science for a changing world

Herpetofaunal and Ant Inventory of Carmel Mountain and Del Mar Mesa Preserves of San Diego, California

Final Report, 2003

Prepared for:
Keith Greer and Holly Cheong
City of San Diego

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY
WESTERN ECOLOGICAL RESEARCH CENTER

Herpetofaunal and Ant Inventory of Carmel Mountain and Del Mar Mesa Preserves of San Diego, California

By Carlton Rochester, Krista Pease, Stacie Hathaway, Chris Brown, and Robert Fisher

---

U.S. GEOLOGICAL SURVEY
WESTERN ECOLOGICAL RESEARCH CENTER

Final Report

Prepared for:
Keith Greer
City of San Diego

San Diego Field Station
USGS Western Ecological Research Center
5745 Kearny Villa Road, Suite M
San Diego, CA 92123

Sacramento, California
2003

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, SECRETARY

U.S. GEOLOGICAL SURVEY
Charles G. Groat, Director

For additional information, contact:

Center Director
Western Ecological Research Center
U.S. Geological Survey
7801 Folsom Blvd., Suite 101
Sacramento, CA 95826

Table of Contents:

List of Tables

List of Figures

1. Introduction and background

The herpetofauna (reptiles and amphibians) of coastal southern California are very diverse (Stebbins, 1985; Fisher and Case, 2000) due to a variety of factors including topography, history, and climate. The complex topography, with steep slopes, canyons and hills combined with flat regions on mesas and in lowlands, provides for many different microhabitats that can support unique fauna. These microhabitats, in combination with the Mediterranean climate in southern California, support high levels of herpetofauna and ant biodiversity by providing adequate moisture and producing mild and warm temperatures, allowing for activity nearly all year. The herpetofauna consists of over 70 species in coastal southern California, of which 24 are considered sensitive at the state or federal levels (Fisher and Case, 1997a; Jennings and Hayes, 1994). Suarez et al. (1998) documented 46 native and four exotic ant species in coastal San Diego County in habitats similar to those in this study. Urban, industrial and agricultural development has left much of the remaining open space highly fragmented. The future of herpetofaunal and ant diversity in southern California will depend on an understanding of the distribution and abundance of these species within this fragmented landscape. Management decisions for protecting these fragments should be based on scientific research in order to best maintain this region's natural resources. In southern California, the Multiple Species Conservation Plan (MSCP) is a large reserve of high quality habitat for conservation of biodiversity in urban San Diego. As such, it plays an important role in maintaining coastal populations of the herpetofauna (herps), as it is one of the few significant protected regions in coastal San Diego County.

The Carmel Mountain and Del Mar Mesa Preserves are within the MSCP reserve, but are fragmented by urban and industrial development,. An important step towards maintaining herpetofaunal diversity, particularly sensitive species, is identification of immediate management needs. In addition, ants serve many roles on different ecosystem levels, and can serve as sensitive indicators of change for a variety of factors. Data gathered from studying these taxa in this area can provide the baseline data on which long-term land management plans can be based. To achieve this goal, we conducted a biological inventory of the Carmel Mountain and Del Mar Mesa Ecological Preserves, including vegetation characterization, systematic inventory of herpetofauna (amphibians and reptiles) and ants, and incidental records for mammals. We have established infrastructure with the potential for long-term monitoring stations for herpetofauna, small mammals, and ants.

2. Materials and methods

Carmel Mountain is owned by the City of San Diego with two private in-holdings. It is located just southeast of the intersection of Interstate 5 and Highway 56. The ownership of Del Mar Mesa is split among five public and non-profit land owners/managers. Del Mar Mesa is situated to the east of Carmel Mountain, just south of Highway 56 (Figure 1). The Carmel Mountain and Del Mar Mesa Preserves are used as recreational areas for mountain biking, horseback riding, hiking, and other activities. The habitat of the Carmel Mountain and Del Mar Mesa Preserves consist primarily of chaparral and coastal sage scrub communities. A biological inventory of these preserves, which included vegetation characterization, and a systematic inventory of herpetofauna (amphibians and reptiles), incidental mammals, and ants, was conducted in accordance with the City of San Diego Multiple Species Conservation Plan (MSCP) sensitive species monitoring objectives and consistent with prior herpetofaunal and ant monitoring within the MSCP region conducted by USGS (Case and Fisher, 2001; Rochester et al., 2001).

From July 2001 through December 2002, we conducted an intensive study of the diversity and autecology of the herpetofauna, incidental mammals, and ants of the Carmel Mountain and Del Mar Mesa Preserves. Pitfall trap arrays have been utilized by the USGS to detect and monitor the herpetofauna of the MSCP region since 1995 (Fisher and Case, 2000; Case and Fisher, 2001; and Fisher et al., 2002) and ants have been targeted using additional traps since 1999, but not previously at these sites. The USGS field coordinator selected multiple potential sites within these preserves, avoiding archeological sites and environmentally sensitive areas. Final site selection was made with approval from a representative of the RECON Consulting Firm, Mark Dodero. Based on the input from Mark Dodero, several potential sites were abandoned due to their proximity to known sensitive species or habitats (e.g., short-leaved dudleya (*Dudleya brevifolia*) and vernal pools). As a result of these limitations, the placement of pitfall arrays was confined to specific portions of both preserves. Below we describe the methods used for: 1) sampling herpetofauna and incidental mammals, 2) sampling ants, and 3) vegetation and site characterization.

Herpetofauna and incidental mammals

Arrays were distributed across the various habitats within each study site, within the established guidelines. Five (5) pitfall trap arrays were constructed on both properties, for a total of ten (10) arrays. Each array consisted of seven 18.9 liter buckets as pitfall traps, connected by shade cloth drift-fences (15 meter arms), in the shape of a Y (Figure 2). A double-ended hardware cloth funnel trap was placed along each of the three arms for capturing large snakes and lizards. Each pitfall array site was measured using a handheld GPS to determine its position and plotted on maps (Figures 3 & 4). Beginning in July 2001 and ending in December 2002, sampling was conducted for four (4) consecutive days every four to five weeks, for a total of 68 sample days. This sampling regime was spread evenly across all seasons. Traps were closed between each sampling period.

The amphibians and reptiles captured were individually marked (except for slender salamanders) either by toe clipping or scale clipping (snakes). The reptiles and amphibians were processed in the field and released. Processing reptiles and amphibians included marking, weighing, and measuring the body length; the toe-clips from lizards and tail tips from snakes are kept in ethanol for future molecular systematic work. The pitfall traps also incidentally collected small mammals. However, they were only identified to genus or species where possible and then released. All animal records from the pitfall traps and the vegetation survey data were collected in the field using handheld computers and digital data sheets.

We have calculated the average capture rate per array per day for each of the two study sites. The capture rate plotted was the total number of captures for a taxon at a site, divided by the number of arrays at the site, and the number of days that a site has been sampled. This procedure standardizes capture rates, accounting for the fact that different sites have both varied numbers of arrays and sample days. The standardized rates allow comparison of capture rates and species presence among sites. The number is further manipulated by multiplying by 1000 sample days, resulting in the average number of captures per 1000 sample days per array at each site.

Mathematically:

$$CR = [n_i/(a_s \times d_p)] \times 1000$$

where

CR = mean capture rate for each taxa at a site
n_i = number of individuals of a species
a_s = number of arrays per site
d_p = number of days site has been sampled

Ants

Ant pitfall traps were installed at all ten herpetofaunal pitfall arrays. At each array, five ant pitfall traps (50 mL tubes) were used. The five ant traps "overlaid" the existing herpetofaunal array in the shape of the "5" on a die (Figure 2). The four corners of the "5" were approximately 20 m apart from each other. Holes were made in the soil using a metal stake. A polyvinyl chloride sleeve constructed from a 1" pipe was inserted into each hole, and an ant pitfall trap was inserted into the sleeve so that it was flush with the ground. Each ant pitfall trap was left open for ten consecutive days and contained approximately 25mL of Sierra™ brand antifreeze. This product preserves the specimens while remaining environmentally safe (Suarez et al., 1998). The sleeves were closed between sampling visits. Samples were then sorted, identified and counted at the US Geological Survey, San Diego Field Station, with identification verification from UC Berkeley. The five ant traps from each array were combined for analysis. These data were used to estimate abundance and diversity by sampling location. Hypogeic, or belowground foraging, and arboreal ants may be under-sampled using this technique, since the pitfall trap design is geared toward the collection of epigeic, or aboveground foraging ants. An evaluation of pitfall traps as a sampling method for ground-dwelling ants found that most epigeic ants are well represented, especially in open habitats (Bestelmeyer et al., 2000). Also, Suarez et al. (1998) found reasonable epigeic diversity estimates using the proposed sampling technique in coastal sage scrub habitat. Queens and males were noted but not used in analysis since they may have originated from outside the sites. Other incidental captures of invertebrates and small vertebrates were saved for future use in additional diversity estimates.

Vegetation and Site characterization

Once the pitfall trap sites were installed, vegetation and substrate were recorded in the vicinity of each array following a modified version of the protocols developed by the California Native Plant Society (Sawyer and Keeler-Wolf, 1995; Case and Fisher, 2001). Line transect surveys were completed to characterize the plant communities associated with each pitfall array. Substrate was also characterized. Other site characteristics elevation, slope and aspect were also recorded, as described in Laakkonen et al. (2001) and Fisher et al. (2002). Distances between arrays were calculated from the GPS coordinates.

3. Results and discussion

Below we present and discuss the results of the herpetofauna surveys and incidental mammals followed by that of the ant surveys. Additional species-specific discussions are presented in Section 4 and capture rates are reviewed in Section 5.

Herpetofauna and incidental mammals

Seventeen herpetofauna sampling periods (six in 2001 and eleven in 2002), each four sample days long, occurred between July 2001 and the end of December 2002. Twenty-four sample days occurred in 2001, and forty-four sample days took place during 2002, for a total of 68 sample days. All ten arrays were sampled during the same time periods, Table 1.

The pitfall trapping arrays produced 388 animal records in the year and a half that the study sites were sampled, not counting invertebrate species. There were 158 herpetofauna records from Carmel Mountain, representing 13 species. Del Mar Mesa produced 15 herpetofauna species, but generated fewer records, 91. Two species of salamanders, two species of frogs or toads, six species of lizards, and three species of snakes were reported for Carmel Mountain. Our efforts at Del Mar Mesa documented all of the same species as were found at Carmel Mountain with the addition of one toad and one snake species. Across these two sites we recorded 249 herpetofaunal observations representing 15 species total. The results of these herpetofauna survey efforts are outlined in Table 2.

Several additional species of herpetofauna were expected to occur on the Preserve, but as of yet, have not been detected by this survey. The second and third most common snake species recorded by the USGS in the MSCP, the California kingsnake (*Lampropeltis getulus*) and the San Diego gopher snake (*Pituophis melanoleucas*) (Rochester et al., 2001), were not reported for either study site. Both of these species have been reported from nearby Torrey Pines State Park (Fisher and Case, 1997b), which is approximately 3.5 kilometers west of the Carmel Mountain study site, and was studied for five years. The night snake (*Hypsiglena torquata*) is also likely to occur in the Carmel Mountain and Del Mar Mesa Preserves, but is traditionally extremely secretive and difficult to detect. Additional species detected at Torrey Pines State Park, but not observed during this study, include: silvery legless lizard (*Anniella pulchra*), coastal western whiptail (*Cnemidophorus tigris*), western yellow-bellied racer (*Coluber constrictor*), and the two-striped garter snake (*Thamnophis hammondii*). The lack of detection of these species should not be interpreted as a lack of presence. It may be a result of the drought conditions during this survey effort and/or the brevity of the survey.

In addition to reptiles and amphibians, small mammals were also documented at Carmel Mountain and Del Mar Mesa, 67 and 62 records, respectively. A summary of the small mammal captures is presented in Table 3. Eight species of small mammals were identified at Carmel Mountain and eight species were identified at Del Mar Mesa for a total of nine species. However, not all small mammal captures could be identified to the species level.

While at the study sites, field technicians also recorded the presence of four additional non-target species by incidental observation, Table 4. Mule deer (*Odocoileus hemionus*) were recorded on four instances at Carmel Mountain and twice at Del Mar Mesa. The second species, tarantulas (*Aphonopelma spp.),* were reported once at Carmel Mountain and three times at Del Mar Mesa. (These tarantula records may represent more than one species.) Black-tailed jack rabbits (*Lepus californicus*) and desert cottontails (*Sylvilagus audubonii*) were reported near array #2 at Carmel Mountain.

Ants

Ants were sampled three times: summer 2001, winter 2001 and summer 2002. An additional sample was taken from Carmel Mountain array #5 in winter 2002 because all ant traps from that array during the winter 2001 sample disappeared in the field. Fourteen species were collected at Carmel Mountain, and eight species were collected at Del Mar Mesa (Table 5 and Table 6), for a total of sixteen unique species (Table 7). Only one exotic species, the Argentine ant (*Linepithema humile*), was found. Argentine ants were collected at Carmel Mountain array #5 during all three sample periods (Table 5). Although species diversity (6 species) appeared equivalent to other arrays across sample dates, few native ants were trapped there. In summer 2002, the pitfall traps at Carmel Mountain array #5 captured no native species (Table 8). Also, the number of native ant individuals trapped across sample dates there (15 individuals) was less than 1/3 of the number of native ants at each of the remaining nine arrays. *Prenolepis imparis* (the winter ant) outnumbered Argentine ants in winter 2002 at Carmel Mountain array #5, and has been shown to display reasonable abundance in the presence of Argentine ants in other studies due to opposing seasonal activity patterns (Ward, 1987; Human and Gordon, 1996; Suarez et al., 1998).

Vegetation and Site characterization

Results of the vegetation surveys are summarized in Table 9 and Table 10, along with the positional data for each array. Four plant communities were identified: coastal sage scrub (CSS), non-native grassland (NNG), native grassland (NG), and chaparral (CHAP). Five arrays consisted of 50% or more chaparral plant species, the vegetation at two other arrays was made up of 50% or more of coastal sage scrub species, and the three remaining were a mixture of plant communities with no one community comprising a majority of the vegetation. A complete list of plant species, common names, scientific names, and four-letter codes can be found in Appendix 1. Each of the four plant communities was identified at both sites.

Four substrate categories were identified, sandy soil (SS), leaf litter (LL), cryptogammic rock (CR), and bare rock (BR) (Table 9 and Table 10). Sandy soil and leaf litter were found at every array, with leaf litter being the most frequent form of substrate at all but one array. Bare rock was found at every array at Del Mar Mesa and two arrays at Carmel Mountain while cryptogammic rock was found at one array at Del Mar Mesa.

The arrays ranged in elevation from 97 to 127 meters. Array #1 at Del Mar Mesa was the steepest array at a slope of 20°, while array #1 at Carmel Mountain was flat, a slope of 0°. Aspect ranged from 0° to 294° from north. Three arrays were on northeast facing slopes, one on a southeast slope, two faced to the southwest, two sampled northwest slopes, and one was on flat ground.

The distance between each array within each site is calculated in Table 11. The minimum distance between any two arrays, array #2 and #3 at Carmel Mountain, was 135 meters. The maximum space between two arrays within a site was the distance between array #1 and array #5 at Carmel Mountain, 1173 meters. The only movement between arrays that this survey was able to detect was that of a western spadefoot toad (*Spea hammondii*) that traveled the distance between array #2 and array #3at Carmel Mountain, which also happen to be the two arrays closest to each other.

The only arrays with any recorded fire history were arrays #2, #3, and #4 at Carmel Mountain (California Department of Forestry et al., 2001; Stephenson, 2002). Arrays #2 and #3 are within the boundaries of the 1986 fire, which has been confirmed by visual inspection. Array #4 is on the edge of the area burned during the 1990's. Although no fire history could be found for Del Mar Mesa for the area specific to this study, there is visual evidence of fire on the mesa above array #1 at this site.

Photographic documentation of each array can be found in Appendix 2.

4. Status of sensitive species

Here we give an account of the status of the sensitive species that have been detected within the Carmel Mountain and Del Mar Mesa study sites. In addition, we suggest specific management recommendations that the MSCP could implement to maintain populations of these sensitive species.

A. Western Spadefoot Toad (*Spea hammondii*)

Status: California and Federal Species of Special Concern (Protected)

The western spadefoot toad has been in decline throughout its range primarily due to loss of breeding habitat from the destruction of vernal pools (Jennings and Hayes, 1994; Fisher and Shaffer, 1996). This species has survived habitat loss in some areas by utilizing cattle tanks, road ruts, and other artificial temporary aquatic habitats. This species was documented at both study sites (Table 2). Six individual adults were recorded at Carmel Mountain, two of which were each caught a second time. Three juveniles and one adult, each captured once, were recorded at Del Mar Mesa.

One of the recaptures in particular should be noted. On March 22, 2002, an adult western spadefoot toad was captured and marked at array #3 at Carmel Mountain. On December 17, 2002, the same individual was recaptured at array #2, representing a move of 135 meters, Table 11. A pool complex existing along the ridge between these two arrays could serve as a breeding site for this species.

In addition to the animals documented by the pitfall trapping efforts, signs of breeding by the western spadefoot toad have been observed at both study sites. At the time of this report, multiple pools at Carmel Mountain support developing western spadefoot tadpoles. Multiple egg masses were first observed in the pool complexes located in the vicinity of arrays 1 through 3 in late December 2002. By early January 2003, the tadpoles had hatched out. At the time of this writing, multiple pools continue to support developing tadpoles, although several pools with tadpoles dried out before the larvae were able to completely develop and disperse. Further monitoring would be required to document successful recruitment. At Del Mar Mesa, only a few eggs masses were detected in a single pool. The egg masses appeared to be spent, lacking any sign of tadpoles. No larvae could be visually detected in the pool. The majority of pools in the unfenced portion of Del Mar Mesa are so heavily disturbed by motor vehicle traffic that they are better characterized as basins of suspended mud or clay. The protection of existing pools or rehabilitation of historic pools would greatly help this species to remain viable within the reserve

B. Western / Coronado Skink (*Eumeces skiltonianus*)
Status: California Species of Special Concern

The local subspecies of western skink, the Coronado skink has only recently received interest and although the species is widespread the subspecies is not very well known (Jennings and Hayes, 1994). A total of six individuals were recorded, three at each site. Two adults and one juvenile were observed at Carmel Mountain and one adult and two juveniles were reported at Del Mar Mesa.

Long-term maintenance of this species in the reserve may be dependent on appropriate management practices including addressing the issue of Argentine ant (*Linepithema humile*) invasion. This ant species appears to be negatively affecting these lizards in other coastal sites (Fisher, unpub. data). Sites with Argentine ants have relatively low abundance of the Coronado skink. Continued Argentine ant invasion may put the persistence of the Coronado Skink at risk. Further study is required to determine specific management recommendations for this species.

C. Orange-throated Whiptail (*Cnemidophorus hyperythrus*)
Status: California and Federal Species of Special Concern (Protected)

This species has been a federal concern for many years, although much of the biology of this species is still unknown (Jennings and Hayes, 1994). Widespread in Baja California, this species only occurs in coastal southern California in the United States. This species was the second most common species at both study sites (Table 2). It occurred at all pitfall arrays. Of the 33 individuals recorded at Carmel Mountain, only nine would be considered to be juveniles. At Del Mar Mesa, only three of the 24 individuals were juveniles. Additional records for this species consist of recaptures of these individuals. It would be inappropriate to make any statements on the recruitment success or failure of this species at these study sites based on this data. The data generated by this study represents only a year and a half of fieldwork. The recapture data detected no movement between pitfall arrays for this species.

D. Coast Horned Lizard (*Phrynosoma coronatum*)

Status: California and Federal Species of Special Concern (Protected)

The coast horned lizard has been a species of concern at the state and federal level for numerous years. Historically, this species was very common throughout southern California, especially in coastal dune systems (Jennings and Hayes, 1994; Fisher and Case, 1997a; Fisher et al., 2002). There has been a marked decline in this species for several decades, although the causes are still unknown. This species was recorded at two pitfall arrays at each study site (Table 2). Coast horned lizards appear to prefer chamise chaparral. This lizard species prefers a diet of native ants (Suarez et al., 1998). The invasion of the non-native Argentine ant could change the ant community and be a cause for the decline of the coastal horned lizard in many areas in the MSCP (Suarez et al., 1998; Fisher et al., 2002). This species tends to occur along dirt roadsides, especially near thick vegetation, as was the case for the two specimens reported for array #5 at Del Mar Mesa. These two individuals were noted on or near the trail leading to the array, and not at the array itself.

Hatchlings of the year were recorded once at each study site. However, both of these records were in July 2001. No hatchling coast horned lizards were detected during the second calendar year of the study. Juvenile coast horned lizard activity is typically highest in August, followed by June, July, and October (Fisher et al., 2002). As such, sample periods during these months should have detected their presence.

New trails and roads should be restricted in areas where they are known to occur. This species is easily captured and often collected for pets. This should be discouraged through educational signage indicating their protected status. House cats severely impact native wildlife and two individual Coastal Horned Lizards used in a radio tracking survey in the Torrey Pines State Reserve Extension were attacked by what appear to be cats (Jon Richmond, personal communication). Educating residents on the impacts of house cats on wildlife will help.

E. Western Ring-necked Snake (*Diadophis punctatus*)

Status: Federal Species of Special Concern (Sensitive)

The western ring-necked snake has been detected at one array at Del Mar Mesa (Table 2). This species is very secretive most of the year, although often in spring they may be found foraging during the day. They tend to prefer areas with increased moisture levels, including riparian zones. Any additional sightings of this species should be noted in order to better understand what factors may limit its distribution throughout San Diego County. Further study is required to determine specific management recommendations for this species.

F. Red Diamond Rattlesnake (*Crotalus ruber*)
Status: California and Federal Species of Special Concern

The red diamond rattlesnake was widespread throughout southern California historically, and still appears to be widespread but with a patchier distribution. It was detected only twice during the course of this survey (Table 2). Red diamond rattlesnakes are typically under sampled by the techniques used here and are more commonly found as incidentals while field technicians are at the study site. The one red diamond rattlesnake observed at Carmel Mountain was found crossing one of the many dirt roads while the field coordinator was looking for potential pitfall sites. Unfortunately, the only red diamond rattlesnake observed at Del Mar Mesa was run over by a visitor's vehicle, even after the visitor had been informed of its presence in the road by a field technician. No red diamond rattlesnakes were documented during the Torrey Pines State Reserve pitfall survey conducted between 1995 and 2000 (Fisher and Case, 1997b). If portions of the MSCP region could be insulated from roads, this species might be able to persist in a core area with little human activity. However, these areas would need to incorporate specific habitat features for this species to survive in these fragments.

G. Black-tailed jackrabbit (*Lepus californicus*)
Status: California and Federal Species of Special Concern

The black-tailed jackrabbit was reported as an incidental observation only at the Carmel Mountain Preserve (Table 4). As these survey techniques are not designed specifically to target this species, these data only serves to record the presence of this species with no indication of densities. Further study is required to determine specific management recommendations for this species.

H. Mule deer (*Odocoileus hemionus*)
Status: MSCP Covered Species

Mule deer were reported as incidental observations at both the Carmel Mountain and Del Mar Mesa Preserves (Table 4). As these survey techniques are not designed specifically to target this species, these data only serves to record the presence of this species with no indication of densities. Further study is required to determine specific management recommendations for this species.

5. Species capture rates for reptiles and amphibians of Carmel Mountain and Del Mar Mesa

With the data collected as a result of our survey efforts, capture rates have been calculated for each species detected. Capture rates from three additional sites have been include in Table 12 for a rough comparison. It should be noted that the data from these three sites do not represent the same time period as the data for Carmel Mountain and Del Mar Mesa. Year to year variances are likely and may cause fluctuations in capture rates. Point Loma is included as an isolated fragment, the Wild Animal Park represents a large area with high diversity, and Torrey Pines is the closest study site to Carmel Mountain and Del Mar Mesa. The source for these figures is Rochester et al, 2001.

Of the five sites presented, Carmel Mountain showed the highest capture rates for five species, the western rattlesnake, Pacific chorus frog, western spadefoot toad, western fence lizard, and side-blotched lizard. Carmel Mountain and Del Mar Mesa had equal capture rates for arboreal salamanders, which were higher than the rate at Torrey Pines State Park, the only one of the three comparison sites to document this species. Of the 15 species documented at the Carmel Mountain and Del Mar Mesa study sites, seven have not been found at the Pt. Loma study site. The arboreal salamander was recorded at both of the current study sites, but as of yet, has not been found at the much drier Wild Animal Park. Two species not found at Torrey Pines State Reserve, the closest neighbor, were found at Carmel Mountain and Del Mar Mesa, the western spadefoot toad and the red-diamond rattlesnake. The three comparison sites have documented species not found at Carmel Mountain or Del Mar Mesa, which have been omitted from this comparison.

6. Recommendations for management and monitoring small vertebrates

We have identified management activities that could benefit some of the species present at the reserve.

A. Exotic Species Control:

- Argentine ants

We have found the exotic Argentine ant (*Linepithema humile*) to be widespread in southern California (Pease and Fisher, 2001). These ants are known to displace native ant species in San Diego (Suarez et al., 1998), and could possibly affect higher trophic levels if they spread within the Reserve. The California horned lizard, for example, is an ant specialist that prefers a diet of native ants to Argentine ants (Suarez et al., 2000). There also is evidence that the desert shrew (*Notiosorex*) is negatively impacted by this species (Laakkonen et al., 2001). Within the MSCP region of San Diego, Argentine ants appear limited by moisture, and have not widely invaded natural habitats (Suarez et al., 1998). These ants may also play a role in disrupting and depressing the arthropod community within natural areas (Bolger et al., 2000), and therefore might negatively affect many species in the region. Argentine ants may benefit from additional water runoff into the region. Increased moisture level associated with irrigation would play a role in their invasion. The dead humus from exotic plants (i. e., ice plant), irrigation from adjacent landscaping, and silt runoff from construction might also help raise moisture levels in the region and benefit the ants, and should be managed for and kept to a minimum. Continued monitoring is essential to track potential Argentine ant expansion into the Reserve.

- Red Imported Fire Ants

The timing of this study is particularly appropriate since a non-native fire ant (*Solenopsis invicta*), also called the red imported fire ant, has recently invaded several areas of Orange, Riverside, and northern San Diego Counties. Red imported fire ants were first reported in Orange County in fall 1998. The invasion of this ant threatens existing reserve ecosystems as its range and impacts expand (http://pi.cdfa.ca.gov/rifa/). These ants may become a problem in the future and monitoring will need to continue in order to detect their presence and inform management.

- House/feral cats

Although domestic cats have not been reported from Carmel Mountain and Del Mar Mesa, they are typically a problem at most wildland/urban boundaries. As the urban developments surrounding these sites become more established, the probability of domestic cats encroaching on the reserve will undoubtedly increase. We know from previous and on-going studies that they are predators of lizards, small mammals and birds (Crooks and Soulé, 1999). Some data from San Diego County suggests that they may be major predators of coast horned lizards. During initial horned lizard radio-tracking studies at Torrey Pines Reserve Extension, the first two lizards were attacked by what were suspected to be cats (Suarez, unpublished). If coyotes persist within the reserve boundaries, the ability of cats to invade should be minimized. Any residents within the MSCP region should keep their cats indoor not only for their safety, but also to restrict them from incidental killing of native wildlife.

B. Enforcement:

The following items may need increased enforcement within much of the MSCP region of San Diego (Open Spaces and Parks), as well as at Carmel Mountain and Del Mar Mesa.

- **Bikes on trails**

We have personal observations of animals killed and maimed by bikes in natural areas and they are evidence for increasing mountain bike restrictions in a majority of the open spaces in the MSCP regions. Incidental mortalities might be avoided by posting signs at the base of trails indicating fines for cycling. Informing the public of risks to species along bike trails may encourage cyclists to avoid hitting animals where cycling is permitted.

- **Access Gates**

Access in and out of these properties should be limited through the use of gates and barriers. Off-road motorcycles, four-wheel drive trucks, and street vehicles will continue to drive onto the site as long as there remains a way for them to get onto the property. Many of the vernal pools have been driven through repeatedly and have deteriorated to not being functional for certain species. For example, the spadefoot toads and Pacific treefrogs anchor their egg masses to grass or vegetation growing in the pools. Our observations of pools along the road at Del Mar Mesa and some of the ones at Carmel Mountain is that there is no vegetation left as the vehicles driving through these pools have destroyed it, leaving them no where to attach eggs. If eggs were laid, the disturbance of vehicles would still probably cause mortality and reduce the temporal length of the pool by displacing the water with each crossing.

An attempt to fence off portions of Del Mar Mesa has been circumvented by trespassers driving around the barriers, over the habitat, creating a new road. As evidenced by the red diamond rattlesnake mortality at Del Mar Mesa, vehicle access ultimately results in the loss of animals. Limiting access into the reserve will aide in the survivorship of snakes as they cross the internal roads of the reserve.

- **Poaching**

Signage should be installed around reserves indicating that it is illegal to collect from the property. Trails should avoid areas where coast horned lizards and other species sensitive to poaching have been detected.

C. Education:

- **Information on rattlesnakes**

Educational fliers and/or billboards about rattlesnakes should be available and/or posted in open spaces in San Diego. They should address safety issues and include statistics on snakebites relative to other injuries in the park. These should also show how to differentiate the southern pacific rattlesnake from the red diamond rattlesnake. We know that these snakes are widespread in the region and prefer using trails. Therefore, it is inevitable that people will see them. San Diego could have a checklist identifying where snakes have recently been seen (and when). This may help identify locations where physical barriers could be used to keep rattlesnakes out of public facilities.

7. Conclusion

We have documented significant diversity in reptiles and amphibians within coastal San Diego. We have over 20,000 captures from a total of 39 different species throughout the MSCP region of San Diego (Rochester et al., 2001), which now includes Carmel Mountain and Del Mar

Mesa preserves. Species richness and capture rates within and between these sites can be indicators of overall habitat and ecosystem health. Factors such as habitat fragmentation, introduced/exotic species, and disturbance (grazing, off road activity and recreation) all appear to have negative effects on the native herpetofauna. In highly fragmented and disturbed study sites, the species richness of the herpetofauna is much lower than larger sites. As can be demonstrated by comparing the number of species at the Wild Animal Park, a large, intact habitat, closed to the public, with 33 species, to Pt Loma which is isolated from any other natural lands and only has 12 documented species. While Carmel Mountain and Del Mar Mesa, with 13 and 15 species respectively, may at first appear to be on the low end of the scale, it must be considered that the current study sites were only sample for a single year.

Continued maintenance of herpetofaunal diversity relies on active management of the open space and reserve lands of the MSCP. Keeping disturbance of native habitats to a minimum is necessary. Planning development near high quality habitat should be avoided; regions of habitat with lower biodiversity can be utilized as buffer zones between development and species rich habitat.

Roads and trails within reserve lands should be minimized and planned carefully so they do not pass through preferred habitat of sensitive species (such as ridgelines in chaparral, mesas with vernal pools and other regions where sensitive species have been documented). Where roads and trails already exits through such habitats, as is the case with the vernal pool complexes at Carmel Mountain and Del Mar Mesa, measures will need to be established to direct traffic away from or around these sensitive areas. Signs with descriptions of the local herpetofauna discussing their natural history, habitat requirements and value to the ecosystem as part of trophic levels and as indicators of overall ecosystem health should be posted in open spaces and parks. The more that the public is aware of their surroundings, the more likely these features will be seen a valuable parts of our environment.

Exotic species including feral cats, dogs, Argentine ants, and introduced plant species may all have negative effects on herpetofaunal and ant diversity. Study sites impacted by these exotics tend to have lower capture rates and overall species richness than those without. The long-term effects of exotic species have not been fully determined in many cases, however, it is likely that removing exotics may help restore or maintain high biodiversity.

Herpetofaunal and ant diversity should be monitored throughout the MSCP region to document effects of further development and other habitat disturbance. Continued monitoring is necessary to document the success of restoration and conservation projects throughout San

Diego. Baseline data for many areas within the MSCP will be important for future management in determining the relative success of various management strategies.

8. Acknowledgements

The United States Geological Survey – Biological Resources Discipline would like to thank the City of San Diego, Keith Greer, and Holly Cheong for their efforts and support of this project. For his assistance in site selection, we thank Mark Dodero from the RECON Consulting Firm. Much appreciation goes to Andy Suarez and Phil Ward for their assistance with the ant portion of this study. Without the USGS field crew, none of this would have happened, thanks to Sierra Hayden, Anita Herring, Dino Barhoum, Allan Hebbert, Denise Clark, Mark Mendelsohn, Tritia Matsuda, and James Starrett.

9. Bibliography

Bestelmeyer, B. T., D. Agosti, L. E. Alonse, C. R. F. Brandao, W. L. Brown Jr., J. H. C. Delabie, and R. Silvestre. 2000. Field Techniques for the Study of Ground-Dwelling Ants. Pages 122-144 *in* D. Agosti, J. D. Majer, L. E. Alonso, and T. R. Schultz, editors. Ants: standard methods for measuring and monitoring biodiversity. Smithsonian Institution Press, Washington, USA.

Bolger, D.T., A.V. Suarez, K.R. Crooks, S.A. Morrison, and T.J. Case. 2000. Arthropods in urban habitat fragments in southern California: area, age, and edge effects. Ecological Applications 10(4):1230-1248.

California Department of Forestry, Fire Protection, and United States Department of Agriculture Forest Service. 2001. Fire Perimeters. California Department of Forestry and Fire Protection. OID: 655.

Case, T. J., and R. N. Fisher. 2001. Measuring and predicting species presence: Coastal sage scrub case study. *In* Hunsaker, C. T., Goodchild, M. F., Friedl, M. A., and T. J. Case (eds.), Spatial Uncertainty in Ecology, pp. 47-71. Springer-Verlag, New York.

Crooks, K.R., and M.E. Soulé. 1999. Mesopredator release and avifaunal extinctions in a fragmented system. Nature 400:563-565.

Fisher, R. N. and T. J. Case. 1997a. A field guide to the reptiles and amphibians of coastal southern California. 48 pages.

Fisher, R. N. and T. J. Case. 1997b. Torrey Pines State Reserve Reptile and Amphibian corridor and autoecology study. Draft Report prepared by University of California, San Diego for California Department of Parks and Recreation.

Fisher, R. N., and T. J. Case. 2000. Southern California herpetofauna research and monitoring: 1995-1999 data summation report. California Fish and Game, Sacrament, and U.S. Fish and Wildlife Service, Carlsbad, California.

Fisher, R. N., and H. B. Shaffer. 1996. The decline of amphibians in California's great central valley. Conservation Biology **10**: 1387-1397.

Fisher, R. N., A. V. Suarez, and T. J. Case. 2002. Spatial patterns in the abundance of the coastal horned lizard. Conservation Biology 16: 203-215.

Jennings, M.R. and M.P. Hayes. 1994. Amphibian and reptile species of special concern in California. Final report to the California Department of Fish and Game, Inland Fisheries Division, Rancho Cordova, California, under contract number 8023.

Laakkonen, J., R. N. Fisher, and T. J. Case. 2001. Effect of land cover, habitat fragmentation, and ant colonies on the distribution and abundance of shrews in southern California. Journal of Animal Ecology 70:776-788.

Pease, K. H., and R. N. Fisher. 2001. Report on pitfall trapping of ants at the biospecies sites in the Nature Reserve of Orange County, California.

Rochester, C., S. A. Hathaway, C. Brown, K. Pease and R. N. Fisher. 2001. Herpetofaunal Monitoring in MSCP Region of San Diego.

Sawyer, J. O., and T. Keeler-Wolf. 1995. A manual of California vegetation. California Native Plant Society, Sacramento, California.

Stebbins, R.C. 1985. A field guide to western reptiles and amphibians. The Peterson Field Guide Series. Houghton Mifflin Co.

Stephenson, B. A. 2002. Draft Carmel Mountain Preserve and Del Mar Mesa Preserve Management Plans.

Suarez, A. V., D. T. Bolger, and T. J. Case. 1998. Effects of fragmentation and invasion on native ant communities in coastal southern California. Ecology 79(6):2041-2056.

Suarez, A. V, J. Q. Richmond, and T. J. Case. 2000. Prey selection in horned lizards following the Argentine ants in southern California. Ecological Applications 10: 711-725.

http://pi.cdfa.ca.gov/rifa/

Table 1. Pitfall sample periods at Carmel Mountain and Del Mar Mesa.
The sampling effort at Carmel Mountain and Del Mar Mesa are outlined, showing the duration of each sample period, as well as the field technician who performed the field work for a given sample period.

Sample Period Number	Week Of	Number of Days in Sample Period	Primary Field Technician	Other Field Technician*
1	7/17/01	4	DB	AH
2	8/6/01	4	DB	AH
3	9/4/01	4	ATB	
4	10/1/01	4	AH	
5	10/29/01	4	DB	
6	12/3/01	4	ATB	
7	1/7/02	4	DB	
8	2/11/02	4	AH	
9	3/18/02	4	DB	
10	4/29/02	4	DB	AH
11	5/20/02	4	DB	
12	6/24/02	4	SKH	
13	8/5/02	4	AH	
14	9/9/02	4	SKH	
15	10/21/02	4	SKH	
16	11/18/02	4	ATB	DRC
17	12/16/02	4	ATB	DRC
	Total Sample Days:	68		

* Field technician initials are: DB = Dino Barhoum, AH = Allan Hebbert, ATB = Anita Herring, SKH = Sierra Hayden, and DRC = Denise Clark.

Table 2. Herpetofauna Species Captures by Array at Carmel Mountain and Del Mar Mesa.
The number of captures of each species is shown for each array, along with the number of species per array and for each site overall.

		Carmel Mountain						Del Mar Mesa					
		1	2	3	4	5	Total	1	2	3	4	5	Total
Salamanders													
Garden Slender Salamander	*Batrachoseps major*	1		2		2	5	1	1	2			4
Arboreal Salamander	*Aneides lugubris*			1		1	2					2	2
	Number of Salamander Captures	1		3		3	7	1	1	2		2	6
	Number of Salamander Species	1		2		2	2	1	1	1		1	2
Frogs and Toads													
Pacific Chorus Frog	*Hyla regilla*		1	1	5*	1	8		1	1	2	2	6
Western Toad	*Bufo boreas*							1				1	2
Western Spadefoot	*Spea hammondii*	1	6	1			8		2	2			4
	Number of Frog or Toad Captures	1	7	2		1	16	1	3	3	2	3	12
	Number of Frog or Toad Species	1	2	2		1	2	1	2	2	1	2	3
Lizards													
Southern Alligator Lizard	*Elgaria multicarinatus*	1	1	1			3		1		1		2
Western Skink	*Eumeces skiltonianus*		1	2			3	1		1	1		3
Orange-Throated Whiptail	*Cnemidophorus hyperythrus*	12	15*	7	6	2	42	7	11	3	4	2	27
Western Fence Lizard	*Sceloporus occidentalis*	6*	15	12*	4	9	46	6	5	6	4	10*	31
Side-Blotched Lizard	*Uta stansburiana*		10	7	19		36		2*		1		3
Coast Horned Lizard	*Phrynosoma coronatum*		1*	1			2	1				2*	3
	Number of Lizard Captures	13	27	18	29	11	132	15	17	10	11	2	69
	Number of Lizard Species	2	4	5	3	2	6	4	3	3	5	1	6
Snakes													
Ringneck Snake	*Diadophis punctatus*											1	1
California Whipsnake	*Masticophis lateralis*				1*		1				1		1
Red Diamond Rattlesnake	*Crotalus ruber*						*[a]			1*			1
Western Rattlesnake	*Crotalus viridis*				1*	1	2			1*			1
	Number of Snake Captures					1	3				1	1	4
	Number of Snake Species					1	3				1	1	4
	Total Number of Captures	15	34	23	29	16	158	17	21	15	14	8	91
	Total Number of Species	4	6	9	3	6	13	6	6	6	7	5	15

* - Includes animal observations which may not have been in either trap type, but were observed near the array.

[a] - Observed on site, but not in association with any pitfall array.

Table 3. Small Mammal Species Captures by Array at Carmel Mountain and Del Mar Mesa. The number of captures of each species is shown for each array.

		Carmel Mountain						Del Mar Mesa					
		1	2	3	4	5	Total	1	2	3	4	5	Total
Desert woodrat	*Neotoma lepida*					1	1						
Deer mouse	*Peromyscus species*		2	1	3	2	8	1	4	1	2		8
Deer mouse	*Peromyscus maniculatus*				1		1		2		2	1	5
California mouse	*Peromyscus californicus*		2				2	1	1				2
Cactus mouse	*Peromyscus eremicus*	1			1		2				1		1
Desert shrew	*Notiosorex crawfordi*	2	6		1	2	11	5	2	5	5	1	18
Ornate shrew	*Sorex ornatus*	4	2			10	16	2		2	2	7	13
	Unknown shrew		1	1		1	3						
California vole	*Microtus californicus*			1		1	2				1		1
Western harvest mouse	*Reithrodontomys megalotis*	4		3	8		15	5	2	1	2	1	11
San Diego pocket mouse	*Chaetodipus fallax*								1				1
House mouse	*Mus musculus*												
	Unknown mouse				2		2						
	Unknown rodent			1			1			2			2
	Number of Captures	11	13	7	16	17	64	14	12	11	15	10	62

Table 4. Additional Species Observed by Array at Carmel Mountain and Del Mar Mesa. The number of observations of each species is shown for each array.

		Carmel Mountain						Del Mar Mesa					
		1	2	3	4	5	Total	1	2	3	4	5	Total
Mule Deer	*Odocoileus hemionus*	3				1	4	1				1	2
Tarantula	*Aphonopelma spp.*				1		1			2	1		3
Desert cottontail	*Sylvilagus audubonii*		2				2						
Black-tailed jack rabbit	*Lepus californicus*		1				1						
	Number of Records	3	3		1	1	8	1		2	1	1	5

Table 5. Carmel Mountain ant data from summer 2001, winter 2001, and summer 2002. Bold indicates exotic species.

Summer 2001 through Summer 2002	Arrays					Total Individuals	% Array Occurrence
	1	2	3	4	5*		
Subfamily Dolichoderinae							
Dorymyrmex insanus Pyramid Ant		4		2		6	40
Linepithema humile **Argentine Ant**					**19**	**19**	**20**
Subfamily Ecitoninae							
Neivamyrmex nigrescens Army Ant	1					1	20
Subfamily Formicinae							
Camponotus dumetorum Carpenter Ant	2					2	20
Formica moki Wood Ant					1	1	20
Myrmecocystus sp. Honey Pot Ant			2			2	20
Myrmecocystus testaceus Honey Pot Ant	24	5	83	1		113	80
Prenolepis imparis Winter Ant					11	11	20
Subfamily Myrmecinae							
Crematogaster californica Acrobat Ant			12		1	13	40
Leptothorax andrei	2	3		1	1	7	80
Myrmecina americana					1	1	20
Pheidole hyatti	14	5		44		63	60
Pheidole vistana	22	55		5		82	60
Solenopsis xyloni Native Fire Ant	8	7		3		18	60
Total Individuals	73	79	97	56	34	339	
Total Species	7	6	3	6	6	14	

*No data was recovered from Carmel Mountain array 5 during winter 2001, so a sample taken during winter 2002 is included.

Table 6. Del Mar Mesa ant data from summer 2001, winter 2001, and summer 2002.

Summer 2002 through Summer 2002	Arrays					Total Individuals	% Array Occurrence
	1	2	3	4	5		
Subfamily Formicinae							
Camponotus dumetorum	13	14	21	19	1	68	100
Carpenter Ant							
Camponotus vicinus			6		9	15	40
Carpenter Ant							
Formica moki	13	1	9	18	15	56	100
Wood Ant							
Subfamily Myrmecinae							
Crematogaster californica	8		4		23	35	60
Acrobat Ant							
Leptothorax andrei	1	1		1	2	5	80
Pheidole vistana	25	47	20	5		97	80
Solenopsis xyloni	6	26				32	40
Native Fire Ant							
Stenamma diecki					1	1	20
Total Individuals	66	89	60	43	51	309	
Total Species	6	5	5	4	6	8	

Table 7. Species list of ants collected at Carmel Mountain and Del Mar Mesa. Bold implies exotic species

Subfamily	Species	Common Name
Dolichoderinae		
	Dorymyrmex insanus	Pyramid Ant
	Linepithema humile	**Argentine Ant**
Ecitoninae		
	Neivamyrmex nigrescens	Army Ant
Formicinae		
	Camponotus dumetorum	Carpenter Ant
	Camponotus vicinus	Carpenter Ant
	Formica moki	Wood Ant
	Myrmecocystus sp.	Honey Pot Ant
	Myrmecocystus testaceus	Honey Pot Ant
	Prenolepis imparis	Winter Ant
Myrmecinae		
	Crematogaster californica	Acrobat Ant
	Leptothorax andrei	
	Myrmecina americana	
	Pheidole hyatti	
	Pheidole vistana	
	Solenopsis xyloni	Native Fire Ant
	Stenamma diecki	

Table 8. Carmel Mountain array #5 ant data for summer 2001, summer 2002 and winter 2002. Bold implies exotic species.

	Summer 2001	Summer 2002	Winter 2002	Total Individuals
Subfamily Dolichoderinae				
Linepithema humile	**9**	**6**	**4**	**19**
Argentine Ant				
Subfamily Formicinae				
Formica moki	1			1
Wood Ant				
Prenolepis imparis			11	11
Winter Ant				
Subfamily Myrmecinae				
Crematogaster californica	1			1
Acrobat Ant				
Leptothorax andrei	1			1
Myrmecina americana			1	1
Total Individuals	12	6	16	34
Total Species	4	1	3	6

Table 9. Vegetation Survey and Site Statistics for Carmel Mountain.

	Carmel Mountain				
	1	2	3	4	5
Canopy Height, m					
Average	61.2	94.3	68.4	74.4	135.1
Standard Deviation	51.4	75.7	53.2	107.4	99.9
Median	63.0	104.0	78.0	16.0	111.5
Minimum	0	0	0	0	0
Maximum	158.0	223.0	175.0	359.0	503.0
Leaf Litter Depth, cm					
Average	0.69	0.56	0.75	1.02	1.67
Standard Deviation	0.69	0.58	0.65	1.71	1.79
Median	0.50	0.50	0.50	0	1.00
Minimum	0	0	0	0	0
Maximum	3.00	3.00	4.00	8.00	10.00
Vegetation Layer Structure					
Total Trees		1.3%		6.9%	7.2%
Total Shrubs	68.1%	89.7%	76.2%	60.9%	84.9%
Total Herbs	31.9%	9.0%	23.8%	32.2%	7.9%
Total Hits	113	78	84	87	139
Substrate					
Sandy Soil	29	29	14	50	9
Leaf Litter	67	71	86	44	91
Cryptogamic Rock					
Bare Rock	4			6	
Total	100	100	100	100	100
Vegetation Community[a]					
Coastal Sage Scrub	48.7%	20.5%	60.7%	32.2%	78.4%
Non-Native Grassland	6.2%	5.1%	1.2%		
Native Grassland	8.0%				
Chaparral	29.2%	69.2%	34.5%	57.5%	18.0%
Total*	92.0%	97.5%	96.4%	89.7%	96.4%
Most Common Plant[b]					
First:	ADFA (22%)	CEVR (68%)	SAME (43%)	XYBI (30%)	SAME (37%)
Second:	SAME (21%)	MALA (6%)	CEVR (20%)	ADFA (20%)	ERFA (27%)
Third:	ERFA (20%)	COSE (5%)	ERCO (17%)	HESC (18%)	RHIN (10%)
Latitude, North	32.9283	32.9312	32.9312	32.9345	32.9367
Longitude, West	117.2228	117.2151	117.2136	117.2177	117.2151
Elevation, m	118	127	111	114	97
Slope	0°	4°	4°	12°	11°
Aspect	0°	230°	80°	40°	42°
Fire History		in 1986 burn area	in 1986 burn area	in 1990's burn area	

* Balance of plant species may fall into more than one category or did not fit into any of the communities listed here.

[a] - For individual plant species in each vegetation community, see Appendix 1.

[b] - See Appendix 1 for full species names.

Table 10. Vegetation Survey and Site Statistics for Del Mar Mesa.

	Del Mar Mesa				
	1	2	3	4	5
Canopy Height, m					
Average	71.1	63.1	168.9	100.6	158.7
Standard Deviation	51.2	55.9	90.6	34.8	128.3
Median	80.5	58.0	147.0	97.5	180.0
Minimum	0	0	0	0	0
Maximum	165.0	180.0	400.0	238.0	456.0
Leaf Litter Depth, cm					
Average	0.50	0.86	1.45	0.71	1.25
Standard Deviation	0.66	1.06	1.53	0.73	1.48
Median	0.50	0.50	1.00	0.50	1.00
Minimum	0	0	0	0	0
Maximum	3.00	7.00	9.00	4.00	9.00
Vegetation Layer Structure					
Total Trees			6.3%		16.3%
Total Shrubs	63.3%	48.9%	87.4%	93.2%	75.5%
Total Herbs	36.7%	51.1%	6.3%	6.8%	8.2%
Total Hits	120	137	127	118	98
Substrate					
Sandy Soil	31	12	16	18	28
Leaf Litter	54	82	82	78	71
Cryptogammic Rock		1			
Bare Rock	15	5	2	4	1
Total	100	100	100	100	100
Vegetation Community[a]					
Coastal Sage Scrub	40.0%	30.7%	14.2%	7.6%	19.4%
Non-Native Grassland		21.9%			
Native Grassland	14.2%				
Chaparral	43.3%	29.9%	83.5%	92.4%	77.6%
Total*	97.5%	82.5%	97.6%	100.0%	96.9%
Most Common Plant[b]					
First:	ADFA (35%)	ADFA (28%)	QUDU (39%)	ADFA (77%)	QUDU (58%)
Second:	SAME (20%)	CNDU (27%)	ADFA (35%)	SAME (8%)	HEAR (15%)
Third:	CNDU (14%)	BRSP (20%)	XYBI (9%)	ARCR (8%)	RHIN (9%)
Latitude, North	32.9421	32.9446	32.9423	32.9404	32.9405
Longitude, West	117.1750	117.1681	117.1680	117.1717	117.1742
Elevation, m	104	127	102	126	105
Slope	20°	4°	10°	10°	16°
Aspect	114°	290°	218°	294°	24°
Fire History					

* Balance of plant species may fall into more than one category or did not fit into any of the communities listed here.

[a] - For individual plant species in each vegetation community, see Appendix 1.

[b] - See Appendix 1 for full species names.

Table 11. Distance Between Arrays.
The distance between each pitfall array within a site is calculated in meters. The distance between two arrays can be found by selecting the position where the column and row of the selected arrays intersect.

Carmel Mountain

	1	2	3	4	5
1	0				
2	787	0			
3	912	135	0		
4	831	437	524	0	
5	1173	607	622	345	0

Del Mar Mesa

	1	2	3	4	5
1	0				
2	703	0			
3	651	254	0		
4	357	580	408	0	
5	192	736	615	233	0

Table 12. Relative capture rates at Carmel Mountain, Del Mar Mesa, and three additional study sites. Capture rates are calculated to standardize the results across sites that have varying numbers of arrays and different numbers of days of field effort. Not all species detected at Pt. Loma, the Wild Animal Park, or Torrey Pines are shown in this table.

		Carmel Mountain	Del Mar Mesa	Pt. Loma	Wild Animal Park	Torrey Pines*
	Number of Arrays:	5	5	17	20	*
	Days Sampled:	68	68	280	305	*
Salamanders						
Garden Slender Salamander	*Batrachoseps major*	14.7	11.8	18.3	4.9	25.1
Arboreal Salamander	*Aneides lugubris*	5.9	5.9	-	-	2.2
Frogs and Toads						
Pacific Chorus Frog	*Hyla regilla*	23.5	17.6	-	0.8	2.0
Western Toad	*Bufo boreas*	-	5.9	-	7.0	0.2
Western Spadefoot	*Spea hammondii*	23.5	11.8	-	2.8	-
Lizards						
Southern Alligator Lizard	*Elgaria multicarinatus*	8.8	5.9	34.7	8.5	40.4
Western Skink	*Eumeces skiltonianus*	8.8	8.8	-	33.0	9.3
Orange-throated Whiptail	*Cnemidophorus hyperythrus*	123.5	79.4	94.5	517.9	76.4
Western Fence Lizard	*Sceloporus occidentalis*	135.3	91.2	106.7	70.0	135.1
Side-blotched Lizard	*Uta stansburiana*	105.9	8.8	75.0	46.7	69.4
Coast Horned Lizard	*Phrynosoma coronatum*	5.9	8.8	-	22.3	5.1
Snakes						
Ringneck Snake	*Diadophis punctatus*	-	2.9	1.5	1.1	0.2
California Whipsnake	*Masticophis lateralis*	2.9	2.9	8.8	19.2	12.2
Red Diamond Rattlesnake	*Crotalus ruber*	**	2.9	-	5.7	-
Western Rattlesnake	*Crotalus viridis*	5.9	2.9	1.5	1.3	3.2

*Torrey Pines consisted of three subsites, each with a different number of arrays and sample days.
** The red diamond rattlesnake was only observed as an incidental at Carmel Mountain before pitfall trapping had begun.

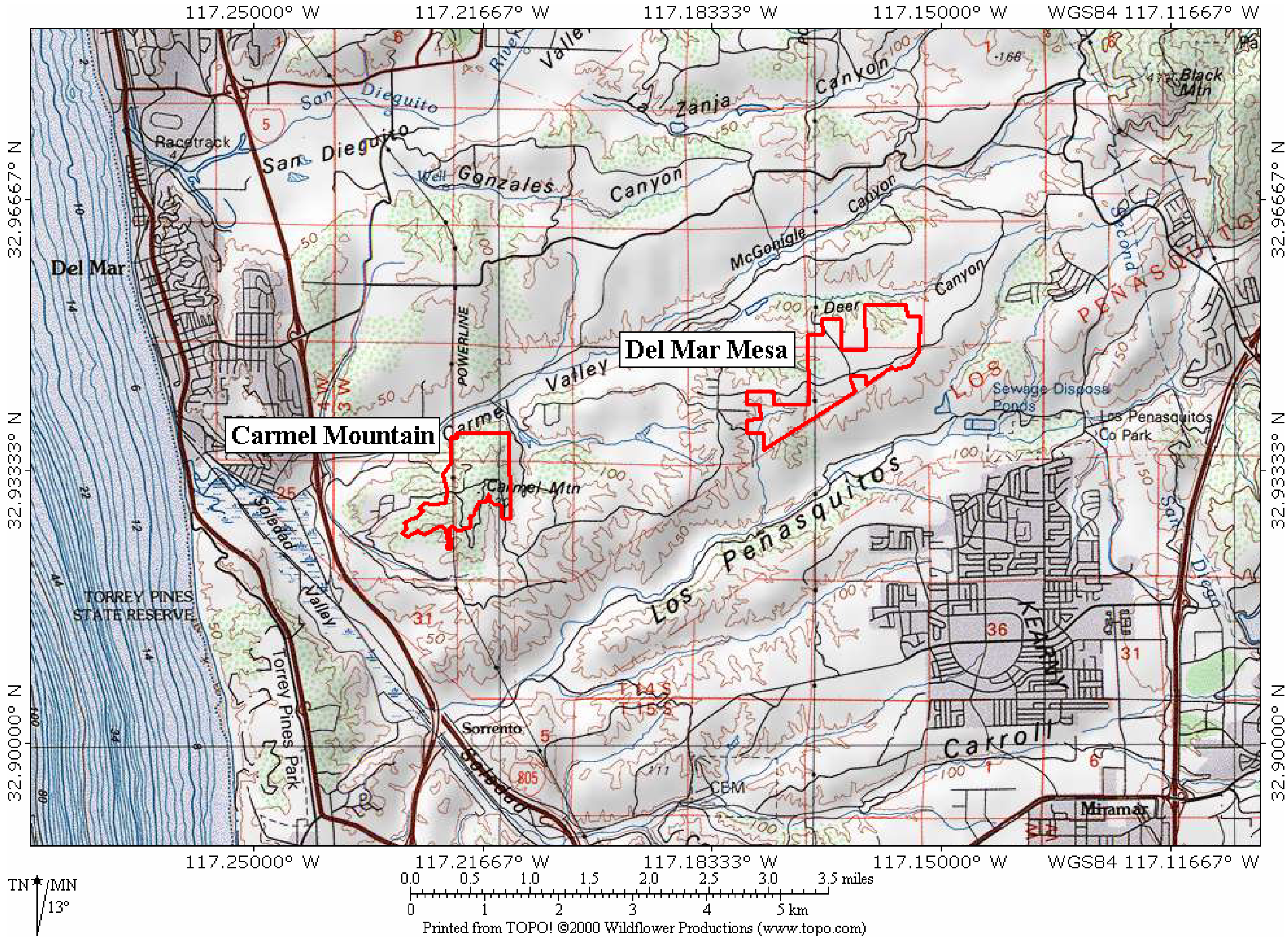


Figure 1. Carmel Mountain and Del Mar Mesa Preserves.

Approximate boundaries for the Carmel Mountain and Del Mar Mesa Preserves are shown in relation to each other. The juncture of Interstate 5 and 805 is at the bottom, left of center.

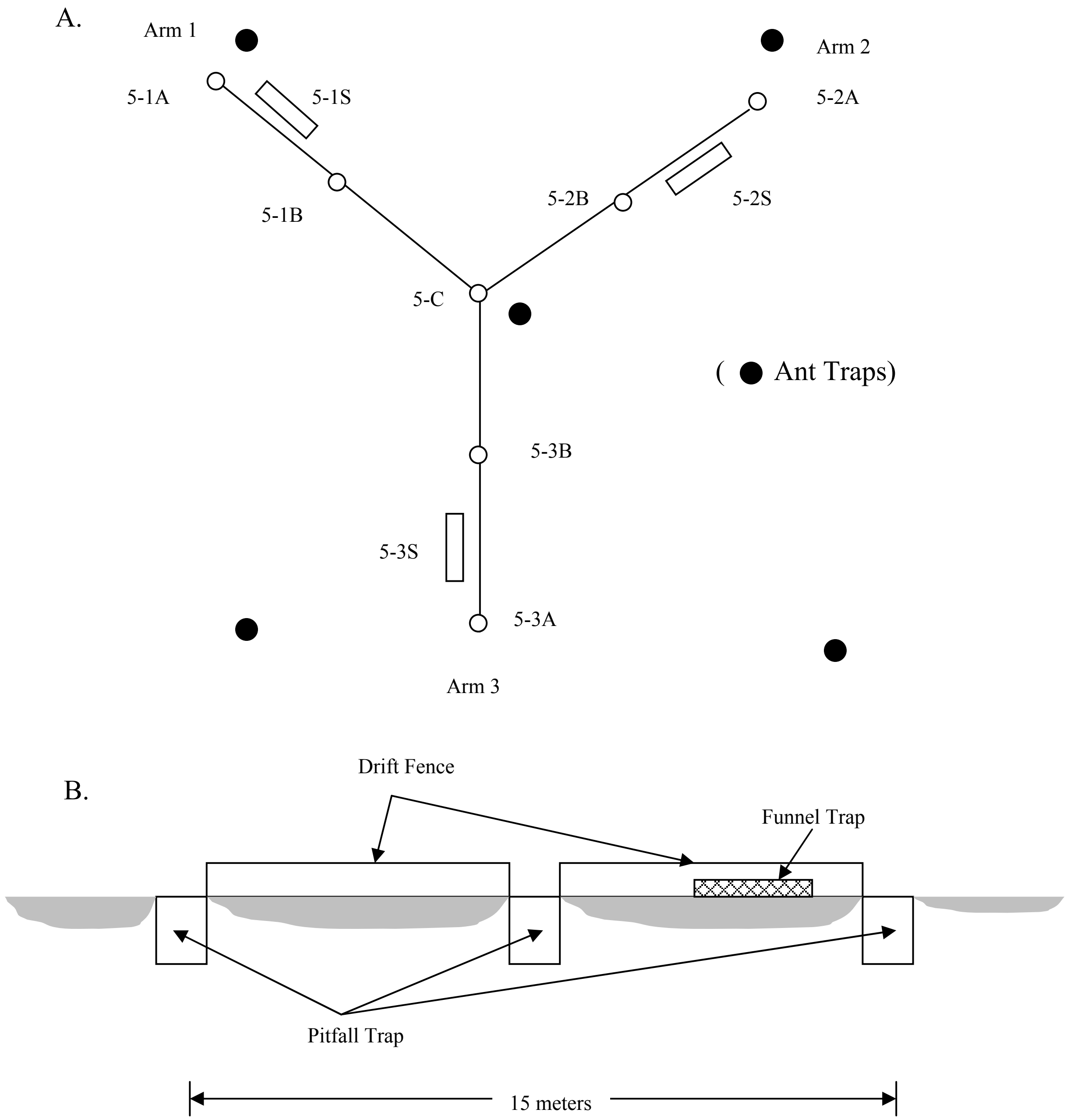


Figure 2. Pitfall Array Design.
A. Overhead view of array design, showing pitfall traps, funnel trap, and drift fences. For the purposes of this example, the traps are numbered as if at array 5 of the study site. B. The side view of a single arm, indicating the relative positions of the three trapping elements. Diagrams not to scale.

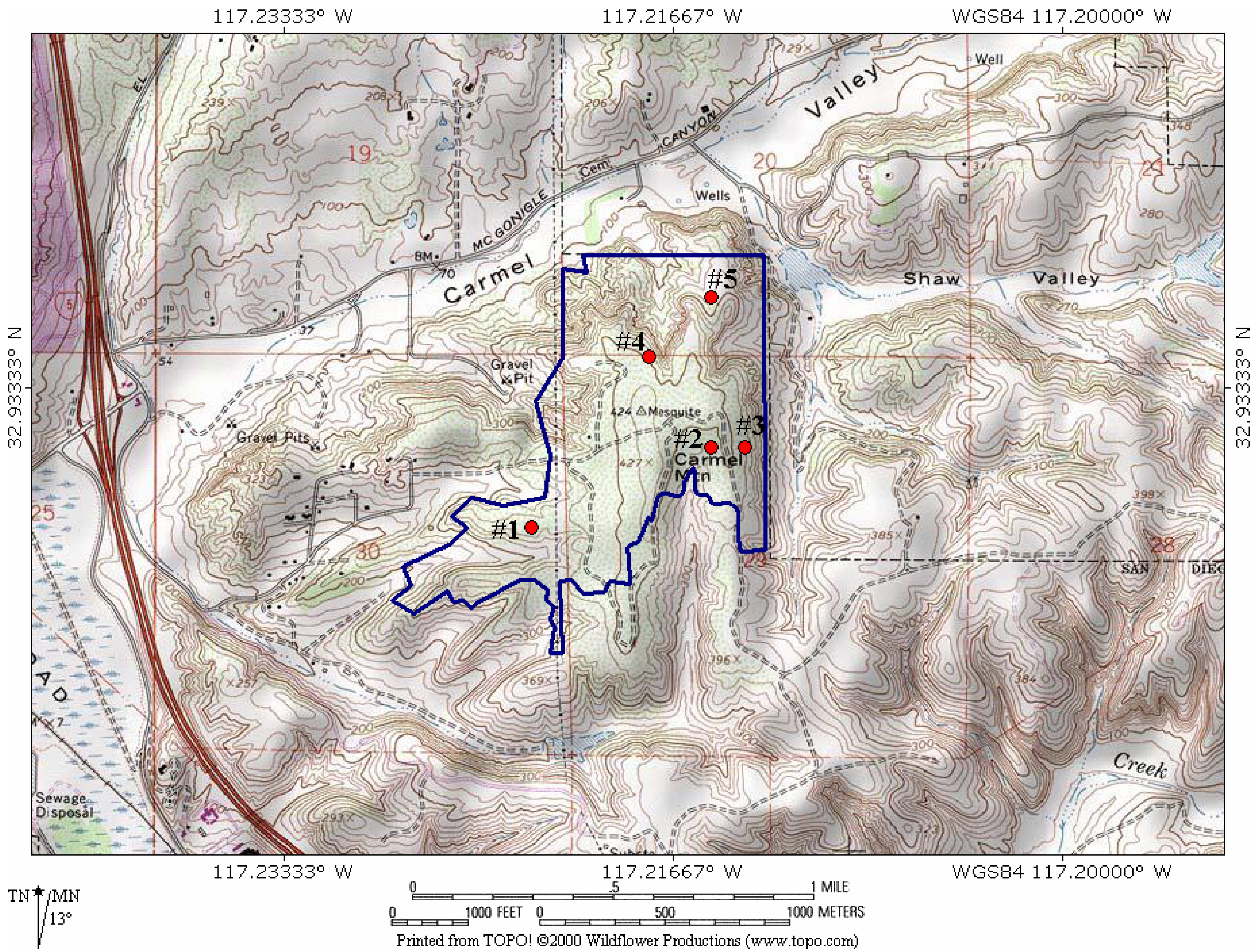


Figure 3. Locations of pitfall arrays at Carmel Mountain.

Approximate boundaries and array positions are shown for the Carmel Mountain Preserve study site.

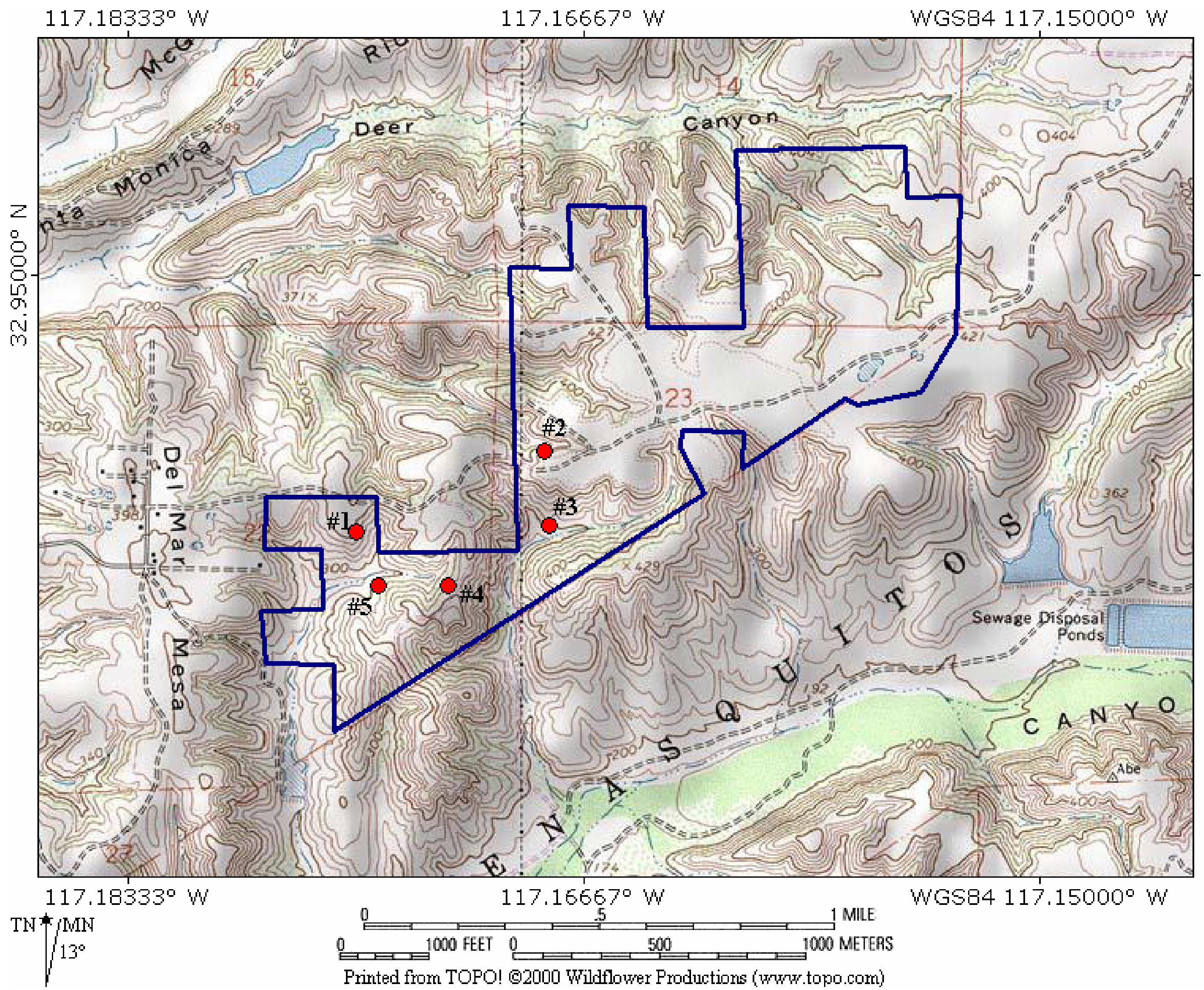


Figure 4. Locations of pitfall arrays at Del Mar Mesa .
Approximate boundaries and array positions are shown for the Del Mar Mesa Preserve study site. Locations for pitfall arrays were limited to the western section of this property, due to vernal pool and rare plant presence throughout the rest of the site.

Appendix 1. Plant Species List.

A complete list of plant species noted at the 10 arrays at Carmel Mountain and Del Mar Mesa Preserves. Included are the four-letter code, the scientific name, the common name, and the family.

Code	Species	Common Name	Family
ARCA[a]	*Artemesia californica*	California Sagebrush	Asteraceae
ARCR[b]	*Arctostaphylos glandulosa* ssp. *crassifolia*	Del Mar Manzanita	Ericaceae
ADFA[b]	*Adenostoma fasciculatum*	Chamise	Rosaceae
BASA[a]	*Baccharis salicifolia*	Mule-fat, Seep-willow	Asteraceae
BASR	*Baccharis sarothroides*	Broom Baccharis	Asteraceae
BRSP[c]	*Bromus sp.*	Brome grass	Poaceae
CESO	*Centaurea solstitialis*	Yellow Star-thistle	Asteraceae
CEVR[b]	*Ceanothus verrucosus*	Wart-stem Lilac	Rhamnaceae
CNDU[a]	*Cneoridim dumosum*	Coast Spice Bush, Bushrue	Rutaceae
COSE[c]	*Cortaderia selloana*	Pampas Grass	Poaceae
CUCA	*Cuscuta californica*	Dodder	Cuscutaceae
DW		Dead Wood	Various
ERCO[a]	*Eriophyllum confertiflorum*	Golden-yarrow	Asteraceae
ERFA[a]	*Eriogonum fasciculatum*	California buckwheat	Polygonaceae
FEVI	*Ferocactus viridescens*	Coast Barrel Cactus	Cactaceae
GASP	*Galium sp.*	unk. Bedstraw	Rubiaceae
GNSP	*Gnaphalium sp.*	unk. Everlasting, Cudweed	Asteraceae
HEAR[b]	*Heteromeles arbutifolia*	Toyon	Rosaceae
HESC[a]	*Helianthemum scoparium*	Peak Rush-rose	Cistaceae
LOIN	*Lonicera interrupta*	Chaparral honeysuckle	Caprifoliaceae
LOSC	*Lotus scoparius*	Deerweed	Fabaceae
MALA[a]	*Malosma laurina*	Laurel Sumac	Anacardiaceae
NAPU[d]	*Nassella pulchra*	Purple Needlegrass	Poaceae
OPSP	*Opuntia sp.*	unk. Prickly-pear	Cactaceae
PHSP	*Phacelia sp.*	unk. Phacelia	Hydrophyllaceae
QUDU[b]	*Quercus dumosa*	Nuttall's Scrub Oak	Fagaceae
RHCR	*Rhamnus crocea*	Spiny Redberry	Rhamnaceae
RHIN[a]	*Rhus integrifolia*	Lemonadeberry	Anacardiaceae
SAME[a]	*Salvia mellifera*	Black Sage	Lamiaceae
SECI	*Selaginella cinerascens*	Mesa Spike-moss	Selaginellaceae
STSP	*Stephanomeria sp.*	Wreath-plant	Asteraceae
XYBI[b]	*Xylococcus bicolor*	Mission Manzanita	Ericaceae
VUMY[c]	*Vulpia myuros*	Fescue	Poaceae
YUSC	*Yucca schidigera*	Mohave Yucca	Agavaceae

[a] Included in the Coastal Sage Scrub Vegetation Community.
[b] Included in the Chaparral Vegetation Community.
[c] Included in the Non-Native Grassland Vegetation Community.
[d] Included in the Native Grassland Vegetation Community.

Appendix 2. Photographs of Pitfall Arrays at Carmel Mountain and Del Mar Mesa.

Carmel Mountain, Array #1

Carmel Mountain, Array #2

Carmel Mountain, Array #3

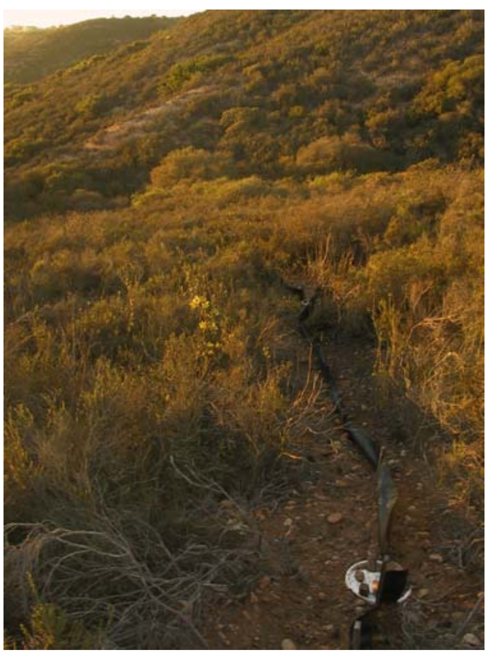
Carmel Mountain, Array #4

Carmel Mountain, Array #5

Del Mar Mesa, Array #1

Del Mar Mesa, Array #2

Del Mar Mesa, Array #3



Del Mar Mesa, Array #4

Del Mar Mesa, Array #5