Protocol Surveys for the Morro Bay Kangaroo Rat (Year 1) 2008

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EXECUTIVE SUMMARY

Currently, no population of Morro Bay Kangaroo Rats (MBKR - *Dipodomys heermanni morroensis*) is known to exist. This report summarizes a 2008 protocol survey effort to rediscover MBKRs in the wild. The pre-survey effort evaluated two types of sites. First, surveys were conducted on previously occupied sites within the historic range. The previously occupied "extension" area east of Los Osos Creek was evaluated for the first time since 1958. Buckskin was not evaluated because permission to access could not be obtained. Pecho was only partially evaluated due to a lack of time. Second, sites with sandy soil outside of the historical range were identified through a GIS analysis of soil type. Surveys were conducted on sandy sites that represented putative habitat islands. For the two types of sites, a habitat assessment was conducted to determine if suitable habitat was present. If suitable habitat was identified, it was searched for sign of MBKR. These searches evaluated 100% of the ground surface within any patch of suitable habitat for sign of MBKR. If suitable habitat with sign was identified through the pre-survey, then a live trapping survey was conducted.

No high-density colony of kangaroo rats was discovered in pre-surveys. The conclusion was that any persisting population would be at low density. In determining where to conduct trapping surveys it was regarded as acceptable to err on the side of over interpreting any potential MBKR sign as actual sign of MBKR. Therefore, small mammal live trapping was conducted in areas that satisfied two conditions: suitable MBKR habitat and possible sign of MBKR activity. Two trapping sessions were conducted. One of the two trapping sessions was conducted in August - outside of the time window for protocol trapping surveys due to constraints imposed by State Park personnel's schedules. No MBKRs were live trapped in 948 trap-nights. A reference site in the Guadalupe-Nipomo Dunes National Wildlife Refuge produced 94 *D. h. arenae* captures in 420 trap-nights in July, and 188 captures in 420 trap-nights in October. This represents a 3 month doubling time for the reference population over the same time period as the MBKR surveys.

Population decline has resulted from the direct loss of habitat due to development, indirect loss of habitat due to plant succession, and an inability for locally extinct populations to be re-established through dispersal due to dispersal barriers between fragmented habitat patches. Public lands within the MBKR range are unconnected habitat islands with no potential for dispersal between islands. There has been a reduction in the amount of suitable habitat within the MBKR's range due to plant succession in previously occupied sites (e.g.: Bayview).

No population of MBKR was discovered through this effort. There are two paths for future action. Both are strongly recommended. The first path is to move towards recognition of possible extinction. This path would require the 2008 surveys be repeated in 2009 in order to satisfy the protocol requirement for visual and trapping surveys in two consecutive years. The second path is to expand the re-discovery effort to sites within the historical range that were not assessed in 2008 (Pecho and Buckskin), and to islands of sandy habitat outside of the historical range that have yet to be evaluated. There are 2 high priority islands. The North-East corner of the "extension" has a sand island that was not evaluated in 2008. Los Osos creek drains the Clark Valley watershed. Within that watershed is a sand island approximately the same size as the "extension" area, and approximately ½ Km from the Bayview site.

INTRODUCTION

The Morro Bay Kangaroo Rat (*Dipodomys heermanni morroensis*) is a subspecies of Heerman's Kangaroo Rat (1, 2). The subspecies' original range was described by Stewart and Roest in 1960 (3). The subspecies is listed as Federally (1970) and State endangered (1971) (4).

Quite a bit has changes since the subspecies' range was described and it was listed as endangered. The number of human dwellings occupying the subspecies' range has increased from 624 (1959) when the range was described, to 1,614 (1970) when the subspecies was listed, to 5,715 (2000). This is a cumulative increase by a factor of 9.15 between 1959 and 2000 (5). A genetic analysis of microsatellite DNA has demonstrated that the subspecies is genetically distinct, and that there is no gene flow between this subspecies and other subspecies of Heermann's Kangaroo Rat in San Luis Obispo County (6). Studies in Kangaroo rat demography are showing that medium density populations (e.g.: 20 krats/ha) are not intrinsically stable, and can double or go to extinction over the course of 3-4 months (7, 8). Kangaroo rats in general have traditionally been categorized as granivores, but more specifically they appear to be grass seed specialists (graminivores) (9). Some of the experts that work with this subspecies, and the California Department of Fish and Game, consider the subspecies "potentially extinct" (10,11).

Morro Bay Kangaroo Rats have not been trapped in the wild since 1985 (12). A reintroduced population, derived from a captive breeding program (13), died out in 1989. Diagnostic sign of Morro Bay Kangaroo rats (e.g.: tail drags) were last seen in 1990 (14). Efforts to locate individuals of this subspecies over the last eighteen years have all failed. This report summarizes a protocol survey (as outlined in the Draft Revised Recovery Plan (14)) approach that was used in 2008. The intent of this survey was to "re-discover" an extant population of this subspecies within or adjacent to its original range.

METHODS

Study sites

Possible study sites were identified by comparing the distribution of sandy soil to the original range of the MBKR (Figure 1). This analysis showed that the entire historical range occurred on sandy soil, with the exception of two trap line that produced kangaroo rats in the far North East corner of the "extension" (sensu Stewart and Roest, 1960, **Figure 1**). Therefore, all the sandy soils that underlie the cities of Los Osos, Baywood Park and Questa-By-The-Sea once represented potentially suitable habitat and currently represents potential study sites. Superimposing a map of urban development and public lands, onto a map of the original range, allowed identification of undeveloped lands (**Figure 2**). This map was used to identify private landowners or public agencies that should be approached for access to survey sites within the original range. Finally, a map of sandy soils relative to the original range of the MBKR (**Figure 1**) was used to identify islands of sandy soil potentially harboring suitable habitat outside of the range described by Stewart and Roest (3).

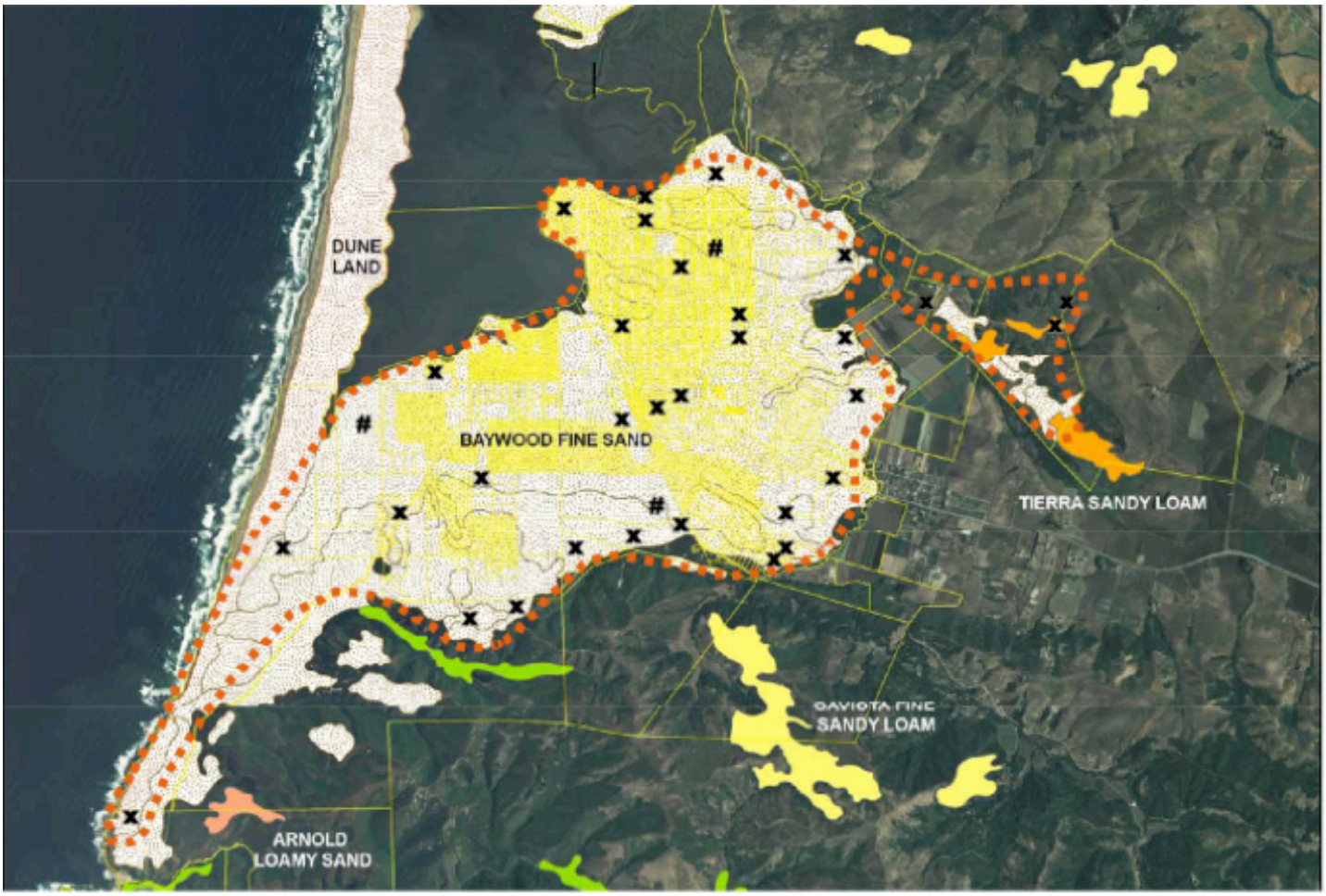

Figure 1. GIS map of all five sandy soil types found in or near the historical range of the Morro Bay Kangaroo Rat. The historical range is based on the estimation by Stewart and Roest (3) and is shown as a dashed orange line. The historical range was determined in part by the successful capture of kangaroo rats in trap lines (x) and grids (#) during 1957 and 1958. This map was used to determine that the vast majority of the historical range occurred on sandy soils, and that all areas within Los Osos, Baywood Park and Questa-By-The-Sea once represented potentially suitable habitat and currently represent potential study sites. An enlarged version of this figure is shown in appendix 1.

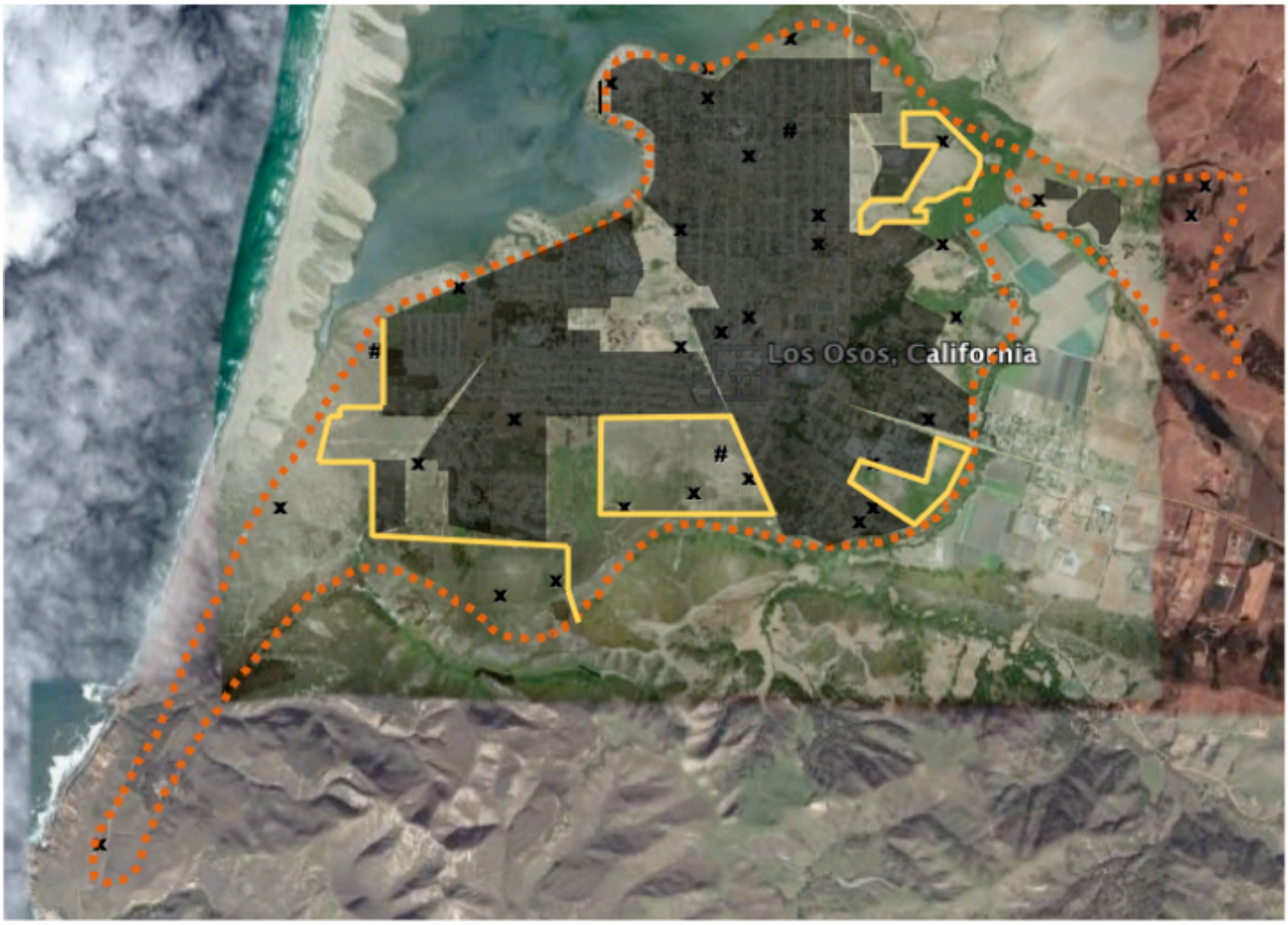

Figure 2. Aerial photo of the Los Osos area from Google Earth. The historical range of the MBKR is shown as a dashed orange line. The historical range was determined in part by the successful capture of kangaroo rats by Stewart and Roest in trap lines (x) and grids (#) during 1957 and 1958. The grey polygons represent historical MBKR habitat lost to urban development. The yellow polygons represent public lands. Clockwise from the top is the combined site Powell I, II and III (aka Junior High, California State Parks), Los Osos Oaks Reserve in the lower right (California Dept of Fish and Game), Morro Dunes Ecological Preserve in the center (aka Bayview, California Dept of Fish and Game), while the yellow line on the left marks the Eastern boundary to Montana de Oro (aka Pecho North, California State Parks) relative to the historical range. This map was used to identify private and public lands, both within and adjacent to the original range, where permission to access was sough by the U.S. Fish and Wildlife Service.

Selection of study sites within the historical range was obvious: all undeveloped sites where access could be obtained were targeted. Selection criteria of potential study sites from outside of the historical range were less obvious. The selection criteria were developed that prioritized sand islands as follows: patches of sandy soil closest to the historical range, large patches of sandy soil further from the historical range and lastly, small and distant patches of sandy soil. The 2008 surveys were able to survey all the patches of Baywood Fine Sand, Arnold Loamy Sand, and Tierra Sandy Loam in **Figure 1** (with the exception of one area shown in figure 10). The area of Gaviota Fine Sandy Loam in **Figure 1** was not surveyed due to a lack of access.

Habitat Assessment

The nine sites to which access could be legally obtained are shown in **Figures 3-11**, in the results section. From west to east and in a counter clocklike fashion these sites were named: Shark Inlet, Butte, Islands east of Pecho, Bayview, Silva, Los Osos Oaks, Powell I, II and III, Morrissey and Lilly and Lee, Branin, and Tonini. The figures (**Figures 3-11**) show the location of the sites and the legends provide the parcel numbers for private property. All nine of these sites were subjected to a habitat assessment.

Habitat was assessed by considering the plant community of the stand, the amount of ground cover, and the average distance between shrubs. Sites with low and open, early successional, Coastal Sage Scrub vegetation, and with bare sand between plants, were considered the most suitable for MBKR. Sites with mature Coastal Sage Scrub, Manzanita Chaparral, Chamissal, Oak Woodland, Riparian Woodland, or Eucalyptus Forest were considered unsuitable. Sites with mid-successional Coastal Sage Scrub, or ruderal vegetation were evaluated on a case-by-case basis.

Presence of possible MBKR sign and trap site selection

Pedestrian surveys (pre-trapping surveys) of all suitable habitat were conducted by examining 100% of the ground surface for signs of MBKR. There was not one case in which definitive sign of MBKR was located. Therefore, the conclusion was made that any persisting population of MBKRs would be at a very low density. In determining where to conduct trapping surveys it was regarded as acceptable to err on the side of over interpreting any potential MBKR sign as actual sign of MBKR. Therefore, small mammal live trapping was conducted in areas that satisfied two conditions: suitable MBKR habitat and possible sign of MBKR activity.

Empirically, the possible sign of MBKR ended up taking two forms: burrows that were close enough in shape to the typical MBKR burrows, and tail drags that were possibly MBKR tail drags. In some cases it is possible to confuse gopher burrows for an MBKR burrow. Therefore, even if a borrow approximated a kangaroo rat burrow, it was excluded as sign of MBKR if no other sign of kangaroo rats could be found locally, or if the closest neighboring burrows were those of pocket gophers. Three species leave tail drags in the Baywood Fine Sands: Western Fence Lizards, California Pocket Mice and Morro Bay Kangaroo Rats. Lizard tail drags can be recognized because they are a shallow “V” shaped trough. A large pocket mouse and a small kangaroo rat would both leave the same shallow “U” shaped sinuous trough. Adult kangaroo rats leave a distinct, deep, “U” shaped sinuous trough. Any tail drag that was “U” shaped, whether it was shallow or deep, was considered possible sign of MBKR.

Live Trapping
When small mammal sign within suitable habitat was regarded as potential MBKR sign, then live trapping was conducted. See **Figures 3-11** in the results section for the location of all the trap lines. The names of the live trapping areas, the number of trap lines, number of trapping stations, and the inter-station intervals are summarized in **Table 1**. Trapping was done 30 June- 2 July 2008. This trapping session followed protocol, which includes trapping between April 1st and June 30th, during the new moon phase, and checking traps at midnight as well as at dawn. This trapping was conducted with assistance from three U.S.F.W.S biologists. Trapping was also done, 30 July – 1 August, during a new moon phase, but outside of the protocol period. During this trapping session, traps were set in the evening and only checked at dawn. This trapping was constrained by the schedules of two California State Parks biologists that assisted.

Table 1. Summary of live trapping effort by area and date during 2008 surveys to re-discover a population of Morro Bay Kangaroo Rats. The total number of trap nights = total number of stations x 2 traps per station x 3 nights = 948

AREA	DATE	NUMBER OF TRAP LINES	NUMBER OF STATIONS PER LINE	STATION INTERVAL (Meters)
SHARK INLET	30 JULY-1 AUG	6	7	20
	30 JULY-1 AUG		7	20
	30 JULY-1 AUG		7	20
	30 JULY-1 AUG		7	20
	30 JULY-1 AUG		7	20
	30 JULY-1 AUG		7	20
BUTTE	30 JULY-1 AUG	3	6	20
	30 JULY-1 AUG		6	20
	30 JULY-1 AUG		6	20
BAYVIEW	30 JUNE-2 JULY	1	16	20
POWELL SPOT	30 JULY-1 AUG	0	1	0
POWELL III	30 JULY-1 AUG	2	8	10
	30 JUNE-2 JULY		6	10
LEE	30 JUNE-2 JULY	1	16	20
BRANIN	30 JUNE-2 JULY	6	8	10
	30 JUNE-2 JULY		8	10
	30 JUNE-2 JULY		10	10
	30 JUNE-2 JULY		10	10
	30 JUNE-2 JULY		7	10
	30 JUNE-2 JULY		8	10
TOTAL		19	158	

Reference population of *D. h. arenae.*
Rodents typically show an r-selected life history (high reproductive rates, low survivorship of young, and short lifespan of adults). Therefore, rodent populations can fluctuate dramatically. Indeed, kangaroo rats show this pattern (7,8). The detectability of any animal declines as a function of its density (15). Therefore it is possible that MBKRs could be interpreted as "possible extinct" when in fact they are simply in the low portion of a population cycle. Granted

this alternative explanation becomes less and less likely if a taxon is not detected during multiple searches (like over the last 18 years!). But, knowing whether the protocol survey is occurring during a low or a high portion of a population cycle may make interpretation of the results more reliable and defensible. Therefore, a reference population of *D. h. arenae* was monitored at the Guadalupe-Nipomo Dunes National Wildlife Refuge during the 2008 MBKR field season.

The reference population of *D. h. arenae* was evaluated using a single trap line through a Coastal Sage Scrub community that is being invaded by Veldt grass (*Erharta arenarea*). The line was 1400m in length, trap stations were at 20m intervals, with 2 traps per station. Each trapping session consisted of three nights or 420 trap nights. Trapping occurred quarterly: 23-25 July and 18-20 October, 2008.

RESULTS

Habitat assessments and the distribution of suitable habitat

The nine sites to which access could be legally obtained are shown in **Figures 3 -11**. From west to east and in a counter clocklike fashion these sites are: Sharks Inlet (**Figure 3)**, Butte (**Figure 3**), Islands east of Pecho (**Figure 4),** Bayview (**Figure 5**), Silva (**Figure 6**), Los Osos Oaks (**Figure 7**), Powell I, II and III (**Figure 8**), Morrissey and Lee (**Figure 9**), Branin (**Figure 10**), and Tonini (**Figure 11**). Several of these sites are under public ownership. These sites are: Sharks Inlet, Butte, Islands East of Pecho, Bayview, Los Osos Oaks, Powell I, Powell II, and Powell III. The reminder of the sites are privately owned. These sites are referred to here as Silva, Morrissey and Lilly and Lee, Branin, and Tonini.

The figure legends (**Figures 3-11**) show the location of the study sites, provide names for the sites, and provide the parcel numbers for private property. The figures also show the extent of the area that was subjected to a habitat assessment at each of the sites. The figures deliniate the areas that are designated as potentially suitable habitat, and the exact location of traplines used to sample for Morro Bay Kanagaroo Rats.

See figures starting next page…

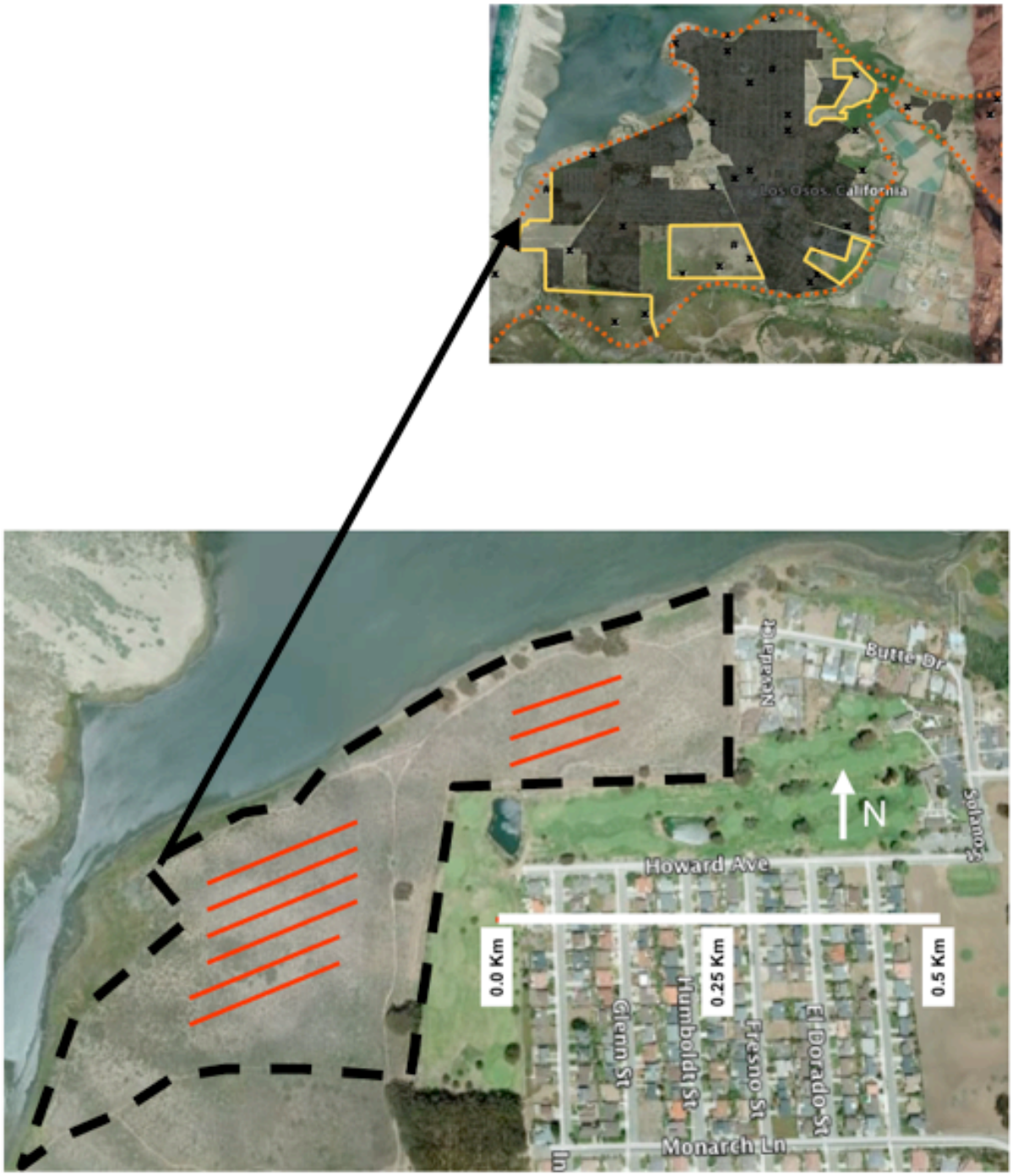

Figure 3. Shark inlet (area with 6 trap lines) and Butte (area with 3 trap lines) site. This is a new land acquisition for Montana de Oro (California State Parks). The bold dashed line indicates the habitat assessment area. The vegetation is early to mid successional Coastal Sage Scrub. The entire area was regarded as potentially suitable habitat and evaluated by a 100% visual survey for sign of MBKR during the trapping pre-survey. Both sites were trapped due to the presence of suitable habitat and potential sign of MBKR. No MBKR were captured.

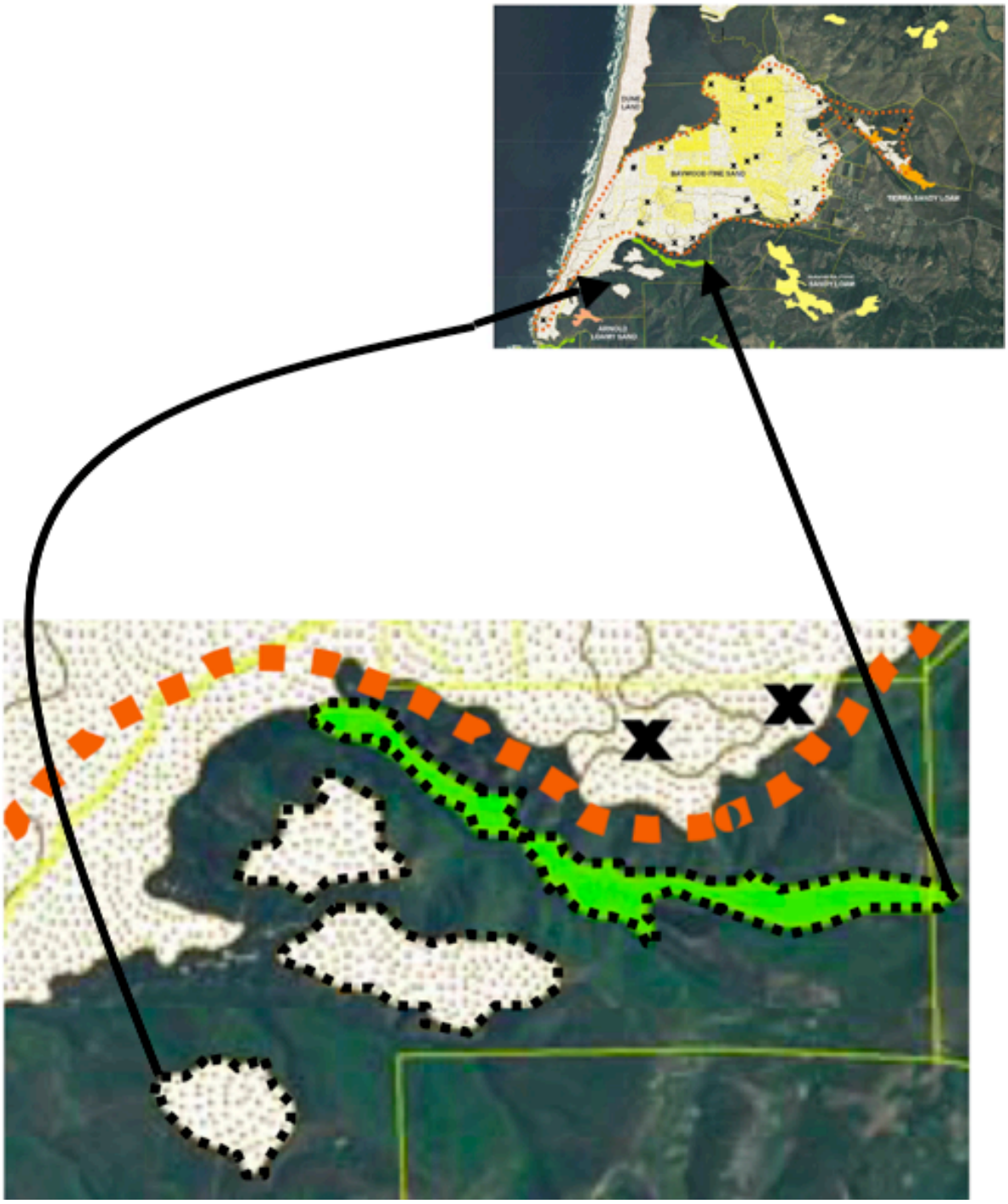

Figure 4. Islands of sandy soil East of Pecho Rd. and within Montana de Oro State Park. Bold dotted lines indicate the habitat assessment area. No suitable habitat was found on these islands. The three bottom islands (Baywood Fine Sands) are loosely aggregated sand stone ridges vegetated with mature, closed canopy, Manzanita Chaparral. The elongate upper island contains horse corral and horse camp. The vegetation is disturbed Coastal Sage Scrub, Oak woodland, and riparian woodland. No suitable MBKR habitat was found on any of these sand islands.

Figure 5. Bayview (California Department of Fish and Game). The bold dashed line indicates the extent of the habitat assessment area. The yellow line encloses the area of potentially suitable habitat evaluated by a 100% visual survey for sign of MBKR during the trapping pre-survey. The potentially suitable habitat is in advanced stages of natural succession. Suitable habitat is currently distributed in multiple small patches (generally <50m diameter). The only possible sign of Kangaroo rats was in the area parallel to Calle Cordoniz. The red line shows the approximate location of the one trap line used. No kangaroo rats were captured.

Figure 6. Bayview Sand Island (Parcels 074-229-001 and 067-131-055; aka Silva property). The bold dashed line indicates the habitat assessment area. Some of the site was scattered Coastal Sage Scrub, with open space, while some was Coast Live Oak Woodland. Though some of the habitat was unsuitable, the entire site was evaluated by a 100% visual survey for sign of MBKR during the pre-survey activity period. There was no sign of Kangaroo rats detected.

Figure 7. Los Osos Oaks State Preserve (California Department of Fish and Game). The bold dashed line indicates the habitat assessment area. The yellow lines enclose areas of potentially suitable habitat evaluated by a 100% visual survey for sign of MBKR during the trapping pre-survey. The potentially suitable habitat is currently distributed in three patches: two small patches of mature Coastal Sage Scrub with open space in the canopy, and one large patch of open and low growing Coastal Sage Scrub with a hard packed hydrophobic soil crust. There was no sign of Kangaroo rats found.

Figure 8. Powell I, II and III, and a "spot check" site (California State Parks). The bold dashed line indicates the habitat assessment area. The solid yellow lines enclose the areas of potentially suitable habitat evaluated by a 100% visual survey for sign of MBKR. The Southern area (below the running track) of suitable habitat has Coastal Sage Scrub that is largely disturbed. The red "x" shows the approximate location of a solitary burrow that was spot trapped. A larger area (East of the Junior High) has several large stands of vegetation: there is a stand of Coyote Brush, a stand of Silver Beach Lupine, a stand of Dune Aster, and a stand of Tarweed. All of the sign that might have been produced by Kangaroo rats was in the Lupine and Dune Aster stands. The red lines show the approximate trap line locations. No kangaroo rats were captured.

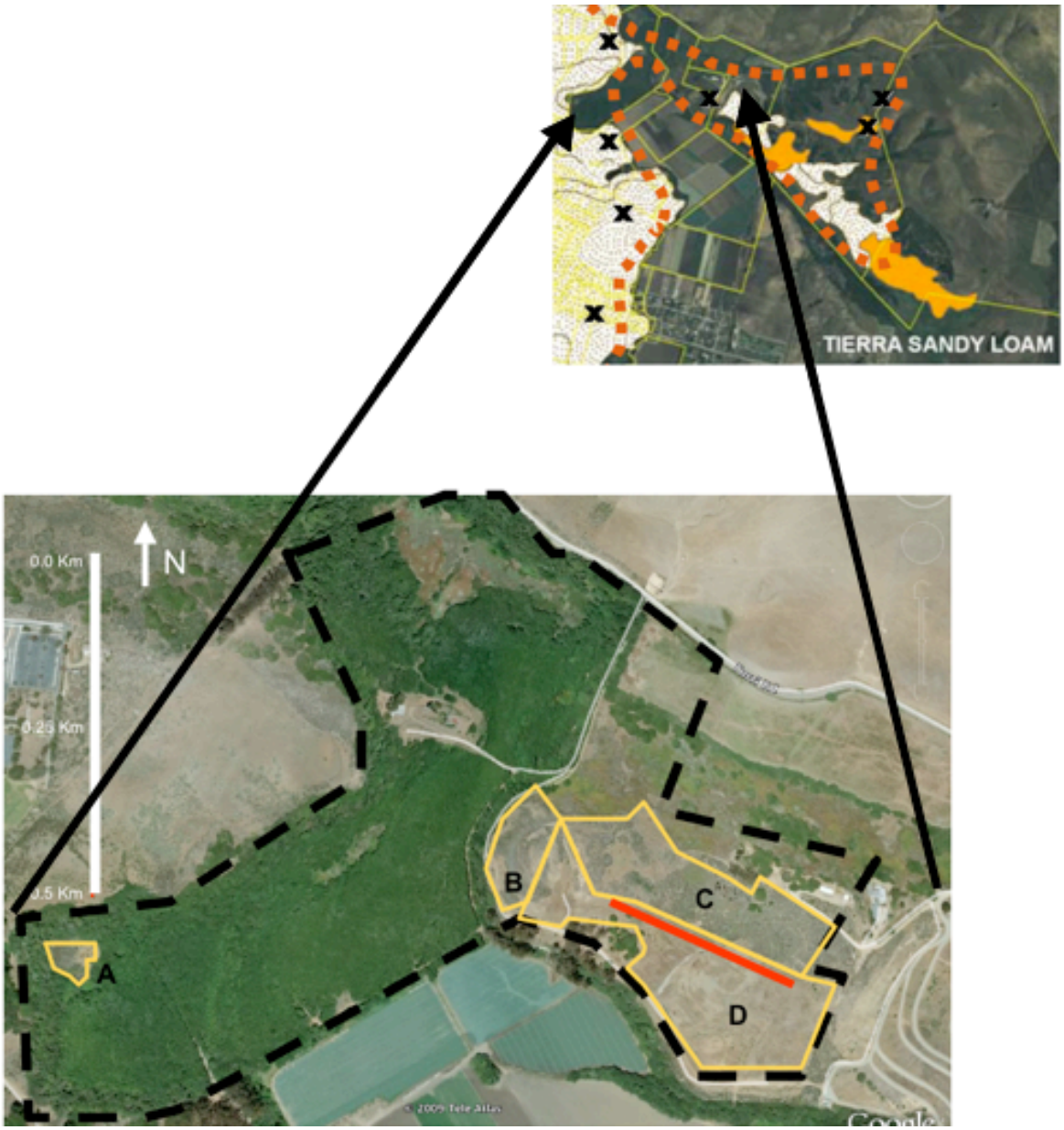

Figure 9. Private Parcels (067-011-018, 067-011048, and 067-011-49, aka Morrissey, Lilly and Lee) located immediately East of Powell I, II and III. The bold dashed line indicates the habitat assessment area. The solid yellow line encloses the areas of potentially suitable habitat evaluated by a 100% visual survey for sign of MBKR. If an area is contained within the bold dashed line but is not enclosed in solid yellow, then it represents currently unsuitable habitat. Area "A" was marginally suitable with dense Coastal scrub. It was evaluated carefully because of its proximity to the Powell site. Area B had suitable vegetation, but was a steep slope with some exposed sandstone. Area "C" was primarily a thick stand of Coastal Sage Scrub. This area was evaluated by a 100% visual survey because it contained a large number of trails and therefore had localized open space. Area "D" was composed of early successional Coastal Sage Scrub, and ruderal grasses. Possible sign of MBKR were only seen in area D. The approximate location of the trap line is shown by a red line. No MBKR were captured.

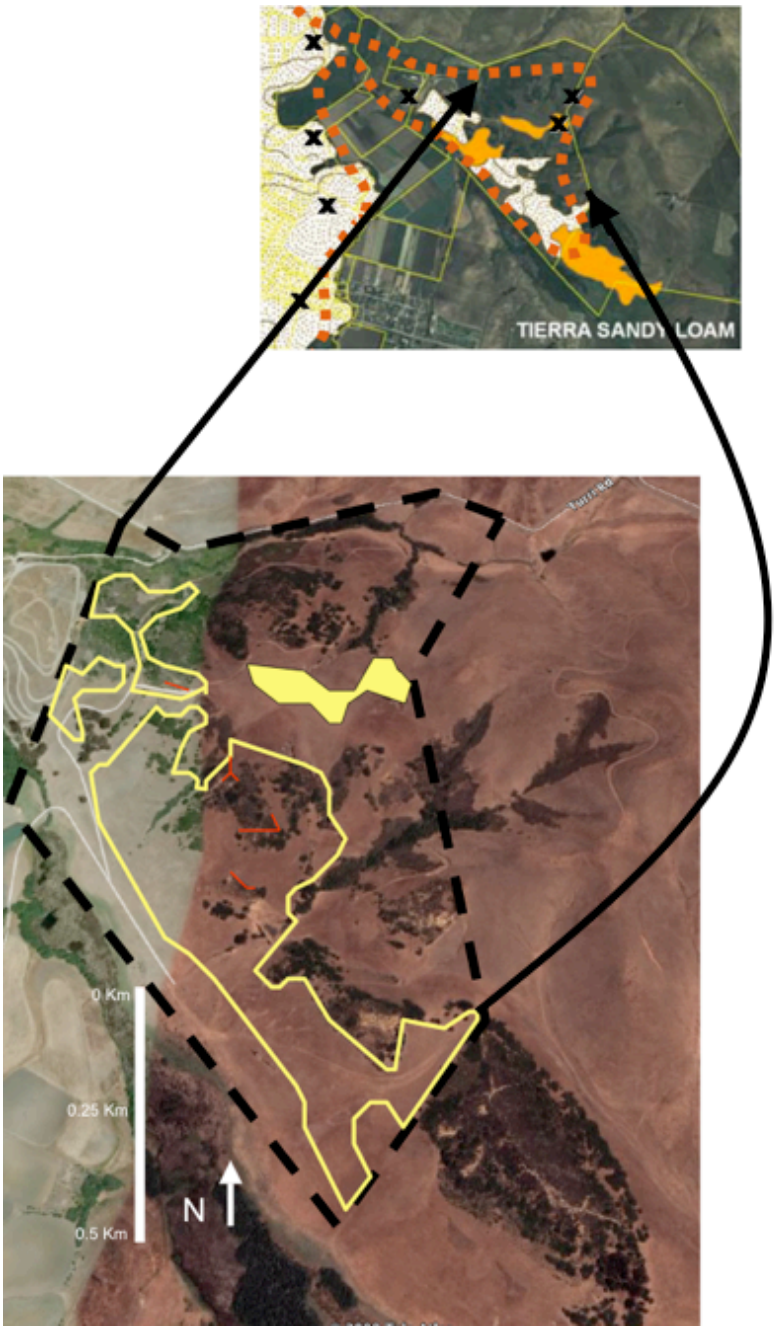

Figure 10. Parcel 067-011-003 (aka Branin). The bold dashed line indicates the extent of the Habitat Assessment area. Areas with a dark canopy were Coast Live Oak woodland, mature Coastal Sage Scrub, or Manzanita Chaparral. Areas without a dark canopy were annual grasslands and scattered Coastal Sage Scrub. The solid yellow outlines represent the local distribution of sandy soils. The surface of all of the sandy soil area was evaluated by a 100% visual survey. The edges or boundaries of sandy soils were easily located in the field. The areas with sandy soil supported annual grasslands and Coastal Sage Scrub and are all potentially suitable habitat for MBKRs. Areas of suitable habitat that had possible signs of MBKR were live trapped. The approximate location of the six trap lines are indicated by red lines (one pair of adjacent lines make a "T" shape and another pair of adjacent lines make a "7" shape). No MBKR were captured. The filled yellow polygon is an area of sandy soil that was not located or explored in 2008. This area contains *non-sandy* soil that is known to have supported kangaroo rats in 1958.

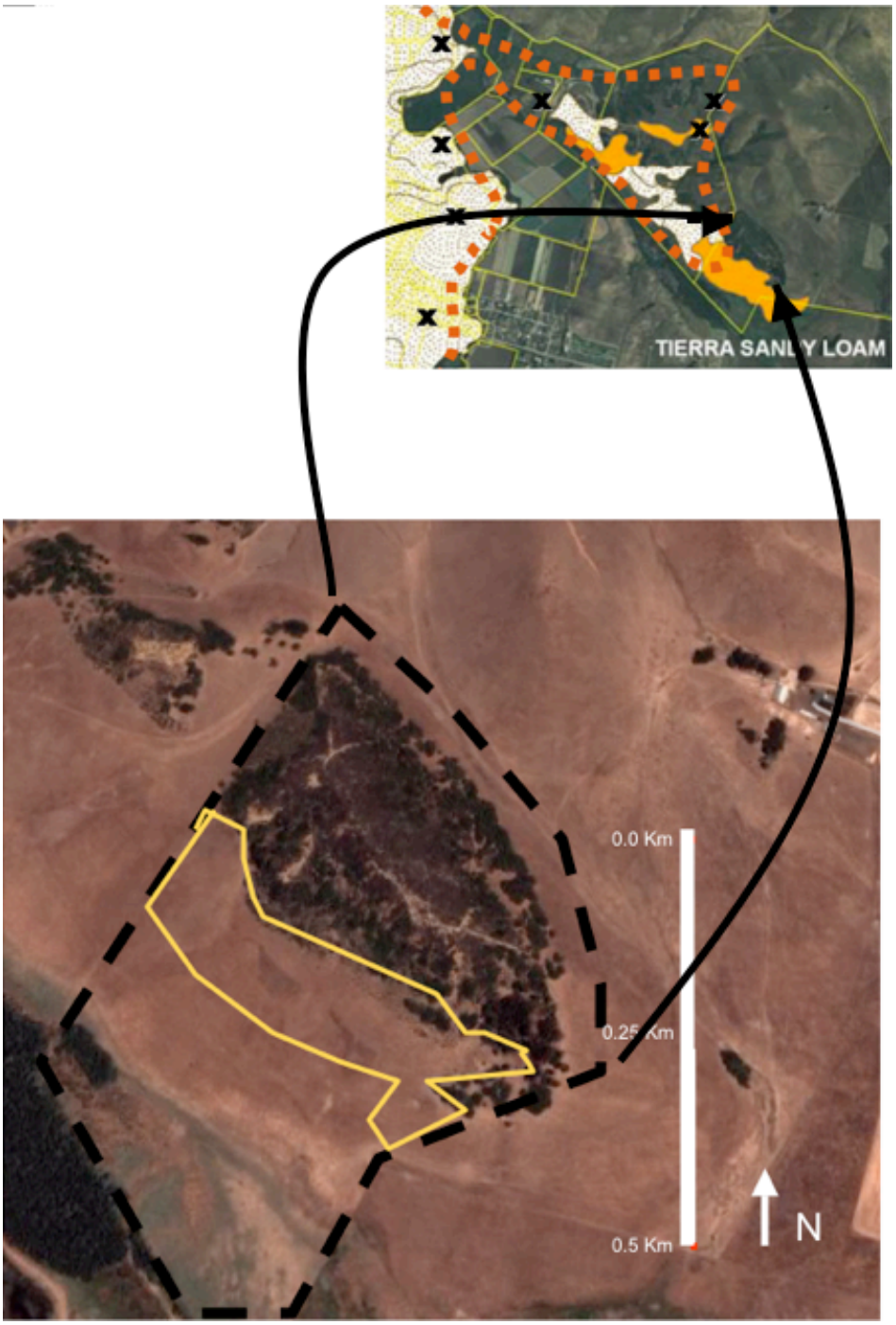

Figure 11. Portion of Parcel 067-031-001 (aka Tonini). The bold dashed line indicates the extent of the habitat assessment area. The solid yellow line is the approximate distribution of sandy soils and encloses the area of potentially suitable habitat. The entire area of potentially suitable habitat was evaluated by a 100% visual survey for possible signs of MBK. No sign of MBKR was observed. This area is not regarded as part of the original range because it was not surveyed in 1958 (3) though it is adjacent to sandy and *non-sandy* soils that are known to have supported kangaroo rats during the original surveys (3).

Evidence of habitat loss through succession: Bayview
The loss of suitable MBKR habitat to urban development is now obvious (**Figure 2)**. Even after the MBKR was listed, the number of new dwellings within the MBKR's original range increased by a factor of 3.5 (from 1,614 to 5,715) from 1970 to 2000. The number of dwellings has remained roughly static since 2000 following a building moratorium. The loss of habitat due to natural succession is much more difficult to appreciate. Empirically, it is difficult to determine what climax Coastal Sage Scrub looks like, what time frame is required to reach climax, and how suitable or unsuitable climax Coastal Sage Scrub is for MBKRs. In 1984 Morro Bay Kangaroo Rats could be trapped on grid KKLLMM west of Bayview (near Broderson) (12). This trapping grid was visited in 2008. Photos of the vegetation on that grid in 1985 and 2008 are compared in **Figure 12**. From this 24 year comparison it is clear that at Bayview the vegetation has changes sufficiently to go from suitable MBKR habitat to unsuitable, climax coastal scrub, habitat.

Live trapping
The number of captures, for each small mammal species, across all areas sampled, are shown in **Table 2**. No MBKRs were live trapped in a 948 trap-night effort. The reference site in the Guadalupe-Nipomo Dunes Nation Wildlife Refuge was trapped for 420 trap-nights in July and in October with 94 and 188 *D. h. arenae* captures respectively. This represents a 3-month doubling time for the reference population over the same time period that no MBKR we captured.

Typically, MBKRs are captured in a small mammal community composed of California Pocket Mice (*Chaetodipus californicus*), Deer Mice (*Peromyscus maniculatus*) and Kangaroo rats (12, 17). MBKRs are typically not captured in trap lines with Dusky-footed Woodrats (*Neotoma fuscipes*), California Mice (*Peromyscus californicus*), or Brush Mouse (*Peromyscus boylei*), because these species occur in areas with significant shrub cover. Therefore, only Shark Inlet, Butte, and Powell III had community structures consistent with the presence of MBKRs.

Table 2. Summary of the trapping effort and number of captures per species in 2008. Trap lines were only placed in areas with suitable habitat and possible sign of Morro Bay Kangaroo Rats. No MBKR were captured in 948 trap-nights. Species names abbreviations are: *N. fus* (*Neotoma fuscipes*), *P. cal* (*Peromyscus californicus*), *P. boy* (*Peromyscus boylei*), *P. man* (*Peromyscus maniculatus*), *C. cal* (*Chaetodipus californicus*), and *R.meg* (*Reithrodontomys megalotus*).

AREA	DATE	NUMBER OF TRAP LINES	NUMBER OF TRAP NIGHTS	CUMMULATIVE CAPTURES PER AREA					
				N. fus	*P. cal*	*P. boy*	*P. man*	*C. cal*	*R.meg*
SHARK INLET	30 JULY-1 AUG	6	252	-	-	-	8	10	1
BUTTE	30 JULY-1 AUG	3	108	-	2	-	4	11	-
BAYVIEW	30 JUNE-2 JULY	1	96	2	5	-	-	7	-
POWELL SPOT	30 JULY-1 AUG	0	6	-	-	-	-	-	-
POWELL III	30 JULY-1 AUG	2	96	-	5	1	13	11	-
LEE	30 JUNE-2 JULY	1	96	6	5	1	22	10	1
BRANIN	30 JUNE-2 JULY	6	294	24	18	-	10	21	-
TOTAL		19	948	32	35	2	57	70	2

Figure 12. Succession on Bayview plot KKLLMM (12, 17). The upper photo illustrates suitable habitat at a plot that produced MBKRs in Aug 1984. The lower photo illustrates unsuitable habitat at the same location in Jan 2008. The letters a-e refer to the same sequence of 5 peaks which can be seen below the crest of the Santa Lucia Mountains in the background. The shrubs in the foreground of the 2008 photo are 3-4 feet tall, shrubs in the background are 5-6 feet tall. This habitat has transitioned from suitable for MBKRs in 1984 to unsuitable in 2008.

DISCUSSION AND RECOMMENDATIONS

There is still apparently suitable habitat for Morro Bay Kangaroo Rats within their original range, though it is getting more and more difficult to find. Suitable habitat within the original range has been lost due to development (**Figure 2)**. Suitable habitat within the original range has been lost due to succession (**Figure 12)**. Suitable habitat within the original range has been fragmented resulting in spatially unconnected habitat patches (**Figure 2)**.

All of the suitable habitat within nine areas (**Figures 3-11)** was thoroughly surveyed for any sign of Morro Bay Kangaroo Rats. No definitive signs of an active MBKR was ever discovered. All areas with suitable habitat and potential sign of MBKRs were live trapped. No MBKR were captured in 948 trap nights. In contrast, 420 trap-nights resulted in 94 and 188 *D. h. arenae* captures (in July and October 2008 respectively) in a stand of Coastal Scrub and Veldt Grass in the Guadalupe-Nipomo Dunes National Wildlife Refuge.

It is possible that the Morro Bay Kangaroo Rat is extinct. This is one conclusion that could be supported by the fact that no MBKRs have been located for nearly 20 years. Yet, several alternatives conclusions are also consistent with the same observation (no definitive sign of MBKRs detected, and no MBKRs captured). One alternative is that MBKRs persist within the historic range but at a density below detection level. One way to test this hypothesis would be to restore habitat in large continuous portions of the original range in order to increase the population density and afford detection. This would require that patches of habitat be maximally connected so that individuals in a low-density population would actually have access to restored habitat areas. Another way to test this hypothesis would be to increase the detection effort by conducting longer term and higher intensity trapping than has been conducted to date. A second, and potentially more likely hypothesis, is that MBKRs still persist outside of their historic range. This is the hypothesis being tested when islands of sandy soil outside of the original range are evaluated for suitable habitat and sign of MBKRs. To date, none of the sandy soil islands have shown a combination of suitable habitat and sign of MBKR activity. Not only time, but more data, will allow us to determine which of these three alternative hypothesis is correct. There are still alternative hypotheses to be tested.

The possibility that MBKRs still persist outside of the historic range needs to be fully explored. This possibility needs to be fully tested by determining which (if any) areas of sandy soil outside of the historical range have habitat suitable for Morro Bay Kangaroo Rats. There is one large sand island that has yet to be explored. This area is upstream from the Bayview site along Los Osos Creek, in the Clark Valley watershed (**Figure 13**). Likewise, the most Eastern portion of the extension (**Figure 10**) has a sand island that previously supported kangaroo rats (3). This site was not evaluated in 2008.

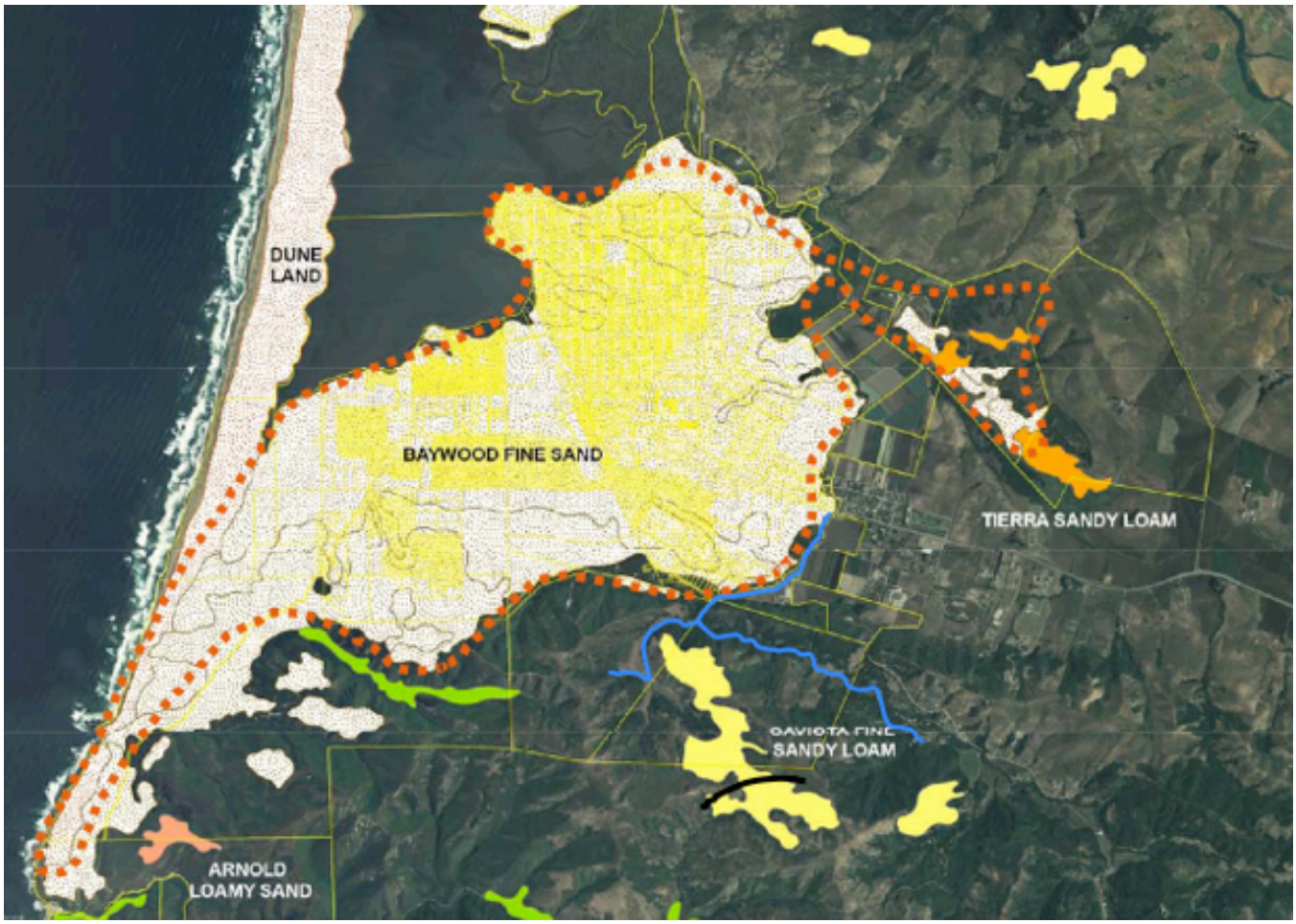

Figure 13. Sand islands in the Clark Valley Watershed. The blue line represents the approximate location of Los Osos Creek. Los Osos Creek originates on the slopes of Clark Valley in the Irish Hills, and flows north until it reaches the floor of Clark Valley, where it turns west and flows towards Los Osos Valley. When it reaches Los Osos Valley it abruptly reverses direction and heads northeast, before heading north and west again and joining with Warden Creek (18). The sandy stream bed within Los Osos creek does not directly connect with either of the two patch of Gaviota Fine Sandy Loam. Yet, most of the Gaviota Fine Sandy Loam is within the Los Osos Creek Watershed and approximately ½ Km from the Bayview site. Only the portion south of the black arc does not drain into Los Osos Creek Watershed.

Data on other species and populations of kangaroo rats suggests that several assumptions or assertions made in the Draft Revised Recovery Plan are incorrect. *If these assumptions are in fact incorrect, then they have potentially misguided management and survey efforts*.

Assertion 1: The MBKR population of 1984 was showing a gradual linear decline. The original Recovery Plan has a graph showing the estimated population size (from live trapping data) up until 1985, and the projected continued *linear* decline of the population. It is now clear that *Dipodomys* in general, and also *D. h. arenae*, have large (up to 10 fold) fluctuations in population size over the course of 12-month periods. *This rate of population decline suggests that Kangaroo rat populations go locally extinct and are subsequently re-established through*

reproduction and dispersal from neighboring or persisting populations. This rate of population expansion greatly exceeds the highest rate ever achieved in captivity. *This suggests that restoring and actively managing habitat (i.e.: manipulating seed base, predators and competitors) may be profoundly more successful than a captive breeding approach*. At least a combination of approaches (captive breeding and habitat management) seems prudent – if insurance against different negative scenarios is desirable.

Assertion 2: Coastal Sage Scrub invaded by Veldt grass represents unsuitable habitat for Morro Bay Kangaroo Rats. There is no data, published or unpublished, to support this assertion. Logically, it made sense that a thick mat of Vedlt grass (i.e.: near 100 % cover) would preclude richochetal locomotion by Kangaroo Rats and that this habitat would either be avoided, or lead to higher predation rates (lower escape rates). This inductive reasoning has resulted in basically writing off the Buckskin site as unsuitable habitat. The simple assertion that Coastal Sage Scrub invaded by Veldt grass represents unsuitable habitat for Morro Bay Kangaroo Rats can be rejected (at least for *D.h. arenae*). The reference population at the Guadalupe-Nipomo Dunes National Wildlife Refuge occurs in areas with up to 75% Veldt Grass cover (the maximum observed in the 1400m transect). *This suggests that the Buckskin site should be regarded as potentially suitable habitat that has not been evaluated since 1984 and could potentially harbors a population of Kangaroo Rats. Access needs to be gained immediately in order to evaluate this possibility.* Given that the simple assertion regarding Veldt Grass can be rejected, the study in the National Wildlife Refuge is being used to test whether there are differences in population density (none detected to date), reproductive rates (ongoing), or survivorship (ongoing), across areas with variable percent Veldt Grass cover or across years.

Assertion 3: Morro Bay Kangaroo Rat activity significantly declines after June 30th. Activity of *D.h. arenae* at the Guadalupe-Nipomo Dunes National Wildlife Refuge *increased* after June 30th in 2008. Therefore, the validity of this assertion in MBKR needs to be explored using historical data. Specifically, the question needs to be asked whether there is a decline in activity by MBKR after June 30th, or if historically there was a decline in field survey efforts that would result in a lack of comparable data for the fall months. Roest (16) reported that 96% of all female MBKR trapped with embryos were trapped in May and June, and that 56% of all immatures trapped were caught in August. Even limited data (N=4) indicate that pregnancy, parturition and lactation occur most frequently between March and August (17). *If reproduction occurs into the summer months, then at least young of the year should be active into the fall months as they develop their seed caches.* If this is indeed the case, then the protocol survey window should be extended past June 30th.

Specific recommendations for the 2009 protocol survey search effort include:

1) Repetition of the 2008 visual surveys of all suitable habitat for signs of MBKR activity.
2) Repetition of the 2008 trapping surveys to satisfy the second year of the protocol survey.
3) Expansion of the habitat assessment, visual surveys and trapping into:
    a. Montana de Oro State Park (Pecho North, Pecho South and Hazard).
    b. Buckskin.
    c. Eastern portion of the extension (within and adjacent to the historical range).
    d. Clark Valley watershed (parcels 067-131002 and 067-131-005).

4) Continue the demographic survey of a reference population at the Guadalupe-Nipomo Dunes National Wildlife Refuge
5) Expand the protocol survey window from April 1st -Sept 30th.

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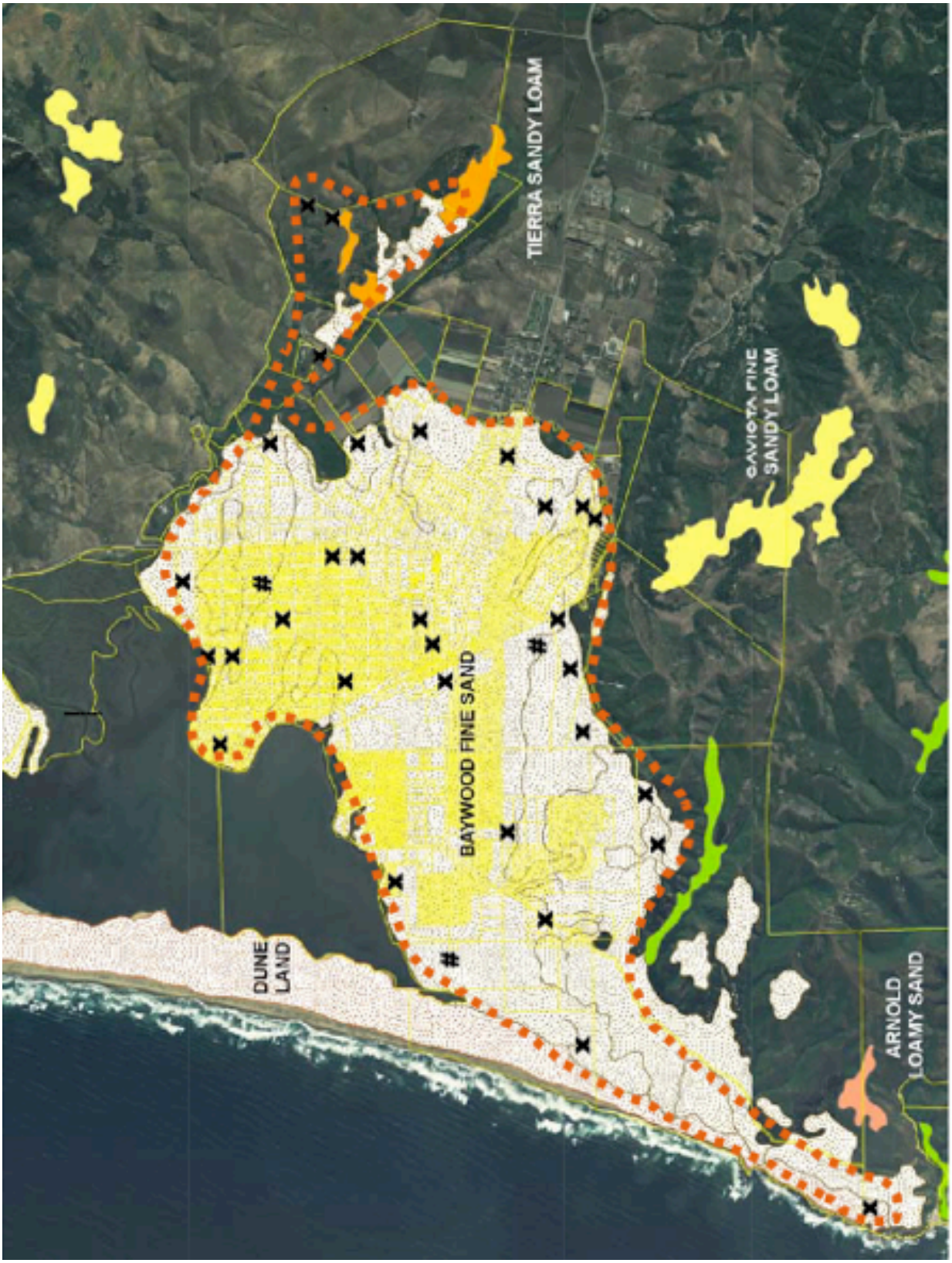
Appendix 1. Enlarged version of **Figure 1** from the methods section.