A STUDY OF THE ECOLOGICAL ASPECTS RELATED TO THE REINTRODUCTION OF *Acanthomintha obovata* ssp. *duttonii*

Submitted To

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OVERVIEW

A survey of several ecological parameters including soil nutrients, the uptake of these nutrients and habitat characteristics was made for the federally and state-listed Endangered species Acanthomintha obovata ssp. duttonii (San Mateo Thornmint). This plant is one of the rarer endemic ephemerals found growing on nutrient imbalanced serpentine soils in the San Francisco Bay region. In San Mateo County, where the thornmint is restricted, there are several areas of exposed serpentine soils, some of which may have historically supported the plant.

The purpose of this study was to characterize the habitat of the San Mateo thornmint and find suitable habitat for its possible reintroduction.

METHODS

The unusual nutrient chemistry of serpentine soil has been well documented (Kruckeberg 1984). Adaptive radiation of plants on serpentine soil with a resulting high degree of endemism and species diversity has become an exciting issue in evolutionary ecology. Ecologists studying the adaptations of plants on serpentine soils have considered the following three aspects; a tendency toward low nutrient concentrations, an imbalance in calcium and magnesium cations and the presence of toxic heavy metals (Fiedler 1985, Johnston and Proctor 1981, Kruckeberg 1984, Turitzin 1982). Previous studies have not localized any single factor in the soil that one can focus on for characterizing soil habitat requirements. Rather, as pointed out by Kruckeberg (1984 p. 83), it is necessary to consider multiple-factors such as soil chemistry, physical features of the environment and biological aspects such as microrhizae.

Soils were collected and analyzed from the known locality of the San Mateo thornmint and five other serpentine sites for comparative purposes. Soil nutrients surveyed were carbon, nitrogen, phosphorus, calcium, magnesium, potassium and sodium. Heavy metals surveyed were manganese, nickel and chromium. In addition, soil pH, bulk density, cation exchange capacity, field capacity and permanent wilting point were measured. Soil samples were collected at depths of 0-5 cm, 5-10 cm, 10-20 cm and 20-30 cm. Serpentine soil is often shallow and rocky. Thus, actual depths surveyed was a function of the soil depth above the parent rock.

Soil collections were made using a 10 cm soil cylinder. Each sample was oven dried, weighed, and sieved with a 0.2 cm mesh sieve to separate out gravel and rock. Nutrients and trace elements were extracted and determined using an atomic absorption spectrophotometer. Extraction for nickel and chromium was done with a DTPA chelate. Serpentine soil was sampled from three sites in Edgewood County Park (map 1 and 2) including the known site of <u>Acanthomintha</u> <u>obovata</u> ssp. <u>duttonii</u> (California Natural Diversity Database element occurrence # 5). Samples were also take from the Triangle (map 1, and 2)

, from Pulgas Ridge (map 1 and 3), and from

Stanford University's Jasper Ridge Preserve (map 1).

In order to evaluate how the thornmint may have adapted to the serpentine soils, plant tissues analysis of some soil nutrients was performed. Plant tissue from ten flowering individuals of the thornmint was dried and separated into leaves and stems. Nutrients and heavy metals surveyed in both leaves and stems were nitrogen, phosphorus, calcium, magnesium, potassium, sodium, manganese, iron, zinc, nickel and chromium. Atomic absorption spectrophotometry followed perchloric acid digestion of the plant material.

In addition, the habitat was characterized for slope, soil depth and plant associations.

RESULTS

SOILS--The soil analyses (Appendix I) display considerable variation within a location i.e. Edgewood samples 1, 2 & 3 as well as between locations. The soils associated with the San Mateo thornmint at Edgewood Park have three potentially significant characteristics: 1) The nutrients carbon, nitrogen and phosphorus have very low concentrations, 2) The ratio of calcium/magnesium is very low, due both to the low concentration of calcium, and to the extremely high magnesium concentration (45.91-48.89 Meq), 3) Soil field capacity and permanent wilting point both have very high percent moisture. In addition to the three aspects listed above, it is notable that the heavy metals manganese and nickel are in low concentrations, while chromium occurs in relatively high concentrations. Since chromium concentrations are very low in the neighboring soils, the higher concentrations in the thornmint soil sample may be due to accumulation through binding with the local serpentine clay. The Edgewood sample 1, the thornmint site, has a high bulk density and the general texture of the soil is like that of a dense clay.

Serpentine soil samples from other locations have a broad range of similarities and differences to the soil on which the thornmint grows. The Triangle soil sample is in nearly all respects most similar to the Edgewood sample 1 soils e.g. very low calcium/magnesium ratio with a relatively high magnesium concentration, low carbon, nitrogen and phosphorus, and high percent soil moisture. In addition, the Triangle soils are very deep in one particular area (map 2) and have a high bulk density very close to that of Edgewood sample 1. The remaining soil sample sites exhibit fewer similarities than the Triangle to the native thornmint soil habitat. The high degree of variation in soil characteristics noted between the sites illustrates the localized nature of serpentine soil.

PLANT TISSUE ANALYSIS-- Leaves and stems of the San Mateo thornmint were analyzed (Appendix II) to determine the physiological response of the plant to the soil nutrients. The low calcium/magnesium ratio observed in the leaf tissue (1.07) reflects the very low ratio found in the soil. Similarly, the stems had a low calcium/ magnesium ratio (0.73). The stems also displayed a high accumulation of iron.

GENERAL OBSERVATIONS--The deep serpentine clay soil supporting the thornmint is very limited in distribution. Further, the size of the largest population is only 4-by-24 meters. The habitat is situated between narrow fractures of the parent serpentinite rock. These fractures have been collecting the fine erosional debris for what must have been a considerable length of time as supported by the depth of this soil. The habitat surrounding the thornmint is a shallow, rocky soil more typical of other serpentine localities.

BIOLOGICAL OBSERVATIONS--The thornmint habitat also supports twelve other plant taxa (table 1). The twelve species represent a relatively low plant diversity and suggests the habitat has inherent resource limitations restricting the number of species able to colonize it. Although the habitat supports a few small bunches of Stipa pulchra, a common native bunchgrass, and Delphinium vriegatum, which has a perennial rootstock, most of the associates are annual species.

Though the thornmint does not immediately appear to be the most common species due to its low cryptic habit, it does in fact have the highest frequency. Several unidentified common bee or bee-like pollinators were observed visiting the thornmint flowers as well as flowers of Orthocarpus purpurascens and other plant species outside the thornmint habitat. A random survey of mature plants in June found that all flowers had been fertilized and that each flower had a full complement of four mature nutlets.

CONCLUSIONS

The soil habitat that Acanthomintha obovata ssp. duttonii occurs on is unique. It is characterized by low concentrations of nitrogen, carbon, phosphorus and calcium, extremely high magnesium concentrations, high chromium concentrations, extremely high soil moisture as measured by permanent wilting point and field capacity, and by the fact that they are deep clay soils which are restricted to fractures in the parent serpentenite. The above characteristics of the soil environment approach the multiple-factor condition which Kruckeberg (1984) has applied to the habitat complexities of the unique serpentine barrens syndrome.

Some adaptation of the San Mateo thornmint to its unique habitat is suggested by the nutrient levels in the leaves and stem. The low calcium/magnesium ratios in both leaves and stem and the accumulation of high concentrations of iron in the stem are only observed in plants adapted to serpentine soils (Fiedler 1985).

Biological observations find that the San Mateo thornmint is probably pollinated by a set of relatively common insects and that seed set is very high. Therefore, the fecundity can probably be considered to be high based on local plant density, pollinator availability and seed set. However, seed dispersal to other potential habitat localities has become more limited due to man-made barriers. Artificial reintroduction will be necessary to compensate for the new barriers to seed dispersal.

The extreme restriction of the thornmint to the particular serpentine microhabitat in which it grows is best exemplified by the fact that there are several hundred acres of serpentine habitat unoccupied by the plant and surrounding the remaining population. Reseeding attempts in the past to other serpentine areas, such as Jasper Ridge, have failed (Sommers pers. comm.).

While urban development has caused the largest negative impact to the San Mateo thornmint through the destruction of habitat, local population extinctions, possibly also related to development activities, have probably occurred, leaving historic habitat sites intact. It appears that some historical population localities still remain; whether these sites can still support the thornmint is not known.

The serpentine soil habitats are quite variable. This is easily recognized by noting the large differences between the serpentine soil samples from within Edgewood Park itself. It is important to realize that the San Mateo thornmint habitat is one of many unique microhabitats. Many of the other microhabitats also are known to support rare plants (see discussion below). Therefore, in recommending the single site below for potential reintroduction is not to say that other potential sites, as yet unknown, do not exist.

REINTRODUCTION SITES

Acanthomintha obovata ssp. duttonii was known to historically occur in areas neighboring Edgewood Park such as Crystal Springs Reservoir. Unfortunately the exact location at Crystal Springs is not known. Future surveys in this area may discover these former locations or at least similar habitat.

The results of this study find that the soil sample from the Triangle location (map 2) is most similar to the Edgewood sample 1 site and should be considered for a reintroduction study. The Triangle soil sample site, like the thornmint habitat, is very localized (ca. 4 x 10 meters) and appears situated in a fracture of the parent rock. Surrounding this local situation the soil is very shallow (5-10 centimeters deep) and rocky and supports a different plant association. The plants in the Triangle "serpentine clay" site include Agoseris heterophylla, Orthocarpus lithospermoides and Holocarpha virgata which are also found in association with the San Mateo thornmint.

CONSIDERATIONS FOR REINTRODUCTION

EDGEWOOD PARK POPULATION--The San Mateo thornmint population at Edgewood County Park is the only known source for seed for reintroduction studies. Therefore, it is critical that no human activities be allowed which could jeopardize the remaining population. Table 2 lists activities that would have a detrimental impact on the San Mateo thornmint. Habitat loss is a significant direct impact. However of equal importance would be changes in the soil chemistry and hydrology. Any addition of chemicals or organic litter would change the soil chemistry. Fertilizers, herbicides, pesticides, and construction substances such as cement mix, paints and petroleum products will change the soil chemistry and the very delicate biological microflora. Destruction of the symbiotic microflora (microrhizae) which the native plants depend upon for nutrient assimilation (St. John 1986) could cause the extirpation of the San Mateo thornmint. Serpentine soils in particular are known to have a very high level of microrhizae (Hopkins pers. comm.). In addition, increased fertilization of the soil would allow weedy invasive non-native plant species to grow in the serpentine habitat, which would cause nutrient competition with the natives.

Changes in the hydrology through either decreasing or increasing water would change the unique soil moisture features of the serpentine clay. Increased water would cause excess flooding that would create anaerobic conditions in the soil for an extended length of time. Extended anaerobic conditions could delay seed germination or possibly kill germinating seeds. Water available to the plant is limited to the region between the field capacity and permanent wilting point (Etherington 1975). The higher percent soil moisture as measured by the field capacity and permanent wilting point found in the thornmint soils points to the unique moisture conditions present in that habitat. Decreasing or increasing the water levels would either cause early season field capacities to be reached or unseasonably late field capacities and permanent wilting points to be reached. The main concern about any changes in water quantities would be decreased growth in the thornmint and increased invasion from weedy non-native plant species.

SEED COLLECTION & DISPERSAL--The limited seed source of the last remaining population must be treated with care to ensure the reintroduction process does not impact it. To provide maximum genetic diversity to the reintroduced populations, seed should be collected from throughout the existing thornmint population. Only one seed per ovary and two seeds per plant should be removed initially. The number of plants of the largest colony was estimated at 2,000 individuals (Sommers pers. comm.) during the 1986 season. There was an average of twenty seeds produced per plant equaling forty thousand seed produced for the season. It should be noted that, in the previous year, nearly three times more individuals were observed (Sommers pers. comm.). If one estimates there were six thousand plants in the previous year, then the 2,000 plants produced this year, 1986, represents approximately two percent survivorship. Obviously a considerable decrease has occurred and any proposals to remove seed must take into account population fluctuations. Based on seed production for 1986, a total recommended seed take should be no more than 200 seeds or half of one percent. Ultimate decisions will have to be based on the seed set for 1987. Artificial dispersal of thornmint seed within the known habitat at Edgewood Park has shown that a higher rate of approximately eight percent survivorship can occur (Sommers unpubl.).

It has been suggested that some seed could be grown under artificial conditions for the purpose of increasing the seed bank on which to draw (Gankin pers. comm.). I am unaware of successful attempts to grow this plant artificially and produce viable seed. Certainly all possible ways to generate propagules should be examined and artificial propagation would require the skills of those knowledgeable in serpentine plant ecology. Artificial propagation should be tried with emphasis at institutions near the San Mateo serpentine habitat where native soils could be obtained it necessary. It has been pointed out that many rare plants, especially serpentine endemic species, are genetically predisposed for very slow growth (St. John 1986). Therefore, we cannot expect to create an artificial situation that allows us to produce many generations within one season. A small subset (<25%) of the seeds to be used for the reintroduction study should be considered for artificial experiments. Another subset (ca 10%) of the seeds collected should be sent to an established California seed bank.

The remaining seeds collected should be dispersed by individuals familiar with the plant habitat and serpentine ecology into selected sites. The emphasis on personnel qualifications is to ensure that the seed is not accidentally dispersed into non-habitat sites due to the limited geographical distribution of appropriate areas. Some seed could be placed in artificially bored holes with the soil plug replaced after seeding. Placement of the seed is important in order to limit seed loss from runoff off from the habitat and deep into the fissures of the parent rock.

MONITORING--The reintroduction process must include subsequent monitoring of both the parent population and the introduced one(s). Permanent fifty centimeter plots based on a grid should be set up for measuring density and frequency of all plant species in the habitat. Monitoring should include soil water potential and plant water potential (see additional research below) and local rainfall.

ADDITIONAL REINTRODUCTION SITES--In addition to the proposed reintroduction site at the Triangle, locations in other areas should be searched given the information now available. The Crystal Springs Reservoir should be given special attention due to the known historical occurrence of the thornmint. A reasonable goal would be to add two additional reintroduction sites during the 1987 season so that three sites will be considered for seed dispersal in 1988.

ADDITIONAL RESEARCH

All new reintroduction sites should have a complete soil analysis done which is at least equal to those in this report. Rainfall information may be critical based on previous observations (Sommers unpubl.) of population size fluctuations. Rain gauges should be set out next to the known population and at reintroduction sites.

Soil and plant water potential may provide the most detailed information for physiological responses to rainfall patterns. The unusual soil moisture characteristics of the serpentine clay may be a key environmental factor. Ideally soil water potential should be monitored on a monthly basis throughout the year with twice monthly analysis while the plant is growing and flowering. Plant leaf water potential is extremely useful for directly determining the plant response to water conditions. Using a thermocouple psychrometer, plant water potential can be measured using a single leaf and causing minimal plant damage and yet allowing for a statistically meaningful sample size.

Plant community species composition and thornmint populations should be monitored for frequency and density. Biological impacts on the thornmint such as invasion from non-native plants can only be accurately determined quantitatively. Permanent fifty centimeter plots based on a habitat grid can be established without impacting the habitat or the populations. Monthly community and population surveys would adequately provide quantitative plant information.

Root microrhizal analysis for the thornmint should be made to determine the types, if any, of plant symbionts. This information would aid any approaches to artificial propagation in controlled environments. If microrhizae are present, it may suggest a requirement for native serpentine soils for germination and growth.

SUMMARY

The habitat of *Acanthomintha obovata* ssp. *duttonii* was characterized based on soil analysis and physical and biological observations. The microhabitat for this plant is unique in soil moisture, metal cation and heavy metal concentrations, formation, depth, particle size (clay) and plant associations. Comparison of six soil samples from different areas suggests that one site, the Triangle, has soils similar to those currently supporting the San Mateo thornmint. This site is recommended as a potential area for reintroduction of the plant. Recommendations are made for monitoring and managing the last population of the San Mateo thornmint and possible future reintroduction sites.

Acknowledgements

The San Mateo thornmint and the serpentine environment in which it grows is enormously complex. This limited study could not have accomplished what it did without the direct help of several individuals. I wish to thank Toni Corelli and Suzanne Sommers in particular for sharing their experience and knowledge of the San Mateo thornmint. I thank Dr. Roman Gankin, Dr. Neil Havlik and Mr. Tom Lindenmeyer for informative discussions, Dr. Nona Chiariello for permission and help in serpentine soil samples from Jasper Ridge Preserve, and Mr. David A. Christy for issuing a permit to collect soils and plant material from Edgewood County Park.

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TABLE 1

Plant Species Associated With The San Mateo Thornmint

Species
Agoseris heterophylla
Calachortus albus
Delphinium variegatum
Holocarpha virgata
Lotus micranthus
Lolium multiflorum
Lotus subpinnatus
Orthocarpus lithospermoides
Orthocarpus purpurascens
Sidalcea malviflora
Stipa pulchra
Trifolium fucatum

TABLE 2

Management Recommendations And Potential Impacts

To

Acanthomintha obovata ssp. duttonii

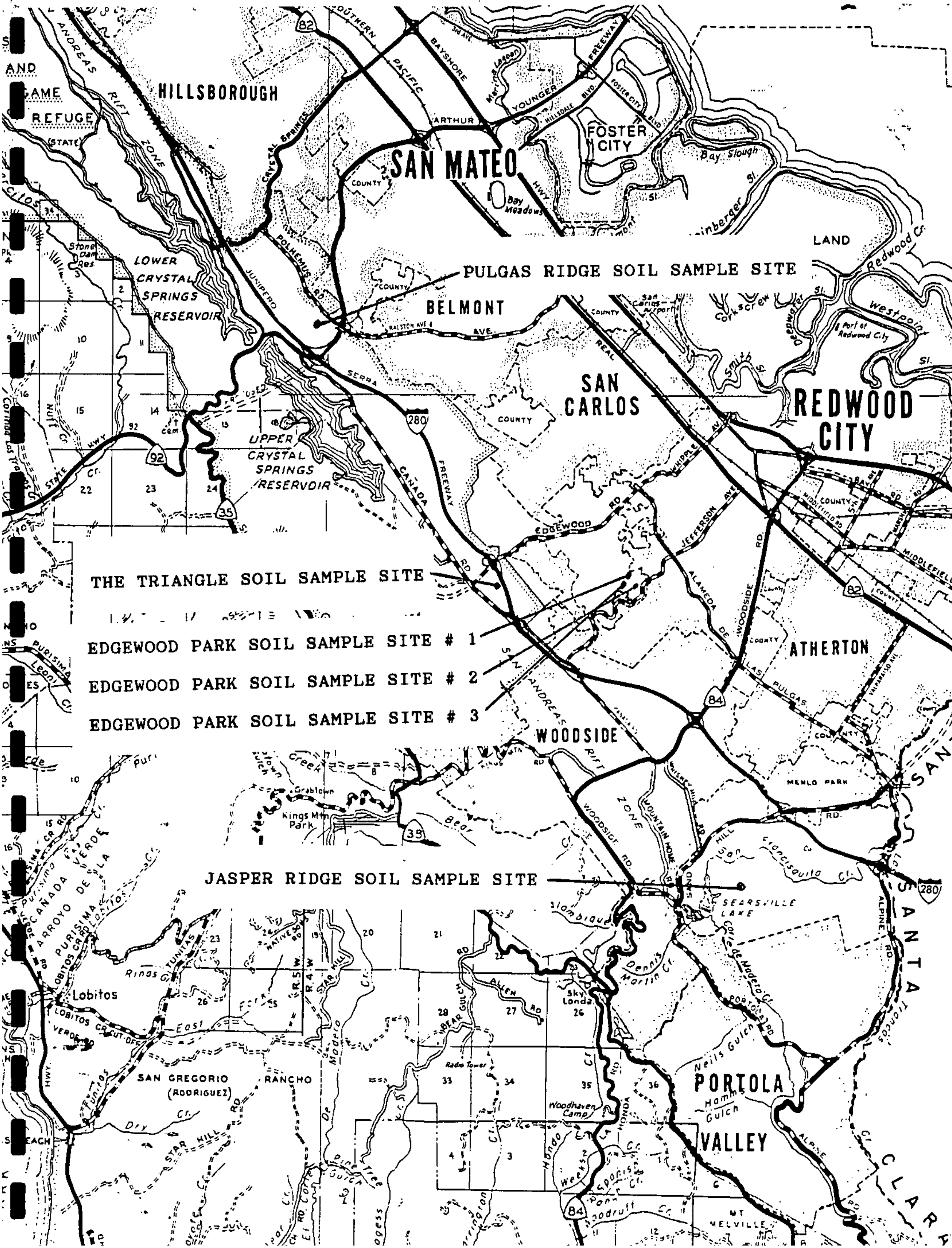
Area of Changes	Type of Change	Effects
Soil Chemistry	Fertilizer and other chemicals	Kill native plants and symbiotic microrhizae, change soil nutrient balance, invasion by non-native weeds
Soil Environment	Physical Disturbance	Destroy soil homogeneity and symbiotic microrhizae, invasion by non-native weed
Hydrology	Increase Water	Roots die from anaerobic conditions, soil erosion, More seeds washed off of habitat
Hydrology	Decrease Water	Low seed germination and a decrease in population size

MAP 1

SAN MATEO COUNTY: EDGEWOOD COUNTY PARK

THE TRIANGLE

JASPER RIDGE PRESERVE


PULGAS RIDGE SOIL SAMPLE SITE
THE TRIANGLE SOIL SAMPLE SITE
EDGEWOOD PARK SOIL SAMPLE SITE # 1
EDGEWOOD PARK SOIL SAMPLE SITE # 2
EDGEWOOD PARK SOIL SAMPLE SITE # 3
JASPER RIDGE SOIL SAMPLE SITE
HILLSBOROUGH
SAN MATEO
FOSTER CITY
BELMONT
SAN CARLOS
REDWOOD CITY
ATHERTON
WOODSIDE
MENLO PARK
PORTOLA VALLEY
LOWER CRYSTAL SPRINGS RESERVOIR
UPPER CRYSTAL SPRINGS RESERVOIR
SAN ANDREAS RIFT ZONE
GAME REFUGE
SEARSVILLE LAKE
Kings Mtn Park
Lobitos
SAN GREGORIO (RODRIGUEZ)
RANCHO
SANTA CLARA
Bay Slough
Redwood Cr.
Port of Redwood City
San Carlos Airport
Bay Meadows
EDGEWOOD RD
ALAMEDA DE LAS PULGAS
WOODSIDE RD
JEFFERSON AVE
MIDDLEFIELD
CAÑADA RD
FREEWAY
280
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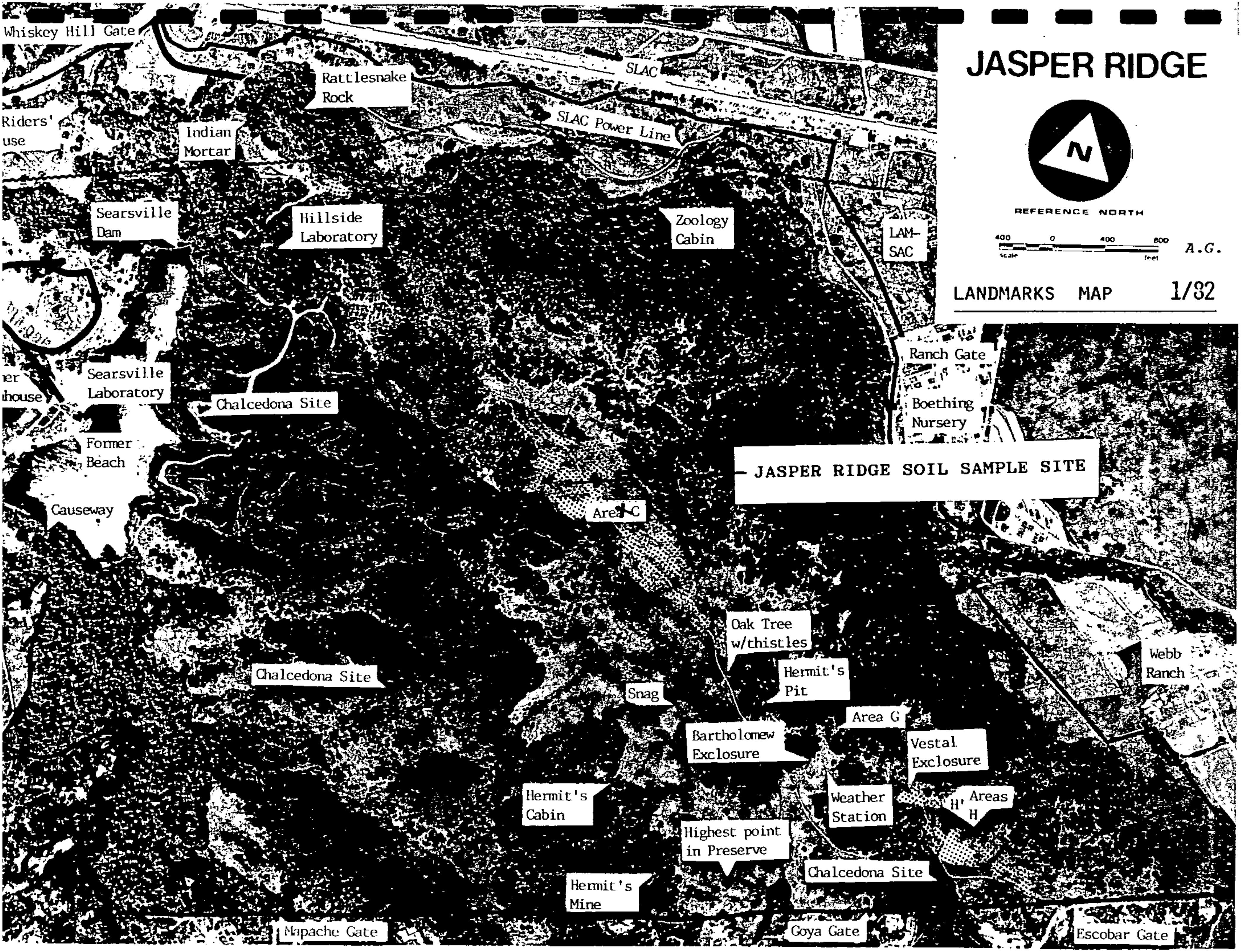
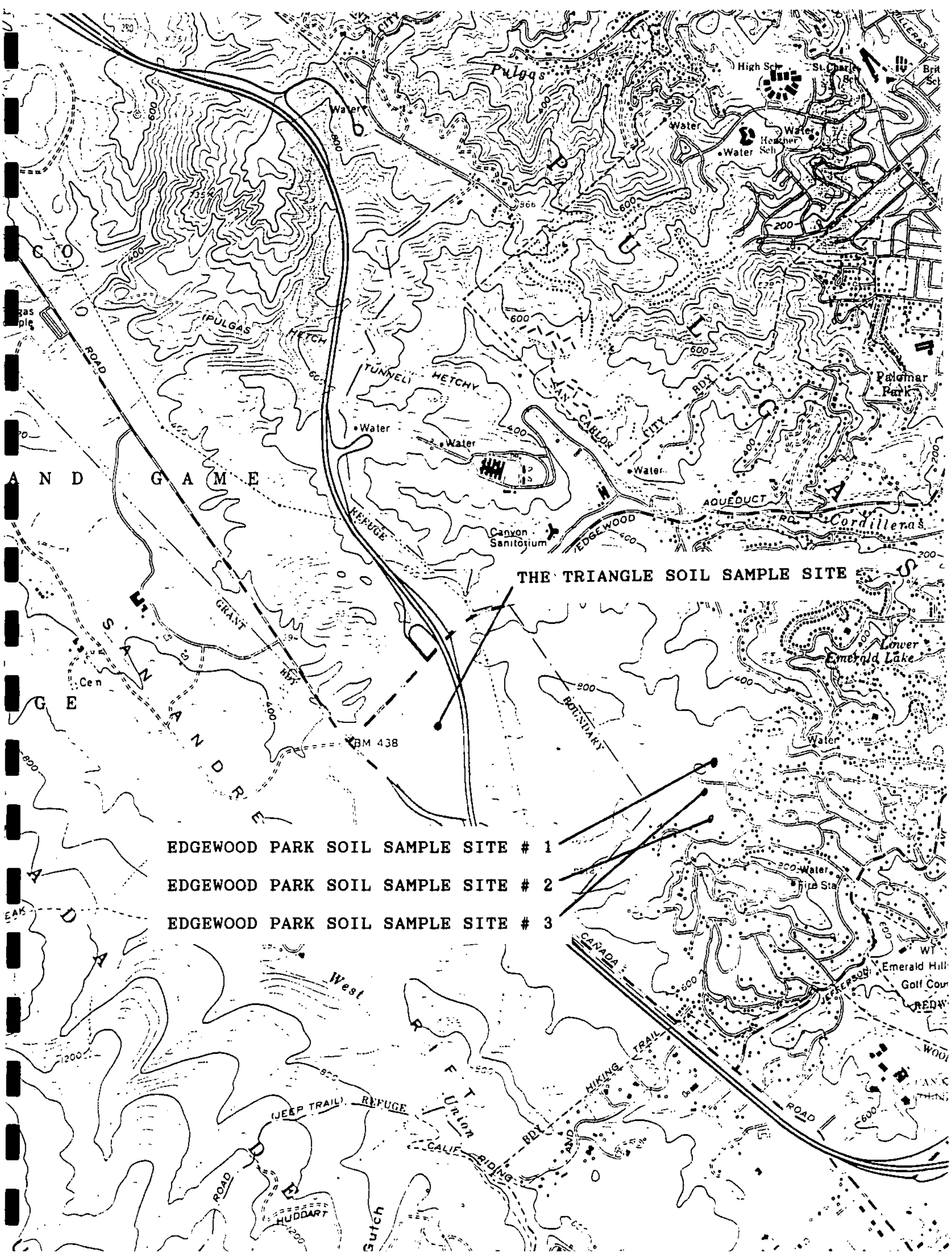
35
82
84

JASPER RIDGE



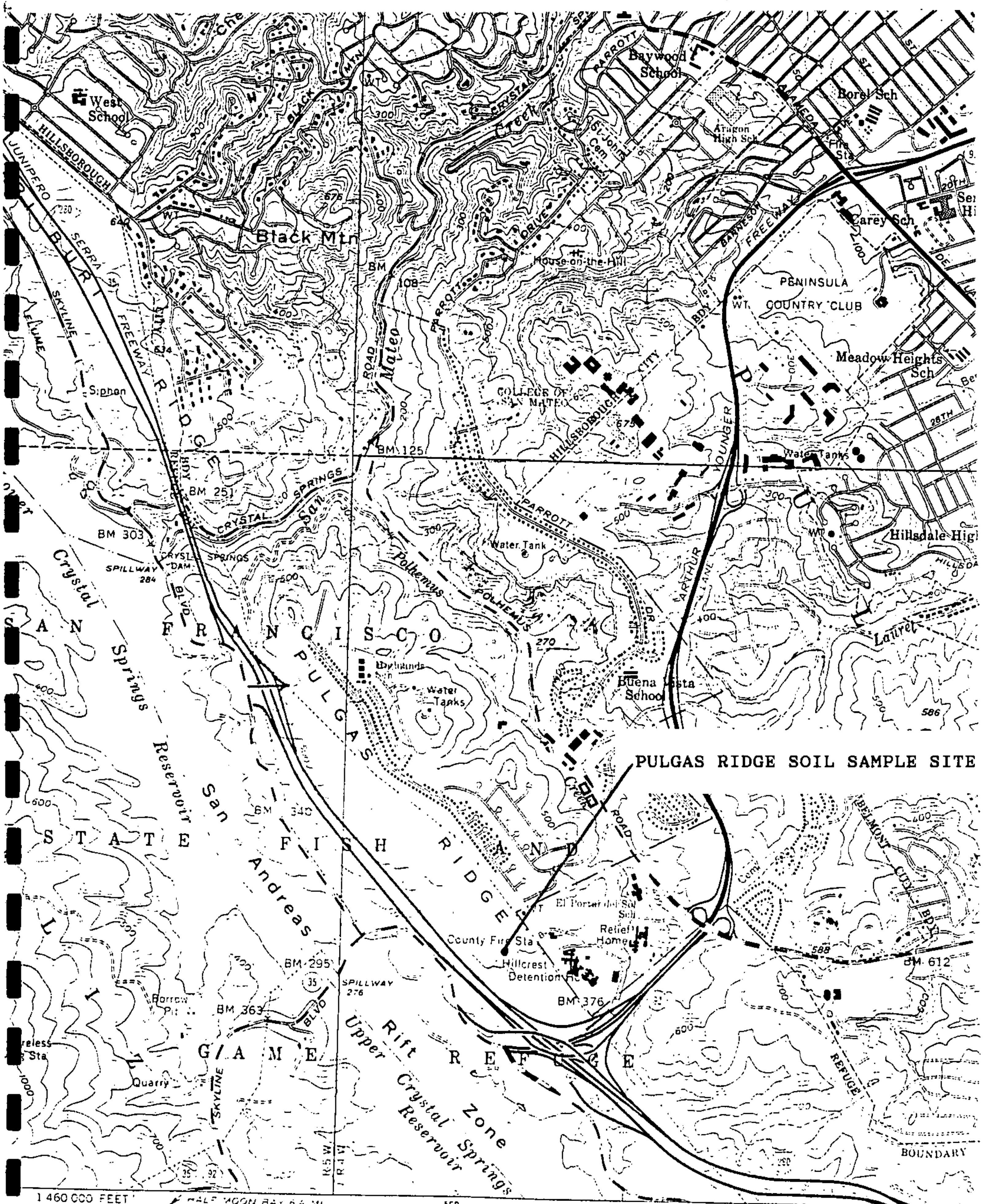
MAP 2

EDGEWOOD COUNTY PARK, THE TRIANGLE REINTRODUCTION SITE


THE TRIANGLE SOIL SAMPLE SITE
EDGEWOOD PARK SOIL SAMPLE SITE # 1
EDGEWOOD PARK SOIL SAMPLE SITE # 2
EDGEWOOD PARK SOIL SAMPLE SITE # 3
Pulgas
High Sch
St Charles Sch
Heather Sch
Water
Palomar Park
PULGAS
HETCH
TUNNEL
HETCHY
SAN CARLOS CITY BDY
AQUEDUCT
EDGEWOOD
RD
Cordilleras
Canyon Sanitorium
REFUGE
AND GAME
GRANT
BDY
BM 438
BOUNDARY
ROAD
Lower Emerald Lake
Fire Sta
Emerald Hills
Golf Cou
JEFFERSON
CAÑADA
ROAD
West
Union
HIKING TRAIL
AND
BDY
CALIF RIDING
(JEEP TRAIL)
REFUGE
HUDDART
ROAD
Gulch
Cen
Pulgas Temple

MAP 3

PULGAS RIDGE AND CRYSTAL SPRINGS RESERVOIR



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SCALE

APPENDIX I

Soils Analysis

USING THE SOILS TABLES

1) All element values are in milliequivalents.

2) Bulk density is in grams from a 150 mm soil cylinder.

3) Permanent Wilting Point (PWP) and Field Capacity (FC) are in percent moisture.

EDGEWOOD

SAMPLE 1

SOIL COMPONENT	SOIL DEPTH (CENTIMETERS) 0-5	5-10	10-20	20-30
Carbon	1.17	1.16	1.01	1.04
Nitrogen	0.107	0.097	0.091	0.097
Phosphorus	0.76	0.54	0.37	0.94
Calcium	4.26	3.82	3.58	3.39
Magnesium	47.85	47.85	45.91	48.89
Ca^{++}/Mg^{++}	0.089	0.08	0.078	0.069
Potassium	1.06	0.87	0.82	0.86
Sodium	0.64	0.59	0.30	0.19
Manganese	0.29	0.23	0.13	0.15
Nickel	0.009	0.006	0.002	0.001
Chromium	0.042	--	--	--
pH	6.0	6.2	6.2	6.1
C.E.C	53.10	51.55	52.50	52.55
Bulk Density	1.024	--	--	--
F.C.	53.11	52.03	51.31	52.35
P.W.P.	32.97	30.54	30.11	30.80

EDGEWOOD

SAMPLE # 2

SOIL COMPONENT	SOIL DEPTH (CENTIMETERS) 0-5	5-10	10-20	20-30
Carbon	6.16			
Nitrogen	0.370			
Phosphorus	1.80			
Calcium	12.48			
Magnesium	23.89			
Ca^{++}/Mg^{++}	0.522			
Potassium	0.68			
Sodium	0.29			
Manganese	2.20			
Nickel	--			
Chromium	--			
pH	5.6			
C.E.C	38.00			
Bulk Density	--			
F.C.	41.00			
P.W.P.	22.35			

ENDGEWOOD PARK

SAMPLE # 3

SOIL DEPTH (CENTIMETERS)

SOIL COMPONENT	0-5	5-10	10-20	20-30
Carbon	1.70	1.17		
Nitrogen	0.167	0.118		
Phosphorus	0.77	0.32		
Calcium	4.31	3.92		
Magnesium	30.49	34.48		
Ca^{++}/Mg^{++}	0.141	0.114		
Potassium	0.72	0.54		
Sodium	0.21	0.17		
Manganese	0.75	0.58		
Nickel	0.029	0.029		
Chromium	--	--		
pH	5.6	5.7		
C.E.C	36.80	40.25		
Bulk Density	0.882	--		
F.C.	34.36	36.25		
P.W.P.	18.96	21.05		

THE TRIANGLE

	SOIL DEPTH (CENTIMETERS)			
SOIL COMPONENT	0-5	5-10	10-20	20-30
Carbon	1.23	0.92	0.75	
Nitrogen	0.120	0.101	0.083	
Phosphorus	0.97	1.89	1.53	
Calcium	3.77	3.46	3.06	
Magnesium	34.20	36.78	37.51	
Ca^{++}/Mg^{++}	0.110	0.094	0.082	
Potassium	0.74	0.68	0.57	
Sodium	0.21	0.25	0.17	
Manganese	0.28	0.21	0.10	
Nickel	0.010	0.008	0.003	
Chromium	--	--	--	
pH	6.4	6.1	6.2	
C.E.C	39.95	39.73	40.35	
Bulk Density	1.056	--	--	
F.C.	43.47	45.49	45.47	
P.W.P.	26.68	27.12	27.04	

JASPER RIDGE PRESERVE

SOIL COMPONENT	SOIL DEPTH (CENTIMETERS) 0-5	5-10	10-20	20-30
Carbon	1.99	1.98		
Nitrogen	0.192	0.201		
Phosphorus	1.01	3.27		
Calcium	3.58	3.25		
Magnesium	29.11	29.27		
Ca^{++}/Mg^{++}	0.123	0.111		
Potassium	0.33	0.28		
Sodium	0.22	0.24		
Manganese	0.53	0.52		
Nickel	0.050	0.052		
Chromium	--	--		
pH	6.2	5.6		
C.E.C	35.00	35.75		
Bulk Density	0.899	--		
F.C.	28.96	42.89		
P.W.P.	26.63	26.08		

PULGAS RIDGE

SOIL COMPONENT	SOIL DEPTH (CENTIMETERS) 0-5	5-10	10-20	20-30
Carbon	3.94			
Nitrogen	0.398			
Phosphorus	2.18			
Calcium	6.39			
Magnesium	37.28			
Ca^{++}/Mg^{++}	0.171			
Potassium	0.99			
Sodium	0.26			
Manganese	0.79			
Nickel	0.055			
Chromium	--			
pH	5.6			
C.E.C	49.70			
Bulk Density	0.750			
F.C.	46.75			
P.W.P.	31.84			

APPENDIX II

Plant Tissue Analysis

of

Acanthomintha obovata ssp. duttonii

Component	Leaf	Stem
Nitrogen (%)	1.251	0.456
Phosphorus (ppm)	2191	852
Calcium (%)	0.527	0.438
Magnesium (%)	0.494	0.601
Ca^{++}/Mg^{++}	1.07	0.73
Potassium (%)	1.295	1.052
Sodium (%)	0.013	0.024
Manganese (ppm)	15	12
Iron (ppm)	115	500
Zinc (ppm)	70	49
Nickel	trace	trace
Chromium	trace	trace