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COUNTY OF SAN DIEGO

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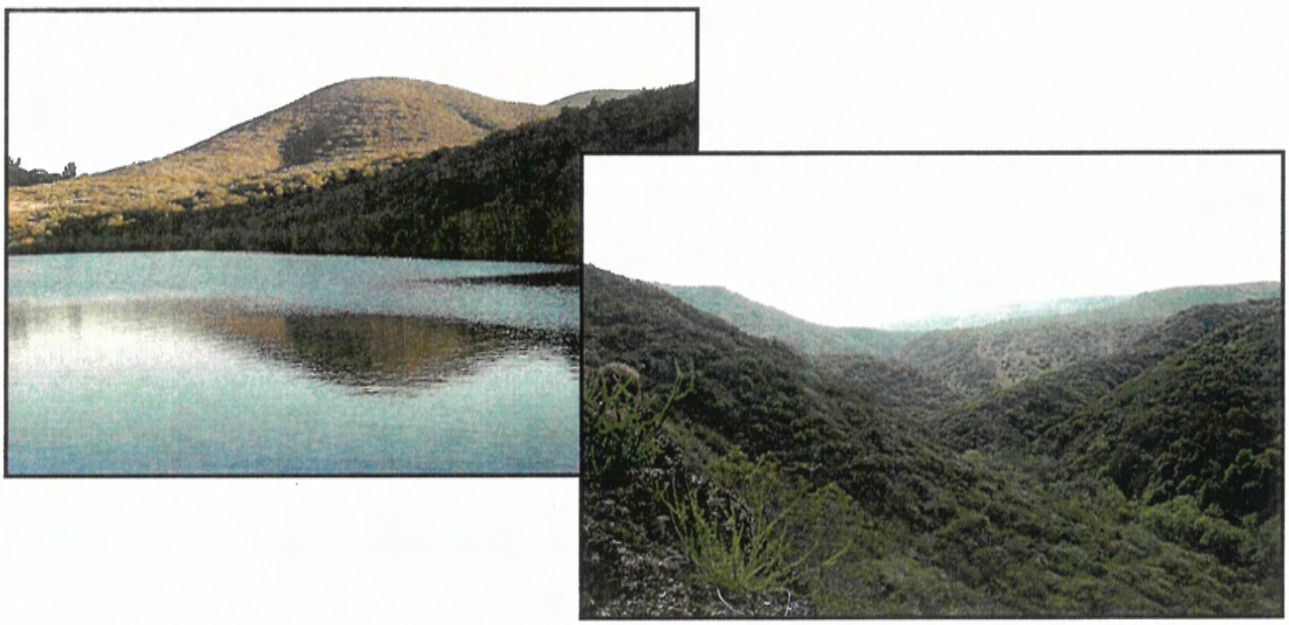

FINAL REPORT: IMPLEMENTATION OF DIGITAL IMAGING TECHNOLOGIES TO ENHANCE FIELD MAPPING AND MONITORING IN MSCP/NCCP RESERVES

MARCH 1, 2002

11/1/2002

Lusardi Creek/4s Ranch: Multispectral Change Detection Techniques Using Landsat Thematic Mapper Data and Airborne Data Acquisition and Registration (ADAR) Data

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Remote Sensing Research Technical Report

Abstract:

This research investigates two types of multispectral remote sensing platforms: Airborne Data Acquisition and Registration (ADAR) and satellite based Landsat. Several multi-date change detection techniques are used and their application to biological monitoring evaluated. The results indicate that the scale and budget of any remote sensing biological monitoring research must dictate the type of platform used. Landsat appears to be useful for rough scale - broad area analysis of land use / land change, while ADAR is ideally suited for site specific quantitative analysis.

Keywords: Change Detection, Remote Sensing, Landsat,
ADAR, Rare Plants, MSCP, County of San Diego

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I. Introduction

To effectively manage conserved biological preserve lands, a land manager must map important biogeographic features such as vegetation structure and landform change over time and space, e.g., urban growth patterns and habitat disturbance. This type of mapping/analysis is traditionally done with frequent *in situ* field visitations covering limited spatial and temporal extents. However, for San Diego County's Multiple Species Conservation Program (MSCP) projected 101,000 acres of preserve in the initial sub area plan, the staff and time requirements, to perform comprehensive field visits is considered to be logistically impractical and economically unfeasible. An alternative approach to conducting large-scale landscape monitoring and change analysis is the use of remote sensing. With this approach a researcher can remotely detect and map surface variability temporally, spatially, and spectrally through the use of airplane or satellite based sensors.

In this circumstance, satellite and airborne multi-spectral digital imaging techniques have proven useful (Singh 1989) for detecting and monitoring landscape variability with image to image digital number comparisons which among the photogrammetric and remote sensing professional community is referred to as "change detection" (Lambin and Strahler 1994).

Change detection involves the use of multi-temporal images, i.e., data from the same location and at least two different time periods, to discriminate areas of landscape change over time. This comparative process has several considerations when dealing with the desired resolution of the data.

Ideally, remotely sensed imagery used in a change detection process will be acquired at a constant *temporal resolution*, i.e., anniversary dates, while having common ground resolution elements (GRE), or *spatial resolution*. Furthermore, an assumption of digital change detection is that a difference exists in the spectral response of a pixel between two dates if the biophysical materials have changed. This is referred to as *spectral resolution*. Finally, the data storage and collection format is considered in *radiometric resolution*,[1] e.g., the imagery collected was based on an 8-bit data model on both dates (Hall et al. 1991, Jensen 1996). Scientifically robust change detection methods require that these resolution factors be comparable between image dates. This was

achieved in the research conducted on the study areas of Lusardi Creek and 4S Ranch in San Diego County, California (figures 1-1.1, 1-1.2, and 1-1.3).

This report describes the change detection techniques and remote sensing research conducted in these areas, and briefly describes the vegetation survey and fieldwork performed. Beyond the requirements of the research design, an additional remote sensing platform: satellite-based Landsat Thematic Mapper (TM) was compared and contrasted to the original research platform: airplane based Airborne Digital Acquisition and Registration (ADAR) in our study areas.

II. Study Areas, Preserve Areas, and Field Methods

In situ information is essential knowledge for any remote sensing project. To this extent, field visits were conducted by county staff before, during, and after the imagery was captured in 2000 and 2001. Extensive natural history/botanical survey work was performed in the spring of 2001. The preserve areas of Lusardi Creek and 4S Ranch are proximal to each other on an east to west axis. These areas are entirely contained in the remote sensing study areas (figure 1-1.2 and figure 1-1.3). The spatial extent of remote sensing analysis areas are larger than the preserve areas so as to avoid the potential of edge effects that could result in false change detection. Subsequently, information derived from these study areas describes features both inside and outside of the official MSCP preserve system.

These preserve sites are located in the middle to western portions of the County of San Diego in an area where only recently (within the last 10 years) mass land development has occurred. The initial field surveys were performed to record the locations of rare plants. Later field visits were conducted to verify or field check areas in the preserves and surrounding areas for changes in remotely sensed imagery flown in the years of 1992 to 1999 and 2000 to 2001.

The Lusardi Creek preserve area (figure 2-1) can be physically described as a roughly rectangular preserve area east of Solana Beach. Black Mountain Ranch borders it to the south, Rancho Santa Fe and Fairbanks Ranch to the west, and a rural estate development along Artesian Road to the north. Lusardi Creek flows from near the southeastern

Figure 1-1.1 Locator Map

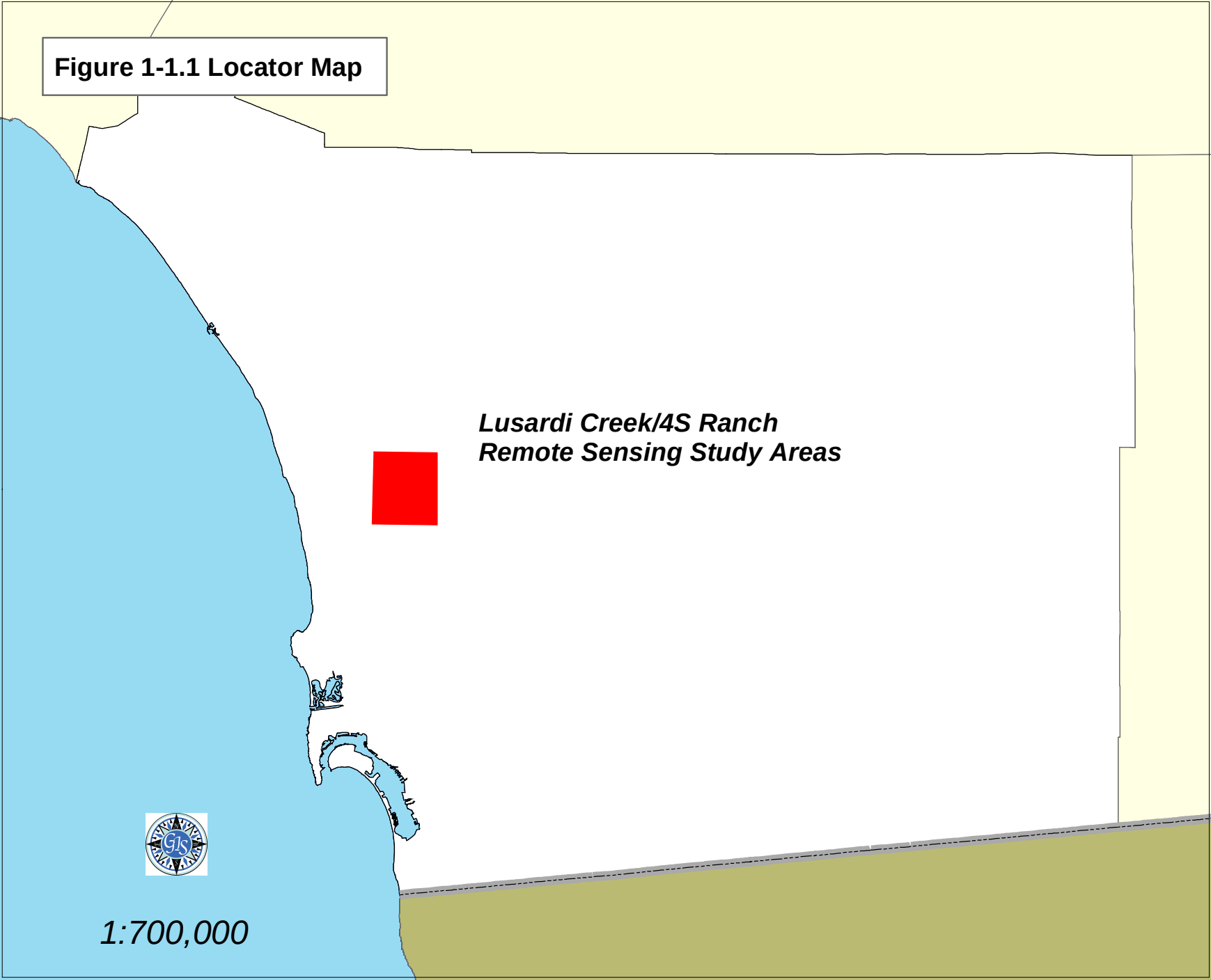
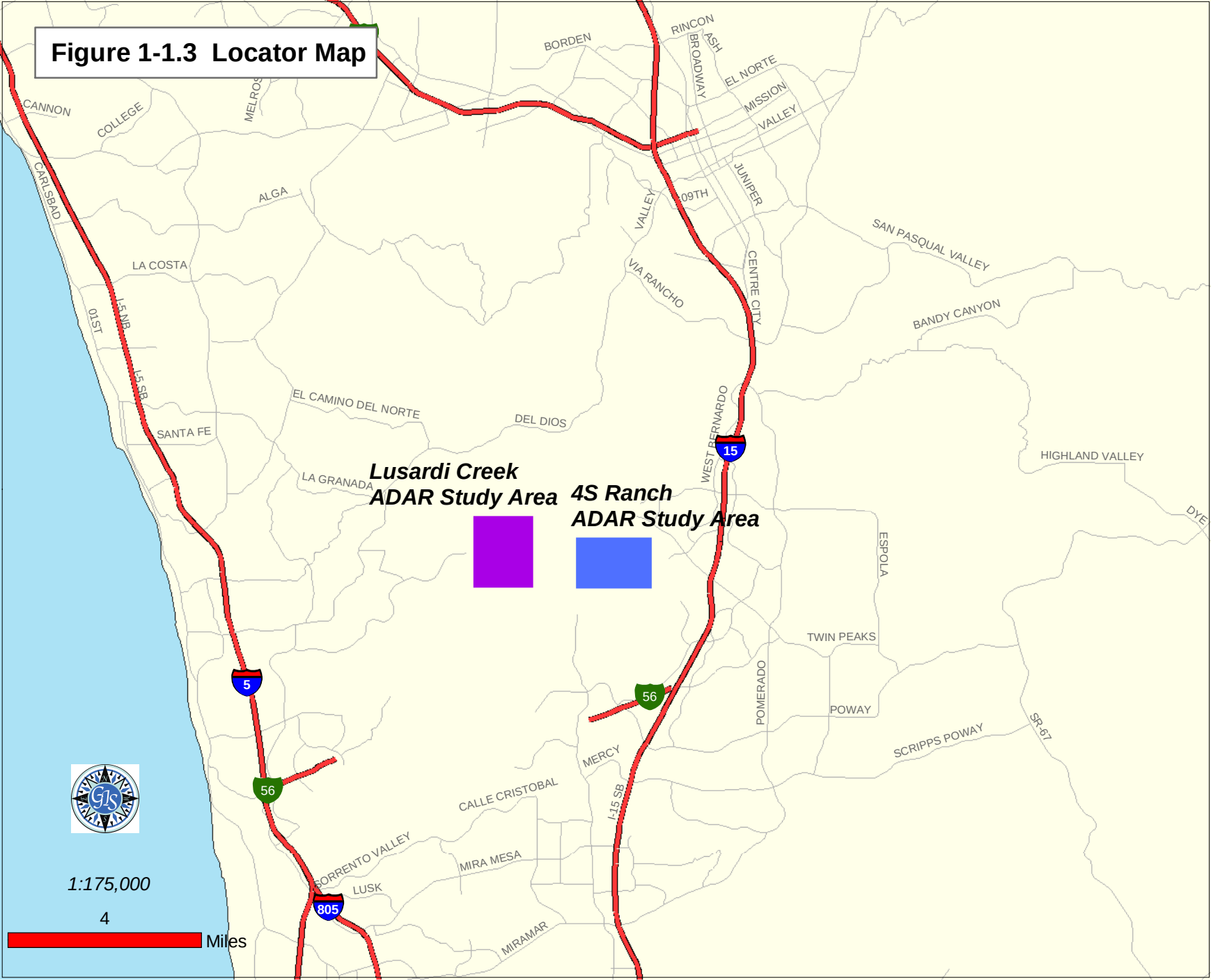


Figure 1-1.2 Locator Map

Figure 1-1.3 Locator Map



boundary west through the southwestern portion of the parcel. Lusardi Creek is dominated by three relatively level mesas with gentle or steep slopes falling toward Lusardi Creek. The eastern most portion of the preserve area is dominated by a rugged series of slopes bordering a south-flowing canyon. The elevation of Lusardi Creek varies from about 20 to 113 meters (65 to 370 feet). Lusardi Creek is dominated by riparian vegetation. The two western most mesas are dominated by chamise chaparral. The easternmost mesa is dominated by open grassy coastal sage scrub with weak mima mounds.

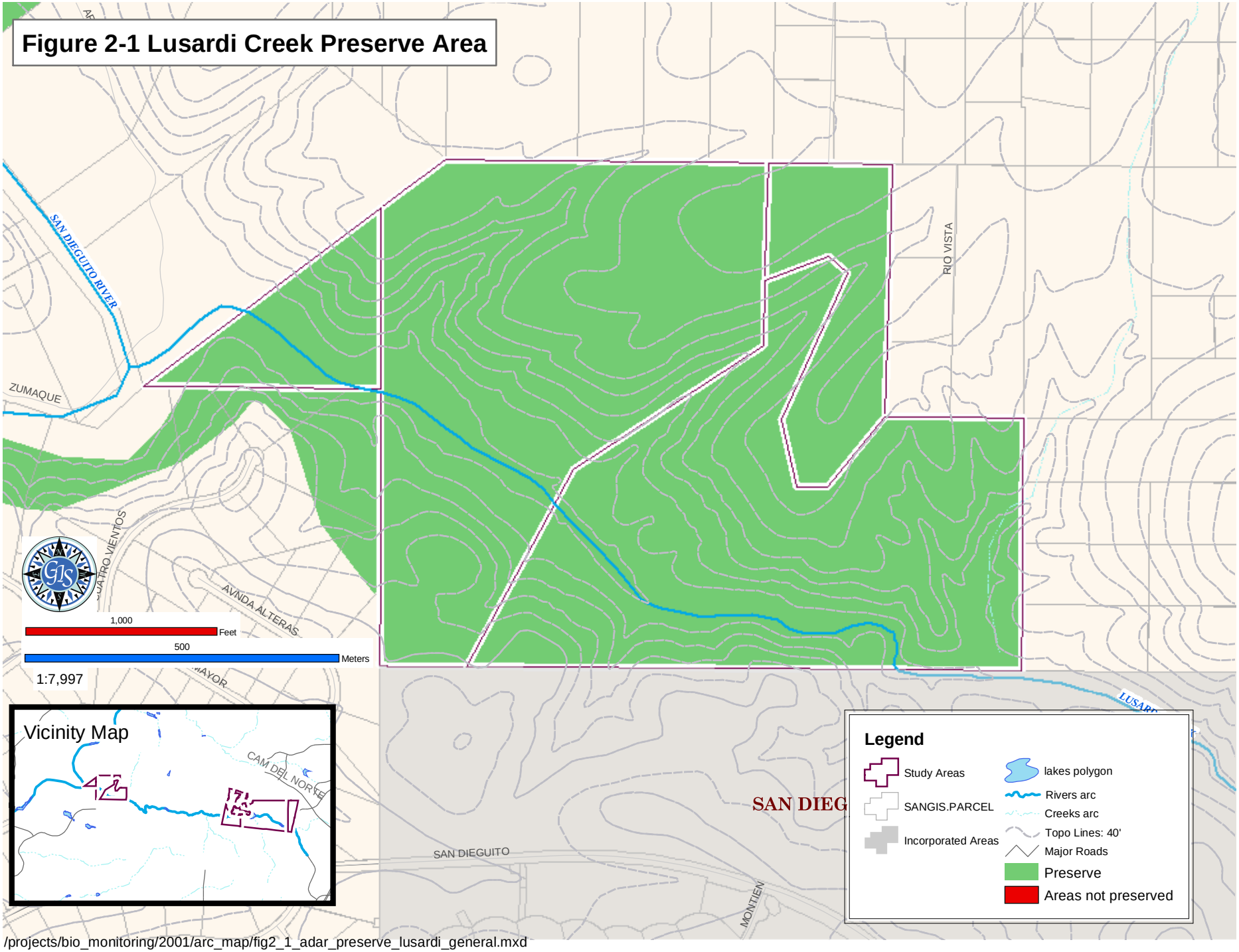
4S Ranch is a relatively narrow preserve area (figure 2-2) with an east to west axis following upper Lusardi Creek. The terrain is generally fairly gentle with the highest slopes in the east and a central lake. The elevation varies from 110 to 308 meters (360 to 1,010 feet). The eastern hills are dominated by coastal sage scrub that has recently burned. The central portion is dominated by annual grassland that has been heavily invaded by wild artichoke thistle following a narrow marshy area with a lake. The western portion consists of low hills dominated by coastal sage scrub and a gentle north-facing slope dominated by southern needlegrass grassland.

The field methods implemented included presence surveys for rare plants with counts and population estimates made for specific species. These surveys were conducted throughout the study area from mid March through June with three additional one-day surveys in July and November 2001. Surveys were conducted on the Lusardi Creek preserve area on April 18th, 19th, 24th, 25th, 26th, May 3rd, 10th, 24th, 30th, and June 19th, 2001. Surveys were conducted on the 4S Ranch preserve area on April 26th, May 2nd, May 4th, May 8th, June 19th, June 21st, and July 12th, 2001.

Generally the weather was cool and cloudy in March and April gradually becoming more clear and hot by late May and June. March 26th, however, was an exceptionally hot day for the season. The peak of the bloom on Lusardi Creek occurred in late April while the peak bloom occurred in May for 4S Ranch. By early June most of the rare plants identified were concentrated along watercourses.

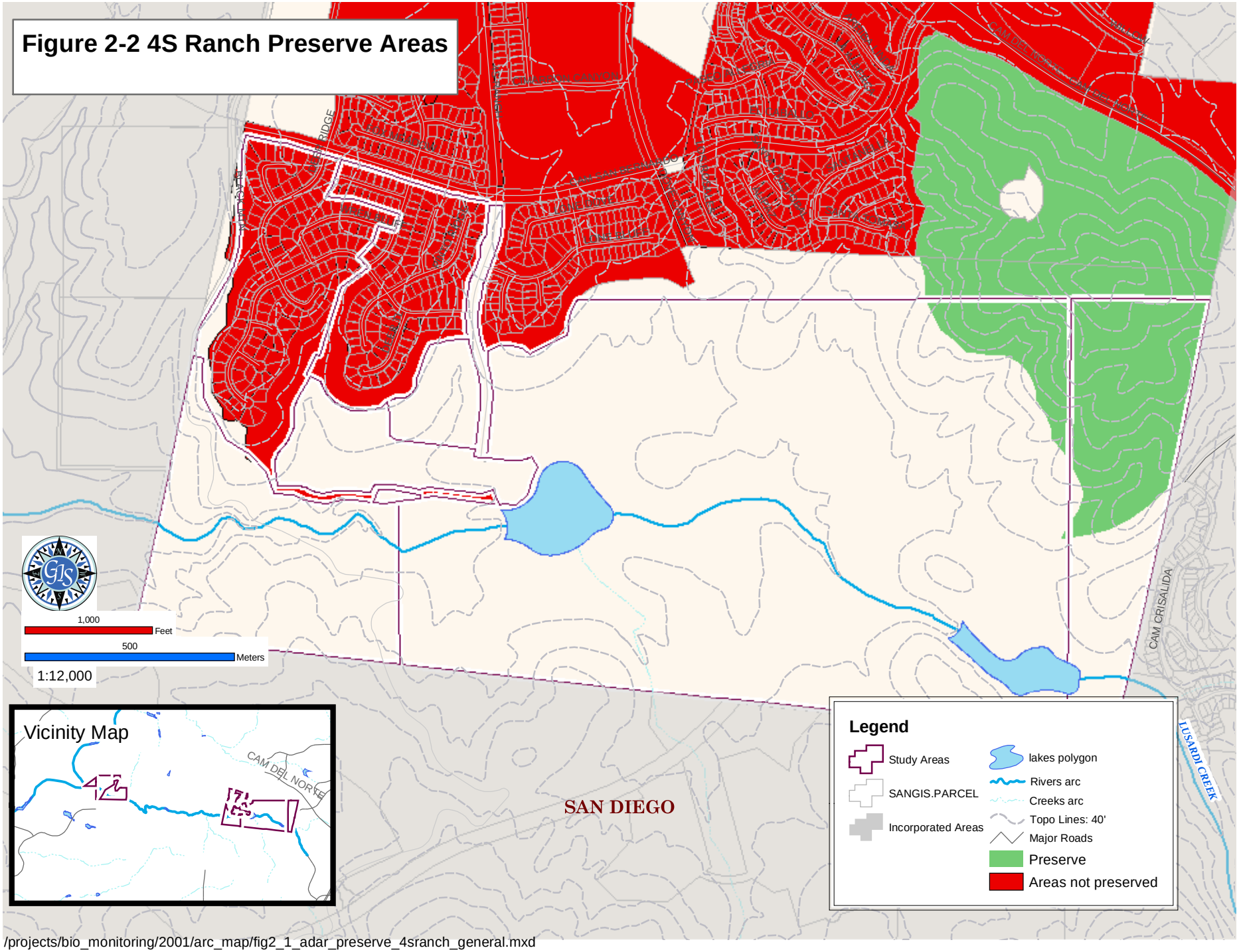
Surveys were conducted primarily on foot favoring ridgelines and barrens. Each colony of rare plants located was given a unique identifier code (See "Rover files" Appendix 1). Rare plant sites were delineated generally and/or specifically when

Figure 2-1 Lusardi Creek Preserve Area



/projects/bio_monitoring/2001/arc_map/fig2_1_adar_preserve_lusardi_general.mxd

Figure 2-2 4S Ranch Preserve Areas



/projects/bio_monitoring/2001/arc_map/fig2_1_adar_preserve_4sranch_general.mxd

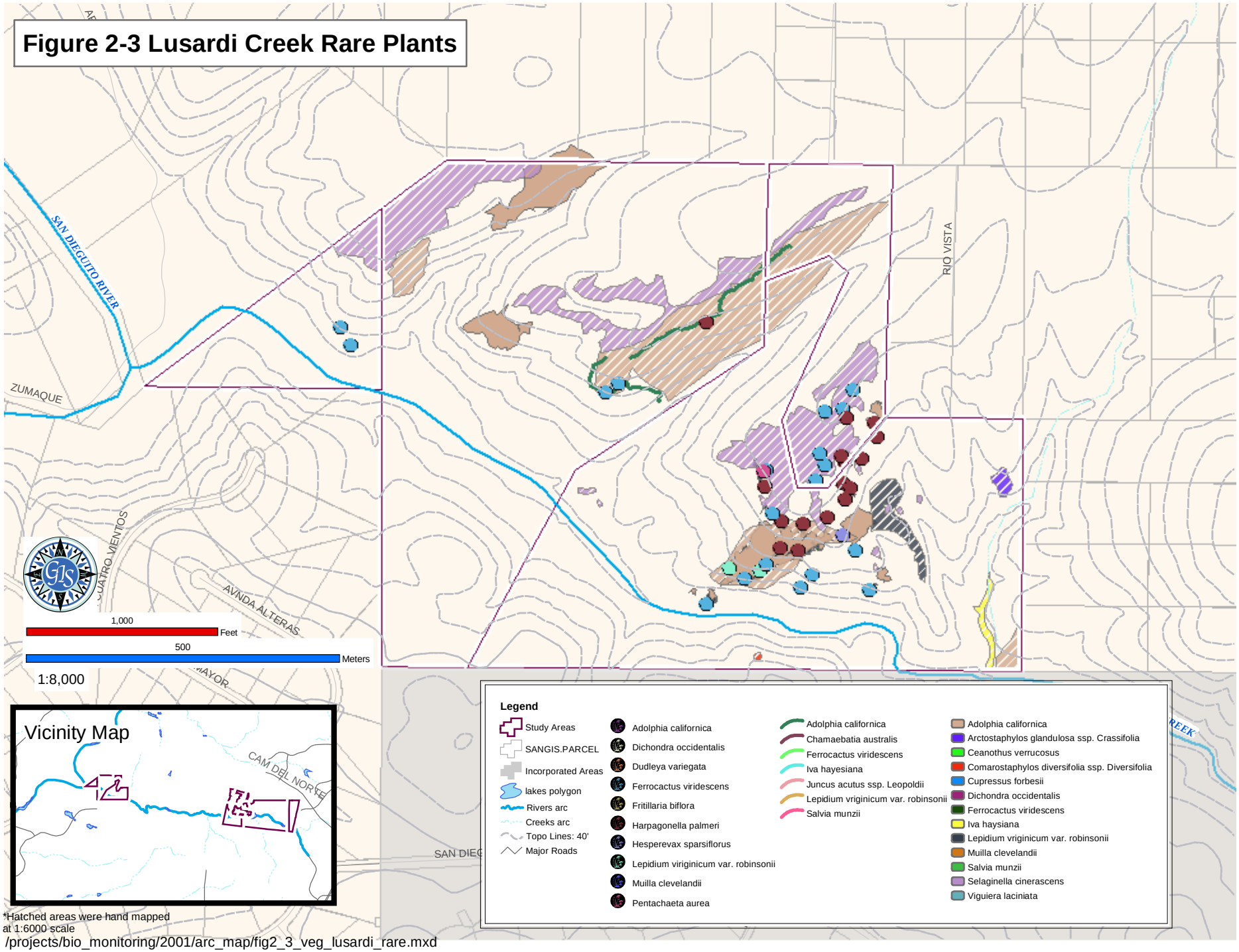
possible. Specific point, line, and polygon locations of rare plants were marked with a GPS unit (Trimble Geoexplorer III). Individual GPS points were used to record the location of individual or small groups of rare plants that did not cover an appreciable area. GPS Polygons were used where rare plants formed a well-defined patch or extended group that could be delineated by walking around it. Nested points were occasionally collected where additional species were noted within the larger polygon of another species. Colonies were considered distinct if they were more than 15 meters apart or easily distinguished on field maps (1:6000 scale). The GPS files were downloaded, corrected for GPS error, and imported into an ArcGIS 8.0 geodatabase (figures 2-3 and 2-4) by County of San Diego, Department of Planning and Land Use - MSCP Division staff on a weekly basis.

The approximate abundance of plants per colony (or stand) was recorded by direct count or through estimation if the numbers exceeded 500 to 1,500 individuals. Since this initial field research represents the first presence surveys conducted in these newly created preserve areas, no parametric or quantitative methods were used beyond counts or rough population size estimations. Notes were taken on the ecological features (exposure, aspect, soils, associated species) for each colony (or stand). In species such as western dichondra (*Dichondra occidentalis*), where number is either undeterminable or irrelevant, site coverage was estimated.

Typically, GPS records were not made for wart-stemmed ashy spike moss (*Selaginella cinerascens*). Locations for these species were noted on a field map. Aspect and vegetation information was recorded where possible. In most cases, general site data does not include estimated numbers of individuals for concomitant but not rare plant species.

Representative vouchers were taken for the majority of rare plant species with at least one representative for each area. Vouchers are noted under specific colonies (or stands) (See Notes: Appendix 1). Vouchers will be deposited at the San Diego County Natural History Museum. Finally, County vegetation maps for each of the parcels were reviewed. Modifications to these maps were made in the associated Holland vegetation classes (Appendix 2) where errors, corrections, or minor changes were appropriate. The modified vegetation maps were then digitized and edited into an Arc INFO 8.0 polygon

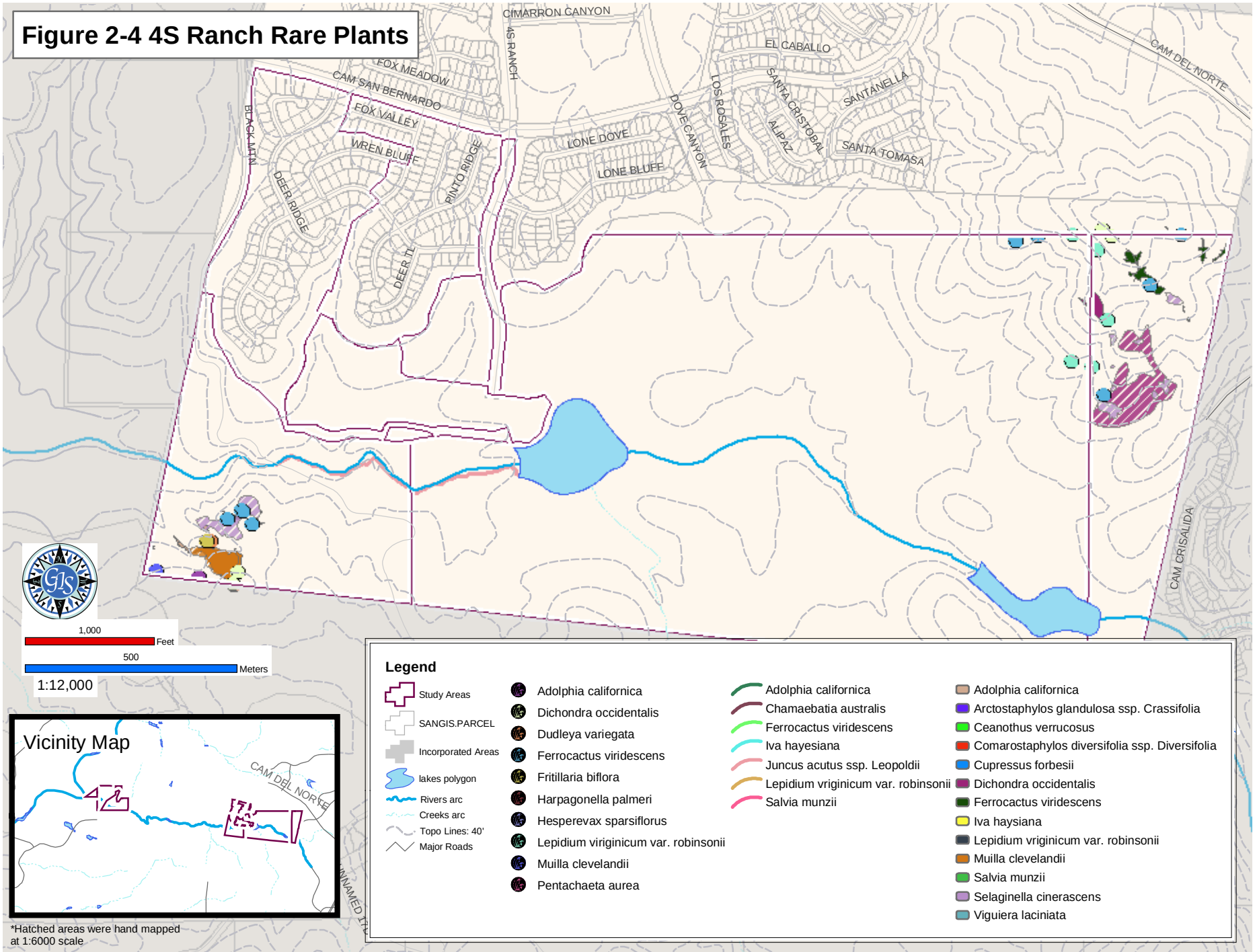
Figure 2-3 Lusardi Creek Rare Plants



*Hatched areas were hand mapped at 1:6000 scale

/projects/bio_monitoring/2001/arc_map/fig2_3_veg_lusardi_rare.mxd

Figure 2-4 4S Ranch Rare Plants



Legend

- Study Areas
- SANGIS.PARCEL
- Incorporated Areas
- lakes polygon
- Rivers arc
- Creeks arc
- Topo Lines: 40'
- Major Roads

- Adolphia californica
- Dichondra occidentalis
- Dudleya variegata
- Ferrocactus viridescens
- Fritillaria biflora
- Harpagonella palmeri
- Hesperevax sparsiflorus
- Lepidium viriginicum var. robinsonii
- Muilla clevelandii
- Pentachaeta aurea

- Adolphia californica
- Chamaebatia australis
- Ferrocactus viridescens
- Iva hayesiana
- Juncus acutus ssp. Leopoldii
- Lepidium vriginicum var. robinsonii
- Salvia munzii

- Adolphia californica
- Arctostaphylos glandulosa ssp. Crassifolia
- Ceanothus verrucosus
- Comarostaphylos diversifolia ssp. Diversifolia
- Cupressus forbesii
- Dichondra occidentalis
- Ferrocactus viridescens
- Iva haysiana
- Lepidium vriginicum var. robinsonii
- Muilla clevelandii
- Salvia munzii
- Selaginella cinerascens
- Viguiera laciniata

*Hatched areas were hand mapped at 1:6000 scale

/projects/bio_monitoring/2001/arc_map/fig2_4_veg_4sranch_rare.mxd

coverage (figures 2-5 and 2-6).

Fifteen species of rare plants were encountered in the preserve areas. Twelve of these species are listed within the California native Plant Society's Inventory of Rare and Endangered Plants of California (See Table 2.1). The sparse-flowered hesperevax (*Hesperevax sparsiflorus*), which is found in the Lusardi Creek area, is considered locally rare. Additionally, the Del Mar manzanita (*Arctostaphylos glandulosa* ssp. *crassifolia*), which is also present in limited numbers, is currently listed as endangered under the federal or State Endangered Species Acts. Rare species and their rank are summarized in Table 2.1.

Table 2.1 – Rare Plant Flora of Lusardi Creek and 4S Ranch Preserve Areas

Latin Binomial	Common Name	Rank
Adolphia californica	Califronia Adolphia	CNPS 2
Arctostaphylos glandulosa ssp. Crassifolia	Del Mar Manzanita	Fed E, CNPS 1B
Comarostaphylos diversifolia ssp. Diversifolia	Summer Holly	CNPS 1B
Convolvulus simulans	Small-flowering Morning Glory	CNPS 4
Dichondra occidentalis	Western Dichondra	CNPS 4
Dudleya variegata	Varigated Dudleya	CNPS 1B
Ferrocactus viridescens	San Diego Barrel Cactus	CNPS 2
Harpagonella palmeri	Palmer's Grappling Hook	CNPS 4
Hesperevax sparsiflorus	Sparse-flowered Evax	Locally rare
Iva hayesiana	San Diego Marsh-elder	CNPS 2
Juncus acutus ssp. Leopoldii	Spiny Rush	CNPS 4
Lepidium virginicum var. robinsonii	Robinson's Peppergrass	CNPS 1B
Microseris douglasii var. platycarpha	Small-flowering Microseris	CNPS 4
Pentachaeta aurea	Golden-rayed Pentachaeta	CNPS 4
Selaginella cinerascens	Ashy Spike Moss	Locally rare

Fed E = Species designated as endangered under the federal Endangered Species Act
CNPS 1B = Plants Rare, Threatened or Endangered in California and elsewhere
CNPS 2 = Plants Rare, Threatened or Endangered in California but more common elsewhere.
CNPS 4 = Plants of limited distribution.

Figure 2-5 Lusardi Creek Vegetation

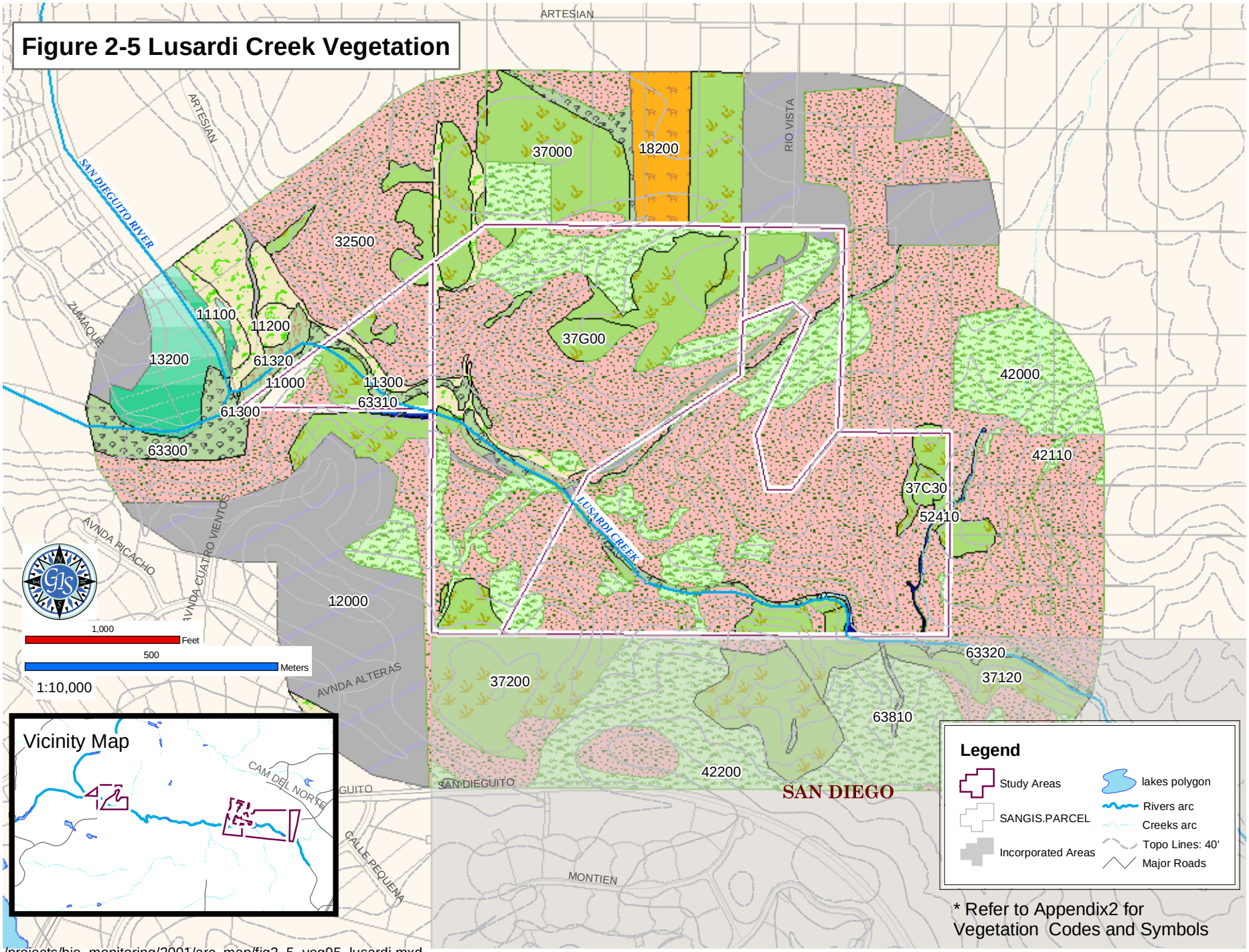


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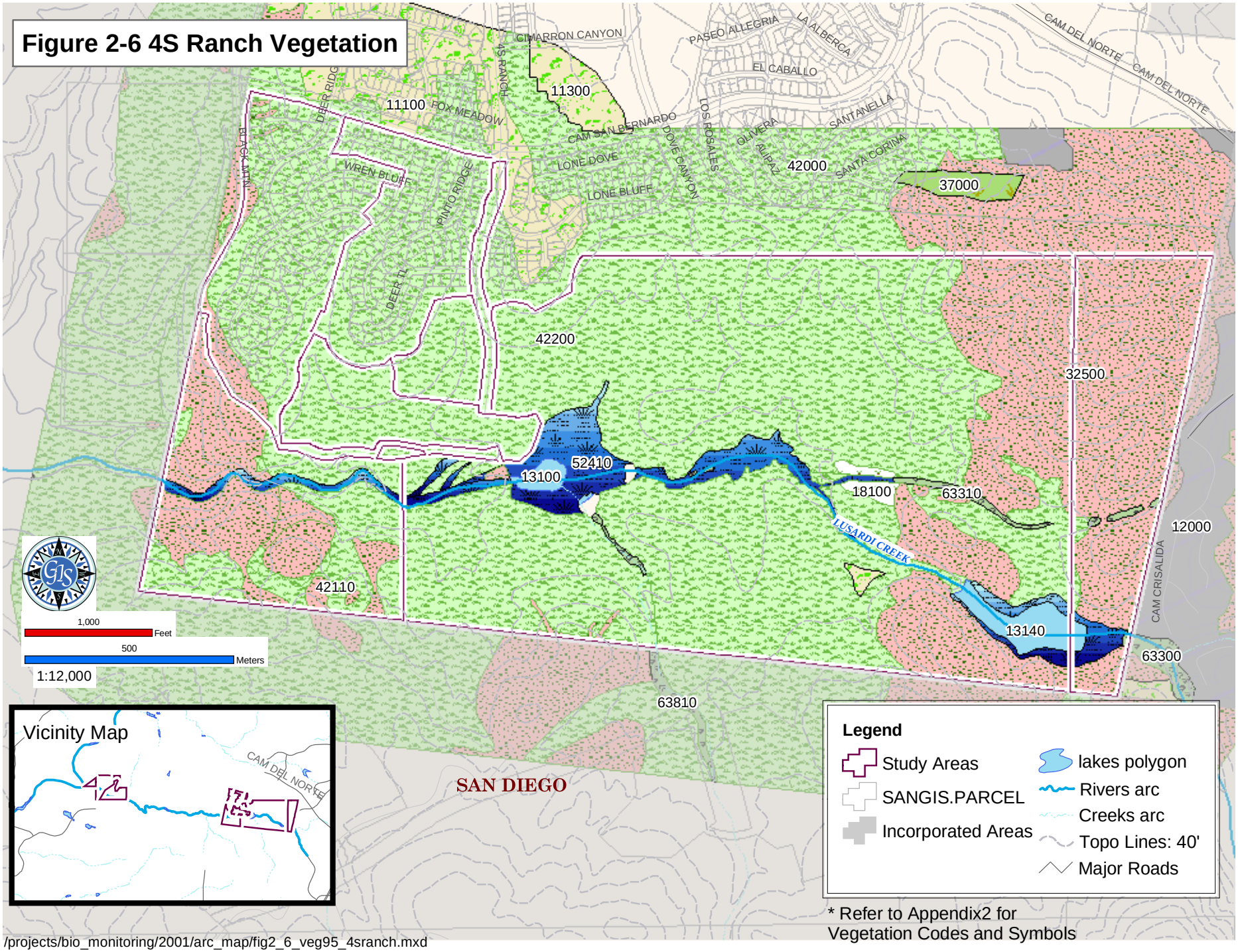
Figure 2-6 4S Ranch Vegetation



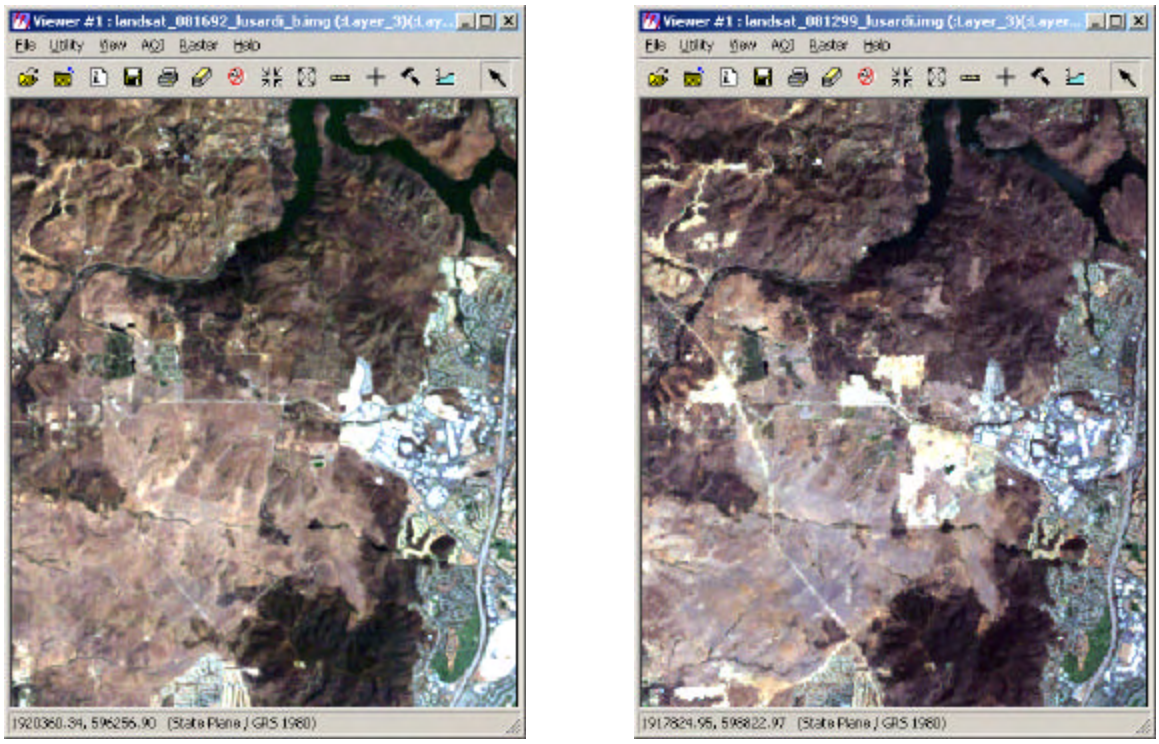
* Refer to Appendix2 for Vegetation Codes and Symbols

/projects/bio_monitoring/2001/arc_map/fig2_6_veg95_4sranch.mxd

III. Change Detection Techniques Using Landsat Thematic Mapper Data

The images shown below (figure 3-1) are portions of two Landsat TM digital images recorded on August 1992 and August 1999 from an approximate altitude of 700 km. Landsat TM images have an approximate spatial resolution of 30 meters. The images shown cover the Lusardi Creek and 4S Ranch area of San Diego County. The images were geometrically registered to each other, meaning that the same pixel within both images represents the same location on the ground. They were also radiometrically calibrated using pseudo-invariant feature subtraction (Hall et al. 1991, Schott et al 1988).

Figure 3-1 Landsat Imagery of Lusardi Creek and 4S Ranch bands 3,2,1

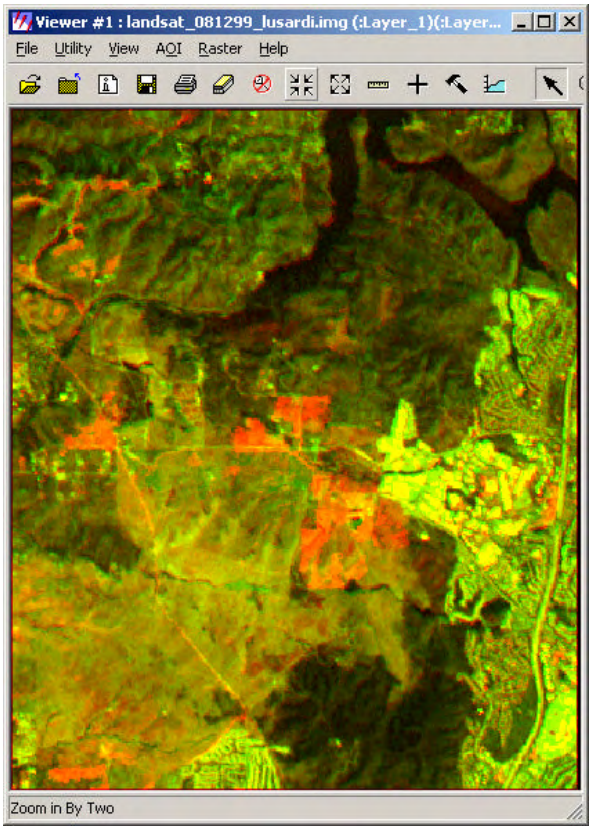


1992 **1999**

Three change detection methods were performed and their outputs visually compared. The multitemporal image pair was used as input into the change-detection procedures to generate digital change images. The digital data were processed using Erdas IMAGINE 8.5 digital image processing software.

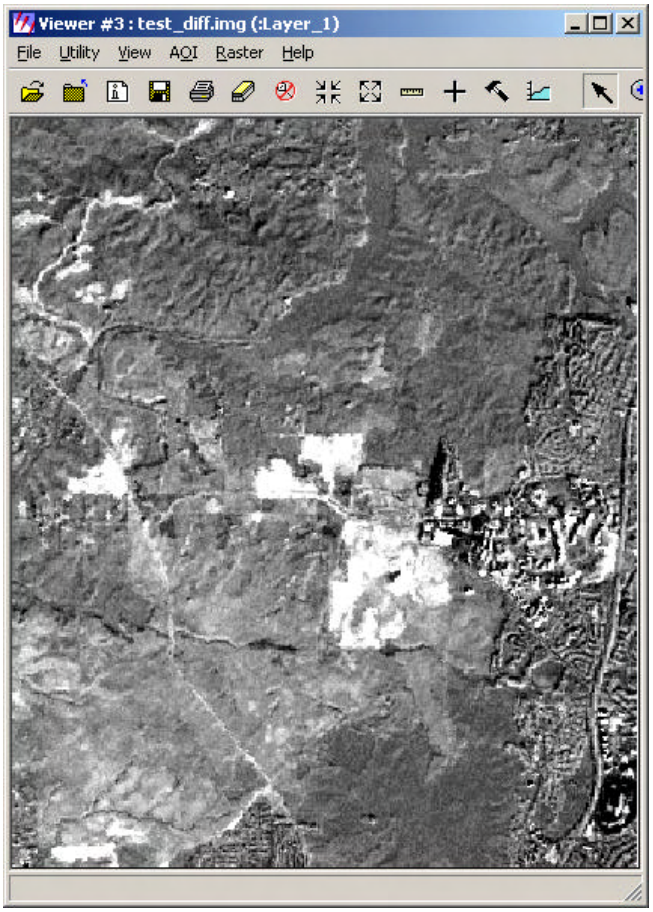
It is possible to visually identify change in the imagery, for up to three image dates, by inserting individual bands of data into specific write function memory banks (red, green, blue) in ERDAS IMAGINE (Jensen, 1996). The result of inserting band 1 from the 1992 image in the green color gun, band 1 in the 1999 image in the red color gun, and no image in the blue color gun can be seen in figure 2. All areas that did not change are depicted in yellow. This method builds off of *additive color theory* where equal intensities of green and red result in yellow. The graphic depicts new urban development and vegetation clearing in red. Potential vegetation re-growth and non-native landscaping in the urbanized areas are depicted in green.

Figure 3-2 Landsat Multi-date Additive Color Composite



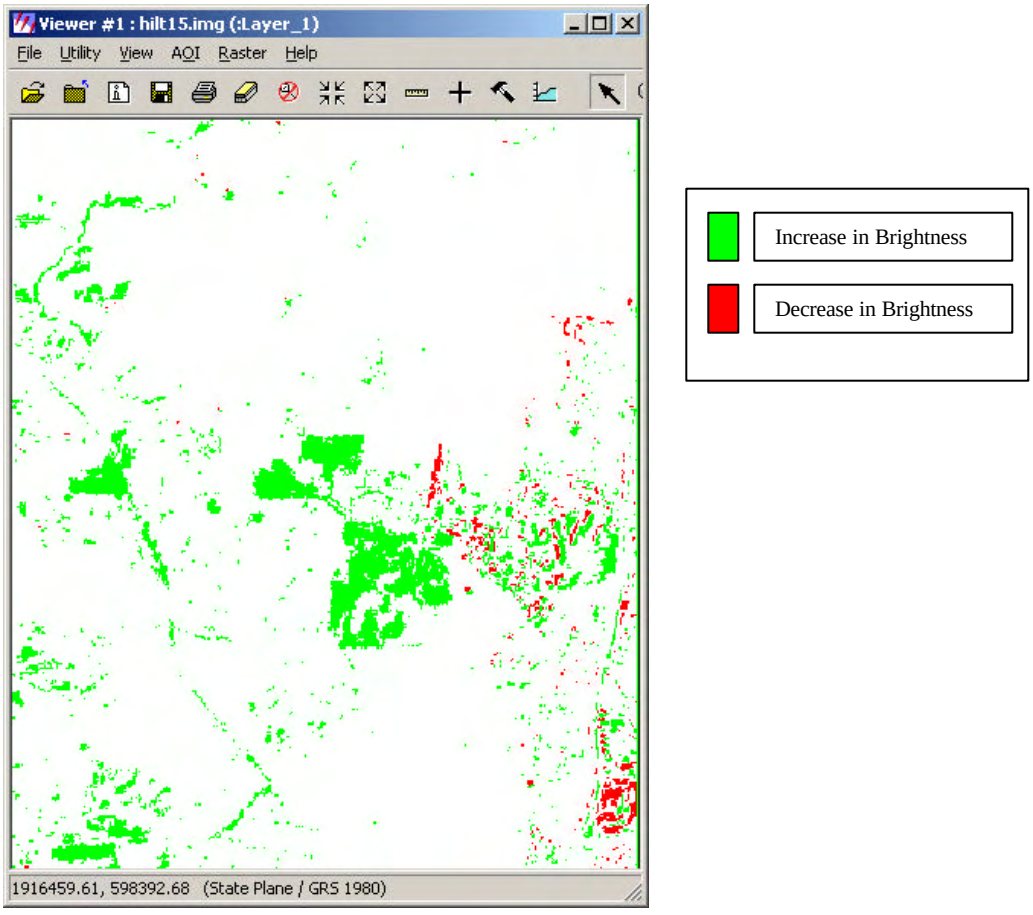
In a different technique, simple identification of the amount of change is possible between two images by image differencing the same band in the two images (Green 1994 in Jensen 1996). Image differencing involves subtracting one date's image from another. The result is positive and negative values in areas of change and zero values in areas of no change (figure 3-3). The change image usually results in a histogram of brightness values (BV) having a Gaussian distribution. The pixels of no BV change are distributed around the mean and pixels of change are found in the tails of the distribution (Price et al 1992 in Jensen 1996). Therefore, "the gray tones of each pixel on a change detection image portray the amount of difference between the original images" (LOGICON 1997). This technique offers no information of the nature of change. Rather, it identifies the areas that may have changed.

Figure 3-3 Landsat Image Differencing Output



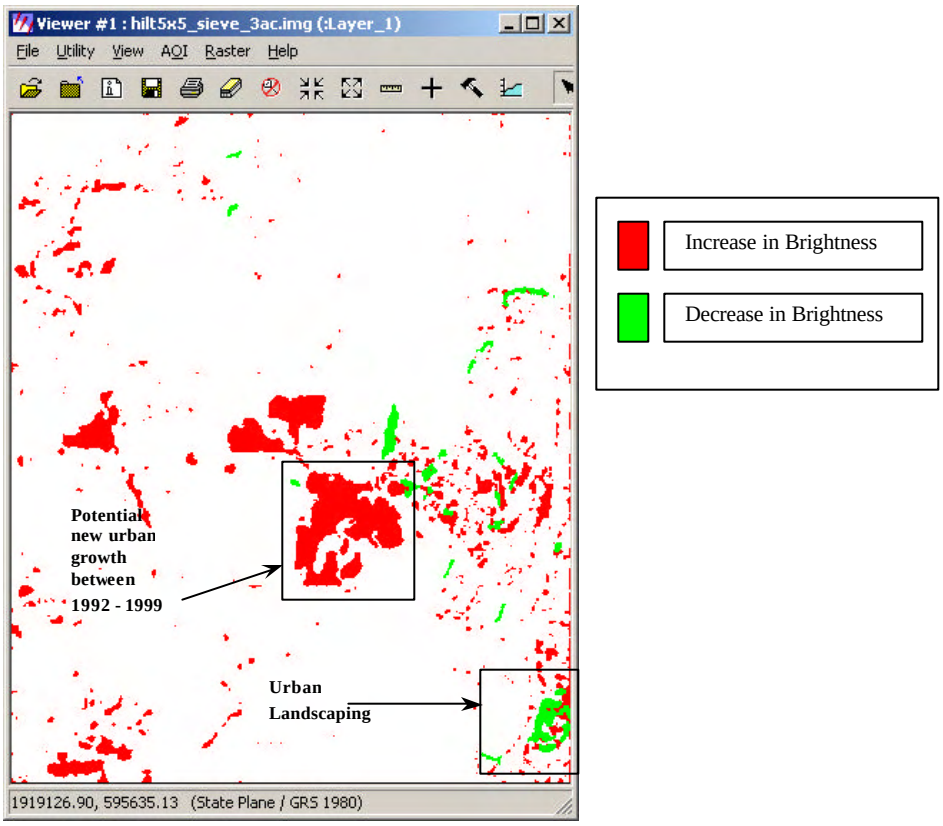
Quantification of potential change is possible using a binary change mask. A threshold boundary between change and no-change is decided upon. Areas of change are recoded to a value of one, and areas of no change are recoded with a value of zero. The graphic below shows the areas of change in red and green (figure 3-4). Green depicts areas that increased in BV and red depicts areas that decreased in BV. A threshold of 10% change[2] was chosen based on comparison with the multi-date composite image discussed above. The binary change mask can then be imported into a GIS and quantification of the potential change can be performed. Of the approximately 22,000 acres in the Lusardi Creek/4S Ranch Landsat study area, roughly 1,680 acres or 8% changed between the two dates using a 10% change-no change threshold.

Figure 3-4 Landsat Binary Change Mask



The second binary change mask is the result of aggregating the continuous areas of change with a minimum unit of 3 acres (Note the colors are reversed from the above graphic, see figure 3-5). This method is useful in creating change hotspots that require field investigation or further interpretation using higher resolution imagery such as that created with the ADAR or IKONOS (5 meter multispectral satellite-based; see www.spaceimaging.com) platforms.

Figure 3-5 Aggregated Landsat Binary Change Mask



Multispectral vegetation indices, such as the normalized difference vegetation index (NDVI), can also be used in this type of research to compare between date differences in the greenness of an area. The graphics below are NDVI images for 1992 and 1999 (figure 3-6).

Figure 3- 6 Landsat NDVI Output

1992

1999

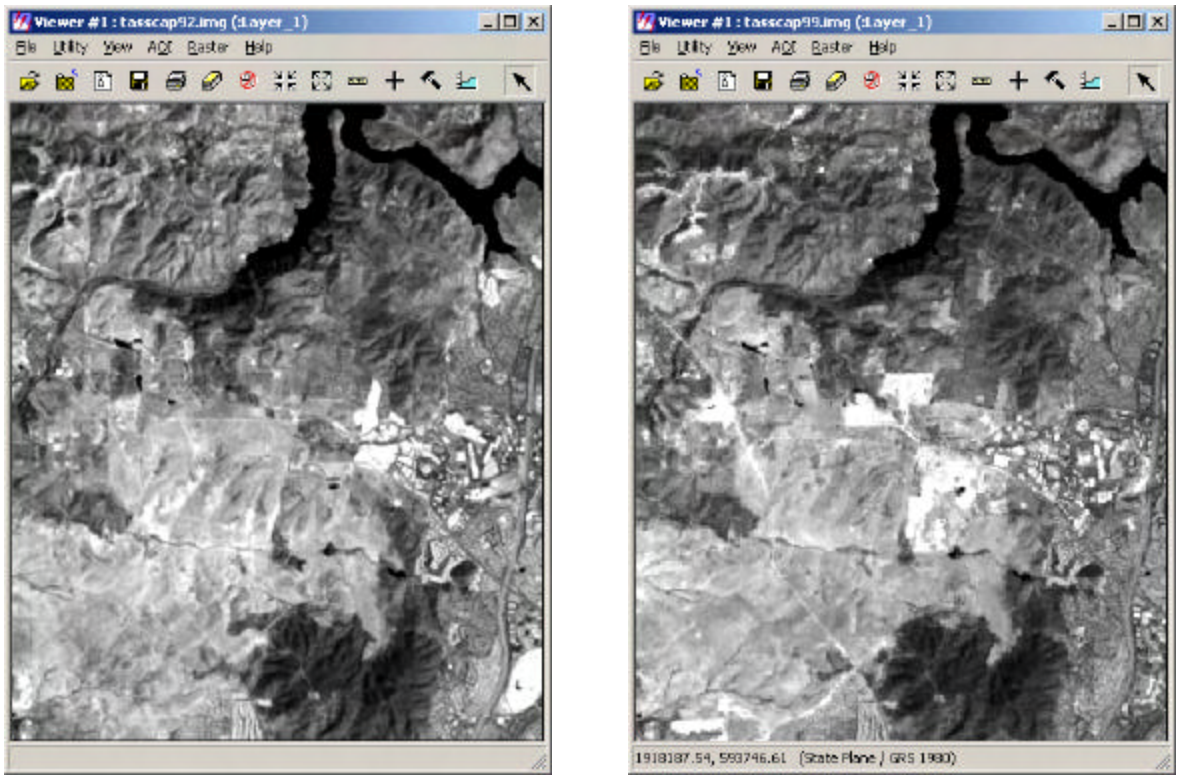
Because NDVI diminishes the spectral influences of the illumination angle, slope, and aspect, it has proven useful in vegetation cover monitoring (Lillesand and Kiefer 1994). The technique can be used to study vegetation phenology of a given community, leaf area index measures, calculating percent bare soil, as well as photosynthetic biomass. The index is typically formulated as follows:

$$NDVI = (NIR - Visible)/(NIR + Visible)$$

With this calculation the range of values extends from 0 to 200, with 0 to 100 generally representing water, soil, and other non-vegetated surfaces and values greater than 100 representing vegetated surfaces. The bright areas in the NDVI images shown here correlate to vegetated surfaces.

In addition to NDVI, other methods exist that aid in detecting change in surface features between dates using remotely sensed imagery. The Tasseled Cap Transformation is one such example where coefficients are applied to the imagery to enhance the greenness, brightness and wetness features in the image scene. The resulting brightness features (i.e. bare soil and concrete) in two image dates can then be differenced to depict potential changes. The following images (figure 3-7) show the bare soil and/or concrete features for the two years and their difference image. The 1999 image clearly indicates an increase in brightness related to bare soil and/or concrete in the study area.

Figure 3-7 Landsat Tasseled Cap Transformation Brightness Output

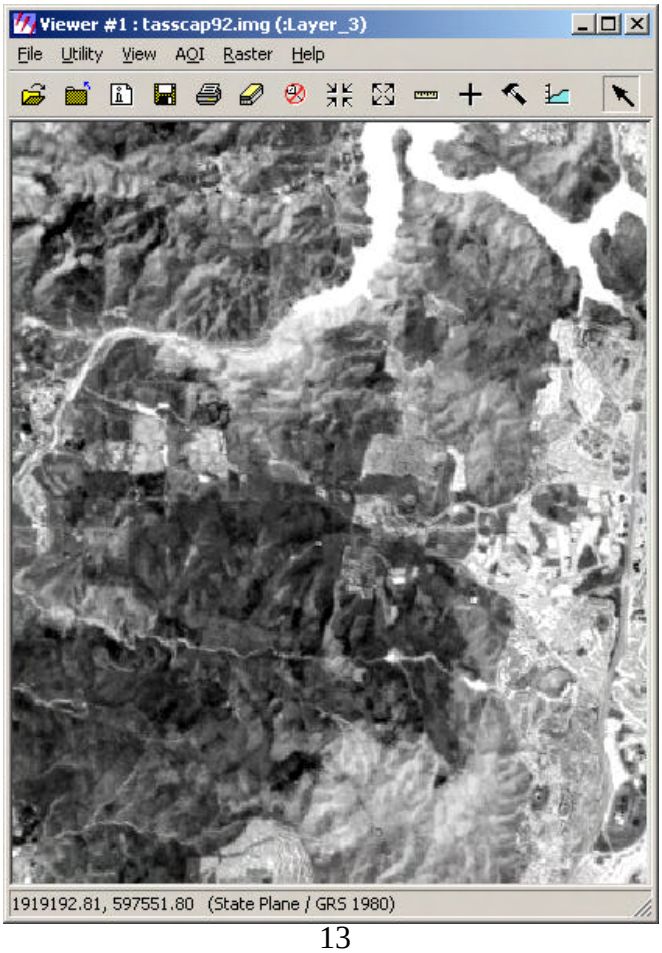


1992 **1999**

The same is true for green and wet features. The image in figure 3-8 depicts the wetness features in the study area in 1992. In this image, the bright areas correspond with the lake and the riparian areas along the creek. Bright gray features in urbanized areas indicate an irrigated landscape, while open water appears bright white (see in upper right, i.e., Lake Hodges).

In addition to spectral indices and band-to-band subtractions, more time-consuming techniques exist that involve classifying the multi-date imagery into individual land cover classes. With these methods, which are beyond the scope of this research, it is possible to difference the classification results. This method is useful because it does give from-to change information. However, the overall accuracy of the change detection is dependant upon the accuracy of each of the individual image classifications. It requires the image analyst have previous knowledge of the study area as well as field data for training the imagery (telling the software which pixel values correspond to which land cover types) and verification of the classification results.

Figure 3-8 Landsat Tasseled Cap Transformation Wetness Output

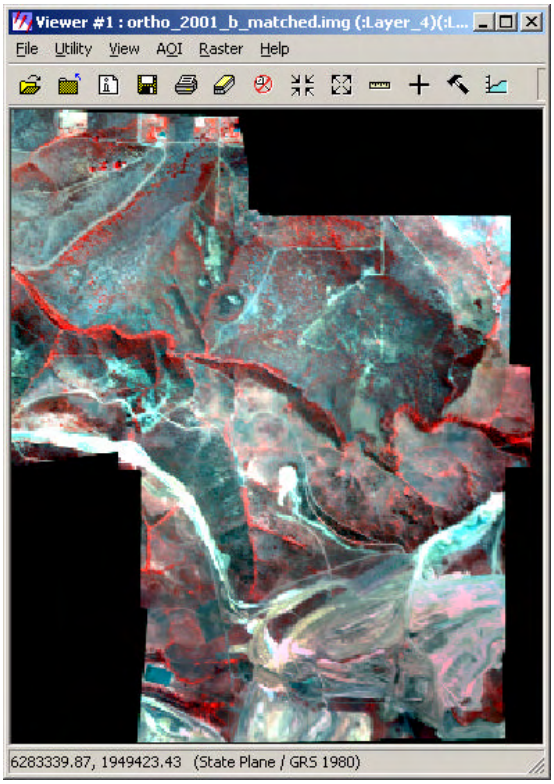


IV. Change Detection Techniques Using ADAR Data

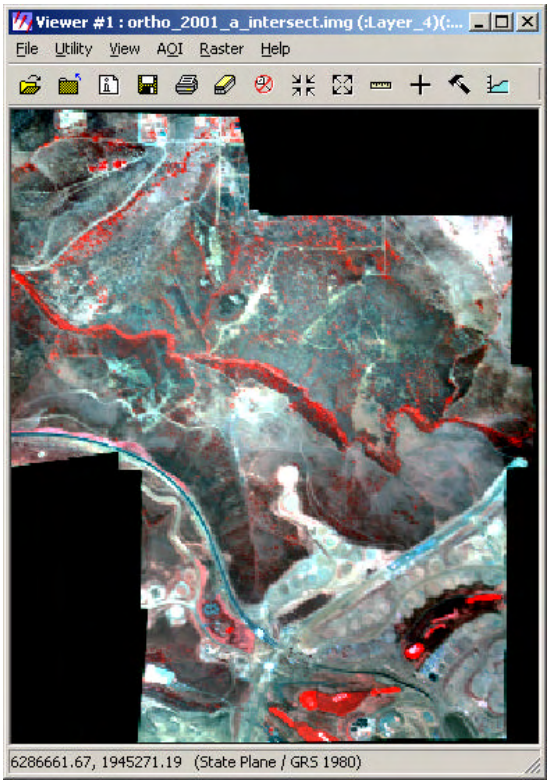
The ADAR System 5500, developed by Positive Systems; Whitefish, Montana, acquires digital photographs in four configurable spectral bands using four different digital cameras. It is typically used in diverse applications including wetlands monitoring, forestry management, precision agriculture, mining, military surveillance and environmental compliance and monitoring. The system is airplane based and can generate 0.5 to 3 meter GRE multi-spectral imagery for a reasonable cost. All ADAR imagery not produced as a synoptic scene requires radiometric correction and mosaicing (Jensen 1994, pg 121; LOGICON Multispectral imagery reference guide 1997, pg 4-1). Mosaicing, which will be discussed in greater detail, usually is monetarily expensive and/or time intensive.

The images below are 2000 and 2001 (figure 4-1.1 and figure 4-1.2) ADAR multi-spectral images for the two study areas, Lusardi Creek and 4S Ranch (figure 1-1.3). The data were collected by the Center for Earth Systems Analysis and Research (*CESAR*) at San Diego State University. The data were pre-processed by Integrated GIS Technologies; San Diego, California prior to input into the change detection algorithms. Pre-processing included ortho-rectification using ERDAS OrthoBASE. Additionally, the images were geometrically registered and radiometrically[1] calibrated (a process not required with the Landsat TM). In these images the 2000 scene has a much brighter histogram than the 2001 image. Consequently the 2000 scene histogram was matched against the 2001 scenes. This technique reduces erroneous change detection results due to different spectral responses that might be caused by seasonal variation and camera calibration differences between the two dates.

Figure 4-1.1 ADAR Lusardi Creek bands 4,3,2

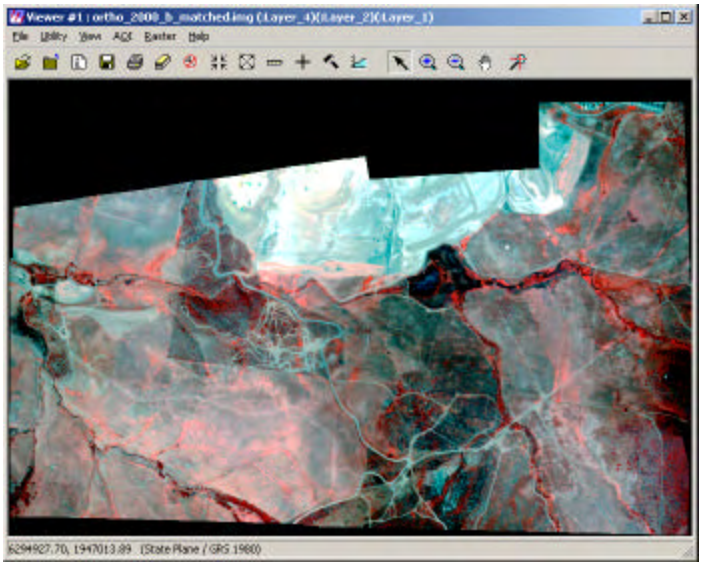


2000

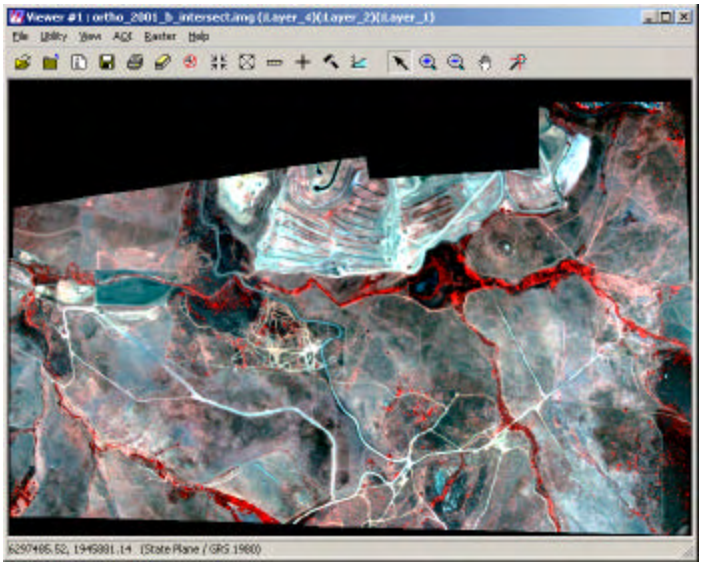


2001

Figure 4-1.2 ADAR 4S Ranch bands 4,3,2



2000

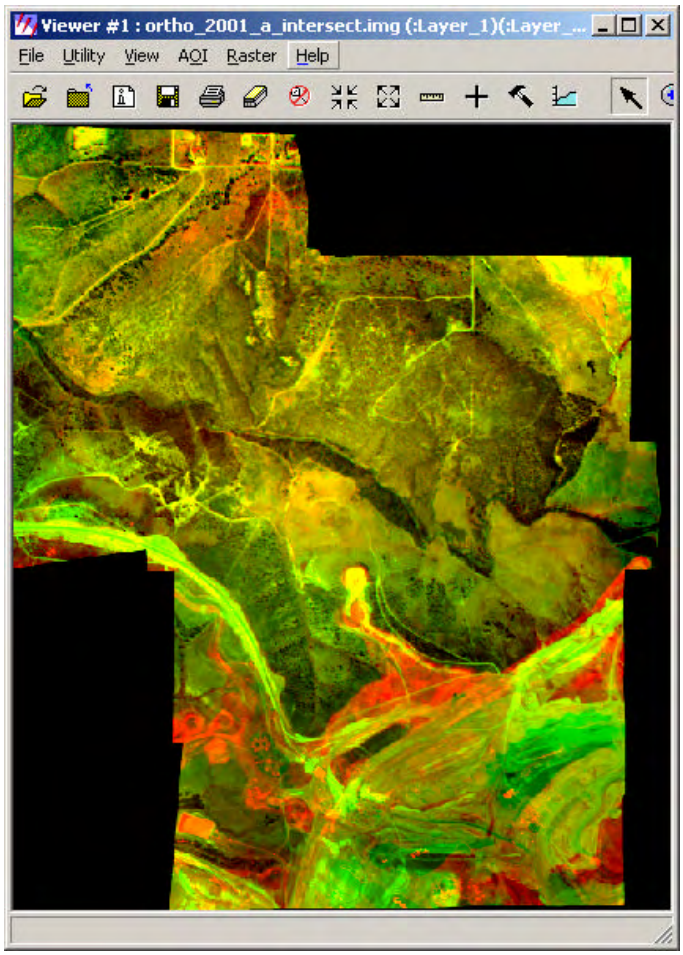


2001

Two change detection methods were performed using the ADAR imagery and their outputs visually compared. The multitemporal image pair was used as input into the change-detection procedures to generate digital change images. The data were again processed using ERDAS IMAGINE digital image processing software.

As with the Landsat TM imagery, change was initially assessed using the write function memory insertion technique previously described. The image in figure 4-2 is a result of inserting Band 1 from the 2000 Lusardi Creek image in the green color gun, Band 1 in the 2001 Lusardi Creek image in the red color gun, and no image in the blue color gun. All areas that did not change are depicted in yellow. The graphic depicts potential new urban development and vegetation clearing in red. Potential vegetation re-growth and landscaping in the urbanized areas are depicted in green.

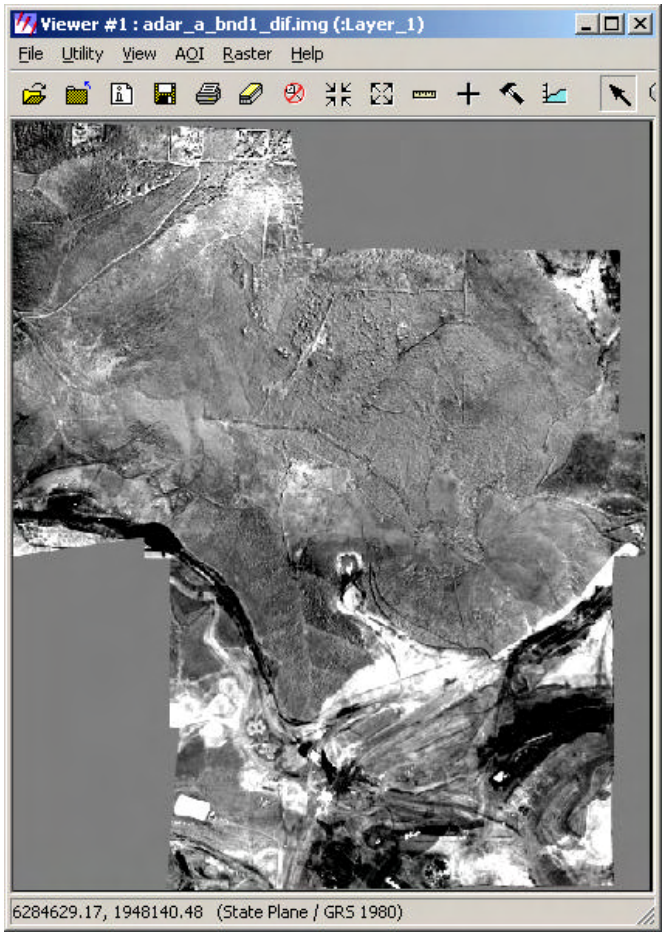
Figure 4-2 ADAR Multi-date Additive Color Composite



The change showed in figure 4-2 was verified through field visits. The red in the above image corresponds to new grading that occurred. The green in the lower right corresponds to landscaping of a residential area and new golf course. The red in the upper left, however, corresponds to a change in the phonological state of non-native grasses (*Avena fatua*) that exist in that area.

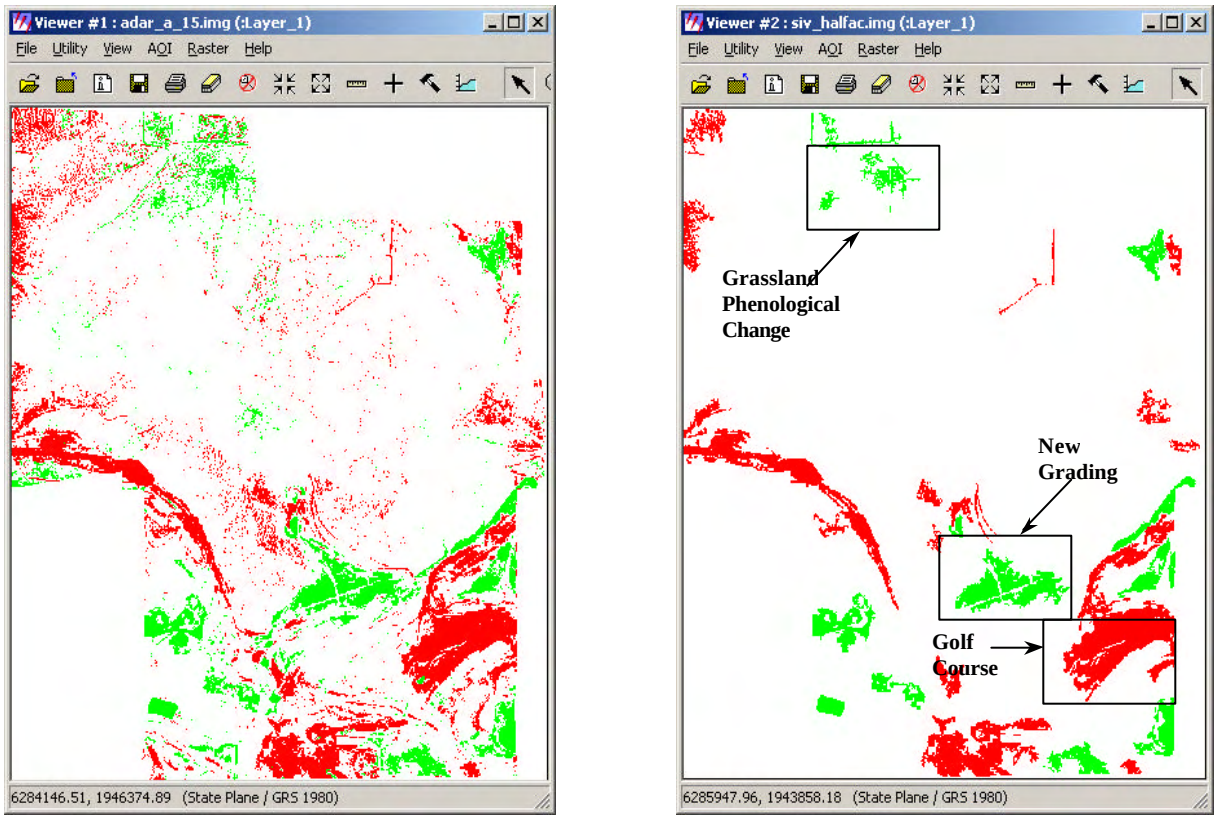
Band-to-band image differencing of Band 1 of the two years yielded change hotspot areas similar to that of the write function memory insertion above. In figure 4-3 the image of Lusardi Creek, change is seen in white and black while no change is in gray. In this example, change due to vegetation removal and phenological difference is not discernible without field checking.

Figure 4-3 ADAR Image Differencing Output



As with the Landsat example, quantification of potential change is possible using a binary change mask. A threshold boundary between change and no-change was decided upon. Areas of change were recoded to a value of one and no change is recoded to a value of zero. The first graphic below shows the areas of change in red and green. Green depicts areas that increased in BV and red depicts areas that decreased in BV. A threshold of 15%[2] change was chosen based on comparison with the multi-date composite image discussed above. The binary change mask is then imported into a GIS for quantification. Of the approximately 1,400 acres in the Lusardi Creek ADAR scene, approximately 186 acres or 13.23% changed between the two dates using a 15% change-no change threshold. The second binary change mask (figure 4-4) is the result of aggregating the continuous areas of change with a minimum unit of a ½ acre. This reduces some of the "noise" in the change-no change mask that might be caused by extraneous factors such as misregistration (Townshend et al. 1992). With the ½ acre minimum mapping unit, change is calculated at 123 acres or approximately 9% of the total 1400 acres in the ADAR scene.

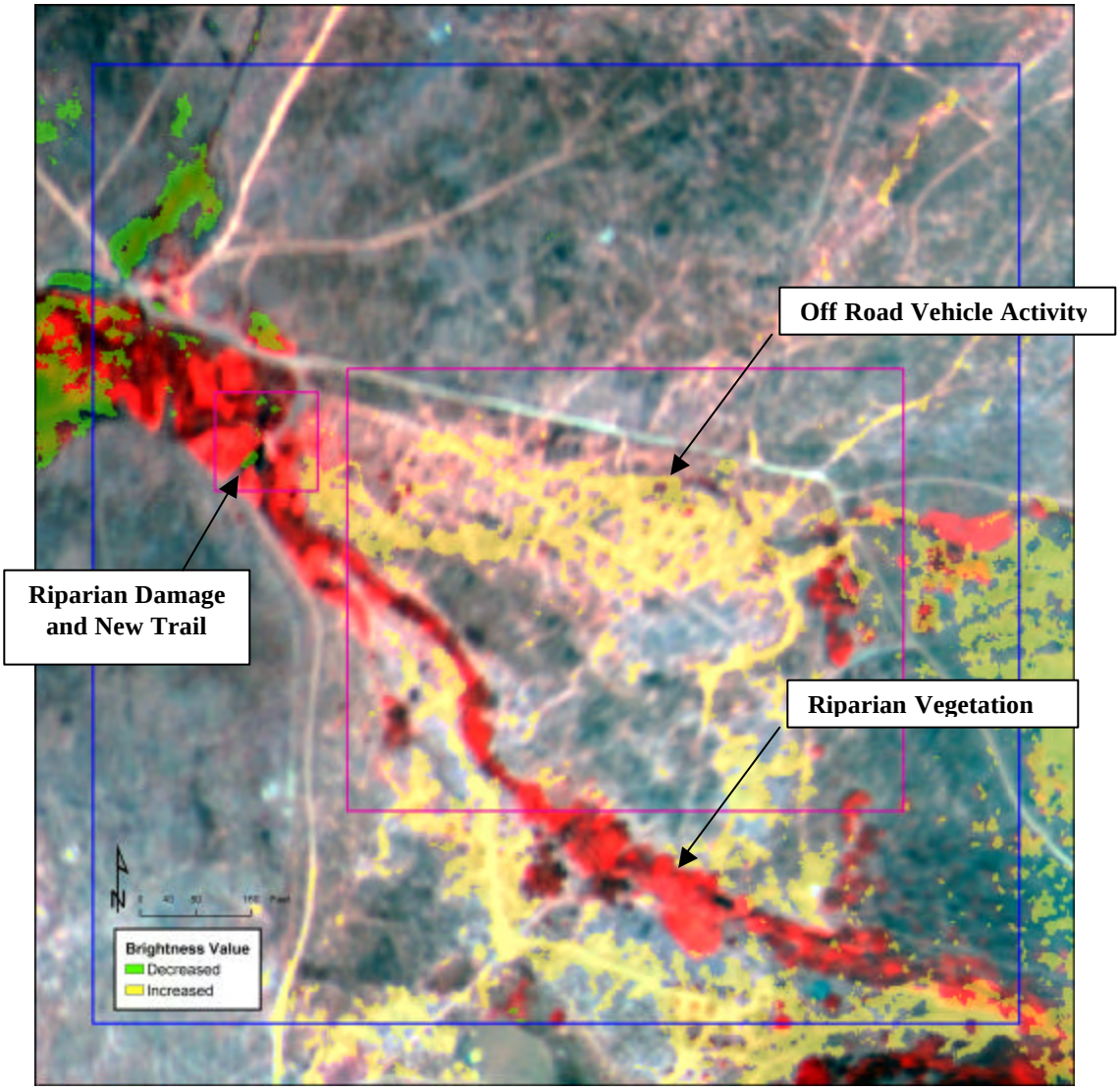
Figure 4-4 ADAR Raw and Aggregated Change Masks



The direction of change (i.e. vegetation removal or vegetation regrowth) can be assumed from the above change-no change mask, where green represents an increase in BV or potential vegetation removal and yellow represents a decrease in BV or potential vegetation re-growth. However, it is noted that these assumptions should be made with caution. The image in figure 4-5 is a subset of the 4S-Ranch ADAR scene. In this image, signatures corresponding to a decrease in BV between dates along the riparian corridor could have been erroneously categorized as an increase in vegetation. However, after a field visit to this location, it was determined that the decrease in BV actually corresponded to mud from a new road being cut through the stream channel.

Although BV changes can incorrectly categorized the land use change, this seems to be the exception rather than the rule in ADAR image interpretation. For example figure 4-6 indicates how well the detected (and field checked) changes can be categorize with ADAR.

Figure 4-5 ADAR 4S Ranch 2001 Brightness Change Overlay - Field Check



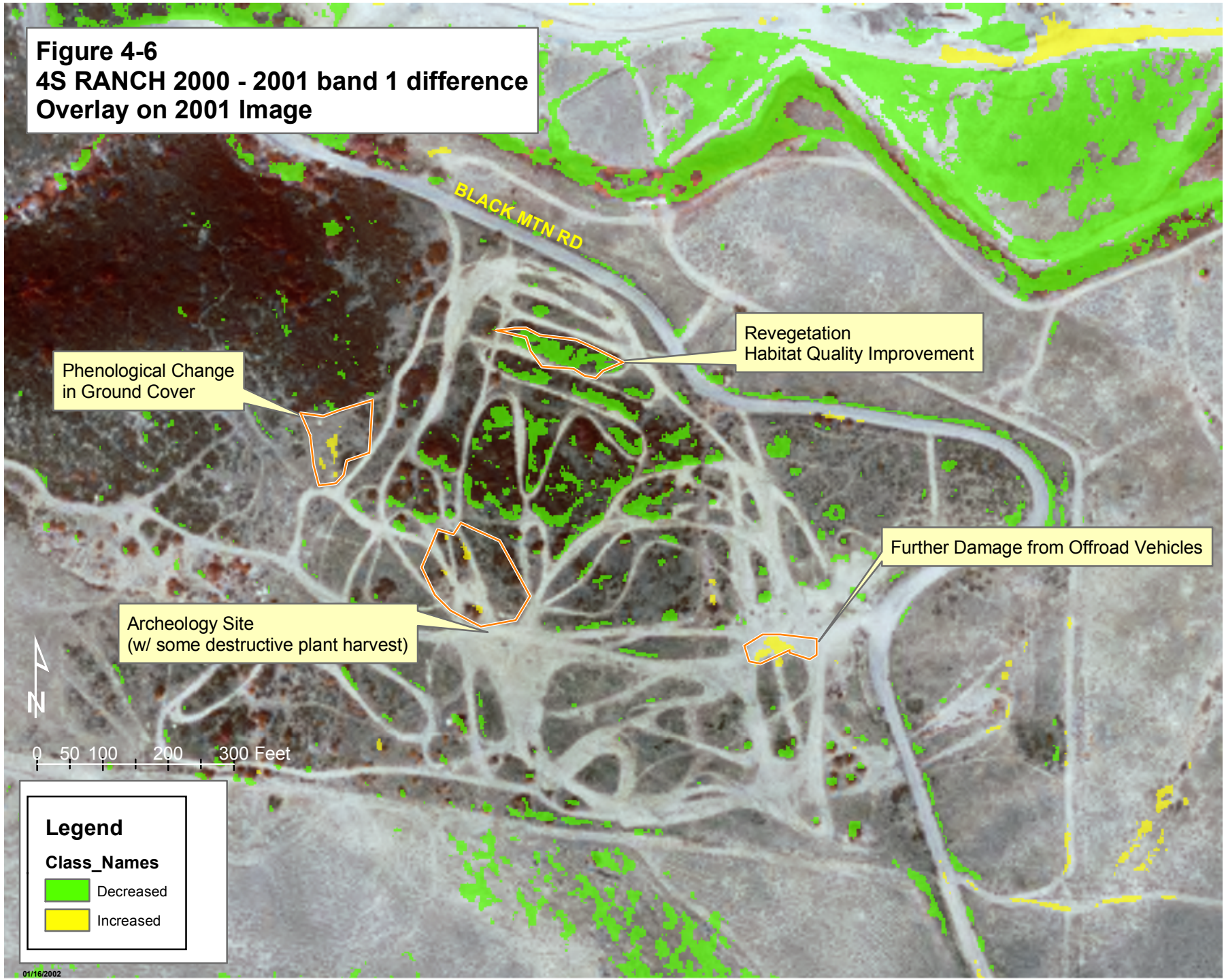


Figure 4-6
4S RANCH 2000 - 2001 band 1 difference
Overlay on 2001 Image
BLACK MTN RD
Revegetation
Habitat Quality Improvement
Phenological Change
in Ground Cover
Further Damage from Offroad Vehicles
Archeology Site
(w/ some destructive plant harvest)
N
0 50 100 200 300 Feet
Legend
Class_Names
Decreased
Increased
01/16/2002

V. Discussion of Landsat and ADAR Remote Sensing Techniques as Biological Monitoring Utilities

The well tested and relatively inexpensive nature of Landsat imagery makes it an ideal choice for large land use/land change analysis in the MSCP preserve system. In compliance with the approved MSCP, periodic surveys of the preserve system are required to insure non-conforming land uses have not accidentally or surreptitiously occurred, e.g., illegal grading. With limited funds and personnel availability, it appears very prudent to utilize Landsat as a yearly initial assessment technique (See Table 5.1).

Table 5.1 Landsat – ADAR Cost Comparison

	Landsat	ADAR
Image Cost	.04 Cents per square mile per scene*	$150-300 per square mile per flight
Change Detection Image Prep	$120 per scene*	$1021 per square mile
Resolution	30 meter	1 meter
Bands	7	4
Staff time for change detection	4 hrs	4 hrs

* One Landsat scene is 13214 square miles

The results of a regular remote assessment could better direct the time and efforts of field biologist towards future areas of concern or change where the preserve system's sensitive flora and fauna could be threatened.

The rough scale detail of Landsat falls short of the level of detail required to resolve individual groups of sensitive plants or features less then the pixel size (30 m). When a circumstance requires highly detailed multi-spectral information of a site or a specific disturbance, such as a fire, high resolution imagery is a requirement. ADAR imagery can provide this level of detail, however it requires a more time intensive level of pre and post processing to create a usable imagery product. This is a cost benefit decision that must be based upon the type of questions asked in any monitoring or remote sensing research. For example to answer the question "what is the estimated vegetated cover in a 24,000 acre preserve before a fire and five years after the fire?", Landsat should be used. However, to answer the question of "whether the preserve is type converting because of the fire?", would require ADAR or a similar system. A more comprehensive comparison is offered in table 5.2.

Table 5.2 Landsat - ADAR Resolution Assessment Potential Comparison

Targets Well Resolved	Landsat	ADAR*
Bare soil	Yes	Yes
Vegetation	Yes	Yes
Individual Plants (Trees-Shrubs)	No	Yes
Vegetation Community Classification	Limited	Yes
Cars	No	Yes
Streets	No	Yes
Freeways	Yes	Yes
Individual Houses	Limited	Yes
Building	Yes	Yes
Grading	Yes	Yes
Off-Road Activity	Very Limited	Yes
Trails	No	Yes
Fire Scars	Yes	Yes
Phenological change	Limited	Yes
Successional Changes	Limited	Yes

* Costs considered exorbitant for areas greater than 3000 acres

VI. Conclusion

The primary benefits of Landsat are its relatively inexpensive acquisition cost and its ease of application due to the level of preprocessing that has been done prior to purchase. Although the pixel size of the Landsat imagery limits its use with very small ground features, it performs very well on landscape scales resolving larger features, i.e., fires, grading, large extent vegetation change, impermeable surfaces, landslides, natural disasters, etc. (features >30 m^2). Landsat imagery is considered a "commercial-off-the-shelf" (COTS) product in the remote sensing community. This imagery can be used in an initial assessment of potential land cover and vegetation change over large areas requiring relatively little time and low cost. The change detection results can then be used to determine areas requiring field assessment or areas requiring higher resolution aerial photography such as 1 meter ADAR or lower resolution satellite imagery such as 5 meter IKONOS for more spatially extensive change detection applications. These technologies have potential practical applications for land use agencies in areas that have significant natural and human generated disturbances, e.g., fire and off-road activity, and could prove invaluable to conservation programs responsible for large open space areas. The

County of San Diego intends to further explore the use of these technologies in its land use analyses and MSCP monitoring program.

Acknowledgements

-Thanks are extended to Doug Stow of San Diego State University's CESAR Lab, Andres Abeyta of Integrated GIS Technologies, and Fred Roberts for his botanical skills. Special thanks to R. Asher, T. Boaz, M. Casey, L. Coulter, M. Hanley, D. Martin, T. Oberbauer, R. Ross, and R. Winslow

Endnotes

1.) *Radiometric registration* or normalization, sometimes confused with Radiometric resolution, refers to the process that matches the radiance values of two or more images by means of a linear transformation (Hall et al. 1991).

2.) The 10-15% change mask figure reflects an iterative process of experimentation where the desired results were an improved signal to noise ratio between actual change and false change. Although the percent figure could have been set at a lower threshold of change detection, we consider it scientifically unsound. Expected natural year to year variability of vegetation physiogamy (or possibly due to minor pixel to pixel registration errors), ecologically insignificant or nonexistent amounts of change (noise) will still be recorded as "change". Subsequently, the resulting change mask would introduce more error than it would detect in actual change.

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Appendix 1 - Lusardi Creek - 4S Ranch Preserve Area Rare Plants

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
A041801	Lusardi Creek	4/18/2001	Selaginella cinerascens	Scattered individuals in small colony growing along old dirt road on low ridge passing through coastal sage scrub. Associated with Bromus madritensis, B. diandrus, Stipa pulchra, Erodium botrys, Isocoma menziesii, Chlorogalum parviflorum, Lotus scoparius, Plantago erecta, Filago arizonica, Artemisia californica, and Salvia mellifera
A041901	Lusardi Creek	4/19/2001	Selaginella cinerascens	Small patch, 0.1m squared, on gentle east-facing slope in opening in coastal sage scrub. Associated with Sisyrinchium bellum, Eriophyllum confertiflorum, Salvia mellifera, Stipa lepida, Rhus integrifolia, Crassula connata, Lotus scoparius, and Chlorogalum parviflorum
A041902	Lusardi Creek	4/19/2001	Selaginella cinerascens	Relatively large and extended colony growing in open spider web-like pattern among mima-mound like topography along boarder of broad hilltop mesa, along southeast-facing ridge, and on slopes of drainage in coastal sage scrub and in open coastal sage scrub with numerous native grassland openings. Associated with Salvia mellifera, Artemisia californica, Stipa Relatively large and extended colony growing in open spider web-like pattern among mima-mound like topography along boarder of broad hilltop mesa, along southeast-facing ridge, and on slopes of drainage in coastal sage scrub and in open coastal sage scrub with numerous native grassland openings. Associated with Salvia mellifera, Artemisia californica, Stipa Relatively large and extended colony growing in open spider web-like pattern among mima-mound like topography along boarder of broad hilltop mesa, along southeast-facing ridge, and on slopes of drainage in coastal sage scrub and in open coastal sage scrub with numerous native grassland openings. Associated with Salvia mellifera, Artemisia californica, Stipa
A041903	Lusardi Creek	4/19/2001	Selaginella cinerascens	Colony growing on gentle east-facing slope in opening in coastal sage scrub
A041904	Lusardi Creek	4/19/2001	Selaginella cinerascens	Colony growing on east-facing slope in opening in coastal sage scrub
A041905	Lusardi Creek	4/19/2001	Selaginella cinerascens	Colony growing on west-facing slope above drainage in opening in coastal sage scrub
A041906	Lusardi Creek	4/19/2001	Selaginella cinerascens	Colony growing on gentle east-facing slope at southern end of a clay barren in coastal sage scrub

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
A042401	Lusardi Creek	4/24/2001	Selaginella cinerascens	Colony growing on gentle southwest-facing slope in opening in coastal sage scrub
A042402	Lusardi Creek	4/24/2001	Selaginella cinerascens	Colony growing on gentle southwest-facing slope along abandoned dirt road in opening in coastal sage scrub
A042601	Lusardi Creek	4/26/2001	Selaginella cinerascens	A single colony growing on southeast-running ridge with gentle east-facing aspect in opeen coastal sage scrub on crumbly slate cobble clay soil. Associated with Eriogonum fasciculatum, Salvia mellifera, Cneoridium dumosum, Chaenactis glabriuscula, Cryptantha intermedia, Chlorogalum parviflorum, and Porophyllum gracile.
A042602	Lusardi Creek	4/26/2001	Selaginella cinerascens	A single extended colony growing on a southwest-facing slope in coastal sage scrub and on a hill top with slight south-facing aspect in open, grassy coastal sage scrub on clay soil. Associated with Artemisia californica, Eriogonum fasciculatum, Vulpia myuros, Centauria melitensis, Chlorogalum parviflorum, Filago gallica, Erodium cicutarium, Gilia angelensis, Lasthenia californica, Adolphia californica, Ferrocactus viridescens, Bromus madritensis, Dichelostemma pulchellum, and Avena barbata.
A050207	Lusardi Creek	5/2/2001	Selaginella cinerascens	Broad patch growing on south-facing slope along ridge on rocky clay barren within burned coastal sage scrub
A050208	Lusardi Creek	5/2/2001	Selaginella cinerascens	Small patch growing on south-facing slope along ridge on rocky clay barren within burned coastal sage scrub
A050209	Lusardi Creek	5/2/2001	Selaginella cinerascens	Small patch growing on gentle south-facing slope along ridge on rocky clay barren within burned coastal sage scrub
A050210	Lusardi Creek	5/2/2001	Selaginella cinerascens	Several scattered clusters growing on steep southwest-facing slope along along drainage on heavy clay within burned coastal sage scrub
A050211	Lusardi Creek	5/2/2001	Selaginella cinerascens	Growing on gentle south-facing slope along ridge crest on rocky clay barren within burned coastal sage scrub
A050212	Lusardi Creek	5/2/2001	Selaginella cinerascens	Several scattered patches growing on steep south-facing slope on rocky heavy clay within burned coastal sage scrub
A050213	Lusardi Creek	5/2/2001	Selaginella cinerascens	Growing on steep south-facing slope on rocky heavy clay within burned coastal sage scrub

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
A050301	Lusardi Creek	5/3/2001	Iva haysiana	Hundreds occupying about a 1.5 meter wide by 40 meter long ollowing north-south drainage in narrow riparian corridor and chaparral - coastal sage scrub transitional vegetation. Associated with Malosma laurina, Salvia mellifera, Iva hayesiana, Rhus integrifolia, Conium maculatum, Tamarix sp., Baccarhis sarothroides, and B. pilularis
A050302	Lusardi Creek	5/3/2001	Juncus acutus ssp. leo	About 10 individuals following north-south drainage in narrow riparian corridor and chaparral - coastal sage scrub transitional vegetation. Associated with Malosma laurina, Salvia mellifera, Iva hayesiana, Rhus integrifolia, Conium maculatum, Tamarix sp., Baccarhis sarothroides, and B. pilularis
A050801	Lusardi Creek	5/8/2001	Selaginella cinerascens	Growing with FvJ19-8 on a gentle to steep, east to southeast-facing slope mostly on open rocky clay barrens or in mixed coastal sage scrub nand annual grassland, to open grassy coastal sage scrub on rocky clay loam soil. Associated with Artemisia californica, Eriogonum fasciculatum, Malosma laurina, Chlorogalum parviflorum, Brachypodium distachyon, Dudleya pulverulenta, Centauria melitensis, Stipa lepida, Salvia mellifera, Opuntia littoralis, Ferrocactus viridescens, and Deinandra fasciculata
A050802	Lusardi Creek	5/8/2001	Selaginella cinerascens	Growing with FvJ19-11 on a relatively flat ridge top on rocky clay loam barren in coastal sage scrub with scattered rock outcrops. Associated with Ferrocactus viridescens, Artemisia californica, Eriogonum fasciculatum, Chlorogalum parviflorum, Bromus madritensis, B. hordaceus, and Centauria melitensis
A051001	Lusardi Creek	5/10/2001	Arctostaphylos glandulo	About 30 individuals growing along ridge on west-facing slope above drainage on loamy sand soils in southern maritime chaparral. Associated with Adenostoma fasciculata and Xylococcus bicolor
A052401	Lusardi Creek	5/24/2001	Selaginella cinerascens	Large, relatively dense and extended stand growing on mesa top and extending onto steep southwest-facing slopes on rocky heavy clay soil primarily in chamise chaparral but extending into coastal sage scrub
A053001	Lusardi Creek	5/30/2001	Adolphia californica	About 75 individuals growing on steep southeast-facing slope in dense coastal sage scrub. Associated with Artemisia californica, Salvia mellifera, Malosma laurina, and Eriogonum fasciculatum

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
A053002	Lusardi Creek	5/30/2001	Selaginella cinerascens	Large, mostly thin, and extended stand with scattered pockets of high density, particularly in the south, growing on mesa borders on gentle south and east-facing slope on rocky heavy clay soil primarily in chamise chaparral and coastal sage scrub
A061901	Lusardi Creek	6/19/2001	Comarostaphylos diver	About 3 individuals (seen only from distance) growing on relatively steep north-facing slope in coastal sage scrub with scattered chaparral elements. Associated with Malosma laurina, Salvia mellifera, Xylococcus bicolor, and Eriogonum fasciculatum
R02423E	Lusardi Creek	4/24/2001	Ferrocactus viridescen	5 individuals, 2 about 4 meters to N of GPS point. Growing in native grassland opening in coastal sage scrub in cobbly soil on gentle east-facing slope. Associated with Stipa lepida, Harpagonella palmeri, Deinandra fasciculata, Chlorogalum parviflorum, Sisyrinchium bellum, Stylocline gnaphaloides, Eriogonum fasciculatum, Salvia mellifera, Artemisia californica, and Lotus scoparius
R02423F	Lusardi Creek	4/24/2001	Harpagonella palmeri	6 individuals covering less than a .5 meter square. Growing on clay lens on gentle east-facing slope in native grassland opening in coastal sage scrub in cobbly soil. Associated with Stipa lepida, Bromus madritensis, Sisyrinchium bellum, Erodium cicutarium, Eriophyllum confertiflorum, Chlorogalum parviflorum, Lotus scoparius, Deinandra fasciculata, Salvia mellifera, and Artemisia californica
R024500A	Lusardi Creek	4/24/2001	Dudleya variegata	About 860 individuals growing in a hollow in mima mound-like topography near top of mesa and on gentle east-facing slope on cobbly clay lens in native grassland opening in coastal sage scrub. Associated with Stipa lepida, Harpagonella palmeri, Ferrocactus viridescens, Chlorogalum parviflorum, Sisyrinchium bellum, Salvia mellifera, Artemisia californica, Lotus scoparius, Stylocline gnaphaloides, Deinandra fasciculata, and Selaginella cinerascens
R041918A	Lusardi Creek	4/19/2001	Adolphia californica	About 30 individuals scattered over east-facing slope in rocky loamy clay soils in moderately open coastal sage scrub. Associated with Salvia mellifera, Artemisia californica, Malosma laurina, Lotus scoparius, Rhus integrifolia, Baccharis pilularis, Dichelostemma pulchellum, Sisyrinchium bellum, and Chlorogalum parviflorum.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R041919C	Lusardi Creek	4/19/2001	Harpagonella palmeri	About 52 individuals growing on east-facing slope on a rocky clay lens dominated by native grassland and surrounded by coastal sage scrub. Associated with abundant Chlorogalum parviflorum, in addition to Deinandra fasciculatum, Bromus madritensis, Avena barbata, Salvia mellifera, Artemisia californica, Rhus integrifolia, and Lotus scoparius
R041919D	Lusardi Creek	4/19/2001	Harpagonella palmeri	About 500 individuals growing on east-facing slope on a rocky clay lens dominated by native grassland and surrounded by coastal sage scrub. Associated with abundant Chlorogalum parviflorum, in addition to Deinandra fasciculatum, Selaginella cinerascens, Bromus madritensis, Avena barbata, Salvia mellifera, Artemisia californica, Adolphia californica, Rhus integrifolia, and Lotus scoparius. Olivehain cobbly loam extending into Huerhuero loam soil series at western end near top of hill. Ferrocactus viridescens maybe present here but no separate record was made.
R041921A	Lusardi Creek	4/19/2001	Harpagonella palmeri	5 individuals growing in habitat similar to Hp19-D but with more Hemizonia. A much smaller clay lens in middle of AcA19-3. Colony about 1 x 2m
R041921B	Lusardi Creek	4/19/2001	Harpagonella palmeri	8 individuals growing on east-facing slope on rocky clay lens in native grassland surrounded by coastal sage scrub. Associated with Stipa lepida, Lotus scoparius, Deinandra fasciculata, Dichelostemma pulchellum, Chlorogalum parviflorum, and Sisyrinchium bellum. Colony about 1 x 5 meters
R041921C	Lusardi Creek	4/19/2001	Harpagonella palmeri	7 individuals covering area less then 1 meter square. Growing on east-facing slope on rocky clay lens in native grassland surrounded by coastal sage scrub. Associated with Stipa lepida, Linanthus dianthiflorus, Lotus scoparius, Deinandra fasciculata, Dichelostemma pulchellum, Chlorogalum parviflorum, and Sisyrinchium bellum
R041921D	Lusardi Creek	4/19/2001	Ferrocactus viridescen	A total of 10 individuals: 4 individuals with 4 more to immediate north and 2 to immediate east. Growing on clay lens near hill top ridge with gentle east-facing aspect in open, rocky clay within open coastal sage scrub. Associated with Chlorogalum parviflorum, Linanthus dianthiflorus, Stipa lepida, Selaginella cinerascens, Bromus madritensis, Artemisia californica, Salvia mellifera, Eriogonum fasciculatum, Selaginella cinerascens, and Sisyrinchium bellum

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R041921F	Lusardi Creek	4/19/2001	Ferrocactus viridescen	Revised boundary for FvA19-1 (see above)
R041921G	Lusardi Creek	4/19/2001	Harpagonella palmeri	Number not certain. Growing on east-facing slope on rocky clay lens in native grassland surrounded by coastal sage scrub. Associated with Chlorogalum parviflorum, Bromus madritensis, Stipa lepida, Lotus scoparius, Sisyrinchium bellum, Linanthus dianthiflorus, Cynara cardunculus, Salvia mellifera, and Malosma laurina
R041921H	Lusardi Creek	4/19/2001	Harpagonella palmeri	6 individuals growing on east-facing slope on small rocky clay lens in native grassland surrounded by coastal sage scrub. Associated with Deinandra fasciculata, Apiastrum angustifolium, Lotus scoparius, L. salsuginosus, Chlorogalum parviflorum, Filago californica, Lupinus succulentus, Artemisia californica, and Salvia mellifera. Less then a square meter covered
R041921I	Lusardi Creek	4/19/2001	Harpagonella palmeri	2 individuals growing on east-facing slope on small rocky clay lens in native grassland surrounded by coastal sage scrub. Associated with Deinandra fasciculata, Chlorogalum parviflorum, Lotus scoparius, Eriogonum fasciculatum, Centauria melitensis, Salvia mellifera, and Artemisia californica
R041921J	Lusardi Creek	4/19/2001	Adolphia californica	About 9 individual shrubs growing on east-facing slope in rocky clay loam soil in coastal sage. Associated with Salvia mellifera, Artemisia californica, Rhus integrifolia, Lotus scoparius, Cynara cardunculus, Calochortus splendens, Bromus madritensis, Deinandra fasciculata, Chlorogalum parviflorum, and Sonchus asper.
R041922A	Lusardi Creek	4/19/2001	Harpagonella palmeri	Three individuals covering <0.1 meters squared. Growing on east-facing slope in rocky barren clay lens surrounded by coastal sage scrub. Associated with Chlorogalum parviflorum, Deinandra fasciculata, Anagalis arvensis, Lotus scoparius, and Chorizanthe staticoides
R041922B	Lusardi Creek	4/19/2001	Harpagonella palmeri	28 individuals growing on east-facing slope on barren similar to HpA19-12
R041922C	Lusardi Creek	4/19/2001	Harpagonella palmeri	4 individuals growing on a gentle southeast-facing slope at head of ridge on clay barren surrounded by open coastal sage scrub. Associated with Chlorogalum parviflorum, Centauria melitensis, Deinandra fasciculata, Sisyrinchium bellum, Salvia mellifera, and Rhus integrifolia

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R041922D	Lusardi Creek	4/19/2001	Harpagonella palmeri	About 560 individuals growing on southeast-facing slope near centerline of short ridge on rocky clay lens barren surrounded by coastal sage scrub. Associated with Plantago virginica, Porophyllum gracile, Chlorogalum parviflorum, Centauria melitensis, Bromus madritensis, Stipa lepida, Lotus scoparius, Salvia mellifera, Muhlenbergia microsperma, Hesperevax sparsiflora, Plantago erecta, Adolphia californica, Apiastrum angustifolium, and Sisyrinchium bell
R041922E	Lusardi Creek	4/19/2001	Adolphia californica	About 60 shrubs growing on east-facing ridge slope in rocky clay-loam soil in coastal sage scrub and along border of clay barren (see HpA19-15). Associated species primarily Salvia mellifera and Artemisia californica and other species as in HpA19-15
R041923A	Lusardi Creek	4/19/2001	Hesperevax sparsifloru	About 65 individuals growing on the eastern edge and down slope end of the clay barren supporting HpA19-15. According to Scott McMillan, this species is tightly restricted to clay soils and is declining, therefore, while not yet considered rare by CNPS, should probably be considered a species of local concern and monitored by the County.
R041923B	Lusardi Creek	4/19/2001	Ferrocactus viridescen	2 individuals growing amongst mima-mound like topography along boarder of broad hilltop with gentle southeast-facing aspect. Growing in clay loam soils in open coastal sage scrub with numerous native grassland openings. Associated with Salvia mellifera, Artemisia californica, Stipa lepida, Bromus madritensis, eriogonum fasciculatum, Chlorogalum parviflorum, and Selaginella cinerascens
R041923C	Lusardi Creek	4/19/2001	Ferrocactus viridescen	1 individual growing amongst mima-mound like topography on top of broad hilltop. Habitat and associated species similar to FvA19-2
R042423A	Lusardi Creek	4/24/2001	Ferrocactus viridescen	One individual growing in mima mound-like topography along broad ridge top in open coastal sage scrub in cobbly soil. Associated with Stipa pulchra, Erodium cicutarium, Bromus madritensis, Avena barbarta, Hypochaeris glabra, Vulpia myuros, Artemisia californica, Dichelostemma pulchellum, and Lotus scoparius
R042423B	Lusardi Creek	4/24/2001	Ferrocactus viridescen	One individual growing in hollow in mima mound-like topography along broad ridge top on cobbly clay lens in open coastal sage scrub. Associated with species similar to above but much Chlorogalum parviflorum, Salvia mellifera, and Dudleya variegata

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R042423C	Lusardi Creek	4/24/2001	Harpagonella palmeri	About 24 plants growing over about 9 meter square area on broad ridge top with gentle east-facing aspect in clay lens/native grassland dominated opening in coastal sage scrub. Growing in cobbly clay soil. Associated with Stipa lepida, Lotus scoparius, Plantago erecta, Deinandra fasciculataa, Erodium cicutarium, Chlorogalum parviflorum, and Stylocline gnaphaloides
R042423D	Lusardi Creek	4/24/2001	Harpagonella palmeri	
R0424500C	Lusardi Creek	4/24/2001	Dudleya variegata	About 712 plants growing in same clay grassland opening as FvA24-4 above
R0424500D	Lusardi Creek	4/24/2001	Dudleya variegata	About 39 plants growing on gentle east-facing slope of mesa in cobbly clay soil of native grassland opening in coastal sage scrub. Associated with Stipa lepida, Brachypodium distachyon, Bromus hordeaceus, Deinandra fasciculata, Harpagonella palmeri, Sisyrinchium bellum, Lostus scoparius, Erodium moschatum, Chlorogalum parviflorum, Artemisia californica, Salvia mellifera, and Stylocline gnaphaloides
R0424501A	Lusardi Creek	4/24/2001	Dudleya variegata	An extension of DvA24-3
R0424501B	Lusardi Creek	4/24/2001	Pentachaeta aurea	5 individuals, located at same location and in same habitat as DvA24-3
R0424501C	Lusardi Creek	4/24/2001	drying vernal pool	a small drying vernal pool (less then 2 meters square) with some Psilocarphus brevissimus but no other obvious indicator species. Also has Lythrum hyssopifolium. A Navarretia present later turned out to be N. hamata, an upland species
R0424501D	Lusardi Creek	4/24/2001	Ferrocactus viridescen	One individual growing along spine of mesa in mima mound-like topography along old dirt road bed. Growing in cobble soil in native grassland opening of coastal sage scrub. Associated with Opuntia littoralis, Deinandra fasciculata, Stipa lepida, Bromus madritensis, Erodium botrys, Selaginella cinerascens, Chlorogalum parviflorum, Artemisa californica, and Avena fatua
R0424501E	Lusardi Creek	4/24/2001	Ferrocactus viridescen	One dying individual growing near top of mesa on gentle east-facing slope in cobbly soil, native grassland openings in coastal sage scrub. Associated with Artemisia californica, Eriogonum fasciculatum, Bromus madritensis, Vulpia myuros, Avena barbata, Stipa pulchra, Deinandra fasciculata, Selaginella cinerascens, Chlorogalum parviflourm, Stylocline gnaphaloides, Dichelostemma pulchellum, and Daucus pusillus

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R0424501F	Lusardi Creek	4/24/2001	Ferrocactus viridescen	2 individuals (one possibly reported as FvA19-2 or 3). Growing on gentle southeast-facing slope of mesa in cobbly clay soil, grassy openings in coastal sage scrub. Associated with Artemisia californica, Salvia mellifera, Lotus scoparius, Stipa lepida, Chlorogalum parviflorum, Selaginella cinerascens, Plantago erecta, Bromus madritensis, Deinandra fasciculata, and Eriogonum fasciculatum
R0424501G	Lusardi Creek	4/24/2001	Ferrocactus viridescen	One individual growing on gentle south by southwest-facing slope of mesa in grassy, open coastal sage scrub in cobbly clay soil. Associated with Stipa lepida, Bromus madritensis, Eriogonum fasciculatum, Artemisia califronica, Deinandra fasciculata, Erodium moschatum, Selaginella cinerascens, Chlorogalum parviflorum, and Filago gallica
R0424502A	Lusardi Creek	4/24/2001	Ferrocactus viridescen	One individual growing on gentle south-facing slope in cobbly clay lens dominated by native grassland and surrounded by coastal sage scrub. Associated with Stipa lepida, Chlorogalum parviflorum, Erodium moschatum, Selaginella cinerascens, Harpagonella palmeri, Bromus madritensis, Apiastrum angustifolium, Lotus scoparius, Plantago erecta, Filago gallica, Deinandra fasciculata, Erogonum fasciculatum, and Salvia mellifera
R0424502B	Lusardi Creek	4/24/2001	Harpagonella palmeri	About 41 individuals growing with FvA24-10
R042500B	Lusardi Creek	4/24/2001	Ferrocactus viridescen	One individual growing on a gentle east-facing slope near top of mesa in association with a clay lens and native grassland opening in coastal sage scrub. Associated with Stipa lepida, Sisyrinchium bellum, Dudleya variegata, Deinandra fasciculata, Chlorogalum parviflorum, Eriogonum fasciculatum, Salvia mellifera, Hypochaeris glabra, and Selaginella cinerascens
R042518A	Lusardi Creek	4/25/2001	Harpagonella palmeri	Four individuals growing on a south-facing slope in open grassy coastal sage scrub in rocky clay soil. Associated with Deinandra fasciculata, Plagiobothrys collinus, Bromus madritensis, Lotus scoparius, Arstida adscensionis, Dichelostemma pulchellum, Erodium cicutarium, Salvia mellifera, Sonchus asper, Daucus pusillus, Stipa pulchra, and Centauria melitensis

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R042518B	Lusardi Creek	4/25/2001	Lepidium virginicum var	Five individuals growing on south-facing slope in grassy opening in coastal sage scrub in clay rocky clay soil. Associated with Avena barbata, A. fatua, Deinandra fasciculata, Bromus madritensis, Lotus scoparius, Calochortus splendens, Stipa lepida, Apiastrum angustifolium, Daucus pusillus, Chlorogalum parviflorum, Aristida adscenscionis, and Salvia mellifera
R042518C	Lusardi Creek	4/25/2001	Lepidium virginicum var	About 15 individuals in habitat similar to LvrA25-1 but with more Centauria melitensis, Lotus scoparius, Daucus pusillus, Eriogonum fasciculatum, Lotus scoparius, and Bromus madritensis
R042520A	Lusardi Creek	4/25/2001	Adolphia californica	About 235 individuals scattered on gentle to steep south-facing slope in cobbly soil, clay, and soil with broken slate in coastal sage scrub, open coastal sage scrub, grassland, and xeric barrens. Associated with Salvia mellifera, Artemisia californica, Eriogonum fasciculatum, Malosma laurina, Rhus integrifolia, Deinandra fasciculata, Harpagonella palmeri, Ferrocactus viridescens, Chlorogalum parviflorum, Brachypodium distachyon, Avena sp., Bromus madritensis, Centauria melitensis, and Calochortus splendens. Olivenhain cobbly loam soils series. About 115 in measured polygon and about 80 individuals are on the slope immediately adjacent to the south of this polygon forming an extension that could not be measured via GPS
R042521A	Lusardi Creek	4/25/2001	Adolphia californica	About 30 individuals growing on gentle to relatively steep south-facing slope in annual grassland with scattered Rhus integrifolia. Associated with Rhus integrifolia, Isocoma menziesii, Opuntia prolifera, O. littoralis, Eriogonum fasciculatum, Phacelia cicutaria, Avena fatua, Brachypodium distachyon, Calochortus splendens, Convolvulus simulans, Encelia californica, and Malosma laurina
R042521B	Lusardi Creek	4/25/2001	Adolphia californica	About 17 individuals growing in isolated patch on gentle south-facing slope along ecotone of coastal sage scrub and annual grassland in rocky soil. Associated with Artemisia californica, Brachypodium distachyon, Isocoma menziesii, Selaginella bigelovii, Lotus scoparius, and Calochortus splendens
R042522A	Lusardi Creek	4/25/2001	Ferrocactus viridescen	A single individual growing on a south-facing slope in crumbly slate in coastal sage scrub. Associated with Eriogonum fasciculatum, Artemisia californica, Adolphia californica, malosma laurina, Phacelia cicutaria, Dichelostemma pulchellum, Salvia columbariae, and Centauria melitensis

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R042522B	Lusardi Creek	4/25/2001	Lepidium virginicum var	About 25 individuals growing on a south-facing slope in crumbly slate on xeric barren along coastal sage scrub-annual grassland transition. Associates similar to FvA25-1 but with Avenia barbata, Brachypodium distachyon, and Muhlenbergia microsperma
R042522C	Lusardi Creek	4/25/2001	Convolvulus simulans	About 40 individuals scattered over terrace at base of southwest-facing slope in annual grassland with scattered coastal sage scrub elements in loamy soil. Associated with Brachypodium distachyon, Avena fatua, Adolphia californica, Calochortus splendens, Lepidium virginicum, and Lotus scoparius.Voucher specimen FMR 5440 (SD).
R042522D	Lusardi Creek	4/25/2001	Lepidium virginicum var	A single individual growning on south by southwest-facing slope in mixed coastal sage scrub and annual grassland. Associated with Artemisia californica, Rhus integrifolia, Brassica rapa, Brachypodium distachyon, Centauria melitensis, Encelia californica, Brassica nigra, and Malosma laurina.
R042522E	Lusardi Creek	4/25/2001	Lepidium virginicum var	About 20 individuals growing on southwest-facing slope in mixed native grassland and coastal sage scrub. Associated with Stipa pulchra, Brachypodium distachyon, Centauria melitensis, Lupinus succulentus, Artemisa californica, Rhus integrifolia, Eriogonum fasciculatum, Bromus madritensis, and Calystegia macrostegia.
R042522F	Lusardi Creek	4/25/2001	Ferrocactus viridescen	Two individuals, one growing in clearing 2 meters to southwest of point. Plants growing on steep slope in crumbly slate in mosaic of annual grassland and coastal sage scrub. Associated with Selaginella bigelovii, Artemisia californica, Adolphia californica, Brachypodium distachyon, Mirabilis californica, Plantago erecta, and Centauria melitensis.
R042523A	Lusardi Creek	4/25/2001	Ferrocactus viridescen	About 19 individuals growing at edge of cliff on a crumbly slate barren similar to FvA25-2 but with Lepidium virginicum, Chlorogalum parviflorum, Dudleya pulverulenta, and Eschscholtzia californica.
R042523B	Lusardi Creek	4/25/2001	Lepidium virginicum var	About 113 individuals growing with FvA25-3.
R042523D	Lusardi Creek	4/25/2001	Ferrocactus viridescen	One individual growing on a southwest-facing slope in grassy opening in coastal sage scrub on rocky clay soil. Associated with Artemisia californica, Brassica rapa, Brassica nigra, Stipa pulchra, Brachypodium distachyon, Calochortus splendens, Eriogonum fasciculatum, and Allium haematochaeton.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R042523E	Lusardi Creek	4/25/2001	Lepidium virginicum var	About 135 individuals growing on a south-facing slope and scattered over mixed native and annual grassland opening in coastal sage scrub on rocky clay soil. Associated with Stipa pulchra, Brachypodium distachyon, Avena barbata, Calochortus splendens, Deinandra fasciculata, Harpagonella palmeri, Allium haematochiton, Centauria melitensis, Sonchus asper, Adolphia californica, Artemisia californica, Salvia mellifera, and Calystegia macrostegia.
R042523F	Lusardi Creek	4/25/2001	Harpagonella palmeri	About 7 individuals growing at northern margin of, and in same habitat as LvrA25-8.
R042523G	Lusardi Creek	4/25/2001	Harpagonella palmeri	About 14 individuals scattered over a 1.5 x 1.5 meter area along northeastern margin of clearing with LvrA25-8. Associates generally the same but more Apiastrum angustifolium, Plantago virginica, Deinandra fasciculata, and Sonchus asper.
R042523H	Lusardi Creek	4/25/2001	Harpagonella palmeri	About 130 individuals growing on south-facing slope in rocky barren with cracked clay surrounded by coastal sage scrub. Associated with Centauria melitensis, Deinandra fasciculata, Plantago virginica, Chlorogalum parviflorum, Lotus scoparius, Avena barbata, Eriogonum fasciculatum, and Lepidium virginicum. Border elements include Adolphia californica, Salvia mellifera, and Eriogonum fasciculatum.
R042619A	Lusardi Creek	4/26/2001	Adolphia californica	About 44 individuals growing along a southeast-running ridge with a gentle east-facing aspect in open coastal sage scrub on rocky, crumbl slate cobble. Associated with Salvia mellifera, Eriogonum fasciculatum, Artemisia californica, Malosma laurina, Lotus scoparius, Dichelostemma pulchellum, and Cryptantha intermedia.
R042620A	Lusardi Creek	4/26/2001	Ferrocactus viridescen	Two individuals growing on steep southwest-facing slope in open coastal sage scrub on clay soil with crumbly slate cobble. Associated with Melica frutescens, Avena barbata, Chaenactis artemisifolia, Centauria melitensis, Phacelia parryi, Camissonia californica, Salvia columbariae, Lepidium virginicum, Mirabilis californica, Eriogonum fasciculatum, Lupinus sparsiflorus, Malosma laurina, and Bebbia juncea.
R042620B	Lusardi Creek	4/26/2001	Lepidium virginicum var	About 15 individuals scattered with and in same habitat with FvA26-5.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R042620C	Lusardi Creek	4/26/2001	Ferrocactus viridescen	One individual growing on southeast-running ridge with gentle east-facing aspect in opeen coastal sage scrub on crumbly slate cobble clay soil. Associated with Eriogonum fasciculatum, Salvia mellifera, Cneoridium dumosum, Chaenactis glabriuscula, Cryptantha intermedia, Chlorogalum parviflorum, and Porophyllum gracile
R042620D	Lusardi Creek	4/26/2001	Ferrocactus viridescen	4 individuals growing on southwest-facing slope in open coastal sage scrub on cobbly soil. Associated with Eriogonum fasciculatum, Adolphia californica, Salvia mellifera, Porophyllum gracile, Chlorogalum parviflorum, Chaenactis glabriuscula, Salvia columbariae, Gutierrezia californica, Cryptantha intermedia, Lepidium virginicum, and Muhlenbergia microsperma
R042620E	Lusardi Creek	4/26/2001	Lepidium virginicum var	About 8 widely scattered individuals growing in clearing with FvA25-5
R042620F	Lusardi Creek	4/26/2001	Ferrocactus viridescen	4 individuals growing on southwest-facing slope in open coastal sage scrub on cobbly soil. Associated with Eriogonum fasciculatum, Adolphia californica, Salvia mellifera, Porophyllum gracile, Chlorogalum parviflorum, Chaenactis glabriuscula, Salvia columbariae, Gutierrezia californica, Cryptantha intermedia, Lepidium virginicum, and Muhlenbergia microsperma.
R042620G	Lusardi Creek	4/26/2001	Harpagonella palmeri	8 individuals growing on a gentle south-facing slope on cobbly clay barren in coastal sage scrub. Associated with Bromus madritensis, Centauria melitensis, Lotus scoparius, Calystegia macrostegia, Deinandra fasciculata, and Apiastrum angustifolium.
R042620H	Lusardi Creek	4/26/2001	Lepidium virginicum var	About 8 individuals growing on a south-facing slope on a cobbly clay barren in coastal sage scrub. Associated with plantago virginica, Centauria melitensis, Deinandra fasciculata, Avena barbata, Apium angustifolium, Bromus madritensis, Sonchus asper, Brassica nigra, Salvia mellifera, Artemisia californica, and Adolphia californica
R042620I	Lusardi Creek	4/26/2001	Harpagonella palmeri	About 21 individuals growing on southwest-facing slope in grassy opening of coastal sage scrub in cobbly clay soi.l. Associated with Brachypodium distachyon, Chlorogalum parviflorum, Allium haematochiton, Centauria melitensis, Deinandra fasciculata, Lotus scoparius, Artemisia califronica, Rhus integrifolia, and Salvia mellifera

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R042620J	Lusardi Creek	4/26/2001	Harpagonella palmeri	Two individuals growing along a trail near edge of mesa on gentle southwest-facing slope in open coastal sage scrub. Associated with Artemisia californica, Salvia mellifera, Chlorogalum parviflorum, and Deinandra fasciculata
R042620K	Lusardi Creek	4/26/2001	Lepidium virginicum var	Five individuals occupying less then 0.1 square meters on southwest-facing slope in opening in coastal sage scrub in loamy soil. Associated with Deinandra fasciculata, Chlorogalum parviflorum, Dichelostemma pulchellum, Erodium cicutarium, Eriogonum fasciculatum, Artemisia californica, Salvia mellifera, Bromus madritensis, and Stipa pulchra
R042621A	Lusardi Creek	4/26/2001	Ferrocactus viridescen	A single individual growing on a southwest-facing slope in open coastal sage scrub on rocky clay soil. Associated with Eriogonum fasciculatum, Artemisia californica, Salvia mllifera, Chlorogalum parviflorum, Selaginella cinerascens, and Calochortus splendens
R042621B	Lusardi Creek	4/26/2001	Ferrocactus viridescen	Three individuals growing on a southwest-facing slope in open grassy coastal sage scrub in rocky clay soil. Associated with Centauria melitensis, Deinandra fasciculata, Harpagonella palmeri, Artemisia californica, Calochoretus splendens, Dichelostemma pulchellum, Bromus madritensis, Lepidium nitidum, Chlorogalum parviflorum, Eriogonum fasciculatum, and Brachypodium distachyon. R042621B also represents Harpagonella palmeri. Colony HpA26-4. 46 scatttered individuals.
R042621C	Lusardi Creek	4/26/2001	Harpagonella palmeri	About 14 plants occupying about a 1 x 3 meter area on a southwest-facing slope on a cobbly clay lens in mixed annual grassland/coastal sage scrub. Associated with Eriogonum fasciculatum, Lotus scoparius, Artemisia californica, Erodium moschatum, Dichelostemma pulchellum, Apium angustifolium, Deinandra fasciculata, Chlorogalum parviflorum, Bromus madritensis, and Brachypodium distachyon.
R042621D	Lusardi Creek	4/26/2001	Ferrocactus viridescen	Four widely scattered individuals growing on gentle west-facing slope on clay barren in mixed annual grassland/coastal sage scrub. Associated with Deinandra fasciculata, Eriogonum fasciculatum, Stipa lepida, Bromus madritensis, Hyphocharis glabrata, Chlorogalum parviflorum, Selaginella cinerascens, Calochortus splendens, and Avena barbata
R042621F	Lusardi Creek	4/26/2001	Lepidium virginicum var	About 60 individuals growing with and in same habitat as FvA26-10.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R042621G	Lusardi Creek	4/26/2001	Ferrrocactus viridescen	One individual growing in habitat similar to FvA26-10 but more on mesa and with Pentachaeta aurea.
R042621H	Lusardi Creek	4/26/2001	Harpagonella palmeri	About 10 individuals growing with FvA26-10.
R042621I	Lusardi Creek	4/26/2001	Pentachaeta aurea	Three individuals growing along margin of mesa with gentle southwest-facing aspect in grassy coastal sage scrub on cobbly clay barren. Associated with Deinandra fasciculata, Lotus scoparius, Selaginella cinerascens, Harpagonella palmeri, Erodium moschatum, Ferrocactus viridescens, Hypochaeris glabra, Chlorogalum parviflorum, and Calochortus splendens.Voucher: FMR 5441 (SD).
R050318A	Lusardi Creek	5/3/2001	Adolphia californica	About 130 widely scattered individuals growing on southwest-facing slope in open grassy coastal sage scrub on rocky clay-loam soil. Associated with Artemisia californica, Salvia mellifera, Encelia californica, Eriogonum fasciculatum, Malosma laurina, Mirabilis californica, Brassica nigra, and Chlorogalum parviflorum.
R050319A	Lusardi Creek	5/3/2001	Adolphia californica	About 22 individuals growing on a southwest-facing slope along shallow drainage in open grassy coastal sage scrub on rocky clay soil. Associated with Artemisia californica, Eriogonum fasciculatum, Encelia californica, Rhus integrifolia, Brachypodium distachyon, Calochortus splendens, Chlorogalum parviflorum, and Stipa pulchra.
R050319B	Lusardi Creek	5/3/2001	Adolphia californica	One individual growing on steep southwest-facing slope growing in habitat similar to AcM3-3.
R050319C	Lusardi Creek	5/3/2001	Adolphia californica	One individual growing on steep southwest-facing slope growing in habitat similar to AcM3-3.One individual growing on steep southwest-facing slope growing in habitat similar to AcM3-3.
R050319D	Lusardi Creek	5/3/2001	Adolphia californica	About 36 individuals growing on south-facing slope in open grassy coastal sage scrub on rocky clay soil. Associated with Artemisia californica, Eriogonum fasciculatum, Encelia californica, Rhus integrifolia, Brachypodium distachyon, Calochortus splendens, Ferrocactus viridescens, Chlorogalum parviflorum, and Stipa pulchra.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R050319E	Lusardi Creek	5/3/2001	Ferrocactus viridescen	Two individuals (each with two stems) growing on a south-facing slope north of shallow ravine in open, grassy coastal sage scrub in cobbly clay-loam soil. Associated with Artemisia californica, Adolphia californica, Brachypodium distachyon, Eriogonum fasciculatum, Avena barbata, Stipa pulchra, and Calochortus splendens.
R050319F	Lusardi Creek	5/3/2001	Adolphia californica	About 66 individuals growing on a terrace at foot of southwest-facing slope in a mosaic of coastal sage scrub and mixed grassland in clay loam soil. Associated with Artemisia californica, Malosma laurina, Brachypodium distachyon, Lolium multiflorum, Avena barbata, Bromus madritensis, B. diandrus, Calochortus splendens, and Centauria melitensis.
R050320A	Lusardi Creek	5/3/2001	Iva haysiana	c.a. 300 individuals growing along drainage along canyon floor. Population generally about 2-3 (-4) meters wide and averaging about 3 meters across. Growing in dense riparian vegetation. Associated with Salix lasiolepis, S. goodingii, Baccharis pilularis, Ambrosia psilostachya, Conium maculatum, Brassica nigra, and Carduus pycnocephala.
R050320B	Lusardi Creek	5/3/2001	Harpagonella palmeri	About 213 individuals growing on low ridge with gentle west-facing aspect along old dirt road. Growing in opening of coastal sage scrub on cobbly exposed clay. Associated with Plantago erecta, Deinandra fasciculata, Bromus madritensis, and Chlorogalum parviflorum.Originally located and counted on April 18 but was not recorded on the GPS unit due to lack of memory space. Voucher FMR 5435.
R050321A	Lusardi Creek	5/3/2001	Adolphia californica	About 19 individuals growing on a terrace at top of south-facing ravine slope in coastal sage scrub on rocky clay. Associated with Artemisia califronica, Mirabilis californica, Eriogonum fasciculatum, Centauria melitensis, Rhus integrifolia, Eriophyllum confertiflorum, and Marah macrocarpus.
R050321B	Lusardi Creek	5/3/2001	Adolphia californica	A single individual growing on a moderately steep southwest-facing slope in dense coastal sage scrub on rocky loamy-clay soil. Associated with Artemisia californica, Cneoridium dumosum, Salvia mellifera, Marah macrocarpus, Malosma laurina, and Rhus integrifolia.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R050321C	Lusardi Creek	5/3/2001	Adolphia californica	About 70 individuals growing on a gentle to steep slope in open coastal sage scrub on rocky clay loam. Associated with Salvia mellifera, Artemisia californica, Rhus integrifolia, Eriogononum fasciculatum, Brassica nigra, Brachypodium distachyon, Lolium multiflorum, Calochortus splendens, Centauria melitensis, Dichelostemma pulchellum, and Bloomeria crocea.
R050321D	Lusardi Creek	5/3/2001	Harpagonella palmeri	About 12 individuals growing on a rocky clay barren at edge of mesa in open grassy coastal sage scrub. Associated with Chlorogalum parviflorum, Centauria melitensis, Calochortus splendens, Aristida adscensionis, Bromus madritensis, Lotus scoparius, Eriogonum fasciculatum, Artemisia califronica, Brachypodium distachyon, Ferrocactus viridescens, Deinandra fasciculata, Filago arizonica, and Lepidium nitidum.R050321D also represents Ferrocactus viridescens, colony FvM3-2. 2 individuals growing with HpM3-1.
R050321E	Lusardi Creek	5/3/2001	Ferrocactus viridescen	One individual growing on gentle southwest-facing slope on rocky clay-loam in open, grassy coastal sage scrub. Associated with Artemisia californica, Eriogonum fasciculatum, Lotus scoparius, Centauria melitensis, Stipa pulchra, Calochortus splendens, Brachypodium distachyon, Bromus madritensis, Avena fatua, Chlorogalum parviflorum, and Selaginella cinerascens.
R050321F	Lusardi Creek	5/3/2001	Ferrocactus viridescen	One individual growing in habitat similar to FvM3-3.One individual growing on gentle southwest-facing slope on rocky clay-loam in open, grassy coastal sage scrub. Associated with Artemisia californica, Eriogonum fasciculatum, Lotus scoparius, Centauria melitensis, Stipa pulchra, Calochortus splendens, Brachypodium distachyon, Bromus madritensis, Avena fatua, Chlorogalum parviflorum, and Selaginella cinerascens.
R050321G	Lusardi Creek	5/3/2001	Ferrocactus viridescen	Two individuals growing about 1 meter apart. Found on rocky clay barren in grassy coastal sage scrub. Associated with Artemisia californica, Eriogonum fasciculatum, Stipa lepida, Selaginella cinerascens, Deinandra fasciculata, Chlorogalum parviflorum, Calochortus splendens, Erodium spp., Filago gallica, and Bromus madritensis.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R050322A	Lusardi Creek	5/3/2001	Dudleya variegata	About 7 individuals growing on mesa top with gentle west-facing aspect in grassy hollow bordering coastal sage scrub. Associated with Brachypodium distachyon, Stipa pulchra, Bromus hordaceus, Chlorogalum parviflorum, Artemisia californica, Lotus scoparius, Hedypnois cretica, Sisyrinchium bellum, Dodecatheon clevelandii, Selaginella cinerascens, and Dichondra occidentalis.
R050322B	Lusardi Creek	5/3/2001	Dichondra occidentalis	Less than 0.1 meters squared growing about shrubs with DvM3-1.About 7 individuals growing on mesa top with gentle west-facing aspect in grassy hollow bordering coastal sage scrub. Associated with Brachypodium distachyon, Stipa pulchra, Bromus hordaceus, Chlorogalum parviflorum, Artemisia californica, Lotus scoparius, Hedypnois cretica, Sisyrinchium bellum, Dodecatheon clevelandii, Selaginella cinerascens, and Dichondra occidentalis.
R050322C	Lusardi Creek	5/3/2001	Ferrocactus viridescen	One individual (with two stems) growing on mesa in open coastal sage scrub/mixed grassland ecotone on clay barren. Associated with Selaginella cinerascens, Chlorogalum parviflorum, Stipa pulchra, Brachypodium distachyon, Artemisia californica, Salvia mellifera, and Erodium cicutarium.
R050322D	Lusardi Creek	5/3/2001	Ferrocactus viridescen	Three clumps growing on mesa edge in mixed grassland with scattered coastal sage scrub elements on clay barren. Associated with Selaginella cinerascens, Chlorogalum parviflorum, Bloomeria crocea, Stipa pulchra, Brachypodium distachyon, Lessingia filaginifolia, Artemisia califronica, Salvia mellifera, and Erodium cicutarium.
R050322E	Lusardi Creek	5/3/2001	Ferrocactus viridescen	One individual growing in habitat similar to FvM3-7 but with the addition of Lolium multiflorum.Three clumps growing on mesa edge in mixed grassland with scattered coastal sage scrub elements on clay barren. Associated with Selaginella cinerascens, Chlorogalum parviflorum, Bloomeria crocea, Stipa pulchra, Brachypodium distachyon, Lessingia filaginifolia, Artemisia califronica, Salvia mellifera, and Erodium cicutarium.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R050402A	Lusardi Creek	5/3/2001	Lepidium virginicum var	About 3000 individuals growing along ridge and on east-facing slopes in slate cobble and clay soil in openings in coastal sage scrub. Associated with Salvia mellifera, Malosma laurina, Eriogonum fasciculatum, Porophyllum gracile, Cryptantha intermedia, Chaenactis glabriuscula, Ferrocactus viridescens, Adolphia californica, Centauria melitensis, and Muhlenbergia microsperma. San Miguel-Exchequer rocky silt loam soils series. Point represents south end of population.
R051000A	Lusardi Creek	5/10/2001	Microseris douglasii var	About 21 plants distributed thinly over a clay barren on a gentle to moderately steep west-facing slope in mixed native and annual grassland. Associated with Bloomeria crocea, Stipa pulchra, Centauria melitensis, Calochortus splendens, Adolphia californica, Isocoma menziesii, Dodecatheon clevelandii, Brachypodium distachyon, Dudleya variegata, Lotus oparius, and Hesperevax spsarsiflora.R051023A also represents: Harpagonella palmeri, colony HpM10-5, about 20 widely scattered individuals growing with MdpM10-3. R051023A also represents: Hesperevax sparsiflora var. sparsiflora, colony HsM10-2, about 33 individuals, mostly growing at the west end (lower) part of the polygon.
R051018C	Lusardi Creek	5/10/2001	Adolphia californica	About 29 plants scattered over southwest-facing slope in open coastal sage scrub along border of chaparral. Associated with Salvia mellifera, Eriogonum fasciculatum, Lotus scoparius, Malosma laurina, Brachypodium distachyon, Harpagonella palmeri, and Calochortus splendens.
R051018D	Lusardi Creek	5/10/2001	Adolphia californica	Three individuals growing on an east-facing slope along in coastal sage scrub. Associated with Salvia mellifera, Eriogonum fasciculatum, Lotus scoparius, Malosma laurina, Brachypodium distachyon, Harpagonella palmeri, and Calochortus splendens.
R051018E	Lusardi Creek	5/10/2001	Lepidium virginicum var	
R051018F	Lusardi Creek	5/10/2001	Adolphia californica	About 47 plants growing on gentle east-facing slope on barrens, grassy openings, and borders of coastal sage scrub. Associated with Salvia mellifera, Eriogonum fasciculatum, Ferrocactus viridescens, Harpagonella palmeri, Malosma laurina, Brachypodium distachyon, Avena barbata, Calystegia macrostegia, Centauria melitensis, Bromus madritensis, Calochortus splendens, Prunus ilicifolia, and Lonicera subspicata.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R051019A	Lusardi Creek	5/10/2001	Ferrocactus viridescen	About 11 plants scattered over east-facing slope on slate cobble barren in open coastal sage scrub. Associated with Eriogonum fasciculatum, Malosma laurina, Adolphia californica, Muhlenbergia microsperma, Centauria melitensis, Porophyllum gracile, Bromus madritensis, Selaginella bigelovii, Chlorogalum parviflorum, and Brachypodium distachyon.
R051019B	Lusardi Creek	5/10/2001	Harpagonella palmeri	About 170 plants growing on slate cobble-clay barren terrace and along shallow ravine on east to northeast-facing slope bordered by coastal sage scrub. Associated with Plantago erecta, Chlorogalum parviflorum, Bloomeria crocea, Lepidium virginicum, Calochortus splendens, Centauria melitensis, Dodecatheon clevelandii, Eriogonum fasciculatum, Bromus diandrus, and Hesperevax sparsiflora.R051019B also represents Hesperevax sparsiflora var. sparsiflora, colony HsM10-1. About 110 individuals. H. sparsiflora is a locally rare species according to Scott McMillan.R051019B also represents Microseris douglasii var. platycarpha, colony MdpM10-1 representing about 30 individuals. MdpM10-1 is represented by a voucher, FMR 5451, to be placed at the San Diego Natural History Museum.
R051020A	Lusardi Creek	5/10/2001	Ferrocactus viridescen	13 individuals found on a gentle south-facing ridge slope on slate cobble-clay soil in open coastal sage scrub. Associated with Chaenactis glabru\iuscula, Bromus madritensis, Adolphia californica, Opuntia prolifera, Eriogonum fasciculatum, and Selaginella cinerascens.
R051020B	Lusardi Creek	5/10/2001	Ferrocactus viridescen	Four closely spaced individuals growing along southeast-running ridge line with gentle eastern aspect on slate cobble-clay soil in coastal sage scrub. Associated with Eriogonum fasciculatum, Malosma laurina, Salvia mellifera, Porophyllum gracile, and Cryptantha intermedia.
R051020C	Lusardi Creek	5/10/2001	Adolphia californica	About 12 widely scattered individuals growing along east-facing slope of south-running ridge on slate cobble-clay soil in coastal sage scrub. Associated with Eriogonum fasciculatum, Malosma laurina, Salvia mellifera, Mirabilis californica, Porophyllum gracile, and Cryptantha intermedia.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R051020D	Lusardi Creek	5/10/2001	Adolphia californica	About 12 widely scattered individuals growing along east-facing slope of south-running ridge on slate cobble-clay soil in coastal sage scrub. Associated with Eriogonum fasciculatum, Malosma laurina, Salvia mellifera, Mirabilis californica, Porophyllum gracile, and Cryptantha intermedia.
R051020E	Lusardi Creek	5/10/2001	Ferrocactus viridescen	5 plants growing along flat ridge lne on slate cobble-clay soil and small rock outcrops in coastal sage scrub. Associated with Eiogonum fasciculatum, Cryptantha intermedia, Salvia mellifera, Porophyllum gracile, Dudleya pulverulenta, Cneoridium dumosum, and Chaenactis glabriuscula.
R051020F	Lusardi Creek	5/10/2001	Ferrocactus viridescen	Two plants (one about 4m to S of GPS point) growing along a south-running ridge with gentle south-facing aspect on slate cobble-clay in coastal sage scrub. Associated with Lepidium virginicum, Porophyllum gracile, Eriogonum fasciculatum, Salvia columbariae, and Chaenactis glabruiscula.
R051020G	Lusardi Creek	5/10/2001	Harpagonella palmeri	About 50 individuals, many fading, growing along gentle south-running ridge top on clay barren surrounded by coastal sage scrub. Associated with Deinandra fasciculata, Filago arizonica, Eriogonum fasciculatum, Centauria melitensis, Lotus scoparius, Dichelostemma pulchellum, and Salsola tragus.
R051020H	Lusardi Creek	5/10/2001	Convolvulus simulans	A single faded individual growing along gentle south-running ridge top on clay barren surrounded by coastal sage scrub. Associated with Deinandra fasciculata, Harpagonella palmeri, Filago arizonica, Eriogonum fasciculatum, Centauria melitensis, Lotus scoparius, Dichelostemma pulchellum, and Salsola tragus.
R051020I	Lusardi Creek	5/10/2001	Adolphia californica	About 34 widely scattered individuals growing along west-facing slope of ridge on clay in open coastal sage scrub. Associated with Salvia mellifera, Lotus scoparius, Eriophyllum confertiflorum, Centauria melitensis, Chlorogalum parviflorum, Malosma laurina, and Cneoridium dumosum.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R051021A	Lusardi Creek	5/10/2001	Microseris douglasii var	About 55 scattered individuals growing along top of ridge and on east-facing slope on clay barren surrounded by coastal sage scrub. Associated with Bloomeria crocea, Stipa lepida, Centauria melitensis, Plantago virginica, P. erecta, Hedypnois cretica, Calochortus splendens, Navarretia hamata, Apium angustifolium, Chlorogalum parviflorum, and Anagalis arvensis.R051021A also represents Harpagonella palmeri, colony HpM10-3, about 25 widely scattered individuals with MdpM10-2.R051021A also represents Hesperevax sparsiflora var. sparsiflora, colony HsM10-2, about 7 individuals, mostly along east (down slope) end of polygon.
R051021B	Lusardi Creek	5/10/2001	Adolphia californica	Six scattered individuals growing on east-facing ridge slope on clay soil in coastal sage scrub. Associated with Salvia mellifera, Malosma laurina, Eriophyllum confertiflorum, Mimulus aurantiacus, Bloomeria crocea, and Stipa lepida.
R051021C	Lusardi Creek	5/10/2001	Lepidium virginicum var	Southern extension of colony LvrM3-1.
R051021D	Lusardi Creek	5/10/2001	Juncus acutus ssp. Leo	Seven individuals found at base of steep hill at border of riparian vegetation and coastal sage scrub along creek following east-west drainage (Lusardi Creek). Associated with Lolium perenne, Brassica nigra, Bromus diandrus, Salvia mellifera, Ambrosia psilostachya, Malosma laurina, Hordeum murinum, Iva hayesiana, and Salix lasiolepis.
R051021E	Lusardi Creek	5/10/2001	Iva hayesiana	Two clumps, each about 2 meters wide, found at base of steep hill at border of riparian vegetation and coastal sage scrub along creek following east-west drainage (Lusardi Creek). Associated with Lolium perenne, Brassica nigra, Bromus diandrus, Salvia mellifera, Ambrosia psilostachya, Malosma laurina, Hordeum murinum, Juncus acutus, and Salix lasiolepis.
R051021F	Lusardi Creek	5/10/2001	Adolphia californica	About 75 individuals scattered mostly over south-facing slope at end of ridge on rocky clay-loam in coastal sage scrub. Associated with Artemisia californica, Malosma laurina, Salvia mellifera, Eriogonum fasciculatum, Bromus didandrus, Deinandra fasciculata, Chlorogalum parviflorum, and Centauria melitensis.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R051022A	Lusardi Creek	5/10/2001	Ferrocactus viridescen	One individual growing on south-facing slope at end of ridge on rocky clay-loam in coastal sage scrub. Associated with Artemisia californica, Malosma laurina, Salvia mellifera, Eriogonum fasciculatum, Bromus didandrus, Deinandra fasciculata, Chlorogalum parviflorum, and Centauria melitensis.
R051022B	Lusardi Creek	5/10/2001	Adolphia californica	Colony found east of GPS line to east and south borders of parcel. About 60 individuals scattered over south to southwest-facing slope on loamy clay soil in coastal sage scrub. Mostly on east side of dirt road. Associated with Salvia mellifera, Cneoridium dumosum, Rhus integrifolia, Malosma laurina, Harpagonella palmeri, Brachypodium distachyon, Allium haematochiton, and Chlorogalum parviflorum.
R051022C	Lusardi Creek	5/10/2001	Harpagonella palmeri	A single plant growing on southwest-facing slope on rocky clay in small clearing in coastal sage scrub. Associated with Brachypodium distachyon, Allium haematochiton, Calochortus splendens, Lotus scoparius, Deinandra fasciculata, Eriogonum fasciculatum, Eriogonum fasciculatum, Salvia mellifera, and Adolphia californica.
R051022D	Lusardi Creek	5/10/2001	Harpagonella palmeri	Two individuals growing on southwest-facing slope on small rocky loam-clay barren in coastal sage scrub. Associated with Stipa lepida, Allium haematochiton, Chlorogalum parviflorum, Deinandra fasciculata, Calochortus splendens, Salvia mellifera, and Brachypodium distachyon.
R051023A	Lusardi Creek	5/10/2001	Microseris douglasii var	About 21 plants distributed thinly over a clay barren on a gentle to moderately steep west-facing slope in mixed native and annual grassland. Associated with Bloomeria crocea, Stipa pulchra, Centauria melitensis, Calochortus splendens, Adolphia californica, Isocoma menziesii, Dodecatheon clevelandii, Brachypodium distachyon, Dudleya variegata, Lotus scoparius, and Hesperevax spsarsiflora.R051023A also represents: Harpagonella palmeri, colony HpM10-5, about 20 widely scattered individuals growing with MdpM10-3. R051023A also represents: Hesperevax sparsiflora var. parsiflora, colony HsM10-2, about 33 individuals, mostly growing at the west end (lower) part of the polygon.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R051023B	Lusardi Creek	5/10/2001	Adolphia californica	Four individuals found in a cluster on a gentle west-facing slope on clay barren in mixed native and annual grassland. Associated with Bloomeria crocea, Stipa pulchra, Centauria melitensis, Calochortus splendens, Adolphia californica, Isocoma menziesii, Dodecatheon clevelandii, Brachypodium distachyon, Microseris douglasii, Lotus scoparius, and Hesperevax spsarsiflora.
R051023D	Lusardi Creek	5/10/2001	Dudleya variegata	About 76 individuals found on gentle west-facing slope among low, exposed rocks on clay barren in mixed native and annual grassland. Associated with Bloomeria crocea, Stipa pulchra, Centauria melitensis, Calochortus splendens, Adolphia californica, Isocoma menziesii, Dodecatheon clevelandii, Brachypodium distachyon, Microseris douglasii, Lotus scoparius, and Hesperevax spsarsiflora.Voucher specimen: FMR 5452.
R051023E	Lusardi Creek	5/10/2001	Microseris douglasii var	Four individuals growing on steep west-facing slope on heavy clay surrounded by coastal sage scrub. Associated with Bloomeria crocea, Plantago erecta, Centauria melitensis, Harpagonella palmeri, Hesperevax sparsiflora, and Stipa pulchra.R051023E also represents Harpagonella palmeri, colony HpM10-6. 12 individuals about 3 meters below MdpM10-4. R051023E also represents Hesperevax sparsiflora var. sparsiflora, colony HsM10-4, 75 individuals growing with HpM10-6.
R051100A	Lusardi Creek	5/10/2001	Ferrocactus viridescen	Three individuals growing on narrow ridge line with gentle south-facing aspect among rock outcrops and clay in coastal sage scrub. Associated with Salvia mellifera, Eriogonum fasciculatum, Cneoridium dumosum, Stipa lepida, Chaenactis artemisifolia, Malosma laurina, and Mirabilis californica.
R051100B	Lusardi Creek	5/10/2001	Adolphia californica	10 individuals, only two at GPS point, 8 others extending to north to R05100D (see map) along ridge with south-facing aspect. Growing in coastal sage scrub on clay soil. Associated with Salvia mellifera, Eriogonum fasciculatum, Cneoridium dumosum, Stipa lepida, Chaenactis artemisifolia, Ferrocactus viridescens, Malosma laurina, and Mirabilis californica.
R051100C	Lusardi Creek	5/10/2001	Ferrocactus viridescen	One individual growing on steep ridge line with south-facing aspect. Growing in coastal sage scrub on clay soil. Associated with Salvia mellifera, Eriogonum fasciculatum, Adolphia californica, Cneoridium dumosum, Stipa lepida, Chaenactis artemisifolia, Malosma laurina, and Mirabilis californica.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R051100D	Lusardi Creek	5/10/2001	Adolphia californica	One individual growing on steep ridge line with south-facing aspect. Growing in coastal sage scrub on clay soil. Associated with Salvia mellifera, Eriogonum fasciculatum, Adolphia californica, Cneoridium dumosum, Stipa lepida, Chaenactis artemisifolia, Malosma laurina, and Mirabilis californica.
R051100E	Lusardi Creek	5/10/2001	Adolphia californica	At least 70 individuals, appears to extend farther to west on slopes. Found primarily along ridge line on gentle south-facing slope in coastal sage scrub on loamy clay soil. Associated with Salvia mellifera, Eriogonum fasciculatum, Cneoridium dumosum, Stipa lepida, Chlorogalum parviflorum, Chaenactis artemisifolia, Malosma laurina, and Mirabilis californica.
R051100F	Lusardi Creek	5/10/2001	Arctostaphylos glandulo	About 50 individuals growing on flat rocky terrace at top of ridge and on steep, rocky, east-facing slopes of ravine on loamy sand soils in southern maritime chaparral. Associated with Adenostoma fasciculata, Quercus dumosa, Xylococcus bicolor, and Fraxinus dipetala.R051100F also represents Quercus dumosa, colony QdM10-1, about 15 individuals, growing with AgcM10–1.
R053020A	Lusardi Creek	5/30/2001	Ferrocactus viredescen	One individual growing on a south-facing slope on rocky clay loam soil in coastal sage scrub. Associated with Salvia mellifera, Artemisia californica, Stipa lepida, Deinandra fasciculata, and Centauria melitensis. Olivenhain cobbly loam soils series. Elev. 36m.
R053020B	Lusardi Creek	5/30/2001	Ferrocactus viridescen	One individual growing on a south-facing slope on rocky clay loam soil in open grassy coastal sage scrub. Associated with Artemisia californica, Cneoridium dumosum, Opuntia prolifera, Centauria melitensis, Brassica geniculata, Mirabilis californica, and Salvia mellifera. Olivenhain cobbly loam soils series. Elev. 49m.
R053021A	Lusardi Creek	5/30/2001	Adolphia californica	About 275 individuals scattered over gentle to steep southeast-facing slope in coastal sage scrub or as isolated individuals in annual grassland. In Coastal sage scrub associated with Artemisia californica, Eriogonum fasciculatum, Avena barbata, Stipa pulchra, Selaginella cinerascens, and Deinandra fasciculata. In grassland associated with Eriogonum fasciculatum, Brachypodium distachyon, Centauria melitensis, Bromus madritensis, Avena fatua, Brassica nigra, and Calystegia macrostegia. Olivenhain cobbly loam soils series. Elev. 72-96m.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R053023A	Lusardi Creek	5/30/2001	Adolphia californica	About 80 individuals scattered over edge of mesa and steep south and west-facing slopes on rocky clay-loam soil in mosaic of coastal sage scrub and grassland. Associated with Artemisia californica, Eriogonum fasciculatum, Deinandra fasciculata, Avena barbata, Selaginella cinerascens, and Isomeris arborea. Olivenhain cobbly loam soils series. Elev. 73-91m. Ground shows evidence of past tilling.
R053100A	Lusardi Creek	5/30/2001	Adolphia californica	Area east of line down to road is occupied habitat. About 350 plants growing along border of mesa on relatively steep south to southeast-facing slope on rocky clay loam soil in transitional coastal sage scrub annual grassland. Associated with Artemisia californica, Eriogonum fasiculatum, Chlorogalum parviflorum, Dienandra fascicualta, and Avena barbata.Elev. 55-122m. Ground shows evidence of past tilling.
R053101A	Lusardi Creek	5/30/2001	Ferrocactus viridescen	One individual growing on a south-facing slope on rocky clay-loam soil in coastal sage scrub. Associated with Artemisia califronica, Eriogonum fascicualtum, Opuntia prolifera, Adolphia californica, Centauria melitensis, Brachypodium distachyon, and Deinandra fasciculata. Olivenhain cobbly loam soils series. Elev. 72m.
R053101B	Lusardi Creek	5/30/2001	Ferrocactus viridesens	Two individuals growing on steep south-facing slope on rocky clay-loam soil in open disturbed coastal sage scrub. Associated with Artemisia californica, Eriogonum fasciculatum, Deinandra fasciculata, Chlorogalum parviflorum, Chorizanthe fimbriata, Adolphia californica, Bromus madritensis, Selaginella bigelovii, Opuntia prolifera, and Stipa pulchra.Elev. 82m.
R053101C	Lusardi Creek	5/30/2001	Adolphia californica	Extension of AcM30-4 (see above). Occuppied habitat east of line down to road.Associated with Artemisia californica, Eriogonum fasciculatum, Deinandra fasciculata, Chlorogalum parviflorum, Chorizanthe fimbriata, Adolphia californica, Bromus madritensis, Selaginella bigelovii, Opuntia prolifera, and Stipa pulchra.Elev. 82m.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R053101D	Lusardi Creek	5/30/2001	Harpagonella palmeri	Four individuals scattered over a 4 x 4m clay barren surrounded by open coastal sage scrub along edge of mesa on southeast-facing slope. Associated with Selaginella cinerascens, Denandra fasciculata, Chlorogalum parviflorum, Eriogonum fasciculatum, Artemisia californica, and Bromus madritensis.Elev. 107m. Observed late in season, population probably larger.
R053101E	Lusardi Creek	5/30/2001	Adolphia californica	Extension of AcM30-4 (see above). Occuppied habitat east of line down to road.Associated with Artemisia californica, Eriogonum fasciculatum, Deinandra fasciculata, Chlorogalum parviflorum, Chorizanthe fimbriata, Adolphia californica, Bromus madritensis, Selaginella bigelovii, Opuntia prolifera, and Stipa pulchra.Elev. 82m.Occuppied habitat east of line down to road.
R061917A	4S Ranch South	6/19/2001	Ferrocactus viridescen	Seven individuals growing on southwest-facing slope in open, burned, grassy coastal sage scrub among rocks on rocky clay. Associated with Dichondra occidentalis, Deinandra fasciculata, Chlorogalum parviflorum, Brachypodium distachyon, Malosma laurina, Artemisia californica, Lotus scoparius, Salvia mellifera, Calochortus weedii, and Eriophyllum confertiflorum.
R061917B	4S Ranch South	6/19/2001	Ferrocactus viridescen	One individual growing on rocky west-facing slope on clay loam soil in open, burned and grassy coastal sage scrub. Associated with Lotus scoparius, Malosma laurina, Deinandra fasciculata, Stipa lepida, Eriophyllum confertiflorum, Artemisia californica, Bromus madritensis, Avena barbata, and Galium angustifolium.
R061917C	4S Ranch South	6/19/2001	Lepidium virginicum var	At least 1,000 plants estimated on May 2nd. Growing on relatively steep southeast-facing slope in open, burned coastal sage scrub on loamy clay soil. Associated with Salvia mellifera, Malosma laurina, Artemisia californica, Malacothamnus fasciculatus, Deinandra fasciculata, Chlorogalum parviflorum, Dichondra occidentalis, Pentachaeta aurea, and Lotus scoparius.
R061918A	4S Ranch South	6/19/2001	Lepidium virginicum var	Extension of LvrM2-3. GPS point taken along southern boundary of colony.At least 1,000 plants estimated on May 2nd. Growing on relatively steep southeast-facing slope in open, burned coastal sage scrub on loamy clay soil. Associated with Salvia mellifera, Malosma laurina, Artemisia californica, Malacothamnus fasciculatus, Deinandra fasciculata, Chlorogalum parviflorum, Dichondra occidentalis, Pentachaeta aurea, and Lotus scoparius.

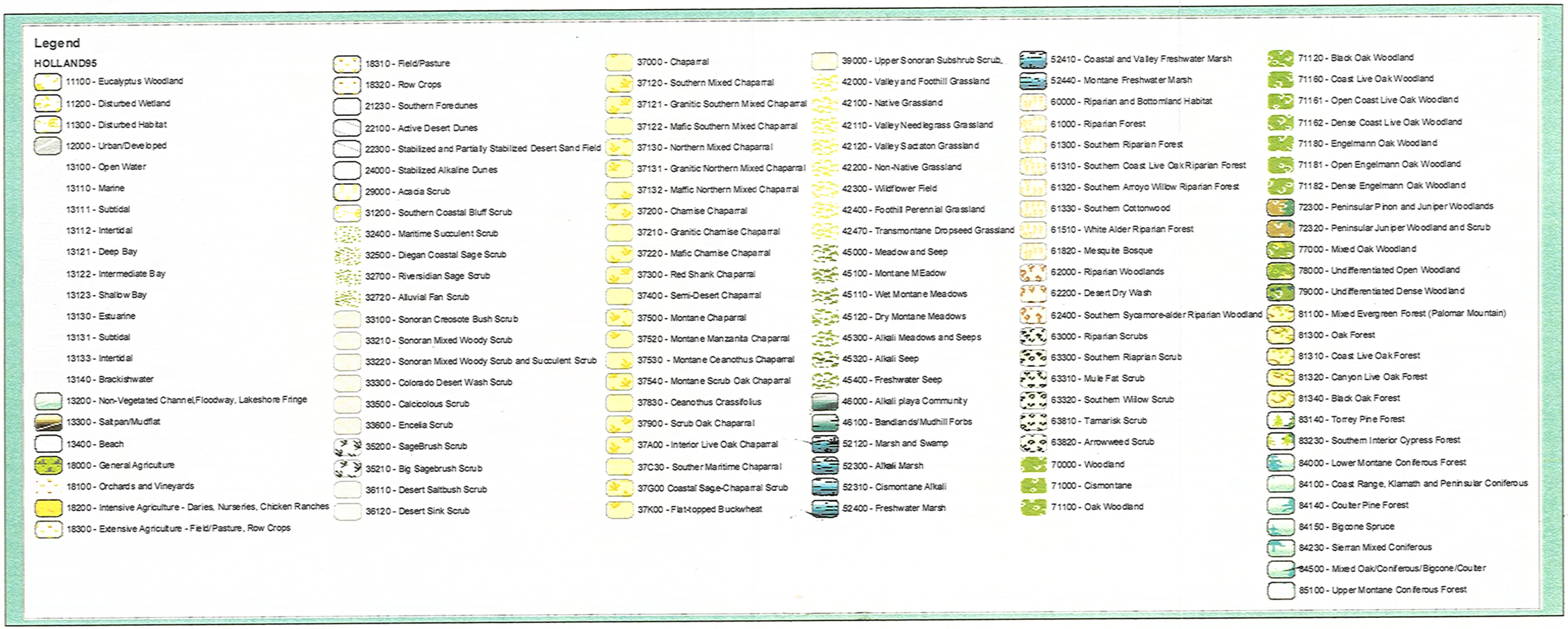
Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R061918B	4S Ranch South	6/19/2001	Dichondra occidentalis	Relatively sparse, growing on gentle to moderately steep southwest-facing slope along ridge on rocky clay among boulders and shrubs in open, recently burned coastal sage scrub. Associated with Salvia mellifera, Artemisia californica, Lotus scoparius, Malosma laurina, Brassica nigra, Brachypodium distachyon, Deinandra fasciculata, Calystegia macrostegia, Calochortus weedii, Salvia apiana, and Eriophyllum confertiflorum.
R061919A	4S Ranch South	6/19/2001	Lepidium virginicum var	Extension of LvrM2-3. GPS point taken along northern boundary of colony.At least 1,000 plants estimated on May 2nd. Growing on relatively steep southeast-facing slope in open, burned coastal sage scrub on loamy clay soil. Associated with Salvia mellifera, Malosma laurina, Artemisia californica, Malacothamnus fasciculatus, Deinandra fasciculata, Chlorogalum parviflorum, Dichondra occidentalis, Pentachaeta aurea, and Lotus scoparius.
R061919B	4S Ranch South	6/19/2001	Lepidium virginicum var	Thousands of individuals noted on May 8th. Colony growing on relatively steep to very steep south-facing slope on recently burned grassy coastal sage scrub on clay loam soil. Associated with Salvia mellifera, Artemisia californica, Lotus scoparius, Malosma laurina, Centauria melitensis, and Stipa pulchra.GPS point represents northeastern edge of colony. Voucher: FMR 5450 (SD).
R061919C	4S Ranch South	6/19/2001	Lepidium virginicum var	Extension of LvrJ19-1. GPS point represents north edge of colony.
R061919D	4S Ranch South	6/19/2001	Ferrocactus viridescen	Two individuals growing on south-facing slope, one individual about 8 m to WNW of GPS point, near ridge top in open, burned coastal sage scrub on clay soil. Associated with Malacothamnus fasciculatus, Malosma laurina, Artemisia californica, Eriogonum fasciculatum, Deinandra fasciculata, Bromus madritensis, and Chlorogalum parviflorum.
R061919E	4S Ranch South	6/19/2001	Ferrocactus viridescen	One individual growing on gentle ridge with southwest aspect on clay loam soil in recently burned open and grassy coastal sage scrub. Associated with Eriogonum fasciculatum, Malacothamnus fasciculatus, Artemisia californica, Salvia mellifera, Lotus scoparius, Bromus madritensis, Deinandra fasciculata, and Malosma laurina.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R061919F	4S Ranch South	6/19/2001	Dichondra occidentalis	Small patch with an area of about 1.5m squared, growing near hilltop on gentle south-facing slope in burned coastal sage scrub on loamy clay soil. Associated with Artemisia californica, Brassica nigra, Galium angustifolium, Malosma laurina, Oxalis albicans, Centauria melitensis, Calystegia macrostegia, and Dudleya pulverulenta.
R061920A	4S Ranch South	6/19/2001	Dichondra occidentalis	Small patch, about 0.2m squared in area, growing near hilltop on gentle, rocky slope with southwest aspect in burned, open and grassy coastal sage scrub on loamy clay soil. Associated with Malosma laurina, Lotus scoparius, Artemisia californica, Encelia californica, Eriophyllum confertiflorum, Deinandra fasciculata, and Bromus madritensis.
R061920B	4S Ranch South	6/19/2001	Ferrocactus viridescen	About 17 individuals on gentle south-facing slope in open grassy coastal sage scrub on loamy clay soil. Associated with Eriogonum fasciculatum, Artemisia californica, Lotus scoparius, Deinandra fasciculata, Chlorogalum parviflorum, Brachypodium distachyon, Opuntia littoralis, and Stipa pulchra.
R061920C	4S Ranch South	6/19/2001	Ferrocactus viridescen	One individual growing on gentle southeast-facing slope in open mixed coastal sage scrub and annual grassland on rocky clay loam soil. Associated with Brachypodium distachyon, Stipa lepida, Deinandra fasciculata, Chlorogalum parviflorum, Gutierrezia californica, Eriophyllum confertiflorum, Salvia apiana, Artemisia californica, and Brassica geniculata.
R061920D	4S Ranch South	6/19/2001	Ferrocactus viridescen	About 102 individuals growing on a gentle to steep, east to southeast-facing slope mostly on open rocky clay barrens or in mixed coastal sage scrub and annual grassland, to open grassy coastal sage scrub on rocky clay loam soil. Associated with Artemisia californica, Eriogonum fasciculatum, Malosma laurina, Chlorogalum parviflorum, Brachypodium distachyon, Dudleya pulverulenta, Centauria melitensis, Stipa lepida, Salvia mellifera, Opuntia littoralis, Selaginella cinerascens, and Deinandra fasciculata.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R061921A	4S Ranch South	6/19/2001	Ferrocactus viridescen	About 66 individuals growing on southeast-facing slope on clay barrens and in open, grassy coastal sage scrub to mixed coastal sage scrub and annual grassland on rocky clay loam. Associated with Artemisia californica, Lotus scoparius, Eriogonum fasciculatum, Selaginella cinerascens, Deinandra fasciculata, Brachypodium distachyon, Chlorogalum parviflorum, Opuntia littoralis, Stipa lepida, Avena barbata, Salvia apiana, S. mellifera, and Malosma laurina.
R061922A	4S Ranch South	6/19/2001	Ferrocactus viridescen	About 103 individuals growing along ridge on gentle south-facing slope in open grassy coastal sage scrub on somewhat rocky clay loam barren. Associated with Dudleya pulverulenta, Eriogonum fasciculatum, Artemisia californica, Isocoma menziesii, Salvia apiana, Mirabilis californica, Chlorogalum parviflorum, Deinandra fasciculata, Avena barbata, Stipa pulchra, Gutierrezia californica, and Centauria melitensis.Many dead individuals among the living.
R061922B	4S Ranch South	6/19/2001	Ferrocactus viridescen	Extension of colony FvJ19-9.About 103 individuals growing along ridge on gentle south-facing slope in open grassy coastal sage scrub on somewhat rocky clay loam barren. Associated with Dudleya pulverulenta, Eriogonum fasciculatum, Artemisia californica, Isocoma menziesii, Salvia apiana, Mirabilis californica, Chlorogalum parviflorum, Deinandra fasciculata, Avena barbata, Stipa pulchra, Gutierrezia californica, and Centauria melitensis.Many dead individuals among the living.
R061923A	4S Ranch South	6/19/2001	Ferrocactus viridescen	One individual growing on gentle south-facing slope on open rocky clay-loam barren in mixed grassland and coastal sage scrub. Associated with Deinandra fasciculata, Eriogonum fasciculatum, Chlorogalum parviflorum, Artemisia californica, Centauria melitensis, Brachypodium distachyon, and Stipa lepida.
R061923B	4S Ranch South	6/19/2001	Ferrocactus viridescen	One individual growing on a relatively flat ridge top on rocky clay loam barren in coastal sage scrub with scattered rock outcrops. Associated with Selaginella cinerascens, Artemisia californica, Eriogonum fasciculatum, Chlorogalum parviflorum, Bromus madritensis, B. hordaceus, and Centauria melitensis.

Rover	*Descriptive Location*	*Date*	*Latin Binomial*	*Notes: (as typed by the biologist)*
R061923C	4S Ranch South	6/19/2001	Ferrocactus viridescen	About 27 individuals in dense stand on gentle south-facing slope at end of ridge in coastal sage scrub on rocky clay loam soil. Associated with Salvia mellifera, Artemisia californica, Chlorogalum parviflorum, Stipa lepida, Brachypodium distachyon, Galium angustifolium, Malosma laurina, and Mimulus puniceus.
R061923D	4S Ranch South	6/19/2001	Ferrocactus viridescen	About 35 individuals growing on flat ridge top on rocky clay barren in openings of coastal sage scrub. Associated with Artemisia californica, Eriogonum fasciculatum, Salvia apiana, Chlorogalum parviflorum, Avena barbata, Brachypodium distachyon, Selaginella cinerascens, Calochortus weedii, Deinandra fascicualta, and Opuntia littoralis.
R061923E	4S Ranch South	6/19/2001	Ferrocactus viridescen	About 10 individuals growing on gentle south-facing slope on rocky clay barren in openings of coastal sage scrub. Associated with Brachypodium distachyon, Artemisia californica, Eriogonum fasciculatum, Deinandra fascicualta, Salvia apiana, Stipa lepida, Selaginella cinerascens, Bromus madritensis, and Vulpia myuros.
R062001A	Lusardi Creek	6/19/2001	Ferrocactus viridescen	Two individuals (one individual about 2m upslope from GPS point, the other 5m lower, the the SE) growing on very steep, south-facing slope on broken slate cobble in open coastal sage scrub. Associated with Eriogonum fasciculatum, Salvia mellifera, Selaginella bigelovii, Porophyllum gracile, and Dudleya pulverulenta.
R062001B	Lusardi Creek	6/19/2001	Ferrocactus viridescen	One individual growing on moderately steep south-facing slope in open coastal sage scrub on broken slate cobble soil. Associated with Eriogonum fasciculatum, Malosma laurina, Salvia mellifera, Cneoridium dumosum, and Porophyllum gracile

Appendix 2 – Holland95 Codes and Shades



Note: The above shadeset combines both color and pattern to best represent the numerous possible vegetation community assemblages present in San Diego County.
Although the shadeset does aggregate some classes of vegetation, it does so at the ten thousand-series break in the holland codes (which follow community type, i.e.,woodlands vs sagebrush). Shadesets which further spit the categories add extraneous detail for the purposes of this map.

Appendix 3

Glossary of Terms[†]

Airborne Data Acquisition and Registration (ADAR) – The ADAR System 5550, developed by Positive System acquires high resolution (0.5 to 3 meter GRE) multispectral digital photographs using an airplane platform.

Band – A portion of the electromagnetic spectrum, a range of wavelengths. A spectral band, in the context of remote sensing, is a discrete region of the spectrum resolved by a sensing element within the sensor's imaging array.

Binary change mask[1] – Created by using the output image of a change detection function. A threshold value of change is selected to identify areas of change and no-change in the new image. The change image is then recoded to a value of one for change or a value of zero for no-change.

Change detection – Process by which two images are compared pixel by pixel, and an output is generated whenever corresponding pixels have sufficiently different gray values.

Change detection images – Images prepared by digitally comparing two original images acquired at different times. The gray tones of each pixel on a change detection image portray the amount of difference between the original images.

Color composite (multiband photography) – A color image produced by assigning colors to particular spectral bands. In Landsat TM, for example, assigning red to band 3 (0.63 to 0.69 um), green to band 2 (0.52 to 0.6 um) and blue to band 1 (0.45 to 0.52 um) results in a true color composite, approximating what human vision normally perceives.

Electromagnetic spectrum – The ordered set of wavelengths of electromagnetic radiation extending from short-wavelength cosmic waves to long-wavelength radio waves.

Geographic Information Systems (GIS) – An information system that is able to encode, store, transform, analyze, and display geospatial information.

Gray scale – Range of gray values from black to white.

Ground Resolution Element (GRE) – *See spatial resolution.*

Histogram[1] – A graphic representation of the information content of a remotely sensed image.

Image – Spatial representation of an object, a scene, or a map, that may be abstractly represented by a continuous function of two variables defined on some bounded region on a plane. An ordered two dimensional array of pixels.

Image differencing – The simple identification of the amount of change between two images by subtracting one band of one date from that of a different date. The images must first have been rectified to a common base map.

Image enhancement – Any one group of operations that improve the visual detectability of targets or categories. These operations include contrast improvement, image smoothing, histogram matching and noise suppression.

Image interpretation – The art and science of examining photographic images for the purpose of identifying objects and judging their significance.

Image processing – All operations that can be applied to image data, including preprocessing, enhancement, quantification, and classification.

Image registration – Alignment process by which two images of the same scene are positioned coincident with respect to each so that corresponding elements of the same ground area appear in the same position on the registered image.

Infrared – Pertaining to energy in the 0.7 - .11um wavelength region of the electromagnetic spectrum. For remote sensing, the infrared wavelengths are often subdivided into near infrared (0.7 – 1.1um), shortwave infrared (1.1 – 3um), midwave infrared (3 – 5um), and longwave infrared (5 – 15um).

Landsat – Unmanned, sun-synchrounous orbiting, U.S. earth resources satellite operated by Space Imaging EOSAT.

Map – A graphical representation in a plane surface, at an established scale, of the physical features (natural, artificial, or both) of a part of the earth's surface.

Multispectral Imagery – Images obtained simultaneously in a number of discrete bands in the electromagnetic spectrum.

Near infrared (NIR) – The preferred term for the shorter wavelengths in the infrared region extending from about 0.7um (visible red) to around 1.1um (the definition varies substantially by application and researcher). The longer wavelengths end grade into the shortwave infrared. The term really emphasizes the adiation reflected from plant materials, which peaks around 0.85um. It is also called solar infrared, since most of the IR energy from the sun lies in this spectral region.

Normalized difference vegetation index (NDVI)[1] – A measurement of vegetative amount and condition based on analysis of remote sensing spectral measurements. This techniques involves band ratioing where NDVI = (NIR) – Visible)/(NIR + Visible).

Orbit – The path of a satellite around a body determined by the law of gravity.

Orthorectification – The process of the photogrammetric adjustment of a satellite image to remove geometric distortions caused by the imaging sensor and terrain relief displacement.

Pixel – A picture element having both spatial and spectral properties. The spatial variable defines the apparent size of the resolution cell (i.e., the area on the ground represented by the data values), and the spectral variable defines the intensity of the spectral response for that cell in a particular band.

Preprocessing – Operation applied before image analysis is performed that can remove noise from, register, and enhance images.

Radiometric resolution – The minimum measured differences in signal strength.

Remote sensing – Techniques used to gather and process information about an object without direct physical contact.

Resolution – The measure of the ability of an optical system to distinguish between signals that are spatially near or spectrally similar.

Satellite – An object in orbit around a celestial body.

Scene – In a passive remote sensing system, everything occurring spatially or temporally before the sensor, including Earth's surface, the energy source, and the atmosphere, that the light energy passes though as it travels from its source to the Earth and from the Earth to the sensor.

Sensor – Any device that gathers energy or electromagnetic radiation, converts it into an electronic signal, and presents it in a form suitable for obtaining information about the environment.

Spatial resolution – The ability of an entire remote sensor system to rendor a sharply defined image. Also, a measure of the smallest angular or linear separation between two objects that can be resolved by the sensor.

Spectral bands – An interval in the electromagnetic spectrum defined by the two bounding wavelengths, frequencies, or wavelengths.

Spectral resolution – (1) The width of specific wavelength intervals in the electromagnetic spectrum to which a sensor is sensitive; (2) A sensor's imaging capabilities in terms of the spectral bandwidths, the number of spectral bands, and the location of those bands on the electromagnetic spectrum.

Tasseled Cap Transformation[2] – Rotates the MSS data such that the majority of information is contained in three components or features that are directly related to physical scene characteristics (brightness, greenness, and wetness). Brightness refers to the principal variation in soil reflectance; greenness is strongly related to the amount of green vegetation present in a scene; wetness relates to canopy and soil moisture.

Temporal resolution – Time interval between imaging collections over the same geographic location.

Thematic Mapper (TM) – A 7-bad multispectral sensor carried aboard Landsats –4, 5, 6 and 7. The bands are in the visible (bands 1, 2, 3); near infrared (band 4); shortwave0infrared (bands 5 and 7); and thermal infrared (band 6) regions. The spatial resolution is 28.5 meters for bands 1 through 5 and 7, and 120m for band 6 (60m for Landsat-7).

Wavelength – Distance between successive wave crest or other equivalent points in a harmonic wave.

Write function memory insertion[1] – The insertion of bands of remotely sensed data into specific write function memory banks (red, green, and-or blue) in the digital image processing system to visually identify change in the imagery.

†*All glossary terms taken from the following:*

LOGICON, 1997. Multispectral Imagery Reference Guide. LOGICON Geodynamics, Inc. Spectral Imagery Training Center. Faifax, Virginia.

Except:

[1]**Jensen, J.R**., 1996. Introductory Digital Image Processing. Simon and Schuster. Upper Sadle River, New Jersey.

[2]**Lillesand, T.M. and R. W. Kiefer, 1994**. Remote Sensing and Image Interpretation. 3rd Edition. John Wiley and Sons, Inc. New York, New York.