Recovery and management of Orcutt's spineflower (*Chorizanthe orcuttiana*)

Final Report

Prepared by:

Ellen T. Bauder, Ph D
Department of Biology
San Diego State University
San Diego, CA 92182-4614

Prepared for:

California Department of Fish and Game
South Coast Region
Kim Marsden, Contract Manager
4949 Viewridge Avenue
San Diego, CA 92123

Contract # FG7643R5

November 2000

CONTENTS

TABLES

FIGURES

APPENDICES

MAP APPENDIX A

MAP APPENDIX B

ACKNOWLEDGMENTS

We would like to acknowledge the support and advice of Jim Dice and Kim Marsden (CDFG) who guided the project from inception to completion. Jennifer Stone, Don Lydy, David Pivorunas, and Kim Miller, all of the US Navy were helpful in arranging for access to sites on Point Loma as well as providing us with maps, reports, and other materials. Mike Wells helped us gain access to Torrey Pines State Preserve to look for historic populations as well as to collect soil samples. Phil Cotton, John Frenken, Garret Williams, and John Huston met us on numerous occasions to discuss protection of the Oak Crest Park (Encinitas) population of Chorizanthe orcuttiana. The regulatory agencies were represented by Mark Elvin (US Fish and Wildlife Service) and Kim Marsden (California Department of Fish and Game). Brad Roth of the Cottonwood Creek Conservancy and Tim Phillips of Quail Garden also contributed their expertise. Dave Boyer, of MCAS Miramar, assisted us with permission to look for *C. orcuttiana* on the air station. Samantha Weber assisted us with access to Cabrillo National Monument and helped us obtain maps.

Juda Sakrison assisted in the field collections of soil and collection of population data, reviewed information on the historic populations and field checked the locations, did the germinability tests, and also assisted with data reduction. Juda also collected the climate data from the web. Adrienne Russell contributed to the population study on Point Loma in 1999. She also shared the herbarium specimens she had on loan as part of her master's thesis research. Jonathan Snapp-Cook developed the "suitable site" and soils maps used in the project and assisted in field collection of soils and preparation of soils for shipping to the analytical laboratory. He and Kari Roesch removed exotics and cultivated plants from the vicinity of the Oakcrest Park population. Kari did background research on the pollination ecology of Chorizanthe and arranged for identification of insects collected as part of this study. Marshall Hedin collected all but one of the insects. The Argentine ant was identified by the County of San Diego Department of Agricultural and the remainder by Kathy Williams and her students.

DEDICATION

To Jennifer Stone who championed this rarest of rare plants.

ABSTRACT

The purpose of this study was to review the current and historical distribution of *C. orcuttiana* (Orcutt's spineflower), examine the relationship between soil type and general habitat variables with spineflower occurrence, determine which populations are still extant and their general condition, recommend possible sites for establishment of new (or re-introduced) populations, and suggest management actions. Populations with individuals recently observed were monitored, germination trials were completed, and a limited number of seedlings were established for the purposes of studying reproductive biology.

Only three populations of Orcutt's spineflower are extant: two on Point Loma and one small population at Oakcrest Park in Encinitas. A population may still remain at Torrey Pines State Reserve, but it has not been seen since 1987.

After a careful review of all verified occurrences of Orcutt's spineflower, the conclusion is that this species has a strong association with soils of the Carlsbad series. Soil samples taken in the general vicinity of populations where an occurrence is well documented, indicate a sand fraction of about 90 %, low content of organic matter and nitrate nitrogen, and moderate acidity.

Using digitized information on soil series, land use, and ownership, we developed maps to guide our search for additional populations and sites for possible introduction and population expansions. Sites identified on these maps were field checked. Very little potentially suitable habitat remains for this species.

The Point Loma populations are both on US Navy land and are afforded a substantial degree of protection, but the Oakcrest Park population is at high risk for extinction due to proximity to actively used areas of this small park. Population numbers were relatively high for both Point Loma populations in 1999, but substantially lower in the spring of 2000, presumably due to the sequence of two exceptionally dry years (1999 and 2000). The Oakcrest Park population is extremely small (<30 plants), and plummeted to only 1 observed plant in 2000.

X-ray examination of fresh seed revealed only half the seed had fully formed embryos. Germination of seed was generally unsuccessful. Conditions leading to successful germination were not similar, so that we have no clear picture of what conditions of moisture, light, seed age, and temperature favor germination.

We have worked with both the US Navy and the City of Encinitas to consider management actions that would enhance spineflower habitat. A substantial amount of perennial grass and duff was removed from the soil surface around the Oakcrest Park population to promote the open conditions apparently favored by this species and a fencing plan was developed.

CHAPTER 1. INTRODUCTION

1.1. PURPOSES OF THIS STUDY

The purposes of this study were to review the current and historical distribution of *C. orcuttiana* (Orcutt's spineflower), examine the relationship between soil type and general habitat variables with spineflower occurrence, determine which populations are still extant and their general condition, recommend possible sites for establishment of new (or re-introduced) populations, and suggest management actions. Populations with individuals recently observed were monitored, seed germination trials were completed, and seedlings were established for the purposes of studying reproductive biology. A limited examination of possible pollinators was conducted.

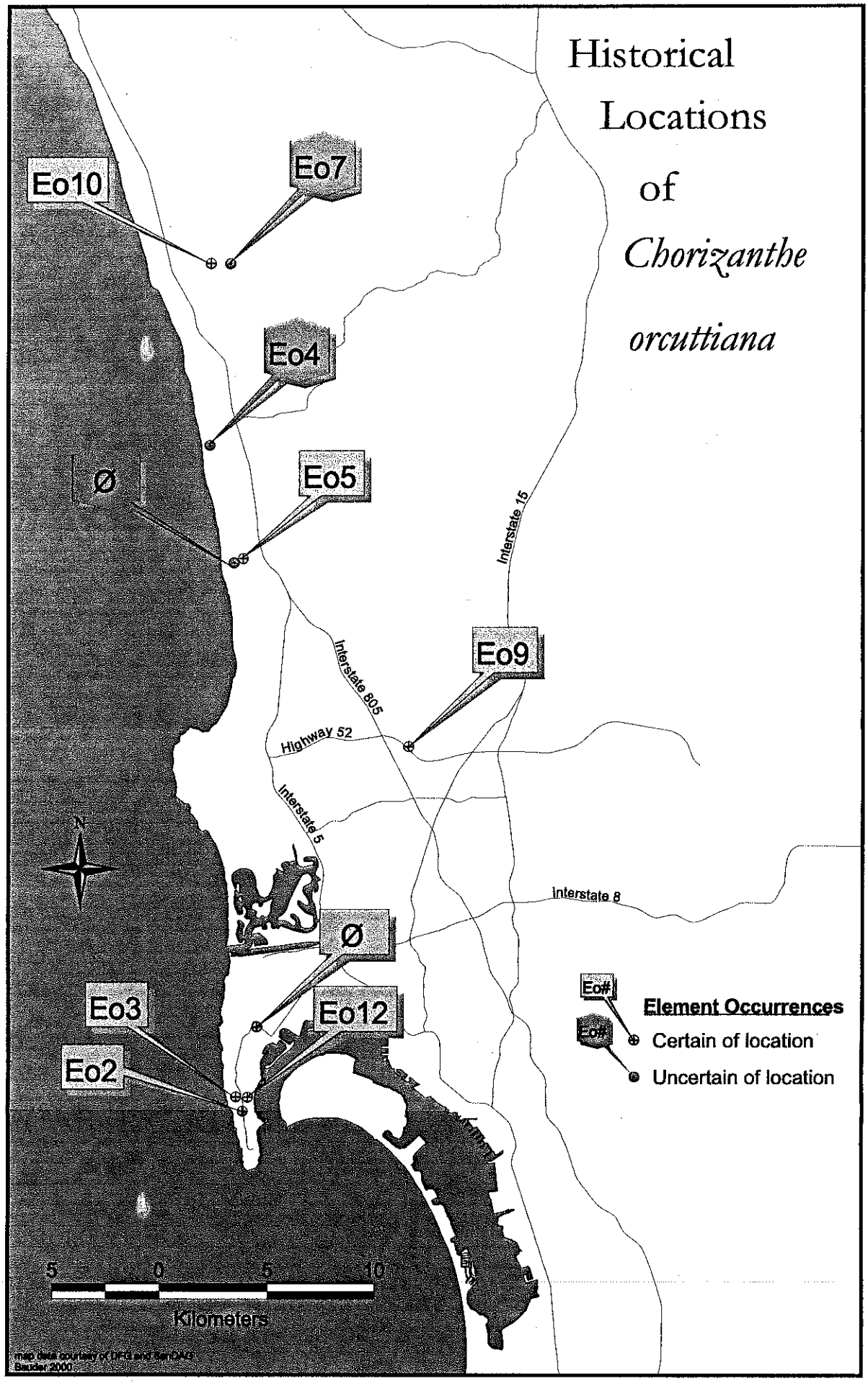
1.2. BACKGROUND

1.2.1. Habitat and Status

C. orcuttiana (Orcutt's spineflower) is Endangered in the State of California, and on the federal list of endangered plants (CDFG 2000, Federal Register 1996). The range of the species is believed to be limited to western San Diego County along the coast. Within this limited geographic range, it is further restricted to isolated patches of sandy soils. Typically, these sandy openings in shrublands occur in relatively flat areas at the toe of coastal bluffs. The soil type is mapped as Carlsbad gravelly loamy sand (Bowman 1973).

The California Department of Fish and Game Natural Diversity Data Base (NDDB) lists nine recorded occurrences (NDDB 1998), and we believe we have identified the site of a tenth (See Section 2.1.8) (Figure 1). Of those ten occurrences, only three populations survive and one may not be extirpated.

C. orcuttiana was thought to be extinct (Hickman 1993)(Reveal and Hardham 1989), but has recently been located at Oakcrest Park in Encinitas (1978, 1995, 1997-2000), Torrey Pines State Reserve (1987), and Point Loma, on US Navy land (1997 to present). The Oakcrest Park population (CDFG EO #10) is very small and at high risk due to the intense recreational activity in the vicinity, runoff from landscaping, and dense stands of exotic plants (See Section 2.2.2). The Torrey Pines population (CDFG EO #5) has not been seen since 1987. This leaves the two Point Loma populations—in close proximity—as the only extant populations


Historical Locations of *Chorizanthe orcuttiana*
Eo10
Eo7
Eo4
Ø
Eo5
Interstate 15
Interstate 805
Eo9
Highway 52
Interstate 5
Interstate 8
N
Ø
Eo3
Eo12
Eo2
Eo#
Element Occurrences
Certain of location
Uncertain of location
5 0 5 10
Kilometers

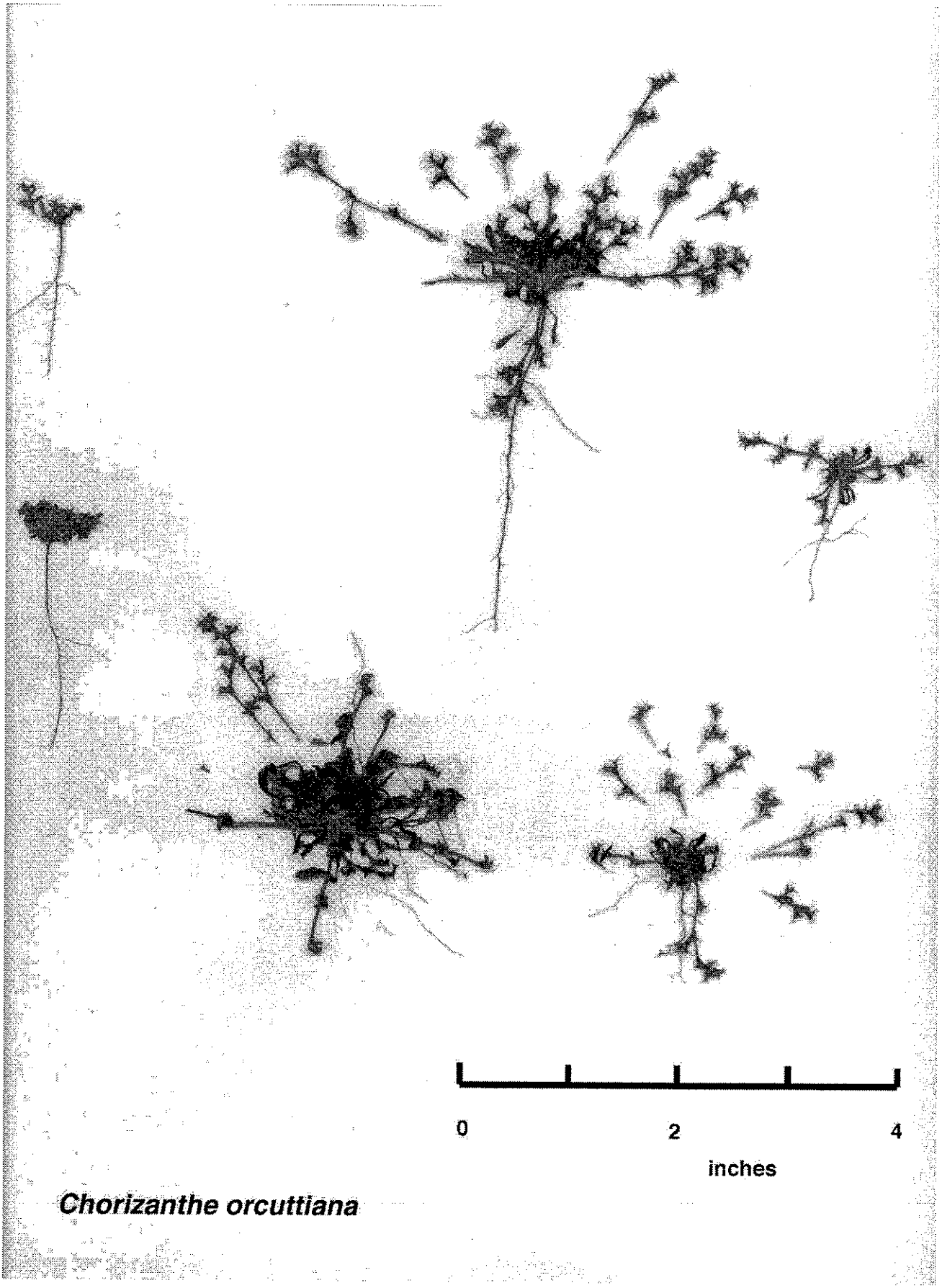
with sufficient numbers and degree of protection to have a reasonable expectation of persistence. The largest Point Loma population (CDFG EO #12) is located on the US Navy Sub-base within an area about 35 m^2, about 300 m south of McClelland Road (See Section 2.1.7). This population is contained within an area proposed for the Point Loma Ecological Reserve. It occurs in sandy openings set in very old, dense chamise chaparral dominated by *Adenostoma fasciculatum*, with occasional individuals of *Ceanothus verrucosus*, *Cneoridium dumosum*, and *Rhus integrifolia*. These openings are reminiscent of other patchy, specialized habitats such as vernal pools and clayey soil patches, both of which support endemic plants of limited distribution (Bauder 2000; Bauder, E. T., S. McMillan and P. Kemp 1994; Bauder and Sakrison 1999; Bauder, E. T. and D. Truesdale 2000, Oberbauer 1993). The general area is infested with mats of *Carpobrotus edulis* (Hottentot fig), with modest amounts in the immediate vicinity of the *C. orcuttiana* plants. Annuals found in the open patches in association with *C. orcuttiana* are *Mucronea californica*, *Camissonia bistorta*, *Cryptantha intermedia*, and *Crassula connata*.

The second, smaller population on Point Loma, is believed to be in the Point Loma Ecological Reserve (NRAD area), just northwest of the intersection of Woodward Road and Cabrillo Memorial Drive. It is likely the historic population documented by Katherine Brandegee in 1906 (EO #3)(See Section 2.2.2). This population is surrounded by a mixture of *Cneoridium dumosum*, *Malosma laurina*, *Rhus integrifolia*, *Ceanothus verrucosus*, *Rhamnus crocea*, *Salvia mellifera*, *Lotus scoparius*, *Euphorbia misera*, *Isocoma menziesii*, *Artemisia californica*, and *Encelia californica*. *Carpobrotus* mats are common in the area, as are seedlings and mature shrubs of Acacia.

1.2.2. The Species

C. orcuttiana (Orcutt's spineflower) is a diminutive, herbaceous annual in the family Polygonaceae (Figure 2). Little is known about the basic biology of this species, so that it is difficult to make important management decisions and prioritize preservation measures.

The few verified occurrences of Orcutt's spineflower locate it on sandy soils developed from eroded coastal bluffs and old beach ridges. The seeds germinate in late fall after the seasonal winter rains begin, and a small rosette of narrowly oblanceolate leaves develops. Rosettes are often no more than 2 cm in diameter, and the leaves are lightly covered with long, silky trichomes, helping to distinguish it in the early stages of growth from the look-alike species, *Mucronea californica*, which has sparse, stiff hairs primarily at the leaf margins. Several-to-many decumbent, open-branched inflorescences are produced in late spring. They



Chorizanthe orcuttiana

contain up to several dozen (occasionally more) flowers, each flower surrounded by three three-angled bracts tipped with recurved spines. The six-lobed perianth is greenish yellow and only 1.5-1.8 mm wide. The breeding system is unknown. One-seeded fruits (achenes) are formed in late spring.

CHAPTER 2. DISTRIBUTION OF *CHORIZANTHE ORCUTTIANA*

2.1. HISTORICAL OCCURRENCES

We obtained a copy of the California Department of Fish and Game's Natural Diversity Data Base (NDDB 1998) records for each Element Occurrence (EO) of *Chorizanthe orcuttiana*. There are twelve EO numbers assigned by the NDDB, but three of these (EO's # 1, 8, and 11) appear to be either erroneous or duplicates of other occurrences (Table 1). We plotted all nine occurrences on a map of western San Diego County (Figure 1) and on finer-grained maps to reveal greater locational detail and relationship to soil series and land use (Map Appendices A and B). Our goal was to put ourselves—quite literally—in the places as described in the records. Because some of the collections date back over 100 years, this required careful review and consideration of the verbal descriptions in the context of what the author would have seen at the time they were written. We used the NDDB forms to determine other helpful sources of information, including herbarium labels, historical maps, and individuals. As part of her master's thesis research, Adrienne Russell obtained over two dozen herbarium sheets of *C. orcuttiana* which we examined—the labels, in particular. We also reviewed historical road and topographic maps to understand what might have been present at the time the collection or record of occurrence was made. Then, we visited each site.

2.1.1. Element Occurrence # 2

A collection by Clare Hardham made in 1962 (Santa Barbara Botanical Garden, Hardham collection # 8945, accession # 062204) gives no specific location (Point Loma), but Hardham provided a map to the California Natural Diversity Data Base (NDDB) in August 1981, indicating the site where she collected *Chorizanthe orcuttiana*. This population is known as EO #2 (NDDB).

The collection label says "At cemetery boundary along Cabrillo Memorial Drive. NW & across Rd from Bennington Monument, Pt Loma." We located the Bennington Monument in the current-day Fort Rosecrans National Cemetery. Across Cabrillo Memorial Drive from the

NDDB OCCURENCE	LOCATION	SOURCE MATERIAL
2	**Point Loma,** "At cemetery boundary along Cabrillo Memorial Drive. NW & across road from Bennington Monument."	Map made from memory by Clare Hardham in 1981 in NDDB files
3	**Point Loma**, "bare gravelly places...at the point where the old road branches to go down a canon towards the new lighthouse."	K. Brandegee April 10,1906 UC Berkeley Herbarium Accession #84558, copy of herbarium sheet label from NDDB files
4	**Del Mar.** "Just south of where road crossed mouth of slough with Torrey Pine." LIKELY AN ERRONEOUS LOCATION	Collection C.B. Hardham #8941, April 4, 1962. Map made from memory by Clare Hardham in 1981. Conversation with Hardham indicates she likely was at the south end of Penasquitos Lagoon where Linda Allen reported it in 1987 (EO #5).
5	**Del Mar.** East grove of Torrey Pines State Reserve. On open w-facing slope in sandy soil. In open coastal sage scrub at ecotone with Torrey pine woodland.	Linda Allen (obs.), 1987, NDDB files.
7	**Encinitas.** "2.5 mi E of Encinitas, on road to Olivenhain." NDDB note: Possibly the old dump site. Could be the same as, or very close to, present-day Oakcrest Park. If so, this would be lumped with EO #10.	F. Gander Collection #5479, May 4, 1938 SDNHM Herbarium and NDDB files.
9	**La Jolla.** "Low hills, north side of 6060 Clairmont Mesa Blvd, 1.5 miles west of interstate 395, Kearney Mesa."	J. Keefe #1642 UCSB Herbarium, March 25, 1967. Also F. Gander, Accession # 10604, SD NHM Herbarium, March 13, 1935 (Madroño 4:33)
10	**Encinitas.** Oak Crest Park; south side of Encinitas Blvd., c. 0.25 mi west of El Camino Real, 0.1 mi east of Balour Drive.	T. Oberbauer, 1978 (Pers comm.); C. Reiser 1989 (obs.), NDDB files.
12	**Point Loma.** East side of Cabrillo Memorial Dr., 0.35 mi NNE of Bennington Memorial.	V. Scheidt 1997 (obs.), NDDB files; S. Eliason & A. Russell, Accession #12630, SDSU Herbarium, April 18, 1997.

Table 1. Natural Diversity Data Base Element Occurrences of *Chorizanthe orcuttiana.*

monument, the property is fenced along the road and along the northern border of the cemetery. The land on the northern and western sides of the fence belongs to the US Navy. With the Navy's permission, we accessed this area.

The general area includes IMAT and Buildings 586, 587, 589, as well as the area corresponding to the location noted by Clare Hardham (Figure 3). Most of the site immediately north of the cemetery fence is road/parking surface and buildings. Buildings 537 and 586-589 all look new. Building 590 may be older. The historical occurrence was probably here. A small sandy area covered by *Carpobrotus edulis* remains between the Navy's fence and Cabrillo Memorial Drive. It also is possible this was the site of the collection as Clare Hardham indicated she was very close to the road when she found the plant.

2.1.2. Element Occurrence # 3

This element occurrence on Point Loma was first described in 1906 by Katherine Brandegee. It is erroneously located in the NDDB as being at the tip of the point. A collection label from the herbarium of the University of California Berkeley, combined with historical maps, gave the best clues for relocating this population. The collection made by Katherine Brandegee is UC Berkeley Accession # 84558 and duplicates. The label on all duplicates reads, " Point Loma Reservation, near San Diego, in the proximity of the Pacific Ocean, the only known station." The Berkeley specimen has an additional hand-written label that says, "Bare gravelly places on the Military Reservation Point Loma, at the point where the old road branches to go down a cañon towards the new lighthouse." According to old maps (USGS surveyed in 1902, culture revised in 1930) of Point Loma, the only road branching from the ridge-top road to the new (lower) lighthouse ran approximately where the present Woodward Road curves through a canyon down the western slope (Figure 4). The old road continued south along the base of the terraces to the end of the point along the present-day Gatchell Road. Near the head of the canyon, sections of old pavement are visible south of—and adjacent to—the present-day Woodward Road.

A small population of *C. orcuttiana* was discovered by Bauder and Sakrison in 1998 just west of Strong Road on a gentle, west-facing slope just above the sharp incline to the coastline below (Figure 5). This site is slightly downslope from Strong Road, in the stretch between Battery Strong and a tower (Building 584). Although much of the area around the eastern end of Woodward Road is now disturbed or developed, the *C. orcuttiana* site is within the general area described by K. Brandegee where she collected *C. orcuttiana* in 1906, and it is likely this is a remnant of a more extensive 1906 population. Figure 3--EO 2 Historic locations-detail

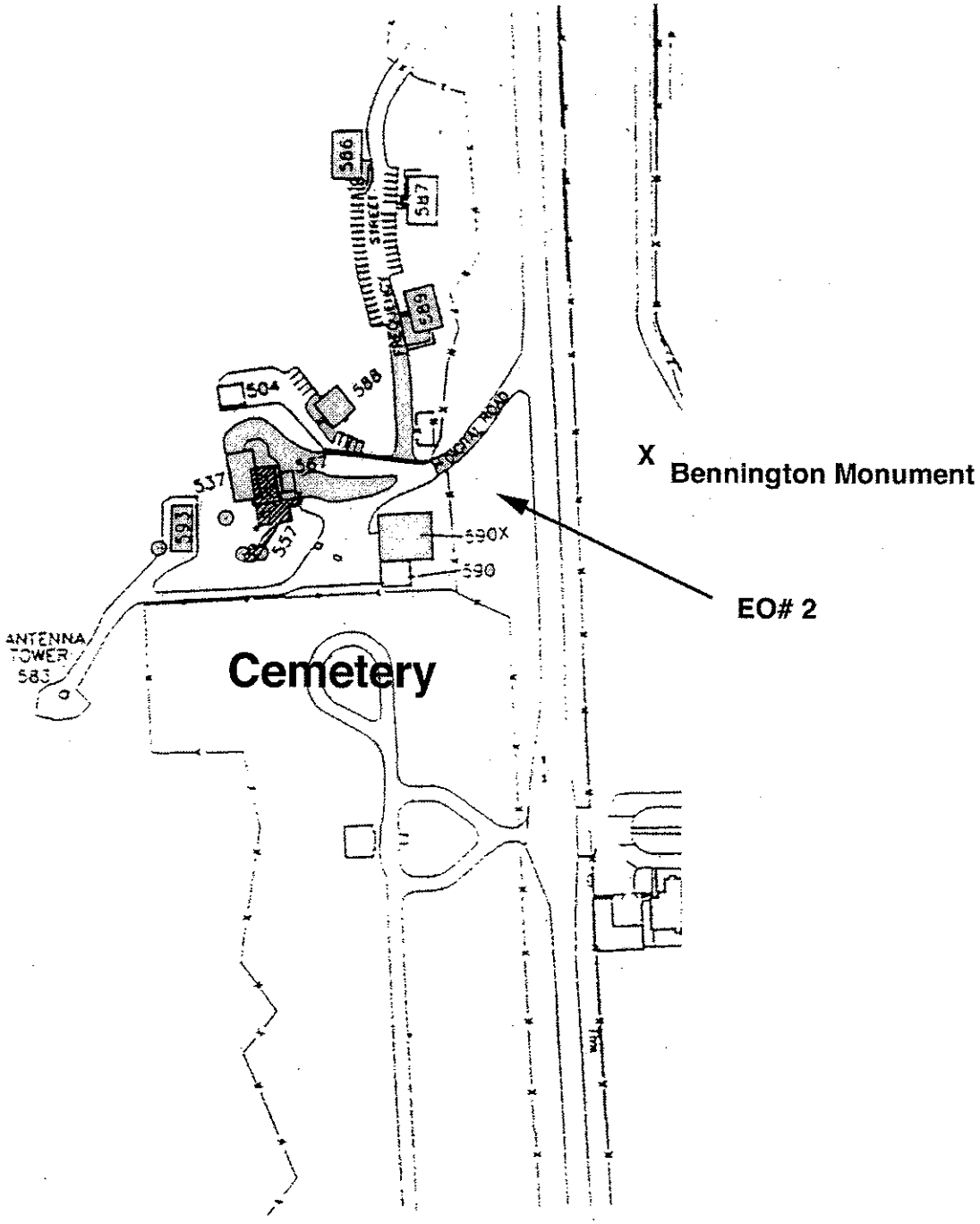


Figure 3. Location of EO# 2 on Point Loma. Map modified from Point Loma Complex Map Book 1996, NRaD.

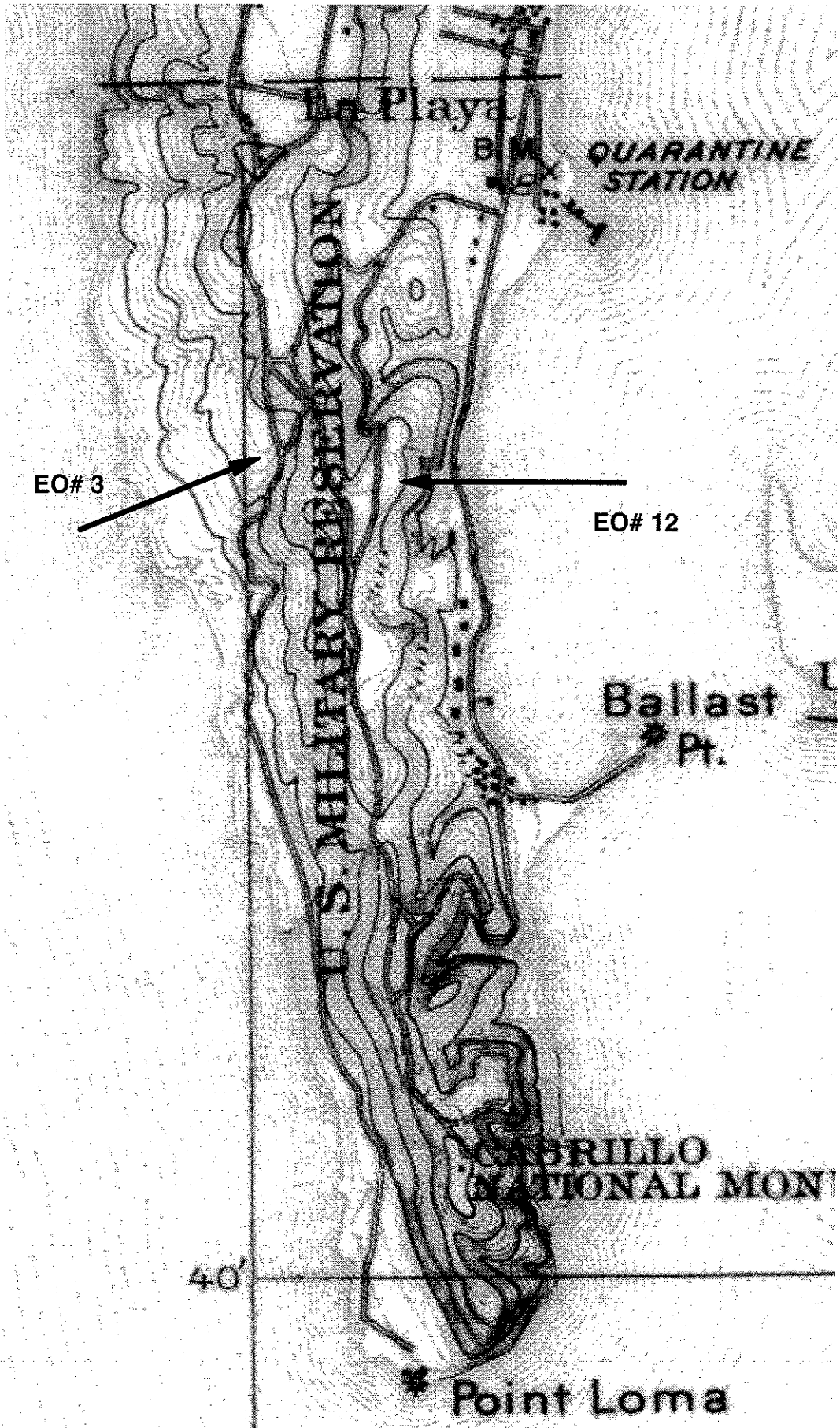


Figure 4. Roads near EO# 3 and EO# 12 on Point Loma in 1930.

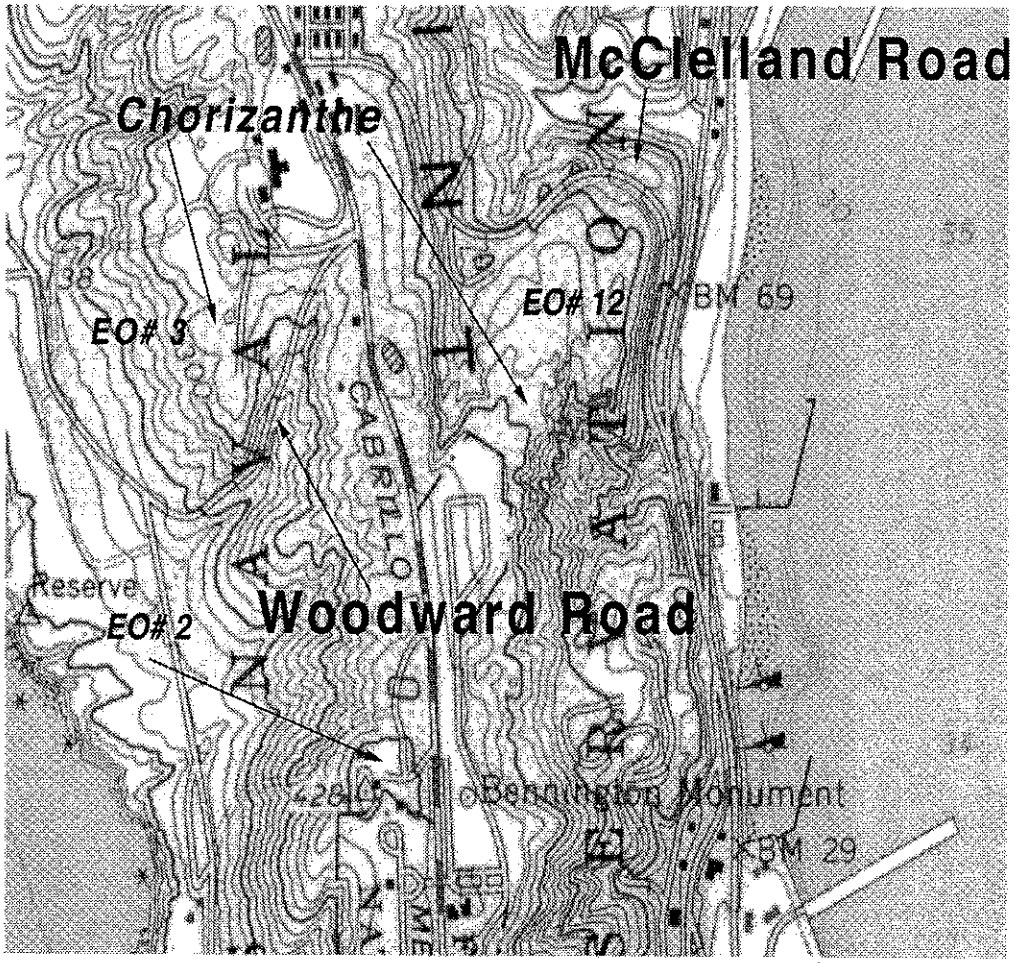


Figure 5. Locations of EO #'s 2, 3, and 12.

The current *C. orcuttiana* population is distributed in a cluster of four small patches, each under the canopy of shrubs that edge open, gently sloping, interconnecting sandy areas. The immediate location is relatively undisturbed, but it is adjacent to an area that was scraped or bladed flat at some time in the past. The bladed area is apparent on the USGS 7.5' topographic map (1967, photorevised 1975)(Figure 5).

The shrub component of the population's surrounding vegetation consists of a dense mixed stand of *Artemisia californica*, *Ceanothus verrucosus*, *Cneoridium dumosum*, *Encelia californica*, *Euphorbia misera*, *Malosma laurina*, *Rhamnus crocea*, *Rhus integrifolia*, and *Salvia mellifera.* Associated annuals found in the sandy patches are *Camissonia bistorta*, *Crassula connata*, and *Mucronea californica*. The herbaceous perennials *Dudleya edulis* and *Lotus scoparius* are present as well. *Mirabilis laevis*, an herbaceous sub-shrub was also on site.

The population does not appear to be vulnerable to foot or vehicle traffic, or other disturbance from use of the nearby facilities. The ubiquitous *Carpobrotus edulis* is moderately common along Strong Road, in the scraped area, and in the vicinity of the *C. orcuttiana* population. Acacias are there as well, especially on the scraped soil.

2.1.3. Element Occurrences # 4 and 5

Element Occurrence #4 is based on a collection made by Clare B. Hardham on April 4, 1962. The collection number is 8941. We examined accession #18052 from the Santa Barbara Botanic Garden. The label description said, "Torrey Pines Assoc. Loose sand. Sepals yellow, anthers red. Del Mar." In 1981, Hardham located the population from memory on a USGS 7.5 minute topographic map of the Del Mar quadrangle (Figure 6). She also marked the location of a second population from which she did not collect. The northernmost of the two populations (the one from which the collection was taken), she placed just to the south of the San Dieguito Lagoon. Her handwritten notes say, "I never succeeded in noticing the race track just south of where road crossed mouth of slough with Torrey Pine." The other population was marked just to the south of the Penasquitos Lagoon, and in the accompanying handwritten note on the map, she said, "I have also found it here but in a dry year & didn't collect. Sandy soil between parking area and coast." Neither written description is consonant with its marked location on the map. Visits to the area south of the San Dieguito Lagoon, revealed that the fairgrounds would be easily visible from the location Hardham marked on the map. Furthermore, the soil is mapped as Tujunga sand, a soil series found on alluvial fans and flood plains. On top of the eroding bluffs to the southeast is potentially suitable habitat where it

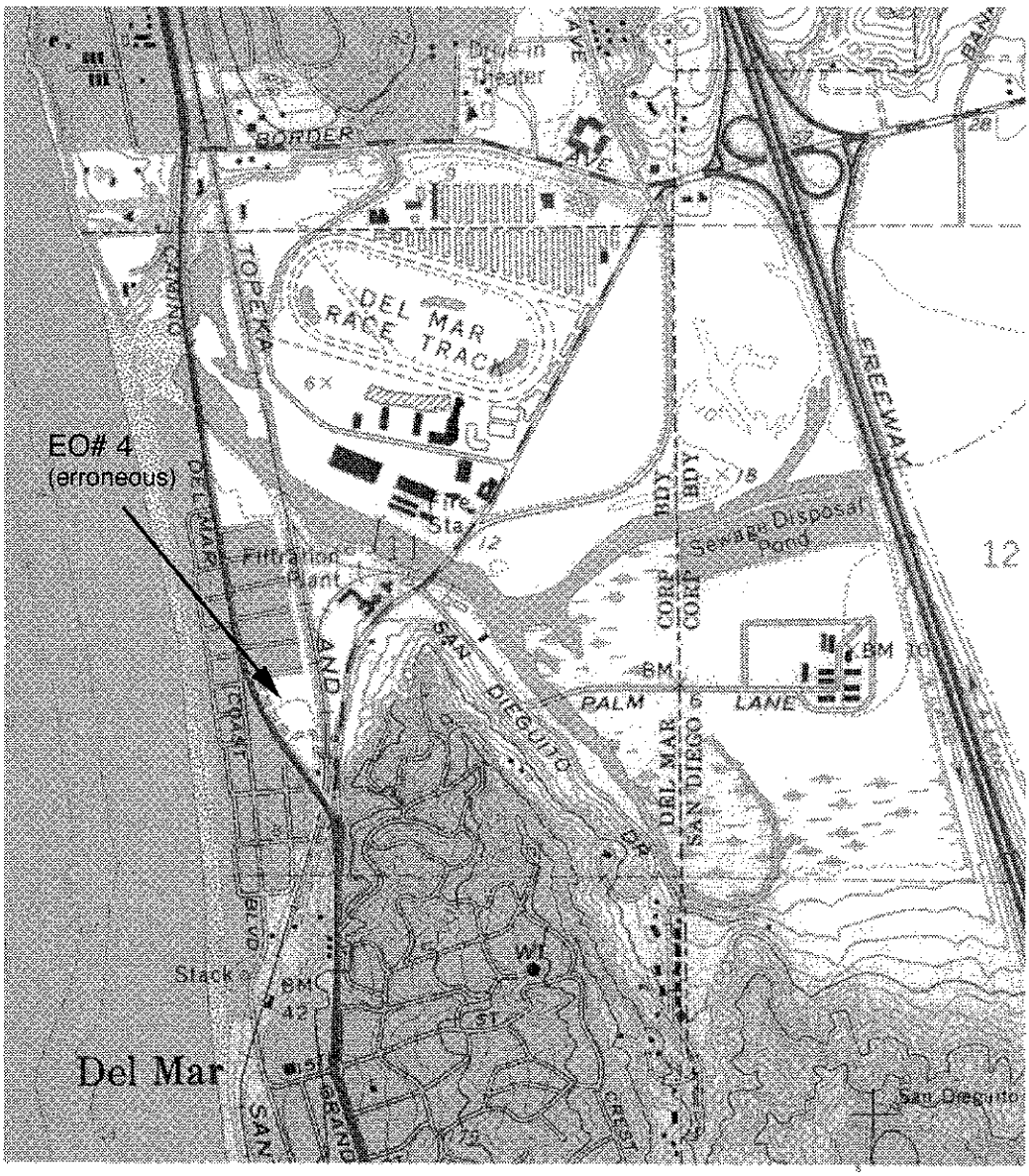


Figure 6. NDDB location of EO# 4 (erroneous).

might be possible she would have been able to view the racetrack, but the area is shown as a fully developed residential neighborhood on the 1953 USGS topographic map (USGS 7.5 minute topographic map—topography 1938-9, culture and drainage revised after a 1950 aerial photograph, and contours revised and field checked in 1953). A conversation with Clare Hardham provided additional details that strongly suggest the population from which she collected was in the general vicinity of EO #5 where Linda Allen observed *C. orcuttiana* in 1987 (Figure 7). The second population, from which no collection was made, was seen to the west of Torrey Pines Park Road, southwest of the visitor center (Figure 7). Hardham indicated it was just to the west of the parking lot and rest rooms on gravelly, sandy soil. EO #4 and EO #5 are apparently one and the same area, and the second collection is an un-numbered EO (Figure 1).

2.1.4. Element Occurrence #7

EO #7 is based on a collection by Frank Gander (Collection # 5479, Accession # 21056, San Diego Natural History Museum Herbarium). He made the collection on May 4, 1938. The location was given as "2.5 mi E of Encinitas, on road to Olivenhain." A plan meter applied to the 1947 USGS 7.5' topographic map measures approximately 2 miles from the center of the old town of Encinitas to present-day Oakcrest Park (EO # 10) and 2.5 miles to a high spot to the southeast of the intersection of present-day El Camino Real and Encinitas Boulevard (Figure 8). This high spot is mapped with Chesterton fine sandy loam which developed from ferruginous sandstone weathered in place, as did the Carlsbad series. The Carlsbad Series is the one most closely associated with *C. orcuttiana* (See Section 2.3). Chesterton soils share many characteristics with Carlsbad soils. The area southwest of this intersection is now developed.

2.1.5. Element Occurrence #9

This occurrence is based on a collection by J. Keefe on March 25, 1967 (Collection # 1642, University of California Santa Barbara Herbarium). The location is given as "Low hills, north side of 6060 Clairmont [sic] Mesa Blvd, 1.5 miles west of interstate 395, Kearny Mesa." The actual address no longer exists, the site presumably lost to the I-805/Clairemont Mesa Boulevard interchange. Much of the ridge of low hills to the north east has been lost to the runways at MCAS Miramar, a City of San Diego landfill, and more recently, a sludge treatment plant. Using a plan meter on a soil survey map, we identified a small area of undeveloped land with suitable soils approximately 1.6 miles east of Highway 395 (Figure 9). It is mapped as loamy alluvial land-Huerhuero complex surrounded by Chesterton soils and is southwest of the

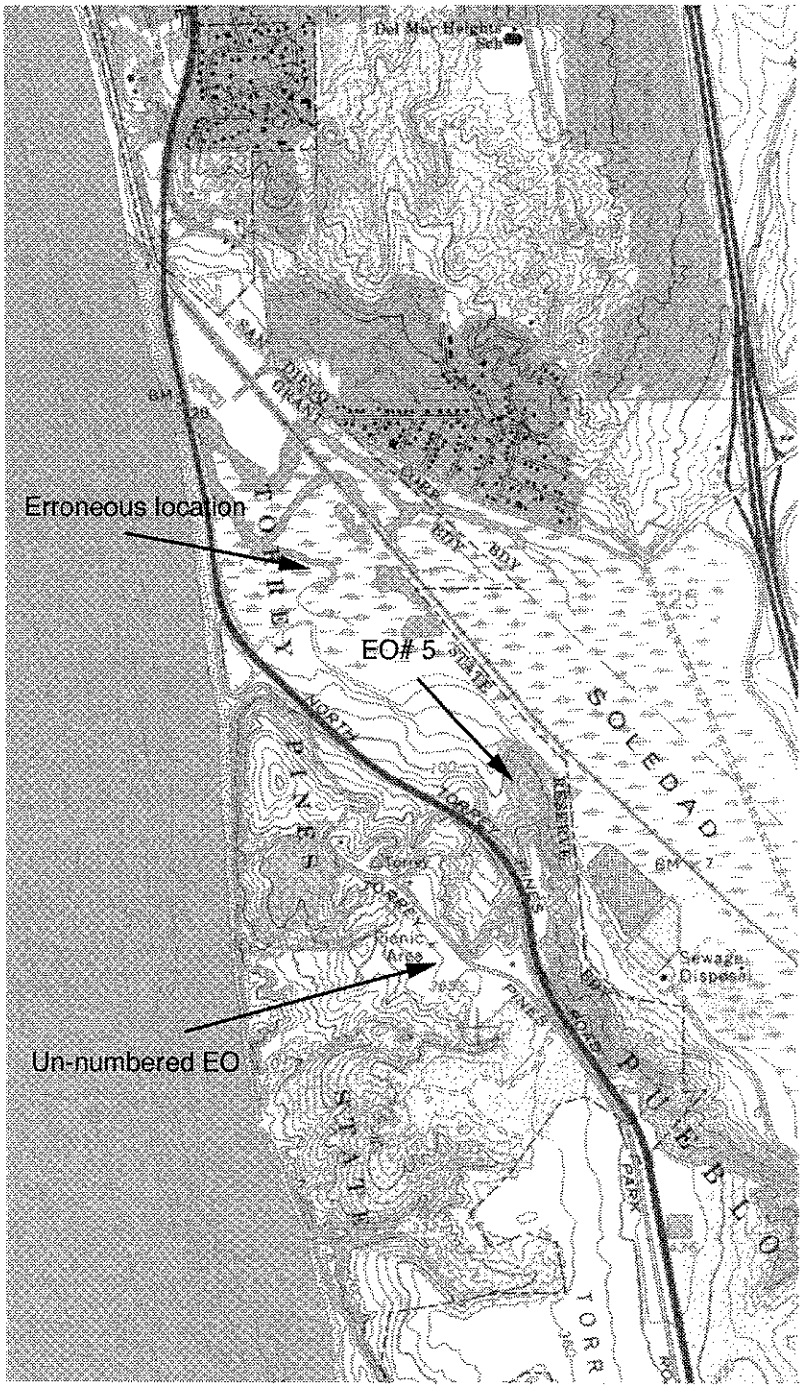


Figure 7. EO's in the Torrey Pines State Reserve area.

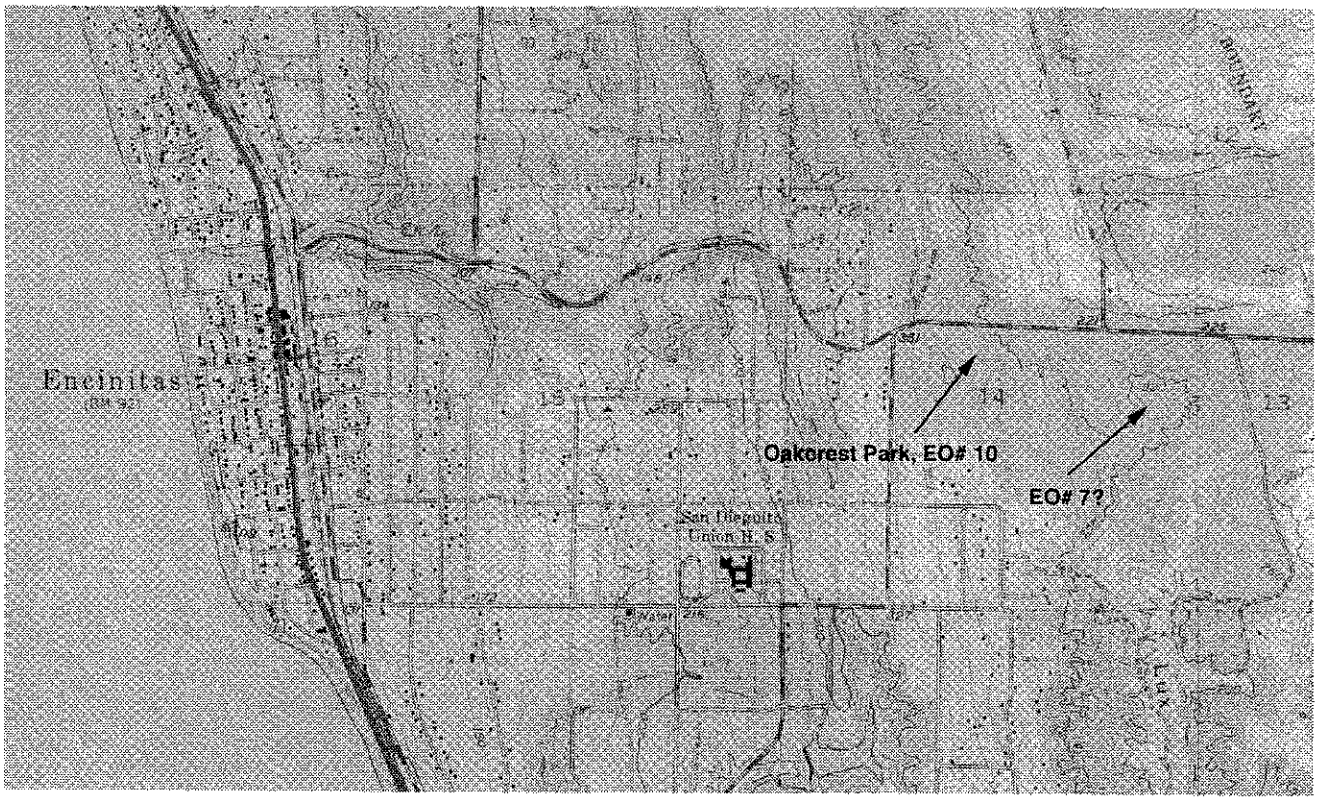


Figure 8. Locations of EO#'s 7 and 10 (USGS 1947).

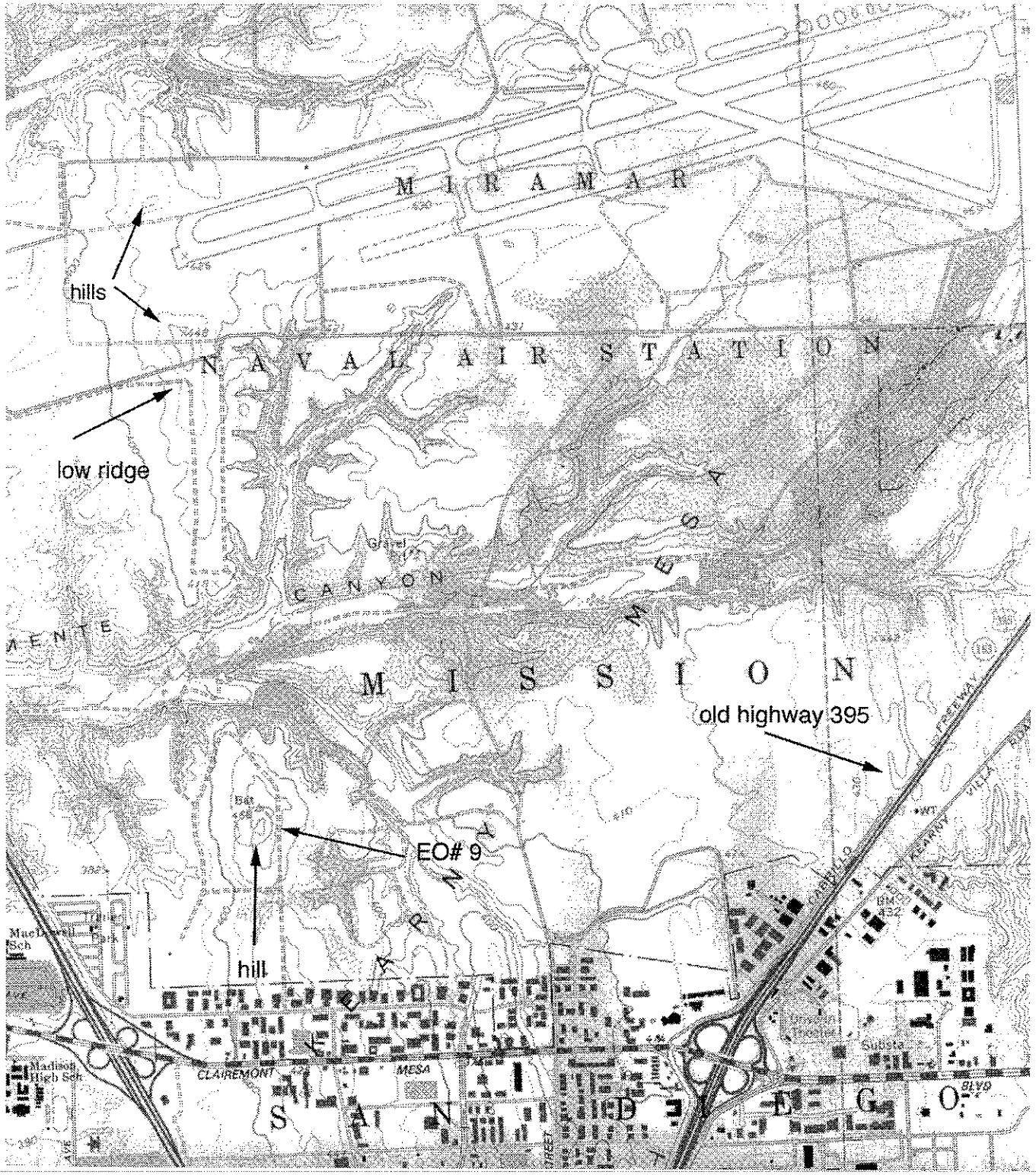


Figure 9. Location of EO# 9, Kearny Mesa.

sludge treatment facility, just north of SR 52, and northeast of the I-805/Clairemont Mesa Boulevard intersection. This soil complex contains remnants of Carlsbad gravelly loamy sand and Chesterton fine sandy loam. The area examined sustains shrub vegetation similar in composition to the areas on Point Loma and in Encinitas where *C. orcuttiana* still occurs, and the herbaceous flora contained several species of *Chorizanthe*. No *C. orcuttiana* was located during the searches made as part of this project.

Another herbarium specimen gives "Kearny Mesa" as a location, with no more specific information. The collection was made by Frank Gander on March 13, 1935 (Collection # 140.11, Accession # 10602, San Diego Natural History Museum Herbarium)(Gander 1937).

2.1.6. Element Occurrence #10

There were apparently two small populations—or one more or less continuous population—in the vicinity of Balour Drive and Encinitas Boulevard (Figure 8). A collection was made on April 7, 1978 by Tom Oberbauer (Accession # 99568, San Diego Natural History Museum Herbarium). He also made a list of plants occurring on the site (Oberbauer 1978). A second collection was made by Craig Reiser on May 2, 1995 (Accession # 138830, San Diego Natural History Museum). One of the two populations/patches is believed to have been extirpated when the driveway from Encinitas Boulevard and the parking lot serving Oakcrest Park were built in the 1980's (Oberbauer, Pers. comm.). The remaining, extant population is between a lawn and picnic area on the south edge and a paved walkway to the north. The shrub community contains *Adenostoma fasciculatum, Baccharis vanessae, Ceanothus tomentosus, Ceanothus verrucosus, Cneoridium dumosum, Rhus integrifolia, Salvia mellifera*, and *Xylococcus bicolor.* Herbaceous elements of the flora include *Camissonia bistorta, Crassula connata, Chorizanthe staticoides, Cryptantha* sp., and *Croton californicus.* This population is at very high risk and sustains chronic disturbance.

2.1.7. Element Occurrence #12

EO #12 is on Point Loma to the northeast of Element Occurrences #2 and #3 (Figures 4 and 5). The majority of this population lies within the path of an old road that appears on a USGS map surveyed in 1902 and culture revised in 1930 (Figure 4). The road scars are still visible today. Prior to the development of the cemetery, the roads to both lighthouses, and military facilities, these occurrences would have been in relatively close proximity (about 0.3 mile).

Vince Scheidt discovered the population in 1997, and a collection was made that year by Scott Eliason and Adrienne Russell (Accession # 12630, San Diego State University Herbarium). This occurrence is extant and has been part of the project reported on here. The plants occur on sandy soils in openings in the scrub vegetation. Dominant shrubs include *Adenostoma fasciculatum*, *Ceanothus verrucosus*, and *Cneoridium dumosum*. The sub-shrub *Lotus scoparius* is scattered throughout. Herbaceous species found in association with *Chorizanthe* are *Mucronea californica*, *Camissonia bistorta*, and *Crassula connata*.

2.1.8. Occurrences not in the NDDB

Katherine Brandegee collected at a site on Point Loma which she identified as "... on hill NE from Brotherhood Grounds."(Reveal and Hardham 1989) This collection was made on April 28, 1905 (University of California Herbarium)(Reveal and Hardham 1989). The Brotherhood Grounds are now the site of the Point Loma Nazarene College. Several low hills lie 1-1.5 miles to the east and northeast of the former Brotherhood Grounds of the Theosophical Institute (Figure 10). They are mapped as Carlsbad gravelly loamy sand. This soil series is associated with the extant Point Loma populations (EO #'s 3, 10 and 12).

Clare Hardham observed but did not collect from a site in Torrey Pines State Reserve southwest of the Visitor Center and to the west of the parking lot and rest rooms (Pers. comm.)(Figure 7).

2.1.9. Occurrences with Indefinite Location

The oldest collection appears to have been made by C. Parry in 1881 (specimen at Missouri Botanical Gardens), who first described the species (Parry 1884). No month, day, or location data are given for the 1881 collection, according to Reveal and Hardham (Reveal and Hardham 1989). Two years later Daniel H. Cleveland collected *C. orcuttiana* on March 17, 1883 (specimen at San Diego Natural History Museum Herbarium). Cleveland and C. R. Orcutt collected it on March 12, 1884 (Accession # 7857, San Diego Natural History Museum) on Point Loma "lighthouse road near mussel beds". They made another collection the next day (Accession # 371749, Field Museum of Natural History Herbarium) at "Point Loma." According to Reveal and Hardham (Reveal and Hardham 1989), the holotype was collected by Orcutt on March 12, 1884 "on sandy soil on Point Loma, San Diego County, California." Further collections were made by either Orcutt or Cleveland on Point Loma in April of 1884 and March of 1885. Three specimens collected in April 1884 by Orcutt give only "San Diego" for

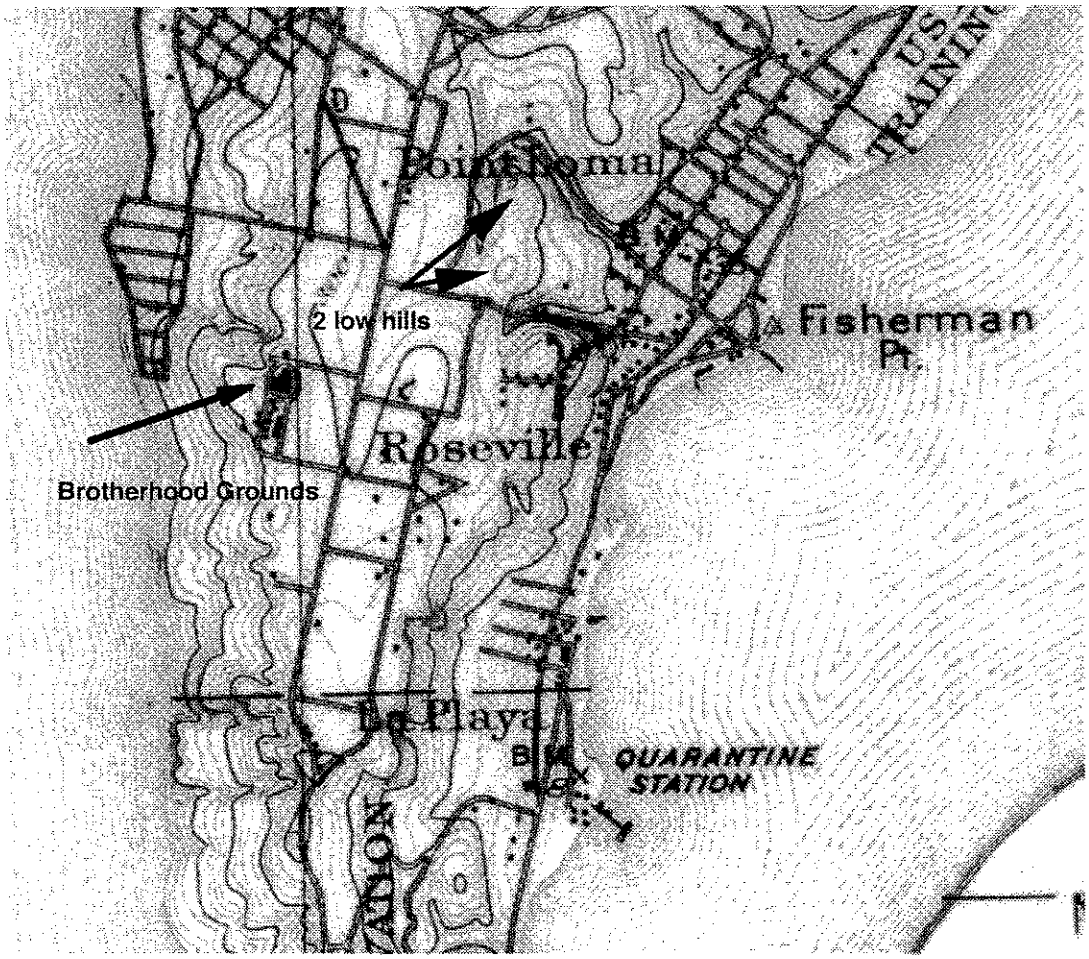


Figure 10. Unnumbered Point Loma occurrence (1930 USGS topographic map).

location. It is interesting to note that the winter of 1883/1884 was the rainiest on record in San Diego County, with records dating from 1852 (US Weather Bureau, Lindbergh Field records).

T. Brandegee collected the plant in 1897, 1905, and 1906 (Reveal and Hardham 1989). Numerous specimens were collected by Katharine Brandegee in April and May of 1906. The label for many of these specimens contained the following location information. "Point Loma Reservation, near San Diego, in the proximity of the Pacific Ocean, the only known station." Several labels say only "San Diego." However, one specimen had additional information which helped us locate an area with *C. orcuttiana* present today, quite likely the population from which K. Brandegee collected, or a remnant of that population (See discussion above of EO #3).

2.2. EXTANT POPULATIONS

At present, only three populations are extant: Element Occurrences # 3, 10, and 12. These populations are located on Point Loma (EO #'s 3 and 12) and in Encinitas (EO# 10). All others are presumed extirpated, with the exception of Element Occurrence #5 and the unnumbered EO, both at Torrey Pines State Reserve. EO #5 was last seen in 1987 by Linda Allen, then an ecologist with the California Department of Parks and Recreation. The unnumbered population was last seen in 1962. The EO #5 area was part of a prescribed burn in 1984, followed by a substantial change in the plant community (NDDB 1998). The open areas in the shrubs are now dominated by exotic grasses.

2.2.1. Point Loma

The two Point Loma populations are on US Navy land that is part of the Point Loma Ecological Reserve or proposed for inclusion in the Reserve. Access to both is restricted by fences. Roads have military checkpoints requiring badges for passage. This provides substantial protection. The Navy's awareness of the two populations and commitment to their protection also helps to reduce accidental disturbance by various military operations.

Two exotic species are impacting the Point Loma *C. orcuttiana* habitat. These are *Carpobrotus edulis* (Hottentot fig) and acacia cultivars. The *Carpobrotus* spreads out over the sandy openings in the shrub community, completely covering the soil surface and depositing a deep layer of organic duff. This plant even spreads over established shrubs. The Navy is initiating a program of *Carpobrotus* removal (Pivorunas, Pers. comm.).

2.2.2. Oakcrest Park

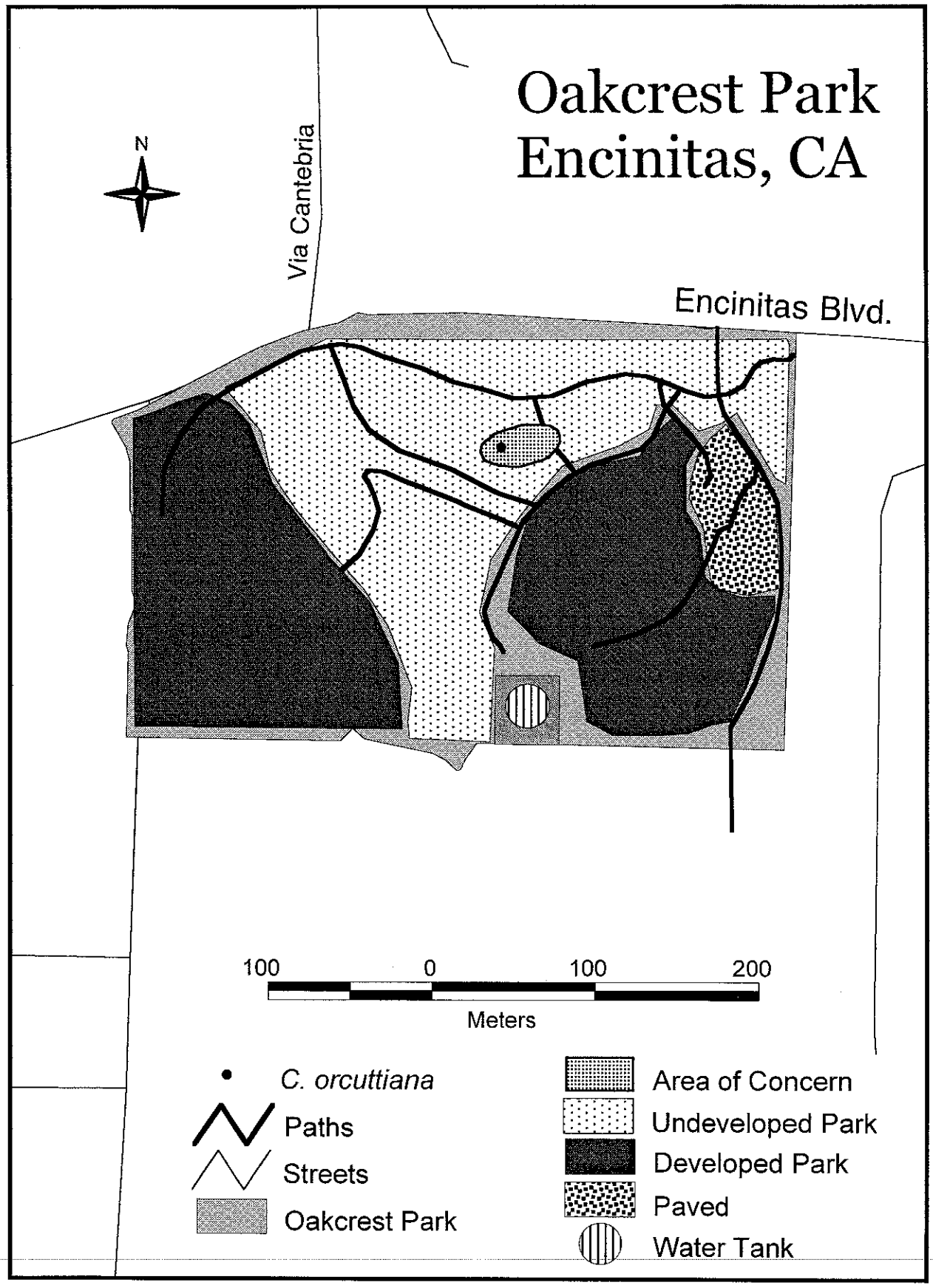
The population in Encinitas is at high risk because it is located in a small area of native vegetation within an actively-used community park, Oakcrest Park (Figure 11). Bicycle and foot paths, dogs, homeless encampments, and other disturbances directly impact the *C. orcuttiana* population and surrounding habitat. Sprinkler runoff from a nearby lawn has favored species such as *Muhlenbergia rigens* (deergrass). *Pinus torreyana* trees (Torrey pine) have been planted, and their needle duff covers much of the open soil that seems to be necessary for the growth of Orcutt's spineflower. A fuller discussion of the management issues related to Oakcrest Park is given below.

2.2.2.1. *Protection*

Several meetings were held with representatives of the City of Encinitas, the US Fish and Wildlife Service, and the California Department of Fish and Game to develop a long-term plan for protection of the *Chorizanthe orcuttiana* population and surrounding habitat. We discussed temporary construction fencing to protect the native plant habitat from impacts due to construction of a new community center. We also worked on a plan to provide greater protection to the Orcutt's spineflower habitat and surrounding vegetation. We discussed relocation of paths, installation of fencing, removal of exotics, and erection of instructional signs. Implementation of these plans is crucial to the continued existence of the spineflower and other rare and uncommon plants that grow in close association with it at this site.

2.2.2.2. *Enhancement*

We removed *Muhlenbergia rigens* (deergrass) from an area c. 4 x 10 m wide in Oakcrest Park adjacent to the *C. orcuttiana* population. In this area, the grass formed a dense thatch. Each plant had a large, shallow root system. The goal of the removal was to return the soil to a similar state as the habitat now occupied by *Chorizanthe orcuttiana.* We developed a three-stage plan. Firstly, thatch was removed with shovels and rakes. Next, the root mass was removed using picks and shovels. Finally, the remaining roots were removed by sifting the soil. The leftover roots were removed from the soils by sifting through a wooden frame which stood on four legs, several cm above the ground. Quarter-inch grid hardware cloth was attached to the frame. The top 25-30 cm of soil was removed and placed on top of the grid, then worked through the grid so that the sifted soil would fall into the newly-exposed area. The remaining


Oakcrest Park
Encinitas, CA
N
Via Cantebria
Encinitas Blvd.
100
0
100
200
Meters
C. orcuttiana
Paths
Streets
Oakcrest Park
Area of Concern
Undeveloped Park
Developed Park
Paved
Water Tank

vegetative matter was then bagged and removed. All of the plant material that was removed was placed in trash bags and placed in an on-site dumpster.

Removal of deergrass opened up a space approximately 3 x 6 m, plus two smaller spaces; c. 3 x 1.5 m and 1 x 1m. The topsoil was homogenized and is ready for replanting with native perennials which have historically been associated with *C. orcuttiana.*

Some of the *Muhlenbergia rigens* could not be completely removed because of the disturbance it would have caused to the surrounding soil in close proximity to previously observed *C. orcuttiana* individuals. In this case, just the above ground mass of the plant was removed. In another instance, some *Muhlenbergia rigens* individuals were too intertwined with Yucca plants to be removed.

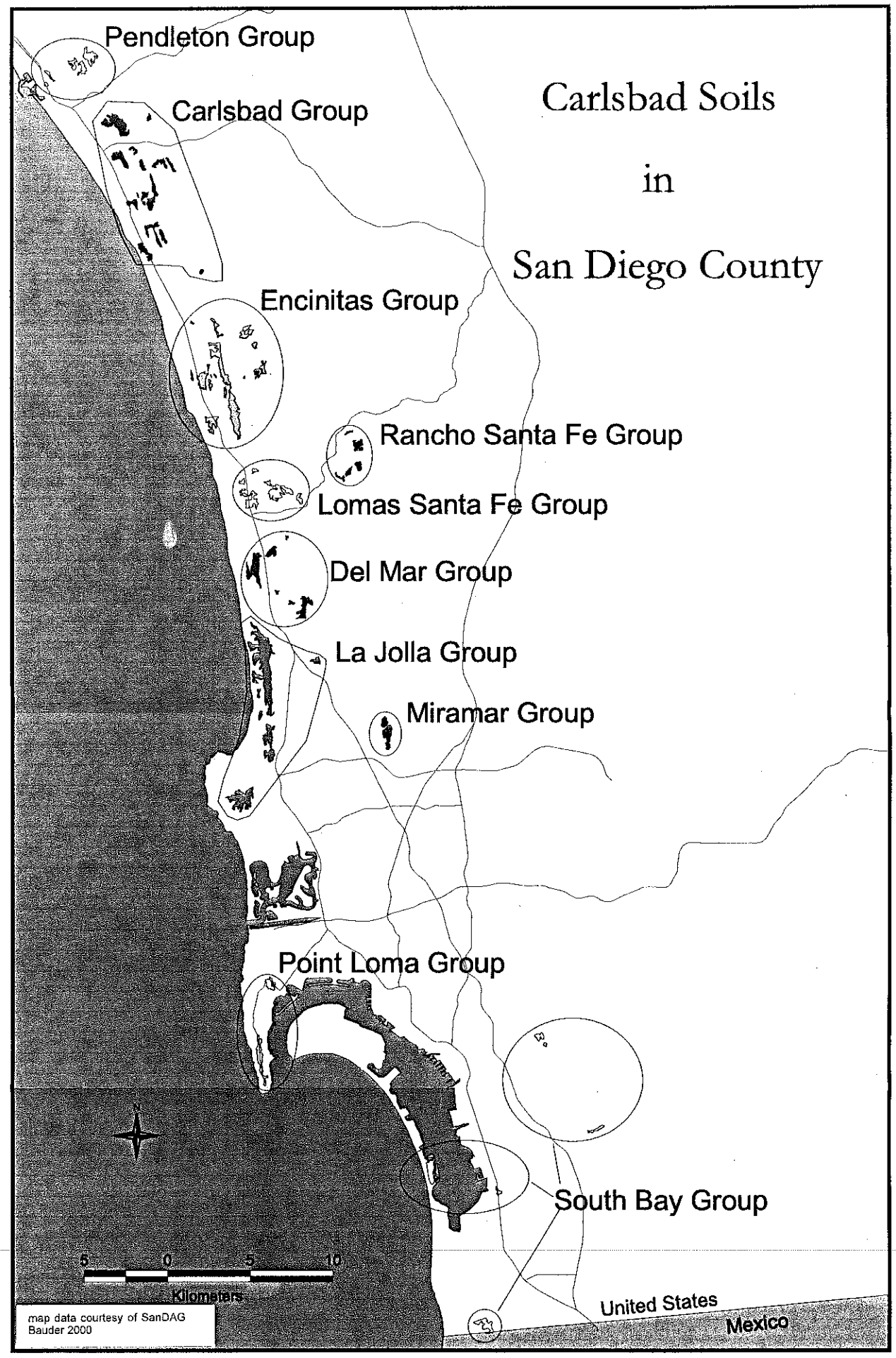
One concern in this area will be possible future erosion because of the loose nature of the replaced soil. In order to keep the soil from moving too far, we left two linear ridges of grass roots. The area should be replanted with native seed collected on site in the spring so as to block the entrance to the clearings with the *C. orcuttiana* population.

2.3. SOIL AND HABITAT CHARACTERISTICS

2.3.1. Description of soil type

The verified occurrences of *C. orcuttiana* location are all on sandy soils derived from old beach ridges, at elevations ranging from 90 m to 120 m, and within 5 km of the coast (Figures 1 and 12 plus Map Appendix A). The soils are neutral to slightly acid, drain moderately well, and often contain iron concretions (Table 2)(Bowman 1973). They are derived from ferruginous sandstone. The predominant soil type appears to be consistent with the characteristics of Carlsbad gravelly loamy sand. This soil series (including mapping units significantly altered by urbanization) accounts for 7,480 acres or 0.339 percent of the 2,204,880 acres of land in San Diego County that have been assigned to a soil series (Bowman 1973). Approximately 12 percent of the County has not been mapped.

Element Occurrences #2 (Point Loma) and #10 (Oakcrest Park, Encinitas) are both mapped as Carlsbad gravelly loamy sand (Bowman 1973). EO # 3 is located on Marina loamy coarse sand, immediately west of a soil mapping unit boundary between Carlsbad gravelly loamy sand and Marina loamy coarse sand. The Marina soil series includes


Carlsbad Soils
in
San Diego County
Pendleton Group
Carlsbad Group
Encinitas Group
Rancho Santa Fe Group
Lomas Santa Fe Group
Del Mar Group
La Jolla Group
Miramar Group
Point Loma Group
South Bay Group
5 0 5 10
Kilometers
map data courtesy of SanDAG
Bauder 2000
United States
Mexico

SOIL SERIES	Soil Texture	Soil Origins	pH Surface/ subsurface	Type of Impervious Layer	Depth of Imp Layer (Inches)	Permeability (In/Hr)	Soil Series Included in Mapping Unit	Iron Concretions
CARLSBAD	gravelly loamy sand	ferruginous sandstone weathered in place	6.0/6.5	weakly cemented sandy duripan	31-39	2.0-6.3	Chesterton, Marina, Redding	up to 20% in top 20 inches
CHESTERTON	fine sandy loam	ferruginous sandstone weathered in place	6.0/5.7	strongly cemented iron hardpan	34	2.0-6.3	Carlsbad, Huerhuero, Marina	many in top 19 inches
GAVIOTA	fine sandy loam	material weathered from marine sandstone	7.5			2.0-6.3	Diablo, Linne, Huerhuero	none
MARINA	loamy coarse sand	ferruginous eolian sand	6.0/6.7			6.3-20.0	Carlsbad, Chesterton, Corralitos	none
LOAMY ALLUVIAL/ HUERHUERO COMPLEX	surface layers lost to erosion					rapid runoff	remnants of Carlsbad, Chesterton, Huerhuero soils	
TERRACE ESCARPMENTS	loamy or gravelly	shallow soils eroded from terraces, overlie sandstone, shale, or gravelly sediments						

Table 2. Characteristics of Carlsbad and related soil series.

small areas of Carlsbad, Chesterton and Corralitos soils, so the actual location of the *Chorizanthe orcuttiana* population could well be on Carlsbad soils. The soil survey map shows EO #12 on Gaviota fine sandy loam, but the population is on soils at the toe of a low escarpment with abundant iron concretions on the surface of the eroding shelf, a feature associated with the Carlsbad and Chesterton soil series. Furthermore, the location is immediately adjacent to a mapping unit boundary between the Gaviota soil series and Carlsbad series. It is likely that *C. orcuttiana* is actually on Carlsbad gravelly loamy sand. The analysis of soil samples suggests that soil type changes just north of the population.

Two of the Element Occurrences (#'s 7 and 9) are likely on loamy alluvial soils that are remnants of Carlsbad and Chesterton soils whose surface layers have eroded away. EO #7 is perhaps part of the Oakcrest Park occurrence (on Carlsbad soils) or slightly to the east on loamy alluvial or Chesterton series soils. Mapping units of Chesterton soils can contain small areas of Carlsbad, Huerhuero, or Marina soils, and loamy alluvial soils can have remnants of Carlsbad and Chesterton soils (Bowman 1973). Element Occurrence #9 is on MCAS Miramar, just east of Convoy Street and north of SR 52. The presumed location is mapped as loamy alluvial and is surrounded by Chesterton fine sandy loam. Numerous iron concretions were present at this location.

2.3.2. Analysis of soil samples

2.3.2.1. *Methods*

Soil samples were collected from the sites of all three extant populations (EO #3, EO #10, and EO #12) plus Torrey Pines State Reserve and Crest Canyon, possible sites of historic populations (Table 3). In most of the areas, multiple samples were taken in three locations: in the sandy openings, at the edge of the shrub canopy, and under heavy duff (a *Carpobrotus edulis* mat, for example). A 6.5-cm length of sharpened steel pipe 5.5 cm in diameter was driven into the soil to loosen the surface. Each soil sample was approximately two pipe-widths wide and one deep. After removal, soils were placed in plastic freezer bags, labeled, and sealed. At the time of sampling, soils were air dry, with the exception of the soils taken at "North Brandegee" and "Crest Canyon." After returning to the lab with these samples, they were exposed to the air on labeled paper plates and allowed to dry. A total of 98 soil samples were collected.

Dried samples were transferred to labeled soil sample bags provided by A & L Agricultural Laboratories and sent to them for processing at their Modesto, CA laboratory. They

NAME OF SAMPLE	GENERAL LOCATION
Main	EO #12, Submarine Base, Point Loma
Cneoridium	same
Ceanothus	same
Drainage	North of EO# 12, at base of shallow escarpment
Herp Trap	same
Ridge	Northeast of EO #12, on point extending towards San Diego Bay
North Mesa	North of dirt access road to EO #12 area, just south of McClelland Drive
Brandegee-main	West of Strong Road, north of Woodward Road
Brandegee-east	10 m east of Brandegee -main
Brandegee-north	Various locations long edge of Point Loma's spine, extending north from EO #3
Torrey Pines	Vicinity of EO #5, west side of the TPSR Extension; near restrooms and parking lot in TPSR
Crest Canyon	East side of the canyon, below Durango Drive/Recuerdo Drive
San Elijo	Upper sandstone area off of Solana Hills Drive
Oakcrest	Oakcrest Park, site of EO # 10
Encinitas Ranch	Open space to the west of El Camino Real

Table 3. General locations of soil samples.

analyzed samples for percent organic matter (on screened soil), phosphorus (Weak Bray and Olsen methods), potassium, magnesium, calcium, sodium, soil pH, cation exchange capacity, nitrate nitrogen, sulfur, zinc, manganese, iron, copper, and boron. Soils were also analyzed by A & L for particle size distribution (% sand, silt and clay).

2.3.2.2. *Results*

All of the soil samples were texturally dominated by the sand fraction. The mean of 11 sites was 90.2% sand, with a range from a low of 82.0% to a high of 96.8%. Of the seven samples with <85% sand, three were from areas where *C. orcuttiana* has been found, but specific samples were taken from locations having heavy duff accumulation; two samples were removed from open areas where *C. orcuttiana* occurs, but duff accumulation is low; and two were taken from sites where *C. orcuttiana* is unknown. There was no significant difference in the sand fraction in samples drawn from the immediate vicinity of a verified occurrence of *C. orcuttiana* and those from sites were Orcutt's spineflowers have not been seen ($F= 0.862$, $p= .3554$, $df = 1, 96$).

The pH was significantly lower in samples drawn from sites with *C. orcuttiana* compared to those without ($F= 6.409$, $p= .0130$, $df = 1,96$). The mean pH for sites with verified occurrences was 5.3 and that for sample sites with no known occurrences was 5.7. The variability in pH among sampling sites, along with basic descriptive statistics, is given in Figure 13. Two of the sites with the highest pH (Drainage and Herp Trap) are just north of the primary population constituting Element Occurrence #12. The soils here appear different in color (more golden) than those directly associated with spineflower populations, and have a very hard layer close to the surface. This area is mapped as Gaviota fine sandy loam, a soil series that has weathered from marine sandstone, as opposed to the Carlsbad and Chesterton soils that weathered from ferruginous sandstones. The other area with a noticeably higher pH was Encinitas Ranch, an open space several miles north of the Oakcrest Park *C. orcuttiana* population.

Potassium (ppm) did not differ between samples with or without known populations of *C. orcuttiana* ($F= 0.004$, $p= .9480$, $df= 1, 96$), but the sampling sites differed significantly among themselves ($F= 2.699$, $p= .0026$, $df= 14, 93$) (Figure 14). Again, the two sites directly north of EO #12 and the Encinitas Ranch site are quite different, with substantially lower levels of potassium compared to the other areas. The Brandegee-east sampling site is only 30 m east of the Brandegee-main site, the location of EO #3, yet the two sub-sites differ

Means Table for pH
Effect: Site

	Count	Mean	Std. Dev.	Std. Err.
Main	12	5.458	.438	.126
Cneoridium	5	4.880	.444	.198
Ceanothus	8	5.225	.369	.131
Drainage	6	6.417	.445	.182
Herp Trap	3	6.500	.458	.265
Ridge	4	5.800	1.042	.521
North Mesa	6	5.083	.462	.189
Brandegee-main	6	5.017	.319	.130
Brandegee-east	7	5.429	1.412	.534
Brandegee-north	12	5.175	.427	.123
Torrey Pines	10	5.790	.656	.207
Crest Canyon	3	5.400	.436	.252
San Eiljo	2	5.950	.495	.350
Oakcrest	12	5.683	.409	.118
Encinitas Ranch	2	6.450	.071	.050

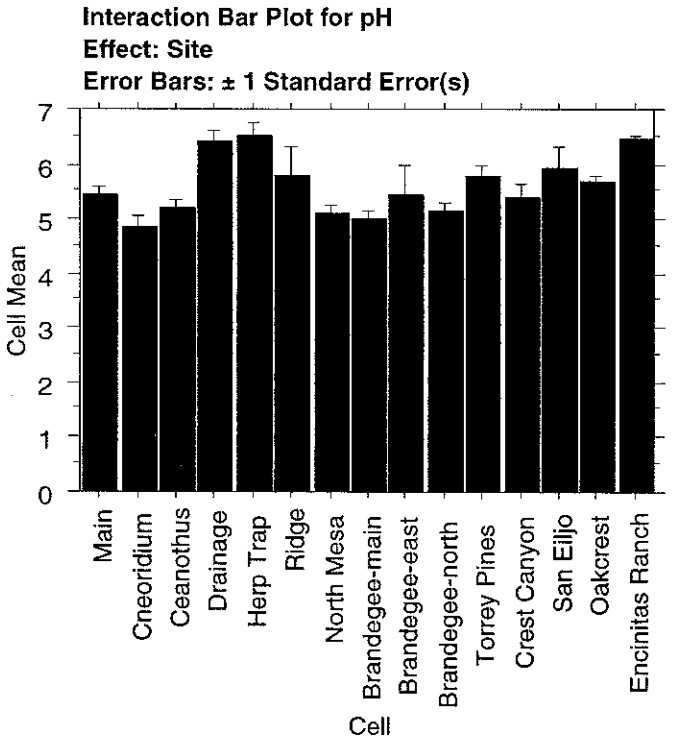


Figure 13. Means table of soil pH.

Means Table for K
Effect: Site

	Count	Mean	Std. Dev.	Std. Err.
Main	12	69.167	36.074	10.414
Cneoridium	5	68.220	31.107	13.911
Ceanothus	8	56.363	28.239	9.984
Drainage	6	38.883	15.118	6.172
Herp Trap	3	29.400	4.029	2.326
Ridge	4	76.425	28.582	14.291
North Mesa	6	48.250	14.552	5.941
Brandegee-main	6	82.950	33.639	13.733
Brandegee-east	7	120.143	33.294	12.584
Brandegee-north	12	66.767	51.066	14.741
Torrey Pines	10	86.900	48.512	15.341
Crest Canyon	3	101.400	53.947	31.146
San Eiljo	2	46.500	17.678	12.500
Oakcrest	12	95.200	34.307	9.903
Encinitas Ranch	2	36.000	.990	.700

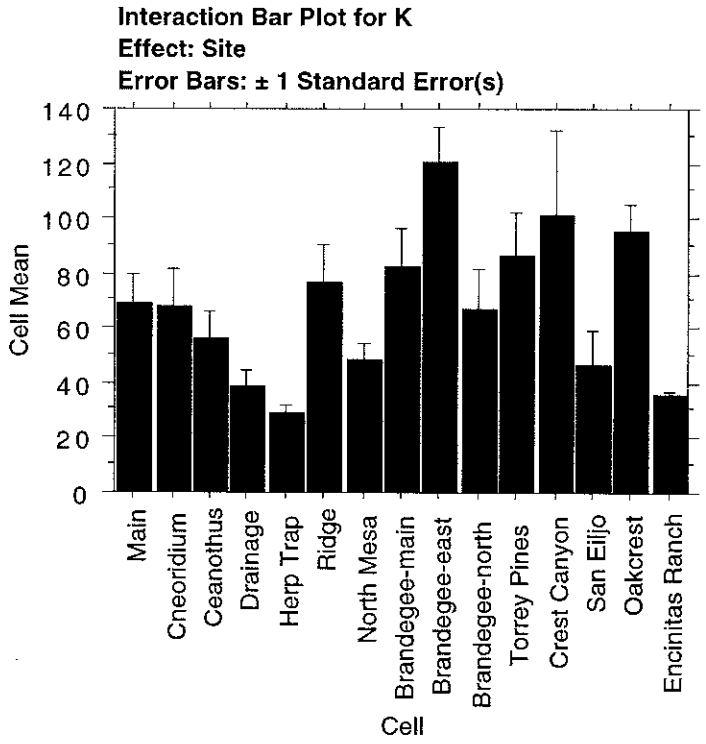


Figure 14. Means table for soil potassium.

significantly in potassium. Both are near an area that was highly disturbed at some time in the past, so the nature and extent of disturbance could be reflected in this soil parameter.

Phosphorus (ppm) was significantly different between sites (F= 4.759, p <.0001, df= 14, 83), but did not differ between sites with *C. orcuttiana* in the vicinity and those without it (F= 1.135, p= 0.2895, df= 1,96). Brandegee-east stands out once again as being exceptionally high compared to the other sites, although the second highest was Brandegee-main (Figure 15).

Organic matter differed significantly between sites (F= 3.923, P<.0001, df= 14,83) and between sites in the open and those either under the edge of the canopy or under a heavy duff layer (F= 5.932, P= 0.0037, df= 2,95), but did not differ between sites with and without *C. orcuttiana* (F= 2.837, p=0.0953, df= 1,96). The mean was only 1.01 percent. Analyses were performed on arcsine square root transformed percentages. Nitrogen as NO_3 (ppm) varied widely from site to site, but was significantly higher in samples taken from areas with *C. orcuttiana* compared to those with no *C. orcuttiana* plants (F= 4.360, p= 0.0394, df= 1,96)(Figure 16).

The cation exchange capacity (CEC) is the total amount of exchangeable cations contained by a given mass of soil. The amount of organic matter and type and amount of clay in a particular soil affect the CEC, with a high CEC favoring retention of cations against loss by leaching. Exchangeable ions supplement the small amount in solution and are a reservoir of nutrients for plant growth (Singer and Munns 1991). CEC values are low for all the sampled sites $\bar{x}$ = 4.4 meq/100g), when compared to soils with higher content of clay or organic matter (Brady 1974, Singer and Munns 1991).

2.3.3. Habitat attributes

Based on common characteristics of the three known extant sites and the historical reports, the attributes of *C. orcuttiana* habitat can be generally described. The plant occurs in loose sandy openings on gentle slopes in coastal or Maritime Chaparral, associated with eroded red sandstone outcroppings that are the remnants of ancient beach ridges. The texture of the sand tends to be fine, and varies in color from very pale to somewhat golden. All of the sites are within 5 km of the Pacific Ocean, at elevations of less than 100 m above sea level.

Shrubs common at all the sites include *Adenostoma fasciculatum, Salvia mellifera, Eriogonum fasciculatum, Ceanothus verrucosus, Cneoridium dumosum, Lotus scoparius,*

Means Table for Phosphorus
Effect: Site

	Count	Mean	Std. Dev.	Std. Err.
Main	12	7.450	1.614	.466
Cneoridium	5	10.360	4.928	2.204
Ceanothus	8	5.837	2.856	1.010
Drainage	6	5.733	2.402	.981
Herp Trap	3	4.500	1.323	.764
Ridge	4	10.275	5.949	2.974
North Mesa	6	6.833	2.935	1.198
Brandegee-main	6	18.067	6.415	2.619
Brandegee-east	7	22.514	15.844	5.988
Brandegee-north	12	11.200	5.441	1.571
Torrey Pines	10	9.400	4.789	1.514
Crest Canyon	3	10.167	4.554	2.630
San Eiljo	2	5.450	5.728	4.050
Oakcrest	12	6.000	2.634	.760
Encinitas Ranch	2	6.600	3.536	2.500

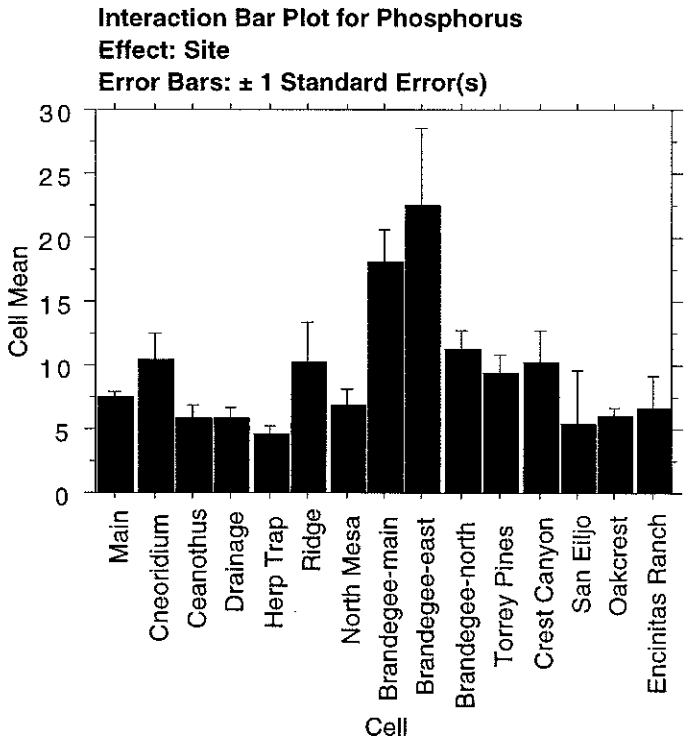


Figure 15. Means table for soil phosphorus.

Means Table for No3
Effect: Site

	Count	Mean	Std. Dev.	Std. Err.
Main	12	7.492	5.008	1.446
Cneoridium	5	2.920	1.722	.770
Ceanothus	8	3.100	1.322	.468
Drainage	6	1.850	.442	.180
Herp Trap	3	2.467	.058	.033
Ridge	4	4.800	3.811	1.906
North Mesa	6	5.083	4.870	1.988
Brandegee-main	6	15.400	8.394	3.427
Brandegee-east	7	4.314	2.940	1.111
Brandegee-north	12	7.758	9.568	2.762
Torrey Pines	10	11.100	10.785	3.411
Crest Canyon	3	5.867	3.092	1.785
San Eiljo	2	.950	.919	.650
Oakcrest	12	7.675	6.258	1.807
Encinitas Ranch	2	1.100	.566	.400

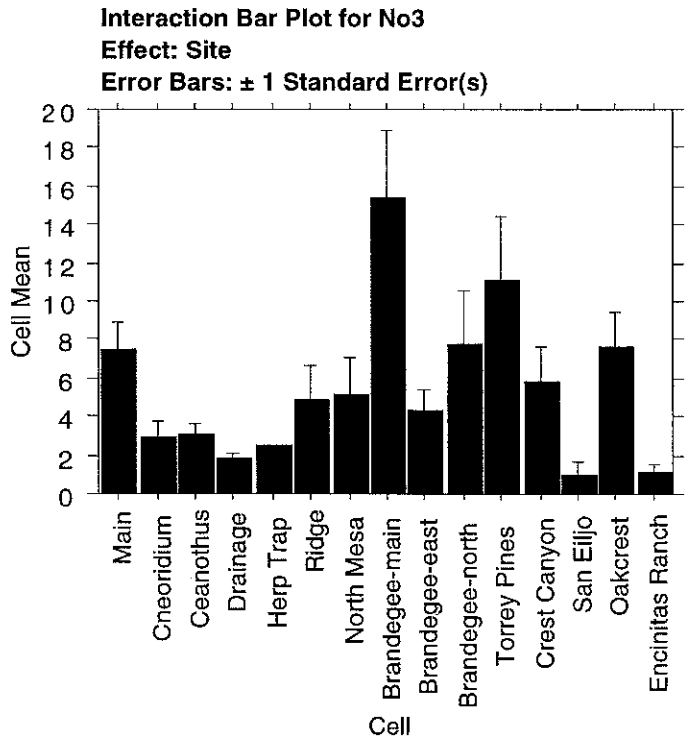


Figure 16. Means table for NO^3.

Malosma laurina, *Rhus integrifolia*, *Eriodictyon crassifolium*, *Yucca schidigera* and *Baccharis sarothroides*. Associated annuals that occur with *C. orcuttiana* include *Camissonia bistorta*, *Cardionema ramosissimum*, *Crassula connata*, *Croton californicus*, *Lastarriaea coriacea*, *Lessingia filaginifolia* var. *filaginifolia*, *Pterostegia drymarioides*, and *Stylocline gnaphalioides*. In addition, *Mucronia californica* appears to have an especially close association with *C. orcuttiana* . We have noted it only within the immediate vicinity of the two Point Loma *C. orcuttiana* population sites, and one other place on the peninsula that had the same characteristic fine, sandy substrate.

2.3.4. Weather

The San Diego coastal region has a typical Mediterranean climate, with warm, dry summers and cool, wet winters. Summer temperatures rarely rise above 25-30°, and winter temperatures rarely drop below about 5° C. Santa Ana conditions in fall and winter often bring periods of unseasonably warm, dry weather. Most of the yearly rainfall occurs between November and April. Long-term monthly climate averages for Lindbergh Field in San Diego are shown in Table 4.

The weather stations closest to the two *C. orcuttiana* populations for which data from mid-1998 to 2000 were obtainable, are Cabrillo National Monument on Point Loma (Table 5) and Palomar Airport in Carlsbad (Table 6). No long-term means were available for these stations. During the period from July 1998 through June 2000, mean monthly maximum and minimum temperatures at Cabrillo National Monument tended to be 1-2 degrees cooler than those recorded for Lindbergh field during the same period (US Weather Service data). Mean

Month	Mean Maximum Temperature (C)	Mean Minimum Temperature (C)	Mean Precipitation (cm)
Jan	19	9	4.57
Feb	19	11	3.89
Mar	19	12	4.50
Apr	20	13	2.01
May	21	15	0.48
Jun	22	17	0.18
Jul	24	19	0.05
Aug	26	19	0.25
Sep	25	19	0.61
Oct	24	16	0.94
Nov	21	12	3.68
Dec	19	9	3.99
		Yearly total:	25.15

Table 4. Long-term mean maximum and minimum temperatures and precipitation recorded at Lindbergh Field, San Diego. US Weather Service data. (www.wrh.noaa.gov/sandiego/county.html#San Diego)

Month	Max temp range (C)	Mean Max temp (C)	Min temp range (C)	Mean Min temp (C)	Precipitation (cm)
Jun-98	18-22	20	12-21	14	0.05
Jul	20-23	21	14-17	16	0.53
Aug	21-33	24	16-22	18	0.00
Sep	21-33	23	14-21	17	0.08
Oct	19-27	21	11-17	14	0.00
Nov	14-24	18	6-16	11	0.74
Dec	12-28	17	2-19	8	1.02
Jan-99	12-24	17	4-12	9	3.66
Feb	11-23	16	6-11	9	1.98
Mar	12-18	15	6-11	8	2.18
Apr	18-27	17	4-15	10	2.08
May	16-19	17	8-14	12	0.00
Jun	17-21	18	10-14	13	0.23
Jul	18-25	21	13-18	16	0.00
Aug	18-24	21	14-18	16	0.00
Sep	18-23	21	12-16	14	0.00
Oct	19-33	24	12-19	14	0.00
Nov	14-24	19	7-15	11	0.13
Dec	15-24	19	4-12	9	0.00
Jan-00	13-24	18	6-17	10	0.99
Feb	14-26	17	6-12	9	8.97
Mar	13-20	16	5-14	9	3.00
Apr	16-21	18	9-16	12	1.75
May	17-22	19	11-17	13	0.00
Jun	19-28	21	13-18	15	0.00

Table 5. Monthly maximum and minimum temperatures and precipitation recorded at Cabrillo National Monument from June 1998 through June 2000 (US Weather Service data).

Month	Max temp range (C)	Mean Max temp (C)	Min temp range (C)	Mean Min temp (C)	Precipitation (cm)
Mar-98	13-25	18	5-14	9	5.33
Apr	15-22	18	7-14	9	5.99
May	17-21	19	10-15	12	3.66
Jun	19-23	21	12-17	14	0.69
Jul	21-27	23	14-18	17	0.33
Aug	22-32	26	15-27	18	0.03
Sep	22-35	24	13-21	17	0.23
Oct	18-31	23	11-17	13	0.30
Nov	15-27	19	7-14	9	1.78
Dec	12-28	19	4-15	7	1.80
Jan-99	14-31	20	5-12	7	4.67
Feb	13-24	18	3-10	7	2.06
Mar	12-19	16	6-11	8	2.16
Apr	13-29	17	4-13	9	3.23
May	15-21	18	5-15	12	0.08
Jun	17-22	19	10-16	13	0.84
Jul	18-27	23	15-19	17	0.05
Aug	21-26	23	14-21	16	0.00
Sep	19-33	22	13-21	16	0.03
Oct	19-33	27	11-18	14	0.00
Nov	17-28	21	7-14	10	0.03
Dec	18-25	21	4-11	8	0.28
Jan-00	14-24	19	4-14	9	0.97
Feb	14-27	19	7-15	9	7.14
Mar	13-23	17	6-12	9	1.88
Apr	16-24	19	8-14	11	0.38
May	18-26	21	11-16	13	0.03
Jun	21-28	22	12-18	16	0.03

Table 6. Monthly maximum and minimum temperatures and precipitation recorded at Palomar Airport, Carlsbad from March 1998 through June 2000 (US Weather Service data).

maximum monthly temperatures at Palomar Airport were similar to those at Lindbergh field, usually within 1 degree, while mean minima were 1-2 degrees C cooler. Total rainfall during those 2 years was below normal in all coastal areas of San Diego County as a result of La Niña conditions, but neither site consistently received more or less rainfall than the other, reflecting the unpredictable pattern of localized rainfall for the region.

2.4. SITE SEARCHES

One of our project goals was to identify all suitable habitat for *C. orcuttiana* in order to search for heretofore unknown populations, re-discover populations believed extirpated, and identify potential habitat for introductions and population expansion of Orcutt's spineflower.

2.4.1. Methods

Review of the historical occurrences of *C. orcuttiana* indicated a close association between this species and soils of the Carlsbad series (Section 2.3). A systematic inspection and review of all potential sites for *C. orcuttiana* presence required maps based on the Carlsbad and associated soil series and the land use where these soils occur. We chose the ArcView 3.2 GIS system to identify "suitable sites" for *Chorizanthe orcuttiana.*

We defined clusters of "suitable sites" for *C. orcuttiana* using information from the Natural Diversity Data Base on historical locations of *C. orcuttiana*, herbarium sheets, and a monograph by Reveal and Hardham (Reveal and Hardham 1989)(Figure 17). These data were combined with digital data available from SanDAG (San Diego Association of Governments), including Soils, Landuse95, and Ownership95 coverages. Both the Landuse95 and Ownership95 data sets were from 1995 and were the most recent data sets available. The resulting maps are divided into 10 geographical groups, with four maps per group, as outlined below (Map Appendix B). From north to south, the 10 groups are: Pendleton, Carlsbad, Encinitas, Rancho Santa Fe, Lomas Santa Fe, Del Mar, La Jolla, Miramar, Point Loma, and South Bay.

The process began with extraction of the Carlsbad soil locations using the SanDAG digital Soils coverage. Because the known *C. orcuttiana* locations were always near the Carlsbad Soils—but not necessarily within Carlsbad soil mapping units—we added a 0.5 km buffer to the Carlsbad soil series mapping units. **Map A** (Map Appendix B) of each of the 10 geographical groups shows this buffer zone. Whenever Carlsbad soil is referred to, it includes the area

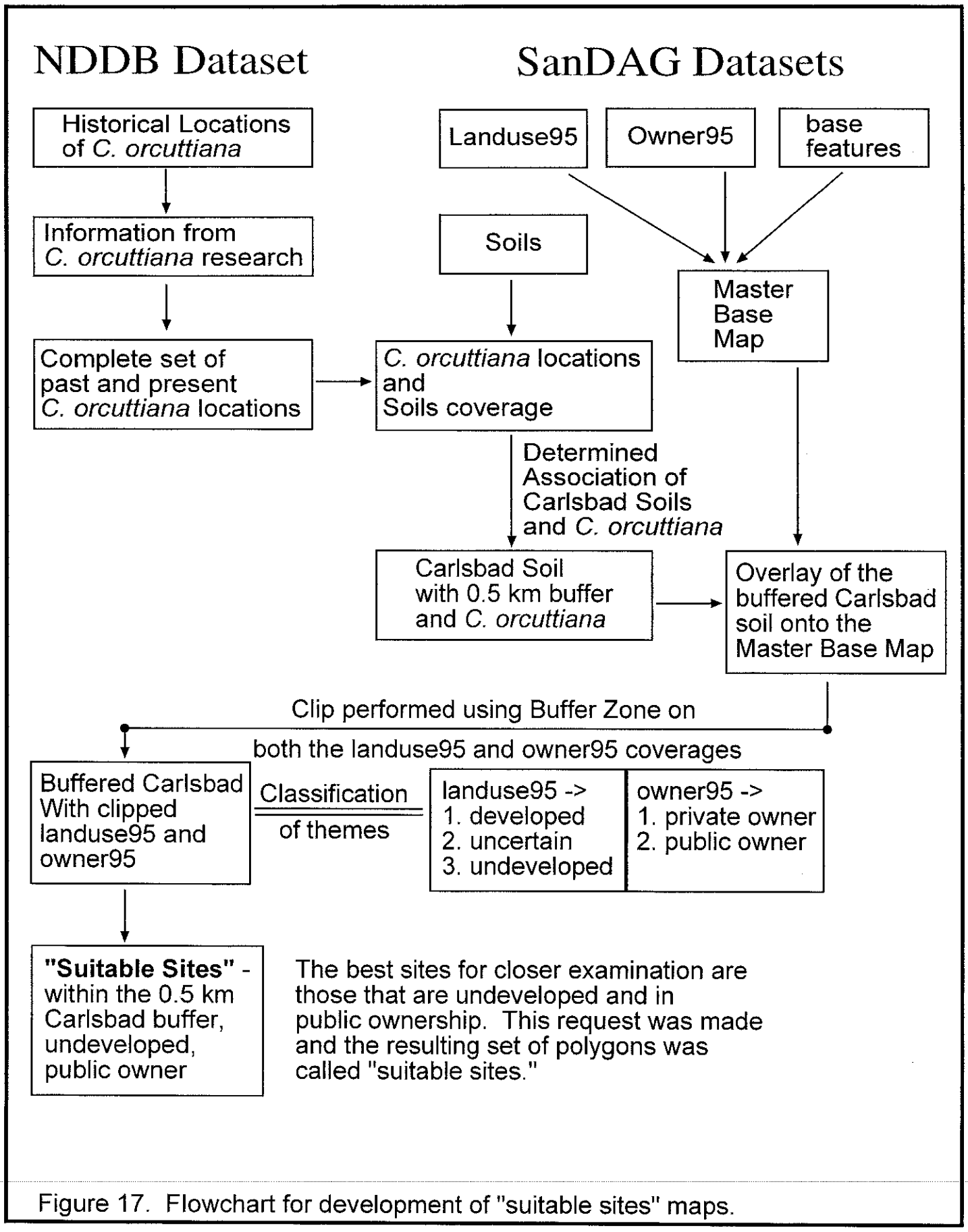


Figure 17. Flowchart for development of "suitable sites" maps.

originally mapped in the Carlsbad soil series as well as the buffer itself.

The Carlsbad soil zone was then used to clip the ownership and land use maps so that the analyzed area on these two coverages was identical to the area covered by the Carlsbad + buffer zone. Because there are several categories of land use and ownership, we aggregated the data so that they would be more useful. The various categories of ownership were assigned to public and private ownership (**Map B**)(Map Appendix B). This coverage had the parcels coded as privately owned or publicly owned by one of various agencies. All of the publicly-owned parcels, regardless of ownership, were clumped into one group.

Land use was broken down into three categories based on the likelihood of being in an undeveloped state. The three categories used were: probably undeveloped, development uncertain, and probably developed (**Map C**)(Map Appendix B). The Landuse coverage was then coded with land use types. We used those categories to decide which parcels had the highest probability of being developed. See Table 7 for the listing of how the land use categories were coded.

We now had three criteria to determine the most likely sites to search for *C. orcuttiana* habitat. The first was the presence of Carlsbad soils or within 0.5 km of Carlsbad soil mapping units. The second was whether or not the land was in public ownership. The third was the likelihood of the land being undeveloped. The most suitable sites were judged to be within the soil buffer zone, in public ownership, and probably undeveloped. Using the GIS of ArcView 3.2, we were able to get a set of sites that met these three criteria. These sites are show on **Map D** in each of the 10 geographical groups (Map Appendix B).

The set of suitable sites was used to focus our study and guide our field work. The soil associations gave us general areas for examination, but the use of the GIS enabled us to focus on specific locations within these general areas. There are some limits to the GIS model which should be noted. First, the soil maps are a generalization and may miss small pockets of suitable soils for *C. orcuttiana* (Bowman 1973). We hoped to account for this with the use of the buffer. The coverages from SanDAG code are for whole parcels of land. It is possible that a piece of land coded as a park would have land that was developed as a playing field or with park facilities in addition to undeveloped, natural open space. These considerations make it important to go out into the field to assess the areas generated by the GIS. We completed Field Survey Forms for sites we were able to visit (Appendix C). For the Point Loma sites, numbers correspond to maps in Bauder 1999.

SanDAG GIS Map Code	SanDAG Land Use Description	Assigned Status*
1	SPACED RURAL	uncertain
2	SINGLE FAMILY	developed
3	MOBILE HOMES	developed
4	MULTIPLE FAMILY	developed
5	SHOPPING CENTERS	developed
6	COMMERCIAL AND OFFICE	developed
7	HEAVY INDUSTRY	developed
8	LIGHT INDUSTRY	developed
9	EXTRACTIVE INDUSTRY	developed
10	TRANSPORTATION, COMMUNICATION, UTILITIES	uncertain
11	EDUCATION	uncertain
12	INSTITUTIONS	developed
13	COMMERCIAL RECREATION	uncertain
14	PARKS	undeveloped
15	INTENSIVE AGRICULTURE	uncertain
16	EXTENSIVE AGRICULTURE	uncertain
17	UNDEVELOPED	undeveloped
18	WATER	developed
19	INDIAN RESERVATIONS	undeveloped
20	PUBLIC/SEMI-PUBLIC	undeveloped
21	MIXED USE	developed
22	MILITARY	undeveloped

*For purposes of this study.

Table 7. Map codes used to classify *Chorizanthe orcuttiana* "potential sites" by land use category.

2.4.2. Site locations, descriptions and present condition

Following is a short description and table for each of the 10 map groups. The numbers within groups refer to numbers on the maps in each "**Map A**" in the 10 geographical areas.

2.4.2.1. *Pendleton Group*

Two mapping units of the Carlsbad soil series occur at the extreme northwestern corner of San Diego County, one on San Onofre State Beach and the other just south of San Onofre Creek on MCB Camp Joseph H. Pendleton. Several other small units occur near Oceanside Harbor and three larger ones are to the east in the vicinity of Wire Mountain (Map Appendix: Pendleton Group, **Maps A-D**). None of these was examined in the field, but our GIS analysis suggests suitable sites, as defined above, exist primarily in sub-areas 4 and 5 on MCB Camp Pendleton.

2.4.2.2. *Carlsbad Group*

Seventeen mapping units of the Carlsbad soil series are found within the cities of Oceanside and Carlsbad, from Oceanside Boulevard south to Batiquitos Lagoon. Most of them are within older residential and commercial districts, or on agricultural land. Isolated patches of native vegetation remain on steep slopes and in some canyons, but most are highly disturbed. The last piece of existing potential habitat in the southeast corner of this cluster, just north of Ambrosia Lane, is now being developed.

1 Urban, mostly residential, with a few small, highly disturbed remnants of native vegetation.

2 Some canyon open space to east and north, but mostly steep or grassy and highly disturbed.

3 Developed shopping mall, residential and Eucalyptus grove.

4 Developed residential, Eucalyptus grove.

5 Developed residential. Any open space to east is steep and/or primarily non-native vegetation.

6 Some open space to north, but mostly steep or grassy and highly disturbed.

7 Some canyon open space to east and north, but mostly steep or grassy and highly disturbed.

8 Developed residential.

9 Developed residential.

10 Developed residential.

11 Developed residential. Some open areas sloping down to lagoon, highly disturbed.

12 Developed residential. Any open space is steep and/or primarily non-native vegetation.

13 Developed residential. Any open space is steep and/or primarily non-native vegetation.

14 Developed commercial, agricultural.

15 Developed commercial, agricultural.

16 Developed commercial, residential.

17 Development in progress. Some remnants of native vegetation still remain, mostly steep, but surrounded by new housing and roads.

2.4.2.3. *Encinitas Group*

The mapping units of this group lie between the Batiquitos Lagoon and San Marcos Creek to the north, and the San Elijo Lagoon to the south. Nearly half of the total area of mapped Carlsbad soils within this group lie along a series of ridges extending north-south, on the western side of Green Valley and Lux Canyon, along El Camino Real. Oakcrest Park and the Encinitas Ranch Open Space Preserve are within this complex of ridges. The sandstone outcroppings are a prominent feature of the landscape in this mostly residential and commercial area. The ridge tops were once primarily agricultural, but are now mainly residential developments and improved parks, including the Encinitas Ranch golf course. To the east of El Camino Real, some patches of open space with natural vegetation remain, but the area is being rapidly developed, leaving only the steepest areas intact.

To the west of the series of ridges, several units occur within older neighborhoods of Encinitas and Cardiff. Most of this land has historically been mixed residential and agricultural, with much of the agricultural land recently or currently being developed. A few natural patches remain along the freeway in Cardiff between Manchester and Birmingham Drive, and within and near Quail Botanical Gardens.

1 Ridge is developed residential. Canyon to north and west mostly native vegetation, to be bought as open space preserve by City of Encinitas? Soil is sandy, but vegetation is dense with few open areas, except towards top of sandstone ridge. Worth another look in a wet year.

2 Ridge is developed residential. Areas below between escarpment and commercial development to east, La Costa Ave to north are good open space, but privately owned.

3 Ridge is agricultural, residential and golf course. Indian Head Canyon open space bounded by Saxony, Quail Hollow and Quail Gardens Dr. is disturbed native vegetation. Grassy, little or no open sand except in creekbed. To east, Encinitas Ranch open space preserve and contiguous area north to Levante has good potential habitat

4 Includes Oakcrest Park. Ridge is developed primarily residential, some agricultural. Below east escarpment, patches of native vegetation remain on private land, mostly inaccessible. Some parcels about to be developed. On southern end, steep escarpment behind Mira Costa college and agricultural fields. To southwest, slope east of I-5 mostly native, and canyon into lagoon with sewage treatment plant, rest area, disturbed.

5 Developed commercial, residential. Small, highly disturbed remnants of native vegetation along Encinitas Blvd.

6 Previously agricultural, residential development in progress.

7 Residential, agricultural.

8 Quail Botanical Gardens exotic plantings, residential.

9 Quail Botanical Gardens native vegetation area, residential, agricultural.

10 Developed commercial, residential and agricultural (Ecke Ranch).

11 Ridge overlooking I-5. Residential. Some disturbed natural vegetation on slopes east of freeway.

12 Developed residential. Some remnants of natural vegetation remain, but mostly steep One privately owned open space park.

13 Developed residential.

14 Developed residential. Sun Vista, small open space park northwest.

15 Developed commercial, residential. On west side, escarpment and remnant of native vegetation above El Camino Real.

16 Developed residential, agricultural. Several acres of natural vegetation remain along I-5 between Manchester Ave. and Birmingham Drive in Caltrans right-of-way. Not easily accessible.

2.4.2.4. *Solana Beach or Lomas Santa Fe Group*

This group encompasses 6 mapping units between the San Elijo Lagoon to the north and the San Dieguito River Valley to the south. Some potential habitat remains on the slopes along the San Elijo Lagoon within the San Elijo Lagoon Preserve, both east and west of I-5. The other possible site within this complex is the steep, undeveloped portion of San Dieguito County Park, along Lomas Santa Fe, east of Highland Drive. This park is heavily impacted with a network of eroded trails enhanced with log bridges and stairs.

1 Developed residential. Natural vegetation remaining to north on slopes above San Elijo Lagoon.

2 Developed residential. Natural vegetation remaining to north on slopes above San Elijo Lagoon.

3 Developed residential and commercial.

4 Developed residential.

5 Developed residential, agricultural, San Dieguito County Park to north has slopes with native vegetation.

6 Developed residential, agricultural.

2.4.2.5. *Rancho Santa Fe Group*

This Rancho Santa Fe Group consists of ridges north and south of the San Dieguito River, within the communities of Rancho Santa Fe and Fairbanks Ranch. Very little natural vegetation remains anywhere, as most of the area is intensively landscaped estates and gated communities.

2.4.2.6. *Del Mar Group*

All of the units in this group lie between the San Dieguito River Valley and Penasquitos Lagoon/Los Penasquitos Canyon. Two important open space preserves, Crest Canyon and Torrey Pines State Reserve Extension, are on either side of the first mapping unit of this group. Of the two, Torrey Pines Extension appears to have better quality habitat, with less obvious human impact, and less overall disturbance. Other areas of natural vegetation remain in a narrow band between the ridgetops and agricultural fields or houses on the south side of the San Dieguito River Valley, on both sides of I-5. The Carmel Mountain/ Arroyo Sorrento Area has recently been intensely developed, with open space preserves left around portions of mapping units 5 and 6. It has been difficult to make site visits to these areas because of the on-going

1 Heights are developed residential. Crest Canyon open space to west has natural vegetation, but is heavily used for recreation. Torrey Pines Extension to north appears less disturbed. Both are worth looking at again in wet years.

2 Developed residential. Natural vegetation remaining to northwest on slopes above lagoon.

3 Developed residential.

4 Developed residential and commercial.

5 Developed residential, open space areas still remain around escarpment.

6 Mostly recently developed residential. Open space areas still remain around escarpment?

construction and limited access. This mesa is probably one of the most frequently surveyed areas in the last decade or so.

2.4.2.7. *La Jolla Group*

Nearly all of the area mapped as Carlsbad soils in this group lies along the massive coastal ridge that extends from Los Penasquitos Lagoon to just north of Soledad Mountain. Torrey Pines State Preserve, at the north end of this ridge, is the site of three recorded occurrences of *Chorizanthe orcuttiana*, and remains the most likely site outside of Point Loma for rediscovery and/or reintroduction of the species. The rest of this ridge complex is almost entirely developed as business park, golf course, residential, and university. The only other remnant of several acres of native habitat is on University of California land, upslope from the Birch Aquarium. The two outlying mapping units occur to the east, just south of Sorrento Valley, and south, comprising most of La Jolla Mesa. The former is entirely business and industrial development, and La Jolla Mesa is one of the older, intensely landscaped residential neighborhoods.

1, 2, & 3 Includes Torrey Pines State Preserve, golf course, glider port, business/medical/research development along N. Torrey Pines Road, UCSD Campus. Except for Torrey Pines State Reserve most of this area is developed and altered. Some small patches of natural vegetation still exist near parking areas of the glider port and the Salk Institute, but area is heavily traveled. Slopes to the east between ridge and I-5 are dominated by grasses and weedy exotics.

4 La Jolla Shores. Old residential. The area just east is a large patch of natural vegetation on university land above aquarium, used as recreational hiking area by neighborhood.

5 Ridge top is residential, surrounded by residential, commercial, university. Pottery Canyon Park on west side is dominated by grasses, no open sandy areas apparent. Most of slopes to the east and south are mostly covered with iceplant or other erosion-controlling vegetation, and not very accessible.

6 Developed commercial.

7 La Jolla Mesa. Old residential. Any remaining open areas are steep, heavily impacted by surrounding community.

2.4.2.8. *Miramar Group*

Area 1 and most of area 2 have been disturbed: severely altered for the landfill, construction, or the air station runways. A small patch of potentially suitable habitat remains. It corresponds to the description for EO #9 (See Section 2.1.5). The soil surface is primarily eroded red hardpan with many iron concretions overlain with patches of soft, white sand. The native vegetation is diverse and appears robust, though some exotic invasives, including *Centaurea melitensis*, *Brassica nigra*, and *Cortaderia* sp. are established in patches. We noted two other *Chorizanthe* species here, *C. fimbriata* and *C. procumbens.* The site is isolated at present from human traffic, except for nearby landfill and sludge plant activities. Expansion of the sludge facility could encroach upon it. Because this is the remaining piece of habitat of an historical occurrence, it should continue to be monitored and has the potential for population expansion.

1 & part of 2 Flightline area, beyond west end of runway. A series of highly eroded, hard red sandstone rises and sandy channels. Iron concretions present. Vegetation patchy, mostly sparse. Two *Chorizanthe* species common. Extensive land alterations and disturbance in the past.

2 & EO 9 The landscape within the landfill area is almost completely altered. One remnant of low hills to southwest, just north of SR 52 and south of sludge plant, is likely the site of EO #9. This area is disturbed and graded in places, but retains some good natural habitat.

2.4.2.9. *Point Loma Group*

Several areas on Point Loma have been identified as suitable for *C. orcuttiana* population expansion (Bauder 1999), and more may be discovered with additional surveying that we will conduct in the area. The Navy's program of exotic removal should lead to rehabilitation of suitable habitat as well as enhancement of areas where *C. orcuttiana* already occurs. One area within Cabrillo National Monument needs to be examined more closely and monitored for *C. orcuttiana*. It also has the potential for population expansion.

1 Three small hills east of the Brotherhood grounds with suitable soils have been fully developed residential areas for 50 years or more.

2 Military land and Cabrillo National Monument contain areas of suitable soils. The entire flat spine of the point fits the criteria for *C. orcuttiana* habitat, but it is almost entirely developed with the lighthouse, parking lots, and the CNM visitor center; military installations; and roads. Occupied and potential habitat still exist at the edges of the developed/disturbed "spine."

2.4.2.10. *South Bay Group*

Only a very small amount of suitable soil was mapped in this area. The GIS-generated maps indicate all potential habitat has been lost, but units 4 and 5 need to be field checked.

1 Area appears open in the 1996 Aerial Fotobank Foto-Map Book, but the site has not been field checked. It may be a park.

2 The 1996 Aerial Fotobank Foto-Map Book indicates this area is completely developed.

3 The 1996 Aerial Fotobank Foto-Map Book indicates this area is completely developed.

4 The area is occupied by the US Navy Radio station. It needs to be examined for possible presence of *C. orcuttiana* as well as the potential for population expansion

5 The 1996 Aerial Fotobank Foto-Map Book indicates this area is undeveloped but disturbed by unpaved roads. It needs to be field checked.

2.4.3. Results and conclusions

Suitable habitat for *C. orcuttiana* is greatly diminished from its historic extent, which was quite small and patchy to begin with (Figure 10). Torrey Pines State Reserve and the US Navy lands on Point Loma remain the largest, most protected areas with suitable soils and co-occurring vegetation. Field checking should continue on MCB Camp Joseph H. Pendleton, several open space areas in North County, MCAS Miramar, Point Loma, and in the South Bay. Some sites that should be monitored for *C. orcuttiana* presence or considered for population expansion are discussed in detail below. Others have been noted above in the discussion of each of the 10 geographical areas.

Encinitas Ranch

The Encinitas Ranch open space preserve and the contiguous area north to La Costa Avenue is "undevelopable" according to the planning departments of Encinitas and Carlsbad (Pers. comm.). They will likely remain open space under their current city development plans. The sandstone ridge to the west is a continuation of the same ridge formation that occurs at Oakcrest Park. Because it is part of the same geologic formation, and within 2 km of the existing population, this is a preferred site for continued observation and consideration of possible future expansion, if excess seed from the Oakcrest Park population becomes available. At present, only a portion of the Encinitas Ranch area is open to the public, and access is limited to a hiking trail along the base of the escarpment. Some evidence of illegal camping was noticed, but in general, any plants that may be found or transplanted here could be protected from human traffic.

Crest Canyon, Del Mar

No *C. orcuttiana* has ever been reported from here, although small pockets of potential habitat may still remain. The possibility of a remnant population is plausible. The canyon is heavily used for recreation, and any discovered or introduced plants would be difficult to protect.

Torrey Pines Extension

This area appears less heavily used and less disturbed than Crest Canyon. It is on the eastern side of the same ridge. The use of this area is primarily restricted to pathways, leaving much of the vegetation undisturbed, though there is less oversight than in the main park. Pockets of habitat with sandy openings amid the shrubs occur on the gentler slopes with little evidence of disturbance. Any plants discovered or introduced here would be possible to protect, depending on the location.

Torrey Pines State Reserve

Two recorded sitings of *C. orcuttiana* are from the Reserve (See Section 2.1.3), so this area is important to continue to monitor. The East Grove slopes, the location of EO #5, have become dominated by grasses, with few sandy open areas remaining. The slopes just to the south are less disturbed, still open and sandy, with few exotics except for *Carpobrotus edulis*. This

section of the park is also little used by the public, since it is across the road from the main part of the Reserve, and parking along the road is restricted.

The habitat of the upper Reserve, west and south of the Visitor Center, is relatively undisturbed, and public access is strictly confined to trails. Discovered or introduced plants could be effectively protected here.

Point Loma, US Navy Land

Several areas on Point Loma have been identified as suitable for *C. orcuttiana* population expansion (Bauder 1999), and more may be discovered with additional surveying that we will conduct in the area. The Navy's program of exotic removal should lead to rehabilitation of suitable habitat as well as enhancement of areas where *C. orcuttiana* already occurs.

Point Loma, Cabrillo National Monument

Most of the suitable habitat on the Monument is occupied by the visitor center, old lighthouse, and parking lots. A small area of potentially suitable habitat still exists on a ridge southwest of the intersection of Humphreys Road and Sylvester Road.

All recommendations for population expansion must be tempered by the knowledge that the seed source is limited to only one population, EO #12. This population's persistence cannot be jeopardized by removal of seed to establish populations elsewhere. Several techniques exist that may allow for propagation of sufficient seed to provide sufficient seed for population expansions. These are discussed in Chapter 6.

CHAPTER 3. MONITORING OF KNOWN POPULATIONS

3.1. METHODS

Methods for population monitoring at the primary population on Point Loma (Element Occurrence #12) were established during the spring of 1998 as part of a study for the US Navy, on whose property the population is located (Bauder 1998). In April 1998, the established seedlings were individually marked with small wooden toothpicks and skewers. When the plants had set seed and dried, permanent transects were established in mid-July in four subsections of the population (Figure 18). A meter tape was laid down the approximate center of each subsection, and marked at regular intervals with 6-inch nails and 18-inch sections of 3/4 inch rebar. We then laid a 50 cm X 25 cm metal sampling frame, divided into two 25 cm X 25 cm sections, along each quarter meter section of the tape and flipped it end over end from the center transect line to the edges of the sandy openings (Figure 19). The number of *C. orcuttiana* individuals in each square quadrat was counted by removing the toothpicks and recording numbers on a graph paper grid. We also noted the presence of shrubs, *Carpobrotus edulis*, or 30% or greater cover of duff in each sampling section. The data were then entered into a computer graphing program and a map was generated showing the density of plants represented by circles proportional to the number of plants per quarter meter square (Bauder 1998).

The census methods were repeated in the spring of 1999 and 2000 with some modifications. We were concerned that the fragile sandy substrate would be damaged by repeated trampling if plants were counted twice during each season. In order to reduce the impacts to the habitat, monitoring activities were limited to one or two preliminary site visits to note presence of seedlings and one complete count when plants had reached maturity. In 1999, we modified our transect method in the "Main" subsection of the population to subsample one eighth of the total area, since seedlings were sparsely distributed and so small that they were difficult to spot and avoid trampling. We used the same method of flipping the frame from the transect line out to the edges, but only sampled the last 25 cm of every two-meter section. We then estimated the total number of individuals in the "Main" subsection from this fractional sample. The censuses of the other sub-sections were done as in the previous year, by counting individuals in each quadrat. In the spring of 2000, data were taken from all the subsections, as in the first year. We also continued to map the presence of shrubs, *Carpobrotus edulis*, and duff cover.

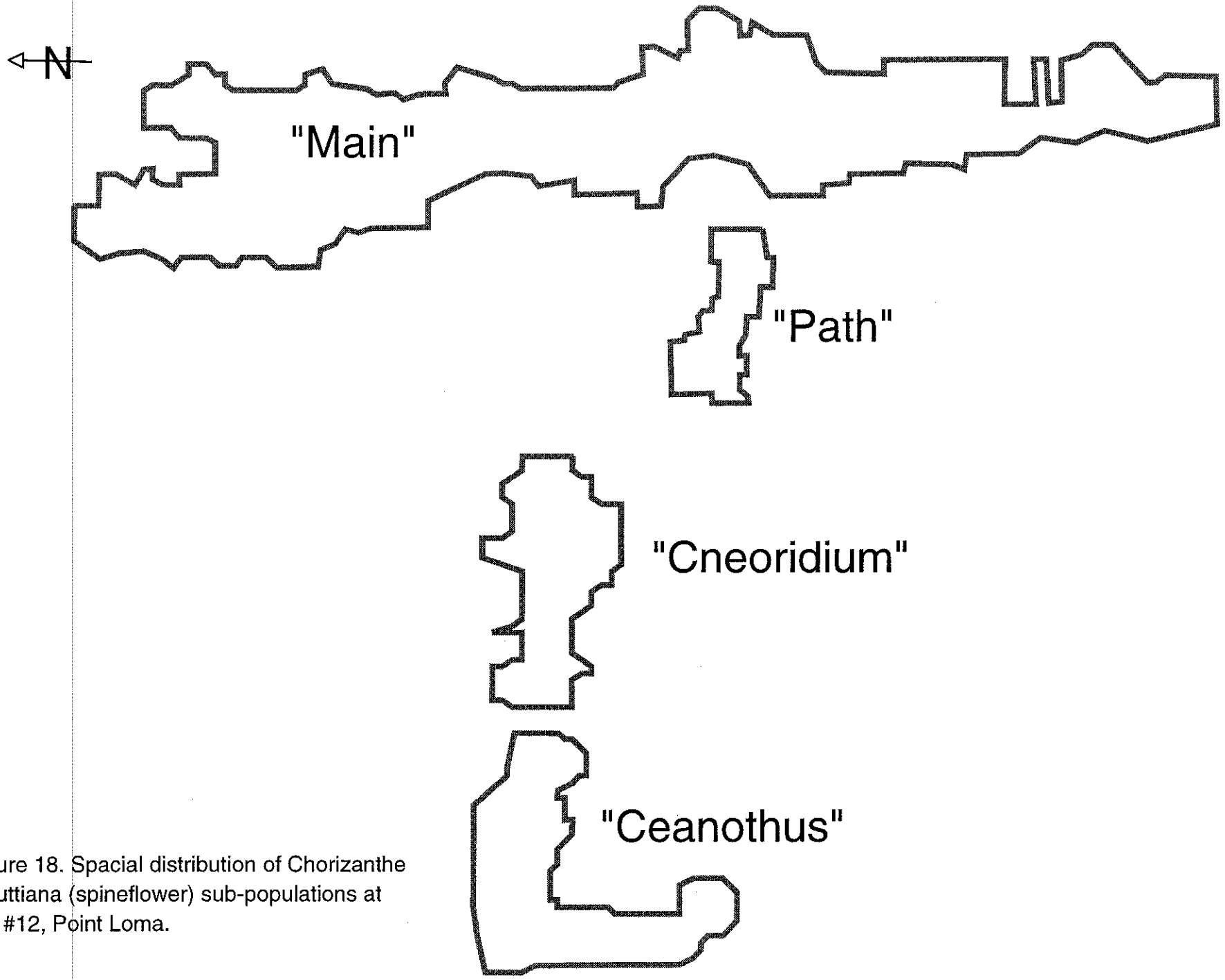


Figure 18. Spacial distribution of Chorizanthe orcuttiana (spineflower) sub-populations at EO #12, Point Loma.

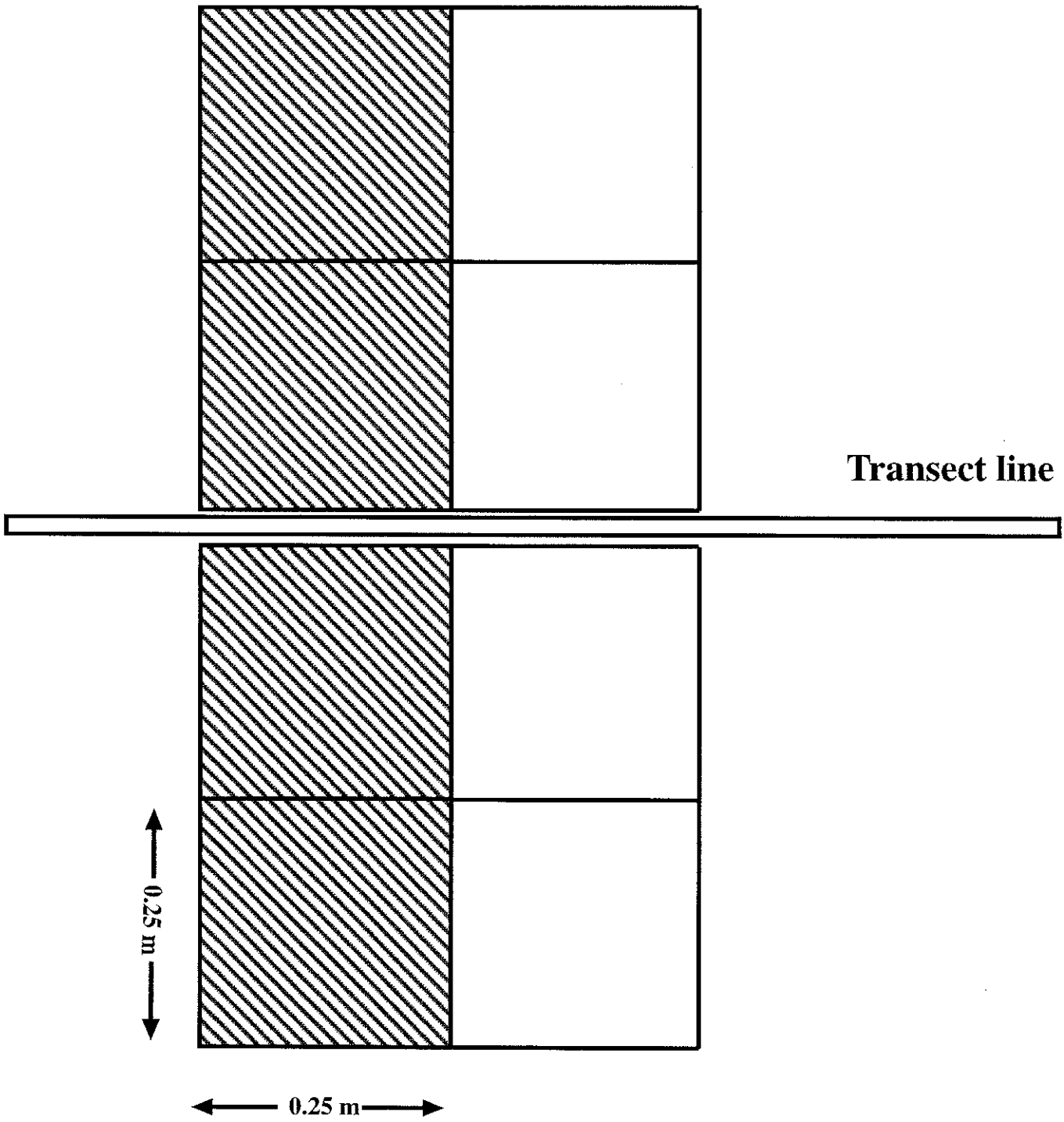


Figure 19. Hatched areas indicate two divided sampling frames. Data were taken for each half of a sampling frame (0.25 m on a side).

Because the Brandegee population is very small and clustered on the edges of a few small sandy openings, the censuses of this population were done by simply counting each individual rather than by establishing a transect. We flagged each individual in 1999, and left the flags in place. In the spring of 2000, we used the flags as a guide to the most likely spots to find seedlings, and to compare locations of this year's plants to those of the previous year.

3.2. RESULTS

In 1999, the Sub-base population (Element Occurrence #12) declined precipitously to about 16% of the individuals counted in 1998 and rebounded in the spring of 2000 to 46% of the 1998 numbers (Table 8). In the year 2000, the sub-population designated "Main" in the 1998 Navy study (Bauder 1998), still accounted for the majority of the individuals.

	1998	**1999**	**2000**
Sub-population			
Main	2213	368	
		(est. based on 46 x 8)	1157
Path	72	6	0
Ceanothus	189	20	6
Cneoridium	33	8	0
Outliers	13	1	0
Total:	2520	403 (estimate)	1163

Table 8. Element Occurrence #12 population censuses, including data from the 1998 study (Bauder 1998).

In 1999, the Brandegee population numbered 31 individuals. In 2000, we found 30 plants within the same area, plus another 17 individuals a few yards downslope, for a total of 47 plants.

At Oakcrest Park in Encinitas we found 20 plants in 1999 and only 1 individual in spring of 2000.

3.3. DISCUSSION

Two relatively dry years have apparently diminished the Sub-base population, at least temporarily. Not only did we see fewer *C. orcuttiana* individuals, but those present were smaller and had fewer inflorescence branches than in 1998. In 2000, we noted that the majority of plants were very small, approximately 1.5 cm or less, and many did not appear to have survived to reproductive maturity. We also noted this year a lack of companion plants such as *Camissonia bistorta*, *Pterostegia drymarioides*, and *Mucronea californica*, compared to previous years. The "Ceanothus" and "Cneoridium" patches were almost completely barren. In the "Main" wash section of the Sub-base population, down-hill movement of sand was evident in 2000, probably as a result of the two or three unusually heavy spring rains during the months of March and April, in an otherwise dry spring. The upper end of the wash, above the end our transect line, was scoured in some spots down to the underlying hardpan, and the sand appeared to have accumulated towards the middle of the transect line between the 10 m to 20m markers. The *C. orcuttiana* seedlings were clustered in this central section of the transect as well.

CHAPTER 4. REPRODUCTION

4.1. BACKGROUND

Our goal was to germinate seeds, cultivate plants, and use these plants to study the phenological development of flowers, including maturation of anthers and stigmas. We also intended to exclude all possible insect pollinators to see what effect this would have on seed set and to gain information on the plant's breeding system. We had difficulty germinating and growing plants, so were unable to collect these data. In the field, we had hoped to observe and collect insects in or near *Chorizanthe orcuttiana*. The task was made difficult by two exceptionally dry years in a row that resulted in a reduced number of plants, depauperate plants, mortality prior to flowering, and few flowers. Only a limited number of insects was collected.

4.2. MORPHOLOGY, HABITAT, AND POLLINATION

During the vegetative stage (late fall to early spring), *C. orcuttiana* develops a small rosette of narrowly oblanceolate leaves (Reveal and Hardham 1989). In the reproductive stage (generally April), it bolts, and the branched inflorescence can extend upwards and outwards 6-10 cm, substantially increasing the overall size of the plant (Pers. obs.). Plant size and morphology vary greatly, apparently depending on conditions for growth in a particular year and microhabitat. This has been observed in *C. pungens* var. *hartwegiana* (Kluse and Doak 1999, McGraw and Levin 1998), *C. palida* (Davis and Sherman 1992), and *Dodecahema leptoceras* (ERCE 1991; Ferguson, Witkus, and Ellstrand 1996) and examined experimentally with *C. pungens* var. *hartwegiana* (Kluse and Doak 1999, McGraw and Levin 1998). Plugs of *C. p.* var. *hartwegiana* transplanted into soil underneath pine tree canopies had greater biomass than untransplanted reference plants or plants moved to more open habitats such as chaparral, sandy openings, or grassland (Kluse and Doak 1999). Greater biomass translated into greater reproductive success when transplants under pine canopies were compared to other transplants, but not when compared to the reference plants. A strong positive correlation between final biomass and number of seeds/plant was also observed (Kluse and Doak 1999), as it has been in *Chorizanthe robusta* var., *robusta* (US Fish and Wildlife Service 2000).

Under controlled conditions, McGraw and Levin (McGraw and Levin 1998) found shading significantly reduced survivorship of *C. p.* var. *hartwegiana*, and resulted in highly elongated stems and fewer flowers per individual. Soils collected beneath pines or redwoods—presumably

higher in nutrients compared to the sandier ones where the plant normally occurs—produced larger plants, except when plants were grown with a high level of shade. It seems clear that this species of *Chorizanthe* responds to increased nutrients with greater biomass, but shading negatively impacts fitness through reduced survivorship, fewer flowers, or both. The eight individuals of *C. orcuttiana* we successfully grew from seed doubled or tripled in size within a week of receiving a watering with half-strength 15-30-15 liquid fertilizer.

Flowers of robust, shorter plants would be more congested, possibly facilitating pollination by small crawling or flying insects. The perianth of *C. orcuttiana* is very small (1.5-1.8 mm) and non-showy (pale yellow)(Reveal and Hardham 1989, Hickman 1993, Pers. obs.) and partially obscured by the fused, 3-parted involucre. Each flower has only one ovule and produces a single-seeded achene as the fruit.

A literature review of other *Chorizanthe* species and close relatives indicates that a wide array of small insects has been observed in, on, or near the plants or their flowers (Table 9). These include ants, parasitic wasps, and solitary bees. Hickman (1974) outlined a set of conditions he believed were strongly associated with ant pollination. These include a hot/dry habitat associated with high ant activity, short and/or prostrate plants with low and/or sessile flowers that can easily be reached by small crawling insects such as ants, inconspicuous blooms with limited nectar and pollen rewards to discourage use by other insects, ant-accessible nectaries, one to few ovules per flower to favor successful pollination even with limited pollen volume, and either dense populations or a plant community with few species to promote intra-specific pollen movement. From what is known about this group of Eriogonoid species, they fit closely the pattern of ant pollinated species as described by Hickman. The median perianth size of California's Chorizanthe species is 2.8 mm (minimum) to 4.0 mm (maximum) (Hickman 1993).

An in-depth insect survey of Point Loma was completed for the US Navy in 1994 (Bruyea Biological Consulting and Barnes Enterprises 1994). This survey included a review of historical records of insects collected on Point Loma and other areas around San Diego Bay. The historical review indicated records for 135 species representing nine orders and 61 families. Other individuals were identified only to genus (16 genera) or family (nine families). The survey done on Point Loma in 1993/94 resulted in identification of 173 specimens to the level of species, 86 to genus, and 38 to family only. Other specimens were still waiting to be identified at the time the report was completed. A comparison of the historical and recent survey indicated that 78 historical species records were duplicated by the 1993/94 survey,

PLANT SPECIES	INSECTS OBSERVED IN, ON OR NEAR (Order, Family, Species)	INFORMATION SOURCE
Chorizanthe orcuttiana	Argentine ant (Hymenoptera, Formicidae, *Linepithema humile*)	collected
	soft-winged flower beetle (Coleoptera, Melyridae)	collected
	halictid bee (Hymenoptera, Halictidae, Halictinae)	collected
	ant (Hymenoptera, Formicidae, Dolochoridae)	collected
	anthophorid bee (Hmenopptera, Anthophoridae)	collected
Chorizanthe parryi ssp. *fernandina*	ants of the *Dorymyrex insanus* complex	CBI 2000
	ant-like spiders (possibly *Micaria* spp.)	
	European honeybees (Hymenoptera, Apidae, *Apis mellifera*)	
	bee-flies (Diptera, Bombyliidae)	
	bumble bee (Hymenoptera, Apidae, *Bombus* sp.)	
	tachnid flies (Diptera, Tachinidae, possibly *Archytas* spp.)	
	parasitic wasps (Hymenoptera10 species, mostly Chalcidoidea)	LaPierre & Wright 2000
	bees, 3+ species (Hymenoptera, Halictidae and Andrenidae)	
	true bug (Hemiptera)	
	bean weevil (Coleoptera, Bruchidae)	
	harvester ant (Hymenoptera, Myrmicinae, *Messor* spp.)	
	harvester ant (Hymenoptera, Myrmicinae, *Pogonomyrmex californicas*)	
Chorizanthe valida	solitary ground-dwelling wasp (Hymenoptera, Sphecidae, *Bembix americanacomata*)	Liam and Sherman 1992
	yellow-faced bumblebee (Hymenoptera, Apidae, *Bombus vosnesenkii*)	
	European honeybee (*Apis mellifera*)	

Table 9 (p. 1). Insects seen in, on, or near Chorizanthe species and near relatives.

Chorizanthe robusta	leafcutter bees (Megachilidae) common hairstreak butterfly (Lepidoptera, Lycaenidae, Theclinae) unidentified skipper (Lepidoptera) buckeye (Lepidoptera) California winglet (Lepidoptera)	Morgan per Rutherford
Dedeckera eurekensis	16 Diptera (Sarcophagidae) 3 wasps damsel fly (Odonata, Zygoptera) ambush bug (Hemiptera, Phymatidae) lace wing (Neuroptera, Chrysopidae)	Wiens, et al. 1986
Dodecahema leptoceras	unidentified ants wasp (Hymenoptera, Sphecidae, *Penoculus dauisii*)	Ferguson, et al. 1996
Polygonum cascadense	ant, (Hymenoptera, Formicidae, *Formica argentea*) ant, (Hymenoptera, Formicidae, *Formica lasioides*) ant, (Hymenoptera, Formicidae, *Formica rufa*) wasps (Braconidae, Chrysidae, Icneumonidae) 2 species of syrphid flies (Diptera, Syrphidae))	Hickman 1974

Table 9 (p. 2). Insects seen in, on, or near Chorizanthe species and near relatives.

57 historical records were not duplicated by the recent inventory, and 95 species were identified during the current survey that were not part of the historical record. The tables included with the study reveal that one of the new species to be found on Point Loma that was not found in the historical records is the Argentine ant, *Linepithema humile* (Bruyea Biological Consulting and Barnes Enterprises 1994).

We collected an Argentine ant (*Linepithema humile*) in the perianth of one individual of *C. orcuttiana* and four other insects in the vicinity, but at the end of the spineflower bloom period. These included a soft-winged flower beetle (Coleoptera, Melyridae), a halictid bee (Hymenoptera, Halictidae, Halictinae), an ant (Hymenoptera, Formicidae, Dolochoridae), and an anthophorid bee (Hymenoptera, Anthophoridae).

4.4. CONCLUSIONS AND DISCUSSION

Outcrossing appears to occur in near relatives of *C. orcuttiana* such as *Dodecahema leptoceras* (Ferguson, Whitkus, and Ellstrand 1996), but this is not a reliable indicator of the breeding system of Orcutt's spineflower. Variations in breeding system among close relatives are known, and in fact an object of study (Ritland and Jain 1984, Karron 1987). Eugene Jones, working with *C. parryi* ssp. *fernandina*, has observed insect visitors to this plant, including small solitary bees and ants (Pers. comm.). He plans exclusion experiments to determine whether or not these insects are effective pollinators. This spineflower's morphological and life history traits, along with habitat preferences, are similar to Orcutt's spineflower. San Fernando Valley spineflower is a diminutive winter annual with a prostrate to spreading growth habit, a small, non-showy perianth, and distribution restricted to low-nutrient, sandy soils that occur in patches within a mosaic of scrubland vegetation.

CHAPTER 5. GERMINATION TRIALS

5.1. GENERAL METHODS

All seeds used in these trials were collected in June 1998 from the Point Loma Submarine Base population (Element Occurrence #12). They were stored in closed containers in a growth chamber at constant 10° C with 11 hours light and 13 hours dark. Involucres used for the trials were selected by appearance to be most likely to have filled seeds. Unless specified, all seeds were imbibed with involucres intact, since this is the natural diaspore for

this species. The seeds were imbibed by placing them on germination pads or filter paper in clear plastic boxes, then wetting the paper with distilled water. Boxes were placed in growth chambers with either constant or alternating day/night temperature regimes. All growth chambers were set to the same 24-hour day/night pattern of 11 hours light and 13 hours dark. Seeds were monitored for germination every 1-2 days, and the papers were re-moistened when necessary.

The temperatures used for the trials were chosen to simulate natural habitat conditions, based on US Weather Service climate records for Point Loma (US Weather Service, Lindbergh Field weather station). *C. orcuttiana* germinates in the late fall and early winter, after seasonal rains begin. Normal daytime maximum temperatures average about 18 ° C, but may range as high as about 24 ° C. Nighttime minimum temperatures average 8-10 ° C. Various temperature sequences were tried to determine if changes in temperature, especially movement from cool to warm, would induce germination. Other treatments attempted were also intended to approximate natural conditions. Leaching may occur during heavy rains when water moves across or just below the sandy soil surface, and seeds may become imbibed, then dry and be re-imbibed. Typical rainfall patterns are sporadic.

5.2. RESULTS

5.2.1. Viability

A batch of 400 involucres was examined by x-ray, a non-destructive method to determine the percentage of filled seed. The seeds were not selected for size or appearance. Analyses were carried out at the State of California Lewis A. Moran Reforestation Center Laboratory in Davis, CA. Approximately 57-59% of the seed was filled. Even if filled, the embryo may not be viable. After one of the germination trials, 10 un-germinated seeds were cut open. They had been kept 6 weeks in a chamber with an alternating temperature regime of 10/24 ° C. Of these 10 seeds, 9 had succulent, white embryos and 1 appeared to be dead. In another germination trial with 6 seeds kept at 20 ° C, 1 germinated after 8 days, and examination of the remaining seeds revealed four live embryos and one dead embryo.

5.2.2. Germination trials

Earlier trials, part of the US Navy contract to study *Chorizanthe orcuttiana*, had given us no clear directions to follow. We were able to germinate only a few seeds, with conditions of

germination inconsistent. We began our germination work for this project with close observations of the process of imbibition in the fall of 1999. We began germination trials again during the winter of 2000. Trials took place in two episodes: winter of 2000 (January and February) and fall of 2000 (September-November). We repeated the imbibition observations on a greater number of seed during the fall of 2000.

5.2.2.1. *Imbibition trial-11/2/99*

The purpose of this trial was to determine whether seeds enclosed in involucres would readily imbibe, or whether the involucre acted as a barrier preventing imbibition. Seeds were tested for impermeability by placing them on moist filter paper at room temperature, then blotting and weighing the seeds at hourly intervals (Baskin and Baskin 1998). Increase in seed weight is considered evidence of imbibition. Seed weight increases during imbibition, plateaus, then rises again with germination (Bewley and Black 1994).

Six involucres were placed on moist filter paper in closed boxes and kept at room temperature (~ 20 ° C). The weight of each was measured hourly for the first 5 hours, then at 22 and 24 hours, then once daily from day 6 through day 8 (Table 10). One seed (Seed #1) germinated after 8 days (Figure 20). The 5 remaining seeds were kept imbibed at room temperature for another 2 weeks, until the involucres molded. They were then excised from the involucres and cut open to determine the condition of the embryo. The embryos in seeds #2, 3, 5, and 6 appeared to be alive. Seed #4 had no filled seed. It also gained the least amount of weight by the end of the trial, (56% of its dry weight, compared to >100% for all the others), suggesting that both the involucre and the seed absorb water.

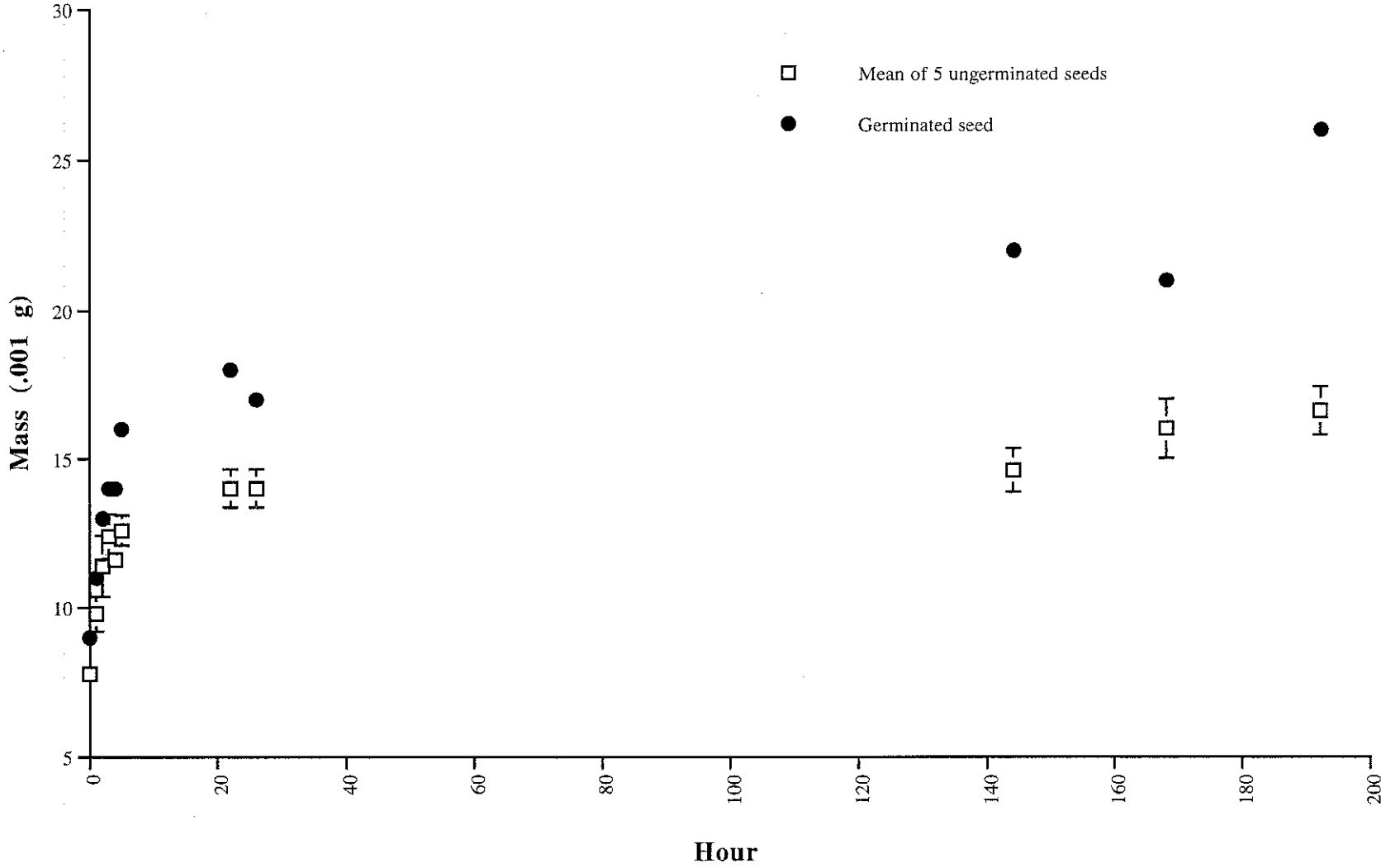


Figure 20. Change in achene mass with imbibition (mean +/- 1 s.e.).

Seeds germinated (#/seeds used)	Pre-treatment (deg C)	Germination temperature (deg C)	Involucre presence (X= yes; 0= no)
1/6	none	20	X
1/20	dark, 10	10/22	X
1/6	10	10/24	0
2/6	8 --> 22	10/24	0
2/12	8/18 -->22	10/24	0
1 + /12	none	8/18	X
2	8/18	10/24	0
1/40	10	10/24	X
3/80	none	10	X
3/80	leaching	10	X
4/20	none	10	0
5/20	none	10/24	0
2/11	10 dark/wet--> 10/22 dried, rewetted	10	0
Total 28/313			

Table 11. Summary of germination successes.

Seed mass (.0001 g)

	Seed number 1	2	3	4	5	6
Dry weight	9	7	8	9	7	8
1 hour	11	11	8	11	10	9
2 hours	13	13	8	11	14	11
3 hours	14	15	11	12	13	11
4 hours	14	13	11	12	11	11
5 hours	16	13	14	12	11	13
22 hours	18	15	15	12	13	15
26 hours	17	16	14	12	14	14
6 days (144 hr)	22	16	15	12	14	16
7 days (168 hr)	21	17	17	12	17	17
8 days (192 hr)	26	19	17	14	16	17

Table 10. Mass of imbibing *C. orcuttiana* seeds within involucres.

5.2.2.1. *First set of germination trials-Winter 2000*

The first set of germination trials resulted in the germination of only 2 seeds out of 126 (Table 11). Germination conditions included: constant 10 ° C; alternating 10/22 ° C followed by a temperature increase to 15/25 ° C; and seeds kept in the dark for 40 days at 10 ° C, followed in sequence by two levels of alternating warm/cool temperatures. During all trials, moldy seeds were removed as seeds were examined for germination. After completion of trials, seeds remaining were returned to the constant 10 ° C chamber and allowed to dry. Eight months later, some of these seeds were excised from their involucres and re-imbibed. Two seeds of one batch of 11 germinated at a constant 10 ° C.

5.2.2.2. *Second set of germination trials-Fall 2000*

The second set of germination trials resulted in the germination of 24 seeds out of 396 freshly imbibed seeds and two seeds out of 11 seeds remaining from the first trial. These latter two seeds had been allowed to dry and were rewetted.

A Chi-squared test on these data indicate that germination success was not independent of the temperature regime or presence/absence of involucre ($p = .0492$, $df = 1$)(Table 12). From these limited results, it appears that removal of the involucre facilitates germination. What

	With involucre	Without involucre
Constant cool temperature	6	6
Alternating cool/warm temperature	2	12

Table 12. Relationship of germination with temperature regime and presence/absence of the involucre.

this means in the native habitat is uncertain because seeds are tightly held in their involucres at the time of maturity, and removal of the involucre requires manipulation with dissecting needles. Since seeds retain viability for several years, it may be that it takes several years for the involucre to deteriorate to the point where it no longer impedes germination.

5.2.2.3. *Imbibition trial-9/20/00*

As part of a set of germination trials, we weighed six sets of 6 seeds each (all still in their involucres) every 2 hours during the first day, and then once a day up to the twelfth day. They increased in mass during the first 24 hours, leveled off, and ceased to gain, with the exception of the one seed that germinated (Figures 21-22). After 37 days, the remaining unmolded/ungerminated seeds were excised from their involucres. Of these 39 seeds, 7 germinated within the next 2 weeks.

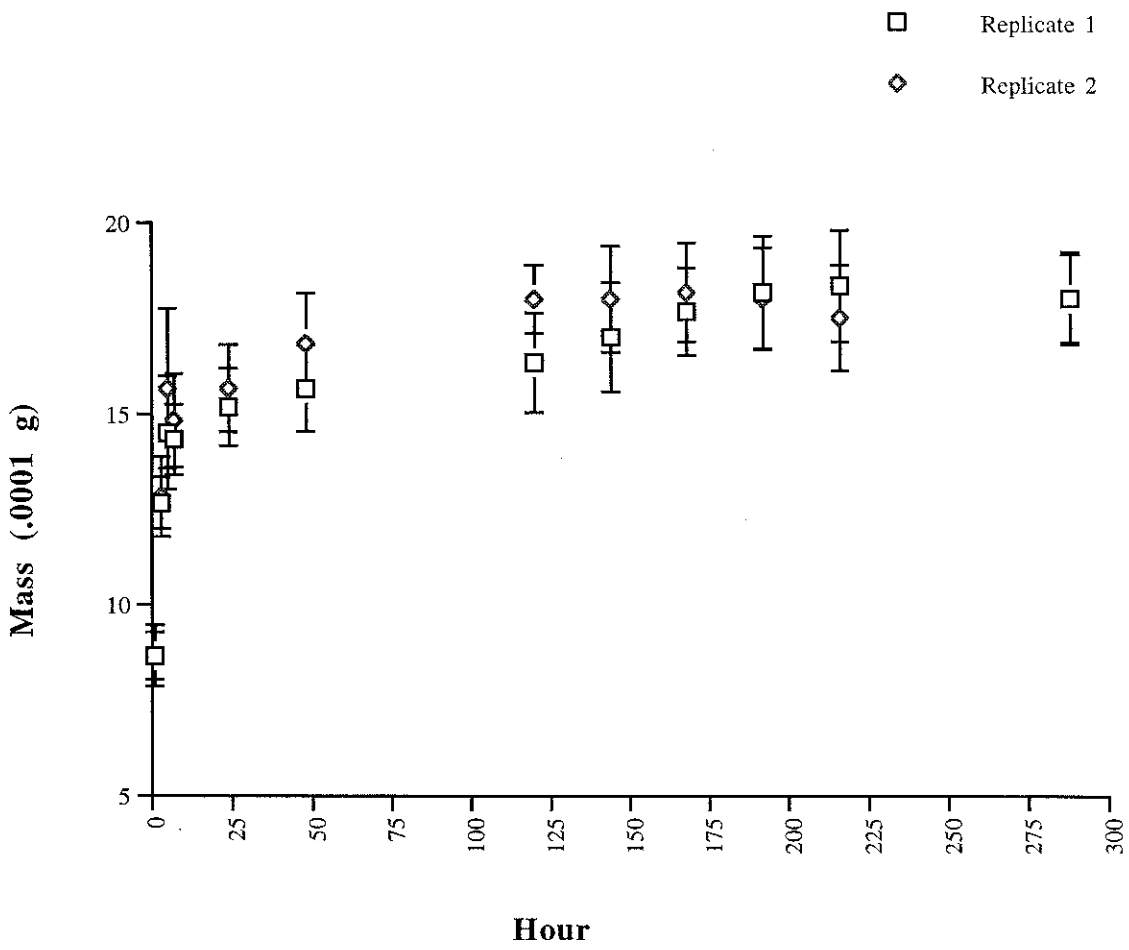


Figure 21. Change in achene mass (mean +/- 1.s.e.) during imbibtion at 8° C, two replicates with n= 6 each.

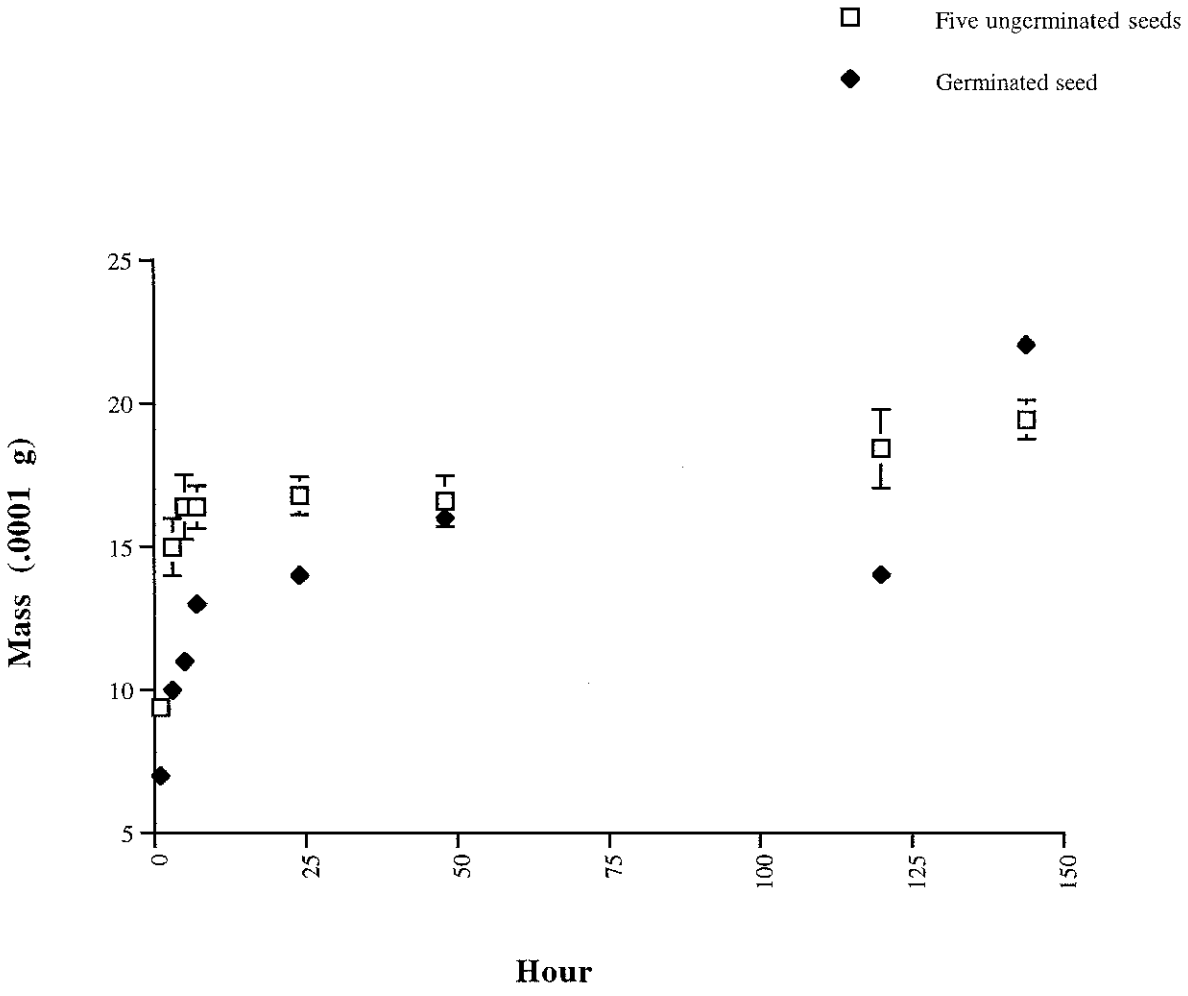


Figure 22. Change in achene mass (mean +/- 1 s.e.) during imbibition at 10/24° C of five ungerminated seeds and one that germinated.

5.3. COMPARISON TO OTHER STUDIES

Michael Wall, the Seed Program Manager at Rancho Santa Ana Botanical Gardens, germinated 20 out of 30 excised (involucres removed) *C. orcuttiana* achenes that were collected from Oakcrest Park, Encinitas in 1997 (Pers. comm.). The seeds sat in a drier unit (at unknown temperature) for 2 years before germination. They were exposed to 14 days of cold-moist stratification at 5° C, then alternating 12/20° C with 11 hours light and 13 hours dark for another 21 days. Many of the seeds germinated during the cold stratification.

Several germination trials were also conducted at RSF on 2 varieties of the closely related species, *Chorizanthe parryi* var. *parryi* and *C. parryi* var. *fernandina* (Table 13) The percent germination for seeds in involucres ranged from 16 to 73% in four tests with cold stratification of 2-3 weeks at 5° C, followed by alternating 12/20° C. Many germinated during the cold stratification. Two tests without cold stratification gave 36% and 46% germination, with the second one including leaching. Excision of seeds from their involucres increased the mean germination to 40-92%. In eight tests, cold stratification appeared to give some advantage. The effect of leaching is less clear, though many seeds also germinated within 24 hours while being leached.

Chorizanthe parryi var. *parryi*

Treatment	Pre-treatment	% germination	
18 C, 11 hr. daylight Germination paper	none	15-45% mean 29%	n=740
18 C, 11 hr. daylight Germination paper	Cold, moist stratified 2 c for 14 days	49-86% mean 65%	5 replicates of 100 each

Chorizanthe parryi var. *fernandina*

Treatment	Pre-treatment	% germination	
With involucre 20/12 C, 11 hr day on agar	none	expected ? 50-60%	
With involucre 20/12 C, 11 hr day on agar	Cold, moist stratified 5 c for 21 days	16% est. viability 63%	n=100
With involucre 20/12 C, 11 hr day on agar	Cold, moist stratified 5 C for 14 days	1) 30% est. viability 81% 2) 25% est. viability 76%	2 replicates of 100 each
Bare seed 20/12 C, 11 hr day on agar	none	56% est. viability 98%	n=50
Bare seed 20/12 C, 11 hr day on agar	none seed coat clipped after some had germinated	46% before clipping, 96% after clipping	n=24
Bare seed 20/12 C, 11 hr day on agar	Cold, moist stratified 5 c for 21 days	18% prior to cold stratification 68% after est. viable 96%	n=50

Table 13 (p. 1). Results of germination trials on species related to *Chorizanthe orcuttiana*. Data are courtesy of M. Wall at Rancho Santa Ana Botanic Garden.

Dodecahema leptoceras

Treatment	**Pre-treatment**	**% germination**	
Greenhouse soil flats	none	Mean 47%	4 replicates of 25 each
Greenhouse soil flats	Cold, moist stratified on filter paper 2 c for 14 days	90%	n=100
Greenhouse soil flats	Cold, moist stratified on filter paper 2 c for 31 days	77-90% mean 84%	n=31, n=26, n=10, n=45

Table 13 (p. 2). Results of germination trials on species related to *Chorizanthe orcuttiana*. Data are courtesy of M. Wall at Rancho Santa Ana Botanic Garden.

5.4. DISCUSSION

Out of approximately 500 seeds exposed to various treatments, only 28 germinated. Several factors that may contribute to the low germination success are:

1. Age of seeds

The seeds used in these trials were collected in July 1998, and were 1.5-2 years old. However, 15 seeds were cut open after being imbibed for 6 weeks or more without germinating. Of these, 13 were alive and two were dead. A few were kept moist on filter paper and began to grow. Loss of viability due to age does not seem to explain the difficulty with germination.

2. Low viability

A batch of 400 involucres was sent to the State of California Lewis A. Moran Reforestation Center Laboratory in Davis for x-ray, a non-destructive method to determine the percentage of filled seed. The analysis estimated that approximately 57-59% of the seed was filled. The batch sent was not selected for size and appearance, while those used in the germination trials were selected, and so more likely to be filled. Even if filled, the embryo may not be viable, but as mentioned above, most of the seeds cut open after trials appeared to have healthy, living embryos.

3. Unbroken dormancy

It is possible that some specific dormancy mechanism is involved, such as a particular temperature sequence or chemical cue. Cold stratification is often used to break dormancy, and in this case, we chose 8° C as an appropriate minimum cold temperature, since on-site minimum temperatures rarely fall below this, and daytime temperatures would be well above it.

4. Lack of after-ripening

C. orcuttiana seeds may require a longer period of exposure to summer heat to mature properly. The seeds used were collected in June after plants had dried. According to our dataloggers that monitor soil surface temperature, the temperature at ground level in summer can reach 40° C or more. Our seeds have been stored at about 10° C, since cool storage is

generally recommended to prolong the life of seeds (Bewley and Black 1994). This may account for the appearance of many unfilled embryos in the x-rays. On the other hand, Wiens et al. (Wiens, D., C. I. Davern, and C. L. Calvin 1988 cited in Nickrent and Wiens 1989) found that the exceptionally low seed set of *Dedeckera eurekensis* was apparently due to embryonic lethals.

5. Mechanical barriers to radicle emergence

Research on 21 species of *Polygonum* indicated that after-ripening, startification, and the pericarp were important elements in seed germination (Justice 1941). Metzger (Metzger 1992) subjected *Polygonum convolvulus* seeds to various treatments and concluded that stratification promoted germination, as did removal of the pericarp and seed testa. For low temperatures to be effective, seeds/achenes had to be imbibed first. Treatments that promoted water uptake did not necessarily increase germination rates. He concluded that there was a mechanical barrier to radicle emergence and applied treatments such as sand abrasion and sterilzation, to study the possible effects of abrasion and microorganisms in degrading the pericarp and testa. Neither technique indicated higher germination rates of treated seeds compared to untreated ones, leaving the matter of the mechanism still open to speculation.

CHAPTER 6. SUMMARY CONCLUSIONS, DISCUSSION, AND MANAGEMENT RECOMMENDATIONS

6.1. SUMMARY CONCLUSIONS

Rarity of *Chorizanthe orcuttiana* (Orcutt's spineflower) appears to stem from four factors: fidelity to a specialized habitat, extensive loss of that habitat, low population numbers and fecundity, and specific requirements for germination. Analysis of soils, examination of locations of verified occurrences of the plant's presence, and reference to the San Diego County Soil Survey all point to a habitat with loose, sandy, low-nutrient soil derived from ferruginous sandstones that once formed beach ridges. This habitat was never extensive and most of it has been lost to development.

C. orcuttiana plants occur in open patches of sandy soil or under the canopy edge of surrounding perennial shrubs. Population numbers are low and fluctuate widely from year to year. Our difficulty in germinating seeds suggests that the proper conditions for germination may not be present in most years, resulting in the wide range of population numbers. Field observations further indicate that seedlings may not survive to reproduction, or if they do, are depauperate and produce few achenes. Little is known about the breeding system and whether or not inbreeding or pollinator limitation may be factors in the rarity of this species.

Chorizanthe orcuttiana is not present in the shade or where duff is thick. This is consonant with research on related species and also with research in general on species of highly specialized habitats. Generally, these narrow endemics do not prefer or require the conditions in the specialized habitat, but are out-competed in more favorable locations by larger, faster-growing species. Hence, spineflowers may tolerate dry, low-nutrient soil patches rather than prefer them. Further evidence of this is their positive response to nutrient additions and reduced growth with heavy shade treatments.

6.2 DISCUSSION AND MANAGEMENT RECOMMENDATIONS

Extant populations need to be protected in the strongest ways possible. At highest risk is the small population at Oakcrest Park, a situation that demonstrates the difficulties associated with protecting native vegetation in conjunction with active recreational uses. This was recognized at the time of development of the park, but most of the recommendations in the Draft EIR were not followed (County of San Diego 1978). The proposed measures for protective

fencing, improved trails and trail markers, exotic removal, and public education will need to be implemented and sustained if this population is to survive.

Access to the Point Loma populations is already limited due to their presence on US Navy land. Education of Navy personnel, particularly those who might be involved in construction or other land-altering projects, could be important in preventing damage to the two populations or to habitat that might be considered for introduction of propagules. Signage should be considered in numerous areas to prevent accidental disturbance. Removal of exotics such as *Carpobrotus edulis* (Hottentot fig) and cultivated acacia should be undertaken and continued until these detrimental species are eliminated. Drainage from culverts, especially those draining under Cabrillo Memorial Drive, needs to be dealt with by constructing dissipators or small retention basins at the outfalls. Erosion and siltation are occurring in areas where Orcutt's spineflower might exist or have the potential to become established.

Field checking and monitoring of areas identified as "suitable" sites needs to be continued. Areas for introduction could then be prioritized. One of the primary barriers to population expansion and recovery for this rare plant are the low population numbers coupled with low seed production. At present, insufficient seed is being produced to justify introduction in areas deemed to have the potential for sustaining new populations. Some measures should be explored to enhance seed production of plants that germinate in the wild, and pursuit of germination and cultivation of plants under controlled conditions must be continued. In the wild, seedlings could be lightly sprayed with water on a regular basis to enhance survival, growth, and presumably greater seed production. Spraying has been a successful way to water the few plants we have under cultivation. It also mimics the extensive fog drip we have witnessed on Point Loma. Moisture enhancement would need to be accomplished without trampling the fragile sand crust and small plants, including *C. orcuttiana*, that occupy the sandy openings. Every so often, fertilzer could be added to the water to promote growth. It is unlikely that these nutrient additions would favor weeds, due to the limited extent of the applications, but the areas would need to be monitored to prevent such an occurrence.

More detailed observations of flowering and insect visitation of Orcutt's spineflower, as well as the associated flora, are recommended, again, taking care not to damage plants in the process. This is a more difficult task than it might seem, on account of the fragile soil surface and diminutive stature and shallow root system of *C. orcuttiana*. If more plants can be grown in a greenhouse setting, observations could be made on them (our original goal), sparing the native habitat from further disturbance. Understanding the breeding system and any dependence on

pollinators would provide valuable information on management of the vegetation surrounding occupied or potential habitat. However, pollinator limitation does not immediately suggest itself as a problem, based on the substantial seed production of other *Chorizanthe* species. Relatedness does not necessarily eliminate the possibility that the fundamental biology of *C. orcuttiana* is quite different.

LITERATURE CITED

Baskin, C. C. and J. M. Baskin. 1998. Seeds: Ecology, biogeography, and evolution of dormancy and germination. Academic Press, San Diego, CA.

Bauder, E. T. 1989. Drought stress and competition effects on the local distribution of *Pogogyne abramsii*. Ecology 70(4): 1083-1089.

————. 1998. *Chorizanthe orcuttiana* (Orcutt's spineflower), Season 1 Summary

————. 1999. *Chorizanthe orcuttiana* (Orcutt's spineflower), Second Annual Report. Natural Resources Office, Southwest Division, Naval Facilities Engineering Command, San Diego, CA and Natural Resources Office, Navy Region Southwest, Naval Air Station North Island, San Diego, CA

————. 2000. Inundation effects on small-scale plant distributions in San Diego, California vernal pools. Aquatic Ecology 34(1): 43-61.

Bauder, E. T. and J. Sakrison. 1997. Autecology of San Diego thornmint (*Acanthomintha ilicifolia)*. California Department of Fish and Game, Sacramento, CA.

Bauder, E. T. and D. Truesdale. 2000. A comparison of *Hemizonia conjugens* (Otay tarplant) with two closely related tarplant species using enzyme electrophoresis and soil textural analysis. California Department of Fish and Game, San Diego, CA.

Bauder, E. T., S. McMillan and P. Kemp. 1994. Surveys and assessment of known *Acanthomintha ilicifolia* populations. California Department of Fish and Game, Sacramento, CA.

Bewley, J. D. and M. Black. 1994. Seeds: Physiology of development and germination, Second Edition. Plenum Press, New York and London.

Bowman, R. H. 1973. Soil survey of the San Diego area, California. Soil Conservation Service, U.S. Department of Agriculture, Washington, D. C.

Brady, N. C.. 1974. The nature and property of soils, 8th edition. Macmillan Publishing Co., Inc., New York.

Bruyea Biological Consulting and Barnes Enterprises. 1994. Insects on Point Loma Navy property, San Diego, California: Sensitive insect survey, historical survey for sensitive insects, comprehensive insect inventory. Prepared for Subase Environmental Naval Command, San Diego, CA.

California Department of Fish and Game, Natural Diversity Data Base. January 2000. Special plants list, Sacramento, CA. 119 pp.

Conservation Biology Institute. 2000. Review of potential edge effects on the San Fernando Valley spineflower (*Chorizanthe parryi* var. *fernandina*. Prepared for Ahmanson Land Company and Beveridge and Diamond, LLP. San Diego, CA.

County of San Diego, Community Services Agency. 1978. Draft Environmental Impact Report: Oakcrest Community Park, Encinitas, California, Project UH 8357. San Diego, CA.

Davis, L. H. and R. J. Sherman. 1992. Ecological study of the rare *Chorizanthe valida* (Polygonaceae) at Point Reyes National Seashore, California.

ERCE. 1991. Seed collection, germination, and propagation studies: Slender-horned spineflower, *Dodecahema* (Centrostegia) *leptoceras.* Report to California Department of Fish and Game, Sacramento, CA.

Federal Register. 1996. 61FR 52370 52384, October 7, 1996.

Ferguson, N., F. Whitkus, and N. C. Ellstrand. 1996. Investigation into the population biology of *Dodecahema leptoceras* (Slender-horned spineflower). Report prepared for the California Department of Fish and Game, Long Beach, CA.

Gander, F. 1937. Notes on the flora of San Diego County, California. Madroño 4: 33-34.

Hickman, J. C. 1974. Pollination by ants: A low-energy system. Science 184: 1290-1292.

————. 1993. Polygonaceae: Buckwheat family. pages 854-895 *in* J. C. Hickman, editor, The Jepson manual: Higher plants of California, University of California Press, Berkeley, CA.

Justice, O. L. 1941. A study of dormancy in seeds of Polygonum. Memoir 235. Cornell University Agricultural Experiment Station, Ithaca, NY.

Karron, J. 1987. A comparison of levels of genetic polymorphism and self-compatibility in geographically restricted and widespread plant congeners. Evolutionary Ecology 1: 47-58.

Kluse, J. and D. Doak. 1999. Demographic performance of a rare California endemic, *Chorizanthe pungens* var. *hartwegiana* (Polygonaceae). American Midland Naturalist 142: 244-256.

LaPierre, L. and P. Wright. 2000. Preliminary report: Survey of ant species and other arthropods associated with the San Fernando Valley spineflower with a discussion of potential pollinators and seed dispersers, Ahmanson Ranch, Ventura County, California

McGraw, J. M. and A. L. Levin. 1998. The roles of soil type and shade intolerance in limiting the distribution of the edaphic endemic *Chorizanthe pungens* var. *hartwegiana* (Polygonaceae). Madroño 45(2): 119-127.

Metzger, J. D. 1992. Physiological basis of achene dormancy in *Polygonum convolvulus* (Polygonaceae). American Journal of Botany 79(8): 882-886.

Nickrent, D. L. and D. Wiens. 1989. Genetic diversity in the rare California shrub *Dedeckera eurekensis* (Polygonaceae). Systematic Botany 14 (2): 245-253.

Oberbauer, T. A. 1978. Botanical and vegetation survey of the Oak Crest Park property, Encinitas. Integrated Planning Office, County of San Diego, San Diego, CA.

————1993. Soils and plants of limited distribution in the Peninsular Ranges. Fremontia 21: 3-7.

Parry, C. C. 1884. Chorizanthe, R. Brown: Revision of the genus, and rearrangement of the annual species—with one exception, all North American. Proceedings Davenport Academy of Natural Sciences 4: 43-63.

Reveal, L. and C. B. Hardham. 1989. A revision of the annual species of *Chorizanthe* (Polygonaceae: Eriogonoideae). Phytologia 66(2): 98-198.

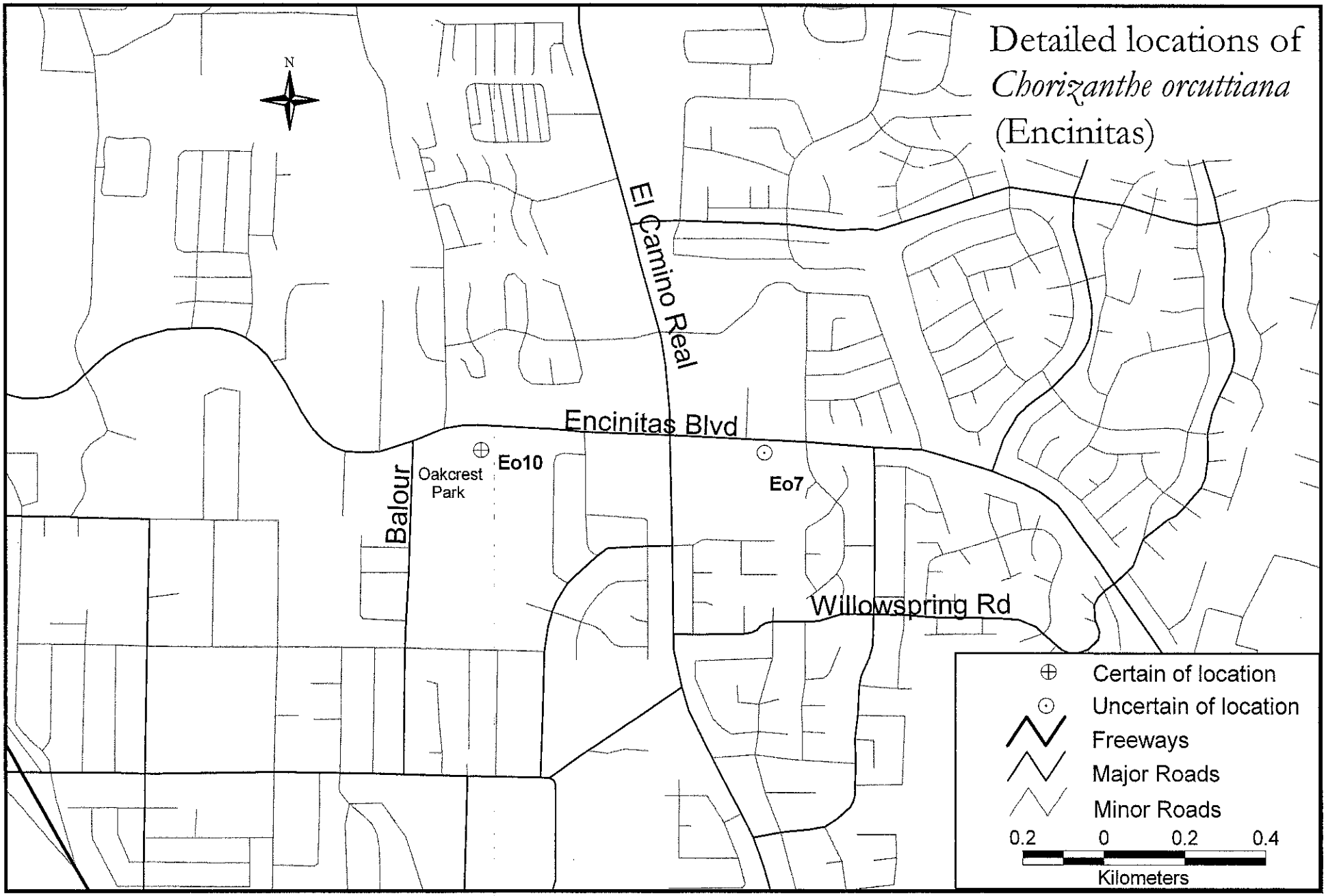
Ritland, K. and S. Jain. 1984. The comparative life histories of two annual *Limnanthes* species in a temporally variable environment. The American Naturalist 124(5): 656-679.

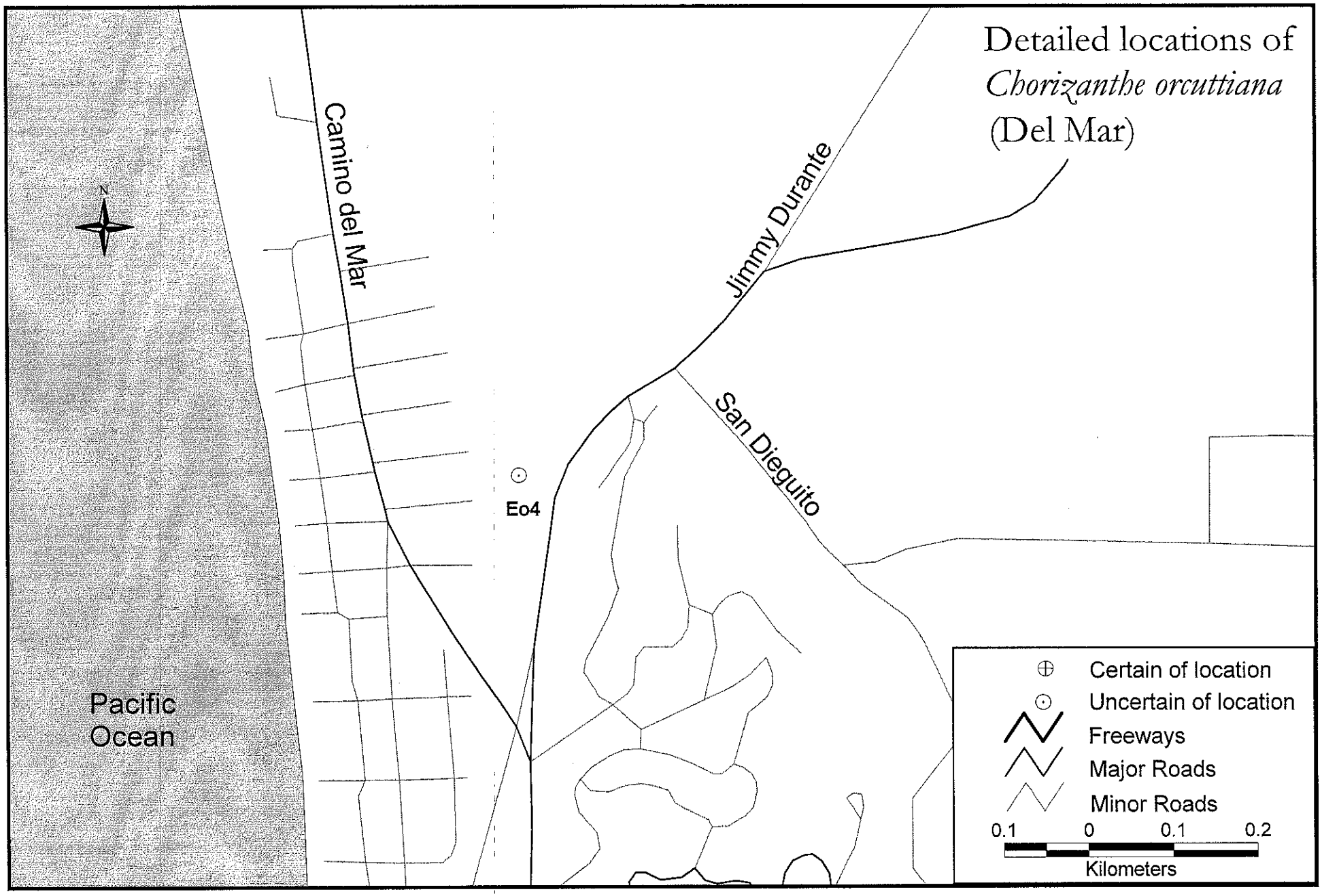
Singer, M. J. and D. N. Munns. 1991. Soils: An introduction, second edition. Macmillan Publishing Company, New York.

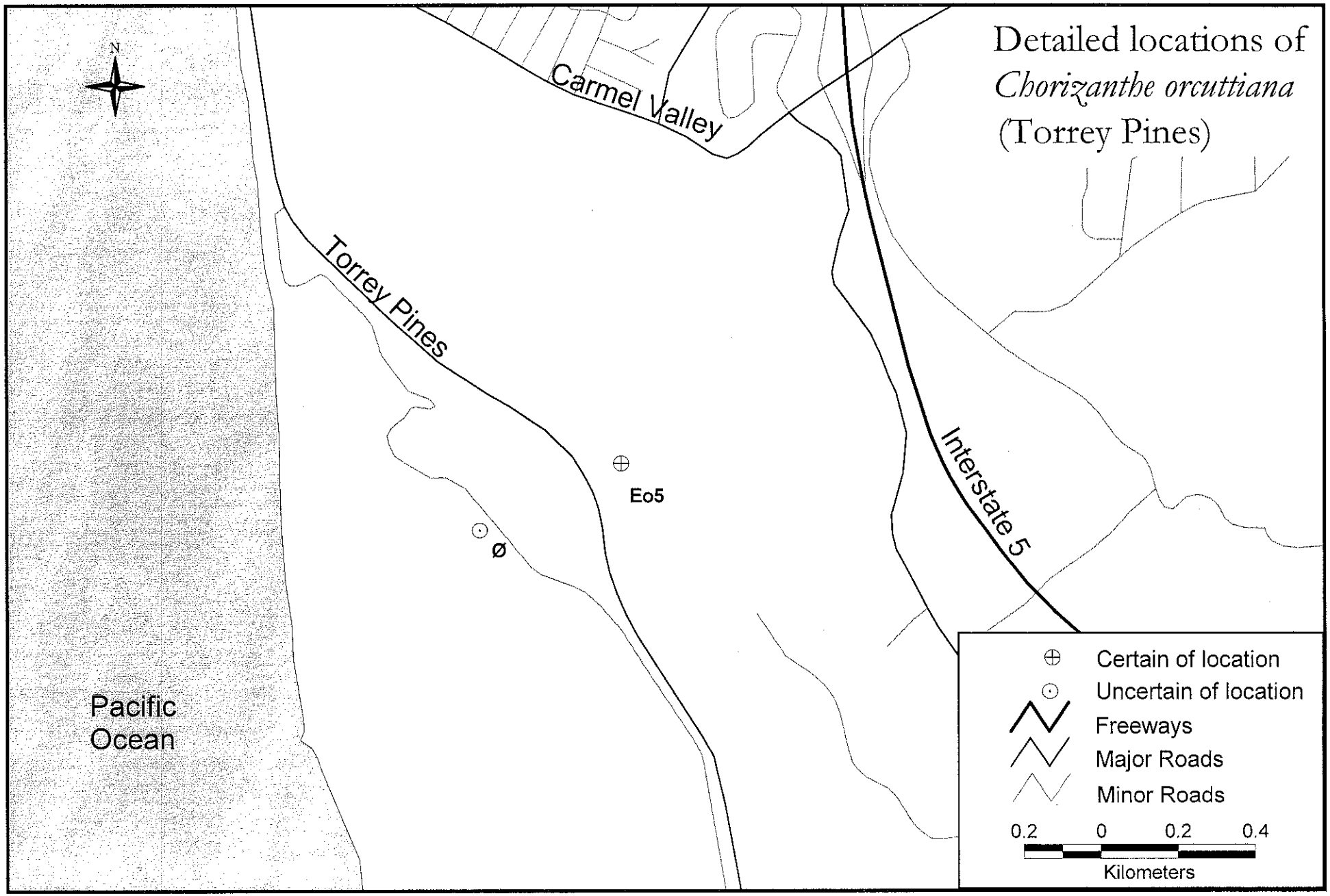
US Fish and Wildlife Service. 2000. Draft recovery plan for the robust spineflower (*Chorizanthe robusta* var. *robusta*). U. S. Fish and Wildlife Service, Portland, OR.

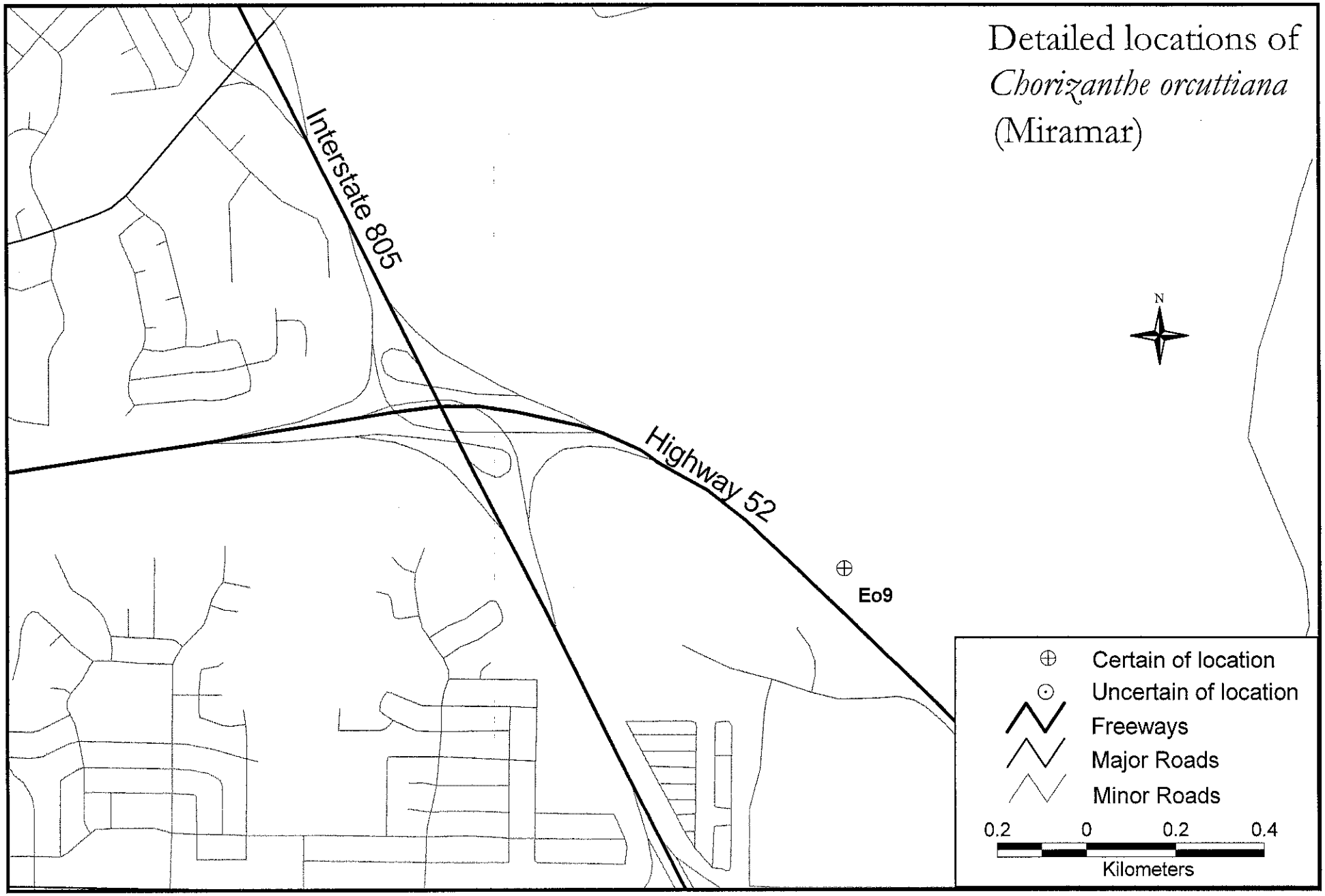
Wiens, D., M. DeDecker, and C. D. Wiens. 1986. Observations on the pollination of *Dedeckera eurekensis* (Polygonaceae). Madroño 33: 302-305.

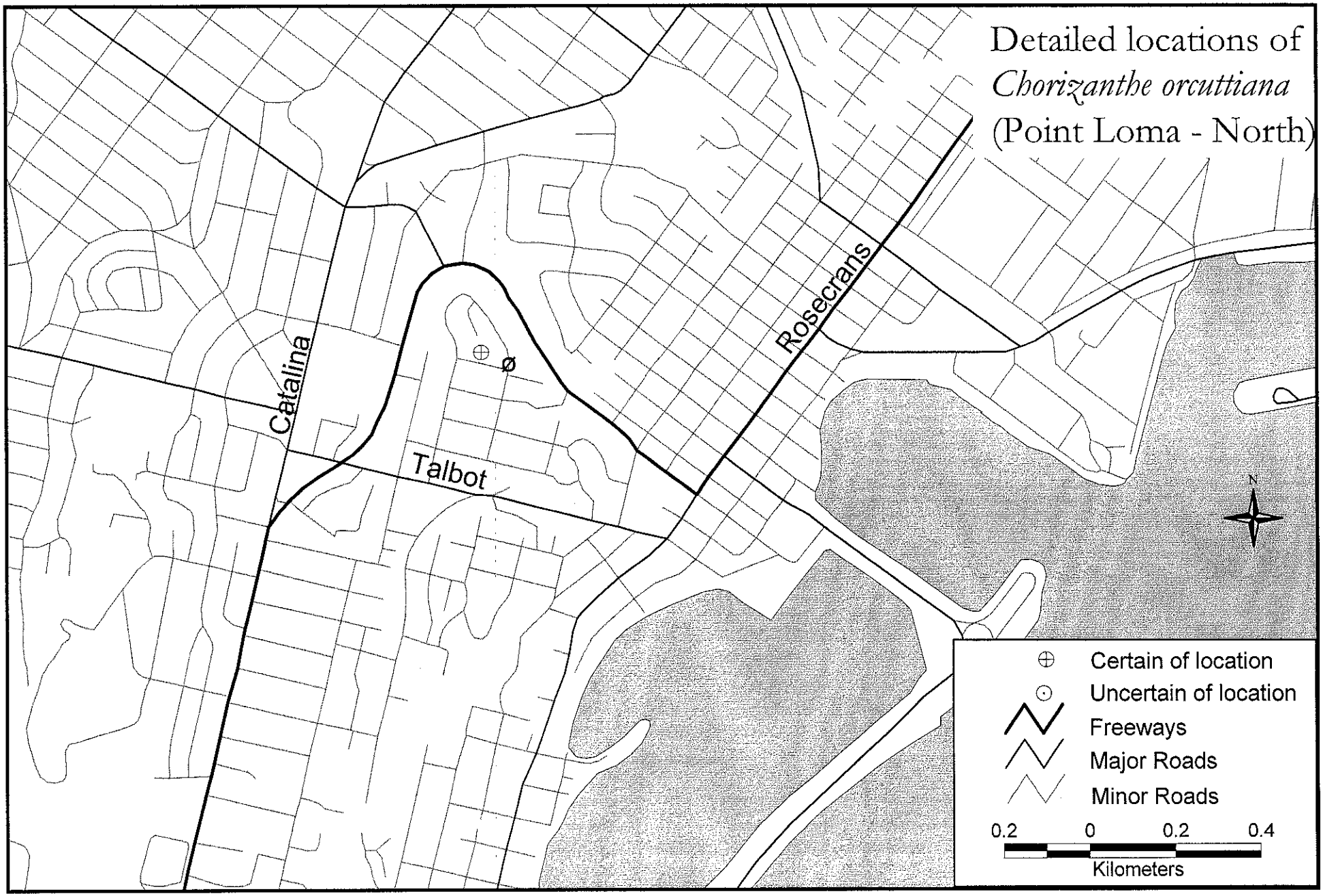
MAP APPENDIX A
HISTORIC LOCATIONS

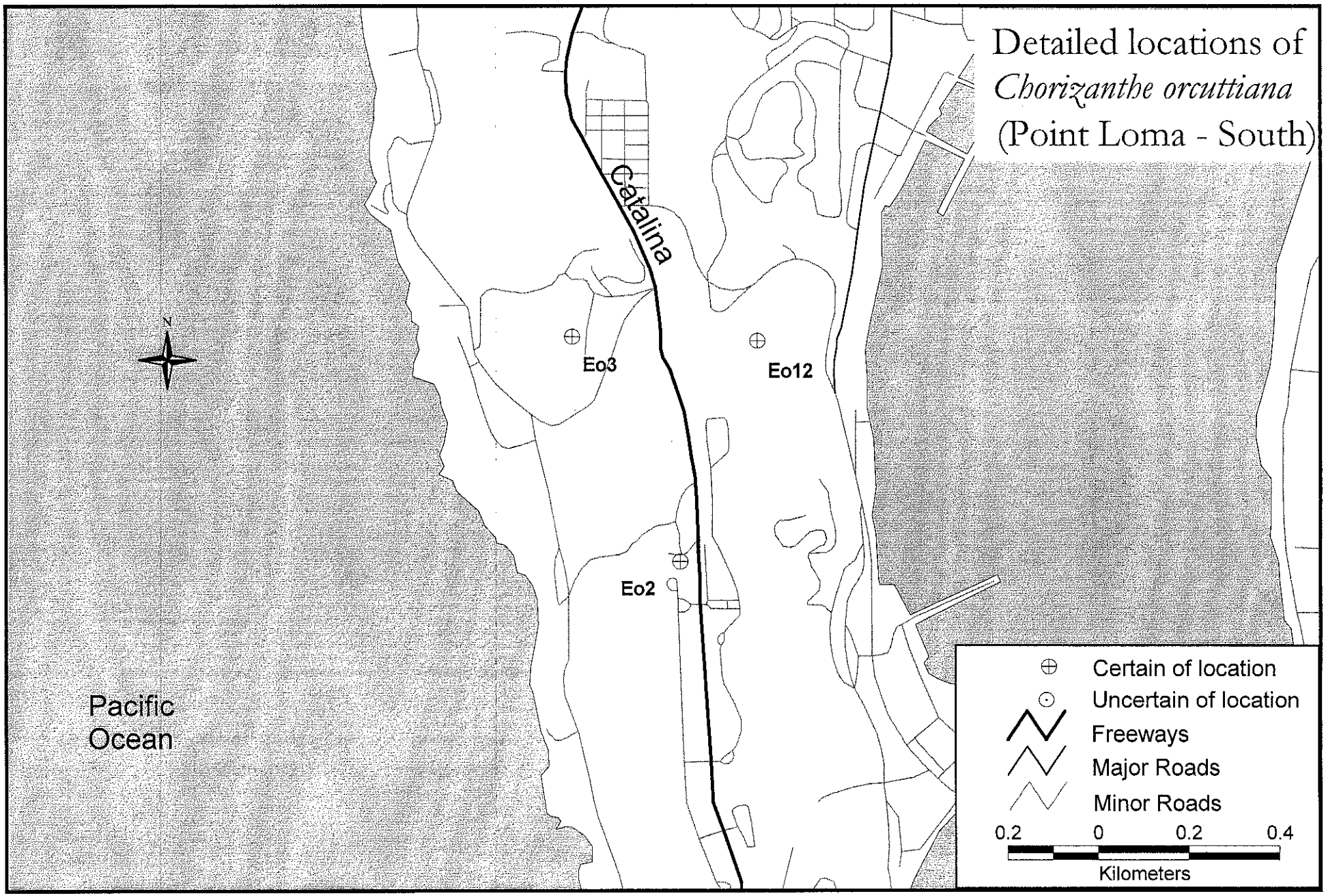

Detailed locations of
Chorizanthe orcuttiana
(Encinitas)
N
El Camino Real
Encinitas Blvd
Balour
Oakcrest
Park
Eo10
Eo7
Willowspring Rd
Certain of location
Uncertain of location
Freeways
Major Roads
Minor Roads
0.2 0 0.2 0.4
Kilometers


Detailed locations of
Chorizanthe orcuttiana
(Del Mar)
N
Camino del Mar
Jimmy Durante
San Dieguito
Eo4
Pacific
Ocean
Certain of location
Uncertain of location
Freeways
Major Roads
Minor Roads
0.1
0
0.1
0.2
Kilometers

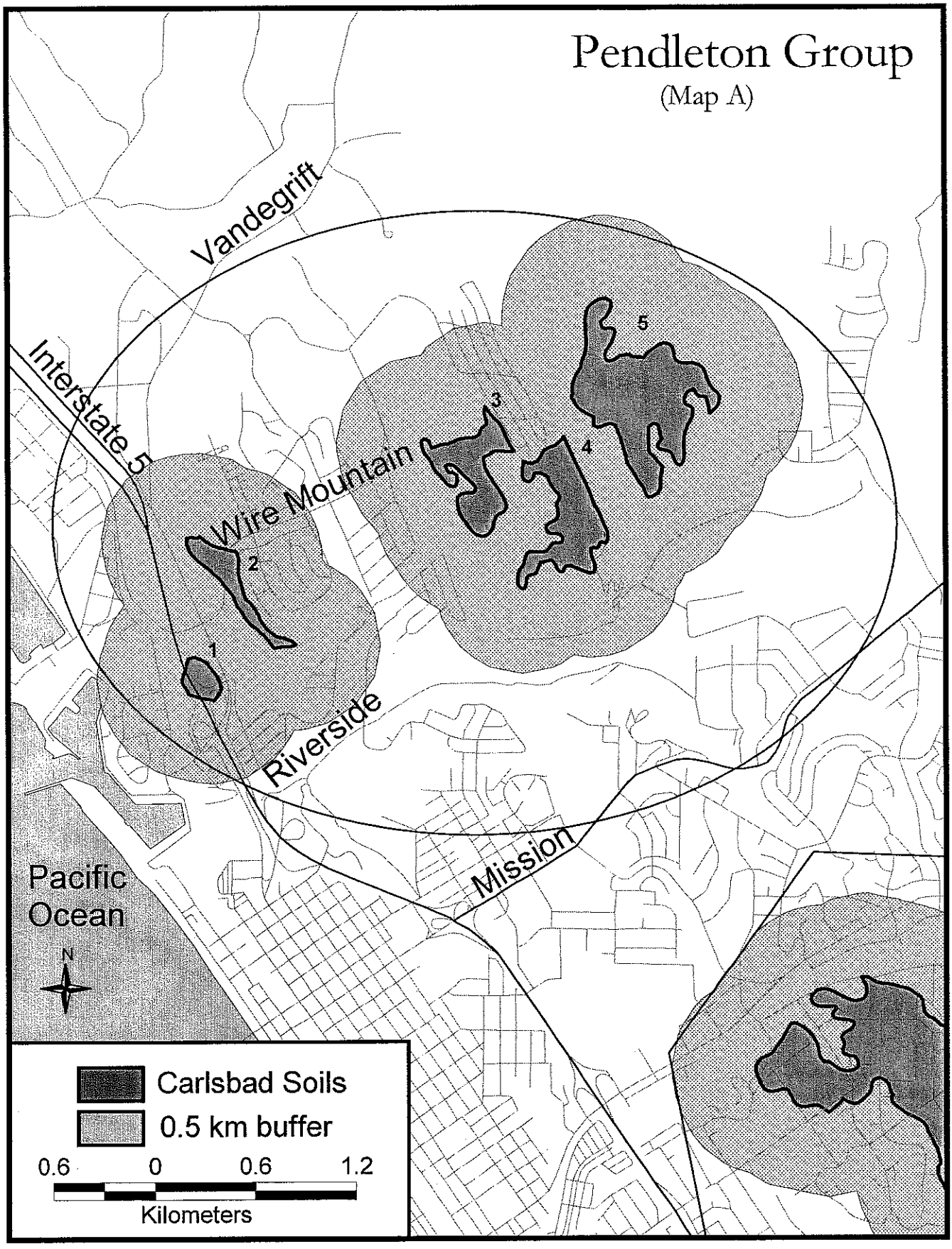

Detailed locations of
Chorizanthe orcuttiana
(Torrey Pines)
N
Carmel Valley
Torrey Pines
Interstate 5
Eo5
Ø
Pacific
Ocean
Certain of location
Uncertain of location
Freeways
Major Roads
Minor Roads
0.2 0 0.2 0.4
Kilometers

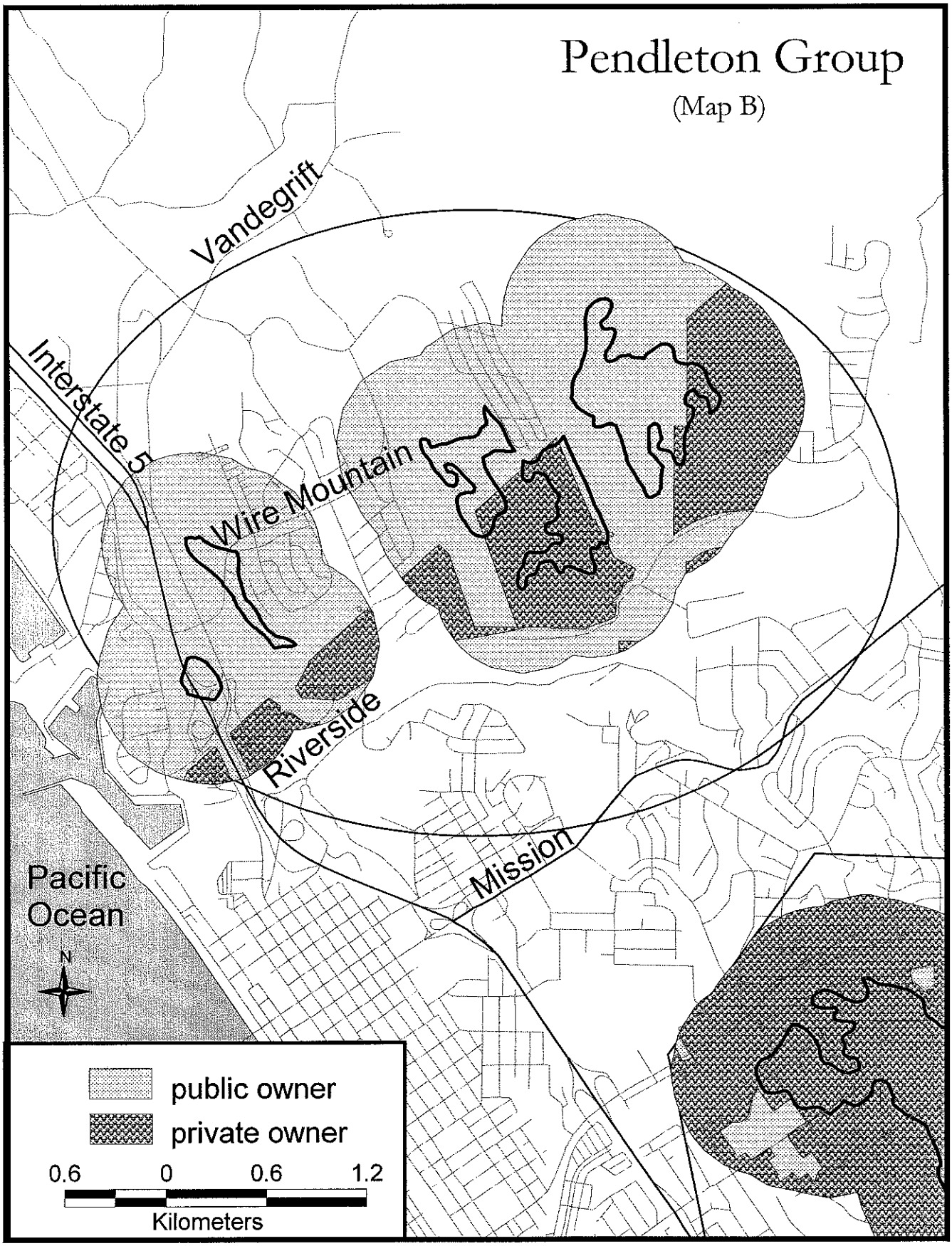

Detailed locations of
Chorizanthe orcuttiana
(Miramar)
Interstate 805
Highway 52
Eo9
N
Certain of location
Uncertain of location
Freeways
Major Roads
Minor Roads
0.2 0 0.2 0.4
Kilometers

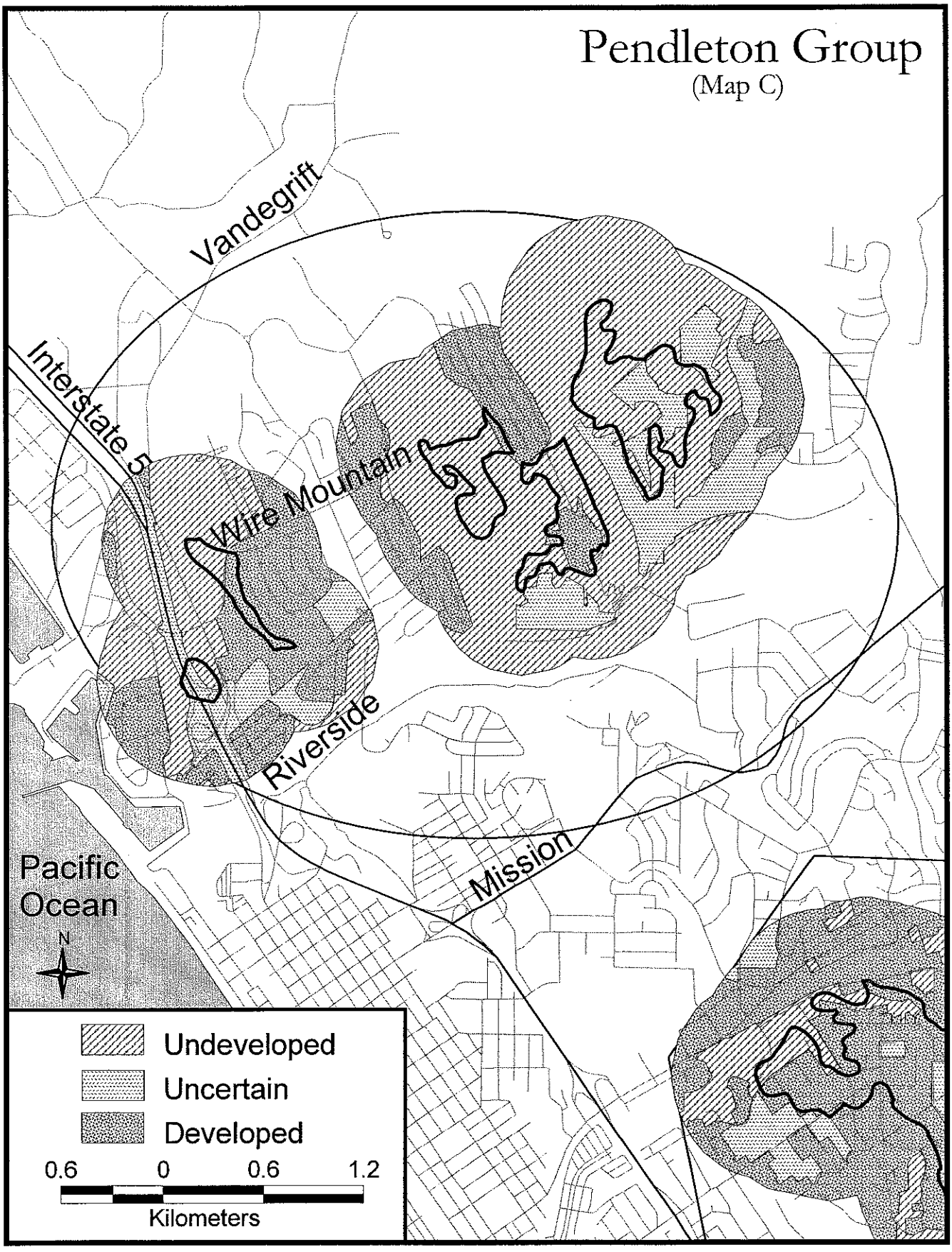

Detailed locations of
Chorizanthe orcuttiana
(Point Loma - North)
Catalina
Talbot
Rosecrans
N
Certain of location
Uncertain of location
Freeways
Major Roads
Minor Roads
0.2 0 0.2 0.4
Kilometers

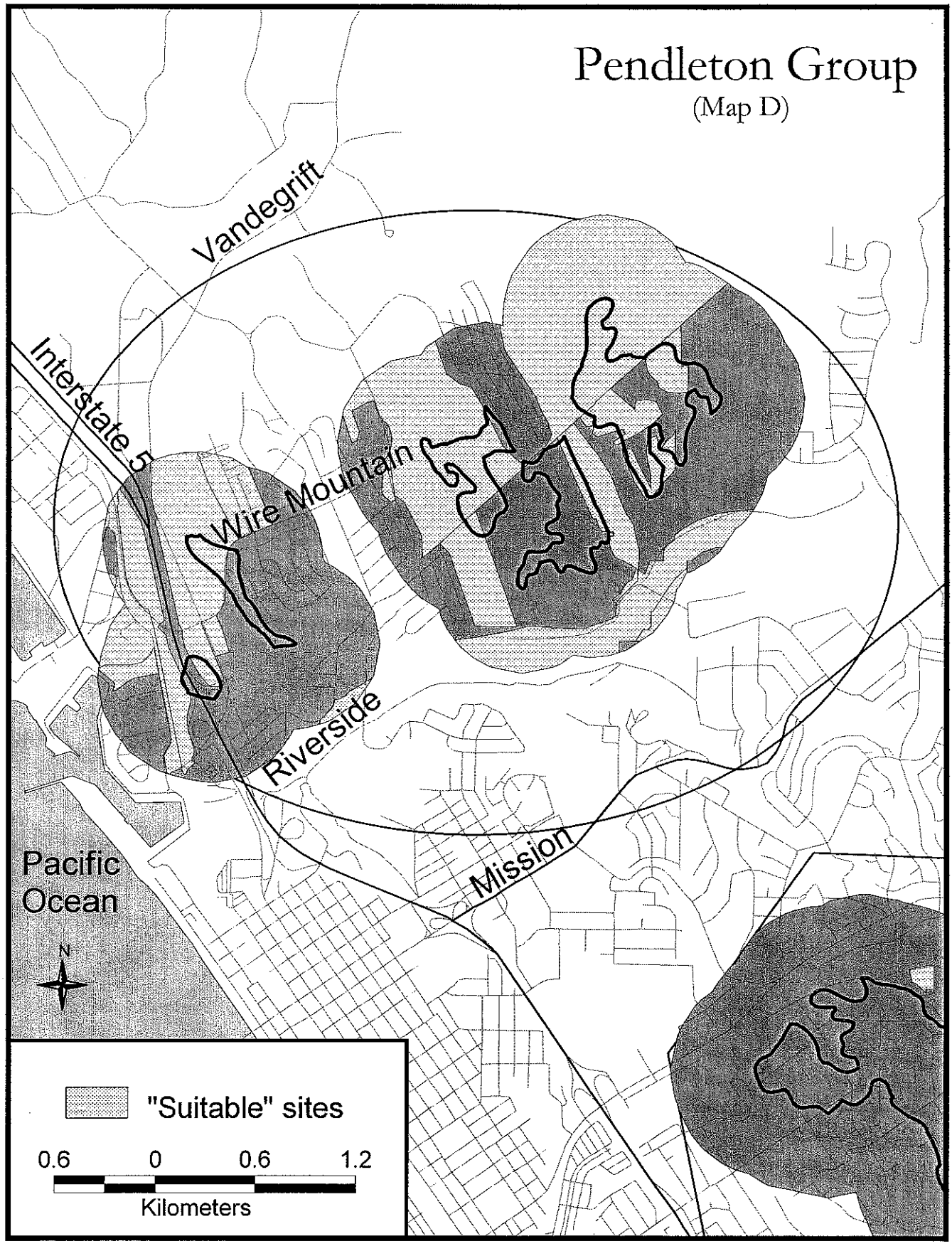

Detailed locations of
Chorizanthe orcuttiana
(Point Loma - South)
Catalina
Eo3
Eo12
Eo2
N
Pacific
Ocean
Certain of location
Uncertain of location
Freeways
Major Roads
Minor Roads
0.2
0
0.2
0.4
Kilometers

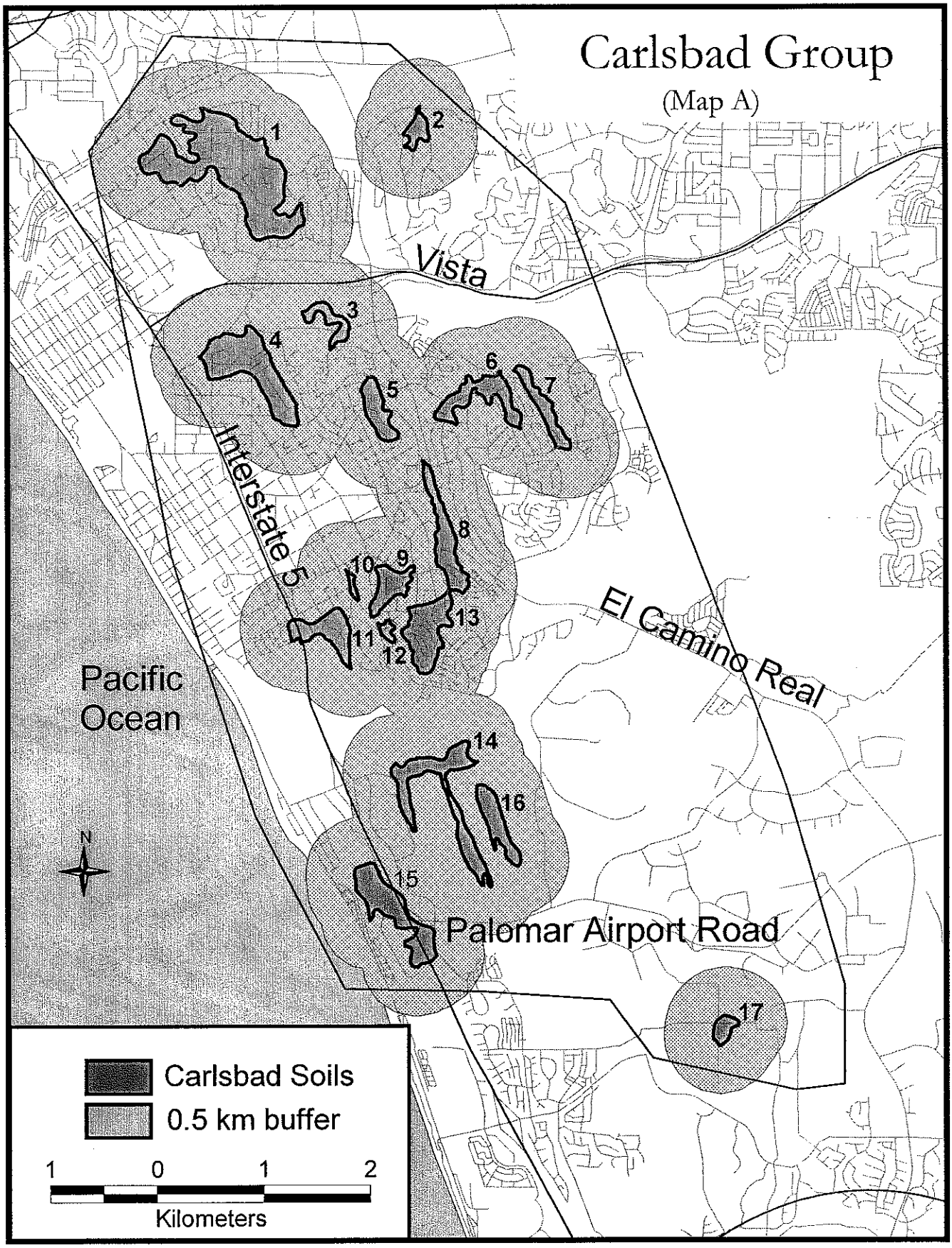
MAP APPENDIX B
"SEARCH" GROUPS

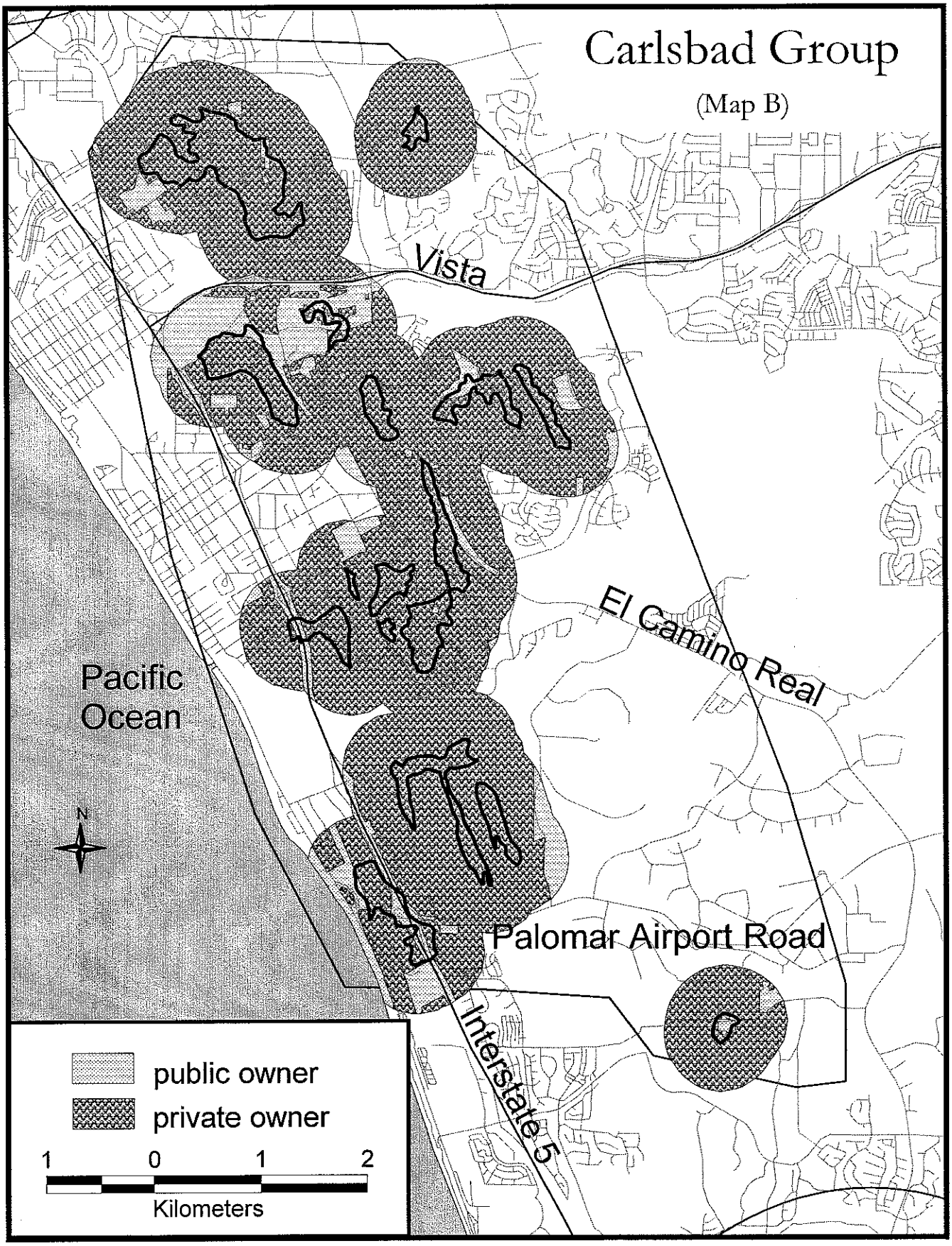

Pendleton Group
(Map A)
Vandegrift
Interstate 5
Wire Mountain
1
2
3
4
5
Riverside
Mission
Pacific
Ocean
N
Carlsbad Soils
0.5 km buffer
0.6
0
0.6
1.2
Kilometers

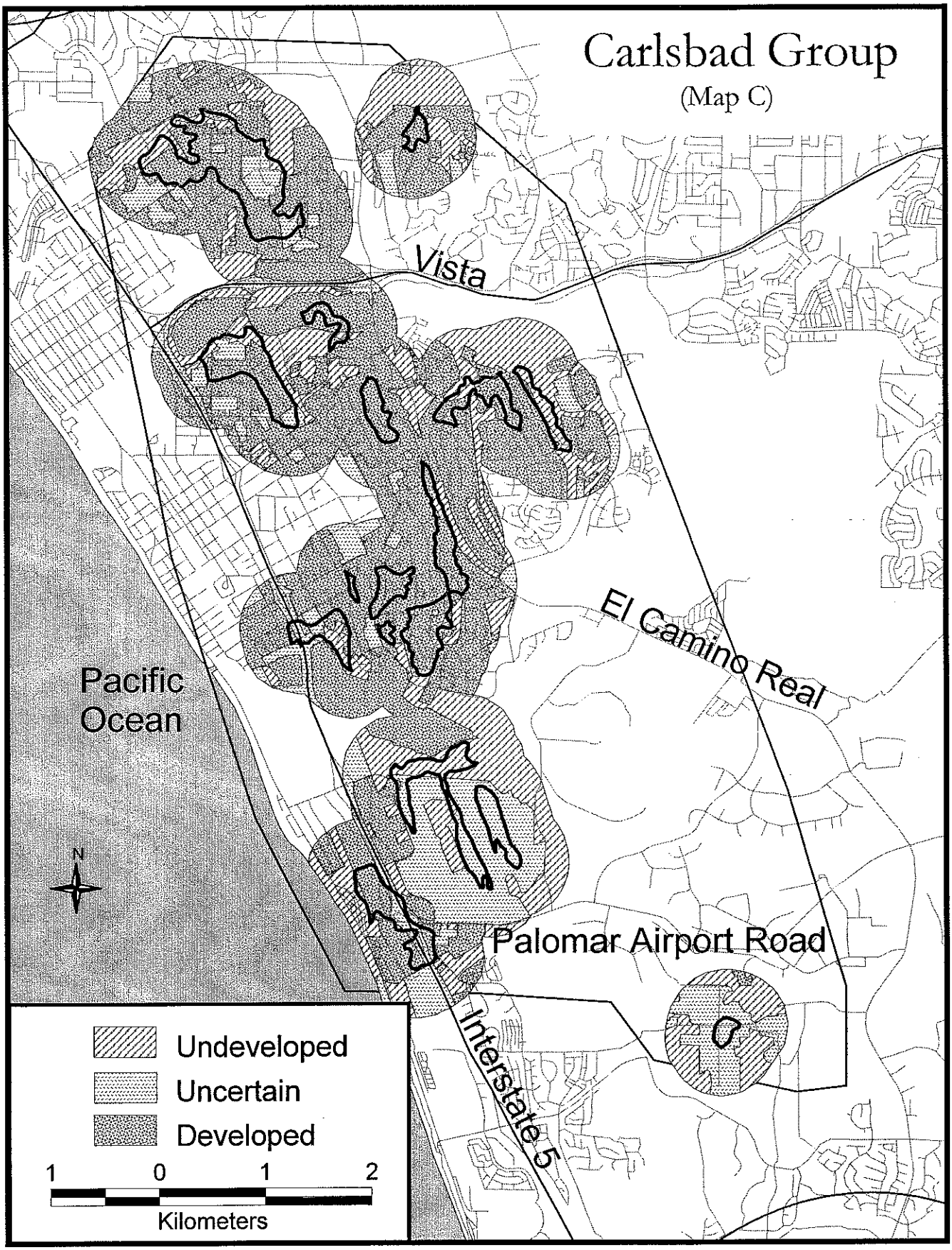

Pendleton Group
(Map B)
Vandegrift
Interstate 5
Wire Mountain
Riverside
Mission
Pacific Ocean
N
public owner
private owner
0.6
0
0.6
1.2
Kilometers

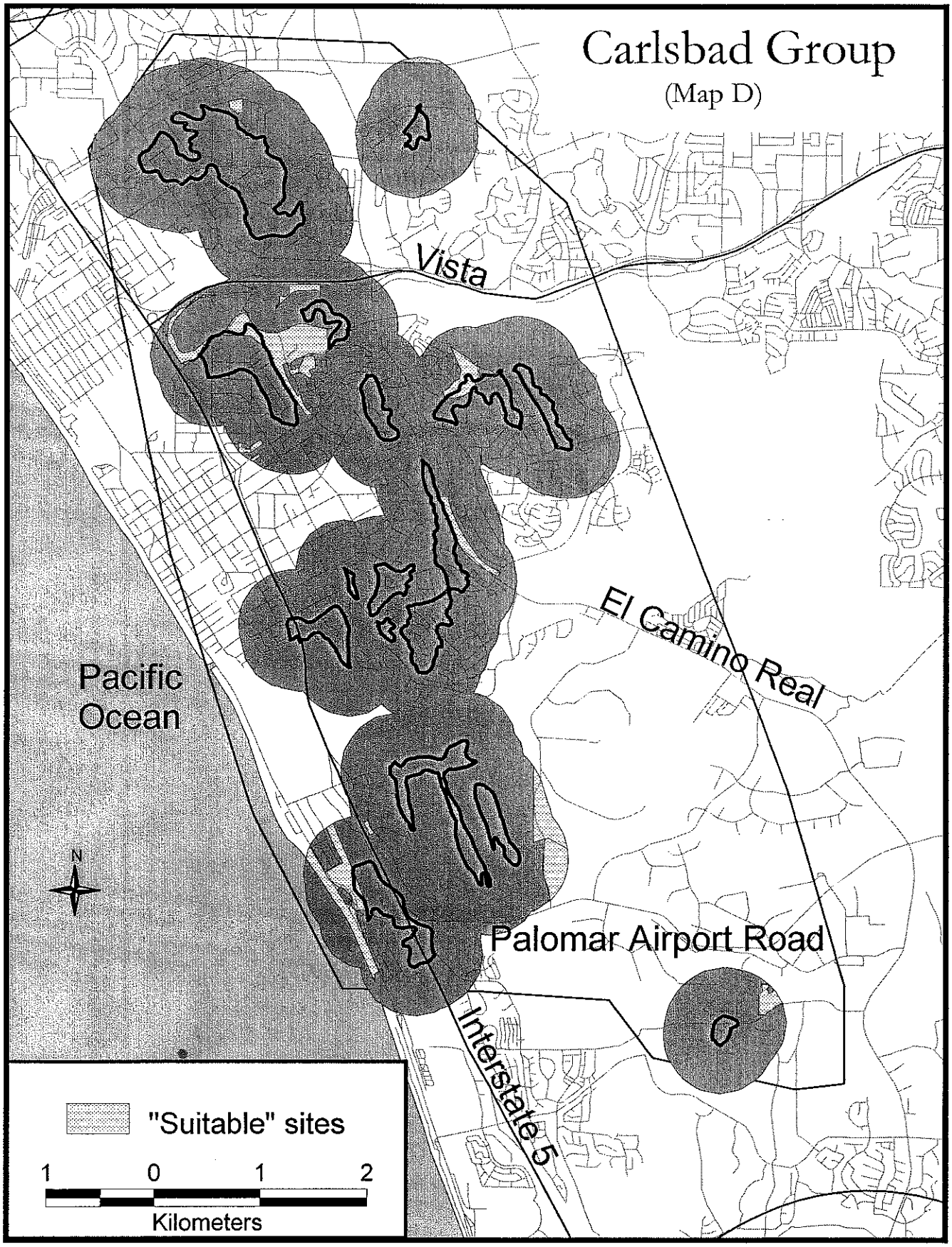

Pendleton Group
(Map C)
Vandegrift
Interstate 5
Wire Mountain
Riverside
Mission
Pacific Ocean
N
Undeveloped
Uncertain
Developed
0.6
0
0.6
1.2
Kilometers

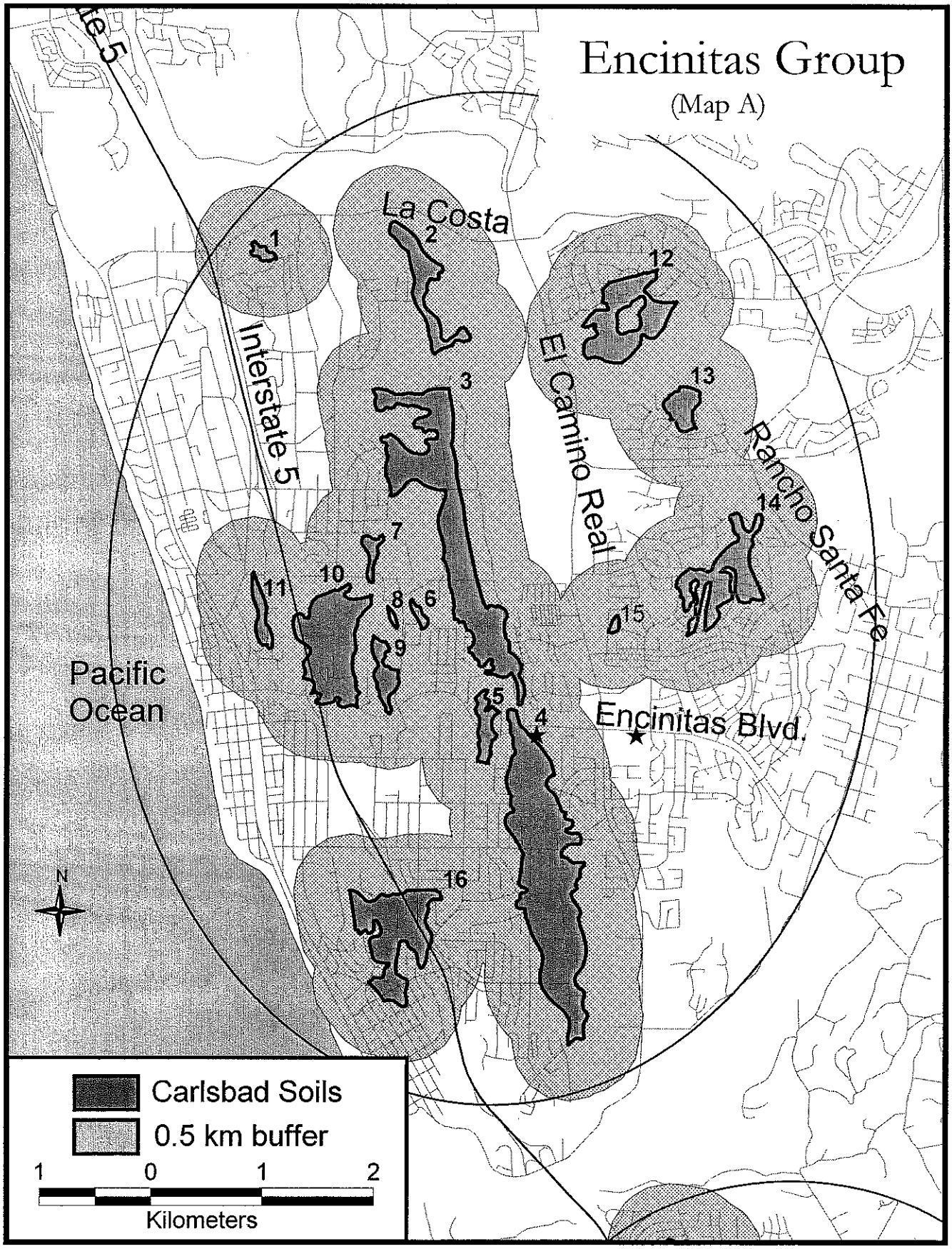

Pendleton Group
(Map D)
Vandegrift
Interstate 5
Wire Mountain
Riverside
Mission
Pacific
Ocean
N
"Suitable" sites
0.6 0 0.6 1.2
Kilometers

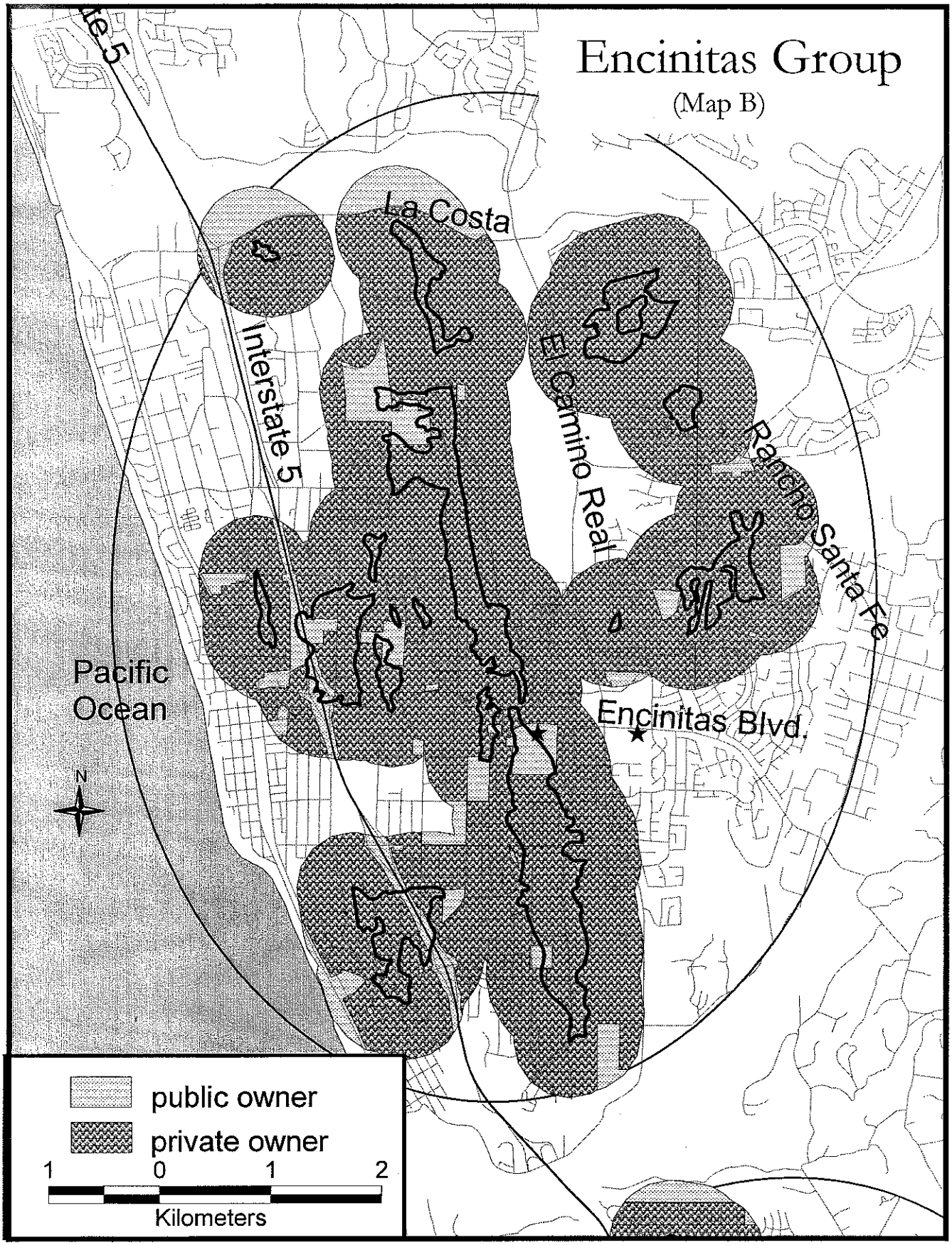

Carlsbad Group
(Map A)
Vista
Interstate 5
El Camino Real
Pacific Ocean
Palomar Airport Road
N
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
Carlsbad Soils
0.5 km buffer
1 0 1 2
Kilometers

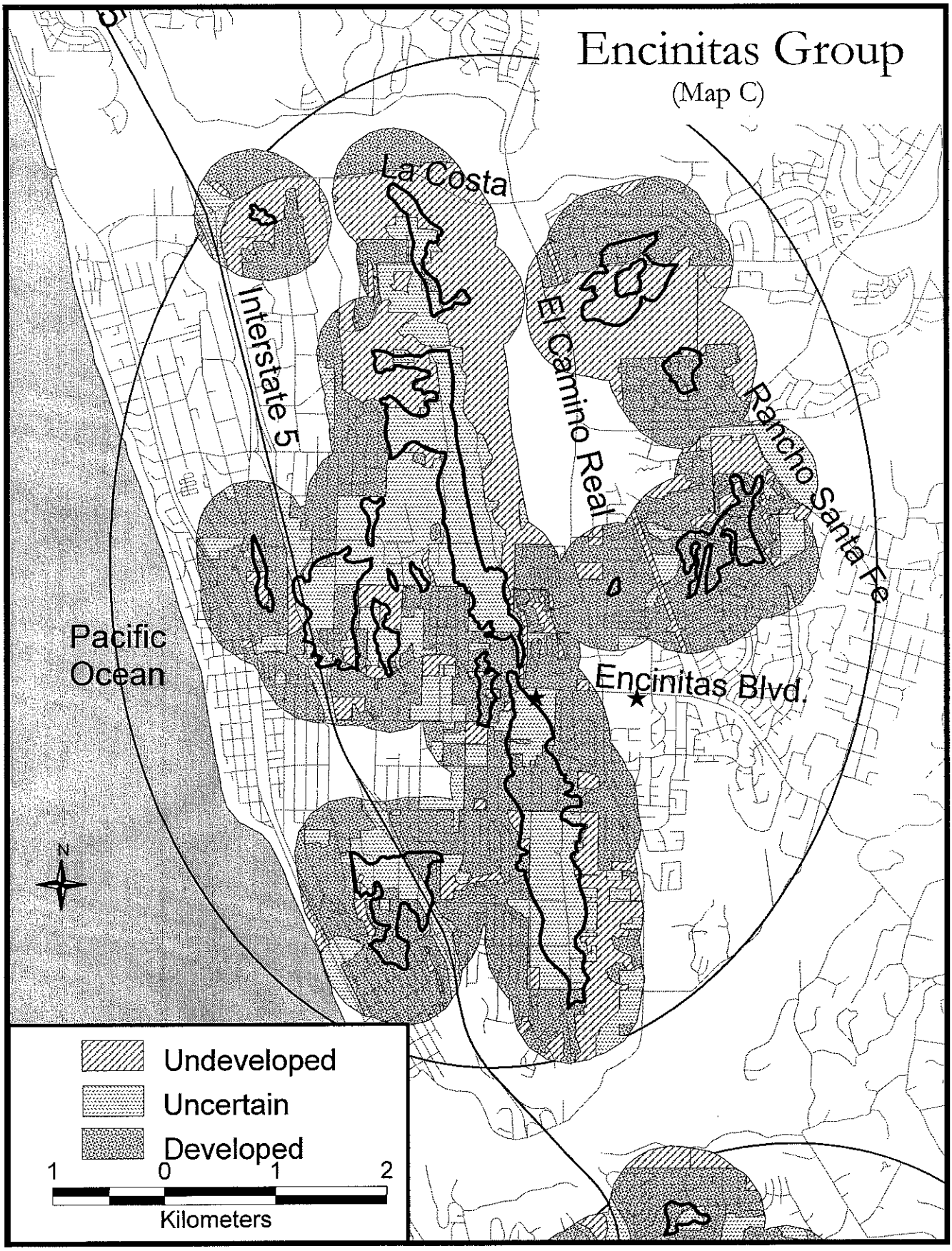

Carlsbad Group
(Map B)
Vista
El Camino Real
Pacific Ocean
N
Palomar Airport Road
Interstate 5
public owner
private owner
1 0 1 2
Kilometers

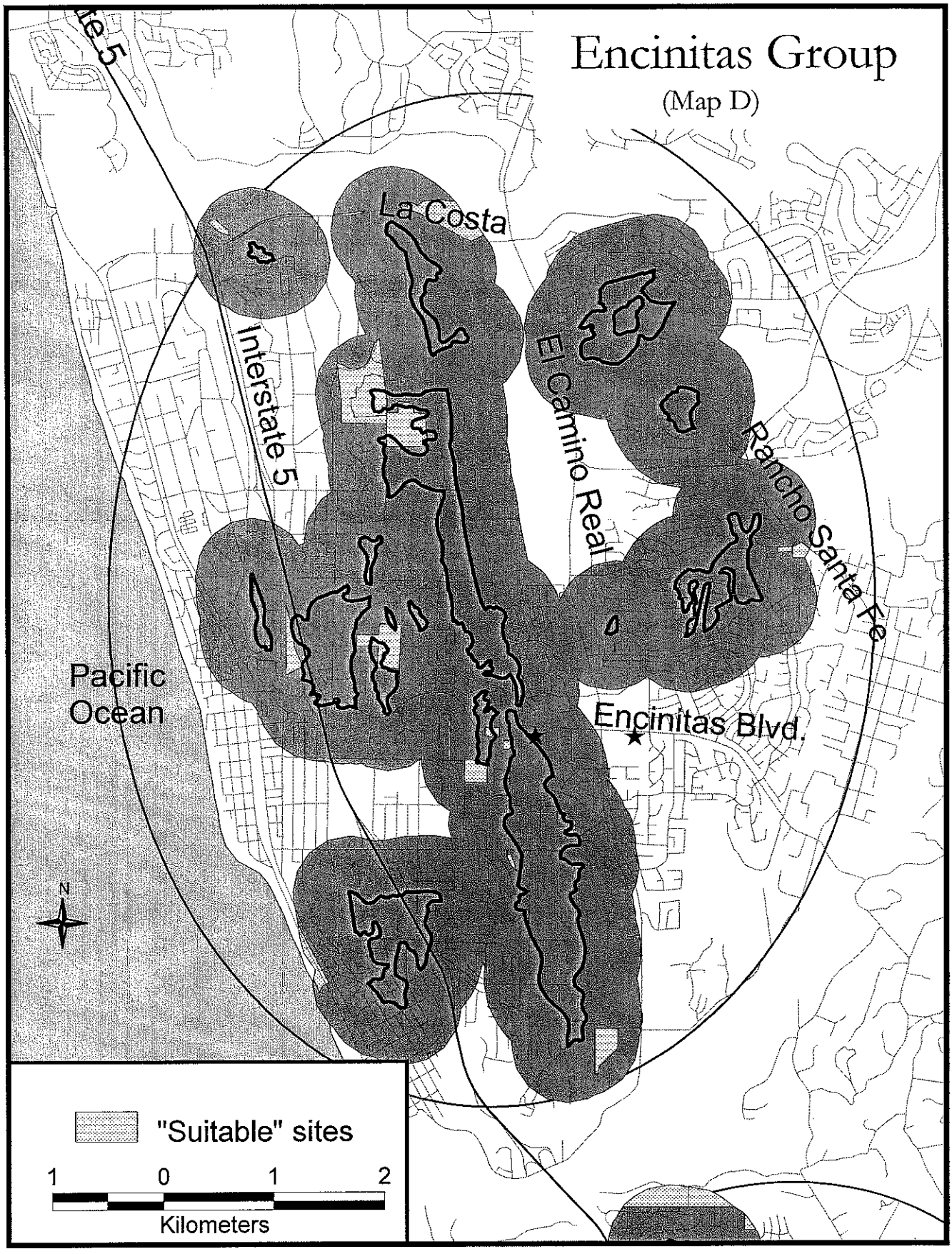

Carlsbad Group
(Map C)
Vista
El Camino Real
Pacific Ocean
N
Palomar Airport Road
Interstate 5
Undeveloped
Uncertain
Developed
1 0 1 2
Kilometers

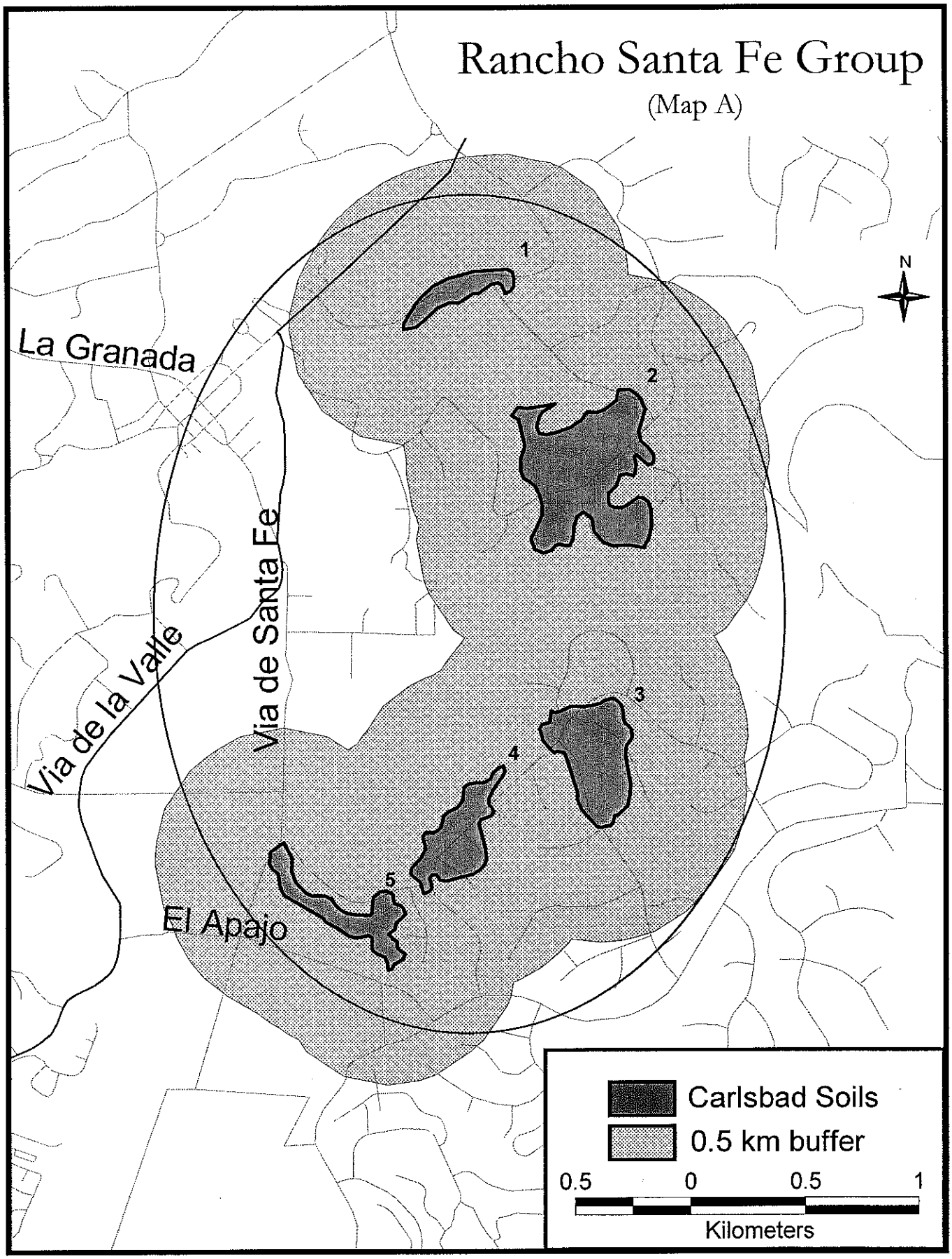

Carlsbad Group
(Map D)
Vista
El Camino Real
Pacific Ocean
N
Palomar Airport Road
Interstate 5
"Suitable" sites
1 0 1 2
Kilometers

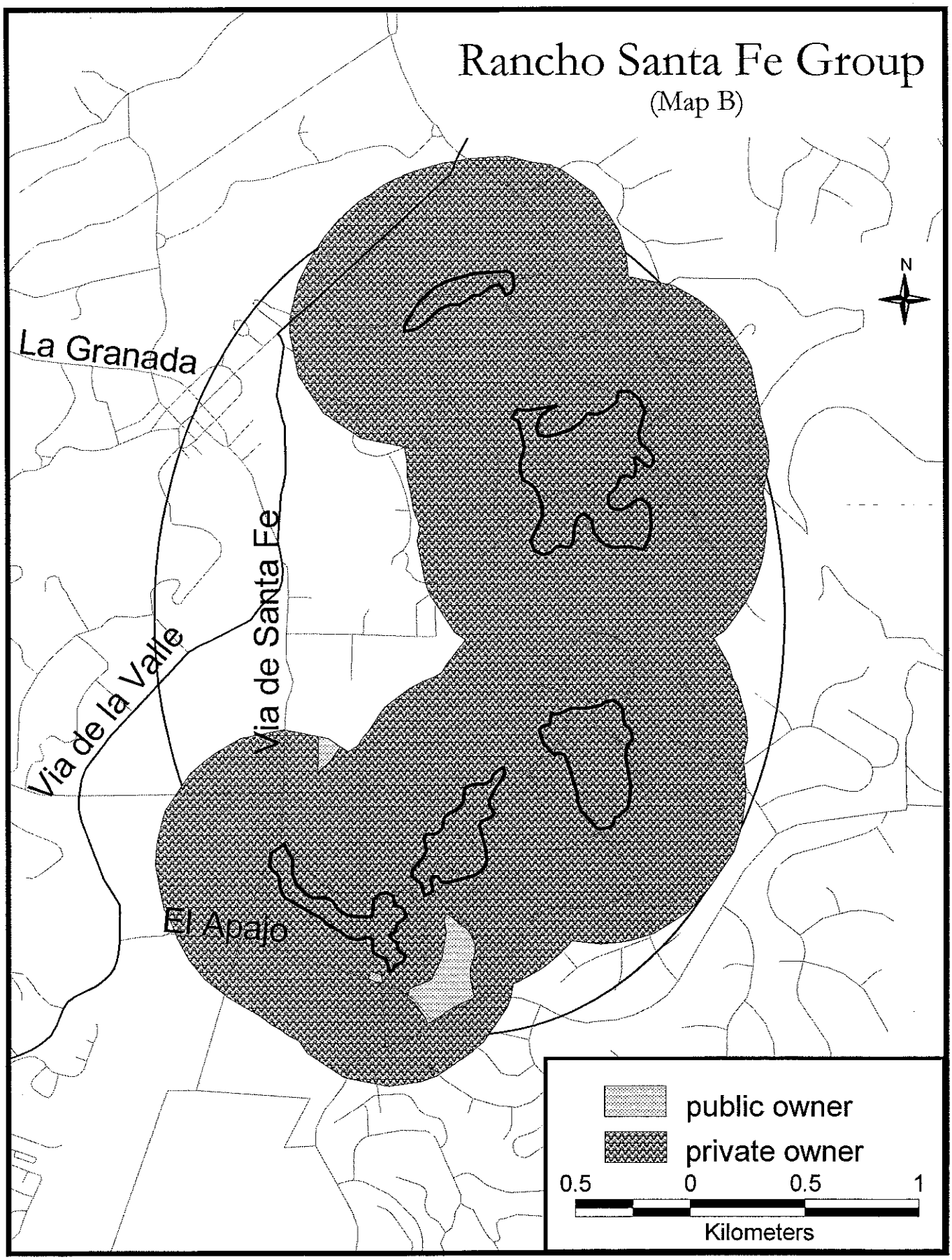

Encinitas Group
(Map A)
La Costa
Interstate 5
El Camino Real
Rancho Santa Fe
Encinitas Blvd.
Pacific Ocean
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
N
Carlsbad Soils
0.5 km buffer
1 0 1 2
Kilometers

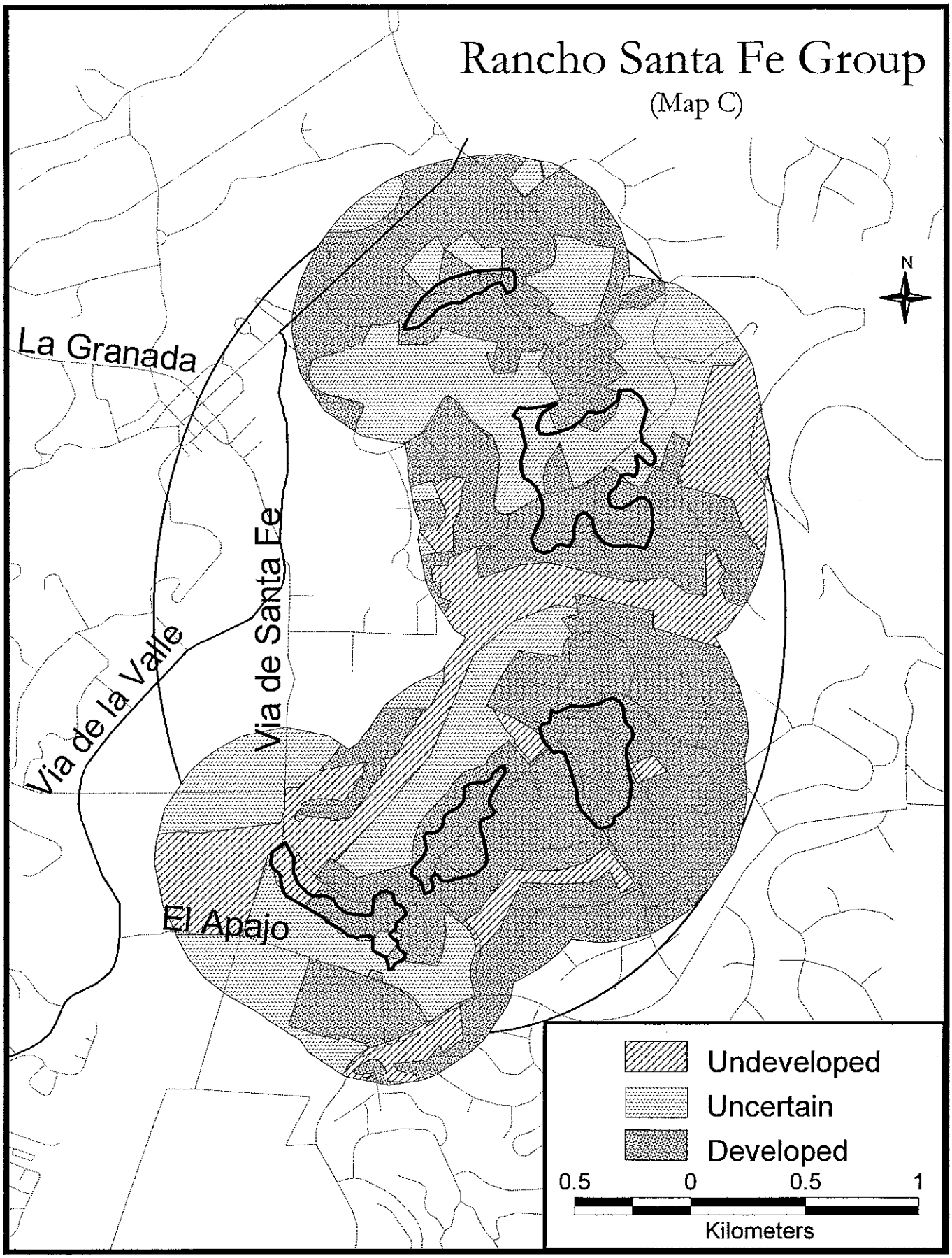

Encinitas Group
(Map B)
La Costa
Interstate 5
El Camino Real
Rancho Santa Fe
Encinitas Blvd.
Pacific Ocean
N
public owner
private owner
1 0 1 2
Kilometers

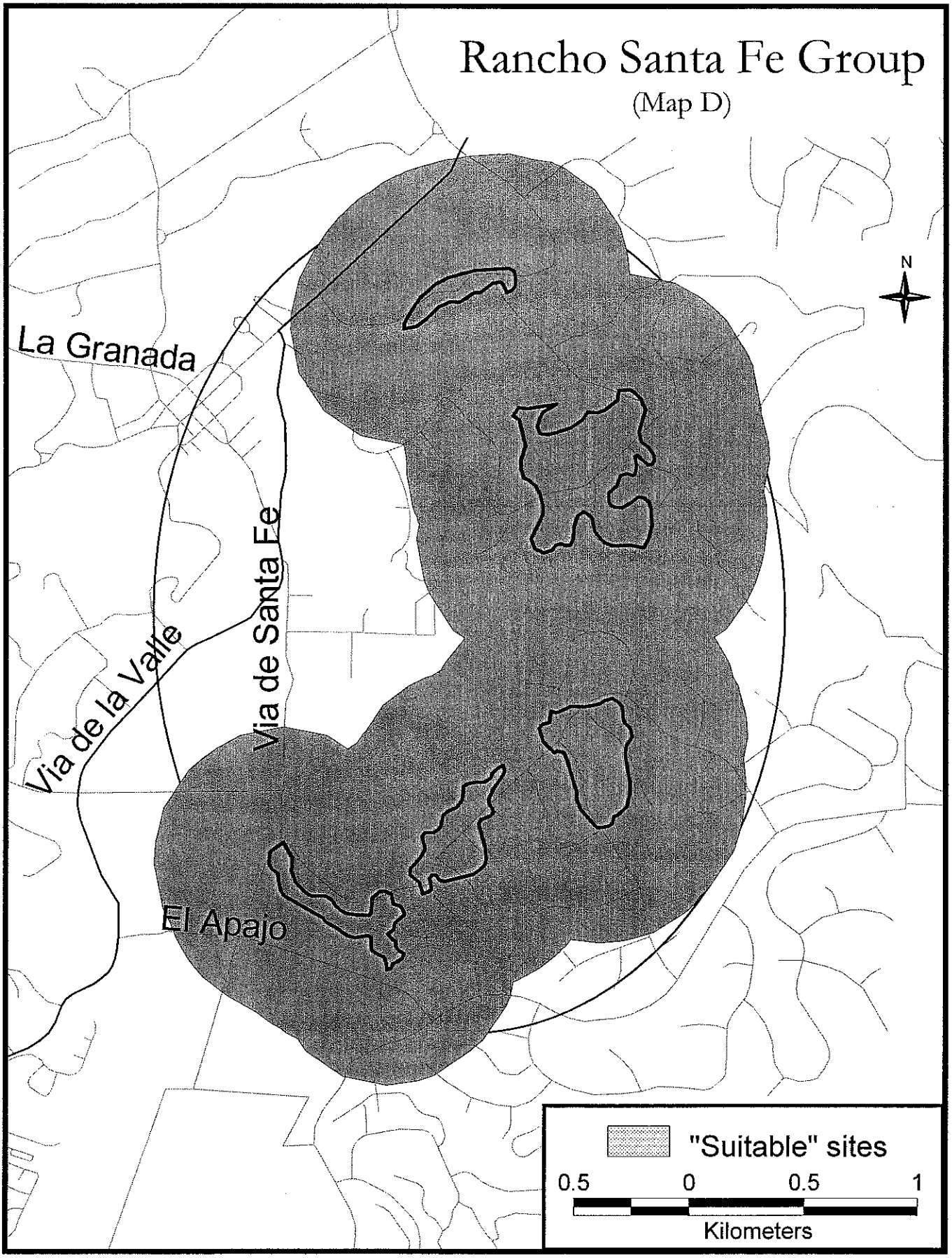

Encinitas Group
(Map C)
La Costa
Interstate 5
El Camino Real
Rancho Santa Fe
Pacific Ocean
Encinitas Blvd.
N
Undeveloped
Uncertain
Developed
1 0 1 2
Kilometers

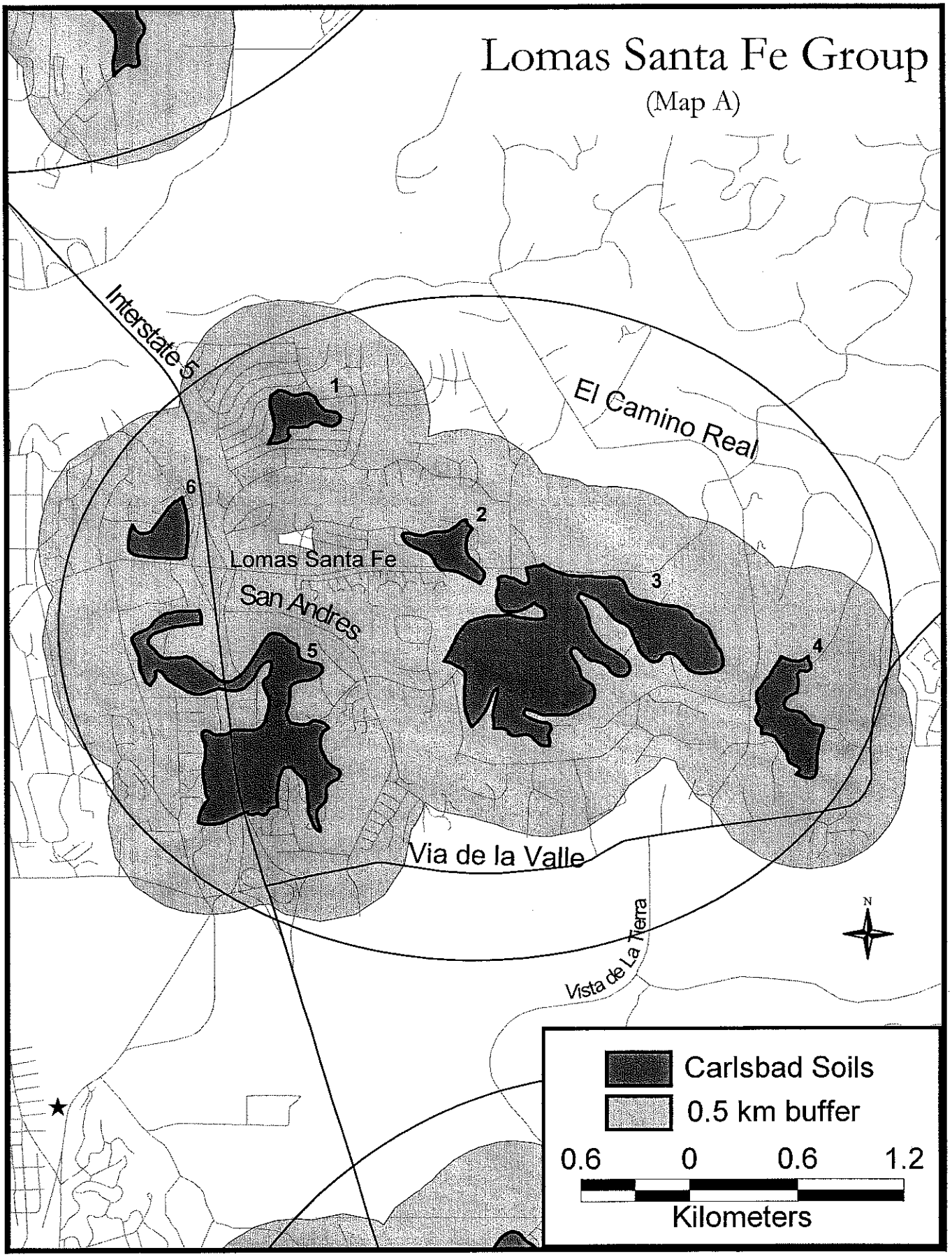

Encinitas Group
(Map D)
La Costa
Interstate 5
El Camino Real
Rancho Santa Fe
Pacific Ocean
Encinitas Blvd.
N
"Suitable" sites
1 0 1 2
Kilometers

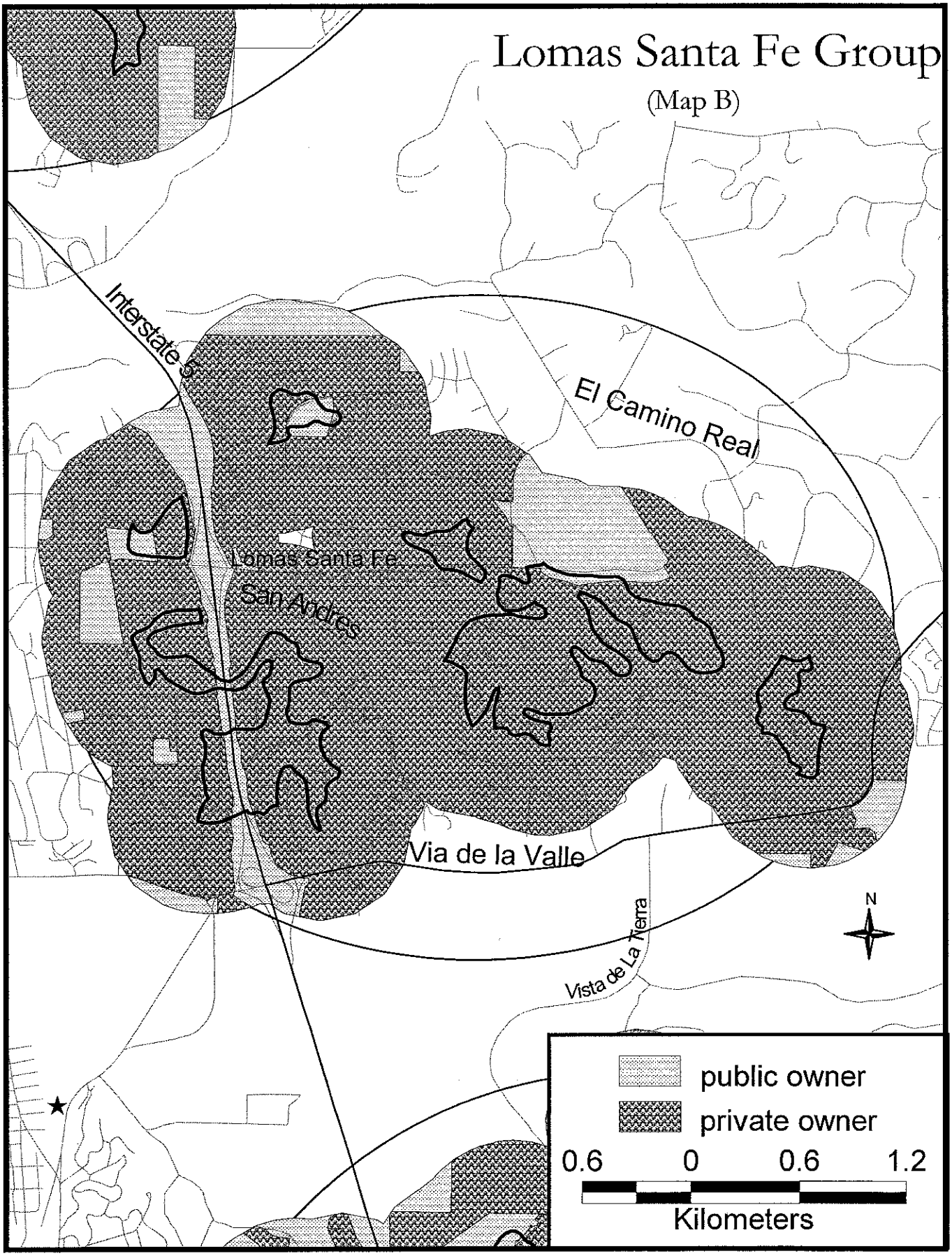

Rancho Santa Fe Group
(Map A)
N
La Granada
Via de la Valle
Via de Santa Fe
El Apajo
1
2
3
4
5
Carlsbad Soils
0.5 km buffer
0.5 0 0.5 1
Kilometers

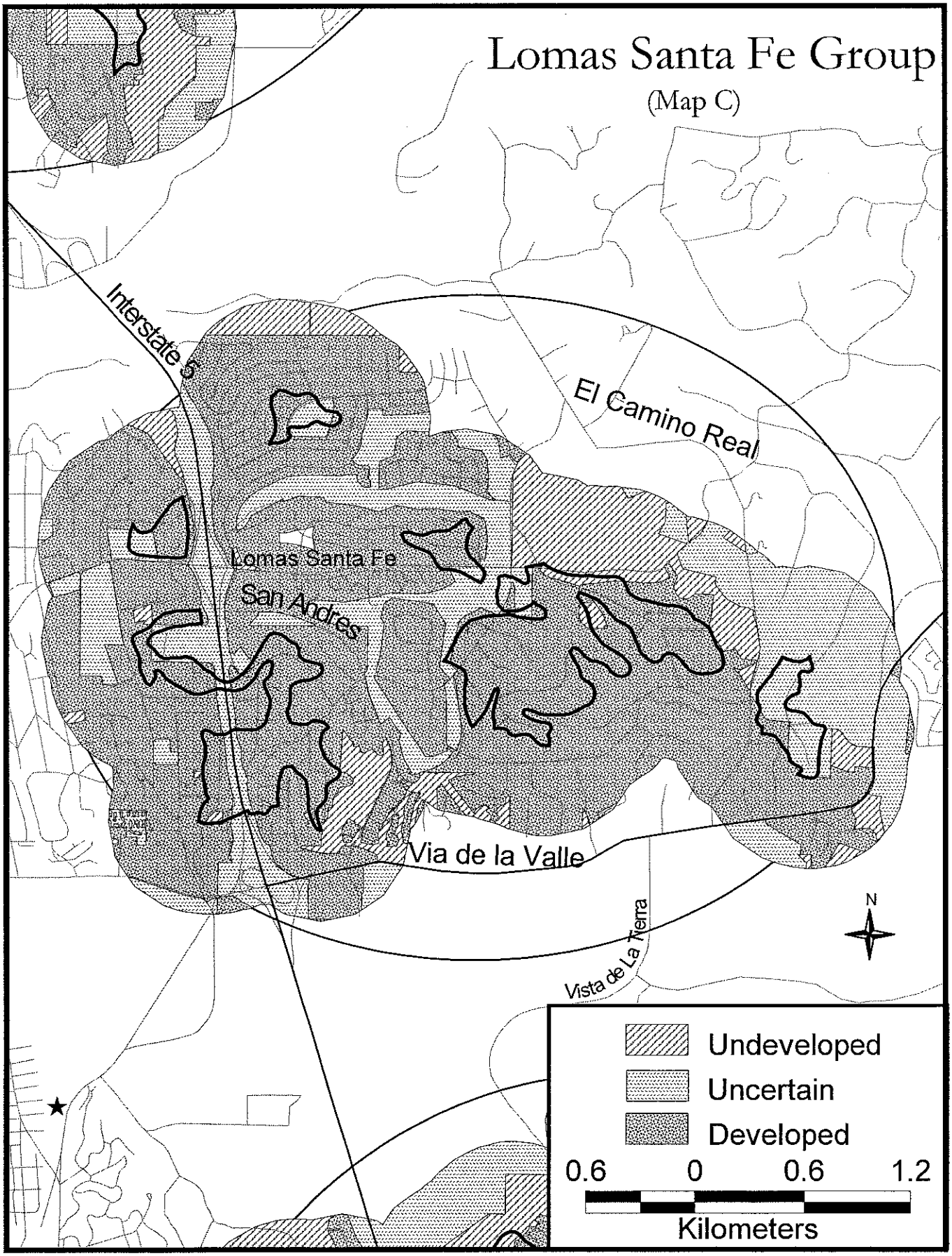

Rancho Santa Fe Group
(Map B)
N
La Granada
Via de Santa Fe
Via de la Valle
El Apajo
public owner
private owner
0.5
0
0.5
1
Kilometers

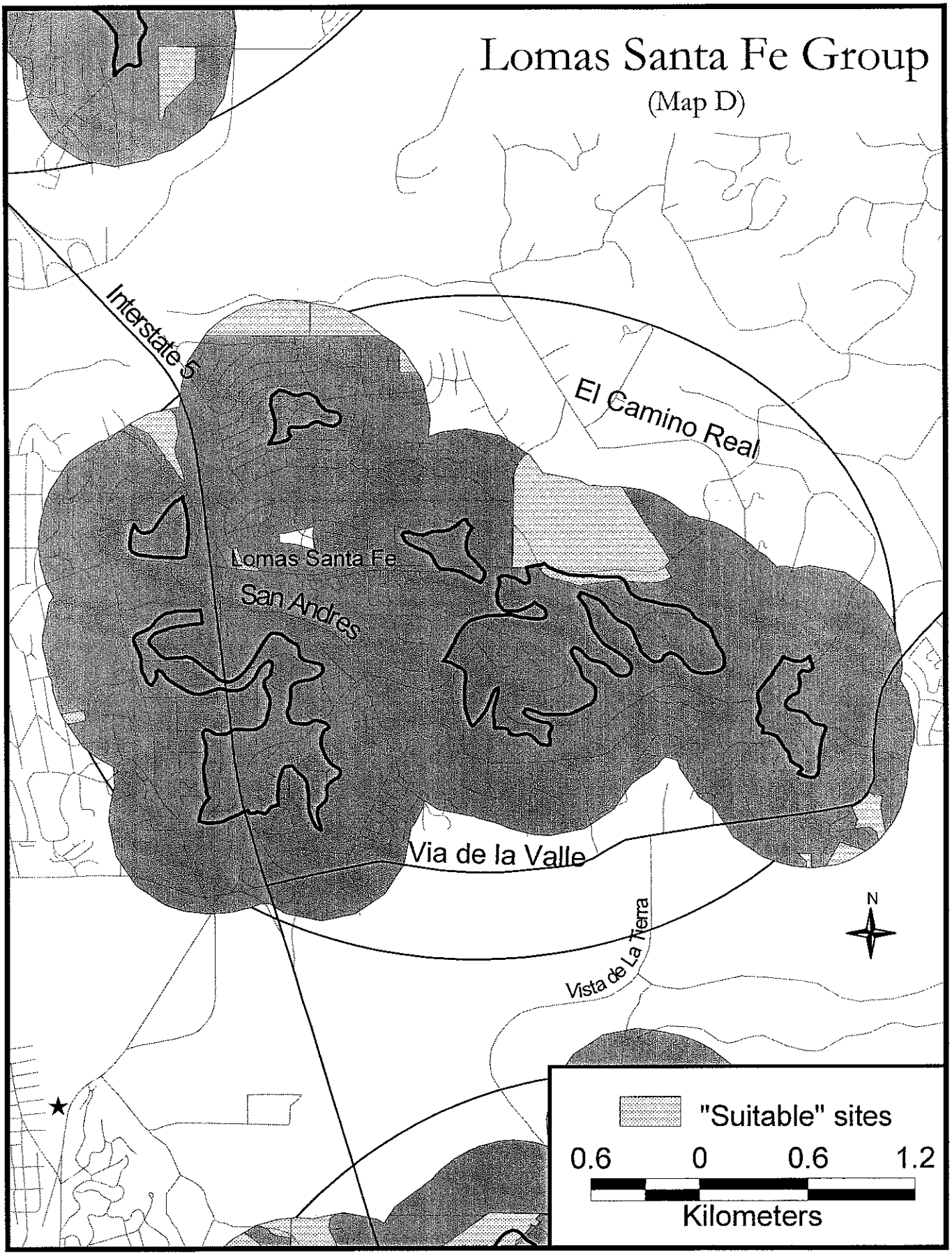

Rancho Santa Fe Group
(Map C)
N
La Granada
Via de la Valle
Via de Santa Fe
El Apajo
Undeveloped
Uncertain
Developed
0.5
0
0.5
1
Kilometers

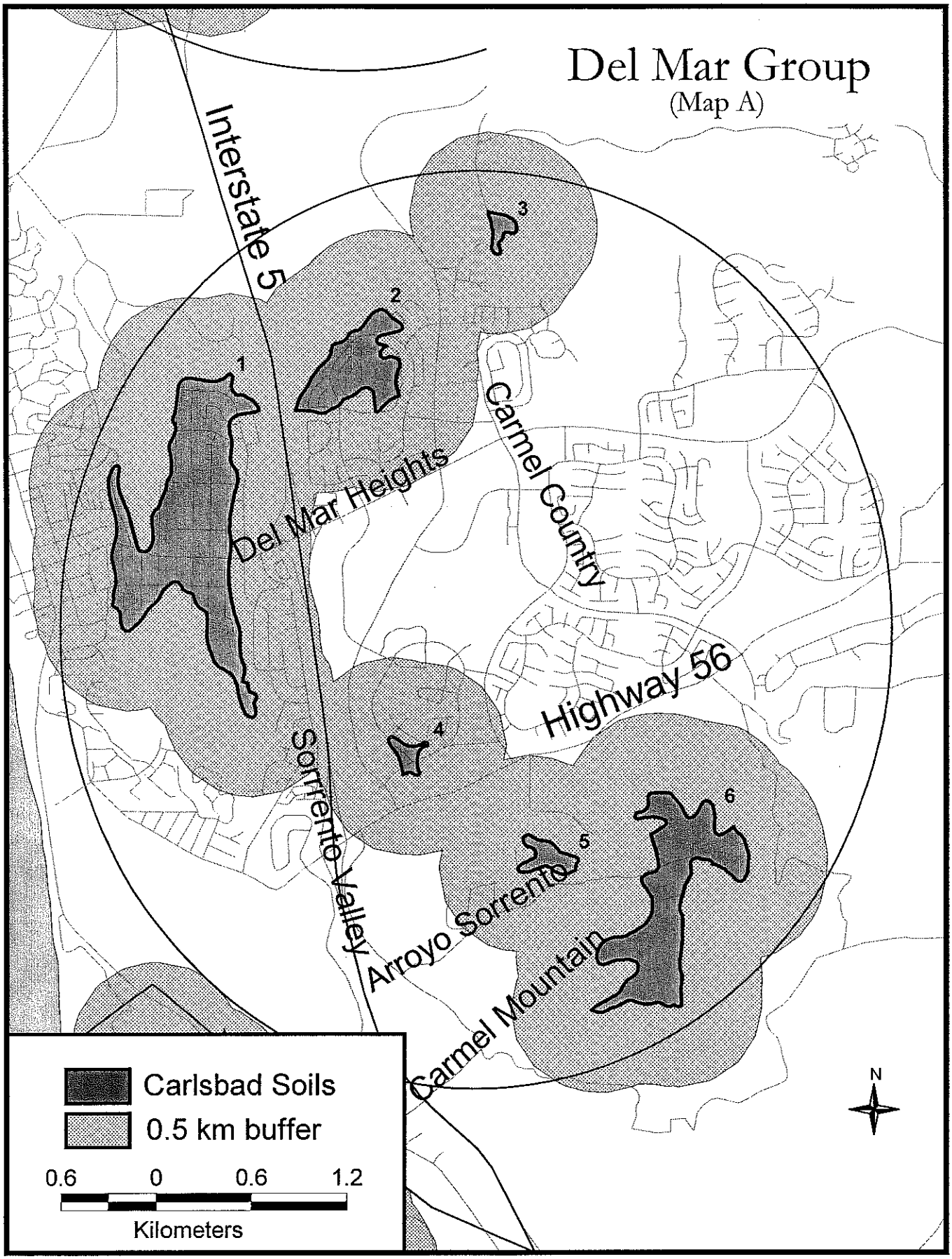

Rancho Santa Fe Group
(Map D)
N
La Granada
Via de la Valle
Via de Santa Fe
El Apajo
"Suitable" sites
0.5
0
0.5
1
Kilometers

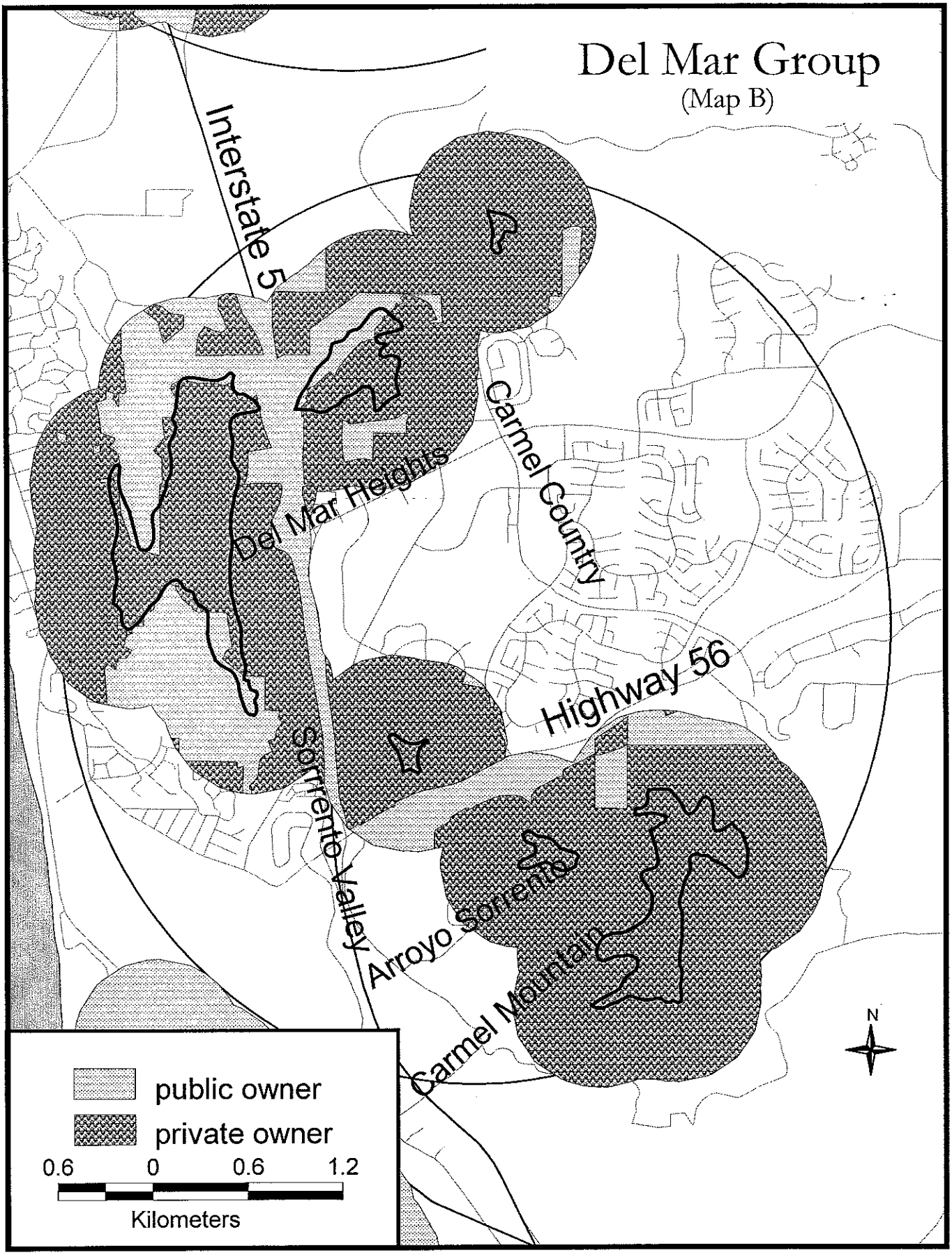

Lomas Santa Fe Group
(Map A)
Interstate 5
El Camino Real
Lomas Santa Fe
San Andres
Via de la Valle
Vista de La Tierra
1
2
3
4
5
6
N
Carlsbad Soils
0.5 km buffer
0.6 0 0.6 1.2
Kilometers

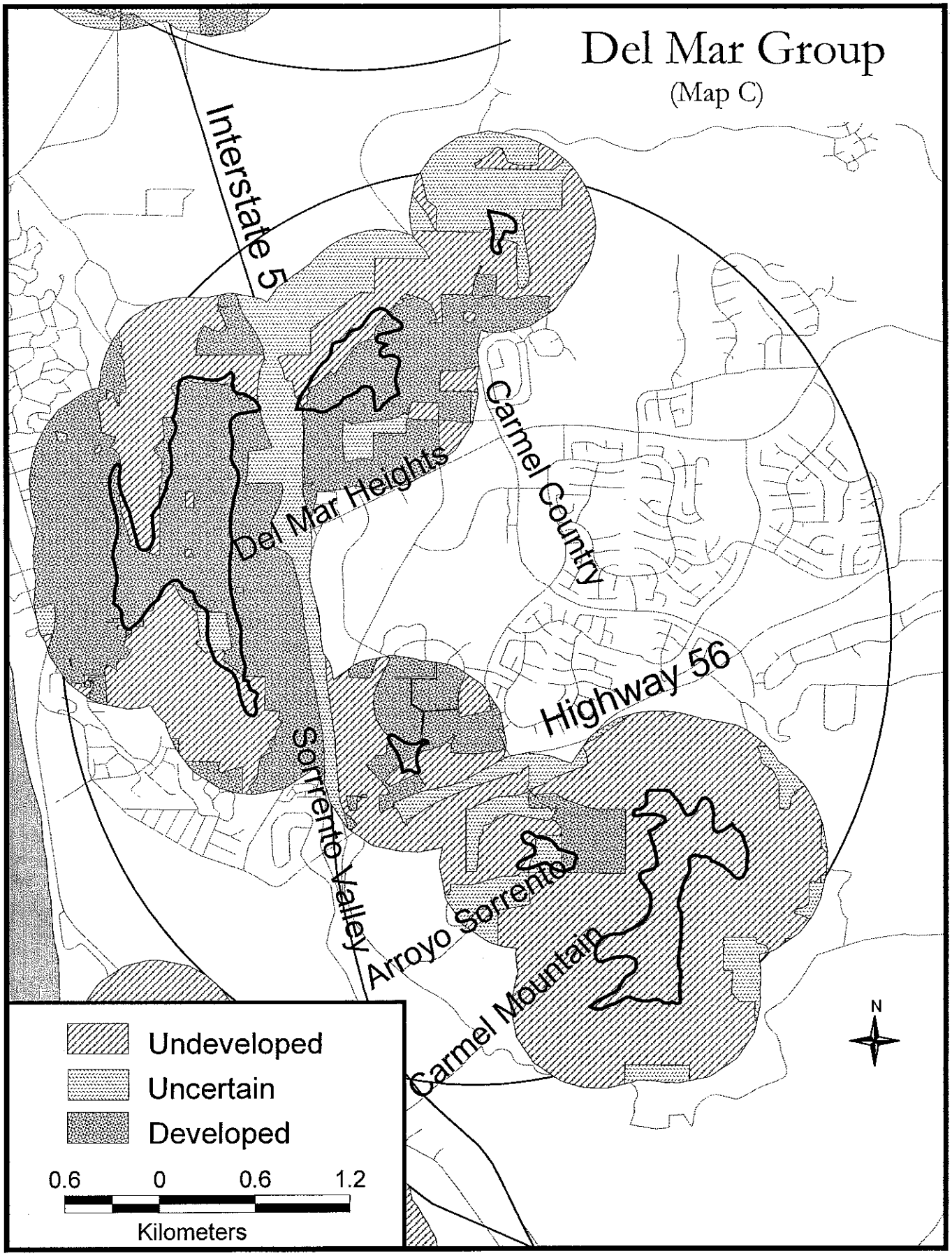

Lomas Santa Fe Group
(Map B)
Interstate 5
El Camino Real
Lomas Santa Fe
San Andres
Via de la Valle
Vista de La Tierra
N
public owner
private owner
0.6 0 0.6 1.2
Kilometers

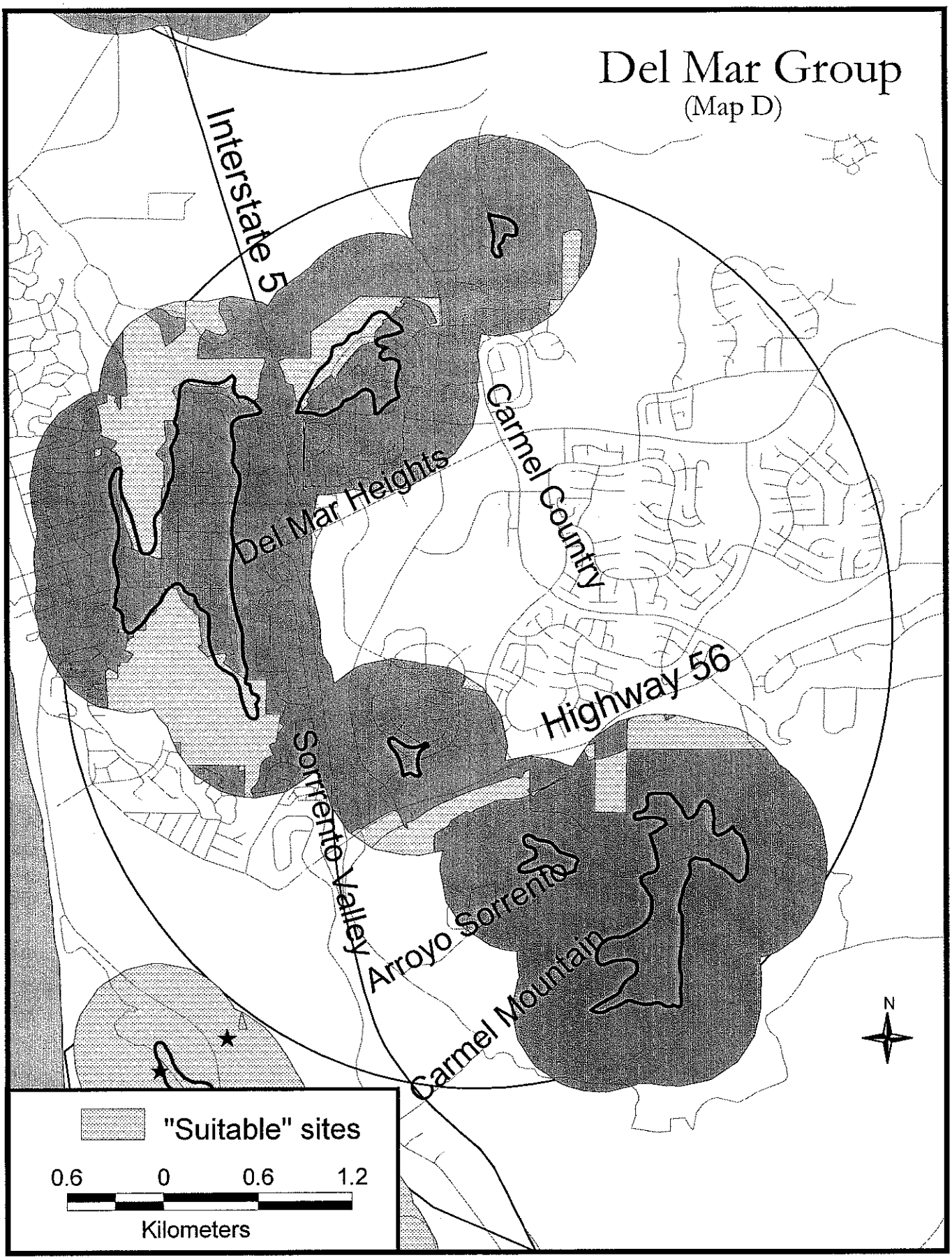

Lomas Santa Fe Group
(Map C)
Interstate 5
El Camino Real
Lomas Santa Fe
San Andres
Via de la Valle
Vista de La Tierra
N
Undeveloped
Uncertain
Developed
0.6 0 0.6 1.2
Kilometers

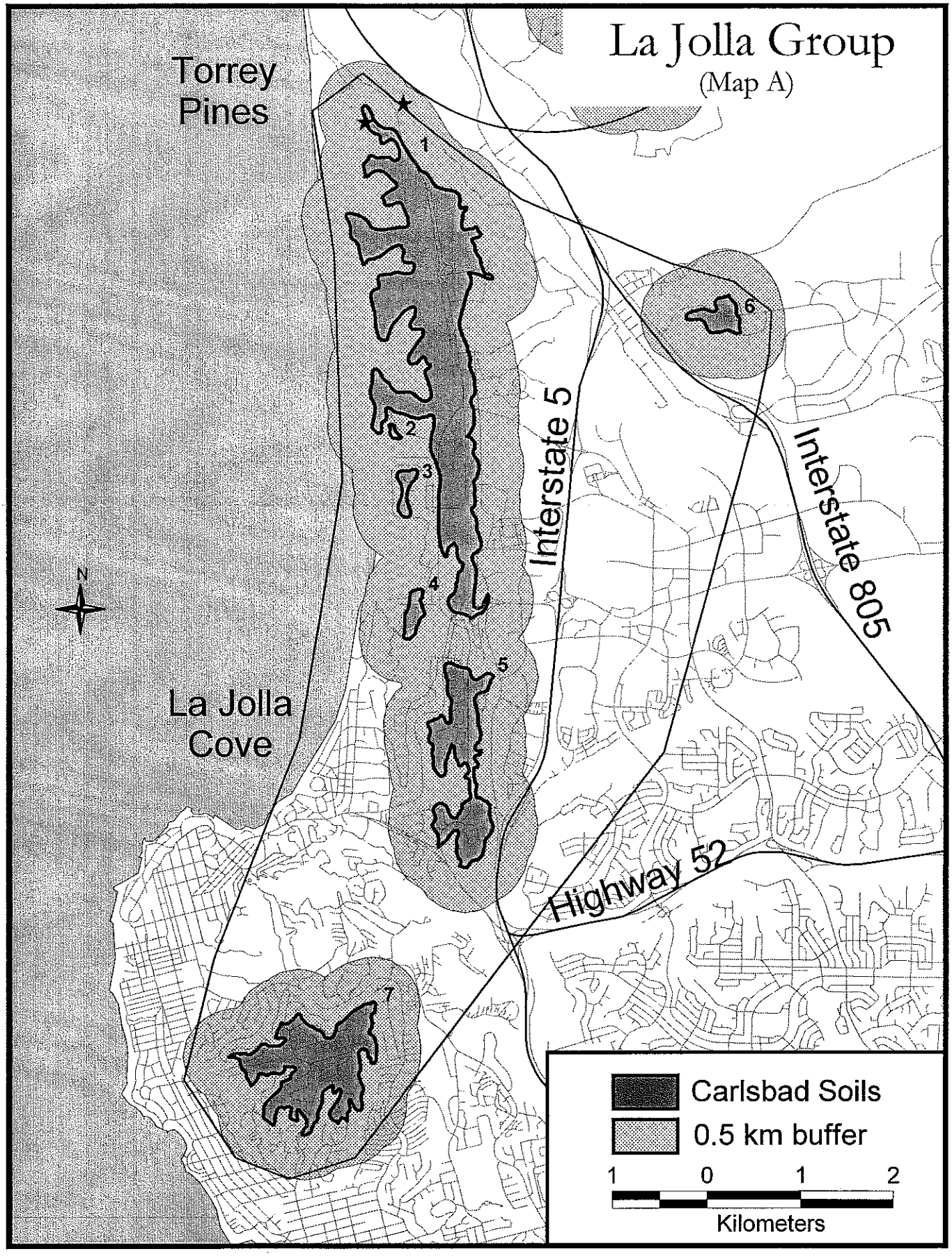

Lomas Santa Fe Group
(Map D)
Interstate 5
El Camino Real
Lomas Santa Fe
San Andres
Via de la Valle
Vista de La Tierra
N
"Suitable" sites
0.6 0 0.6 1.2
Kilometers

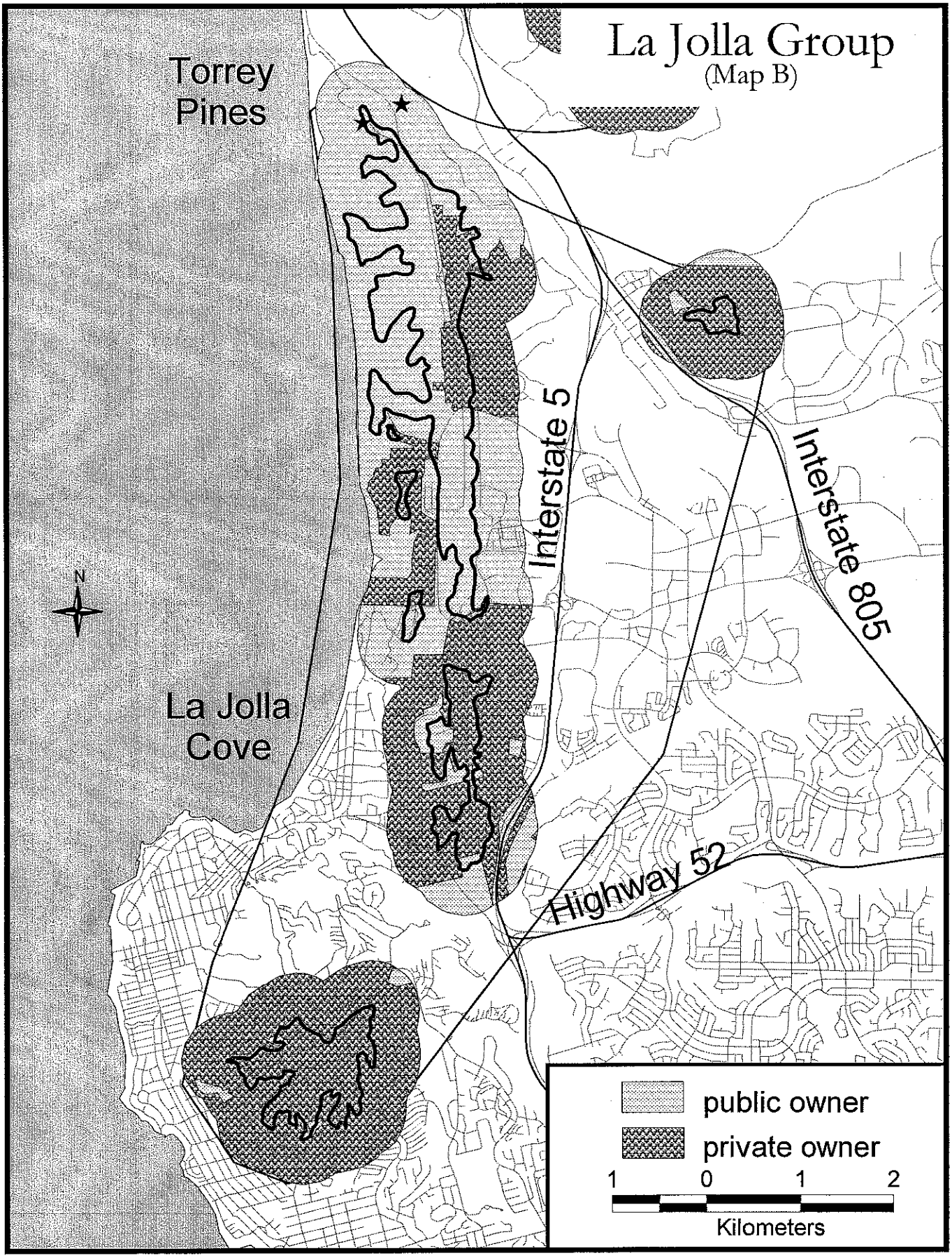

Del Mar Group
(Map A)
Interstate 5
Del Mar Heights
Carmel Country
Highway 56
Sorrento Valley
Arroyo Sorrento
Carmel Mountain
1
2
3
4
5
6
N
Carlsbad Soils
0.5 km buffer
0.6 0 0.6 1.2
Kilometers

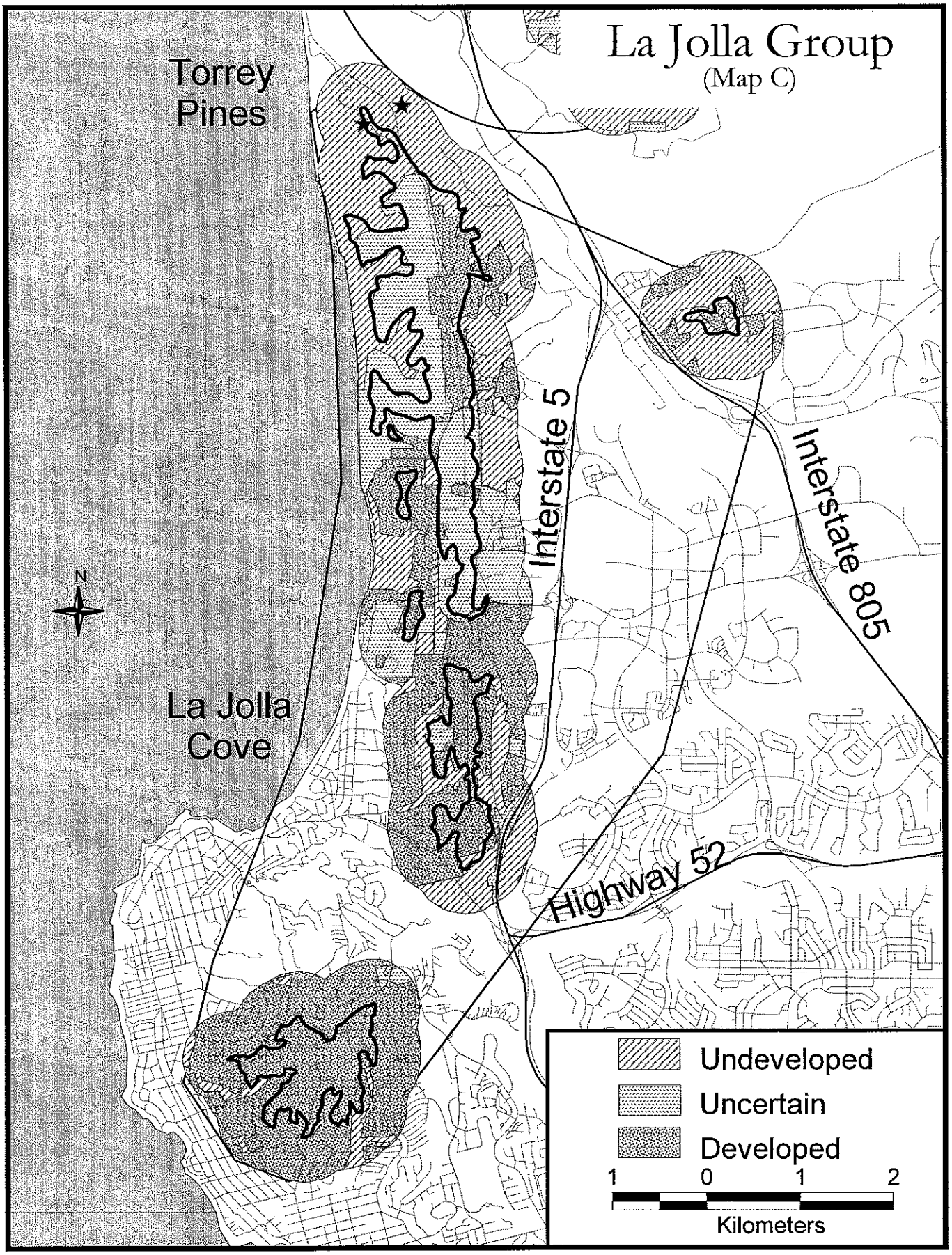

Del Mar Group
(Map B)
Interstate 5
Del Mar Heights
Carmel Country
Highway 56
Sorrento Valley
Arroyo Sorrento
Carmel Mountain
N
public owner
private owner
0.6
0
0.6
1.2
Kilometers

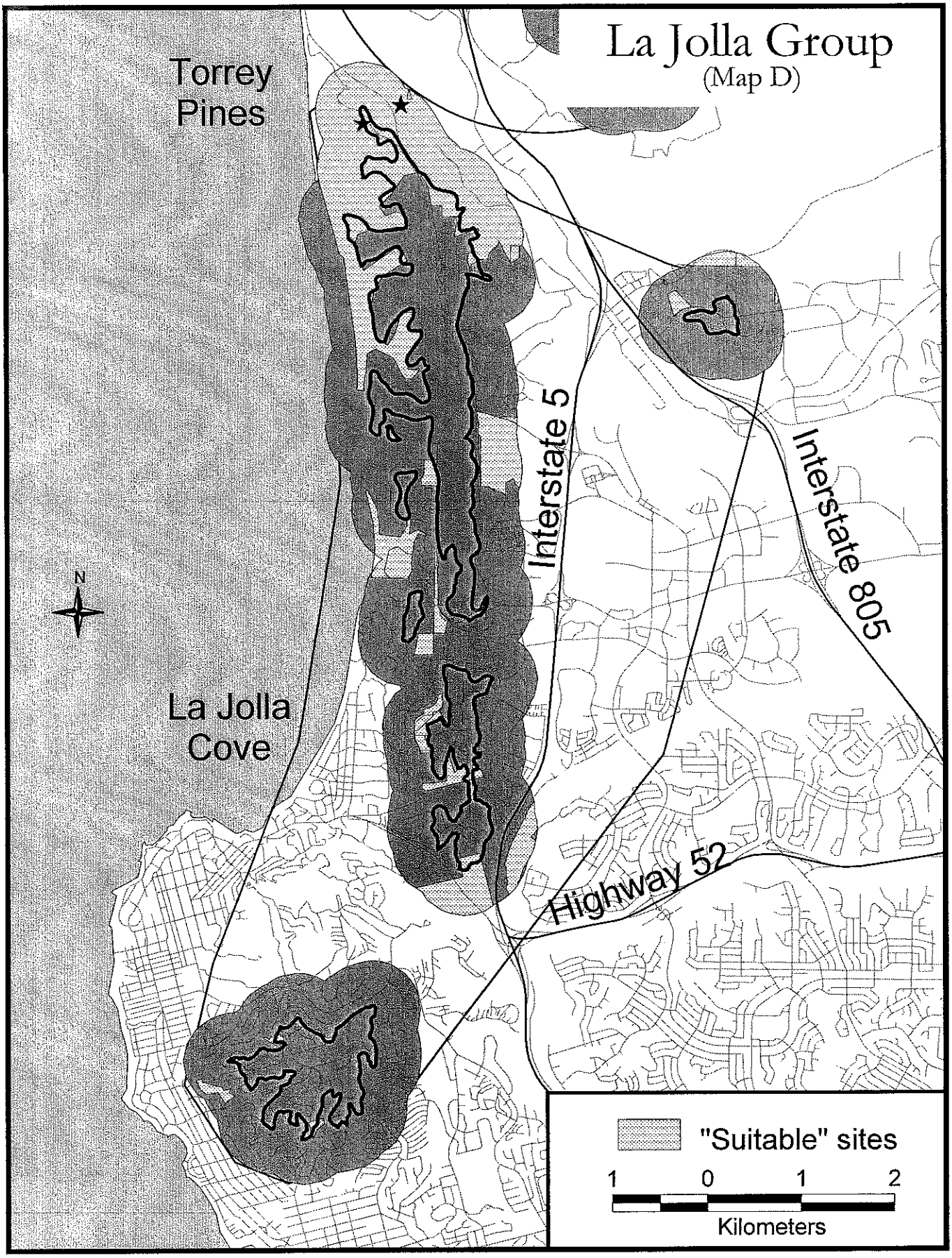

Del Mar Group
(Map C)
Interstate 5
Del Mar Heights
Carmel Country
Highway 56
Sorrento Valley
Arroyo Sorrento
Carmel Mountain
N
Undeveloped
Uncertain
Developed
0.6
0
0.6
1.2
Kilometers

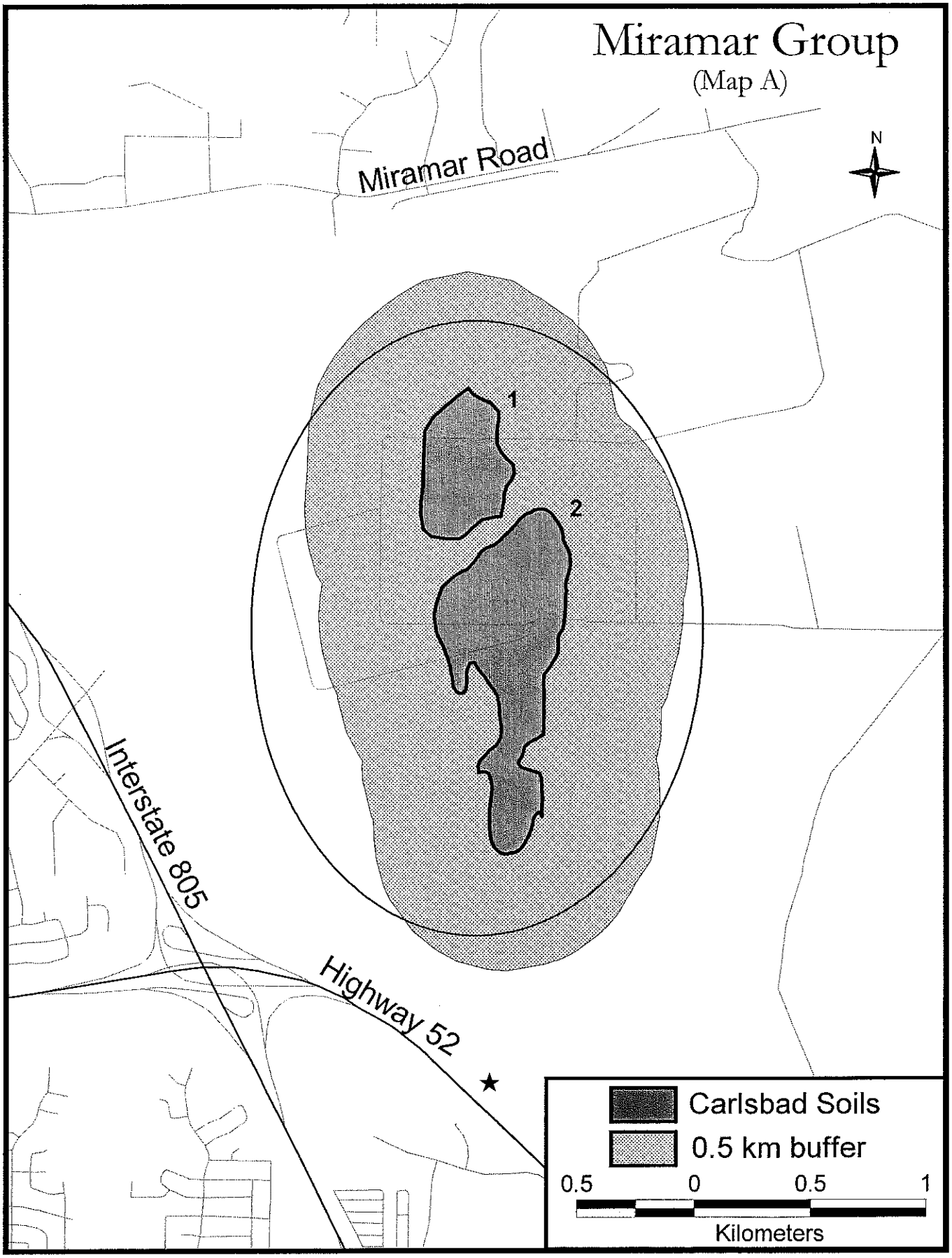

Del Mar Group
(Map D)
Interstate 5
Del Mar Heights
Carmel Country
Highway 56
Sorrento Valley
Arroyo Sorrento
Carmel Mountain
N
"Suitable" sites
0.6 0 0.6 1.2
Kilometers

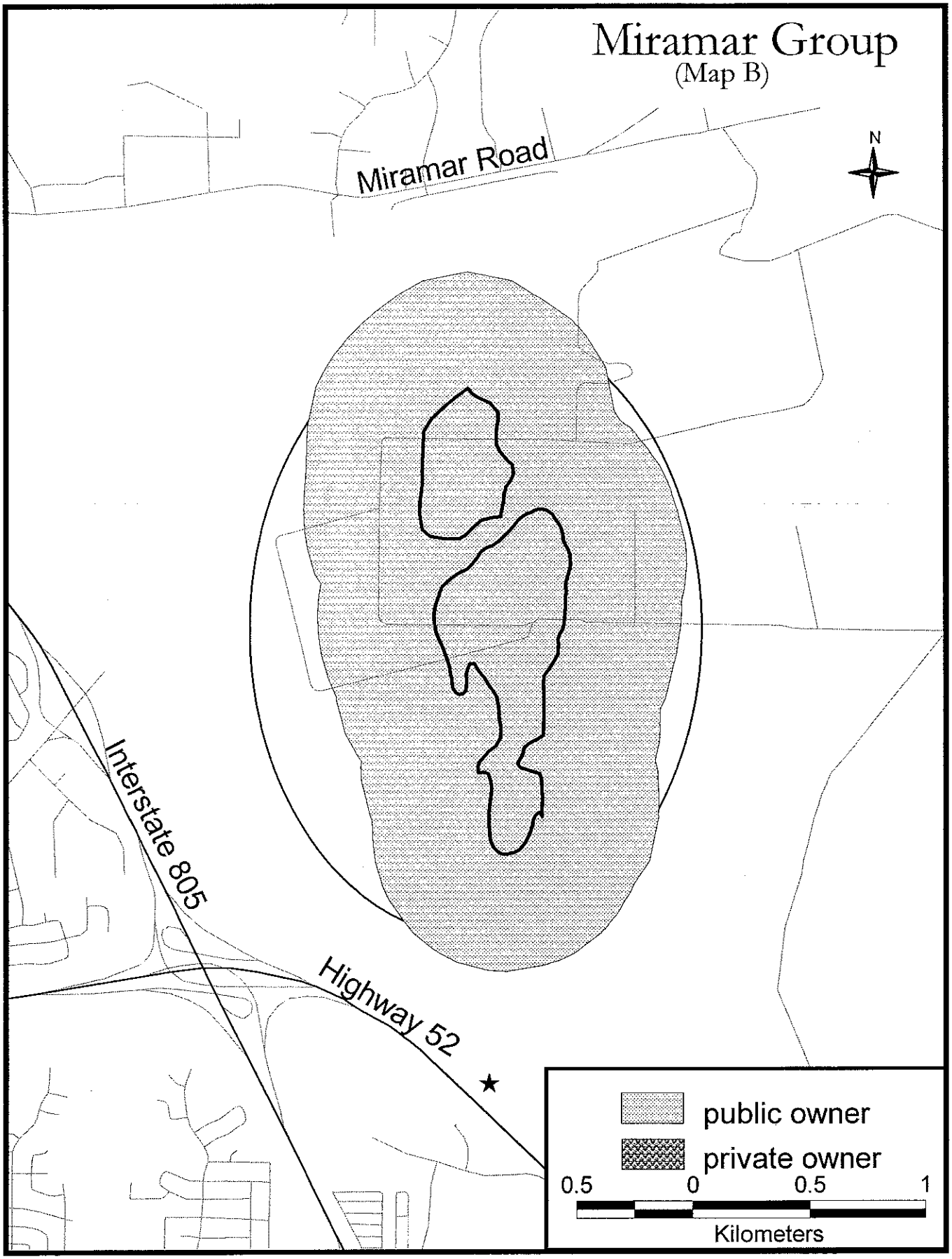

La Jolla Group
(Map A)
Torrey Pines
La Jolla Cove
Interstate 5
Interstate 805
Highway 52
N
1
2
3
4
5
6
7
Carlsbad Soils
0.5 km buffer
1 0 1 2
Kilometers

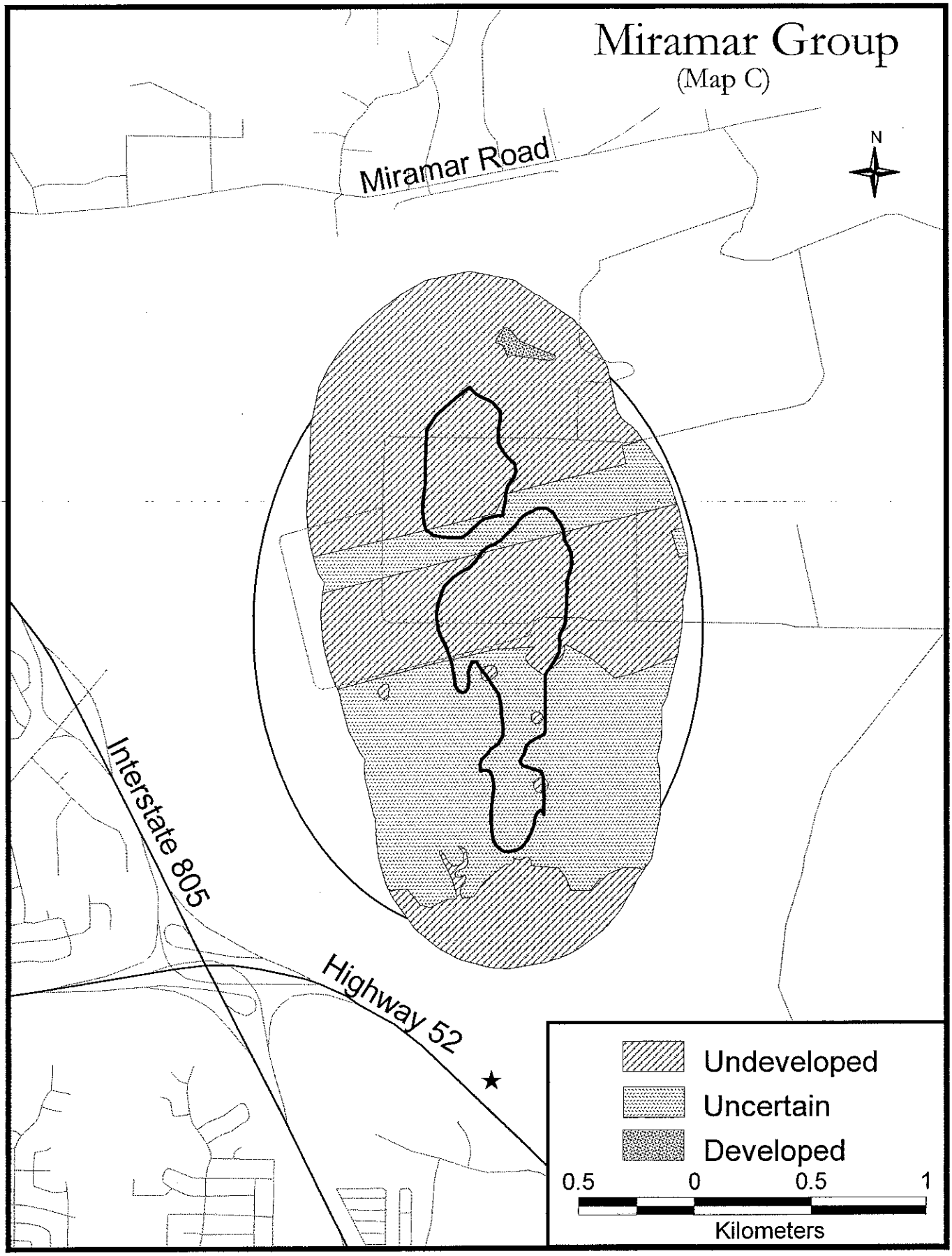

La Jolla Group
(Map B)
Torrey Pines
La Jolla Cove
Interstate 5
Interstate 805
Highway 52
N
public owner
private owner
1 0 1 2
Kilometers

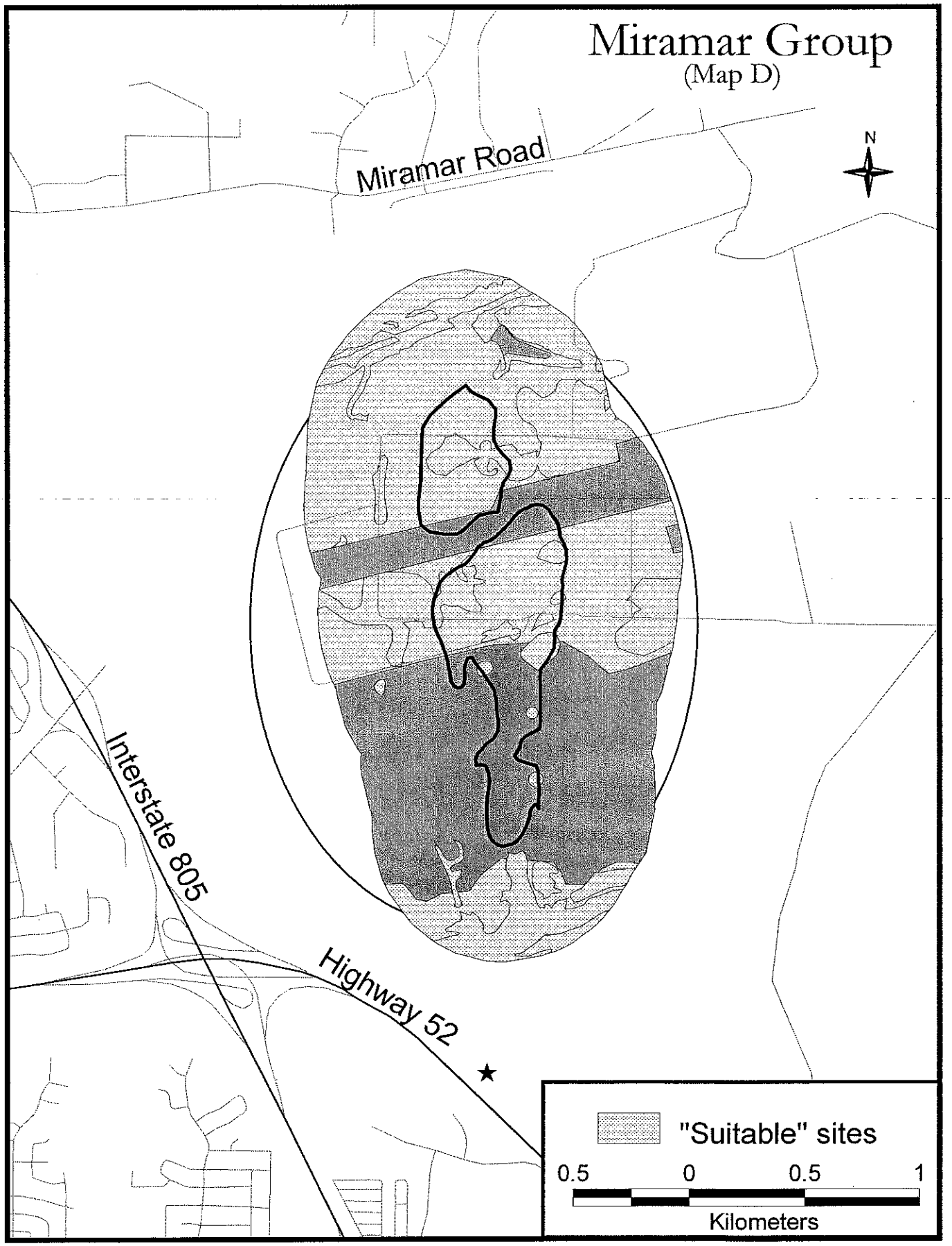

La Jolla Group
(Map C)
Torrey Pines
La Jolla Cove
Interstate 5
Interstate 805
Highway 52
N
Undeveloped
Uncertain
Developed
1 0 1 2
Kilometers

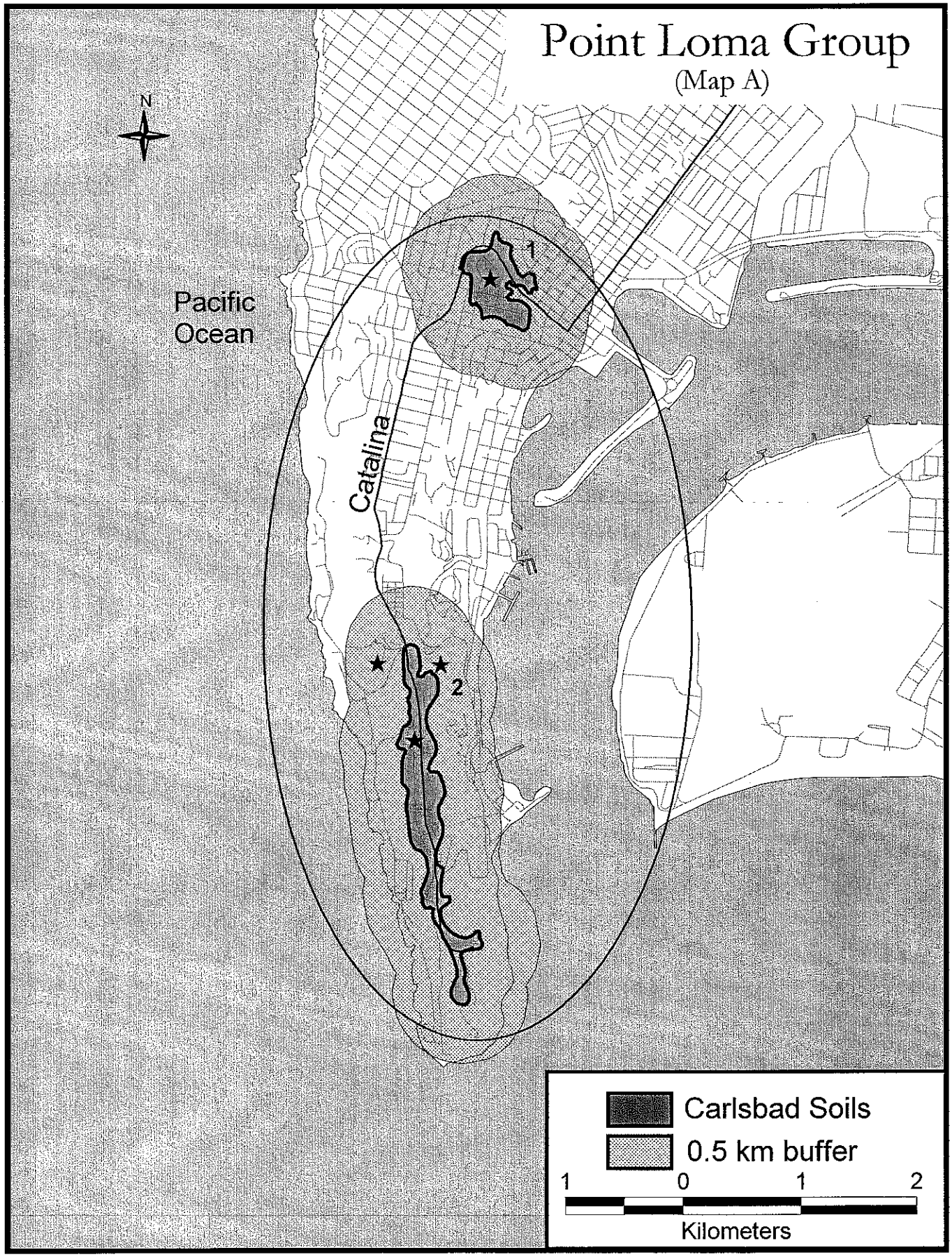

La Jolla Group
(Map D)
Torrey Pines
La Jolla Cove
Interstate 5
Interstate 805
Highway 52
N
"Suitable" sites
1 0 1 2
Kilometers

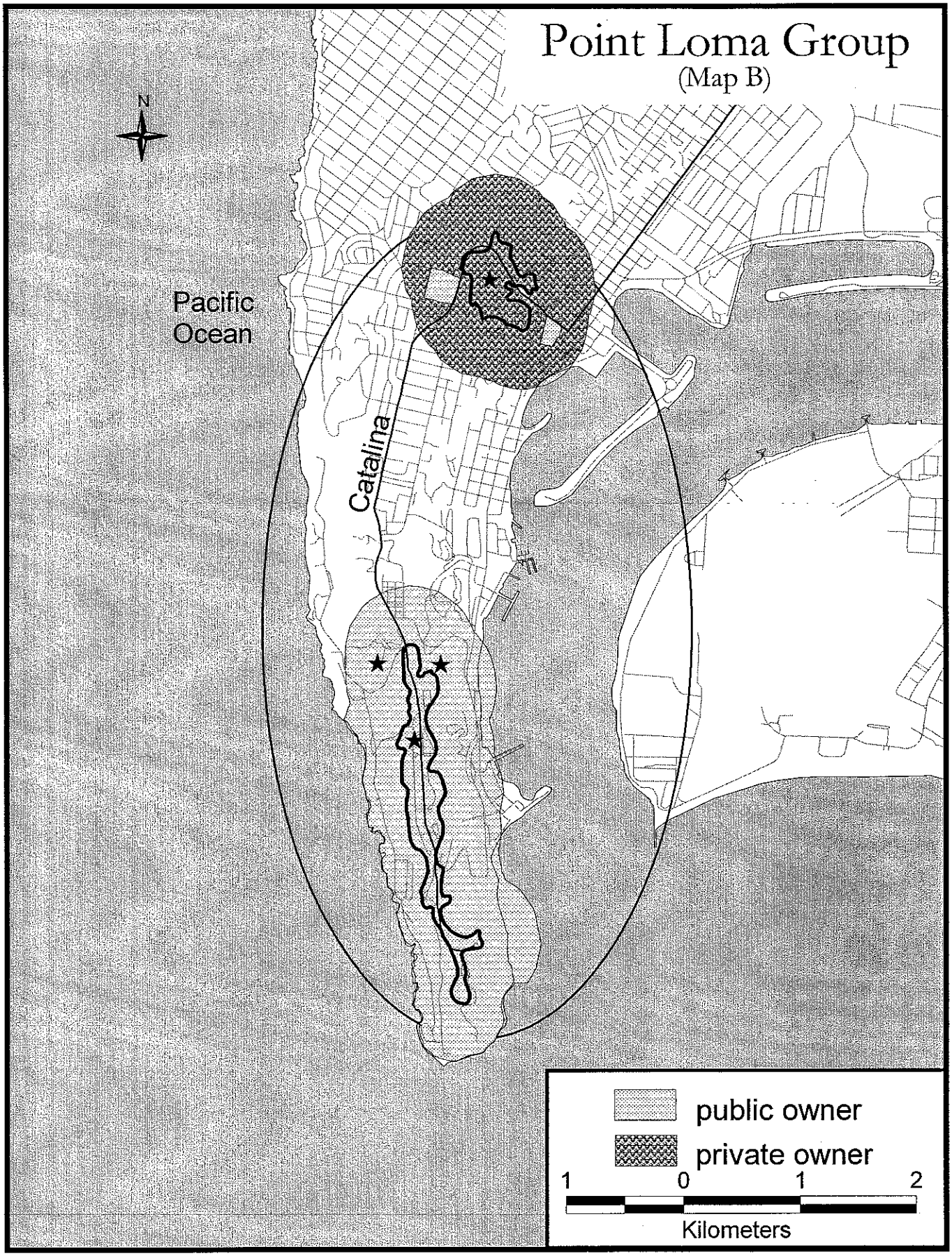

Miramar Group
(Map A)
N
Miramar Road
1
2
Interstate 805
Highway 52
Carlsbad Soils
0.5 km buffer
0.5
0
0.5
1
Kilometers

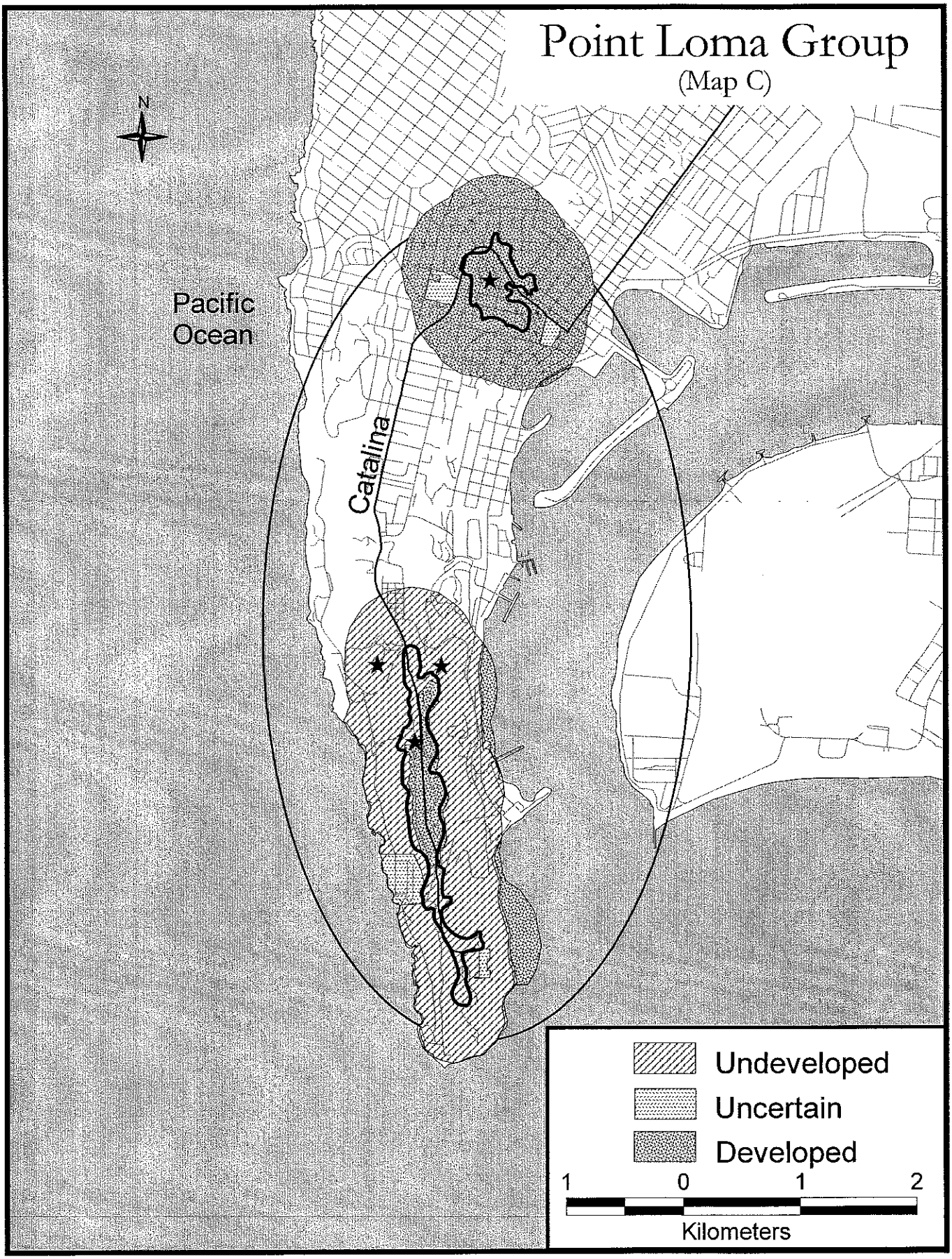

Miramar Group
(Map B)
N
Miramar Road
Interstate 805
Highway 52
public owner
private owner
0.5
0
0.5
1
Kilometers

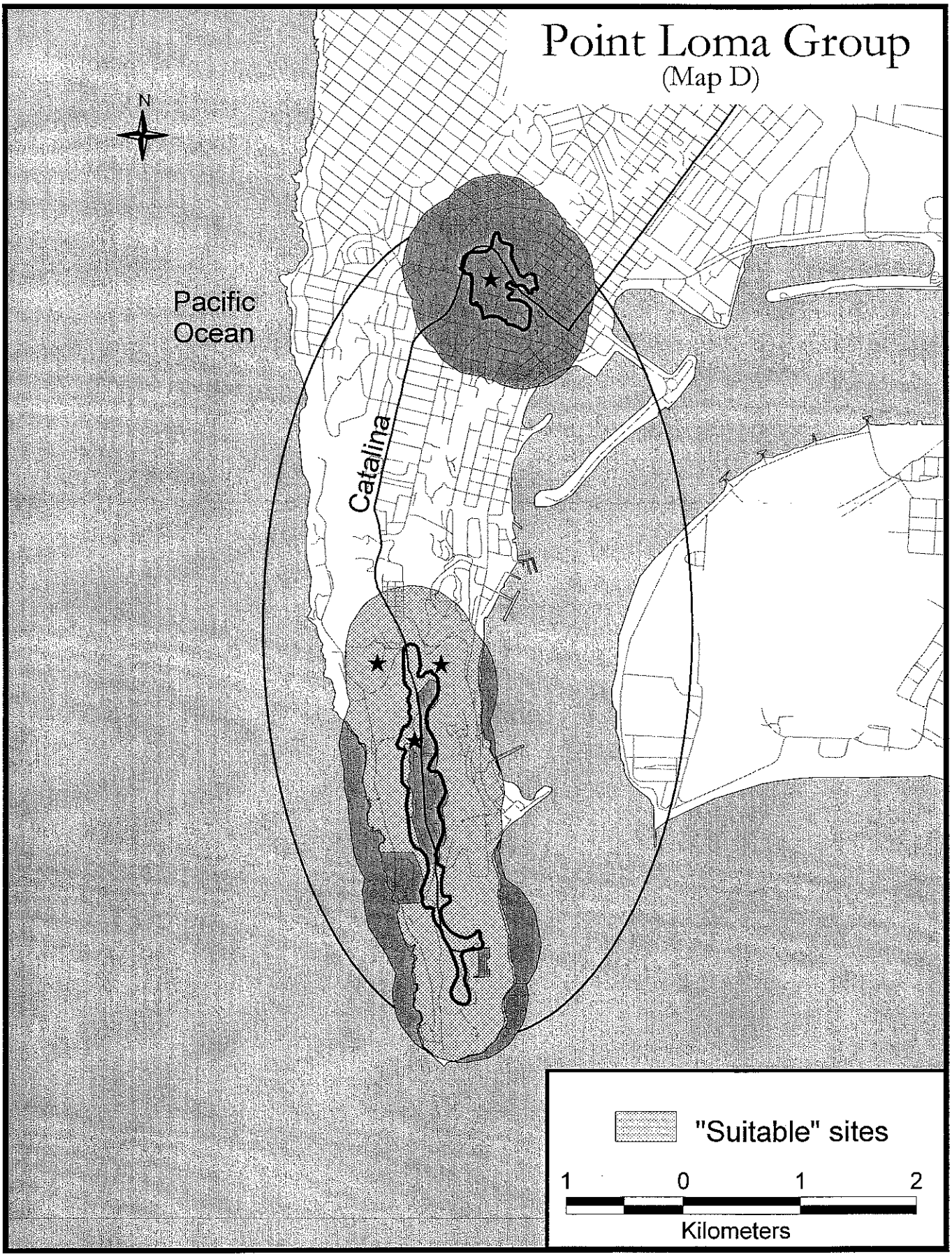

Miramar Group
(Map C)
N
Miramar Road
Interstate 805
Highway 52
Undeveloped
Uncertain
Developed
0.5
0
0.5
1
Kilometers

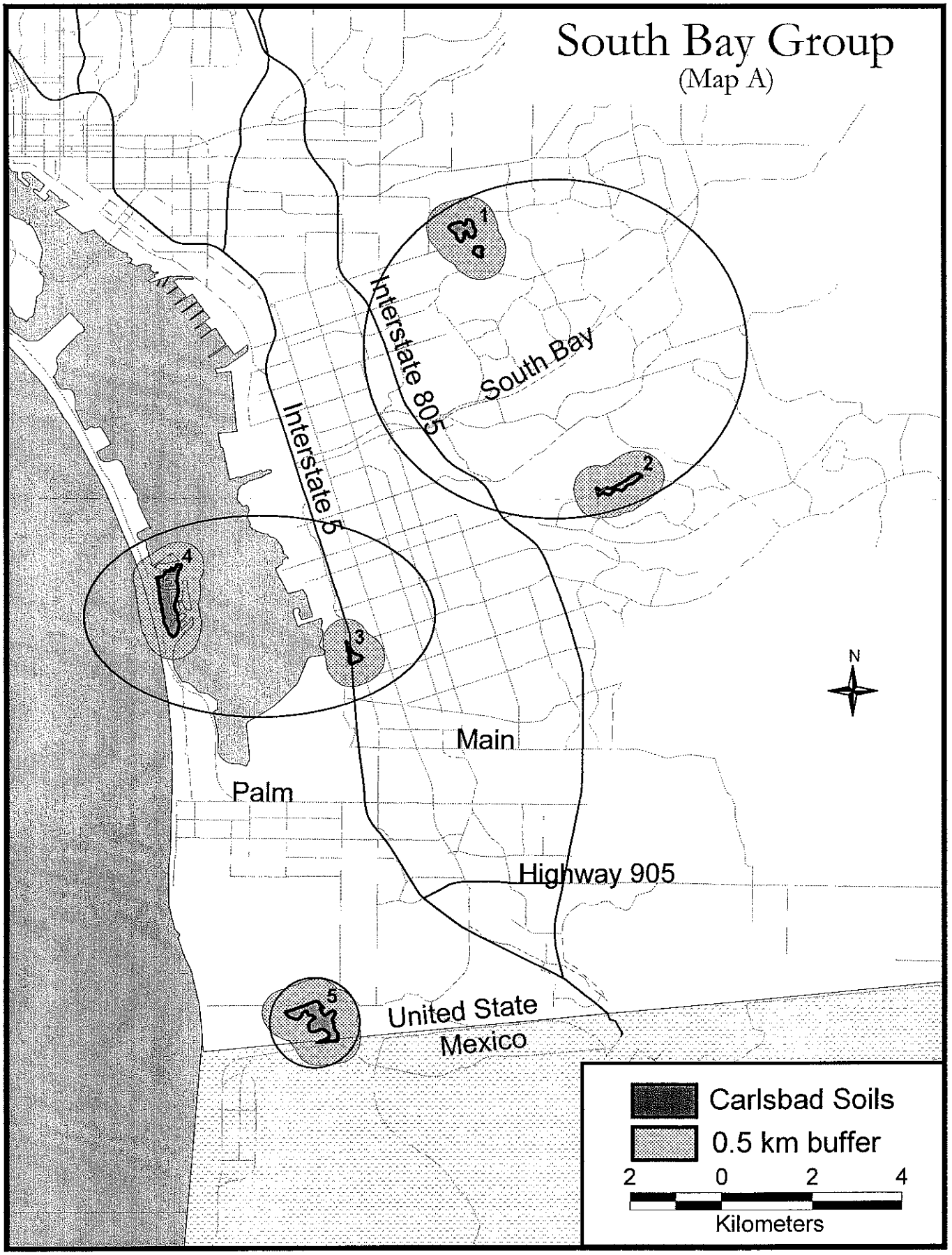

Miramar Group
(Map D)
N
Miramar Road
Interstate 805
Highway 52
"Suitable" sites
0.5
0
0.5
1
Kilometers

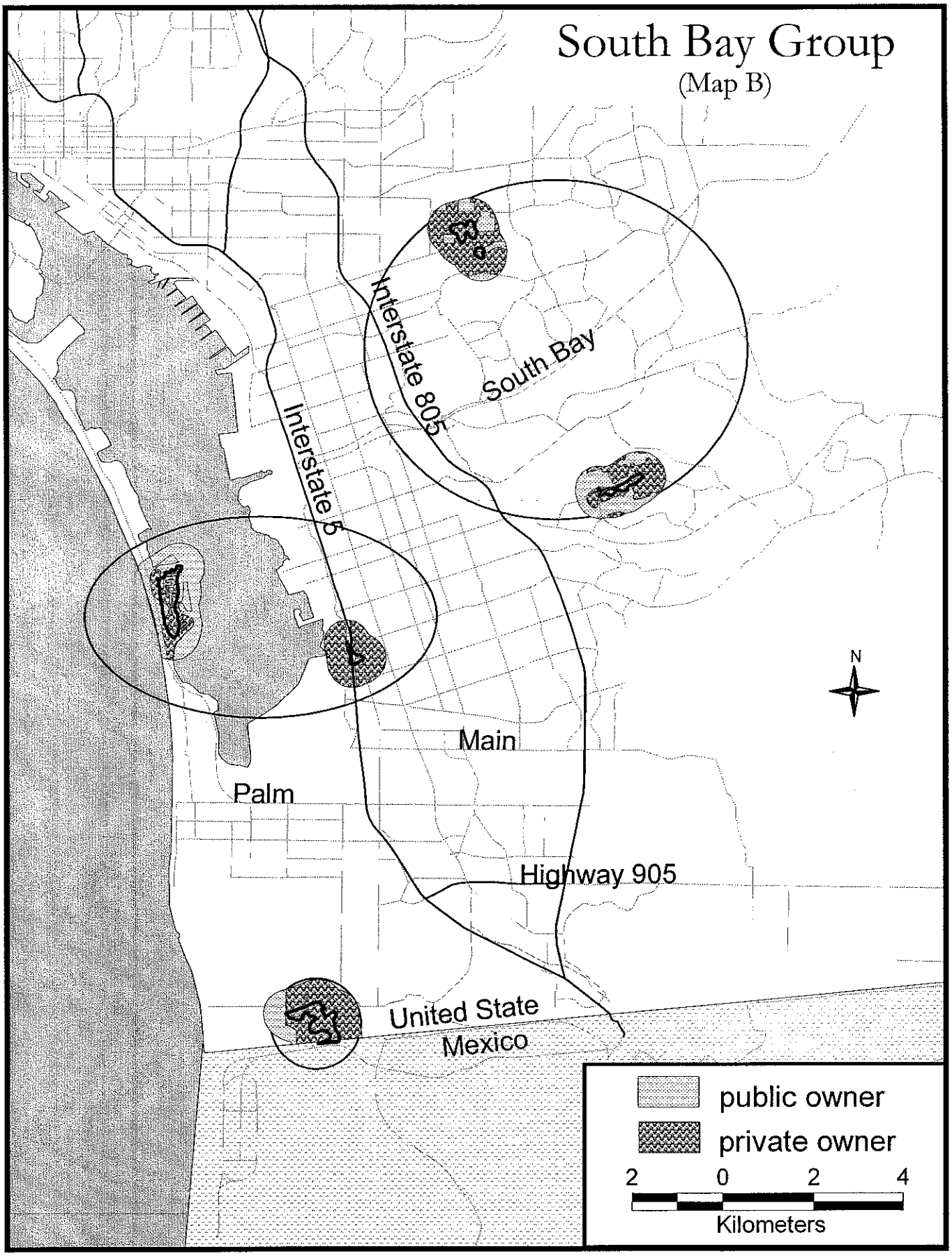

Point Loma Group
(Map A)
N
Pacific
Ocean
Catalina
1
2
Carlsbad Soils
0.5 km buffer
1 0 1 2
Kilometers

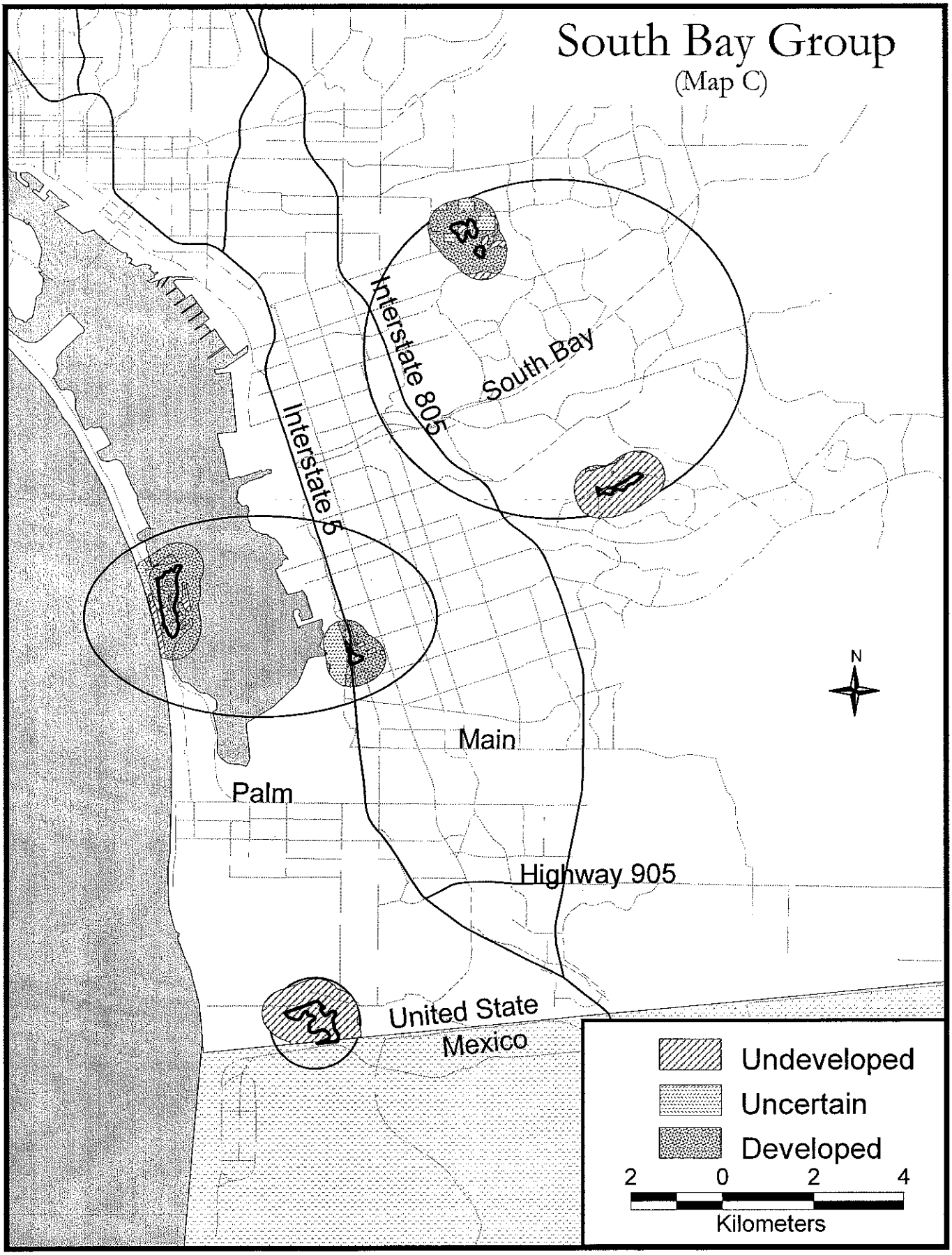

Point Loma Group
(Map B)
N
Pacific
Ocean
Catalina
public owner
private owner
1 0 1 2
Kilometers

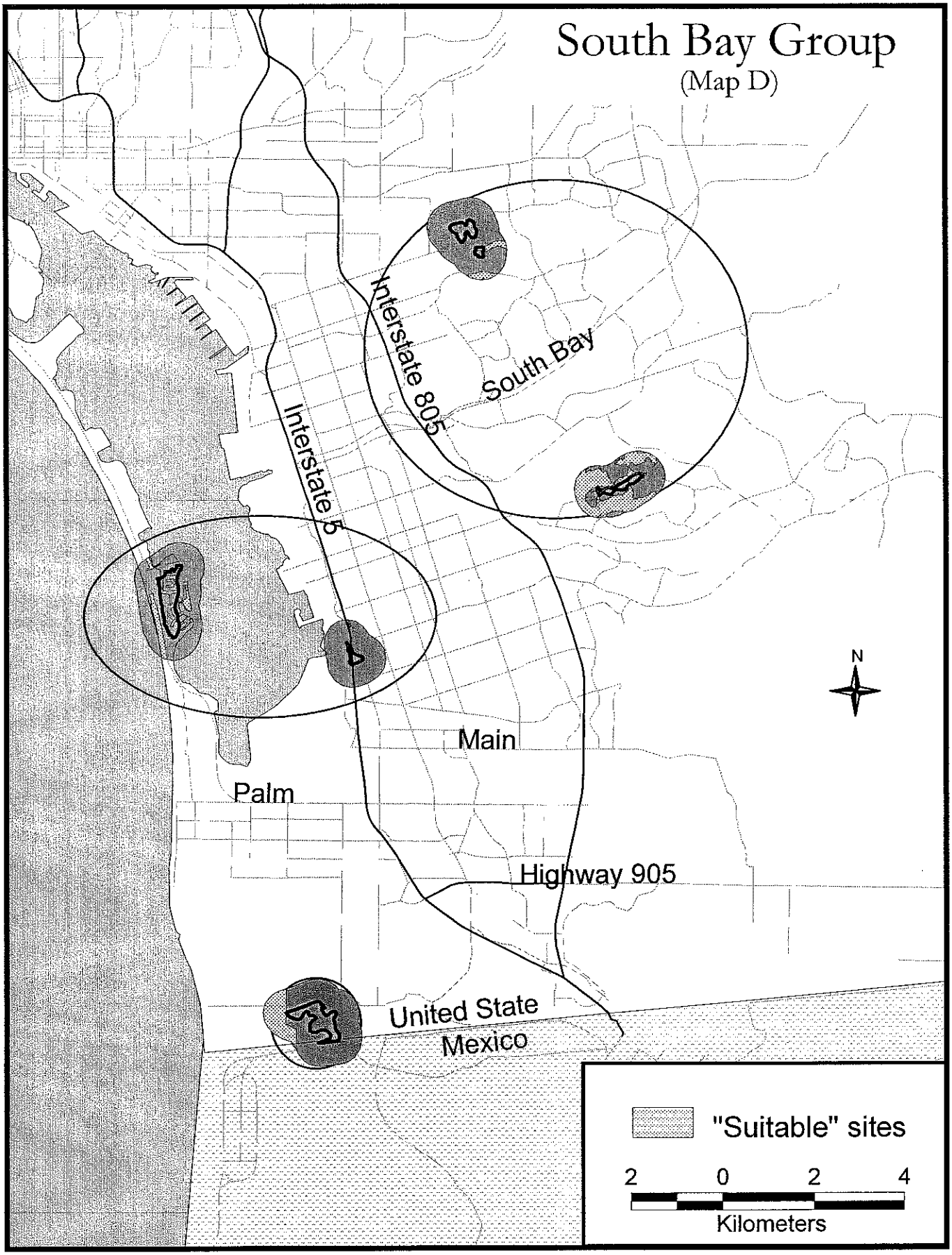

Point Loma Group
(Map C)
N
Pacific
Ocean
Catalina
Undeveloped
Uncertain
Developed
1
0
1
2
Kilometers


Point Loma Group
(Map D)
N
Pacific
Ocean
Catalina
"Suitable" sites
1 0 1 2
Kilometers


South Bay Group
(Map A)
Interstate 805
South Bay
Interstate 5
Main
Palm
Highway 905
United State
Mexico
N
Carlsbad Soils
0.5 km buffer
2 0 2 4
Kilometers


South Bay Group
(Map B)
Interstate 805
South Bay
Interstate 5
Main
Palm
Highway 905
United State
Mexico
N
public owner
private owner
2 0 2 4
Kilometers


South Bay Group
(Map C)
Interstate 805
South Bay
Interstate 5
Main
Palm
Highway 905
United State
Mexico
N
Undeveloped
Uncertain
Developed
2 0 2 4
Kilometers


South Bay Group
(Map D)
Interstate 805
South Bay
Interstate 5
N
Main
Palm
Highway 905
United State
Mexico
"Suitable" sites
2 0 2 4
Kilometers

APPENDIX C
FIELD SURVEY FORMS

CHORIZANTHE ORCUTTIANA FIELD SURVEY FORM

Location: Encinitas Ranch open space

Investigators: Juda Sakurson, Winnie Sunshine Date: 4/25/2000

A. Extent of Population:

Est. number of plants none found Est. area of population: _____

Size of plants: Unbranched 2-3 branches 3-6 branches >6

Phenology: Vegetative Flowering: _____

If no plants, extent of potential habitat: _____

B. Site description:

Soil, slope etc. Sandy soil, generally sloping east from sandstone escarpment. Most of area is not easily accessible. Area just east of free-standing sandstone formation just off path looks very good as habitat with several companion plants, other Chorizanthe

Surrounding perennial plant community:

- ✓ Adenostema fasciculata
- ✓ Artemisia californica
- ✓ Ceanothus verrucosus
- ✓ Cneoridium dumosum
- ✓ Encelia californica
- Euphorbia misera
- ✓ Lotus scoparius
- ✓ Malosma laurina
- ✓ Rhamnus crocea
- ✓ Rhus integrifolia
- ✓ Salvia mellifera
- ✓ Yucca schidigera

Companion annuals:

- ✓ Camissonia bistorta
- ✓ Cardionema ramosissimum
- ✓ Chorizanthe spp.
- ✓ Crassula connata
- Lastarriaea coriacea
- Mucronia perfoliata
- ✓ Pterostegia drymarioides

Other species: _____

_____

C. Disturbance:

Exotics: _____

Human disturbance: Some areas probably grazed, now being revegetated.

Surrounding land use: Agricultural above escarpment. Residential, commercial downslope.

D. Comments

Only looked at easily accessible areas near trail. May be other good habitat elsewhere in this large preserve, but would require serious bush-whacking.

CHORIZANTHE ORCUTTIANA FIELD SURVEY FORM

Location: Canyon in North Encinitas, off of Swallowtail Road, down to La Costa Ave.

Investigators: Juda Sakrison, Kasi Roesch Date: 11/2000

A. Extent of Population:

Est. number of plants none found Est. area of population: _____

Size of plants: Unbranched 2-3 branches 3-6 branches >6

Phenology: Vegetative Flowering: _____

If no plants, extent of potential habitat: _____

B. Site description:

Soil, slope etc. steep canyon, white sandstone at top, steep sides down to eroded creek bed. Dense vegetation, no openings, but soil soft sandy along path.

Surrounding perennial plant community:

- ✓ Adenostema fasciculata
- ✓ Artemisia californica
- ✓ Ceanothus verrucosus
- ✓ Cneoridium dumosum
- ✓ Encelia californica
- Euphorbia misera
- ✓ Lotus scoparius
- ✓ Malosma laurina
- Rhamnus crocea
- ✓ Rhus integrifolia
- ✓ Salvia mellifera
- ✓ Yucca schidigera

Companion annuals: not here at the right time of year.

- Camissonia bistorta
- Cardionema ramosissimum
- Chorizanthe spp.
- Crassula connata
- Lastarriaea coriacea
- Mucronia perfoliata
- Pterostegia drymarioides

Other species: Nassella pulchra

C. Disturbance:

Exotics: Pampas grass in creek. Some exotic grasses along trails.

Human disturbance: Flat area at bottom of canyon along La Costa Ave has been bladed?

Surrounding land use: Residential, top of ridge.

D. Comments Beautiful, relatively undisturbed canyon. Vegetation dense.

CHORIZANTHE ORCUTTIANA FIELD SURVEY FORM

Location: San Elijo lagoon, south side, upper sandstone area accessible from Solana Hills Dr.

Investigators: Juda Sakrison & Kari Roesch Date: 10/2000

A. Extent of Population:

Est. number of plants none found Est. area of population: _____

Size of plants: Unbranched 2-3 branches 3-6 branches >6

Phenology: Vegetative Flowering: _____

If no plants, extent of potential habitat: _____

B. Site description:

Soil, slope etc. White sandstone bluffs, some gently sloping areas with sandy pockets & shrubs.

Surrounding perennial plant community:

- ✓ Adenostema fasciculata
- ✓ Artemisia californica
- ✓ Ceanothus verrucosus
- ✓ Cneoridium dumosum
- ✓ Encelia californica
- Euphorbia misera
- ✓ Lotus scoparius
- ✓ Malosma laurina
- ✓ Rhamnus crocea
- ✓ Rhus integrifolia
- ✓ Salvia mellifera
- Yucca schidigera

Companion annuals: Wrong time of year

- Camissonia bistorta
- Cardionema ramosissimum
- Chorizanthe spp.
- Crassula connata
- Lastarriaea coriacea
- Mucronia perfoliata
- Pterostegia drymarioides

Other species: Crotalus

C. Disturbance:

Exotics: some Carpobrotus

Human disturbance: Some trails, probably not heavily used.

Surrounding land use: residential above, preserve below

D. Comments

Also worth looking at Holmwood Canyon (?) farther west; large canyon opening to lagoon, accessible from Holmwood Lane.

CHORIZANTHE ORCUTTIANA FIELD SURVEY FORM

Location: Crest Canyon - Del Mar

Investigators: J. Sakrison, Winnie Sunshine Date: 4/18/2000

A. Extent of Population:

Est. number of plants ~~none found~~ Est. area of population:

Size of plants: Unbranched 2-3 branches 3-6 branches >6

Phenology: Vegetative Flowering:

If no plants, extent of potential habitat: small patches, but may be too disturbed. Best chance, under edges of shrubs.

B. Site description:

Soil, slope etc. Sandstone escarpment east side of canyon. At base, moderately sloping open areas between shrubs.

Surrounding perennial plant community:

- ✓ Adenostema fasciculata
- ✓ Artemisia californica
- ✓ Ceanothus verrucosus
- ✓ Cneoridium dumosum
- ✓ Encelia californica
- Euphorbia misera
- ✓ Lotus scoparius
- ✓ Malosma laurina
- Rhamnus crocea
- ✓ Rhus integrifolia
- ✓ Salvia mellifera
- ✓ Yucca schidigera

Companion annuals:

- ✓ Camissonia bistorta
- ? Cardionema ramosissimum
- Chorizanthe spp.
- ✓ Crassula connata
- Lastarriaea coriacea
- Mucronia perfoliata
- ✓ Pterostegia drymarioides

Other species: Crotalus, Yerba Santa, Torrey Pines

C. Disturbance:

Exotics: Eucalyptus, escaped exotics

Human disturbance: Heavily used for recreation

Surrounding land use: Residential

D. Comments Some likely habitat near base of sandstone slopes east side, just below access path from retreat. (Durango)
West side of canyon, steep, dense vegetation. Soil doesn't look quite right.

CHORIZANTHE ORCUTTIANA FIELD SURVEY FORM

Location: Miramar west end of flightline.

Investigators: E. Bauder, J. Sakrison, A. Russell, J. Snapp-Cook Date: 5/25/99

A. Extent of Population:

Est. number of plants none seen Est. area of population: _____

Size of plants: Unbranched 2-3 branches 3-6 branches >6

Phenology: Vegetative Flowering: _____

If no plants, extent of potential habitat: _____

B. Site description:

Soil, slope etc. Very eroded red sandstone, hard, with areas of pale, sandy channels. Sparse vegetation. Areas of iron concretions. Also patches of deeply cracked clay, looks like Acanthomintha soil. Low damp areas also.

Surrounding perennial plant community:

- ✓ Adenostema fasciculata
- ✓ Artemisia californica
- _____ Ceanothus verrucosus
- _____ Cneoridium dumosum
- _____ Encelia californica
- _____ Euphorbia misera
- ✓ Lotus scoparius
- _____ Malosma laurina
- _____ Rhamnus crocea
- ✓ Rhus integrifolia
- ✓ Salvia mellifera
- _____ Yucca schidigera

Companion annuals:

- ✓ Holocarpha
- ✓ Hemizonia
- ✓ Isocoma?
- ✓ Baccharis sarotha.

- _____ Camissonia bistorta
- ✓ Cardionema ramosissimum
- ✓ Chorizanthe spp. staticoides and fimbriata?
- ✓ Crassula connata
- _____ Lastarriaea coriacea
- _____ Mucronia perfoliata
- _____ Pterostegia drymarioides

C. staticoides - widespread.

Other species: Navarretia hamata, Plantago spp. (lots), Filago Lotus purshianus, _____

C. Disturbance:

Exotics: Brassica, Rumex, Bromus, Polypogon, Lythrum.

Human disturbance: Some bladed areas.

Surrounding land use: Runway, roads, Landfill to south.

D. Comments

CHORIZANTHE ORCUTTIANA FIELD SURVEY FORM

Location: Miramar Landfill - low red hill n of SR 52, s of sludge plant.

Investigators: E. Bauder, J. Sakrison Date: 5/28/99

A. Extent of Population:

Est. number of plants none seen Est. area of population: _____

Size of plants: Unbranched 2-3 branches 3-6 branches >6

Phenology: Vegetative Flowering: _____

If no plants, extent of potential habitat: _____

B. Site description:

Soil, slope etc. Orange-red hard surface with patches of soft white sand. Sandstone outcrops.

Surrounding perennial plant community:

- ✓ Adenostema fasciculata
- ✓ Artemisia californica
- ✓ Ceanothus verrucosus
- _____ Cneoridium dumosum
- _____ Encelia californica
- _____ Euphorbia misera
- ✓ Lotus scoparius
- ✓ Malosma laurina
- _____ Rhamnus crocea
- ✓ Rhus integrifolia
- ✓ Salvia mellifera
- ✓ Yucca schidigera

Companion annuals:

✓ Eriodictyon
✓ Baccharis

- _____ Camissonia bistorta
- _____ Cardionema ramosissimum
- ✓ Chorizanthe spp.
- ✓ Crassula connata
- _____ Lastarriaea coriacea
- _____ Mucronia perfoliata
- _____ Pterostegia drymarioides

Chorizanthe fimbriata and C. procumbens

Other species: Hazardia, Hemizonia, Lessingia, Helianthemum, Marah macrocarpa, Stylocline gnaphaloides, Gnaphalium
Gnatcatchers?

C. Disturbance:

Exotics: Cortaderia, Centaurea melitensis, Brassica, Avena

Human disturbance: Some grading, digging

Surrounding land use: sludge plant facility to north, freeways to south and west.

D. Comments

Revisit in the future, in year of more rainfall. Interesting variety of natives persist in this isolated remnant of habitat.

CHORIZANTHE ORCUTTIANA FIELD SURVEY FORM

Location: Pt. Loma; from below NRAD child care center, No road, sandy areas north to slopes below building 420 and the anechoic facility? Area 6 on our maps.

Investigators: E. Bauder, J. Sakrison Date: 5/6/1999

A. Extent of Population:

Est. number of plants _____ Est. area of population: _____

Size of plants: Unbranched 2-3 branches 3-6 branches >6

Phenology: Vegetative Flowering: _____

If no plants, extent of potential habitat: On our maps: Area e has some very good habitat, with Mucronia present

B. Site description:

Soil, slope etc. flat to moderate slope. Area e, perfect substrate. Area b, soft sand from above? Iron concretions in d.

Surrounding perennial plant community:

- ✓ Adenostema fasciculata
- ✓ Artemisia californica
- ✓ Ceanothus verrucosus
- ✓ Cneoridium dumosum
- ✓ Encelia californica
- ✓ Euphorbia misera
- ✓ Lotus scoparius
- Malosma laurina
- ✓ Rhamnus crocea
- ✓ Rhus integrifolia
- ✓ Salvia mellifera
- ✓ Yucca schidigera

Companion annuals:

- ✓ Camissonia bistorta
- Cardionema ramosissimum
- Chorizanthe spp.
- ✓ Crassula connata
- Lastarriaea coriacea
- ✓ Mucronia perfoliata lots in area e, not seen elsewhere
- ✓ Pterostegia drymarioides

Other species: Eriogonum gigantea, Dudleya pulver., D. edulis, D. lanceolata, Calyptridium, Euphorb. polycarpa, Isomeris, Stephanomeria or Antirrhinum?, Ferocactus, Eriophyllum, Mirabilis, Lastrenia, Chaenactis? Xylococcus?

C. Disturbance:

Exotics: Carpobrotus, Acacia.

Human disturbance: Some modification of slopes along roads, below buildings

Surrounding land use: Upslopes: child care buildings, road, anechoic facility

D. Comments. Area e, just below and SW of anechoic pond has very good potential for introduction. Many companions, low disturbance, good substrate.

CHORIZANTHE ORCUTTIANA FIELD SURVEY FORM

(Areas 7a and 7b on our maps.)

Location: Pt. Loma. N of Woodward Rd, SSW of buildings 376 and 378.

Investigators: E. Bauder, J. Sakrison Date: 5/4/99

A. Extent of Population: Area 7a: just over ridge west of Strong Road, below flat-bladed (paved?) area.

Est. number of plants 31 Est. area of population: 300 m²

Size of plants: Unbranched 2-3 branches 3-6 branches >6

Phenology: Vegetative Flowering: many

If no plants, extent of potential habitat:

B. Site description:

Soil, slope etc. loose sand, many plants under shrub edges, "misse plants." Slope 5-20°

Surrounding perennial plant community:

___ Adenostema fasciculata	✓ Lotus scoparius
✓ Artemisia californica	✓ Malosma laurina
✓ Ceanothus verrucosus	✓ Rhamnus crocea
✓ Cneoridium dumosum	✓ Rhus integrifolia
✓ Encelia californica	✓ Salvia mellifera
✓ Euphorbia misera	✓ Yucca schidigera

Companion annuals:

7a Camissonia bistorta	___ Lastarriaea coriacea
___ Cardionema ramosissimum	7a Mucronia perfoliata
___ Chorizanthe spp.	___ Pterostegia drymarioides
___ Crassula connata	

Other species: 7a: Mirabilis, Eriophyllum, Hazardia?

7b: Viguiera, Croton, Euphorbia poly, Eriodyction, Yucca, Ferocactus, Dudleya pulv

C. Disturbance:

Exotics: 7a not much disturbance; some Carpobrotus. Carpobrotus, Acacias in 7b

Human disturbance: Area 7b more disturbed. Cut/dead Acacias, fill slope, unnatural contours.

Surrounding land use: Road above, towers nearby.

D. Comments

7a where plants were found is in pretty good condition. Some Carpobrotus. Exotics may continue to encroach from above.

CHORIZANTHE ORCUTTIANA FIELD SURVEY FORM

Location: Pt. Loma (Areas 7c-h) on our maps. West of Cabrillo Dr., N of antenna dish and Bldg. 375 north along base of escarpment to fill slope below NRAD child care facility parking lot

Investigators: E. Bauder, J. Sakrison Date: 5/3/99

A. Extent of Population:

Est. number of plants _____ Est. area of population: _____

Size of plants: Unbranched 2-3 branches 3-6 branches >6

Phenology: ~~Vegetative~~ Flowering:

If no plants, extent of potential habitat: Possibly some patches toward the northern end (7f-h). The rest is moderately disturbed.

B. Site description:

Soil, slope etc. Variable slope below escarpment, sandy ridges separated by canyon fingers.

Surrounding perennial plant community:

- ✓ Adenostema fasciculata
- _____ Artemisia californica
- ✓ Ceanothus verrucosus
- ✓ Cneoridium dumosum
- ✓ Encelia californica
- _____ Euphorbia misera
- _____ Lotus scoparius
- _____ Malosma laurina
- ✓ Rhamnus crocea
- ✓ Rhus integrifolia
- _____ Salvia mellifera
- _____ Yucca schidigera

Companion annuals:

- _____ Camissonia bistorta
- _____ Cardionema ramosissimum
- _____ Chorizanthe spp.
- _____ Crassula connata
- _____ Lastarriaea coriacea
- _____ Mucronia perfoliata
- _____ Pterostegia drymarioides

Other species: Isomeris, Eriodyction, Helianthemum, Toyon, Dudley pulv., Euphorb. polycarpa, Ferrocactus, Happlopappus, Apiacia ushaudia, Hazardia?

C. Disturbance:

Exotics: Carpobrotus, Acacia (dense in places) Eucalyptus

Human disturbance: moderate-high, Some asphalt, trash in d+e. low disturbance f-h.

Surrounding land use: Above escarpment and fill slopes: antenna facility, Pt. Loma Amateur Radio Club, NRAD child care facility parking lot

D. Comments

Much of this area is moderately-highly disturbed, exotic-covered. A few possible patches of habitat on sandy ridges. Not easily accessable, limited.

CHORIZANTHE ORCUTTIANA FIELD SURVEY FORM

Area 9 on our maps.
Location: Pt. Loma. Just N of cemetary, across from Bennington Mnmt.
IMAT Bldgs 586, 587, 589, 590
Investigators: E. Bauder, J. Sakrison Date: 5/99

A. Extent of Population:

Est. number of plants _____ Est. area of population: _____

Size of plants: Unbranched ~~2-3 branches~~ 3-6 branches >6

Phenology: ~~Vegetative~~ Flowering: _____

If no plants, extent of potential habitat: Areas 9e and f - Mucronea in f. Stylocline Camissonia

B. Site description:

Soil, slope etc. Slope shallow to moderate, soil sandy becoming more clayey downslope. Areas 9e and f have correct sandy substrate.

Surrounding perennial plant community:

- ✓ Adenostema fasciculata
- ✓ Artemisia californica
- ✓ Ceanothus verrucosus
- ✓ Cneoridium dumosum
- _____ Encelia californica
- _____ Euphorbia misera
- _____ Lotus scoparius
- _____ Malosma laurina
- ✓ Rhamnus crocea
- ✓ Rhus integrifolia
- ✓ Salvia mellifera
- _____ Yucca schidigera

Companion annuals:

- f Camissonia bistorta
- _____ Cardionema ramosissimum
- _____ Chorizanthe spp.
- e & f Crassula connata
- _____ Lastarriaea coriacea
- f Mucronia perfoliata
- f Pterostegia drymarioides

Other species: Eriogonum (Isomeris), Dudleya edulis, Dud. lanceolata, Astragalus, Eriophyllum, Corethrogyne (in f)

C. Disturbance:

Exotics: Near buildings and cemetary, lots of Carpobrotus

Human disturbance: Moderate-high in most of Area; low in 9e & 9f

Surrounding land use: IMAT Buildings

D. Comments Patches in 9e & f could be considered for introduction.