late summer/early fall).
[MP – Ageing is difficult. Juveniles may reproduce in their first year (=functional adults) thus complicating the apparently simple distinction of adults and juveniles on an annual basis. There may be other means to assess recruitment based on changes in population size between multiple within year visits and a few assumptions about closure.]
CSB- It seems to me that trapping on only 2 occasions, there is still the question as to whether the new animals were young of year, adults not previously captured or adults that moved into new grid location. A small number of intensive sites may be the way to go to try to assess recruitment this way– however- even this could be tricky….

[PM2] Keep in mind that mammalogists usually distinguish between juveniles, subadults, and adults. Subadults can be distinguished in P. maniculatus for example, but apparently not in PPM. Brown pelage in PPM 6-7 days post-weaning would technically be in subadults. Subadults may also be reproductively competent.
[PM2] See earlier note about subadult vs. adults (pg. 6, 1st section). "Juveniles" which become reproductive in 1st year of life are doubtless subadults with adult-like pelage. Juveniles are never reproductive.

Goals for Long Term Monitoring Program:

General

Spatial Monitoring Scheme- Proportion Area Occupied (PAO) with annual sampling.

[EK] No comment
[DHD - Please elaborate – this idea received a lot of discussion and I am not certain we reached consensus]]
[KB] No comment
[PM] No comment
[WM]The following is an excerpt from the Biological Assessment for the Uplands Consultation:

"In addition to the avoidance and minimization of temporary impacts to PPM, the Base is committed to maintaining free from permanent impacts a mass balance of 898 acres of occupied habitat as described by 500-ft-radius around PPM GIS point locations…. Should PPM exhibit a population decline, regardless of the cause of the decline, a population threshold value of 709 acres provides assurances that the Base will meet with the Service to determine necessary remedial actions, if any, to facilitate recovery (see "Population [Occupied Habitat] Threshold")." (Section 8.4.3 MCBCP Uplands Consultation BA)

While the Service remains in discussions with the Base relative to the accuracy and appropriateness of these acreage figures and conservation goals , the above statement about conservation of "occupied" habitat has implications for the monitoring approach. As voiced during the Workshop, the monitoring approach should relate back to the conservation commitments of the Base and any associated management measures. This quote suggests a spatially explicit sampling scheme which can determine occupancy of 709 acres (outside of estimator error) would be warranted given that a trigger for management action is set for a decline in "occupied habitat" below this acreage value. However, there is some looseness in terminology here that appears to relate a decline in population size with a decline in extent of occupied habitat. While there will be a relationship here, it is not certain these two things correspond in a one-to-one manner. We also discussed that because of the precarious size of the occurrences at San Mateo North and San Mateo South more explicit information about population size of these occurrences is probably desirable for guiding the management approach. Bottom line, PAO may not be a "one size fits all" monitoring scheme that is appropriate for all of the MCBCP occurrences.

However, PAO may relate best to the conservation measures suggested in the Uplands BA and a certain level of precision will be needed to meet the conservation approach.
[CSB] The wording in the Biological Assessment for Uplands Consultation is about "occupied habitat". To estimate this, we have to assess populations spatially across all 3 populations using a PAO type approach. I do not believe we should expect relationship between PAO & abundance to be 1:1, as we expect occupancy to be more stable than pop size on an annual basis- would expect a positive relationship.
[CSB]- Where do acreage estimates come from- 500 foot (152 m) radius around all known PPM locations? This seems to be very large area of assumed occupancy. Can estimates from first few years of monitoring studies be used to inform acreage estimates for Biological Assessment? Please see result of PAO models with different buffer sizes. If we added a 150m (~500ft) buffer around the San Mateo populations, PAO would decrease by a substantial amount and so would the amount of effort to sample with 100% coverage (cost prohibitive-almost 4X the person hours than with a 50m buffer). Would need to subsample.
[CSB] Precision will be dependant upon detection probability and proportion of area occupied. Want to maximize both for better precision.
[CSB] this also talks about trigger for mgmt action? Hopefully, results of PAO studies should help inform management also.
[WM] Most substantive of my comments is my belief that spatial distribution and abundance are parameters of particular interest for the two San Mateo occurrences relative to their long term management and the recovery of the subspecies. Thus, I feel that we should structure sampling at these two locations to get at these questions before adopting a PAO monitoring approach for them. I have tossed out a few ideas of how to structure the sampling to get at this but hope that others will weigh in. Probably of greatest concern to me relative to the intensity of the sampling program is the degree of disturbance that may result to PPM habitat from sampling, so I think we need to keep this in mind.
[MP - I am not certain we reached consensus on this goal. The primary goal is to provide useful information to any management program (e.g., to answer the question “has the population declined below a prescribed threshold thus triggering a management action?”), so the goal needs to be set relative to the Base’s management objectives, opportunities, and commitments. If the management objectives of the Base are to enhance already occupied habitat to increase PPM density, then a PAO approach may not yield useful data. I think a discussion with the Base in regards to the nature of their anticipated management actions (e.g., habitat management to increase or maintain a fixed PAO or habitat management in known occupied areas to increase density) and their existing commitments under the biological opinion for the Crucible Challenge Course, their INRMP, and the forthcoming Uplands Programmatic Biological opinion is warranted. Also, I believe we did agree that a single program such as PAO might not work at all 3 sites and that the relatively small acreages at the San Mateo PPM occurrences may require a different approach, such as trends in density estimation.]
[CSB] Agreed –comprehensive trapping for these areas at least for short term until we can re-evaluate whether a PAO program alone can be informative. PAO & density estimation should not have to be mutually exclusive. Should be able to generate a gross density index from PAO sampling. May be as good as trying to get precise estimate since it varies so much within a season?
[CSB] I am confused as to what the management objectives of the base are (above stated occupancy and this comment states density). Shouldn’t the objectives be based upon the results of the monitoring program in first years?. Maybe the we can word the Base commitments to tie in with this monitoring program- including some reassessment period, allowance for adaptive mgmt.
[MP] Also, it may be important to consider this years PAO observations for PPM in Oscar-One/Edson Range before committing strictly to a PAO approach. For those who are not aware, extensive trapping on 62 grids (40 traps per grid, 5m spacing, 4 consecutive nights in June/July) in Oscar-One yielded NO PPM. The sample frame for this effort was the portion of Oscar-One west of the paved road. At the same time, PPM were being captured on a regular basis along the powerline area east of the paved road - where we all stood to overlook the area. The sample frame thus represents the vast majority of the minimum convex polygon around known capture locations. This apparent synchronous disappearance of PPM from such a large area may make it difficult to plan management around PAO results - i.e., there is no "trend" in occupancy, just a decline in density until reproduction can no longer sustain the population, followed by extirpation from large areas. Possibly this is all a matter of scale, or some other metric can be gleaned from a PAO effort that helps predict a trend toward non-occupancy. Never-the-less, I think this years data should be considered before we commit to a PAO approach as a means of gathering data for the purpose of guiding management.
[CSB] It seems that the PAO approach is reasonable in that you have occupied habitat becoming unoccupied- so PAO may be a reasonable trend metric. How much of the area do we think was occupied historically? This is a case for concern regarding getting very low PAO values and thus very poor estimates of occupancy.

[CSB] Please see PAO estimates with different grid sizes- note that with a 50m-squared grid size (larger than above study), we may expect only 5% of grids to be occupied.

[PM2] Well, I am not sure extensive grid sampling is disturbing PPM habitat since it tends to occur in open areas anyway. But more to the point (and relevant perhaps to MP's comments below), "Payne" Pearson once embarrassingly showed me that trapping specifically at "hidey holes" was far more efficient in capturing a target species than placing traps at arbitrary points on a grid. If PPM burrows could be used to orientate focal-point trapping efforts, results for surveys of particular areas might be more successful.

Because the San Mateo North and South populations are much smaller, these areas may require more intense sampling (i.e. 100% coverage) and additional efforts for estimating gross population sizes.

[WM] (Reword recommendation) Because the San Mateo North and South populations are much smaller and their status is unknown, initial efforts will be directed towards updating the current status and distribution for those populations. Initial sampling will encompass 100% of the area where PPM have been captured at those locations and an attempt will be made to estimate gross population size.
[CSB] This statement is regarding long term monitoring- not the initial assessment, which is described as such in the 2008 studies section.

Prefer use of passive sampling technique (high probability of detection, low cost, low impact to PPM)

[EK] No comment
[DHD – If they can be validated]
[KB] No comment
[PM] No comment
[WM] No comment
[MP – Any new technique would need to be validated under the range of conditions (e.g., PPM densities) expected to occur during the monitoring program.]
[CSB] Agree- sampling study should be used for initial validation (if method is not live-trapping). Retain some small ongoing validation/comparison if needed.

Some effort in discovering new populations (10%). Increase survey limit from within 4km of coast to 5km?

[EK] General question: In the 3rd bullet on General Goals for Long-term monitoring - does increasing survey limits away from the coast also include to other off-base efforts?
[DHD} No comment
[KB] No comment (2) Allocation of Effort: Right now 75/25 seems ok to start and maybe keep this way. The concern is about possible spatial shifts where PPM are even as their numbers remain (about) the same. This may occur over some time scale. We just do not know. I do not know an effective way to cope with it. (Can do, but costs a lot more. Have to expand trapping, but by how much?) Here is where passive (spatially wide spread) methods can be real useful.
[PM] Definitely am supportive of additional surveys further inland than 4 km; soil and ground cover seems to be the key, not an arbitrary distance from the coast.
[WM] We should specify the boundary of this effort and clarify if it will occur both on and off base. A 5 km boundary seems reasonable.
[MP – Great idea. This effort may be periodic in nature and not necessarily represent a fixed proportion of the effort in any given year, but a 10% overall effort allocation seems appropriate.]
[CSB] Will MCBCP fund surveys off base?
[WM2]There were questions of whether this would/could include work off Base . It would be nice to clarify this if possible

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Closely tied to management. Would like to assess natural & human impacts to PPM and determine gross effects of management actions, if possible. Should not limit implementation of management actions, though. Management methods could be tried on select number of grids across all 3 populations to incorporate into monitoring.

Alternatives:

Closely tied to management.

May use BACI approach on subset of plots to assess gross effects of management actions on PPM occupancy and/or relative density, if possible. Any need for more comprehensive sampling should be determined before implementation of actions. Lack of power due to low numbers of PPM should not limit implementation of management actions, particularly for making less suitable unoccupied habitat more suitable.

[EK] No comment
[DHD- Be very careful, if you can't track it rigorously, you cannot know it further conservation]
[KB] No comment
[PM] No comment
[WM] No comment
[MP – We need to be careful in assuring any PAO approach is adequate to estimate PAO first, without any compromises due to an attempt to assess cause effect relationships due to management actions or measured human activities. The latter really should be designed using a BACI approach, which may require a scaling up of the PAO effort. Also, I'm not sure how monitoring would limit management actions as inferences are to be made to the entire population (e.g., changes in PAO), not individual monitoring sites.]
[CSB] BACI approach to assess mgmt actions: Tx at a subset of plots vs. no tx at another subset. Would likely require some estimate of relative density or 'use'.

Over the long term, assess if temporal trends in PPM status are similar across populations/ sites (i.e. main drivers of PPM dynamics similar across populations or not?). Thus, PAO estimates required for all populations.

Alternatives:

Over the long term, program should assess if annual trends in PPM status are similar across subpopulations/ sites (i.e. are the main drivers of PPM dynamics similar across populations or not?). Thus, PAO estimates required for all populations.

[EK] No comment
[DHD- Again, be very careful, it seems that you are equating assessing temporal trends with the PAO] [CSB]- PAO is both a spatial & temporal monitoring scheme (i.e. with multiyear colonization & extinction parameter estimates & change rate from year to year). Changed wording from 'temporal' to 'annual' to better clarify.
[KB] No comment
[PM] No comment
[WM] As Doug stated, we are getting fuzzy about PAO and tracking individual population dynamics. The sampling frame(s) should be specified relative to making either type of inference. If the intention is to do a separate PAO estimate for each of the sites then this has implications relative to the intensity of sampling that will be needed at each location.
[MP – Similar temporal trends in one metric (e.g., PAO) at two or more sites does not necessarily imply consistent "drivers" or cause/effect relationships. If PAO does not work within the handful of acres at San Mateo north, then abundance estimation or some other method may be required at the other two sites if data compatibility is a priority. Compatibility in data is a case where we may need to play to the "lowest common denominator", or most constrained site. Although identical methods at each site would be ideal, I personally would rather focus on monitoring designs which best fit the constraints and management opportunities of each site, then determine if small changes can lead to data compatibility.]
[CSB] PAO calculations for all populations will not exclude any additional intense monitoring. See PAO exercise results- will require different size grids for San Mateo populations.

Include some gross relative index of abundance and/or activity? (i.e. number of positive tracking cards per grid, number of unique PPM individuals captured, etc.- depends upon sampling technique chosen). May not be feasible- could collect data & evaluate.

Alternatives:

Include some gross relative index of abundance and/or activity? (i.e. number of positive tracking cards per grid, number of unique PPM individuals captured, etc.- depends upon sampling technique chosen). Will collect data & evaluate.

[EK] No comment
[DHD]- No comment
[KB] No comment
[PM] No comment
[WM] Yes any "index of abundance" should be validated. [CSB- by showing a positive correlation with Sherman live trapping? Since trapping is not necessarily a solid standard- this seems reasonable to me.
[MP – Any index of abundance would need to be validated. For the San Bernardino kangaroo rat, we are implementing a PAO that is augmented with larger trapping grids where abundance is more reliably estimated and related to a suite of habitat covariates. The side benefit is that results can be used to guide habitat enhancement efforts. Data from PAO grids alone may help in distinguishing between occupied and unoccupied habitat, but yields little information on how to enhance or improve already occupied habitat to increase abundance.]
CSB- I think the results may inform habitat enhancement efforts in unoccupied&occupied habitat if we find strong associations. The ability to find habitat associations by having many habitat sample replicates is one of the great strengths of this approach. I also think that by taking habitat data at 2 spatial levels (plot & 'trap'), we could potentially learn a lot more. There is no doubt that the SBKR plan is very good and comprehensive. The data you presented at the workshop, however, make it seem not as applicable to PPM where a great sampling effort in two huge grids in the best habitat showed highly fluctuating estimates of abundance within & among seasons/years- overwhelming task with high potential of little rewards?

Some measure of reproductive success: Idea of high recruitment year vs. low recruitment year. May not be able to get at this due to issues above? May need to infer from PAO.

Alternative:
It will be extremely challenging to measure reproductive success (low vs. high annual recruitment). This is primarily due to difficulties in accurately assessing reproductive status in females and discerning adults from juveniles.

[EK] No comment
[DHD]- No comment
[KB] No comment
[PM] Also (as I think I mentioned), it's now possible to detect circulating hormones in scats and urine from animals; this could give a key to reproduction not available from visual inspection of captured animals. You've got a lab pop. of inland Perognathus longimembris available, so it would be a perfect way to establish a reference point. Definitely high tech, but perhaps feasible
[WM] This will depend on frequency of sampling –see above comments. May want to incorporate some "sentinel" sites for repeat sampling to get at pop dynamics at individual sites.
[MP – No comment]
[CSB] This a good idea (more intense sampling at a few sentinel sites) to inform about reproduction (roughly- high vs. low or none), if possible, to get better annual estimates for detection probability.

Monitoring program results would not substitute for project specific actions on base (i.e. cannot interpret with 100% confidence that a non detection is equal to absence). Could estimate a level of confidence from detection probability results.

Alternatives:
Monitoring program results would inform Base as to PPM distribution and trends, but would not substitute for need to assess project specific actions on base.

[EK] No comment

[DHD]-No comment
[KB] No comment
[PM] No comment
[WM] The first part of this statement is consistent with what is written in the BA for the Uplands Consultation. The second statement needs clarification relative to what this would mean for future survey efforts for project specific actions.
[MP – The first statement is correct. The second part may be mathematically correct, but would not likely be useful in a regulatory context (e.g., "take" is not assessed on a probability basis) so I would leave it at the first statement and not allude to greater utility in this context.]

Adaptive Program- program should be reassessed after set period of time for power to detect changes in occupancy, sample size, detection probabilities, survey plot size, intensity, etc.

[EK] No comment
[DHD]-No comment
[KB] No comment
[PM] No comment
[WM] No comment
[MP – agree!]

Sample (Inference) Area

Sampling Area to be polygons around known habitat & historic captures in Oscar 1, South San Mateo, and North San Mateo. Include small buffer?

[EK] No comment
[DHD] Yes include buffer
[KB] No comment
[PM] No comment
[WM] Current area of "known occupied" habitat is an artifact of trap placements and time of sampling. We anticipate that populations will expand and contract over time. Therefore, a "buffer" based on a model of habitat suitability would be desirable to try to capture population "expansions" and to clarify population limits which were delineated (particularly at San Mateo South) based on fairly limited sampling. As a general monitoring principle it is not a good idea to focus all of your sample effort on "known" occupied habitat since a negative PAO/population trajectory resulting from animals moving outside the survey frame will lead one to conclude the population is in a downward trajectory when in fact the population merely had a change in distribution.
[MP – Need to clarify "polygons" – would these be the minimum convex polygons (MCP) drawn around known capture locations at each site, and does this imply that the sample frame for the PAO estimates will apply only to these "polygons"? Because the MCP are an artifact of past biased trap placement conducted for a different purpose, this may leave out a segment of each population where sampling has been minimal or non-existent. For example, if we only had the most recent trapping at each site we would have vastly different (reduced) MCPs and the monitoring program would miss large segments of the PPM population as it expands into the areas that were historically occupied (especially at the smaller sites like San Mateo North and South). Because the data represent a "snapshot in time" and due to the limitations noted above, I suggest the sampling area be based on models of suitable habitat around each set of known locations. All suitable or highly ranked habitat that is either contiguous or within dispersal "reach" (distance + barriers) could be included. We may not know these parameters precisely, but an educated guess with an error on the side of conservatism may suffice.]

[PM] Strongly concur with MP on this.
CSB- I think this is fine. We need to beware about adding a lot of extra habitat that may drive down our PAO values and dilute our sampling effort in known habitat (see Table 1 estimates). Looks like 50 extra meters into suitable habitat surrounding known polygons is doable. We may need to define the additional suitable habitat as a second strata that is not estimated to the same precision, but for informational and range purposes only (like SKR) and/or have sampling be part of the "discovery" effort). Over time, could redefine PPM habitat based upon any new locations /results?

Edson Range (adjacent to Oscar 1) is very difficult to gain access to, especially for multiple days of trapping. Would like to include in monitoring program if possible- preferably with passive sampling technique.

[EK] No comment
[DHD - Very important]
[KB] No comment
[PM] No comment
[WM]The 2007 results of Spencer et al suggest that Edson Range may be far more important to overall population viability than previously appreciated. Thus, Edson Range should be incorporated meaningfully into the monitoring program. If passive methods are to be used these need to be tested and evaluated.
[MP – Edson Range should be treated as a separate monitoring unit due to 1) its predictable and regularly occurring prescribed fires, 2) its limited access that will likely require different sample methods, sampling intervals, or both, and 3) the limited nature of management options for that area as indicated by the Base. We could therefore define monitoring protocols for four distinct areas, Oscar-1, Edson Range, San Mateo South, and San Mateo North. Passive techniques would need to be validated. Note, from the perspective of the 3 factors listed above, the functional dividing line between Edson Range and Oscar-1 would be the "concertina wire road" located just north of the southern boundary for the Edson Range training area.]
[CSB] Good suggestion. Hopefully the monitoring protocol should be the same for Edson & Oscar 1. For SKR, we do a lot of work on weekends and holidays for the same reason.

Goals for Long Term Monitoring Program, continued.

Allocation of effort:

Stratify sampling over space to focus greatest efforts on sandy soils (60/30/10 suggested for 3 strata or 60/40 for 2 strata?). Requires finer scale soil map. What scale? in proportion to size of grid? Can we use FWS data in Oscar 1 for this?

[EK] No comment
[DHD] No comment
[KB] No comment (2) Allocation of Effort: Right now 75/25 seems ok to start and maybe keep this way. The concern is about possible spatial shifts where PPM are even as their numbers remain (about) the same. This may occur over some time scale. We just do not know. I do not know an effective way to cope with it. (Can do, but costs a lot more. Have to expand trapping, but by how much?) Here is where passive (spatially wide spread) methods can be real useful.
[PM] No comment
[WM] The purpose for stratification and perceived benefits need to be made explicit. If stratification is to gain sampling efficiency then you will want to allocate relatively more sampling effort to the strata with greatest variability (non-sandy soils?). If stratification is proposed to contrast PAO (or animal density) of areas with sandy soils to areas without sandy soils, this is a different question and suggests a more even effort among your strata. There also is a question of whether the Soil Conservation Service mapping is precise enough to make stratification worthwhile. How do you anticipate stratification will deal with a situation like Edson Range where PPM are persisting in loam soil but PPM were not detected in adjoining areas with sandier soil in 2007? Would it make more sense to stratify after a year of baseline data collection?
[MP – Having a base soil map for any proposed stratification is a good idea. However, this years sampling for PAO in Oscar-One and Edson Range suggest our understanding of soil affinity may be less precise than was originally thought (PPM are persisting in loamy soils in Edson Range while having disappeared from sandy loams and loamy sands in Oscar One!). Although we still expect there to be some differences in suitability within the sand-loam range, we do not know the relative importance of the occurrences in the loam (or even clay-loam soils), thus stratification on soil texture may be premature. I suggest soil texture and other soil parameters be collected at each sample location for the initial effort, treated as a covariate in any occupancy or abundance estimation modeling, and then based on the data determine IF stratification should occur, what soil parameters to stratify on, and which strata deserve greater effort. For any soil mapping upon which to base stratification, soils could be mapped as a grid of sample points or as polygons (just like vegetation mapping) with a minimum mapping unit equal to that of the size of any proposed sample unit (e.g., PAO grid). We (FWS) will make all of our data available; however some data is shared property with the Base and may need their concurrence before it is released.]

[CSB]- Agree.
[PM2] Again, right on. I think that the soil is critical to PPM habitat useage.

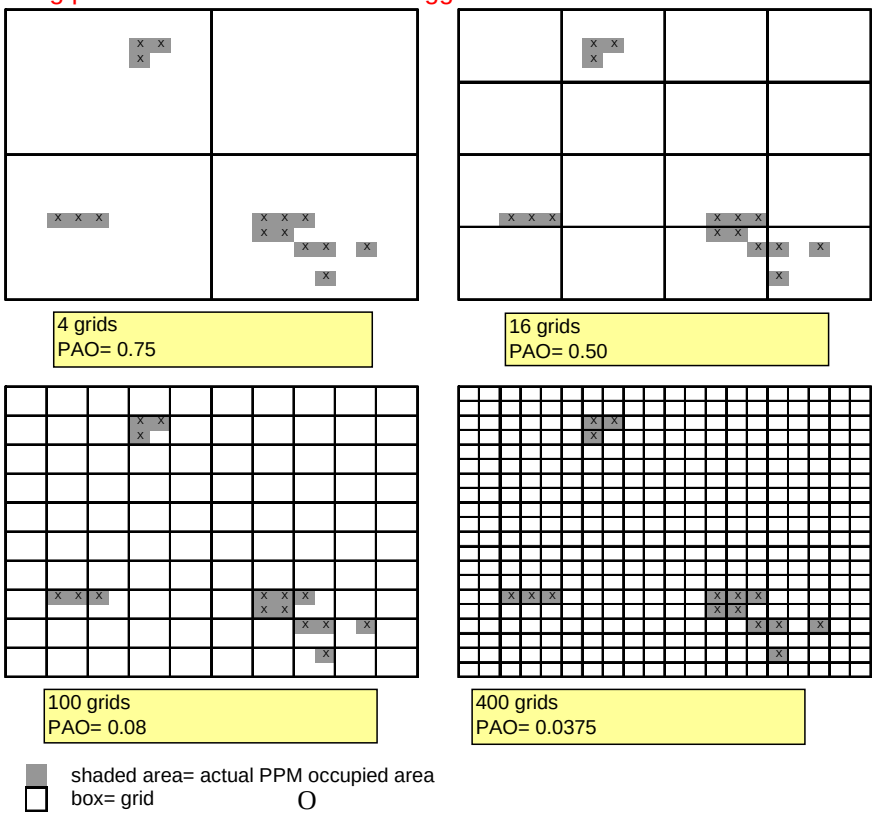
Sample same plots every year for greatest power to detect trends or allocate some effort (25-50%?) to sample some new plots every year? MCBCP would likely prefer some new plots every year for greatest coverage over time.

[EK] No comment
[DHD – This is a very important decision. We are anticipating low power due to low capture probabilities. If that is the case, siphoning off effort to new sites may risk not being able to be confident about the pattern in the key areas. In the long term, I think that additional exploration is needed, but in the short term, I am not sure]
[KB] No comment
[PM] No comment
[WM] No comment
[MP – Given that we know there can be high temporal variability, I suggest you start by emphasizing sampling that best defines the spatial variability, then making the determination of whether time x space variance is important (combo of fixed and moving plots) or if you can focus on temporal variance alone (only fixed plots). Having said that, Doug makes a good point about the risk associated with sampling new sites each year and I will defer to the statisticians on selecting the best approach and the specific effort allocation.]
[CSB] I think it is important to the base and FWS to get a wider area sampled over time. New data will also continue to provide suitable habitat information. Over time will provide a much more complete map of occupied habitat. Also, could miss significant populated areas. For SKR, we are sampling ~33% new plots every year. Could plan on a lesser percentage to start 20%?
[WM2] There was no consensus from the Science Panel on this point though there was discussion that this is an important consideration. Hence, I am not comfortable with the presentation here. If included I would prefer this to be presented as an option for consideration following the results of pilot studies and/or initial PAO efforts.
[CSB] Clarified exact % allocation will be determined following results of pilot studies and/or initial PAO efforts

Size of Sample plot/Grid:

Sample Plot size not determined. Size of plot will directly affect PAO estimates- too large- PAO=1, too small PAO=0. Target 0.2-0.8 (MacKenzie). Home range radius around 30 to 50m.
Note: USGS can lay sampling grids of several sizes (from 10X10m to 100X100m) over historic PPM capture locations within sampling areas in ArcGIS to get a rough estimate of potential PAO vs. grid size for the south& north San Mateo & Oscar 1/Edson populations.
CSB- Done- see revised monitoring plan & results of exercise? Suggests 100m^2 for Oscar 1 Edson and 50m^2 for San Mateo populstions.

Hypothetical example of sample plot size effect on PAO:



O

[EK] No comment
[DHD] No comment
[KB]: the 16 grids case sure seems to me to have POA = 5/16 = 0.31 (not .5). (2) Oscar 1/Edson = 100m2-150m2 (TBD) ~ 1t2 hectares (I assume). North & South San Mateo = 50m2(TBD) ~ 0.25 hectares
[PM] Allocation of effort: I'm in favor of larger grids that sample a larger area at the same time rather than very small ones that limit the spatial scale. My argument is that PPM is so patchy that even if you focused effort only on areas meeting some criteria for soil composition, you might be wasting effort on "empty patches". If this is akin to something like a metapopulation, you'd expect "empty patches" anyway just by chance. Ken alludes to this matter in his comments for Page 4.
[WM] Good idea. Oscar 1 Data may also be used to get rough estimates of potential site level detection probabilities based on various grid sizes.
[MP – Mean animal range (linear maximum distance between captures) across any three night trapping session should be expected to be only 8-10 meters. Based on our data from Oscar-One, trapping for a greater number of sequential nights *may* yield a longer range, but trapping across multiple bouts separated by intervals of no trapping will definitely yield larger "ranges". In the first case animals appear to "home" to the same trap and thus appear more sedentary due to a behavioral response to the trap. Reintroducing the traps multiple times allows you to detect the animal in more parts of its home range, therefore yielding larger measured distances. We/you can examine the large grid data for range estimates based on trapping and/or Debra Shier is collecting telemetry data on movement that may help in estimating the range of PPM.]

[MP – Be careful here as it seems this GIS exercise would require some gross assumptions about how "complete" the previous data collection efforts were. I think data collected in a structured fashion such as the grid data from Oscar-One (1996-2006) or Dana Point (years?) may be useful in this exercise. To the contrary, a GIS analysis based on the San Mateo North and South data could be very misleading as areas without PPM detections could be the result of either no PPM present OR no trapping effort allocated. Proceed with caution.]
CSB- Agreed. This is a gross exercise. Polygon around all known PPM points in Oscar 1/Edson with grid overlay. Likely gave us an underestimate of PAO- but could also be overestimate since using all known locations?, but gives us a rough idea if we are anywhere in the ballpark. We will see in our pilot year of monitoring how close this is.
[WS] I like the subsampling analysis to determine optimal plot size. My gut feeling is that a size that gives results in the lower end of the range considered desirable may be best (e.g., PAOs of 0.2 to 0.4 rather than 0.2 to 0.8), especially since you used all historic captures to generate the samples.
CSB- Still not sure if historic captures would be an under or overestimation of occupied habitat- may be safest to target 0.5.

Goals for Long Term Monitoring Program, continued.

[DHD This section is very good]

Sampling Method:

Passive sampling method preferable. May try to supplement/groundtruth subset of plots annually by live-trapping method. (see 2008 study section).

Additional Data Collection- Covariates:

Include habitat data collection to test current PPM habitat hypotheses and any management activities-Covariates. Probably need to do at both small & larger spatial scales.
Larger scale= Plot size (*see discussion of plot size below*)
Smaller scale= specified area around sampling node (trap, track plate, etc) within 2 m?

[KB] Individuals of a species may be a given place because they were wiped out from everywhere else. Maybe PPM are just where they can be after being wiped out from the bigger area they did occupy. So "they are here because" must not be right. It must be "They are not other places because…"

- Soil texture
- [MP – we may want to include a few additional soil parameters such as percent gravel, bulk density, and even percent carbon (relatively inexpensive at around $10 per sample)]

- Vegetative cover (herbs/forbs, grasses, shrubs, trees) with dominant species recorded for each layer .[WM] Following example of Dodd and Montgomery, we recommend collecting cover data at various strata (e.g. 0-10 in. above ground, 11-30 in. and 31 in. +).
- Slope
- Use of roads/ trails[MP – we need to be specific on how/what is being measured here. For example is this at or within a specified distance from the plot? Do we rank a new single vehicle two track the same as one 1 month old, 1 year old, 1 decade old? There are signs of human use almost everywhere in these areas due to the past 70 years of military training and agricultural practices. PPM may respond to or recover from different human impacts at different rates. These are difficult features to quantify/categorize so we should think very carefully how PPM might respond to these features before creating specific categories. Also, the data would provide information on co-occurrence between PPM and these features, but not on actual *use* or *avoidance*.]
- Ants, other rodents- need to be controlled?

[KB] Ants species and historic land use bullets -seems a wasted effort. Too much history - what time intervals? I agree that understanding why PPM are one place and not another is important. I doubt that the first 2 possible "covariates" would help as we really do not know how to measure them as a PPM might "see" them.

- Invasive grasses
- Historic Land use (old roads, grazing, agriculture, etc.) [MP – again, we need to be very clear on our distinction between historic and current. Roads (especially single vehicle forays into PPM areas), and foot trails are created and abandoned in Oscar-One on a near daily basis. This may complicate the ageing of such features if sampling only occurs once or twice annually –by the time sampling occurs, the animals that were directly impacted by the activity may be long forgotten and new animals moved in thus suggesting the feature had no impact. Time since impact IS likely very important to occupancy by PPM, but time may be difficult to estimate in the field. This deserves some very careful thinking as the results could affect not only the monitoring program but the impact analysis of future projects.] [CSB] This would be very hard to assess in the field
- Others
- [WM] Soil Depth
- [WM] Human Disturbance-visible tracks, soil compaction, habitat alteration but need to define how these are measured in relation to time since disturbance.

[EK] No comment
[DHD] No comment
[KB] averages in some variables (like soil texture) may be of little use; information on spatial variation may be needed. Interspersed sandy areas even if it means only 10% "suitable" may be just fine for the ppm. But if this means mapping soil at square meter resolution that could be hard.
[PM] No comment
[WM] No further comment
[MP] No further comment
[CSB] Incorporated comments: Finer soil analyses would be cost prohibitive at smaller spatial scales. Perhaps include some quick measures at small scales. Gen soil type, presence of sandy patches, etc. Usefulness at larger scale?

[PM2] Somewhere later on, measurements of soil characteristics are mentioned. A very easily taken soil measurement is soil hardness using a soil penetrometer.
[WS], Environmental Covariates. Consider some additional, simple soil descriptors reflecting PPM suitability, such as "compact, hard, friable, coarse, fine…."

Short term goals (for 2008)

No monitoring in Oscar 1 or Edson in 2008.

[EK] No comment
[DHD] No comment
[KB] no comment

[PM] No comment
[WM] No comment
[MP] No comment

Acquire finer detail soil maps within Oscar 1 and San Mateo population sampling boundaries. *Need to explore cost & feasibility.*

[EK] No comment
[DHD] No comment
[KB] no comment
[PM] No comment
[WM] No comment
[MP – see comment above regarding soils. Stratification based on soil parameters for the purpose of differential allocation of effort may be premature based on recent trapping results]

Studies to address following questions:

1) What is the best sampling method for annual monitoring of PPM?

Compare following sampling method options to determine method with lowest cost, highest detection probability, preferably passive. Use *Perognathus longimembris bangsii* in Coachella Valley as surrogate for studies. Use videocamera to view species response to different trap/track types.

- Sherman Traps[MP – Per Peter's suggestion, try different sizes]
- Tracking Plates (in tubes or other containers- want opening to be small to prevent larger mice/rats from entering). In contact with scientist from FLA FWCC., who is monitoring the Perdido Key Beach Mouse using this methodology (Mark rec).
- Hair Snares (in PVC pipes with tracking media?) [CSB- I am a little worried about the safety of PPM with this technique- will try on surrogate species only]
- Pitfall traps (smaller ~1gallon size, use small plastic mouse traps (i.e. Victor Live Catch Mouse Traps 1.6X4.6"/ 2 for $4) and/or other structure (pvc tubes) inside traps to prevent aggressive interactions or predation)
- WM] This is okay on a surrogate species but we still have reservations about the use of pitfalls for PPM. When we consult on actions likely to affect a listed species (e.g. 10(a)(1)(A) Recovery Permits) we typically make recommendations on how to minimize direct or indirect losses to those species. Use of pitfalls will likely fail the standard of "minimizing" impacts to PPM (i.e. there are other available methods that likely will result in lower incidental take). The gain from using pitfalls in terms of information gained or increased detectability should be appreciable to justify this approach. [MP – I concur with Will's comment]
- Dog detection- *Need to explore cost & feasibility- Mark, did you say you were going to look into this or had a reference for me to contact?* MP – Yes, I will get you the information] CSB- Thank you. Looks like this will be feasible to test -at least using a single dog.

[EK] Short-term goals: Study #1: Who is expected to pay for the off-base surrogate sampling efforts for passive sampling techniques. I think that this might be a tough sell for upper management when considering that we will have to pay for some intensive sampling efforts on base. It is not an impossibility…I just have to justify all of the costs that we are looking at over the next few years.
[DHD - I Like this plan very much, provided the videocamera does not interfere or influence the mouse]
Agree with no permanent marking technique.
Preliminary Studies: Good line, may be hard to do it all. Evaluations: Accuracy and detection probability links. If you get really good detection probable- you get decent accuracy. I hope experience with the traps (check literature and local biologists) will suffice to decide the perforated or no issue. Only course for a nocturnal animal, maybe it doesn't matter much.
[CSB]- Because of the limits for number of months we can sample PPM and PELO- this study will occur in 2009 (see revised protocol).

[KB] no comment
[PM] Another indirect technique similar to tracking cards are scat boards. I recall from UCI that the PPM scats were quite small, compact (hard), and dry (possible confusion only with Reithrodontomys megalotis). If you use millet seed as an attractant and keep birds and ants from getting in, it might limit the range of small mammals

likely to leave scats on boards. Maybe both can be done at the same time; do the tracking, and collect scats from cards/boards with verified PPM tracks.
[PM] Finally, one concluding comment that I forgot to mention. A couple of times at the workshop when I queried folks on whether they were using small (2"X2.5"X6.5") Sherman traps, they either didn't respond or said something to the equivalent of "yes". But the traps we saw out at Oscar 1 were medium (3"X3.5"X9") Shermans. If these were only for demonstration, fine, but it does make a difference in what size trap you use. In general, the smaller the trap, the more sensitive you can set it. And you're likely to discourage larger rodents with smaller traps from trying to enter (e.g., woodrats--I saw what appeared to be a nest out at Oscar 1)--and perhaps larger ground-feeding birds (towhees, etc.)--that latter point might be relevant to the effort issue above. So if you're targeting PPM and want to maximize efficiency, this might be a major consideration.
[WM] No comment
[MP – Good plan. However, as *Perognathus longimembris bangsii* is a covered species under the forthcoming Coachella Valley Habitat Conservation Plan, you may encounter difficulties in using them as a surrogate species. You may want to consider *P. l. longimembris* instead for fewer logistical constraints] [MP – Per Peter's suggestion, try different sizes]

2) Are PPM still present in South and North San Mateo sites? If so, are there few or lots?

Live-trap to determine if PPM still present
* Issue- 100% coverage of both sites for 2 bouts of 3 nights of live-trapping will likely be cost/effort prohibitive (See spreadsheet of options to consider). Will require less than 100% coverage (using grids), large trap spacing, and/or or less than 6 nights of trapping. Please see tables on next pages and make recommendations. Focus on previous capture locations vs. grid set up?

- 100% coverage over previously mapped habitat

[WM] Need to be explicit about what is " previously mapped habitat." If this is the minimum convex polygon delineated based on prior capture records (as suggested by Table I) we recommend, if possible, a more expansive sample frame based on a model of habitat suitability.
[MP – same comment as before regarding previously mapped habitat. I suggest sample frame be based on habitat modeling.]

- Census? Get an idea if there are a few or many (5 vs 50?)

[MP – Simple presence trapping would cease at the time of the first capture – the question is answered. However, abundance estimation, even as a course index, goes beyond presence detection. I concur that abundance estimation in some form should be part of the effort(s) at San Mateo, and that the sample design needs to take this into consideration.]

- Trap using Sherman live-traps
- Trap for 3 nights- 2 times (Total of 6 nights) (CSB Note: 2nd version was 3 nights, 1 bout due to cost/effort analyses to obtain 100% coverage of both population sites).

[WM] Based on what we know about detection probabilities we would be reluctant to conclude that either of these populations has become extirpated from such an effort. The level of effort and spacing between efforts should be based on the goals. If abundance estimation, then more nights of consecutive trapping may be warranted to support closed capture models incorporating heterogeneity as a factor governing detection probability (Conn et al. 2006). The idea of spacing among efforts is good in terms of providing temporal coverage but the number of nights per effort should relate back to the goals (e.g. abundance estimation, PAO, qualitative data collection, etc.).
[MP – It is difficult to asses the adequacy of any particular trapping scheme until an approach is agreed upon. For example, the number of trap nights would likely be different if the design was for 100% coverage at 15m spacing as opposed to adaptive sampling where smaller grids are placed at capture locations based on sampling from a larger spaced grid, etc. (see next comment - I think we need the statisticians to weigh in here on selecting the "best" approach). Once the approach is agreed upon, the number of trap nights should be based on the purpose of sampling (occupancy, abundance estimation, etc.). I suggest the data from previous trapping efforts be explored to determine the efficacy of any scheme relative to the primary question being asked.]
.

[EK] Short-term goal: Study #2: I am confused a bit by this study. The question being asked is "Are PPM still present in these areas and if so are there many or few?" However, the sampling methods outlined are intensive live-trapping efforts that seem more appropriate to answer questions of density or abundance rather than

presence/absence and relative number. For this question, why can't we try something more like non-random trap placement in areas that look suitable (e.g., near burrows) that give us a better chance of placing the trap in an area that trappers think they are likely to catch animals rather than random placement where we might miss animals because of the complex natural history. The way this is setting up is that we are going to put in lots of trapping efforts similar to Oscar 1, and based on the USFWS data we now have very low confidence in the data that is being collected there. I think to answer presence/absence we want to find the most efficient method of determining if there are animals still in the area. This non-random trapping could be done over a large area to ensure that the entire parcel is covered. Once it is determined there are animals present, more rigorous methods could be employed to better quantify the number of animals in the area.
[DHD - This is an important discussion point and one that I would like to see discussed]
[KB] no comment
[PM] No comment
[WM] These are two questions that potentially have different implications for survey design. For instance, if one is interested in just determining presence, then selective trap placements (e.g. sign setting focusing on areas of historical captures) may be appropriate. If one is interested in quantifying abundance, then more systematic trap placements at regular intervals would be warranted.

We had discussed that the scale of the distributions at San Mateo South and North appear to be so small that, in the worst case scenario, the sample unit for a PAO could be equivalent to the size of each these sites. Therefore, possibly of greatest value would be to get good spatial coverage over suitable habitat (i.e. an area extending beyond capture locations) at each of these sites during several consecutive trapping bouts to really answer whether the spatial distribution of animals is as confined as has been assumed from prior trapping information. Also it would be desirable to know whether the monitoring program should be as stark as determining when either population has become extirpated. This suggests the data should be collected to give an indication of abundance at each site, since the need to augment these populations to improve their long term viability is a very real management concern that should be answered in the near term.

Table I suggests some number of systematic grids are proposed over the minimum convex polygon delineated at each location based on historic capture locations. We like the approach of combining unbiased grid trap placements with a few selective trap placements in each area to obtain pilot data on whether site level detection probabilities can appreciably be boosted by a surveyor's ability to recognize sign or micro-habitat features preferred by PPM.

Table I further suggests that, in the extreme, this survey effort could involve placing a 5m x 5 m grid over the entirety of each site. However, a primary concern that is expressed is that it would be cost/effort prohibitive to perform 100% coverage at each site in 2008. Thus, the question has been posed whether different trap spacing should be used and/or if smaller grids should be used to sample from within the larger area of mapped habitat area? Another consideration is the level of disturbance that is likely to occur at a site with implementation of high intensity trapping.

There are a multitude of ways to apportion effort but fundamental to any effort is the need to answer the question of interest. We prefer to forego data collection at one site over compromising survey methods in order to obtain suboptimal information at both sites. Increased trap spacing allows greater spatial coverage with fewer traps but there is concern given small observed nightly movement distances for PPM that 10m trap spacing could bridge some animal's territories. A possible compromise would be to employ 7.5 m trap spacing (or another distance between 5-10m). A 5x5 grid at 7.5m spacing with 5 extra traps results in an approximate trap density of 1- trap/30m2. For comparison purposes, a standard 5 x 5 grid at 5 m spacing (no extra traps) has a trap density of 1-trap/16 m2. So even with 5 extra traps, a 7.5m spaced grid reduces the trap density by about ½.

When confronted with the issue of how to logistically get uniform coverage of a site (Dana Point) when it was logistically infeasible to visit the number of traps laid out in a 5m x 5m grid over the entire site, we set traps on every other line for a few nights, then moved to the skipped lines during the remaining nights. This helped to control for spatiotemporal heterogeneity and may be worth considering as an alternate configuration. However this would undermine our ability to get pilot data on the 5x5+5 trapping configuration being considered.

Another alternate configuration that may be worth exploring that the statisticians should weigh in on would be to do a 10m by 10m (or 15m by 15m) grid over the entire sample frame to get comprehensive spatial coverage that

will help answer our question about spatial distribution. When an animal is encountered the design could then be modified to place a 5 x 5 + 5 grid at 5m trap spacing over the capture location to get a more refined abundance estimate in that vicinity. I believe this sort of design makes variation estimation very complicated but could improve our qualitative information about abundance. This design also has implications for the number of nights of trapping in each location. So, if others think this is a good idea, we will need to think about how follow up trapping at the higher trap density will be accommodated within and among efforts.

In conclusion, we continue to feel that abundance is a parameter of primary interest at both of the San Mateo sites and have little confidence in the population limits that have been delineated based on former capture locations. This argues for broad spatial coverage that includes sampling in areas with suitable habitat adjoining the "known occupied" areas and possibly adapting trap density in response to animal captures to improve our inference about animal abundance. However, adaptive or cluster sampling has its shortcomings with respect to variance estimation so the statisticians should weigh in on whether this is wise to explore. Finally, in terms of trade-offs we would prefer to have comprehensive sampling at one site over compromising the methodology in order to obtain data at both sites for a given year.
[MP – I concur with Doug that this is a VERY important issue, and I think Will has done a good job outlining some potential solutions. We should discuss this issue further. see Will's comments]
[CSB- It seems that there is some difference in assumed expectations here than what was discussed at the PPM workshop. Because of the wide variability of abundance estimates we expect within a season, the point that Ken brought up was that we should go for a rough index of abundance by annual census of the entire population. The purpose is to determine if there are few or lots. We must define our expectations reasonably. I think it is reasonable to expect that we will not capture every animal or be able to estimate annual abundance with accuracy and precision. Even if we could- it would be a moving target due to issues with inability to id juveniles, young of the year, and issues of within season torpor or differential activity periods. So for the purposes of a census, we are proposing complete trapping coverage of the areas during May & June (3 nights), when PPM should be active. We are not proposing close trap spacing or high number of sample periods/trap-nights to try to get a precise abundance estimate with Program Mark (heterogeneity models, etc).

Extra nonrandom trap placement is included, as we discussed during the workshop, to increase possibility of capture (still has logistical issues). Adaptive or cluster sampling would be very difficult logistically- as sampling is already very time intensive, would be hard to plan for unknown & extra needed manpower, and may likely require more traps than we would have available.

[PM2] Again, see my earlier comment on pg. 8 of this section vis a vis using "hidey holes" to orientate trapping efforts (a.k. Payne Pearson). Since the objective is to find PPM, this is much more likely to be more efficient.

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3) Can we properly age animals in the field (i.e. young of year). Pelage not good characteristic,
- toothwear/ premolars?
- Relative measurements of hindfoot, body, ear, tail (ears & feet grow first, body & tail take longer to catch up)?

[EK] Short-term goal: Study #3: I question whether there will be enough data collected at any one time to answer any of the questions posed here. It should be noted that this data will have to be collected over many years to determine any patterns.
[PM2] Since PPM don't have evergrowing molars, tooth wear might be useful here. I've heard of people using some sort of impression paper that dentists use to verify their cavity-filling. The living animal bites down on the paper leaving an impression showing the cusps and loops, and hence an indicator of tooth wear and age.
All others- No comment

Further comments by Ken B. on 2nd version- 1st year study July 2008
Page 16: Grid Size: Too small of grids, I think.

Page 17: Does simulation just assume a grid (patch) is occupied or not and then simulate capture-recapture? Yes Issue here is movement of animals is ignored and then now seems like a big deal to me. Yes
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[RS] 2nd bullet point under Supplemental Integral Studies - I'm sure you're aware of this but Debra will be doing constructing genetic markers if their proposal for Captive Breeding is accepted by the FWS. Also, have you guys looked into SNPs (Single Nucleotide Polymorphisms)? I hear they are a useful genetic tool but I don't know if it would be applicable to PPM.

APPENDIX 3. Email correspondence regarding Year 1 study- (Individually numbered pages a-r).

Comments with regard to Year 1 study, survey of North and South San Mateo- March 2008
Email correspondence (per request by William Miller)

From Draft Document "Pacific Pocket Mouse Monitoring Plan for Marine Corps Base Camp Pendleton: Short Term Studies and Long Term Goals"

Short term goals:

In this section, we propose several preliminary studies. The studies will generate information needed to draft a quality program. In 2008, we propose to assess the status of both the North and South San Mateo populations which have not been surveyed since 2003 and 2005, respectively. This will be important in determining if a more intense effort, perhaps involving a gross abundance estimate, is necessary to include in the long term monitoring program for these sites. In 2009, we propose to explore alternate sampling methodologies and assess each method for PPM detection probability, impact to species, and cost/effort. Methodologies will be evaluated on surrogate *Perognathus longimembris* subspecies and validated in Oscar 1. The studies are summarized below.

In 2010, the top sampling method will be employed for PAO monitoring in the Oscar 1 monitoring area. The San Mateo population(s) will also be comprehensively surveyed, if feasible, using the chosen sample method. Data from the 2010 pilot monitoring will then be used to assess initial PAO estimates, detection probabilities, density or activity index, and power to detect changes in occupied habitat. These results will be used to refine the study area, plot size, and 'trap' spacing, if needed. A long term study plan will be drafted in 2010. Detailed study plans for 2009 will be submitted after the 2008 data collection and analyses.

2008 Preliminary Studies

Question 1: Are PPM still present in South and North San Mateo sites? If so, are there few or many?

Question 2: Can we collect meaningful small scale covariate data in a short amount of time that is precise enough to be reliable.

Q1: Live-trap to determine if PPM still present

- 100% coverage over previously mapped habitat (see Figures 5 and 6)
- Census. Get an idea if there are a few or many (5 vs 50?)
- Trap for 3 nights/mornings between May 1 and June 30 (3X3X9" Sherman live-traps- on loan from FWS). Grids will be trapped for 4 nights if no PPM are captured across grids in the first 2 nights.
- 10m spacing between all traps with and extra 3 traps placed subjectively in each $50m^2$ grid. Extra traps placed to maximize detectability of PPM (near open sandy patches with shrub cover edge).
- Collect covariates for Grid (larger spatial scale)
- Collect covariates 3m radius around trap (smaller spatial scale)

Q2: Environmental Covariates:

Data collection for testing hypotheses regarding PPM habitat suitability, species competition, and training/management activities. Data collection to be at both small & large spatial scales. (Smaller scale = 3m around each trap location, Large scale = Plot size ($50m^2$).

Note: data collection must be very fast (example: one person setting 200 traps and collecting 5 minutes of data at each trap would take >16 hours).

- GPS coordinate
- *Presence of sandy patches? (Y/N with estimated proportion)
- *Vegetative cover (growth forms: herbs/forbs, grasses, shrubs, trees, open ground, leaf litter) (Visual estimates). Data recorded at <1m (Dodd, Laabs, and Greene 1999).

- *Dominant plant species recorded for each growth form.
- Recent human disturbance (low (few footprints), moderate (many footprints/trampling), high (vehicle tracks/ heavy trampling & use))
- Slope & aspect (large scale only)
- Other rodent species detected (trap results)

Analyses/ Products:

- Detection probability & Proportion Area Occupied estimates
- Capture probability & simple closed population abundance estimate
- Minimum number known alive (MKNA)
- Observer variability vs. total variability in covariate data*
- Are any covariates predictive of PPM occupation (both spatial scales)

Non permanent marking technique- hair clipping. (note: up to 4 nights -hair clip okay, more nights would require toe clip or elastomer method (D. Shier))

Need FWS approval to use nonpermitted field person for baiting traps. All traps will be checked for sensitivity after placement of seed. CSB will train & regularly check for proper seed placement and trap sensitivity.

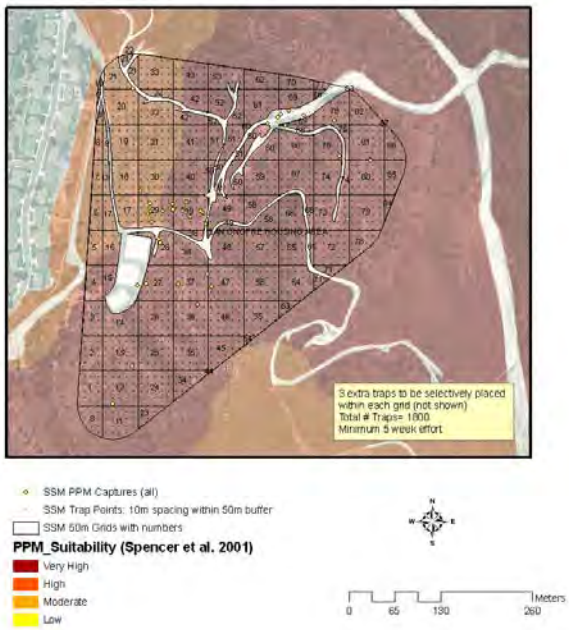
Other considerations:

Can we properly age animals in the field (i.e. young of year). Pelage not good characteristic,

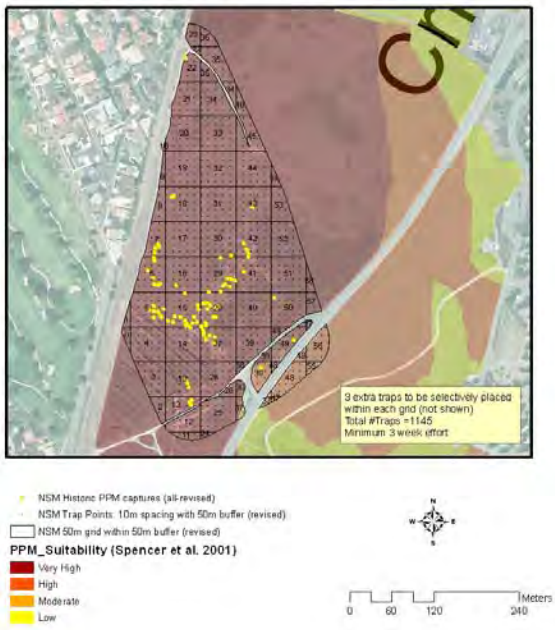
- toothwear/ premolars?
- Relative measurements of hindfoot, body, ear, tail (ears & feet grow first, body & tail take longer to catch up)?
- Test of scat (Growth hormone or other?). Explore cost and feasibility.

No monitoring in Oscar 1 or Edson in 2008.

Proposed Sample Area for PPM in 2008
South San Mateo Population
Minimum Convex Polygon with 50m buffer
10m trap placement and 50m grid



Proposed Sample Area for PPM in 2008
North San Mateo Population
Minimum Convex Polygon with 50m buffer
10m trap placement and 50m grid



>>> Cheryl S Brehme <cbrehme@usgs.gov> 4/9/2008 4:10 PM >>>
Dear all,

We are approaching the time to start our trapping efforts for the South and North San Mateo PPM populations (April 28 or May 5). If you have any comments to this part of the study, please send them soon. There are specific statistical questions (below) that we would appreciate responses from Ken and Doug by April 16th, if possible.

I had a conference call with Mark and Will yesterday to hear some of their comments. They also provided me with some extra PPM records for North San Mateo near Cristianitos Road (from NRA, Inc for P&D Consultants 2003-Foothill Eastern Transportation Corridor Study), which increased the trapping area from 8.2 ha to 9.7 ha. From this conversation, I have a few clarifications and some added questions below.

1) I would like to clarify something about the 50X50m grids (0.25ha) overlaid onto these 2 populations (Tables 1&2): For this preliminary exercise, I counted all grids (partial and whole). That is why the number of grids does not equal the number of hectares multiplied by 4 (can view in Figures 5&6.

2) Although covariate and animal data will be taken at each trap, the 50m grids will be used for collection of the larger scale covariate data and for containing 3 subjectively placed extra traps each. The larger grids will also be used to calculate a PAO estimate for the study area (in addition to MNKA & simple closed capture abundance estimates from individual PPM captures).

Question 1: Should I retain the larger grids for purposes stated above? If not, please recommend alternate strategies for subjective trap placement, larger scale covariate data collection, units for repeat trapping (Q#2), etc. If so, how should I deal with the partial grids? Should I combine partial grids that are adjacent to each other to sum to ~0.25 ha? Any suggestions here are appreciated.

[PM] It was my initial preference that larger grids be employed, which then could be narrowed down to smaller grids in PPM "hot spots". Since you're using 10 m spacing and 5 x 5 arrays, this seems a reasonable compromise over using either very large grids or very small ones which would be logistically difficult. Summing partial grids to reach ca. 0.25 ha seems fine IF you trap both at the same time. In fact, some people have argued that rectangular (as opposed to square) grids are more likely to encompass a given small mammal's home range; but this point is probably moot with PPM since their movement distances are so small.

I like the idea of having 3 extra traps to place arbitrarily. In fact, Oliver Pearson used to argue that if you are trying to catch a particular small mammal species, you should place traps ONLY at "hidey-hole" entrances...

Parenthetically, maybe I'm missing something, but aren't the "50 m2" grids in reality 2500 m2 (or the mentioned 0.25 ha)?
[KB]I might be late. Some questions have become moot I expect.

Question 2: Should we trap a small number of the total grids at each site for more than one 3 night session to obtain better estimates of PPM capture and detection probabilities? If so, how should they be chosen? Mark and Will shared a concern that this may be more of a problem than a benefit due to lack of closure (potential for new juveniles in population in later weeks or animals moving from another location).

Personally, I wouldn't vary your effort among grids. You want to assess distribution and relative abundance with a standardized effort. Although I would have favored a slightly longer session (4 nights), given the tremendous amount of effort that will be entailed by trapping so many grids, 3 nights seems reasonable. The potential for having an open population seems slight with this duration.

[KB] Regarding Juvies, I hope trappers can tel l ‘em when they catch them.

Question 3: Trapping will take anywhere from 3 to 6 weeks per site. I was planning on stratifying the trapping effort both spatially and temporally by randomly choosing a number of grids within the target site each week. Mark and Will suggested trapping randomly chosen traps each week or trapping different lines of traps within each grid. These would both be more logistically difficult than using grids, but would one of these or another alternate strategy be more beneficial- statistically?

Well, personally, I'm not a big fan of either randomly trapping points or moving traps back and forth between lines within a grid. Not only is it a lot of effort (and time-consuming), but it's confusing, creates a lot of wear-and-tear on the vegetation, and will be difficult in a dense shrubby habitat.

[KB] Stratify spatial, to be sure. I’d say do an entire grid for the 3 or so days then another grid (or grids). I hope that is what you are doing. For logistic and data analysis reasons I would not do just a random set of traps per grid or random lines. I have never seen that done before. The grid is a sampling unit itself (sampled at sessions over time).

Please feel free to call me to discuss these and/or other issues as well.
Thank you,
Cheryl

Forgive my ignorance, but what is a "perforated" vs. "nonperforated" trap? Is this a folding vs. nonfolding trap? Or a trap with hardware cloth screen on one side?

Is there any possibility of using 2 traps/station, one a medium Sherman and the other a small one to assess trappability with each? Perhaps not at this late date.

By the way, another covariate you could take is soil hardness using a soil penetrometer. It's just a little spring-loaded plunger available from agricultural supply houses or probably Forestry Suppliers/Ben Meadows.

Cheryl S. Brehme
Western Ecological Research Center
U. S. Geological Survey
4165 Spruance Road, Suite 200
San Diego, CA 92101-0812
Office Phone: 619-225-6427
Cell Phone: 619-559-1213
Fax: 619-225-6436

From: Cheryl S Brehme [mailto:cbrehme@usgs.gov]
Sent: Monday, April 28, 2008 10:21 AM
To: doug@sciences.sdsu.edu; kenb; Mark Pavelka; t80plm1@wpo.cso.niu.edu; wdspencer@cox.net; William B Miller
Cc: Robert N Fisher; Roland.Sosa@usmc.mil; Stacie A Hathaway; William.H.Berry@usmc.mil; Eric.Kershner@usmc.mil
Subject: Re: PPM Monitoring Plan for MCBCP: Short & Long Term Goals

Hi all,

We appreciate the helpful feedback we have received from Peter, and Mark & Will (via conference call mentioned below). Unfortunately, we can no longer make large changes to this years plan and have already

submitted a budget to MCBCP. Therefore, we are planning on conducting the North and South San Mateo trapping effort as presented in the document for 2008, except over a larger area in North San Mateo (mentioned below). We may test some of the smaller traps in the field (as per Peters suggestion). Otherwise, these will be thoroughly evaluated in 2009 (Sampling Study). We have also tried to slim the budgeted hours to 2 persons for every 3-400 traps as recommended by Mark & Will (hope we can still get a few hours of shut-eye!).

We would still appreciate some feedback from all panel members on the questions below and the general plan document. Please let us know when we can expect your comments.

Thank you,
Cheryl

Cheryl S Brehme to: Mark Pavelka, William B Miller 04/30/2008 10:51 AM

Hi Mark & Will,

We are planning to trap for 3 nights each week, unless no PPMs are captured across all grids or PPMs are only captured on the 3rd night- then we will trap 4 nights.
I hope you like this plan a little better. I am putting together the schedule & sampling grids for each week. I will send you a copy when complete. You are both welcome to come out & join/help us at any time. Just give me a call on my cell (personal 858-761-8883 and/or 619-559-1213).

PS. Could you please tell me where to get ant powder?
Thanks so much,
Cheryl

William_B_Miller@fws.gov

05/08/2008 05:38 PM
To
Cheryl S Brehme <cbrehme@usgs.gov>

cc doug@sciences.sdsu.edu, Eric.Kershner@usmc.mil, "kenb" <kenb@lamar.colostate.edu>, "Mark Pavelka" <Mark_Pavelka@fws.gov>, "Robert N Fisher" <rfisher@usgs.gov>, Roland.Sosa@usmc.mil, "Stacie A Hathaway" <sahathaway@usgs.gov>, t80plm1@wpo.cso.niu.edu, wdspencer@cox.net, William.H.Berry@usmc.mil

Subject
PPM Monitoring Plan for MCBCP: Short & Long Term Goals

Cheryl et al.-

The entire PPM working group may not be aware that during the time that USGS requested comments on the draft proposal for this year's PPM monitoring at San Mateo North and South, Mark and I expressed a concern via telephone that we were not enthusiastic about a 3-night trapping protocol and advocated for a minimal effort of at least 4-nights. Peter Meserve shared a similar concern in his emailed comments. USGS addressed our concern through a revision to the protocol that during bouts when no animals are captured during the first three nights across all grids, or animals are only captured on the third night, then a fourth night of trapping would be performed. This has a structure reminiscent of a removal model (e.g. uneven allocation of effort among grids) which may improve the occupancy estimate, but we are unsure how this will be treated in the context of abundance estimation.

Our concern is prompted by the history of low numbers of captures during prior trapping efforts at each of these sites and the general low individual detectability that we have found for this subspecies. An ideal

monitoring program would, in a cost effective manner, get a precise abundance estimate, document the distribution of each population and collect habitat covariates for modeling habitat suitability. However, it is apparent that given low individual detectabilities, obtaining a precise abundance estimate for these sites would be costly and require an intensive trapping effort. Ken Burnham has also pointed out that, given the large population fluctuations exhibited by the subspecies, it may be difficult to interpret what a given abundance estimate means. Based on this, USGS has proposed an initial monitoring approach for these sites that involves trapping in a light to moderate intensity (i.e., 3-nights) the entirety of the area circumscribed by historic trap locations (with a 50-m buffer) in a gridded fashion that will allow for calculation of the proportion of area occupied and collection of habitat covariates. The goals, as we understand them, are to obtain a measure of the area across which PPM are distributed, refine our understanding of habitat associations, and to determine whether there are currently few or many PPM at each San Mateo North and South.

We are confronted by the same challenges at Dana Point and have adopted a similar approach for monitoring this year. However, at Dana Point we are placing grids over about 70% of the site and will do 5-nights of trapping per grid. We have just received preliminary data from the first 5-nights of trapping (over 1/2 of the grids that will be sampled) that we are summarizing for your consideration. We think this data continues to suggest that a minimal effort of 4-nights is appropriate.

Methods: At Dana Point we are using 24 meter grid cells within which we are placing 3 X 3 trap grids (9 traps total) spaced at 8 meter intervals. With traps centered in the grid cells this means that traps in adjoining cells are 8 meters away. Grid cells were randomly selected for trapping with proportional representation of cells where there are historic records of PPM and cells where there are no capture records. Because there was a real concern that we may not capture any animals at Dana Point, the investigators are also placing a few subjectively placed trap lines outside of the sampled cells but in areas of historical occupancy.

Results: In total we captured 14 unique PPM over 5-nights with two animals captured the first night, 4 additional animals caught the second night, 2 additional animals caught the third night, 2 additional animals the fourth night and 4 new animals on the fifth night. Ignoring animals captured in more than one grid cell and animals captured along selectively placed lines, we detected animals in a total of 8 grid cells with the cumulative number of cells that animals were detected in across nights as follows, 2, 3, 4, 5 and 8. Based on a naive occupancy estimate, after three nights we calculate 9 percent of the Dana Point Headlands is occupied but after five nights this value increases to 24 percent. The following graphically displays this information (also viewable in the attached excel file).

William B. Miller
U.S. Fish and Wildlife Service
6010 Hidden Valley Road
Carlsbad, California 92011
(760) 431-9440 extension 206

Cheryl S Brehme/BRD/USGS/DOI

05/12/2008 07:13 AM
To
Robert N Fisher/BRD/USGS/DOI, Stacie A Hathaway/BRD/USGS/DOI

cc
William_B_Miller@fws.gov, doug@sciences.sdsu.edu, Eric.Kershner@usmc.mil, "kenb" <kenb@lamar.colostate.edu>, "Mark Pavelka" <Mark_Pavelka@fws.gov>, "Robert N Fisher" <rfisher@usgs.gov>, Roland.Sosa@usmc.mil, "Stacie A Hathaway" <sahathaway@usgs.gov>, t80plm1@wpo.cso.niu.edu, wdspencer@cox.net, William.H.Berry@usmc.mil

Subject
Re: PPM Monitoring Plan for MCBCP: Short & Long Term GoalsLink

Dear Will et al.

This is surely a challenging species and we would all like to ensure that the data is as thorough as possible! It is not a surprise that more PPM were captured every night at Dana Point, as this is consistent with the data you and Mark presented at the workshop. I am curious as to how the parameter estimates change over time (vs. naive estimates).. Regarding your comment about analyses of abundance, abundance models can incorporate different numbers of trap nights just as occupancy models can. In contrast to the Dana Point sampling you described in your email, we are trying our best to get full 100% coverage of the San Mateo populations as you and Mark requested from the beginning. For the first week in South San Mateo, we had many logistical issues with setting traps in steep, sandy, and thickly vegetated habitat. We were able to set ~200 traps in 6 hours with 3 people. We captured 4 PPM (1 on 1st night, 2 on 2nd, 1 on 3rd,) and stopped after the 3rd night (the proposed compromise was if we did not capture PPM on the 1st or 2nd night, we would continue through 4 nights). This is over our submitted budget for 3 nights per week.

We are continuing with South San Mateo this week and would be happy to try to incorporate a standard of 4 nights if we can have some extra help. Our field crew is currently full time+ with 3 days. Can the FWS contribute field help (1 or 2 people) for 1 night&morning per week to help with this effort?. If not, we are open to suggestions/proposals. We will be starting early this Monday, so that we can set as many traps as possible before sundown. Please call me on my cell phone this week (619-559-1213) to discuss.

Thank you,
Cheryl

5/12/2008

Hmm….

First, about the good news in these data: PPM still survive at both Dana Pt. and SM South, and it appears they are being captured in greater numbers than in recent years (at least at Dana Pt.). Yeah!

It's interesting that the Dana Pt. captures haven't shown any signs of asymptoting after 5 nights. This seems a bit troubling for the PAO approach, but I I'm not the sampling theory expert. I sympathize with the need to compromise on the number of consecutive nights captured in order to maximize areal coverage and seasonal sampling (2 bouts?). Please remind me of the trap spacing and the timing of bouts.

I wish I could afford to volunteer some field time for you Cheryl, but it's just not possible with my schedule.

Best,

Wayne

==========

Wayne D. Spencer, Ph.D.
Conservation Biology Institute
815 Madison Ave.
San Diego, CA 92116----------

Thanks Will. That helps. My memory was sketchy on what the final design was. Only 3 total nights in a single bout is a worrisome, and the rotating panel approach means spatial results could be confounded by temporal variation in trappability. But, I also sympathize with the need to compromise in balancing the overall effort. Not easy.

Best,

Wayne

==========
Wayne D. Spencer, Ph.D.
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815 Madison Ave.
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-----Original Message-----
From: William_B_Miller@fws.gov [mailto:William_B_Miller@fws.gov]
Sent: Tuesday, May 13, 2008 10:05 AM
To: Wayne Spencer
Cc: cbrehme@usgs.gov
Subject: RE: PPM Monitoring Plan for MCBCP: Short & Long Term Goals

Wayne-

Cheryl is out in the field and my guess is it may take a few days for her to respond. My understanding is that USGS is placing a 10-meter grid over the entirety of the San Mateo sites and then trapping "cells" comprised of 5 x 5 arrays (25 traps total). They initiated trapping at San Mateo South the second week in May and are trapping as many cells as they can each week until they cover this site, then they will proceed to San Mateo North. A total of 3-nights of trapping is proposed within each cell this year (i.e.they will not revisit any cells for a second investigation of its occupancy status). They will be trapping 3-nights per week until they complete both sites-sometime in late June early July.

-will
William B. Miller
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FW: PPM Monitoring Plan for MCBCP: Short & Long Term Goals
Ken Burnham to: 'Cheryl S Brehme' 06/14/2008 01:53 PM

Comments below. I started out thinking I'd have little to say here. But I tried to carefully read what Miller wrote, and thought about it. That lead to unexpected thoughts and basically a claim that their data and interpretation do not support an inference that you need 4 nights rather than 3. However, that is not to say 3 is enough (it may not be); rather the different designs and their interpretations are not relevant to your design and goals.

Ken

-----Original Message-----
From: William_B_Miller@fws.gov [mailto:William_B_Miller@fws.gov]
Sent: Thursday, May 08, 2008 6:38 PM
To: Cheryl S Brehme
Cc: doug@sciences.sdsu.edu; Eric.Kershner@usmc.mil; kenb; Mark Pavelka;
Robert N Fisher; Roland.Sosa@usmc.mil; Stacie A Hathaway;
t80plm1@wpo.cso.niu.edu; wdspencer@cox.net; William.H.Berry@usmc.mil
Subject: PPM Monitoring Plan for MCBCP: Short & Long Term Goals

Cheryl et al.-

The entire PPM working group may not be aware that during the time that USGS requested comments on the draft proposal for this year's PPM monitoring at San Mateo North and South, Mark and I expressed a concern via telephone that we were not enthusiastic about a 3-night trapping protocol and advocated for a minimal effort of at least 4-nights. Peter Meserve shared a similar concern in his emailed comments. USGS addressed our concern through a revision to the protocol that during bouts when no animals are captured during the first three nights across all grids, or animals are only captured on the third night, then a fourth night of trapping would be performed. This has a structure reminiscent of a removal model (e.g. uneven allocation of effort among grids) which may improve the occupancy estimate, but we are unsure how this will be treated in the context of abundance estimation.

Different numbers of occasions is not a big issue - it is not really a problem as such.
(KPB)

Our concern is prompted by the history of low numbers of captures during prior trapping efforts at each of these sites and the general low individual detectability that we have found for this subspecies.

Low capture probability (p) is an issue. Need to get p up, but more occasions, with all else fixed is the least useful way. What else to do? More traps? Better traps? Bait, prebaiting? I do not know; it is a biological issue. But just more occasions is not the best solution.
(KPB)

An ideal monitoring program would, in a cost effective manner, get a precise abundance estimate, document the distribution of each population and collect habitat covariates for modeling habitat suitability. However, it is apparent that given low individual detectabilities, obtaining a precise abundance estimate for these sites would be costly and require an intensive trapping effort.

Yes, it just does not seem like a goal that should be attempted – the result, I think, would be failure to get an N-hat we could believe in.
(KPB)

Ken Burnham has also pointed out that, given the large population fluctuations exhibited by the subspecies, it may be difficult to interpret what a given abundance estimate means.

I'd be satisfied to know a site had (or did not) some PPM there and was recruiting (births).
I want to know the area (at a "site") over which ppm seem distributed.
(KPB)

Based on this, USGS has proposed an initial monitoring approach for these sites that involves trapping in a light to moderate intensity (i.e., 3-nights) the entirety of the area circumscribed by historic trap locations (with a 50-m buffer) in a gridded fashion that will allow for calculation of the proportion of area occupied and collection of habitat covariates. The goals, as we understand them, are to obtain a measure of the area across which PPM are distributed, refine our understanding of habitat associations and to determine whether there are currently few or many PPM at each San Mateo North and South.

I think this is a reasonable goal. (KPB)

We are confronted by the same challenges at Dana Point and have adopted a similar approach for monitoring this year. However, at Dana Point we are placing grids over about 70% of the site and will do 5-nights of trapping per grid.

If only 70% has traps on it, and if there are ppm living mostly on the

other 30% this creates a situation for closure violation. The issue (don't know how problematic it is) is that individuals "off" trapping area can travel to a trap and be caught but may do so more after several nights than right away. The increase in M(t+1) over time may be a result of a closure violation. Or not - I do not know. It is vexing. But - if it went up sort of linearly for 5 nights, there is not information there to say if 5, 10, or more, nights is what is needed. If 3 is not enough but 4 was enough I'd be more willing to say definitely do 4 nights. But 4 may not do it, so how many are needed. For the goal of occupancy and some idea of numbers and spatial distribution, 3 seems justified on cost/benefit basis. If cost was not an issue, and impact on ppm was not a potential issue, then I'd say trap the heck out of the - 10 nights or more. But "costs" must be considered. (KPB)

We have just received preliminary data from the first 5-nights of trapping (over 1/2 of the grids that will be sampled) that we are summarizing for your consideration. We think this data continues to suggest that a minimal effort of 4-nights is appropriate.

If these data are only for 1/2 half of the grids (I am not sure what that means)
I again raise the issue of possible spatial closure violation as the reason for increasing
M(t+1). (KPB)

Methods: At Dana Point we are using 24 meter grid cells within which we are placing 3 X 3 trap grids (9 traps total) spaced at 8 meter intervals. With traps centered in the grid cells this means that traps in adjoining cells are 8 meters away. Grid cells were randomly selected for trapping with proportional representation of cells where there are historic records of PPM and cells where there are no capture records. Because there was a real concern that we may not capture any animals at Dana Point, the investigators are also placing a few subjectively placed trap lines outside of the sampled cells but in areas of historical occupancy.

I am trying to fully understand what was done. To the extent I am thinking I know what was
Done the design itself may be the reason for said linear increasing M(t+1) in the 5 nights.
It is not (is it?) the same design you are using, so direct comparison about some data issues is not valid. The aspect I do not know about is this. Are all 9 grids trapped at the same occasions for 5 occasions? Or are some of the 9 trap grids trapped with different grids trapped at different times? The latter (surely not done) would be trapping new areas over time and lead to M(t+1) not declining much over time. It may be that of the 9 grids, a subset was selected to trap and only those were trapped for the 5 nights. But this means a rather small total area trapped for each 3 by 3 grid with possible not trapped areas between girds. So an uneven spatial coverage again leading to closure violation which tends to produce M(t+1) behaving as they saw it.
A key issue, thus: is their design and yours substantially different? It seems so. In that case we cannot learn from them what your # of occasions should be. There is not the needed comparability of methods, or so it seems to me. (KPB)

Results: In total we captured 14 unique PPM over 5-nights with two animals

captured the first night, 4 additional animals caught the second night, 2 additional animals caught the third night, 2 additional animals the fourth night and 4 new animals on the fifth night. Ignoring animals captured in more than one grid cell and animals captured along selectively placed lines, we detected animals in a total of 8 grid cells with the cumulative number of cells that animals were detected in across nights as follows, 2, 3, 4, 5 and 8.

This is more disturbing data - but again if the designs of you and they are as different as I think, there is no way to infer from these data the number of occasions you need to use. By disturbing I mean that for some (3 by 3 grids over 16 meters squared - a small area) it 5 nights to record a capture. But we (I) do not want to know occupancy over such a small area. It means nothing, I think. Patch occupancy, as such, first requires a biologically meaningful definition of a patch. There is no such definition of patch here. So it becomes occupancy, where site is a much larger area than 256 square meters. (a ppm may not often visit a given 256 sq. m. area, so it takes days to register such usage. In some sense the entire site is being used all the time, but some of the tiny sub areas are used rarely). Occupancy needs to be for a larger area than arbitrary 16 meter^2 areas. I think these Results have little or no bearing on doing 3 or 4 or 5 nights trapping for your design.
(KPB)

Based on a naive occupancy estimate, after three nights we calculate 9 percent of the Dana Point Headlands is occupied but after five nights this value increases to 24 percent. The following graphically displays this information (also viewable in the attached excel file).

The whole site is occupied. How the ppm are distributed over that space and how they are using it over time is not very evident from the sparse data. This sort of data collection and analysis will always (in expectation) show such "occupancy" (as % of space visited) increasing a lot over time. In principle, occupancy used their way might really be 100% - that is during the course of the active period of the year for the ppm, every 256 square meters might be visited some time. They are not using occupancy (as a parameter) the way it needs to sensibly be used. Habitat usage is not the same as occupancy.
(KPB)

(Embedded image moved to file: pic05537.jpg)

(See attached file: Naive PAO based on 34 grids 5_08_08.xls)
William B. Miller
U.S. Fish and Wildlife Service
6010 Hidden Valley Road
Carlsbad, California 92011
(760) 431-9440 extension 206

Re: Fw: PPM Monitoring Plan for MCBCP: Short & Long Term Goals
William_B_Miller to: kenb 07/08/2008 09:53 AM

Cc:
doug, Eric.Kershner, "Mark Pavelka", "Robert N Fisher", Roland.Sosa, "Stacie A Hathaway", t80plm1, wdspencer, William.H.Berry, cbrehme, Jonathan_D_Snyder

Ken-

I am responding to clarify some of your questions and to elicit further thinking and hopefully comments on the sampling design for PPM. First, the sampling design used by USGS on Camp Pendleton and by others at Dana Point are actually very similar, so analysis of the Dana Point data is informative relative to what is being done at Camp Pendleton. Both essentially involve placing a massive trapping grid over the entirety of what are fairly small areas of 15-50 acres each which circumscribe historic PPM capture locations at each area. So, for discussion purposes, let's say a given area is covered by a 50 trap by 50 trap grid (2500 traps total) with traps spaced at 10 meter intervals. This super-grid is then divided up into contiguous sub-grids or "sites" comprised of 5 x 5 trap arrays (25 traps total) in the case of USGS, or 3 x 3 arrays (9 traps total) in the case of Dana Point. The subgrids/sites abut one another with the outer traps of each subgrid/site being inset 5 meters from their boundary. Thus, the distance between the outer traps in adjoining grids (10m) is the same as the distance between traps within the same grid.

Based on 25 traps per subgrid/site there would be a total of 100 subgrids/sites within the area surveyed. During trapping all 25- traps within each subgrid/site are operated simultaneously for 3-4 days. However, due to manpower constraints, it is only feasible to trap about 16 subgrids/sites a week (400 traps total). Thus, in order to survey all 100 of the subgrids/sites in this theoretical area, it would take 6 to 7 weeks. Ultimately, the data from each subgrid/site are to be used for generation of a Proportion Area Occupied estimate.

The substantive differences between the USGS study design and the Dana Point study design are: 1) USGS employs 5 trap x 5 trap subgrids and Dana Point employs 3 trap x 3 trap subgrids; 2) USGS proposes to trap all of the subgrids established within an area, whereas Dana Point only trapped ~70% of the available subgrids; 3) USGS performs 3 to 4 nights of trapping on each subgrid depending on results, whereas Dana Point consistently implemented 5 nights of trapping on each subgrid, and 4) PPM at Dana Point were given unique temporary markings while it is our understanding that USGS is using the same batch marks (hair clip) on all individuals which would prevent definitive documentation of animal movements..

Obviously, the meaningful interpretation of results from either of these efforts must confront issues of both spatial and temporal closure. With regards to spatial closure, our data from Oscar One suggests that over a 4-10 night sampling period PPM move on average across an area with a diameter of 16 meters. This suggests that, relative to a 3-5 night sampling period, patch occupancy occurs across fairly small spatial scales that we have attempted to encompass within the size of the subgrids. It also suggests that there is a potential lack of spatial independence among subgrids/sites since traps in adjoining subgrids/sites are only 10 meters away. However, individual marking of PPM at Dana Point allows us to correct for observed violations of spatial closure by allowing us to ignore secondary captures of individuals in adjoining subgrids/sites (which is what we did in the analysis presented earlier).

The issue of temporal closure is potentially more vexing since only a fraction (e.g. 16%-33%) of each area (i.e. San Mateo North, San Mateo South, or Dana Point) can be sampled during a 3-5 night sample period.

Measures of PPM movements are positively correlated with time and PPM reproduction and emergence of juveniles coincides with the period of sampling. Thus, PAO estimates may need to be calculated separately for each week or every two weeks of sampling to address emigration/immigration among subgrids, and to address the emergence and potential dispersal of juveniles over the sampling period.

Since we now have the benefit of having received all of the Dana Point data, it is worthwhile to reiterate the results of the Dana Point effort with a more detailed analysis. Again, 34 subgrids/sites were sampled over a 5 night period with all traps within each subgrid being operated during that time. A total of 14 unique individuals were captured across the five night sample period. Spatial closure was addressed by ignoring secondary captures of individuals in subgrids that differed from the subgrid/site of initial capture. After 3 nights of sampling, PPM were detected in 4 subgrids/sites resulting in a naive occupancy estimate of 12 percent. Detailed capture information from 3-nights leads to a site level detectability of 0.52 (S.E.= 0.18) and an occupancy estimate of 0.13 (S.E.= 0.06, LCI= 0.04, UCI=0.32). After 5 nights of sampling, PPM were detected in 8 subgrids/sites resulting in a naive occupancy estimate of 24 percent. Detailed capture information over 5-nights leads to a site level detectability of 0.36 (S.E. = 0.09) and an occupancy estimate of 0.26 (S.E.=0.08, LCI=0.13, UCI=0.46).

There is a lack of precision associated with sparseness of data which prevents us from concluding that these estimates appreciably differ. However, the occupancy point estimate after 5-nights of sampling is twice the point estimate after 3-nights, which should be cause for concern since this difference arises from sampling variance that does not appear to result entirely from a lack of spatial closure. Additionally, the difference in these estimates that may result from a lack of spatial closure is a problem that is shared in common at Dana Point and Camp Pendleton, since only a fraction of the subgrids/sites in each area can be sampled at once and there always remains the potential that animals may move in and out of the sampled area during the sampling period. If that movement is random then this may not be a significant problem. (Also, if all subgrids were sampled simultaneously then one could control for a lack of spatial independence through review of individual capture histories via animal markings). Still, a long-recognized problem of baited passive trapping grids is that the effective trapping area is larger than the trapping footprint.

Another trapping effort that illustrates low site level detectabilities is sampling that was just performed this June in Oscar One by the San Diego Zoological Society's Department of Conservation and Research for Endangered Species (CRES). Within Oscar One, CRES deployed 10 trapping grids of 100 traps each (5m trap spacing) and trapped for 6 nights on each grid. Cumulatively, they captured 5 unique animals across three of the ten sites with the following capture pattern: 1 animal captured on night 2; 2 animals on night 5; and 3 animals on night 6 (1 recapture). Thus, employing much larger grids than were employed at Dana Point, animals went undetected on 2 of the 3 grids where they were found until nights 5 and 6 of the sample period!

Returning to Dana Point, we can repeat our analysis using all available capture information for each individual including secondary captures in

subgrids other than the site of original capture. Such an analysis might be interpreted as "use" versus occupancy and may give some indication of the lack of spatial closure. After 3 nights, PPM were detected in 6 subgrids leading to a naive "use" estimate of 18 percent. Detailed capture information from 3-nights leads to a site level detectability of 0.38 (S.E.= 0.15) and a "use" estimate of 0.23 (S.E.= 0.10, LCI= 0.09, UCI=0.48). After 5 nights, PPM were detected in 10 subgrids leading to a naive "use" estimate of 29 percent. Detailed capture information over 5-nights leads to a site level detectability of 0.38 (S.E. = 0.08) and a "use" estimate of 0.32 (S.E.=0.09, LCI=0.18, UCI=0.51). As with the "occupancy" analysis, the precision of the detectability estimate appears to improve with more nights of sampling, and the point estimate for occupancy/use increases. Finally, the "use" estimate boosts the "occupancy" estimate by 0.10 after 3 nights and 0.06 after 5 nights, suggesting that some but probably not all of the sampling variance arises from a lack of spatial closure.

Since my original email, an additional 32 subgrids/sites were sampled at Dana Point during the first week of June. This effort captured 17 unique individuals, 16 of which were judged to be juveniles/young of the year with the one adult animal captured being the only animal detected during the prior bout in May. Thus, it appears inappropriate to combine data from trapping bouts implemented 4-weeks apart into a single analysis since the difference in age of captured animals suggests closure was not achieved across the two bouts.

Using the "occupancy" approach to analysis of this bout's data (i.e. ignoring secondary captures in subgrids that differed from the location of original capture), after 3-nights, site level detectability is estimated to be 0.15 (S.E.= 0.09) and occupancy is estimated to be 0.97 (S.E.=0.55, LCI=0, UCI=1). After 5-nights, site level detectability remained low (p=0.16,S.E.=0.06) and occupancy was estimated to be 0.69 (S.E.= 0.23, LCI=0.21, UCI=0.95). Thus, analysis of three nights of data from this bout generates a meaningless occupancy estimate and the occupancy estimate from 5-nights of data also remains terribly imprecise, which likely relates to low site level detectability of PPM.

The point I was trying to stress in the last email was that, indeed, it can take up to 5-nights or more for a PPM to be detected in a subgrid/site due to low detectability of individuals. Behavioral observations and our data suggest that this is not likely to be primarily due to a lack of spatial closure but because this is a fossorial animal that intersperses periods of activity above ground with periods of inactivity below ground; even during the period of seasonal activity for the species as a whole. Thus, reliable estimates of occupancy necessarily rely upon more nights of trapping since increased trap density can do little to increase the detectability of an animal that is temporarily belowground and unavailable for capture.

We highlighted the problem of low detectability in the prior email by presenting naive occupancy estimates at Dana Point after 3 and 5 nights of trapping, which we attempted to correct for a lack of spatial closure. As shown above, the conclusions from the naive occupancy estimates are mirrored by "occupancy" and "use" analyses that take into consideration the detailed site-level capture histories. We, therefore, feel that 3 nights of data is likely to provide a very imprecise occupancy estimate and will grossly inflate negative data that is proposed to be applied in the context

of a covariate analysis.

As you suggest, the questions of interest within the areas supporting PPM (i.e. San Mateo North, San Mateo South, Dana Point) are how PPM are distributed and how does that distribution change over time? To be sure, the issue of scale is fundamental to application of the PAO methodology and we may need to adjust the size of the subgrids employed at Dana Point and/or Camp Pendleton. Over a 4-10 night sample period PPM appear to occupy a fairly small home range, which based on average movement data and assuming a circular home range may be as little as 200 m^2. Thus, this is a species that operates at small spatial scales and it is commonly documented at very low densities. This necessitates high trap densities in order to detect the species but also suggests that larger spatial scales may be needed to have acceptable site level detection probabilities.

However, as larger subgrids/sites are delineated, our ability to make meaningful inferences about distribution, how that relates to habitat covariates and how distribution changes over time becomes impaired. Therefore, we feel that for the PAO methodology to have merit we should delineate reasonably small subgrids/sites that are trapped over enough occasions (i.e. more than 3) to make reliable inference about their occupancy by PPM. While cost considerations must be considered in choosing the number of nights of sampling, we do not feel it is appropriate to proceed with a sampling methodology (or at least we should go into it with reduced expectations) if we have an apriori reason to doubt the utility of the statistical analysis (e.g. application of habitat covariates to unreliable occupancy data).

At the broader scale of each of the areas supporting PPM (the San Mateo sites, Dana Point, Oscar One) your comments about the distinction between "occupancy" and "use" are germaine since logistically it may be unattainable to survey an entire area over a short enough time interval to meet the closure assumption. Thus, by necessity we will commonly be forced to generate occupancy estimates from a sample of the available subgrids/sites which could result in sample size issues. Overall, we think that this year's data suggest there remain many unresolved questions about the utility and practicality of a PAO monitoring approach for PPM that warrant further discussion and input from other PPM Working Group members.

Sincerely,

William B. Miller
U.S. Fish and Wildlife Service
6010 Hidden Valley Road
Carlsbad, California 92011
(760) 431-9440 extension 206

Above: Final email of String….

From: Cheryl S Brehme [mailto:cbrehme@usgs.gov]
Sent: Wednesday, August 20, 2008 5:37 PM
To: doug@sciences.sdsu.edu; kenb; Mark Pavelka; t80plm1@wpo.cso.niu.edu; wdspencer@cox.net; William B Miller
Cc: Eric.Kershner@usmc.mil; William.H.Berry@usmc.mil; Roland.Sosa@usmc.mil; Robert N Fisher; Stacie A Hathaway
Subject: Re: PPM Monitoring -2008 South & North San Mateo Results

Hi all,

Here is a short table of our Pacific pocket mouse trapping results for North and South San Mateo this year. I have also attached maps that include trap locations, historic captures, and new 2008 captures. As many of you know, we did not capture any PPM at North San Mateo after 4 nights of trapping. However, we captured 45 PPM at South San Mateo after 3 nights of trapping that were well distributed throughout the trapping area. Out of 15 animals captured more than once, 3 animals were only recaptured at the same trap. The remainder moved and average of 20 m between successive captures (Range 2-75 m). A comprehensive report & analyses will be completed early next year. Please don't hesitate to contact me with any questions.

Thanks for all of your input.

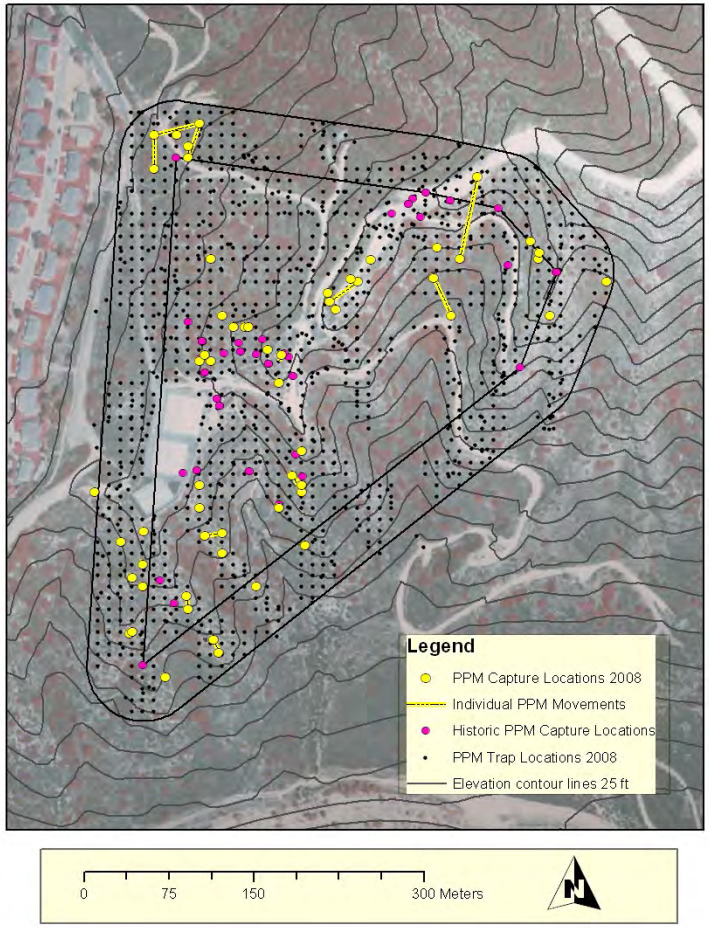
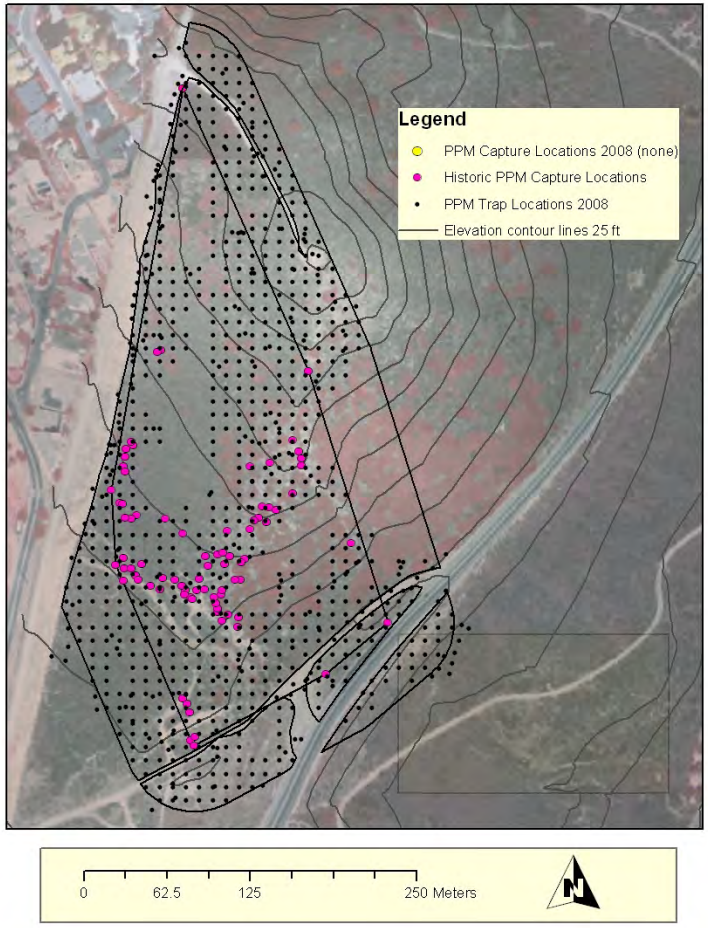
Cheryl

Date	No. Trap Nights/ Mornings	Site	Grids	No. Traps	No. Total Captures	No. PPM Captures	No. new PPM Individuals
5/5-5/8	3/3	South San Mateo	50E ,54-61	175	131	6	4
5/12-5/15	3/3	South San Mateo	0-21	363	299	13	11
5/19-5/22	3/3	South San Mateo	39-53	343	333	16	8
5/27-5/31	4/4	North San Mateo	0, 1, 3-9, 15-23	298	214	0	0
6/2-6/6	4/4	North San Mateo	2,11-14, 24-28, 37-40, 47-50, 55-57	386	180	0	0
6/9-6/13	4/4	North San Mateo	28 (rpt), 29-36, 41-46, 51-54, 58	372	179	0	0
6/16-6/20	3/3	South San Mateo	23-43	474	356	32	15
6/23-6/26	3/3	South San Mateo	63-86	387	383	10	7
Totals				2798	2075	77	45

Result Maps:

Total Area
South San Mateo= 15.3 ha
North San Mateo= 9.7 ha

2008 USGS Survey Results for the Pacific Pocket Mouse at South San Mateo, MCB Camp Pendleton



2008 USGS Survey Results for the Pacific Pocket Mouse at North San Mateo, MCB Camp Pendleton