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Watershed and Riparian Assessment Report (WRAR):

Bureau of Land Management Lands Former Fort Ord, Monterey County, California

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The following report respectfully submitted to the Fort Ord Office of the Bureau of Land Management (BLM). The work was performed under Agreement No. BAA000016 (Task Order Number 001) with The Foundation of California State University Monterey Bay (CSUMB). Faculty, staff, and students at the Watershed Institute at CSUMB carried out the research and writing between Summer 2001 and Winter 2002. The report was presented to the BLM in paper and electronic PDF formats. An ArcView GIS project accompanies the report.

Sincerely

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Table of Contents

Title:

Watershed and Riparian Assessment Report (WRAR) for BLM Lands of Former Fort Ord, Monterey County, California

A: Purpose and Scope of Report

This Watershed and Riparian Assessment Report (WRAR) characterizes the dominant physical, ecological, and cultural components of a portion of the former Fort Ord landscape using natural hydrologic boundaries to delimit the study area. The WRAR is an holistic ecosystem analysis at the watershed scale. The watershed components addressed in this report include topography, physiography, geology, soils, plant and animal communities, and human culture. Special attention is given to the plants and animals identified as "species of concern" in the *Installation-Wide Multispecies Habitat Management Plan for Former Fort Ord, California* (HMP). This WRAR focuses on 7200 acres transferred to the care of the Federal Bureau of Land Management (BLM) on October 18, 1996 (Fig. 1). The WRAR also addresses approximately 7800 additional acres that are to be transferred to the BLM in the future. The analysis of the additional lands is limited because access to the property is restricted by the potential presence of unexploded ordnance.

The WRAR is a bridge between the general policies set forth in the HMP and site-specific work that implements the HMP policies. The HMP is a landscape management plan that broadly prescribes the appropriate reuse of former Fort Ord lands. In general the HMP will "promote preservation, enhancement, and restoration of habitat and populations of HMP species while allowing development on selected properties that promotes economic recovery after closure of Fort Ord" (USACE, 1997). The HMP designates parcels to be used as habitat reserve, habitat corridor, restricted development and full development (Fig. 2). Although the HMP assigns the BLM broad responsibilities for ecosystem stewardship, it does not specifically define how to achieve those goals. The BLM is currently developing a strategy for achieving the HMP goals within the context of its role as the manager of public lands. As part of this BLM strategy, the WRAR was commissioned to summarize the present knowledge of the landscape with respect to ecosystem management and restoration, to identify data gaps, and to help define the context of BLM land resources within the greater El Toro Creek Watershed.

The general goal of the WRAR is to provide an ecosystem and landscape management tool for implementing the HMP policies. We achieve this goal by describing the present state of the lands and ecosystems and through a series of discussions targeting the management needs identified during our field reconnaissance and in discussions with BLM personnel. Although the WRAR was not proposed to generate "new field data," this report is based upon a combination of existing reports, geographic information system layers (GIS), general scientific literature, and limited new field data. The WRAR provides the following results:

- Delineation and naming the hydrologic subwatersheds and flow paths within the complex sand dune and canyonlands physiography of BLM lands;
- Acquisition and analysis of georeferenced 1-meter resolution color aerial photography;
- Spot verification of GIS data used in this report, including vegetation type, soil type, geology, topography, slope, restoration sites, erosion sites, roads and a 1-meter resolution color aerial photograph;
- Analysis of 30-meter resolution digital elevation model (DEM) for watershed characteristics;
- Field reconnaissance of the landscape to locate present significant soil erosion issues;
- Broad analysis of the causes of soil erosion (especially gully formation);
- Identification of data gaps or research needs;
- Discussing the HMP species of concern in the context of ecological restoration;
- Identification of the subwatershed ownerships;
- Identification of land ownership in adjacent lands;
- Discussion of the significance of the Highway 68 corridor;
- Discussion of the role of control burn practices for enhancing at-risk habitats and landscape stability;
- Identification of human-caused and natural disturbances active in the watershed;
- Identification of current and potential future land and ecosystem management problems within the BLM Fort Ord lands;
- Discussion of past restoration efforts; and
- General and specific options for future restoration efforts with a ranking system for prioritizing restoration efforts.

The present and future BLM lands (15,000 ac) are specifically designated as a "habitat reserve," called the Natural Resources Management Area (NRMA). The NRMA management strategy set forth in the HMP includes:

- Development of a detailed habitat enhancement and protection strategy that includes controlled burns as a tool to optimizes a diverse habitat matrix
- Short- and long-term ecosystem recovery in maritime chaparral communities

- Increasing the numbers of sand gilia, Monterey spineflower, Seaside bird's-beak, and other species of concern by tracking their ecological habits and through habitat management.

The WRAR addresses many of the issues that will aid implementation of those management goals.

B. Geological and Cultural History of the NRMA

Geologic History

The present and future BLM lands have a long, complex geologic history that includes approximately 600 km northward translation along the San Andreas Fault system. The events that can be interpreted from the geology exposed, or in the shallow subsurface of BLM lands are summarized in Table 1. The geologic formations (Fig. 3) and attendant soils control, to a large degree, the distribution of plant and animal communities on the landscape. The controls include presence of surface water or groundwater; the ratios of clay silt, and sand; chemical composition; permeability; slope steepness; elevation; erodability; cation-exchange capacity; aspect, and overall morphology of the landscape.

Former Fort Ord lands, including the NRMA, lie at the topographic and geologic transition between the Sierra de Salinas Range to the south, the Salinas Valley to the northeast, and the Pacific coast to the northwest. Topographically, the landscape slopes gradually down toward the northwest from approximately 900 feet above sea level near Impossible Canyon to sea level

Table 1: Regional Physical History (Clark et al., 2000; Malone, 1994; Johnson, 1993; Staal et al., 1990)

Geologic Age	Age Range Years B.P.	Environment or Event(s)	Geologic Evidence	Geologic Formation And Map Symbol
Pre-Late Miocene	>11 million	Complex history as the western edge of North America evolved, BLM land moving north on San Andreas fault system 40 mm/yr	Deeply buried bedrock including old granitic rocks and high-grade metamorphic rocks.	Not present as surface rocks on BLM lands
Late Miocene	5-11 million	Rapid subsidence to deep marine basin	Richly fossiliferous siliceous shale with little continental-derived sediment (present in subsurface)	Monterey Formation Tm
Late Miocene	5-11 million	Uplift of land to shallow-marine (estuarine?) conditions	Fossiliferous, quartzose or akrosic sandstone	Santa Margarita Formation Tsm
Pliocene-Pleistocene	1.7-5.3 million	Rise of Sierra de Salinas and deposition of alluvial fans on BLM lands	Mon-marine, coarse-grained, braided- river deposits	Paso Robles Formation QTc
Pleistocene	10,000-1.7 million	Large dune field repeatedly migrates inland farther than Pilarcitos Canyon, partially buries the alluvial fan deposits and fills hollows and valleys with erodable sands	Cross-bedded sandstone that preserves a dune surface morphology, and the fine sand deposits that are now being excavated by gullying	Aromas Formation Toe
Pleistocene	10,000-1.7 million	Sea level repeatedly rises and falls, Salinas River cuts bluff into Aromas dune field, deposits gravel and sand in valley bottom	Subsurface presence of the "180-foot" aquifer beneath the northwestern part of former Fort Ord land (from well drilling data)	"180-foot aquifer" in regional hydrologic cross sections
Late Pleistocene to Holocene	<25,000	Rise and spread of indigenous tribes in coastal California	Innumerable artifacts, middens and campfire sites	
Late Pleistocene to Holocene	<125,000	Sea level rise, floods Salinas Valley as far inland as Salinas and Gonzales(?), huge estuary spans the entire mouth of the Salinas Valley, and uplift of Fort Ord area	Subsurface presence of "blue clay" aquiclude capping the 180 foot aquiferthat bears marine fossils. Evidence of uplift is beach erosion of Aromas Sand near Seaside	"blue clay" capping the 180 foot aquifer in regional hydrologic cross sections
Late Pleistocene to Holocene	<125,000	Rising sea level(?) and renewed advance of coastal dune fields, formation of vernal pools and other internally drained basins	Preserved dune field that partially buries the Aromas dune field and has younger surface age (less mature soils). Seasonal pools exist in the interdune areas where impermeable Aromas paleosol forms perched water table	“Older dune deposits” Qod
Holocene	<10,000	General development of modern landscape, canyon cutting	Older geologic units dissected by northwest draining canyons (El Toro, Pilarcitos, Engineer, Barloy, Impossible, and Wildcat)	Stream terrace deposits Qt
Holocene	<10,000	Recent modification of the local landscape, deposition of stream alluvium, downslope movement of colluvium and older landslides	Thin stream deposits in canyon bottoms, colluvial aprons on valley flanks, evidence of old landslides	Quaternary alluvium, Qaternary colluvium, Quaternary landslide deposits, Qal, Qc, Qls.
Recent (post-European)	<200	Land-use change from natural to cattle range, including conversion of ecology from woodland, chaparral and native perennial grassland to European annual grasses. Very recent road and trail construction, suppressed water table. Still moving north 40 mm/yr	Very recent gullying throughout the landscape in connection with road construction, presence of modern landslide scarps, head-cutting of canyon bottom streams (e.g. Pilarcitos), and frequent seismicity on San Andreas Fault system	

along the Monterey Bay. Three predominant landforms present within the NRMA are: complex dune topography present in the northern and western areas, curvilinear canyons and ridges in the central and eastern areas, and rolling hilly grasslands located on the southern and southeastern areas. The landscape rises to the southeast, and would form a continuously rising slope to Toro Peak if not dissected by Toro Creek (modified from Malone, 1994).

The geologic transition from the Sierra de Salinas Range to NRMA lands is also gradual. The bedrock present on the southern side of Toro Creek is present in the subsurface of the NRMA, buried by progressively younger deposits. The rise of the Sierra de Salinas Mountains approximately 3 million years ago generated an apron of sediment, carried down slope by high-gradient rivers. That old sediment apron is exposed in the canyonlands of the NRMA as the Paso Robles Formation (Fig. 3). Some of the older bedrock units exposed in the Sierra de Salinas Mountains are present in the deeper subsurface below the NRMA lands (modified from Malone, 1994).

Recent History

Since European settlement of the region, the NRMA lands have been used for grazing and military training. As elsewhere in California, military presence along the Monterey Bay fostered the preservation of a vast tract of natural and restorable land that might otherwise have been economically developed. Heavy use of military vehicles, foot patrols and artillery have physically and ecologically degraded much of the NRMA. The Fort Ord army base was closed pursuant to the Defense Base Closure and Realignment Act of 1990, Public Law 101-510.

According the Fort Ord Reuse Authority (www.fora.org; Feburary 10, 2002), the following milestones mark the transfer of Fort Ord to the public and private domain:

January 1991
The Secretary of Defense announces the proposed downsizing/closure of Fort Ord.

March 1991
Fort Ord Community Task Force formed by Leon Panetta, Henry Mello, Sam Farr and many others. Report issued Spring 1992.

July 1992
California State University Board of Trustees approves a resolution to support the acquisition of a small portion of the Fort Ord Site.

September 1992
Fort Ord Reuse Group forms to formalize regional/local participation in redevelopment planning.

September 1993
Secretary of Defense, William Perry, declares the reuse efforts at Fort Ord as a national model for base conversion.

May 1994
Fort Ord Reuse Authority (FORA) formed by special legislation (SB 899) to replace and authorize work initiated by the Fort Ord Reuse Group.

August 1994
Property is transferred to the California State University and University of California for educational and economic development under special federal authority.

August - 1995
Classes begin at California State University at Monterey Bay (CSUMB).

September - 1995
President Clinton visits and celebrates the opening of the California State University Monterey Bay and commends the community on its reuse efforts.

October - 1995
Fritzsche Army Airfield iss transferred to the City of Marina and becomes available for commercial business.

April - 1996
FORA conducts "Developer's Days" to showcase the former Fort Ord for prospective developers. Two hundred developers attend.

October 23, 1996
Military golf courses transfer to the City of Seaside for a payment of $11 million under special Congressional authorization.

October - 1996
Undeveloped land transfers to the Bureau of Land Management for protection of endangered species and passive recreational uses.

May - 1997
Pilot Deconstruction Project begins fieldwork.

June 13, 1997
FORA Board Approves the Base Reuse Plan and certifies the associated Environmental Impact Report (EIR).

September 1997
The City of Marina and FORA renovate and open 352 affordable housing units on the former Fort Ord for occupancy by military and general public with 20% set aside as lower income.

October - 1997
Fort Ord Reuse Authority submits Economic Development Conveyance application to U.S. Army for all non-claimed properties.

June 1998
California State University Monterey Bay, in its third year of operation; graduates its first class.

June 1999
Memorandum of Agreement authorized between the United States Army and the Fort Ord Reuse Authority

governing the transfer of 5,300 acres of former Fort Ord property under a no-cost economic development conveyance.

September 1999
Congress approves no-cost economic development transfer and President Clinton signs legislation enabling FORA to keep land sale revenues for local needs.

August 2000
First economic development conveyances attended by Deputy Assistant Secretary of Defense and Principal Assistant Secretary of the Army to formally transfer the parcels.

April 2001
The City of Seaside completes negotiations with the Army to acquire the Hayes Housing area under special authorization for new housing.

On October 18, 1996, about 7200 acres were transferred from the Department of Defense to the BLM to manage under guidance provided by the HMP. Since the 1996 winter season, the BLM and community partners have been restoring damaged lands to maximize habitat value in accordance with the HMP.

C. Watershed Overview

The information in this report is organized by watershed, with areas requiring more discussion described by subwatershed. The three major watersheds present in the study area are the Seaside, Salinas, and Toro Creek (Fig.4; Appendix A). Subwatersheds are alphanumerically named starting with two capital letters denoting the associated larger watershed (SE, SA, and TC) coupled with a number to follow the two-letter prefix.

Physical Parameters and Ownership

The area, perimeter, and other physical attributes of the subwatersheds, including ownership, are shown in Appendix A. Ownership of the subwatersheds and adjacent lands is provided in Figure 1. According the Fort Ord Re-use Authority (www.fora.org; Feburary 10, 2002), the following land areas have been transferred directly from the Army to new ownership as part of the Fort Ord Reuse Plan.

Land Use

Projected land use of former Fort Ord is shown in Figure 5. The BLM lands are used primarily as a habitat reserve (Fig. 2), with public access restricted to recreational hiking, road bicycling, and mountain bicycling. Motor vehicle use on paved and unimproved roads is restricted to official BLM business and those with BLM vehicle permits. Approximately 2,500 acres of valley needlegrass are managed as sheep grazing lands, chiefly within the Toro Creek and Pilarcitos watersheds. The grazing is primarily a management tool to control weeds and reduce fire hazard. A small parcel of developed land serves as the BLM management offices (SE10, Fig. 4). Future land use on BLM lands will likely remain the same, with the addition of public motor vehicle access to parking areas. There is a parking area planned for Monterey County; however, the parking lot has no designated access road easement, so further property adjustments may be required and an easement. CalTrans holds an easement for possible future rerouting of Highway 68 (Fig. 2). Specific future land use will be developed by balancing public input from surrounding communities with the HMP habitat management directives governing the NRMA.

The majority of the NRMA land still pending transfer to BLM (Fig. 1) is cordoned off while ordinance and explosives are removed. The removal of ordnance has been slowed because of a recent court order related to the Army's controlled burns used in that process. A federal training facility is located in the upper Impossible Canyon watershed (Fig. 2) and numerous outbuildings are present throughout the region. Future land use of pending BLM lands will be based upon the condition of the lands that are transferred, the input from public survey, and the HMP directives. It is likely that future land use will be a mixture of public recreational areas, and areas off-limits to public access. Restricted areas will protect fragile ecosystem reserves and protect the public from potentially unsafe post-military conditions.

Table 2: Property Transfer as of December 31, 2001

Recipient	Acres
BLM	7,211.9
Children's Services Int. (CSI)	6.1
CSUMB	692.3
Empire West Corp.	23.9
Golden Gate University	7.2
Goodwill Industries	5.1
Housing Authority/Mtry. Co.	8.6
Interim, Inc.	2.2
Marina	888.4
MIRA	1.6
Monterey College of Law	0.6
Monterey Cty/ROW York Rd	2.5
MPUSD	142.0
PG&E/Seaside	1.2
Seaside/Golf Courses	405.4
Shelter Outreach Plus	9.9
UCMBEST	961.0
Veterans Administration	6.1
Veterans Transition Center	10.9
(FORA EDC)	241.2
TOTAL	**10,625.1**

New housing proposed for lands adjacent to present and future BLM lands are projected to bring an additional 37,000 people in close proximity to the property (California Trade and Commerce Agency, 2000; http://www.cedar.ca.gov/military/current_reuse/fort_ord.htm#fort_ord_anchor).

D. Hydrologic Conditions

The average annual discharge of water and sediment from BLM lands is minimal. The NRMA annually receives on average 12 to 15 inches of rainfall, most of which is used in evapotranspiration and groundwater recharge. Based upon our observations the ephemeral streams and gullies within BLM lands convey water off site only during infrequent, very intense rainfalls that follow a period of antecedent soil moisture. Such flows usually last for only several hours because of steep terrain and small watershed size. During times of extreme rainfall intensity, as occurred in 1995, the run-off and sediment transport from BLM lands can be substantial. The only hydrologic record in the region is the El Toro Creek gage operated by the U.S. Geological Survey. Figure 6 is the Log-Pearson type-III analysis of flow frequency past that gage.

Precipitation

Long-term rainfall records for the NRMA are interpolated from those at the Presidio of Monterey and the Salinas Weather Bureau airport stations. Some local records from stations nearer and on the former military base are available but are not of long or consistent duration. In general, the rainfall values collected on Ft. Ord do not differ from those at the Naval Postgraduate School or at Monterey. A long record (1847 ff) has been compiled from records for Monterey (Renard, 2001 and unpublished). The records from January 1952 to the present are compiled in standard formats consistent with a similar period of record available for Salinas airport stations.

50 Year-24 Hour Event

A critical precipitation characteristic for land management is rainfall intensity-duration, which can provide an index of geomorphically-significant events. Landscapes, such as the NRMA apparently evolve under monotonous steady-state conditions that are suddenly punctuated by catastrophic change. For example, valleys and hollows throughout California that had been gradually filling with colluvium and other recent deposits for approximately the last 10,000 years, suddenly experienced a phase of gullying brought on by recent climate swings and high rainfall intensity (Reneau et al., 1986). We suggest that approximately the same history can be seen in NRMA lands that are now severely gullied. In many regions the geomorphically-significant rainfall intensity-duration is taken to be the 24-hour 50 year-event. During this 24-hour 50 year-event, engineered structures that are constructed within stream systems and on quasi-stable slopes will have a high chance of failure as the landscape is pushed from an equilibrium condition. The National Oceanic and Atmospheric Administration (NOAA Atlas 2, 1973; www.wrcc.dri.edu/pcpnfreq.html) estimates the 24-hour, 50-year return period rainfall for the region to be 3.0 inches. The higher-elevation portions of the greater El Toro Creek watershed receive about 4.5 inches in 24-hours as the 50-year event. The original atlas was updated in 1999 as part of a California study that looked at maximum probable precipitation, which is defined as a 1000-year return-period event. Lesser magnitude events can also be interpolated. Table 3 is based on the Monterey climate record interpolated in the 1000-year context. In that study, the 50-year, 24-hour rainfall for Fort Ord is suggested as about 4.0 inches. Therefore, a storm bringing 3 to 4 inches in 24 hours can be expected to induce significant landscape change in the NRMA.

Table 3: Maximum Rainfall For Indicated Number Of Consecutive Days

Monterey County, Elevation 335 Feet - from Goodridge, 1982 et al

RP yr	1 day	2	3	4	5	6	8	10	15	20	30	60	W-YR
2	1.78	2.23	2.51	2.81	3.02	3.24	3.62	4.08	4.75	5.32	6.45	9.78	17.08
5	2.53	3.22	3.63	4.01	4.32	4.57	5.10	5.69	6.64	7.40	8.93	13.70	23.07
10	3.01	3.88	4.38	4.79	5.16	5.39	6.03	6.65	7.77	8.64	10.39	16.05	26.65
25	3.61	4.70	5.32	5.73	6.17	6.37	7.12	7.78	9.09	10.10	12.07	18.79	30.84
50	4.04	5.30	5.99	6.41	6.90	7.06	7.90	8.56	10.01	11.11	13.23	20.69	33.75
100	4.46	5.88	6.65	7.06	7.60	7.73	8.64	9.30	10.87	12.06	14.32	22.50	36.50
200	4.87	6.45	7.30	7.69	8.29	8.37	9.36	10.01	11.70	12.98	15.36	24.23	39.13
500	5.50	7.33	8.30	8.64	9.30	9.28	10.38	10.96	12.82	14.21	16.74	26.55	42.68
1000	5.80	7.74	8.77	9.12	9.83	9.79	10.96	11.57	13.53	14.99	17.63	28.02	44.93
10000	7.08	9.54	10.81	11.09	11.95	11.73	13.13	13.65	15.97	17.68	20.64	33.10	52.68
Values in Inches; RP = Return Period; Values Derived from www.wrcc.dri.edu/pcpnfreq.html													

The Role of El Nino Cycles in Local Landscape Evolution

Because both intensity-duration and antecedent precipitation are determinative in erosion of landscapes, it is a high-intensity rain following prolonged periods of high daily precipitation that generally leads to significant gully, landslide, and soil erosion events. The historical climatic events that have most likely led to changes in the NRMA are the times of “double” or back-to-back El Ninos.

Within the period of record for Monterey and vicinity, we see double El Ninos occurring in the following time windows: 1904 to 1911, 1936 to 1942, and 1992 to 1998.

In general, it is the last one or two years of these 6-year-long periods that cause the greatest erosion and most intense precipitation. According to local newspaper accounts, it was the 1910-1911 precipitation events that led to the largest floods of record in the Carmel Valley and probably in the El Toro Creek area. The 1910 and 1911 floods in the Carmel Valley aggraded sediments and carried braided flows completely across the Carmel Valley, from valley wall to valley wall, according to news and photographic records (Pacific Grove library resources). A similar history fits all the available geologic and historic evidence for the lower El Toro Creek valley. After those floods, El Toro Creek and the Carmel River established new channel positions and began to incise their present watercourses. Subsequent floods have reached near the tops of those new incised channels but, possibly due to fire suppression, have not carried the sediment loads of the 1904-1911 El Nino period and have not refilled the 1911 channels.

The 1997-98 precipitation year was the most intense since record-keeping began in 1847 (www.weather.nps.navy.mil/renard_wx/). In that season there were 47.15 inches of total precipitation between July 1 and June 30, with 120 days of rain. The highest monthly precipitation of record occurred in February 1998, with 14.26 inches. The next highest annual rainfall was in 1982-83 with 40.64 inches recorded locally. January 10, 1995 has the most intense rainfall of record with 2.86 inches in 24 hours and more than 10 inches in most of the mountain regions of the Monterey Bay Area. January and March, 1995, were the most active for landslides and floods in the Santa Cruz and Monterey Bay areas with a record January local precipitation of 10.61 inches and more than 30 inches in many mountainous areas nearby. Precipitation in January of 1998 was just less than the January of 1995 with 10.37 inches recorded locally. January of 1916 holds the record for that month with 11.10 inches at Forest Lake in Pebble Beach.

The recent departures from the long-term climate record are even more pronounced in the Salinas Airport Records (Fig. 7). The largest daily value in the past 50 years (the 50-year event) was 3.0 inches in 2000. Daily values close to that occurred in 1997 and again in 1998 at Salinas.

The maximum drought of record occurred in 1977. The December 1977 maximum rainfall event fell on totally dry, deeply cracked soils at Fort Ord. The rain rapidly infiltrated the cracked soil to form a vast network of subsurface eroding channels and passages called “piping.” The piping then eroded further and caved in during 1982-83 and 1992-93 and subsequent El Nino events creating the systems of active gullies and deeply-incised channels now present within the NRMA and throughout the central California coast from Marin County to San Luis Obispo. Thus, some gullies in the NRMA were not caused by prior on-site land use; however, concentrated run-off from impermeable roads and trails has likely accelerated subsequent gully growth. This climatic history is critical to an understanding of the origins of erosional features on NRMA lands. In general, it can be shown that gully cutting is triggered by drought and wet cycles but locally controlled by land uses that change the rainfall-runoff properties of the landscape (e.g., grazing, agriculture, roads, culverts, and trails).

In summary, the 1977 drought set the stage for the development of subsurface piping. The subsequent intense rain events of 1977 (and later years) produced piping, resulting in gully formation through the process of pipe collapse. Poorly constructed roads and trails have fostered gully formation and growth since that time.

Watersheds of the NRMA

The most important hydrologic function of the NRMA is the capacity for groundwater recharge. Rainfall rarely exceeds local evapotranspiration, and very little is lost as runoff. The 15,000 acres of NRMA land comprise a very efficient site for capture of rainfall. Because the landscape has been repeatedly remolded by dune migration during the past one million years, a complete drainage network has not fully developed on the NRMA lands. Despite the scant 12-15 inches of average annual precipitation, recharge efficiency is probably in the range of 15-20 percent. Thus, 15,000 acres provides approximately 2700 ac-ft of recharge annually to deep groundwater. Some of the groundwater is extracted by wells and some retards seawater intrusion in the Seaside and Del Rey Oaks area.

Three large watersheds and 104 significant subwatersheds are identified in this report (Fig. 4, Appendix A). The principle watersheds are the Seaside (23.4 km^2; 39% of NRMA land area), Salinas (25.3 km^2; 42% of NRMA land area), and Toro Creek (11 km^2; 20% of NRMA land area). The Salinas and Toro Creek watersheds have significant channel networks, whereas the Seaside watershed has chiefly internal drainage (Fig. 8.)

The Seaside watershed conveys water indirectly to the Pacific Ocean via groundwater through the Seaside groundwater basin. The Salinas watershed directs surface water toward the Salinas River, but contributes most of its precipitation to groundwater recharge of the Salinas and Seaside aquifers. The Toro Creek watershed contributes water to the Toro Creek groundwater basin, and conducts water and sediment to Toro Creek before entering the Salinas River.

Hydrology of the Seaside Watershed

The Seaside watershed (Fig. 4) comprises the gently westward-sloping, rolling topography adjacent to the city of Seaside, mainly along North-South Road. The Seaside watershed continues beyond the NRMA border to the modern dunes of Seaside and Sand City. The geology is mainly Quaternary sand dune deposits (Aromas Formation and "older dune" deposits; Fig. 3). The soils formed on those units are the very permeable Arnold and Baywood soil series (Fig. 9). The topography created by a 30-meter digital elevation model clearly preserves the muted dune crests and troughs of the old dune field (Fig. 10).

The old dune morphology, permeable soils, and low slopes have hindered the development of a fully-integrated drainage network. The surface hydrology is a complex mosaic of ephemeral streams with internal drainage. The combination of good vegetative cover, an inefficient surface drainage network, and very permeable old dune soils creates a landscape that greatly favors infiltration over surface runoff. Thus, the Seaside watershed is a critical recharge area for the Seaside groundwater system. Almost no water that falls on the ground here leaves as surface flow. Future land use that alters the hydrology of this area will have a marked effect on the long-term function of the Seaside groundwater basin. The water table is presently approximately 50 ft. above sea level, or about 350 ft. below the land surface. The water table elevation has been dropping through time as groundwater withdrawal chronically exceeds natural recharge.

Hydrology of the Salinas Watershed

The Salinas watershed (Fig. 4) comprises the northeastward-sloping ridges and valleys draining the northwestern half of the BLM property. Like the Seaside watershed, the topography includes the muted dune shapes inherited from the past (Fig. 10), but is more geomorphically dissected than the Seaside watershed. The presence of a greater range of geological substrates and slopes gives rise to six soil types in this watershed (Fig. 9). All of the soils are moderate- to well-drained but susceptible to erosion and slope failure if poorly managed. A network of roads and trails cuts the landscape, but large tracts of intact vegetation exist as a well-connected mosaic.

The old dune morphology preserved in the northern quarter of the Salinas Watershed results in a poorly-integrated surface drainage network that includes vernal pools and other closed depressions. In contrast, the southern three-quarters of the watershed is dissected by subparallel canyons with northeast-flowing ephemeral channels. These valleys include Trail 23 Canyon, Impossible Canyon, Wildcat Canyon, Barloy Canyon, Mudhen Lake, Pilarcitos Valley, and Engineer Canyon. Although a well-developed dendritic stream network is present here, infiltration still dominates over runoff, except during very intense rainfall events. This part of the BLM lands contributes groundwater to both the Salinas basin and Seaside groundwater basin. Although the regional water table is typically several tens of meters deep here, locally perched aquifers exist atop quartz-cemented paleosols in the Aromas Formation. These perched aquifers form local wetlands where the topography is low enough to intersect the water table. Vernal pools exemplify a perched aquifer system (Johnson, 1993). Other local perennial wetlands exist where deep gullies have cut down to intersect a small, perched aquifer. An example of this kind of wetland can be found in Mudhen Lake Gully. The deep water table near this region is approximately 15 ft. above sea level (Underwood, 1998).

Hydrology of the Toro Creek Watershed

The Toro Creek watershed (Fig. 4) forms the southeastern edge of the NRMA. It is a southeasterly sloping region of dissected rolling hills and steep canyons.

The bedrock geology is predominantly Paso Robles Formation with sporadic outcrops of Santa Margarita Formation (Fig. 3). Although not accurately shown on current geologic maps (Fig. 3), the Aromas Formation is also present in the northeastern and southwestern parts of the watershed. These deposits are chiefly covered by the Santa Ynez soil series, but Xerothents, Arnold, and Diablo soils also occur (Fig. 9). The Toro Creek watershed land use includes sheep grazing. This watershed has a lower road and trail density than the other two watersheds.

Well-developed valleys connect the uplands of the watershed with the ephemeral Toro Creek channel. Two types of valleys exist, providing different types of surface hydrology. Colluvial valleys have poorly developed channels, whereas gullied valleys have well-defined channels. The colluvial valleys usually percolate excess precipitation into the subsurface, and convey surface flows only during very intense rains or when soils become saturated late in the rainy season. The gullied valleys are characterized by steep gradients that easily conduct surface runoff and sediment. The amount of runoff and sediment the NRMA contributes to the greater Toro Creek watershed is discussed in detail in section E.

E. Erosion and Sediment Yield

The greatest threat to soil health in the NRMA is widespread erosion, which removes topsoil and leaves a hard-crusted subsoil that is difficult to revegetate. We have identified approximately 100 erosion sites during field reconnaissance of the eastern half of the NRMA (Appendix B, Fig. 11, Fig. 12). Some of these sites require proactive restoration, but others may be left to recover naturally if resources are limited. Gullies and rills are widespread across BLM land, almost independent of soil type, geology, or ecosystem (Appendix C). Gully and erdability factors in the NRMA may be generalized as follows:

1. fewest gullies occur in regions of very low slope, such as SA5-SA10 (Fig. 13),
2. the worst gullies occur in veneers of Holocene dune sands that have partially filled hollows and canyons throughout the NRMA, and
3. parcels of maritime chaparral located far from the influence of roads have the lowest density of erosion sites.

Old cemented soil layers in the Aromas Formation are resistant to gullying; however, wedges of Holocene dunes on steep lee slopes or in protected canyonsare highly susceptible to erosion (e.g., Mudhen Lake gully-Site 10, Appendix B). Almost all ungraded roads made by the military in the Aromas Sandstone areas of BLM lands are located on these Holocene dune sand stringers and blankets because those were the only places with relatively uniform gradients and few rocky outcrops where a jeep or tank could be driven.

Seaside Watershed Erosion Potential

Slopes in the Seaside watershed are generally between 0° and 13°, with slopes rarely as great as 15° (Fig., 13, Appendix A). Specific erosion problems in this area are not well known because access to the area is currently restricted. Where the land is accessible, there are examples of severe erosion associated with old roads (e.g., SE04, Fig. 4). Reconnaissance of a portion of the inaccessible lands by digital orthoquad and 1-m resolution aerial photography reveals that an extensive road and trail system (Fig. 14) through very unstable soils and geological substrate (Qoe, Qod, Fig. 3) has likely lead to considerable erosional problems. Subwatersheds SE12, SE13, SE16, SE29, SE40, SE37, SE45, SE66, SE68, and some adjacent areas appear to have a very high density of roads and will likely require greater restoration effort than other regions of the Seaside watershed (Fig. 4, Fig. 14).

Toro Creek Watershed Erosion Potential:

The Toro Creek watershed has a combination of physical factors that make it exceptionally prone to deep gullying during rare intense rain events. Lands most prone to gullying exist where water runoff has been artificially concentrated by roads. Shallow landslides are present in subwatersheds TC06 and TC03 (Fig. 4). Approximately fourteen landslide features were previously identified in this watershed (Fig. 3; Clark et al., 2000). These features were not verified during this study, so more fieldwork is required for both verification and site specific recommendations.

The landscape instability factors present in the Toro Creek watershed include:

- steep slopes (up to 35 degrees; Fig. 13),
- high relief (up to 700 feet; Appendix A),
- thick erodable soils (xerothents Arnold and Diablo soil series; Fig. 9, Appendix C),
- absence of deeply-rooted shrubs and trees (Fig. 15), and
- abundance of generally shallowly-rooted annual grasslands (Fig. 16).

Salinas Watershed Erosion Potential:

The Salinas watershed has a great physical and ecosystem diversity (Appendix A, Fig. 16), which yields a highly variable erosion potential. Slopes in the watershed are as steep as 35 degrees and the relief is locally as high as 300 ft. Clark et al. (2000) mapped numerous landslide deposits in the Pilarcitos, Barloy, and Picnic Canyon subwatersheds (SA14, SA15, SA12; Fig 4). These features were not verified during this study, and more research is required for evaluation. The Salinas subwatersheds underlain by Paso Robles Formation and supporting a grassland ecosystem will share the general erosion potential described above for the Toro Creek watershed. The Salinas subwatersheds underlain by the Aromas Formation and other dune deposits, which typically support the maritime chaparral ecology, share the erosional potential described above for the Seaside watershed.

Vegetative Cover and Soil Health

The main sources of information on the soils of BLM lands are Soil Conservation Service Monterey County soil maps (USDA, 1978); the "Soils Baseline Study" (USACE, 1992), which was strictly derived from USDA (1978); and, a preliminary soils overview (Johnson, 1993) commissioned by the U.S. Army Corps of Engineers. Both Johnson (1993) and the present study find the USDA (1978) report to be generally accurate in subdividing the soil series present, but also somewhat inaccurate in detail. The regional variability of these soils series was not well described in USDA (1978), so local studies like Johnson (1993) must be commissioned if accurate details are required.

Given a steady climate, the physical integrity of the landscape is generally controlled by the local slope gradient, size of the drainage area contributing flow, geological substrate (rock, alluvium and soil), and the type, and condition, of the plant community. Previous studies (USACE, 1992) have divided the soils of the NRMA into several descriptive classes based upon the Monterey County soil maps (USDA, 1978). U.S. Army Corps of Engineers (USACE, 1992) depict maps showing the distribution of soils with

1) low strength,
2) high shrink-swell potential,
3) piping potential, and
4) a range of erosion potentials (moderate to very high).

As suggested above, data that went into those maps is not as site specific as required for practical land management on BLM lands. Based upon reconnaissance of the BLM lands, we conclude the following points regarding the USACE (1992) report.

1) Soils with low strength are much more widespread than depicted in USACE (1992, p. 13). The areas with stronger substrate are too small, or spatially complex to be usefully depicted at the 1: 84,000 map scale produced in the USACE report.
2) USACE (1992, p.16) greatly underestimates the distribution of soils with piping potential. Soils that produce subterranean piping (integrated macroporosity) are very prone to infrastructure failure and gullying. The map of soils with piping potential in USACE (1992) omits the “Xerothents”

soil series that forms above the Paso Robles Formation (Fig. 9). We observed more piping in the Xerothents series than in any other soil type.

3) USACE (1992, p.18) shows a map with three levels of "erosion potential." Based upon the wide distribution of gullies and other erosional problems, we conclude that the erosion potential of BLM and future BLM lands is virtually independent of mapped soil type, but can be better understood in a broader context of equilibrium landforms, ecology, and land use. This conclusion is supported by Vandekerckhove, et, al (2000) who found that vegetative cover, rather than soil type, was the most important element to consider in predicting gully initiation in Mediterranean climates.

Our observations indicate that excessive erosion, including gullying, is strongly linked to three physical settings (Table 4). First, nearly all of the erosion sites we saw were developed where soil surface permeability is low and surface runoff is concentrated and conveyed to a susceptible landscape. This situation occurs along certain ridge-top roads and roads with steep gradients. Second, there is evidence that the construction of valley bottom ponds or reservoirs modifies the hydraulic gradient enough to generate deeply incised gullies that can quickly grow upstream, downstream, and laterally, leading to severe landscape destabilization. Conversely, the potential for erosion is very low where soil surface permeability is high, vegetation is intact, and roads or trails do not concentrate surface flow. In the absence of landscape disturbance, the combination of vegetative cover, strong root systems, and extremely high infiltration rates of BLM soils ensure that most of the annual precipitation percolates down into the soil profile, rather than producing erosion through overland flow.

Although erosional problems occur in all physical and ecological settings of the NRMA, it is widely understood that appropriate vegetative cover reduces the risk of soil loss because of erosion or mass-wasting processes. The two greatest limits on percent vegetative cover within the NRMA are gullying and bare compacted soils left after
extensive vehicle use. The bare regions include old roads and old, broad, maneuvering areas. The watersheds with the greatest apparent densities of roads include SE12, SE13, SE16, SE29, SE40, SE37, SE45, SE66, SE68, (and some adjacent areas), SA18, SA19, SA07, SA28, SA12, SA11, SA25, SA26, SA20, SA22, and TC02 (Fig. 14). The lowest density of roads is found in the Toro Creek

subwatersheds (TC03-TC11). It is beyond the scope of the current study to catalog the innumerable old roads and broader barren regions that will require restorative measures. A road and trail inventory is concurrently being conducted by the Watershed Institute (California State University Monterey Bay)

Table 4 Typical Erosion Sites of the NRMA

Physical Setting	Soil Erosion Causes	Processes	Example	Prevention	Restoration
Ridge crest road	Concentrated flow	Culvert, roadside ditch, or impermeable surface concentrates flow and conducts it to a high-gradient slope with weak substrate	Skyline Gully and Mudhen Lake Gully	Reconstruct the ridge-crest trail or road to foster sheet flow or infiltration, or redirect flow toward a low-gradient slope with dense vegetation	Same as "prevention," but can restore equilibrium physiobiological conditions in gully and reduce hydraulic connectivity between gully head and ridge top.
High-gradient roads and trails	Concentrated flow	Road or trail with low permeability graded at too steep of an angle down a slope. Resulting concentrated, high velocity flows cut all soil types on BLM lands	Innumerable examples on BLM lands.	Careful geotechnical engineering analysis of corridor where new roads and trails are planned, building roads at lower gradient, and employing strategies to deconcentrate flow or foster infiltration	Alter the surface to redirect the concentrated flow laterally into areas with high strength. Spacing of flow deflectors should be closer on weaker and/or steeper slopes, prepare soil and restore reference ecology
Above and below ponds and reservoirs constructed in valley bottom	Local base level change and gradient changes in valley bottoms	Cutting into valley bottom locally oversteepens the valley bottom on upstream side of excavation, initiates upstream headcut. Pond outflow concentrates flow downstream from reservoir, initiates downstream instability	Pilarcitos Canyon and subwatershed TC03	Avoid cutting ponds in valley bottoms, or correctly engineer them to maintain upstream, downstream and lateral stability in the watershed.	Fill reservoirs, reshape gullies, reestablish equilibrium valley bottom substrate, gradient and vegetation

Another general factor that can limit vegetative cover is soil health. The chaparral ecosystems that flourish on NRMA lands exist, in part, because other communities and many non-native species cannot tolerate the difficult, severely under-fertilized soils found in the region. However, attempts to improve soil health through fertilization may increase the opportunities for invasive species rather than foster a strong native ecosystem.

Ecosystem/Soil issues on Paso Robles Formation Substrate

Soils developed on steep, grassy, eroding colluvial slopes such as those over the Paso Robles Formation of southeastern BLM lands (TC2-TC11, SA20, SA23; Fig. 3) have a plant cover that tolerates both burrowing animals and wet-dry creep cycles. Grassland species of both gramminoids and forbs are adapted to these conditions. Both perennial and annual grasses regrow the roots annually and have many roots so that losses of one cluster of roots are not fatal. Forbs that live with such slope-adapted deep-soil grasses generally have tap roots that tolerate breaking or scraping off of root hairs and that have reserve plant resources to continually regrow those root hairs.

Subterranean piping is very prevalent in this soil. Although deep cracking during wet-dry cycles is probably the leading cause of piping and gullying, an apparent contributing factor is the local high density of mammal burrows. The high density of mammal burrows may be linked to the paucity of predator-supporting trees and bushes.

The southeastern slopes of the NRMA are remarkably barren of trees as compared with the rest of the NRMA and similar landscapes in coastal central California. Figure 15 is a photographic view contrasting the relatively treeless grasslands on the southeastern flank of BLM lands with the more diverse grassland/oak woodland mosaic located on the southeastern side of Toro Creek. The lack of trees may be partly responsible for the local density of soil slips and hillside gullies in this part of the NRMA. There are several links between tree density and slope stability.

- Deeply rooted trees increase the root network for slope stability.
- Trees decrease surface runoff through evapotranspiration and canopy interception of rain.

- An ecosystem mosaic that includes tree patches reduces the density of burrowing mammals by providing perching, hiding, and thermal cover for predators

The general landscape instability and our qualitative observations of similar landscapes in the region strongly suggest that the ecosystems of the relatively treeless southeastern slopes of the NRMA are not within the natural range of conditions typical of the region. However, no change in management strategy is advisable without further specific research that rigorously addresses whether or not the southeastern slope ecosystems fall within the acceptable natural range of the region. If it is found that a mosaic of oak woodland patches is appropriate, then the lands should be managed to enhance those conditions. The oaks and shrubs in similar settings are more abundant in the creases and swales of the landscape than on steep side-slopes, probably owing to slightly elevated soil moisture in that part of the landscape.

Ecosystem/Soil issues on Dune Sand Substrate

In the watersheds where soils are more stable and do not creep every winter or spring season, species with woody roots and mycorrhizal associations are favored. On the Aromas and the "older dune sands," (Fig. 3) soils are poor in nutrients, particularly nitrogen and phosphorus. Plant communities rely on soil microflora and microfauna to balance nutrient exchange, transport and plant seeds, capture and hold dew and sparse airborne moisture from fog, and share and scavenge precious nutrients. Cryptogrammic soil crusts are found in all Fort Ord chaparral communities and complex mycorrhizae probably exist in most communities. Soil organic matter is typically low.

Ecosystem/Soil issues and Invasive Ants

Argentine ants are very common in the suburbs surrounding the NRMA and are present within the NRMA as well. A recent study of an Argentine ant invasion in South Africa indicates that the species can have a very negative impact on ecosystems similar in climate and vegetation to California chaparral (Christian, 2001). A diverse community of the many species of native ants and beetles is necessary to keep the soil aerated, to plant seeds, and to nurture soil fungi. When fresh seeds fall, ants are attracted to them and carry them off to bury in their nests. Different ant species specialize in seeds of different sizes: Ants that work cooperatively bury bigger seeds, while ants that tend to work alone bury smaller ones. If the seeds are not picked up quickly, virtually all are eaten by rodents. Argentine ants do not bury seeds at all, and can eliminate beneficial native ant species (Christian, 2001), thus upsetting a critical process at the base of the ecosystem.

Christian (2001) found that when Argentine ants displace native ants, plants that depend on those ants to bury their seeds do not regenerate after fire. As occurs in California Chaparral, wildfires sweep the fynbos every 15 to 30 years, killing most mature plants. New plants grow from seeds buried in the ground by native ants. Christian (2001) carried out controlled burns of areas in fynbos to see whether the invading ants had a real effect on the plant community. After burning, invaded areas showed a tenfold drop in the number of new plants from large-seeded species as compared to uninvaded areas (Christian, 2001).

Where non-native ants have invaded near NRMA lands, plant regeneration is compromised and species diversity and plant cover decreases. Argentine ants appear to follow roads and trails. The depletion in plant reproduction is seen as a halo around such disturbances in the chaparral communities adjacent to BLM lands on old Fort Ord (Grey Hayes, personal communication, 2001). Although small groups of Argentine ants have been seen near buildings on the NRMA, it is possible that the NRMA will be spared a major invasion because the microclimate is somewhat drier than the coastal areas where the ants have successfully colonized. If the ants do advance on the NRMA, their presence will represent a serious threat to ecosystem and soil integrity in the NRMA. There are currently no sensible management policies that can control the invasion of Argentine Ants.

Dominant Erosion Processes

For the purposes of discussing erosion processes, the NRMA can be divided into undissected dunes where internal drainage prevails, and canyon lands where dunes have been dissected and older formations are exposed. The substrates of the Seaside (SE1-SE60) and northern Salinas (SA1-SA10) subwatersheds are mostly undissected Holocene dunes. Steeper slopes in these areas are highly erosive and subject to gullying where cut by roads and trails; however, most of that sediment will be trapped in the internal drainage of the old dune fields.

High erosion rates in these settings could pose an ecosystem threat if the low, inter-dune areas are supporting vernal pools or other wetland vegetation. A small interdune area near the BLM office is one example of a wetland ecosystem being filled in and dried by locally-derived sand (Fig. 17). The Seaside and northern Salinas watersheds are essentially continuous blankets of dunes while the rest of the Salinas and Toro Creek subwatersheds are mosaics of older substrate materials with young dune sands filling old gullies or deposited on the southeast flanks of hills and cliffs. Those sand-filled canyons and hollows have been stable for 10,000 or more years but were severely gullied in the last decade by the first 6-year El Nino sequence to follow military activities. Mudhen Lake gully and "The Chasm" (erosion sites #2 & #67; Fig. 13, Fig. 18) are examples of sand-filled canyons that were long stable, but are now losing their late Pleistocene and Holocene sand to gullying. This pattern of long-term (10,000 year) stability punctuated by recent landscape instability is very widespread in California (Reneau et al.,1986).

“Skyline gully” (erosion site #33; Fig. 19) apparently began significant erosion in 1992-1993 below an area used by the military to practice road building (Fig. 19). It was the focus of the earliest restoration efforts near the time of Base decommissioning (Watershed Institute, 1995). This site is characterized by colluvial soils derived from a mixture of wind-blown sand and poorly consolidated terrestrial alluvial sediments of the Paso Robles Formation (Fig. 3). In the bottoms of steep canyons the colluvial mantle is approximately 2 m (6 ft) thick. The colluvium was the locus of piping cracks and subsurface channels that eroded to rapidly form a deep inner gorge in the 1980's and 1990's. That process has now reached the headwater and is beginning to cut into old buried side swales.

The deposition of sand generated by erosion of the NRMA is a BLM management issue. Most of the recently-destabilized land surfaces drain into internal low-gradient canyons or closed basins within the NRMA. The primary exceptions are gullied Toro Creek subwatersheds such as Skyline gully (TC6; Fig. 4) and Pilarcitos Canyon mouth (SA20) where net sediment is transported off the NRMA lands. The mouth of Pilarcitos canyon has a sand fan that extends into adjacent Merrill Ranch (Fig. 20). The sand fan has killed a stand of Coast Live Oak Riparian Forest through partial burial. The sand was derived from “The Chasm” (Erosion site #67, Fig 18).

Gully-and-rill erosion is the dominant process that mobilizes sediment within the NRMA. Sediment delivery to watercourses is highly variable over the NRMA. The most efficient delivery is in the El Toro creek basin and the least efficient delivery is in the future BLM lands of the Seaside watershed. Quantitative estimates of sediment yield have not been developed yet, but the existing inventory allows such an assessment to be made. Within the El Toro Creek watershed, NRMA lands probably contributed, over the past decade, approximately equal volumes of sediment from gully-and-rill erosion on uplands and from lateral bank cutting in El Toro channel. Sediment volumes from each source may be on the order of 13,000 cubic yards over the decade 1991 to 2001, based upon local, preliminary serial cross sections.

In the Toro Creek watershed, where the Paso Robles Formation is the substrate, upland gully, rill, and piping erosion deliver sediment directly to ephemeral and intermittent watercourses (e.g., Fig., 18, Fig., 19, Fig. 20, Fig. 21). This sediment may be temporarily trapped in stock ponds, as for example below Eucalyptus gully (erosion site #89; Fig. 19), or may be delivered directly to El Toro Creek through side channels. As side channels become stabilized by vegetation, sediment is trapped and aggradation occurs. Sediment trapping is currently occurring in the lower reaches of most gullies in the NRMA, including Skyline Gully (Fig. 19). The sediment trapping is typical of years with moderate rainfall. During extreme events, it is likely that the sediment stored at gully mouths will be eroded and moved further downstream.

Since piping is clearly a precursor to major gully events, it is advisable to identify and monitor the regions with piping networks. Then those sites can be hydraulically modified to reduce the impact of piping. Sites that are contributing to piping are not easy to define with reconnaissance level reviews. Careful fieldwork is recommended during and immediately after high-intensity rainstorms. One technique for evaluating headcutting subsurface piping networks that lead to later gully formation is to go out immediately after a hard rain and listen, with a long-pole stethoscope, for sounds of moving water underground. With practice, large areas can be assessed within a few available hours after a rain. It is possible that piping erosion is not important today except adjacent to newly formed deep gullies. If we have another several-year drought with infrequent rain that is widely distributed in time, new piping vulnerability may occur due to soil cracking and desiccation. This needs to be assessed with winter fieldwork.

NRMA Hydrology and Sediment-Transport: Context Within Toro Creek Watershed

NRMA lands can contribute relatively little to the surface flow of El Toro Creek or infiltration to the El Toro area alluvial aquifer because the 11 km^2 Toro Creek subwatershed of the NRMA composes only 12% of the 94 km^2 greater Toro Creek watershed (Feikert, 2001), and the NRMA is lower and receives less precipitation than the lands south and east of Highway 68. On the other hand, high-intensity rainfall does generate short-duration high-volume flows from the NRMA into El Toro Creek during some years. These rare events occur because the ephemeral gulches draining southeastward into El Toro Creek have steep gradients and are largely underlain by Paso Robles Formation rather than the more permeable dune deposits prevalent elsewhere within the NRMA (App. A; TC2-TC11, Fig. 3). Based upon measurements in TC03 during one event in 1998, these high-volume flows may comprise 4 to 6 cubic feet per second for durations of up to 6 hours, and thus contribute a small proportion of the storm flow peaks in El Toro Creek. This general magnitude of discharge may be typical of TC06 and TC09 (Fig. 21), and TC11, which are similar watersheds. These flow peaks scour sediments from the gullies on BLM lands and from adjacent lands closer to the Laguna Seca area.

Detailed sediment transport studies have not been done to specifically define the contributions from the urbanized portions of the El Toro watershed as compared to the BLM lands. Based purely on stream channel geometry and bed sediment, it appears that the sediment volume that passes under Reservation Road to enter the Salinas River is primarily derived from bank erosion along El Toro Creek below the Highway 68 bridge. The next largest contribution comes from the El Toro Creek channel and uplands south of Highway 68, while a smaller but still significant contribution comes from BLM lands. As a preliminary estimate we suggest that about 40-60% of the sediment is derived from in-channel sources below highway 68 bridge; 30-40 percent comes from the upper El Toro watershed lands and channels, and 10-15 percent comes from channel erosion and gully erosion on BLM lands. These values are best professional judgment based upon unpublished data (Bob Curry, CSUMB Watershed Institute). We emphasize the need for more detailed, long-term measurements if more accurate values are required for management decisions.

The sediment budget of Toro Creek is complex for a number of reasons, including the interacting effects of natural stream scour and fill cycles, fluctuating water and sediment levels in the Salinas River, and the under appreciated effects of periodic Toro Creek channel "maintenance." In general, when the bed of Toro Creek scours downward or erodes laterally into the mouths of the BLM subwatersheds for any reason, gully-enlarging headcuts migrate up into BLM lands. It is our belief that most of the sediment derived from BLM lands is a direct result of incision and lateral cutting of El Toro Creek itself. The causes of channel incision are many. The Toro Creek channel episodically fills with sediment and then scours down. This is common behavior in arroyos throughout the world (Bull, 1997). Complicating the natural behavior of Toro Creek, is the interaction with the Salinas River system. Natural or anthropogenic fluctuations in the mean elevation of the sandy bed of the Salinas River will alternately produce a dam or headcut at the mouth of Toro Creek. The impacts of that interaction can translate far up the channel, especially during major Salinas flood events. A sewage treatment plant and agricultural return flows provide year-around subsurface water in the lowermost part of the El Toro channel near Reservation Road. The resulting riparian vegetation traps sediment and causes many feet of annual aggradation during years with through flow. Monterey County has been attempting to excavate this sand-sized sediment to allow through transport of sediment to the Salinas River. This periodic excavation of sand from El Toro Creek produces significant headcuts to migrate up Toro Creek. These anthropogenic headcuts can also destabilize the BLM tributaries as described above.

Severe channel adjustments in Toro Creek during rare intense runoff events can also lead to instability in BLM lands. Past student and faculty work at California State University Monterey Bay has documented El Toro bank erosion during the El Nino years of 1995 through 1998 (e.g., West, 1999). Channels have widened by 100 ft or more and have aggraded (built up their beds) several feet in single storm events. We recommend a monitoring program to both document relative contributions from the three primary sediment sources identified here and repeated cross sections to track erosional headcuts and the movement of sediment pulses within the disequilibrated lower El Toro Creek channel.

Encouraging dense riparian vegetation along Toro Creek will greatly reduce sediment contributed by Toro Creek bank erosion. Fostering a high water table is the best way to ensure a healthy riparian corridor. Withdrawal of groundwater in the lower El Toro Creek alluvium and Santa Margarita sandstone beneath and adjacent to the NRMA creates a seasonal groundwater deficit. This is partly replenished by excess domestic runoff in the summer from golf courses and residential sites upstream and adjacent to the lower creek bed. Because of that seasonal deficit, many years are characterized by no flow in El Toro Creek downstream of the mouth of "Skyline gully" and the U.S. Geological Survey El Toro gauge site. Fish that move upstream from the Salinas River on those years when there are short periods of through-flow are almost always stranded in the loosing reach of lower El Toro Creek. It is recommended that BLM not support or allow groundwater withdrawals on its lands along El Toro Creek. A higher summer water table would support a healthy riparian forest along Toro Creek. A healthy riparian ecosystem would virtually eliminate bank erosion problems.

F. NRMA Plant Communities

The NRMA is home to twelve plant ecosystems. Four of these have perilotic associations (pond, vernal pools, coast live oak riparian forest, and mixed riparian). Eight of the communities are upland associations. These include three types of grassland (wildrye, needlegrass, and annual), three coast live oak associations (inland, coastal, and savanna), maritime chaparral , and coastal scrub (Fig. 16). App. D shows the distribution of these ecosystems by subwatershed.

HMP Habitat Types

While twelve habitat types occur within the NRMA, maritime chaparral (64%) dominates the landscape (Fig. 16). Annual grassland composes the next largest plant community (17%). The remaining 19% of the lands comprise:

Blue wildrye grassland (0.5%)
Coast Live Oak Riparian Forest (0.3)
Mixed Riparian Forest (1%)
Coast Live Oak Savanna (2%)
Coastal Coast Live Oak Woodland (3%)
Inland Coast Live Oak Woodland (8%)
Coastal Scrub (1%)
Ponds and Freshwater Marsh (0.2%)
Valley Needlegrass Grassland (3%)

Vernal Pools (0.2%)

The HMP "habitats of interest" are riparian forests, perennial grasslands, and vernal pools. These habitats have low relative abundance, but serve key roles in supporting species of concern and landscape stability.

Native and Introduced Species

The “weeds” of the NRMA are a great threat to ecosystem health. The distribution of non-native plants identified by the BLM is provided in Figure 22). The distribution of non-native species is summarized by subwatershed in App. D. Restoration efforts must include a vigorous follow up effort to eradicate non-native species. A pre-emergent herbicide application may be advisable early in the growing season at restoration sites, but more research should be done on this topic. The “War on Weeds” efforts continue to be a valuable community effort for weed control.

Threatened or Endangered Species

The HMP species of concern that are known to occur within the NRMA include sand gilia, Monterey Spineflower, California linderiella, Seaside bird's-beak, Toro manzanita, sandmat manzanita, Monterey ceanothus, Eastwood's ericameria, coast wallflower, Hooker's manzanita, and California tiger salamander. Potential habitat also exists for red-legged frogs. The known distribution of the species of concern is provided by BLM data Fig. 23, and is shown by subwatershed in App. D. The preferred habitat and estimated habitat NRMA acreage for the species of concern are provided in App. E. By mapping the annual locations of the plant species of concern, the BLM is fulfilling another specific HMP management goal, “Track the ecological habits of sand gilia, Monterey spineflower, Seaside bird's-beak, and other species of concern in order to increase their numbers through habitat management.”

Habitats at Risk

The HMP defines the habitats requiring augmentation or protection. These HMP "habitats of interest" are riparian forests, perennial grasslands, and vernal pools. We agree with that analysis for the following reasons. The riparian forests compose only 1.3% of the NRMA. These forests are at risk from both eroding channel banks in destabilized valleys and from burial by high volumes of sand eroded from upland gully systems (e.g., Fig. 20). The native perennial grasslands are only a few percent of the NRMA ecosystem mosaic, but could add great physical stability to the grasslands of the Toro Creek and Salinas subwatersheds. Gradually replacing annual grasslands with perennial grasses would greatly reduce the number of acres in which non-native species thrive. The vernal pools are critical for year-round support of the amphibian and invertebrate species of concern and Contra Costa goldfields (App. E). However, vernal pool habitat composes only 0.2% of the landscape. Vernal pool habitat and other types of annual wetland can be quickly converted to a grassland or woodland habitat if eroding sands fill in the depression enough to raise the topography above the elevation of the annual or perched water table (e.g., Fig 17, Fig. 21). These three HMP "habitats of interest" should be given special consideration in future restoration and management plans.

Habitat Enhancement Opportunities

Many habitat enhancement opportunities exist in the NRMA. One goal of the HMP is that "significant habitat management efforts and restoration…are expected to add acerage within the NRMA that support the species of concern." That goal is realized annually as the BLM continues its chaparral restoration efforts, continuously adding acreage for the seven chaparral-loving plant species. The BLM will be adding significant new acreage of habitat as numerous miles of dirt roads and large patches of barren landscape undergo ecosystem restoration.

Will ambitious restoration efforts reduce the opportunities for the species of concern that thrive in disturbed sandy landscape (i.e., sand gilia and Monterey spineflower)? In our opinion the answer is no. Those species now thrive in the NRMA along existing roads and trails. Despite the ongoing restoration efforts, there will no doubt be a perennial mosaic of land disturbance because of fire, gullying, and the road and trail network that the BLM will maintain for recreational use, firebreaks and emergency equipment access. Along the perimeter of the NRMA there will soon be extraordinary opportunities for colonization as the adjacent lands are cleared for municipal growth.

The HMP "habitats of interest," vernal pools, riparian forest, and perennial grasslands provide additional enhancement opportunities. As gully systems are repaired or left to recover, the riparian zones and vernal pools impaired by sand deposition may slowly recover (e.g., Fig, 17, Fig. 20). Likewise, arresting headcuts in ephemeral stream channels will protect riparian forest from being undercut and lost. Examples of locations where riparian forest is endangered by head cuts or bank erosion include:

- Pilarcitos canyon (steep-sided channel along much of its length above Jack's Road),
- Subwatershed SA11 (erosion site #20, Fig. 13 is an incised channel and tall headcut),
- Toro Creek (banks are chronically unstable because of impaired riparian ecosystem)

Perennial grasslands can be fostered in all the areas now occupied by annual grasses. As detailed under section E, adding a component of oak woodland to the expansive grasslands in the Toro Creek subwatersheds would likely improve ecosystem function and landscape stability for a number of reasons.

Habitat Limiting Factors

The factors that limit optimization of the NRMA habitats include soil physics, invasive species, gullies, improper use of chaparral burns, feral domestic animals, and the potential for habitat fragmentation. The soils that support chaparral are typically "limited" in a variety of ways, such as having low fertility. These chemical limitations help chaparral out compete non-native species. The decommissioned roads that BLM is attempting to restore typically have very hard topsoil, likely associated with early inorganic cement. Even after ripping the soil for revegetation, the soils tend to return to a very impermeable, dense state that is not conducive to seed trapping and propagation. It is recommended that mulching, using shredded chaparral, be used to improve soil physics (see section G for example; Bert Wilson (Las Pilitas Nursery), personal communication, 2001).

As human populations continue to grow along the boundaries of the NRMA, there will be a natural increase in the number of feral cats and dogs that will impact the ecology in various ways. As has happened elsewhere at the boundaries between wilderness and development in California, there will be public pressure to control threats posed by large carnivores to humans and domestic animals. Mountain lions and coyotes will be lured to nearby neighborhoods for easy prey, especially when natural prey is scarce, as might occur following an ecological burn.

Mountain lions, which require extensive contiguous acreage for habitat, and to a lesser degree, coyotes may be impacted by habitat fragmentation (Nelson, 2001). If adopted, the highway 68 easement might reduce the contiguous acreage available for large mammals (Fig. 2).

G. BLM Restoration Treatments

Since 1995, the BLM and community partners have engaged in a plan of ecosystem restoration on the portion of the NRMA now held by the BLM. Each year the BLM office coordinates the restoration of approximately 8 to 12 sites. Typically the BLM uses graders for recontouring and ripping the sites and for building berms for surface runoff control. The Watershed Institute (California State University Monterey Bay) typically coordinates site revegetation using community volunteers through the "Return of the Natives" program. The restoration efforts have focused upon recontouring and revegetating old roads and other denuded areas, including some that are associated with large gully systems (e.g., the "Chasm" and Skyline gully; Fig. 18 and Fig. 19). As of the end of the 2000-2001 growing season The Return of the Natives program has replanted approximately 70 sites. Within some of those sites there are subplots where experimental procedures are helping to define the optimum use of ripping, amendment, and fertilization.

Location and Type of Treatment

The records of all the past restoration efforts are located in binders in the Fort Ord BLM office. The records include a selection of documentary photographs and limited site descriptions. The details of subplot treatments are recorded, but not always easily interpreted. The records for early sites are less complete than for recent sites. As the program matures, the need for accurate monitoring is realized. We recommend that the restoration records be recast in a standard format for archiving before the personnel with the specific knowledge of the sites lose valuable memories or are no longer associated with the project. The BLM is in the process of obtaining GPS locations for all the past restoration sites and refining the record keeping strategies. Some of the site data are archived in digital format. Appendix F is the list of sites available electronically as of Fall, 2001. We have processed the data from those sites in GIS format (Fig. 25).

Effectiveness of Treatment Meeting Established Goals

The BLM restoration goals are not formalized and success criteria are unclear. It is beyond the scope of this study to visit and evaluate all of the existing sites, but we provide guidance for formalizing the criteria for success and the methodologies for evaluating efficacy of restoration efforts. During our reconnaissance, we noted that some restoration sites were very effective in terms of matching adjacent ecosystems and/or erosion control; however, some sites fell short of common restoration goals. Six restoration sites studied in greater detail include Parker flats, Trail 67, Trail 26, the "Chasm," Skyline gully, and the Mudhen Lake gully system. We summarize our observations for five of those sites below. Mudhen Lake Gully is discussed in detail in Section H.

Parker Flat site evaluation:

The Parker Flat site was an eroded jeep trail that was treated and planted around 1996 (Fig. 17). Three experimental treatments at the Parker Flats restoration site were evaluated to see if topsoil importation or woody soil amendment improved ecosystem recovery and soil infiltration rates as compared to a control plot that was only ripped and planted, with no amendment (Table 5). In summary, soil importation produced the best conditions for infiltration and self-sustaining plant regeneration, however we did not evaluate this treatment for its density of non-native volunteers. We highly recommend that an evaluation of non-native species be done before topsoil importation is used on a widespread basis. The plot with woody soil amendment had locally improved infiltration and seedling volunteerism, but the effect was too sporadic, as if the amendment was sparsely applied or not fully mixed. Soil conditions were better where excess amendment had formed a surface mulch than where the soil had no surface litter. The control site had very hard topsoil with little surface roughness. Seeds that fell on that soil surface were windblown off site rather than being incorporated into the soil. Surface mulching with wood chips on future sites would increase moisture retention, reduce rainsplash erosion, increase the "time to saturation" (reduce surface flows), aid burrowing insects that break up the soil, and foster volunteer seed propagation. A cursory inspection of the undisturbed ecosystem adjacent to the site showed that an organic litter layer is a component of the natural soil system.

Trail 67 and Trail 26 site evaluations:

Trails 67 and 26 were steep jeep trails that had formed deep gullies in weak sandy substrate. The restoration efforts included regrading, forming flow diversion berms and planting. Although the two erosion sites were quite similar, they have responded differently to restoration efforts, with Trail 26 experiencing more post-restoration erosion and worse mortality than Trail 67. CSUMB students surveyed various planform characteristics of Trail 67 and Trail 26 (Fig. 26) to identify the specific elements that lead to the differences in restoration success. The survey data are summarized in very detailed comparative maps of the present geometry of flow diversion berms and rill networks. In brief, a greater frequency of flow diverting berms on Trail 67 produced more safe harbors for revegetation plots. The frequent berms in Trail 67 effectively divert surface runoff thus preventing highly erosive flow. Also, a well-defined sinuous trail that connects the successive berm crests helps protect plantings from bicycles and pedestrian traffic. The trail sinuosity and positive relief prevents erosive, concentrated surface flow from developing on the path. The Trail 67 “dendritic” drainage network is more efficient at draining the site and reducing the flow concentration. In contrast, the “parallel” rill network, oriented parallel to the slope, on Trail 26 tends to concentrate and accelerate flow down slope before being diverted off site. . The key difference in restoration design is the higher frequency of berms and the use of a single berm to define successive small drainage basins (see central berm in Trail 67 (Fig. 26)). The addition of surface mulch to the site would likely foster better soil conditions and improve new plant recruitment.

The “Chasm” site evaluation:

The “Chasm” is a deep gully that formed during intense El Nino rains (Fig. 18). The upland area above “the Chasm” has been regraded and revegetated to reduce the concentrated surface flows reaching the head of the gully. Despite the efforts to reduce overland flow concentration, recent monitoring work by CSUMB students suggests that rainfall in Winter of 2001 was enough to locally induce gully widening and headcutting. Gully evolution remains an ongoing source of sediment in the “Chasm.” It is advisable to

Table 5 Soil Characteristics of the Parker Flats Restoration Site (Fig. 17)

Name	Soil Preparation	Description	Depth of topsoil (cm)	Topsoil description	Typical ground surface "strength" (tons/sq.in before failure)	Typical topsoil "hardness" at 10 cm depth (tons/sq.in before failure)	Topsoil percolation rate (cm/hr)
Natural	Undisturbed	dense vegetation cover, much organic litter and new propagation	30+	greyish brown	very weak...loose leaf litter	1 to 3	Untested, likely very high
Plot A	ripped and mulched	good vegetation cover, slight presence of litter, much new propagation	20	brown, very heterogenous distribution of mulch	over 4.5 tons/ sq. in., but much weaker in mulchy zones	over 4.5 in absence of mulch, 1 to- 3 in mulchy pockets	15 cm/hr
Plot B	Ripped	sparse vegetation cover, no litter, hard barren ground between plantings	none present	tan, indistinguishable from parent material deeper in hole	2 to over 4.5 in top 1 cm of profile	over 4.5	5 cm/hr
Plot C	ripped and new sandy topsoil added	very dense vegetation cover, litter present, abundant volunteer grasses and new propagation	25	brown, sandy, 15 cm thick low-density organic rich layer present	0 to 1 very weak sandy surface	0 to 1.5	231 cm/hr

plant coyote bush within the gully itself to reduce flow velocity and trap sediment. Willow cuttings can also be established in the arroyo bottom and banks where natural seeps keep the gully wet enough to support willows. Reducing the side slopes of the gully walls would facilitate revegetation efforts and would reduce the rate of sediment generation from natural gully evolution, but the presence of heavy machinery would damage the restored upland area. Willows have already established a thick natural stand on the sand fan at the mouth of the gully (Fig. 18). It is likely that this willow forest will trap most of the sand from all but the most intense gully eroding storms. CSUMB students will continue to monitor the chasm to assess the transport and trapping of sediment in the "Chasm" system.

Skyline gully site evaluation:

Skyline gully is a deep, complex network of gullies cut by intense El Nino rains (Fig. 19). Figure 24 shows the barren upper watershed and locally excellent revegetation within the upper part of the gully system. Hay bale "check dams" placed in the upper watershed in 1995 are beginning to fail. Maintenance of that check dam system will help reduce flow concentration during major rain events. Deep-rooted perennial grasses can stem further upland erosion while willow and coyote bush planted to fill the gorges can stabilize the headcuts, and trap more sediment. Reduction of the slope angles on the myriad headcuts would facilitate planting and reduce the rate of headcut migration.

Mudhen Lake gully site evaluation:

The gully formed when intense El Nino rains were concentrated by a barren impermeable surface (Tail 22) in the headwaters. Mudhen Lake gully system includes a deeply incised gully treated with 42 tall check dams. As detailed near the end of this report, tall check dams are prone to failure in deep, young, gully systems. Of the 42 check dams, 18 currently require maintenance. Nearly all of the willow plantings associated with restoration efforts are growing very well. The headwaters are underlain by a very well cemented paleosol in the Aromas Formation. Successful restoration requires improvement I nthe headwater conditions to reduce surface flow and improve soil conditions for planting. Approximately several 100 m southwest of the main gully, another, smaller gully has begun to incise into the same weak substrate (Site #3; Fig. 12). Preventative work in the near future could prevent another large gully from forming in this subwatershed.

Creating and Meeting Restoration Success Criteria:

Successful restoration of BLM lands requires three integrated components:

- definition of "successful restoration,"
- implementation of methodologies that lead to sites with those characteristics.
- monitoring of sites to determine the efficacy of specific restoration techniques

The HMP suggests that a site is successfully restored if it supports naturally regenerating maritime chaparral that becomes a functioning part of the entire dynamic, managed maritime chaparral habitat of the NRMA. It recommends using natural, undisturbed sites as a measurement of success (USACE,1997). The HMP further specifies that successful restoration and management will produce suitable growing conditions for the annual sand gilia, Monterey spineflower, and Seaside Bird's-beak populations.

Reproducible evaluation of restoration sites on BLM lands requires an agreed upon list of (at least) qualitative characteristics that define success or not success. Once the criteria for success have been defined and achieved at a few sites through well-documented experimentation (trial and error), then the successful restoration methodologies can be institutionalized via personnel-training and a written documentation. At present, the criteria for success are not well-defined, the level of experimentation is low, and the documentation of restoration techniques is inadequate. Our recommendations for improvement follow.

Much of the concurrent “ecological” restoration on BLM lands relies on restoring both the biological and physical integrity of the landscape. These two goals are tightly linked because successful ecological restoration requires that the restored lands remain somewhat permeable and stable, and conversely, the stability of the landscape is strongly keyed to surface permeability and both leafy and subsurface plant structure. The best models for integrated physiobiological landscape restoration are local undisturbed reference sites that serve both as the benchmarks and blueprints for success. In wildland settings, where human culture imposes few constraints, a first order goal of restoration can be defined as follows...

Restoration should recreate, upon a disturbed landscape, the physical and biological characteristics and processes that produce equilibrium landforms bearing the highest quality habitat given the constraints of the region. The physical models for specific restoration sites comprise suitable reference sites selected from natural, functioning, undisturbed parts of the nearby landscape. The resulting restoration project should be indistinguishable from the surrounding terrain, given enough time to evolve toward the local climax ecology and equilibrium geomorphology.

Qualitative criteria defining a "successful restoration site" might include...

1) reasonably low mortality among transplants,
2) species composition that matches immediately adjacent, undisturbed reference lands, or has a reasonable chance of evolving toward that species composition through natural processes (e.g., Table 6)
3) strong evidence of sustainable regeneration or volunteerism, or soil surface textures that are conducive to accepting seeds for regeneration and volunteer propagation,
4) soils with relatively high surface permeability (well-drained soils),
5) little or no evidence of local soil erosion, and
6) restoration that enhances the stability of the greater landscape.

All of these qualitative criteria can be met if,

1) the site is reshaped to approximate the local "equilibrium landscape" (criteria 5 and 6),
2) proper species and species densities are selected and planted to match an adjacent ecosystem or reference site (criteria 1 and 2),
3) soil preparation is appropriate (i.e. matches the adjacent productive soils; criteria 1, 3, 4, 5, and 6),

4) landscape engineering reduces velocity of surface flow, fosters sheet flow over concentrated flow, redirects surface flow to an area with low erosion potential, or incorporates "hard" erosion control measures (criteria 5 and 6),

5) public access is limited (criteria 1 and 5), and

7) local rainfall intensity is not extreme before the site has had time to mature (criteria 1,5, and 6).

Table 6 provides an index for determining whether a maritime chaparral restoration site has achieved an appropriate composition. Table 6 was derived by combining tables of "mature" chaparral composition on "undisturbed sites" from the line-intercept sampling studies of Church and Kane (2001). Of note is the wide range of species composition between sites that were deemed by Church and Kane (2000) to be undisturbed. There is clearly no single index for choosing the plants at a restoration site. These data could be interpreted at least two contrasting ways. Either,

1) species composition of undisturbed maritime chaparral ecosystem has a wide range, suggesting great freedom in composing a restoration site, or
2) local climatic, physical, chemical, or genetic parameters strongly influence a local species composition, suggesting that great care should be taken to match the adjacent ecosystem composition.

Although future work might corroborate either hypothesis, it is prudent to refer the landscape adjacent to a restoration site as a guide for selecting the relative densities and spacing of specific plantings. This approach would craft a restoration site that ecologically and aesthetically blends with the ambient landscape as emphasized in the restoration success steps outlined above. Tables of species composition like Table 6 can be developed for other ecosystem types from undisturbed reference sites on the NRMA.

General Recommendations for Conducting Future Restoration Treatments

Soils and Restoration Strategies:

Based upon recent reconnaissance surveys of previous restoration sites on BLM lands, it is clear that soil physics and proper surface flow management are critical for successful restoration efforts. At several sites, the surface and topsoil layers develop a hard crust that severely impedes botanical survivability, regeneration, volunteer recruitment, and also creates excessive overland flow that can lead to erosion and gully formation.

Soil Preparation Strategies:

"Soil restoration" is an integral part of an overall successful restoration program. Site preparation techniques that create a loose, litter-covered, permeable layer of topsoil optimizes vegetative recovery and reduces erosion potential. The topsoil layer need not be deeper than about 20 cm to be effective for plant productivity and rain infiltration. This target soil condition are based upon reference to soils beneath undisturbed chaparral and experimental work at the BLM Parker Flats restoration site (Fig. 17, Table 5).

We recommend further studies that characterize the physical parameters of physically stable, proper ecologically-functioning, undisturbed reference sites within each of the 12 ecosystems of the NRMA. Once these soil parameters are known, then more site-specific soil treatments can be developed as part of the restoration plan.

The goal of soil restoration will likely be a well-drained soil with mycorrhizal function and a low proportion of invasive species in the seed bank. Based upon the treatments of Table 5 (Parker Flats), we recommend treating each ripped site with either a topsoil transplant from a very nearby site, or chipped chaparral. Apparently the chaparral can be used either as an amendment or as a surface mulch, since both uses achieved a loose soil surface at the Parker Flat site.

Table 6: Percent Cover in Mature Chaparral (Line Intercept Sampling Technique), Church and Kane (2001)

SITES	Range 18	Range 19	Range 24	Range 25	Range 26	"2000 burn area"	Average "cover" normalized to 100%
Species							
Sandmat Manzanita	36	17	12	3	0	7	10.32
Shaggy-barked Manzanita	19	68	68	65	53	63	46.24
Chamise	18	6	25	32	17	16	15.69
Sticky monkey flower	15	3	0.4	0.8	0.15	1	2.80
Monterey ceanothus	5	3	0.8	2	10	4	3.41
Black Sage	3	6	3	3	7	7	3.99
Eastwoods goldenbush	0	0.1	0.3	0	0	0.01	0.06
Dwarf ceanothus	0	4	0	0.04	26	1	4.27
Rush rose	0	0	0	0	9	0	1.24
Pitcher Sage	0	0	0	0	5	0	0.69
Coyote Brush	1	0	0	1	1	1	0.55
Mock Heather	3	0.2	0	0.5	0	0.3	0.55
Golden Yarrow	0.5	0.03	0	0.04	0.5	0.06	0.16
Coast Silk Tassel	0	0.5	2	0.3	1	0.4	0.58
Toyon	0	0	0	0	0	0.03	0.00
Deerweed	3	0.1	0	0	0	0.1	0.44
Silverbeach Lupine	0	0	0	0	0	0.06	0.01
Coast Live Oak	0	0.1	1	0.4	0	0.05	0.21
Fuchsia-flowered gooseberry	0	0	0.03	0	0	0	0.00
California Coffeeberry	0	0.2	0	0	0	0.04	0.03
Herbaceous vegetation	8	0	1	1	2	0.61	1.74
Bare ground	12	6	7	9	8	9	7.02

We recommend consultation with environmental professionals specifically experienced in restoration of California maritime chaparral plant communities (e.g., Bert Wilson of Las Pilitas Nursery). The following site preparation and planting techniques have been used in successful maritime chaparral restoration projects in other coastal California locations (Bert Wilson (Las Pilitas Nursery), personal communication , 2001).

1. Choose a site with compacted soils, but without a cemented paleosol, such as an old road.
2. Collect seeds from the undisturbed community of plants adjacent to the site.
3. Do not rip the site, or limit the ripping to one tine, to limit mycorrhizal disturbance and seed bank disturbance.
4. Use a backhoe bucket to excavate holes for transplants if soil is too compacted for hand tools.
5. Distribute the collected seeds to enrich the seed bank
6. Plant predominantly coyote bush on an approximate eight-foot spacing, or at the spacing of that species in the adjacent mature chaparral community.
7. Cover with a mulch of chipped chaparral
8. Manage weed propagation through an application of pre-emergent herbicide during appropriate points in the growing/rainfall season.
9. Allow mature chaparral to gradually evolve through a combination of seedbank sprouting, volunteer growth, and lateral growth of adjacent chaparral.

Although the *Installation-wide multi-species habitat management plan* (HMP; USACE, 1997) specifically suggests ripping compacted soil as part of site preparation, it is advisable to see if sites can be suitably prepared without disturbing the microbial community in the substrate, as suggested by Wilson's work. The benefits include, lower costs, higher success of long-term chaparral recovery, and weed suppression by preserving the extant mycorrhizal community.

Soils and Burning Strategies:

Optimizing the habitat landscape requires optimizing the shape and composition of the habitat mozaic (HMP). Fire-generated disturbance is essential for maintaining a mosaic of successional stands in maritime chaparral. The HMP states that control burns are a part of the NRMA management plan. The HMP suggests that the habitat quality of chaparral can be optimized by sequentially burning sub parcels (500 acres) at a frequency of about 15 years. The resulting patchwork of parcels with differing states of succession from recently burned to climax community could optimize the habitat diversity within the NRMA chaparral (USACE, 1997). However, the appropriate frequency of burns is debated (e.g., Watershed Institute, 1994). The pre-European burning frequency is unknown within the NRMA (Johnson, 1993). Determination of the proper burn frequency for NRMA chaparral must balance between a frequency of burns that optimizes habitat and a burn frequency that will not impair landscape stability through increased erosion. The increased risk of erosion following chaparral fire stems from a waxy resin exuded by burning certain chaparral vegetation. This waxy resin reduces the permeability of the soil, increasing the surface runoff during subsequent rain events. Also, the burned foliage is less effective at rain interception and evapotranspiration, further adding runoff volume. Slope stability returns when the chaparral regenerates itself and when the soil has regained its permeability through bioturbation or other mixing processes. Therefore, great care must be taken in planning the size, locations and frequency of ecological control burns.

A 1994 colloquium on "fire ecology" recommended the following points (Watershed Institute, 1994).

- Generate a good history of fires during the military control
- Study the seasonal effects of fires
  - Moist burns can damage seeds of obligate seeders
  - Spring burns might negatively impact the production of seeds in annuals
  - Native perennial grasses might prosper if burns occur before annual grasses go to seed
- Generate more information on the fire benefits or detriments on disturbance plants (e.g., sandmat manzanita and sand gilia) and other species of concern.
- Convene an annual fire ecology colloquium to discuss results of research.

H. Location and Type of Opportunity/Threat on BLM Lands

Although a great many roads and trails will be decommissioned and restored within the NRMA, this report focuses on erosion sites as the targets of future restoration efforts. Erosion is among the greatest threats to landscape stability and restoration of erosion sites offers the best opportunity to add optimal ecosystem acreage to the NRMA as mandated in the HMP. Here, we discuss gully system dynamics, management, and restoration, and the potential negative impacts of valley-bottom reservoirs. Finally, we provide a semi-quantitative method for prioritizing restoration sites.

Gully Evolution, Management, & Restoration within the NRMA

In section D, we linked gully formation on the NRMA with a dry-wet climate sequence and "back-to-back" El Nino events. We now discuss these gullies both within the broader context of general gully theory and within the narrower context of local landscape conditions to give further bases for land management policy and restoration strategy.

Arroyos and gullies are an historical part of the western North American landscape. Gullies are steep-sided eroding watercourses that are subject to ephemeral flash floods during rainstorms (Morgan, 1979; Hudson, 1985). They are larger than "rills'" which can be tilled (Food and Agriculture Organization, 1965), but smaller than "arroyos" (Bull, 1997). Gullies are always associated with accelerated erosion processes and with landscape instability. Although gully formation and evolution is complex, gullies are usually triggered by intense winter storms falling upon lands with altered hydrology or impaired plant ecology. In nearly every case of hillslope gullying in the NRMA, there is an associated road or trail system that compromised the upland ecosystem and hydrology leading to concentrated overland flow.

The arroyos and hollows where gullies form undergo a long evolutionary cycle that includes alternating periods of aggradation and degradation. Based upon observations on BLM lands and elsewhere in the region, the valleys like those that are present in the Pilarcitos valley bottom, "Mudhen Lake gully," and most of the rolling grassland watersheds that feed Toro Creek follow a somewhat predictable pattern of filling and emptying. They periodically fill with some combination of wind-borne or water-borne sediment and colluvium that slowly creeps and slides down slope from the valley walls. When the winter storms are intense enough to trigger severe erosion, the valley partially evacuates the valley fill through gully growth. When conditions have again changed, the valley will repeat the aggradation phase. These alternating processes are complex and somewhat unpredictable in detail; however, certain of their characteristics are well understood.

A gully erosion and recovery cycle has the following "typical" phases (Fig. 27):

1) equilibrium conditions with broad, well-vegetated valley bottoms;
2) very rapid downcutting (probably occurs in 30 years or less, or can happen in a single intense rainfall if valley ecosystem or hydrology have been modified from natural conditions),
3) gradual widening as unstable gully walls erode back to a lower angle (can stabilize in 10-30 years),
4) slow infilling with sediment (can take over 500 years in typical arroyos)
5) return to equilibrium conditions as the aggrading valley develops both permeable soils and the proper plant ecology.

On BLM lands, where the canyons and hollows were filled with dune sands and stabilized over the last 10,000 years, it is unlikely that the present gully systems will have a "step 4," valley-filling phase in the near future. Once these gully systems stop eroding downward, they will widen, and likely "heal" during steps 3 and 5 as the steep walls erode back and they become revegetated (e.g., steps A through C of Fig. 27).

Gullies are a crucial management issue for BLM personnel because gullies:
- can render large tracts of land impassable to vehicles, and sometimes even to hikers;
- can spread upward or downward through a watershed until the entire watershed is gullied;
- can create highly undesirable, barren, "badlands" topography;
- transport abnormally large volumes of water and sediment during intense rains; and
- typically deposit a "fan" of sediment at their mouths that buries and kills the woody riparian ecosystem; and

Successful gully prevention and restoration is based upon an understanding of how gullies form and naturally "heal" (Fig. 27). Indeed, one philosophical approach to gully management is to allow gully systems to evolve, untended, toward a new equilibrium landform. Gullies can naturally heal without human intervention; however, there is a multi-decade time-lag between gullying and complete self-restoration. Also, sediment erosion and transport can remain sporadically high during the healing process, and if left unchecked, gully networks can expand, converting, large tracts of landscape into badlands topography before significant natural revegetation can occur.

During the natural healing process, gully wall side slopes will become less steep through slope failure, colluvial movement and gravure until an equilibrium angle is achieved (Osterkamp and Toy, 1994). There are numerous gullies in various stages of recovery on NRMA land. Recovering gullies have dense vegetation in the gully bottom and actively retreating side slopes. Eventually, natural revegetation of the side slopes and head cut will occur as well and the rate of erosion and sediment generation will gradually diminish. The natural process of gully healing should lead to full stabilization in another 20 years in the NRMA. This recovery time estimate is based on work along the San Mateo coast and along the Pogonip watershed near UC Santa Cruz. In these two examples, historical aerial photos show gully initiation immediately after the 1929 and 1977 droughts with natural gully healing occurring 20-25 years later.

Gully Prevention

Gully prevention is clearly the most economical and environmentally sound policy for protecting HMP habitats of interest in the NRMA. Gully prevention is possible since we now have a reasonably good understanding of the ecosystems, physiography, hydrology, and land uses that are associated with significant gully systems in the NRMA

Although gullies are ubiquitous in the NRMA (Appendix B), gullies that pose the greatest risk to existing infrastructure and ecology typically form in valleys and hollows with deep, erodable alluvial fill. Examples of gully-prone settings include Mudhen Lake gully, "The Chasm," Pilarcitos Canyon (and its tributary hollows), skyline gully, Site #91, and Laguna Seca gully. Specific management strategies to prevent further gullying can be applied to these and similar valleys and hollows. The high-risk, gully-prone regions in the present BLM lands are:

- all of the grassy canyons and hollows in Toro Creek subwatersheds from TC01 to TC11
- all of the upper watershed and subwatersheds of Pilarcitos Canyon
- sand-filled valleys that are tributaries to Pilarcitos Canyon (e.g., small valleys like "The Chasm")
- sand-filled valleys that are tributaries to Mudhen Lake valley (e.g., Mudhen Lake Gully and its tributaries and Picnic Canyon.

The above regions have the potential to produce deep gullies and expansive gully networks in valleys and hill slopes. Other regions within BLM lands are also exceptionally prone to erosion (Appendix B), but erosion sites in the other regions are generally restricted to poorly constructed, over-used roads on old dune sands.

Appropriate management strategies to reduce the risk of gullying on BLM land is dependent on accurate identification of the local gully forming processes. Most of the gullies on BLM land were formed by intense rainfall acting in conjunction with some combination of the following factors:

- overland flow concentrated by altered hydrology associated with culverts, roadside ditches, or compacted soils from heavy vehicles or overgrazing (e.g., Croke and Mockler, 2001),
- well-developed subterranean piping network developed during preceding drought conditions (e.g., Pillans, 1985; Huddart and Bennett, 2000),
- reduced soil strength caused by altered ecology such as replacement of deep-rooted perennial grasses or woody species with shallow rooted annual grasses, or perhaps overgrazing that reduces plant density in valley bottoms, or
- reservoir construction without adequate upstream grade control, or

Based upon the above conditions, site-specific strategies for gully prevention or control include combinations of:

- improving road, culvert, and roadside ditch design, including outsloping road surfaces and reducing the need for ditches and culverts that concentrate flow (Weaver et al., 1994--*Handbook for Forest and Ranch Roads;* Croke and Mockler, 2001),
- restoring perrenial grasses and dense woody vegetative cover in uplands above high-risk canyons and hollows,
- restoring dense woody vegetative cover along the banks of steep-walled eroded waterways (e.g., Pilarcitos Canyon bottom),
- fostering deep-rooted perennial grasses (e.g., needle grass) rather than annual grasses in grasslands ecosystems,
- establishing a mozaic of woody shrubs or trees in the Toro Creek watershed grasslands (see section D and Fig. 15).
- Improving the infiltration capacity of compacted soils through mulching and revegetation,
- examining grazing practices that might exacerbate erosion or remove vegetative cover,
- decommissioning historic reservoirs, and
- exploring the possibility of installing appropriate grade control structures where the Toro Creek subwatersheds join Toro Creek.

Three additional significant threats to landscape stability on BLM lands are the Highway 68 easement, the proposed Laguna Seca parking lot in subwatershed TC03, and the parking lot access road that will traverse some of the most gully-prone landscape in the NRMA (Fig. 2). Sophisticated design and careful surface water management are essential to prevent gullying as these infrastructure components are implemented.

Gully Restoration

Wildland restoration is best achieved by identifying appropriate reference sites that define the restoration goals. Reference sites for gully restoration, are naturally-healed gullies that have regained equilibrium through some combination of gradient adjustment, gully wall erosion, channel infilling, or revegetation. Gully restoration strategy includes the following steps.

- Identify and address any existing hydraulic conditions that contribute to the gullying, such as decommissioning a reservoir, grading and revegetating an old road above the gully head, or improving the geometry of a required roadbed or culvert so that overland flow is dispersed non-erosively across the landscape rather than concentrated.
- Stabilize the gully head if a steep headcut is present. Regrade the headcut to a lower angle, stabilize with well-keyed-in large rock or logs, densely revegetate the construction site with grasses and woody shrubs, and mulch with chaparral chips to restore permeable soils.
- Reduce the side-slope angles on gullies to allow transplanted woody vegetation and native perennial grasses to grow. Side slope angles are reduced by dressing the banks back and removing the spoil, or by caving the banks inward to partially fill the gully bottom. Inadvertently creating locally steep gradients or headcuts when adjusting the gully bottom.
- Plant willows and coyote bush in the gully bottom to help trap sediment and reduce flow velocities.
- Irrigate plantings early in the season, to foster survivorship. Overwatering will foster non-native species.
- Some sites might require grade-control structures, but tall check dams are not appropriate in active gully systems.
- Continue monitoring and weed eradication. Fertilizing the soil is not recommended, because relatively infertile soils favor the native vegetation over invasive species.

Grade Control Structures in Gullies

Check dams have historically been used to arrest headcuts, trap sediment, and control channel incision in streams and gullies. Although recent evaluations have shown that tall check dams have a high failure rate in gullies (Rosgen, 1996), they continue to be used in gully repairs. Tall check dams in gullies tend to fail because young gully walls tend to widen and reduce their side slope as they naturally evolve toward a new geomorphic equilibrium (Fig. 27). During that widening phase, check dams experience lateral failure as water and sediment bypass around the edges. A detailed examination of the check dams in the Mudhen Lake Gully by students from California State University Monterey Bay (Fall, 2001) found that 18 out of 41 check dams are failing (Fig 28). Nine check dams are failing because of lateral erosion as the gully system naturally widens, and nine dams are failing by undercutting as the gully bottom continues to downcut.

Grade control structures may be a necessary component of gully stabilization in some cases. For example, some gully reaches require grade control structures or hard points to prevent headcut migration or tributary growth. Such grade control measures should be designed to stabilize the present grade, rather than to trap sediment, which increases the average gradient of the system. Therefore, Buried hard structures made of appropriately large rock or logs that do not protrude much above the present channel surface are preferred over taller structures typical of check dams. It is important to dress the side slopes to an approximately stable angle before installing grade control in the gully bottom. If side slope angles are too steep when grade control structures are installed there is a high risk that natural gully wall retreat will cause structural failure or long-term maintenance. All structures should be deeply keyed into the bottom and contoured banks of the gully. The structure design should direct flows away from the gully sides, and toward the center, where the bottom has been armored to resist erosion. Where grade control structures are required, they should be one facet of a restoration plan that primarily focuses on healthy native ecosystems for landscape stability.

Historic Dam-Reservoir Systems

At least four small reservoirs are located within the NRMA; each one is associated with watershed destabilization. For example, the upstream edge of the upper reservoir in Pilarcitos Canyon created a headcut in the highly erodable valley fill. The headcut is migrating up canyon (Figs. 29 and 30). If unchecked this process can lead to an extensive gully network, such as exists in subwatershed TC03. Reservoirs have an overflow pipe or chute on the downstream edge of the reservoir to convey high-velocity water that incises the channel downstream from the reservoir (Fig. 29). These processes are seen at Pilarcitos Canyon (Fig. 30), downstream of Eucalyptus Canyon, and subwatershed TC03.

Three management strategies for these reservoir sites are discussed here. One option is to abandon the reservoirs and allow them to fill with sediment. However, abandoned reservoirs can catastrophically fail during intense winter storms, causing a sudden release mud and water down canyon. Another option is to maintain the reservoir capacity by dredging. Regular dredging of the reservoir and physical maintenance of the dam improves stability during intense rains. However, the degraded reservoir landscape is precluded from returning to “riparian forest,” an HMP habitat of concern; there are high, long-term maintenance costs; the potential to destabilize the upper and lower watershed through gullying and stream incision continues; and there remains the risk of catastrophic failure present in any dam-reservoir system.

The third option is reservoir decommissioning. Decommissioning a reservoir can return the impacted site to a more natural setting and reduce the threat of dam failure. Decommissioning is accomplished through land recontouring and biotechnical engineering that returns the site to an equilibrium condition within the watershed. Careful evaluation of the equilibrium conditions and appropriate engineering measures can lead to a successful, site-specific restoration design. The impacts of decommissioning a reservoirs include one-time cost for restorative work, increased HMP habitat acreage, aesthetic appeal following restoration, lowest risk of catastrophic failure during high-intensity rains compared to previous options, and improved watershed stability.

Mudhen Lake is a dam/reservoir system that could be decommissioned based upon the above arguments, but it now supports a diverse wetland ecosystem that has significant value under the HMP guidelines. Because HMP species of concern exist in and near Mudhen Lake, dredging the fill for capacity maintenance is problematic. Also, abandoning the reservoir could lead to catastrophic failure, so another strategy should be considered.

Location and type of opportunity/threat (on BLM lands)

A continued program of physical and biological restoration will provide opportunities for adding area to HMP habitat categories, and reducing the environmental threats to private property and BLM roads and facilities. Appendix B and Figures 11 and 12 provide a preliminary list of over 100 sites that are eroded because of gully erosion, past vehicle use, or impaired riparian vegetation. Appendix B provides meter resolution NAD83 UTM coordinates for each impaired site or broader region and a simple description of the kind of impairment. Many of the listed sites are photo documented (Appendix B). Each site carries the threat of continued soil erosion, ecosystem impairment, and the opportunity to increase acreage of NRMA ecosystems. The list of potential future restoration sites is not exhaustive. More erosion sites have been located or brought to our attention since the completion of our field reconnaissance. Our list is further restricted to the present BLM lands. Considerable acreage of disturbed landscape is present in the future BLM lands as well.

Ranking of erosion sites for restoration planning

Given the partial list of erosion sites present on BLM land (Appendix B), there are numerous ways to prioritize restoration efforts. We developed a semi-quantitative method employing best professional judgment in concert with a numerical ranking system. The numerical ranking employs five descriptions of priority criteria, weighted from 4 to 0.

- 4 points were assigned to sites bearing the potential to convey water and sediment off BLM property during extreme rainfall events.
- 3 points were assigned if further erosion of site will impact species of concern or habitat of interest.
- 2 points were assigned sites that threaten BLM roads, trails, or other infrastructure.
- 1 point was assigned if a gully system has the potential to rapidly grow, branch, or develop significant "badlands" topography.
- 0 points were assigned to other erosion sites.

Each site is scored based upon the sum of the applicable criteria weights. For example, the highest priority sites are described by all the criteria above and score a 10. The site list is then sorted by the score value. Using best professional judgment, we modified the ranked list, commonly giving higher priority to sites with a strong potential to impact private property over sites that do not, independent of site score.

The ranked list (Appendix G) should be used to guide prioritization. Other factors, such as access and cost are not currently factored into the prioritization. Likewise, it may be deemed more appropriate to concentrate on all sites that potentially impact private property before tackling the sites that do not.

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Donald Kozlowski (B.S.)--- GIS Technician
Regina Williams--- Research Technician
Leslie Turrini-Smith (M.S.)--- Geology, Restoration
Wendi Newman (B.S.)--- GIS Support

J. Acknowledgements

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L. Figures

Figure 1
Ownership of NRMA and Adjacent Lands

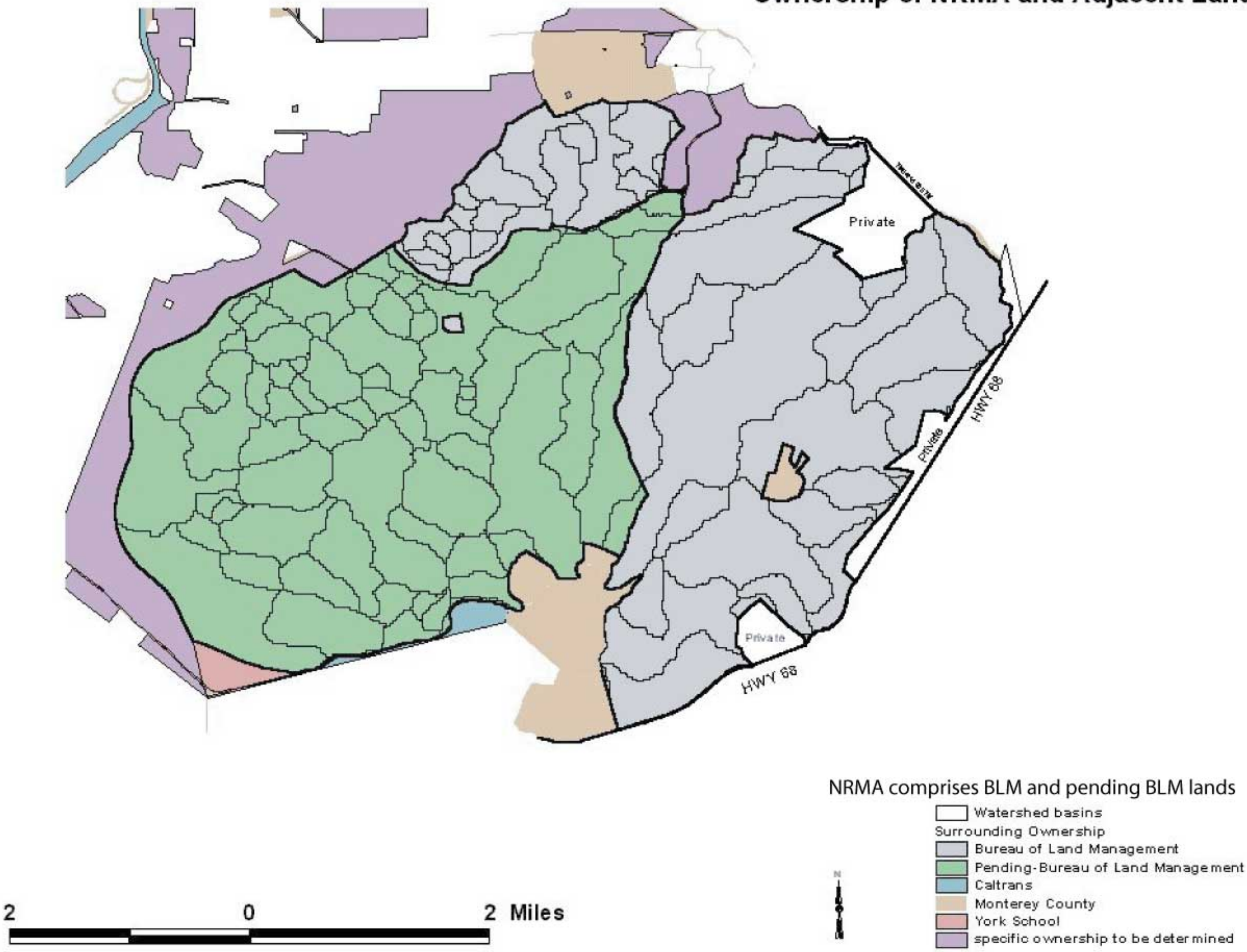
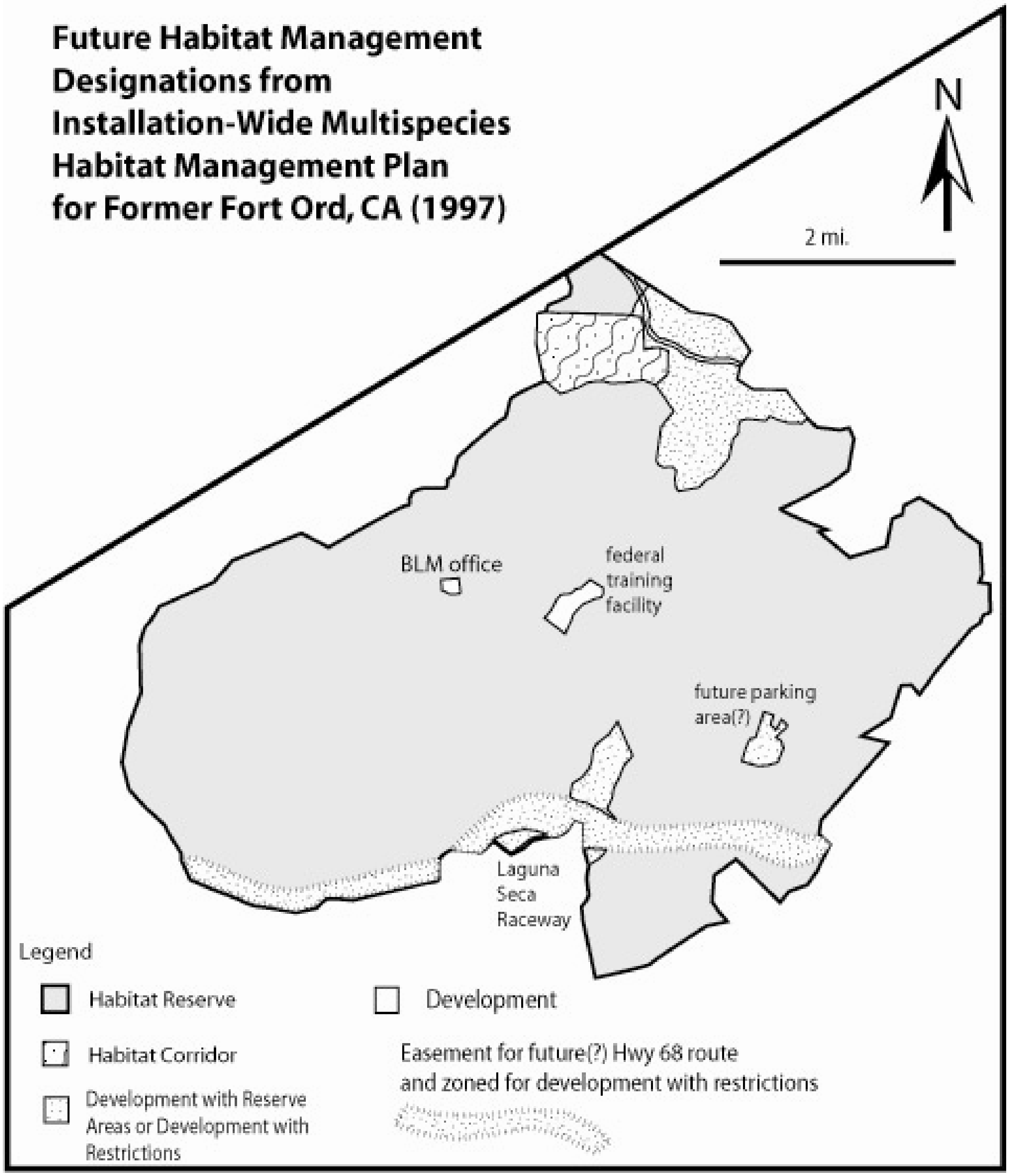


Figure 2

Future Habitat Management Designations from Installation-Wide Multispecies Habitat Management Plan for Former Fort Ord, CA (1997)



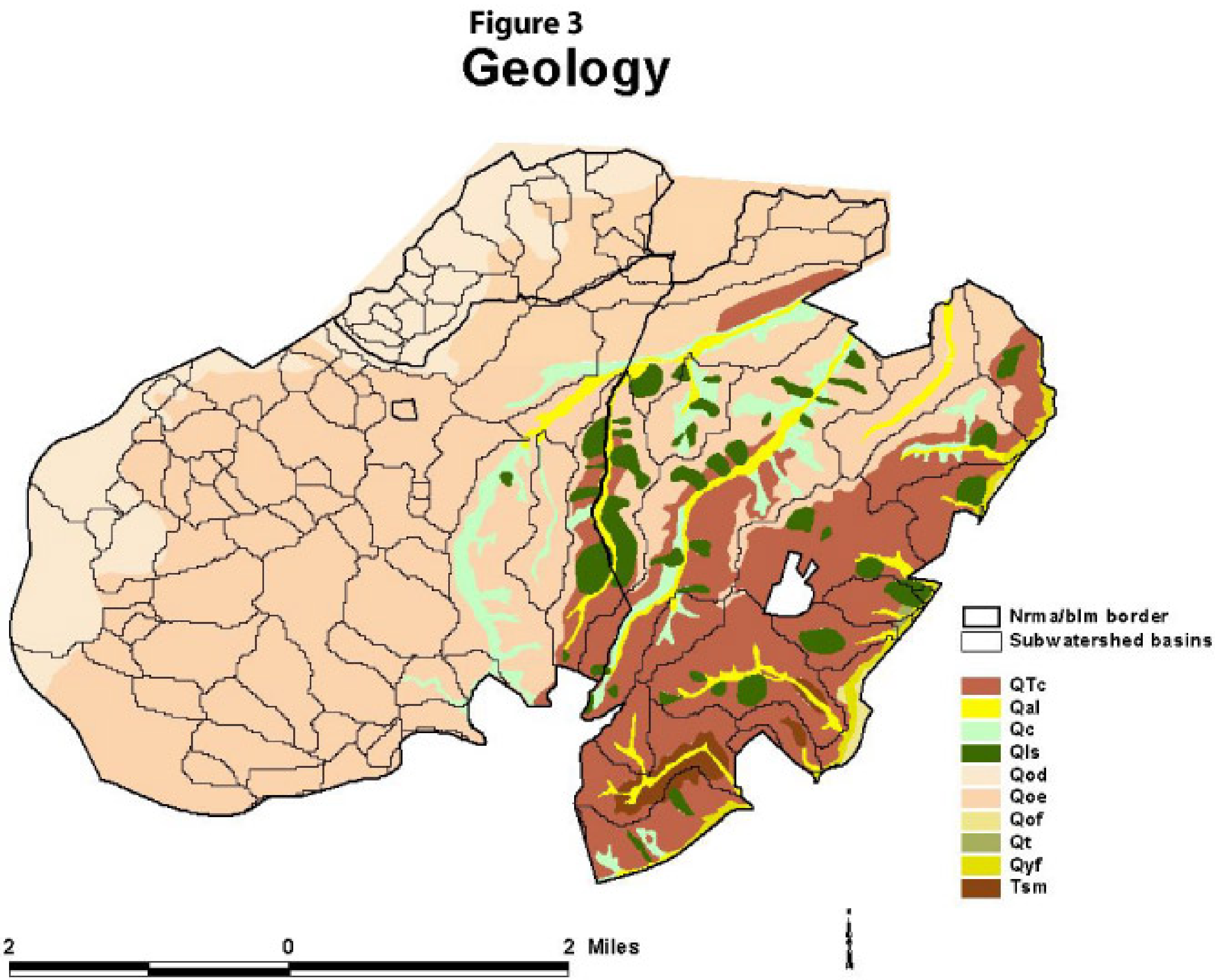


Figure 3
Geology
Nrma/blm border
Subwatershed basins
QTc
Qal
Qc
Qls
Qod
Qoe
Qof
Qt
Qyf
Tsm
2
0
2 Miles

Key to Fig. 3 and Appendix C
Geologic Formation symbols

Alluvium (Qa)

Alluvial deposits of variable thickness and composition fill the bottoms of the major hillside drainages. These deposits consist of unconsolidated, heterogeneous, moderately sorted silt and sand with discontinuous lenses of clay and silty clay, and locally include large amounts of gravel. They may include deposits equivalent to both the younger and older flood-plain deposits (Qyf and Qof, respectively) in areas where these were not differentiated. Their thickness is highly variable (Dupre, 1990a).

Colluvium (Qc)

Colluvial deposits are common in the hillside areas, especially in topographic swales. These deposits are as much as tens of meters wide, hundreds of meters long, and as much as 7 meters thick. Colluvium consists of a variable mixture of unconsolidated, heterogeneous, moderately to poorly sorted silt, sand, and gravel deposited by slope wash and mass movement. Some deposits have undergone minor fluvial reworking. Locally they include numerous small landslides and small alluvial fans; contacts with alluvial deposits are variable

Older and Younger Flood Deposits (Qof and Qyf)

Holocene age younger flood-plain deposits occur in and adjacent to the present Salinas River channel and along Toro Creek. These deposits consist of unconsolidated, relatively fine-grained, heterogeneous deposits of sand and silt, commonly including relatively thin, discontinuous layers of clay. The gravel content is variable and is locally abundant within channel and lower point bar deposits. The thickness of the younger flood-plain deposits is generally less than 6 m.

Landslide Deposits (Qls)

Regions with evidence for recent mass movement on unstable slopes, based chiefly upon aerial photography.

Terrace Deposits (Qt)

Pleistocene-age, elevated fluvial terrace deposits occur as erosional remnants on the north side of Toro Creek and locally south of the Salinas River. These fluvial terrace deposits consist of weakly consolidated to semi-consolidated, moderately to poorly sorted, fine- to coarse-grained silty sand with pebble to cobble gravel.

Older Dune Deposits (Qod)

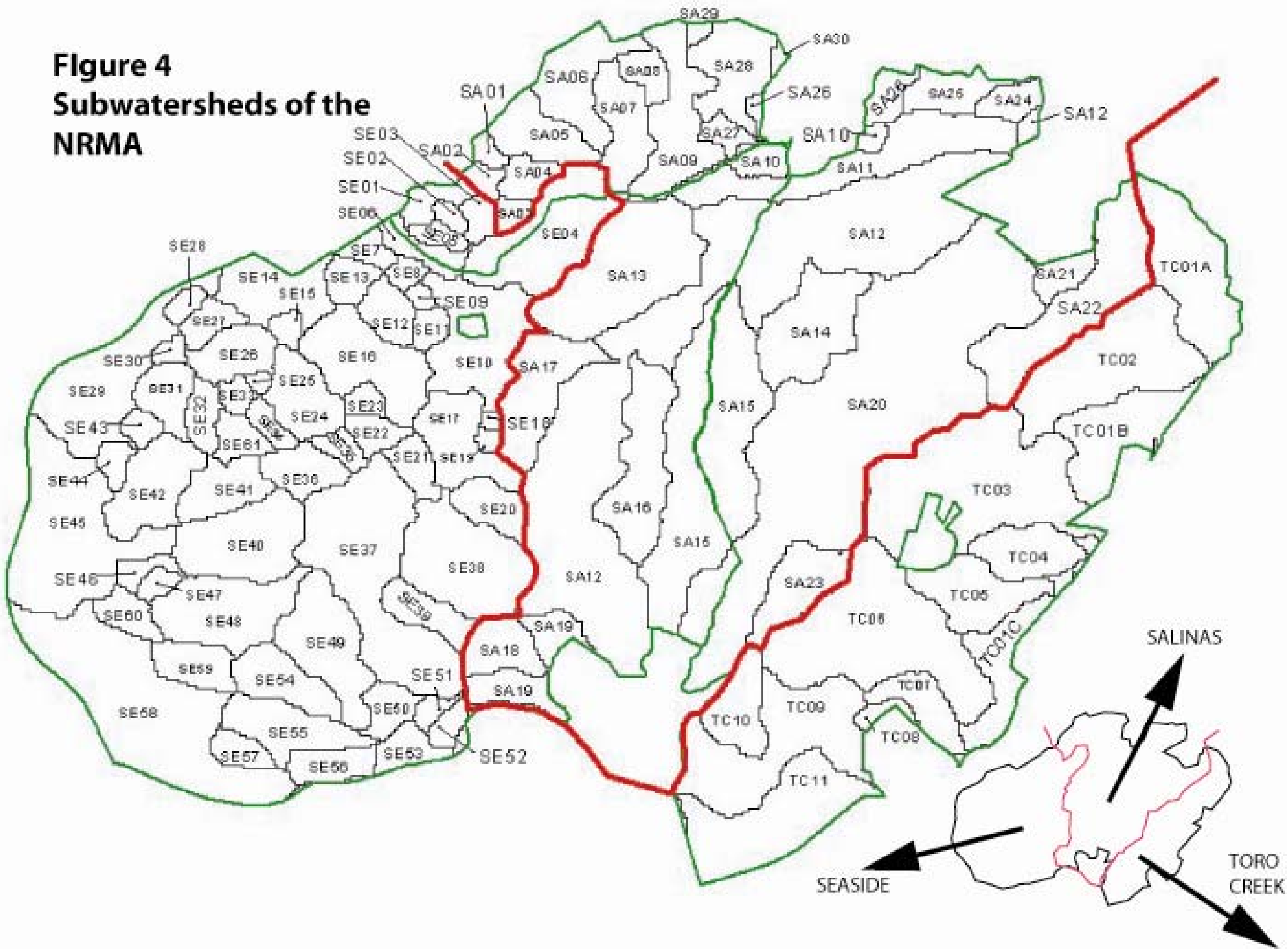
Holocene dune deposits .

Older Eolian Deposits (Qoe)

Exposed on the hilltops of the Fort Ord Military Reservation is a series of Pleistocene eolian deposits largely equivalent to the Aromas Sand as mapped by Dupre and Tinsley (1980). The stratigraphic relationship of the older eolian deposits to the underlying continental deposits (QTc) is unclear. In some areas the older eolian deposits appear to unconformably overlie these continental deposits (QTc) (Bowen, 1965); elsewhere, the two units may be in part facies equivalents (Dupre, 1990b). The older eolian deposits consist of moderately well sorted sand as much as 60 m thick that contains no intervening fluvial deposits. Several sequences of eolian deposits may be present, each separated by paleosols. The upper 3-6 m of each dune sequence is oxidized and relatively well indurated, and all primary sedimentary structures have been destroyed by weathering; the lower parts of each dune sequence may be relatively unconsolidated below the weathering zone (Dupre, 1990a).

Key to Fig. 3 and Appendix C (continued)
Continental Deposits (QTc)
Unconformable upon the Santa Margarita Sandstone, and locally upon quartz monzonite, is a series of nonmarine, semi-consolidated, oxidized, poorly sorted, fine- to coarse-grained, sand beds with common pebble and cobble gravel interbeds. Gravel clasts are angular to subangular and consist of granitic rocks, mica schist, quarzite, and locally Monterey Formation porcelanite and chert. At the base of these deposits in the vicinity of Washington Union School, a distinctive thick, yellowish-gray, ostracod-bearing fresh-water limestone crops out over a 4 km^2 area. Duripan horizons are common in these deposits and weather into prominent ledges, which locally form a barrier to shallow infiltration resulting in debris flows. Herold (1935) correlated these deposits with the Paso Robles Formation of the southern Salinas Valley, a name also applied in later mapping by Bowen (1965) and Dibblee (1973). Because of uncertainty of correlation with the type area to the south, Dupre (1990a) preferred not to use the name "Paso Robles" and called these beds " continental deposits." His usage is followed here. Stratigraphic relations suggest that these deposits are Pleistocene and possibly Pliocene in part and thus younger than the type Paso Robles Formation.
Santa Margarita Sandstone (Tsm)
Conformably overlying the upper diatomite of the Monterey Formation is a marine, white, very thick-bedded to locally cross-bedded, very fine to coarse-grained arkosic sandstone mapped as the Santa Margarita Sandstone. The Santa Margarita Sandstone is exposed locally northeast of the Chupines fault and is commonly penetrated beneath the continental deposits (QTc) by water wells to the north. The Union WW No. 1 well on the Guidotti Ranch penetrated approximately 150 m of the Santa Margarita Sandstone before reaching diatomite of the Monterey Formation. Its conformable position above the Monterey Formation diatomite together with megafossils collected near the Guidotti Ranch (Herold, 1935; Bown, 1965) indicates a late Miocene age for the Santa Margarita Sandstone in the Spreckels quadrangle.

Figure 4
Subwatersheds of the NRMA



HODER FOR FIG 6

FIGURE 6
Log Pearson Type-III Frequency Analysis of U.S. Geological Survey Toro Creek Discharge Record

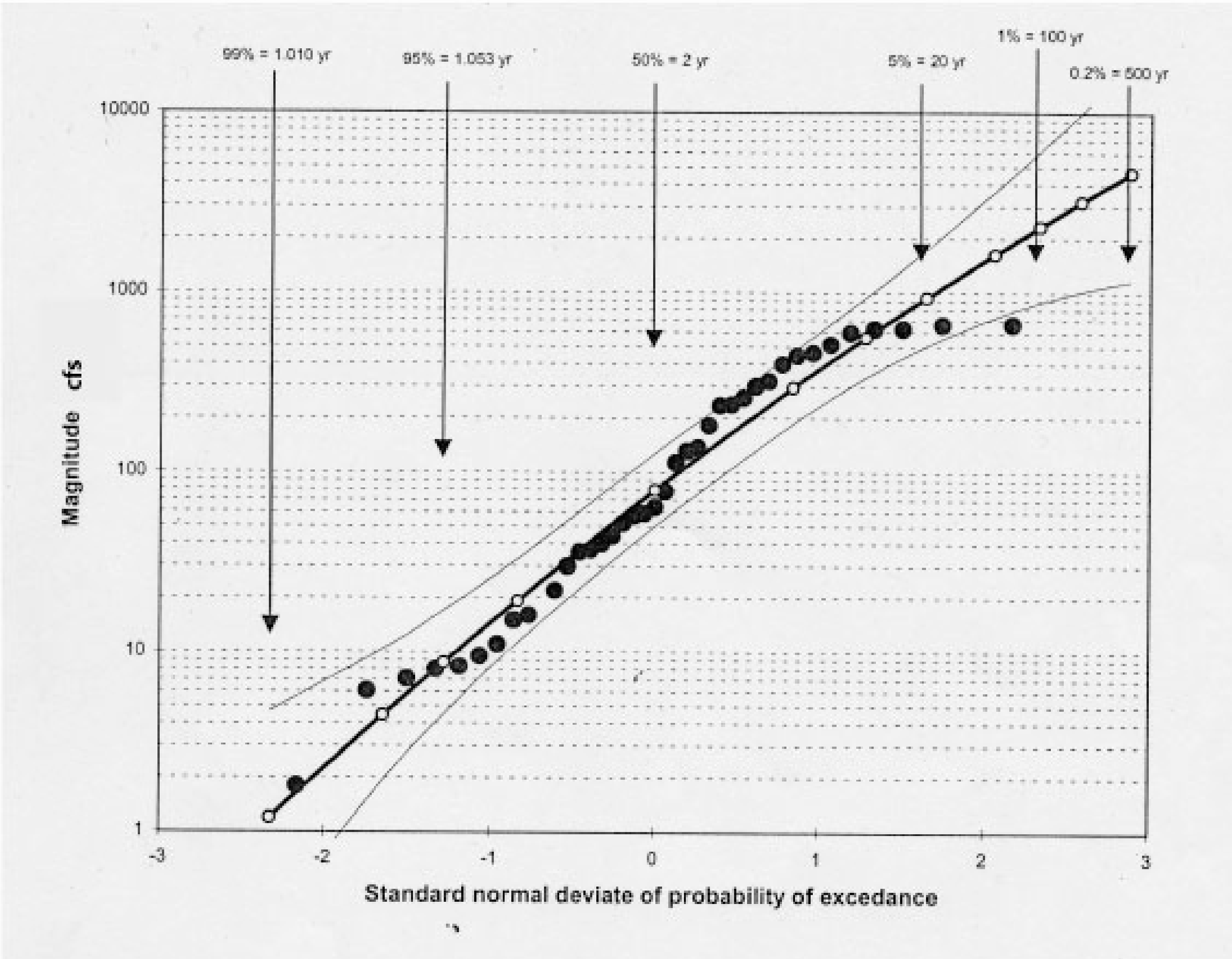
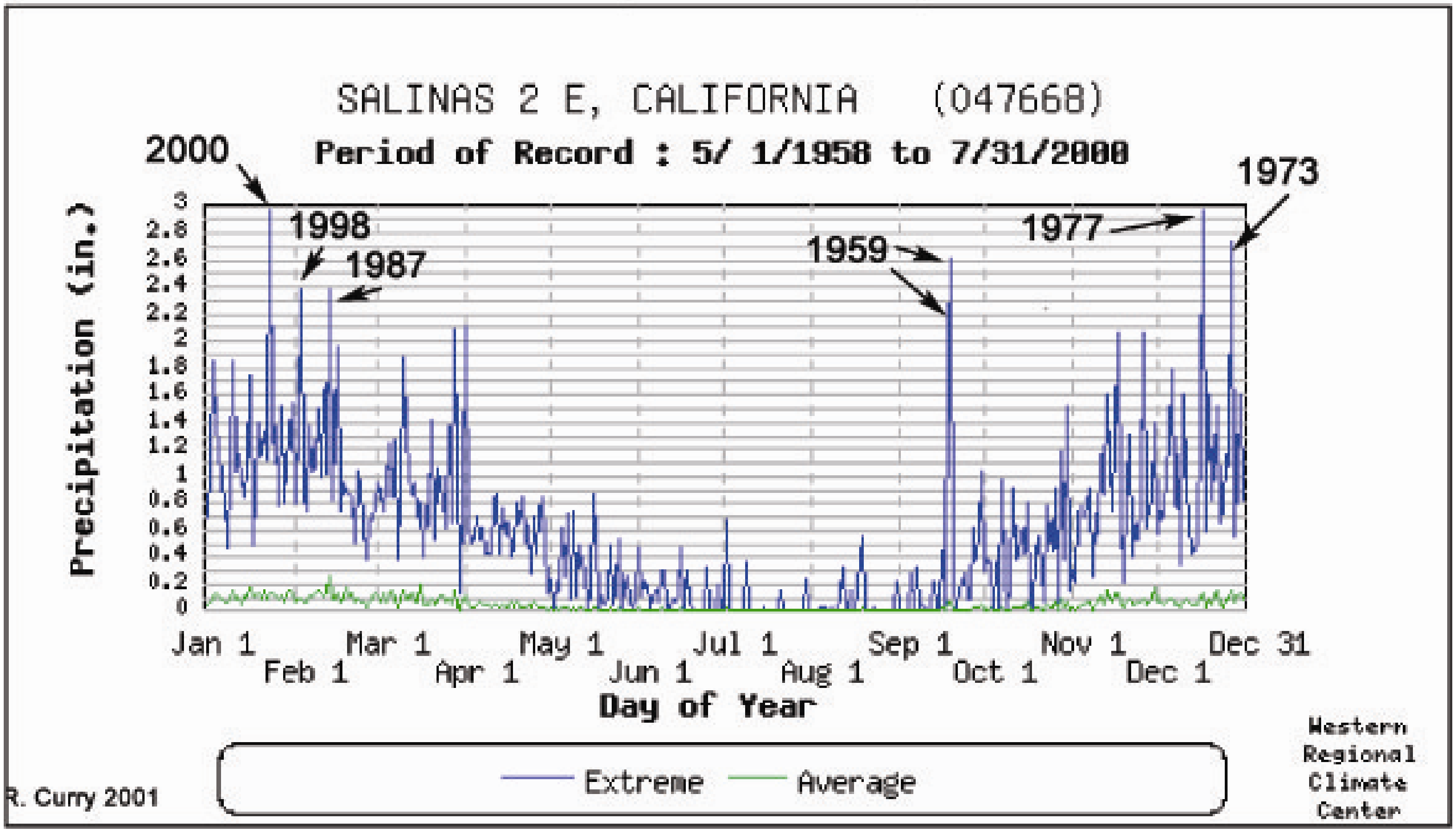


FIGURE 7
Precipitation History



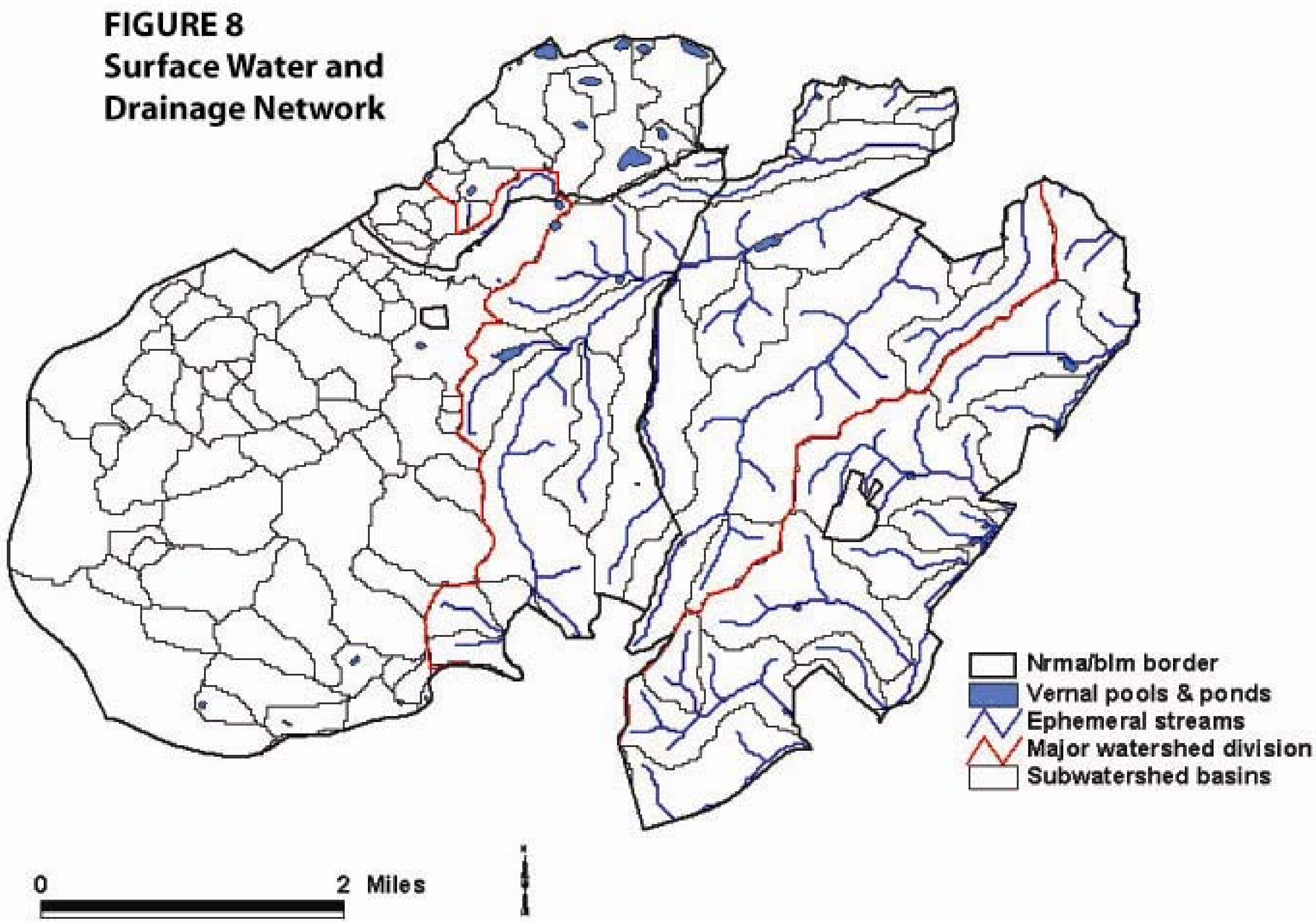
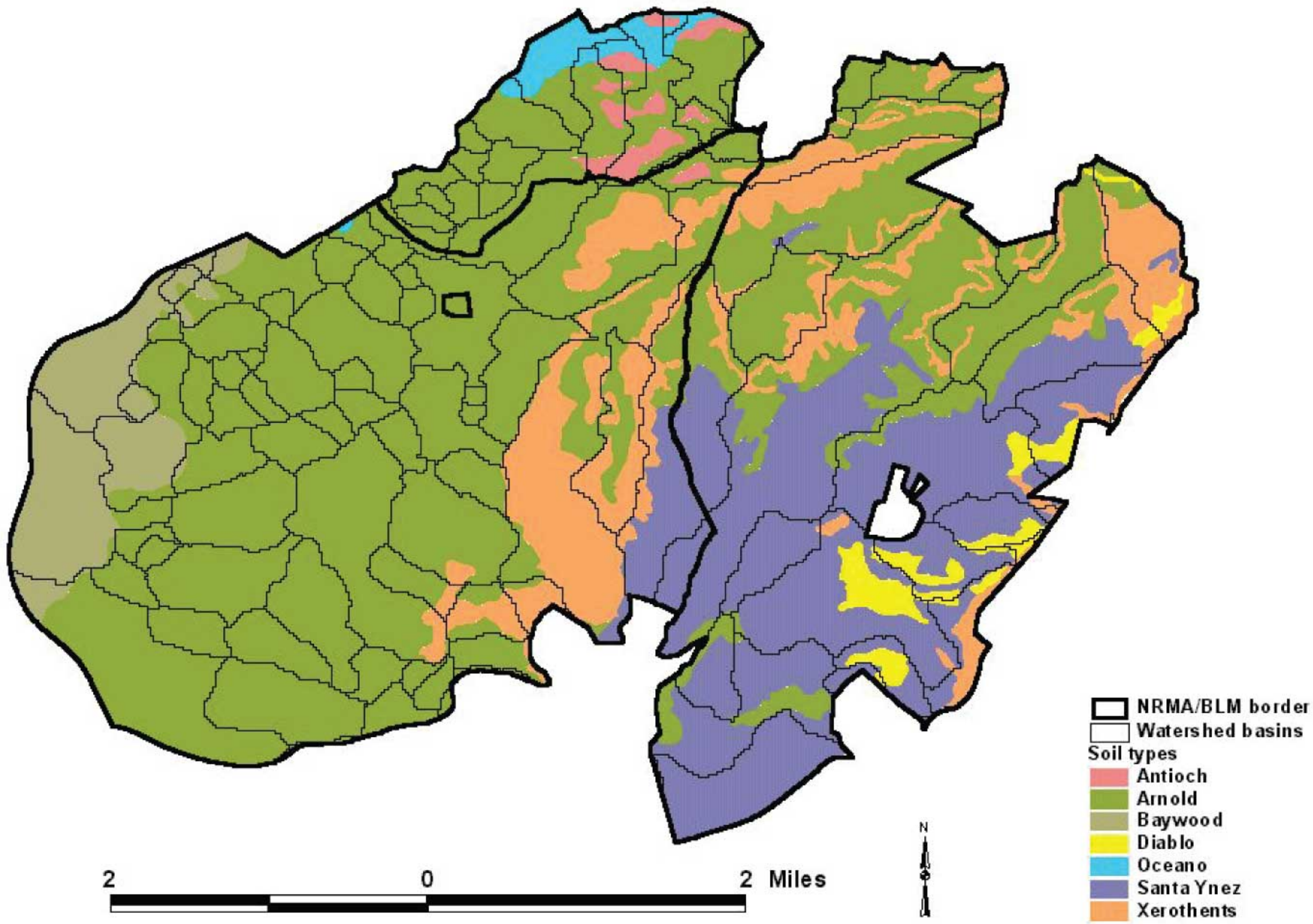


FIGURE 8
Surface Water and
Drainage Network
Nrma/blm border
Vernal pools & ponds
Ephemeral streams
Major watershed division
Subwatershed basins
0
2 Miles

FIGURE 9
Soils



Key to Fig. 9 and Appendix C
Soil series descriptions excerpted from USACOE (1992) and USDA (1982)

Antioch (Ant)

The Antioch series consists of moderately well-drained soils that formed in alluvium derived from sedimentary rocks on alluvial fans and terraces. Antioch soils are found on the western portion of the base. The erosion potential is slight to moderate because of rapid permeability. The available water-holding capacity is approximately 3 inches, and the effective rooting depth is greater than 60 inches.

Arnold (Ar)

The Arnold series consists of somewhat excessively drained soils that formed on uplands and hills in old marine sand dunes or in materials weathered from soft sandstone. These soils are found in the southern portion of the base, in the inland impact area. The erosion potential is slight because of rapid permeability. The available water-holding capacity is approximately 3 to 5 inches, and the effective rooting depth is greater than 60 inches.

Baywood (Bay)

The Baywood series consists of somewhat excessively drained soils that form in stabilized sand dunes. The soils are found on gently sloping stabilized dune land, north and south of the Oceano soils on the western flank of the base. The erosion potential is slight to moderate because of rapid permeability. The available water-holding capacity is approximately 3 inches, and the effective rooting depth is greater than 60 inches.

Diablo (D)

The Diablo series consists of well-drained soils on relatively isolated uplands near Fort Ord's eastern boundary. Slopes range from 9% to 50%. The erosion potential ranges from moderate (for slopes between 15% and 30%) to high (for slopes between 30% and 50%). The available water-holding capacity is 7-12 inches and the effective rooting depth is 40-60 inches.

Oceano (Oc)

The Oceano series consists of excessively drained soils that formed in wind-transported sands on stabilized dunes. These soils, found on rolling dune land, dominate the western and central parts of Fort Ord. Most of the Garrison areas are located on these soils. The erosion potential is slight because of rapid permeability. The available water-holding capacity is approximately 4 inches. The effective rooting depth is greater than 60 inches.

Santa Ynez (SY)

The Santa Ynez series consists of moderately well-drained soils formed on terraces in alluvium derived from sandstone and granitic rock. These soils are found east of Pilarcitos Canyon, along the southeastern boundary of Fort Ord. The erosion potential is moderate because of slope and limited permeability. The available water-holding capacity is approximately 3 to 5 inches. The effective rooting depth is greater than 60 inches, although some roots may be limited by the clay layer.

Xerothents (X)

This soil series consists of dissected, steep to extremely steep soils on bluffs along steep escarpments of fans and terraces and on the banks of deeply entrenched streams and gullies. The unit occurs in the central portion of Fort Ord on ridges and canyons. Slopes are steep, typically 50-65% but can reach as high as 90%. The banks of the series may have not only areas of moderate erosion, but also areas of high erosion. The erosion potential is high to very because of the steep slopes and poorly consolidated texture. Available water-holding capacity varies substantially within short distances.

FIGURE 10

Shaded Relief

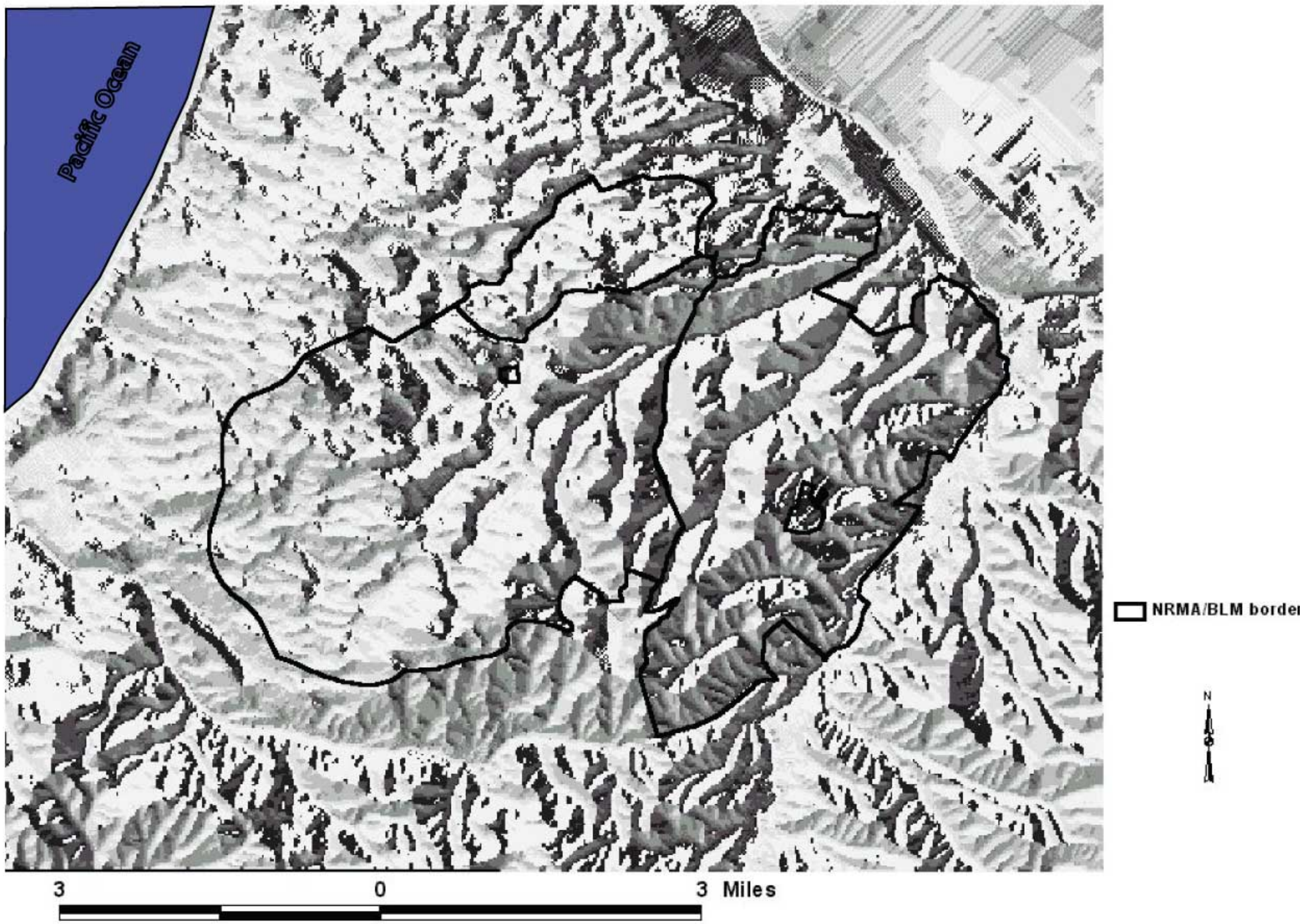


FIGURE 11
Erosion Sites in Subwatersheds
(see Appendix B for descriptions)

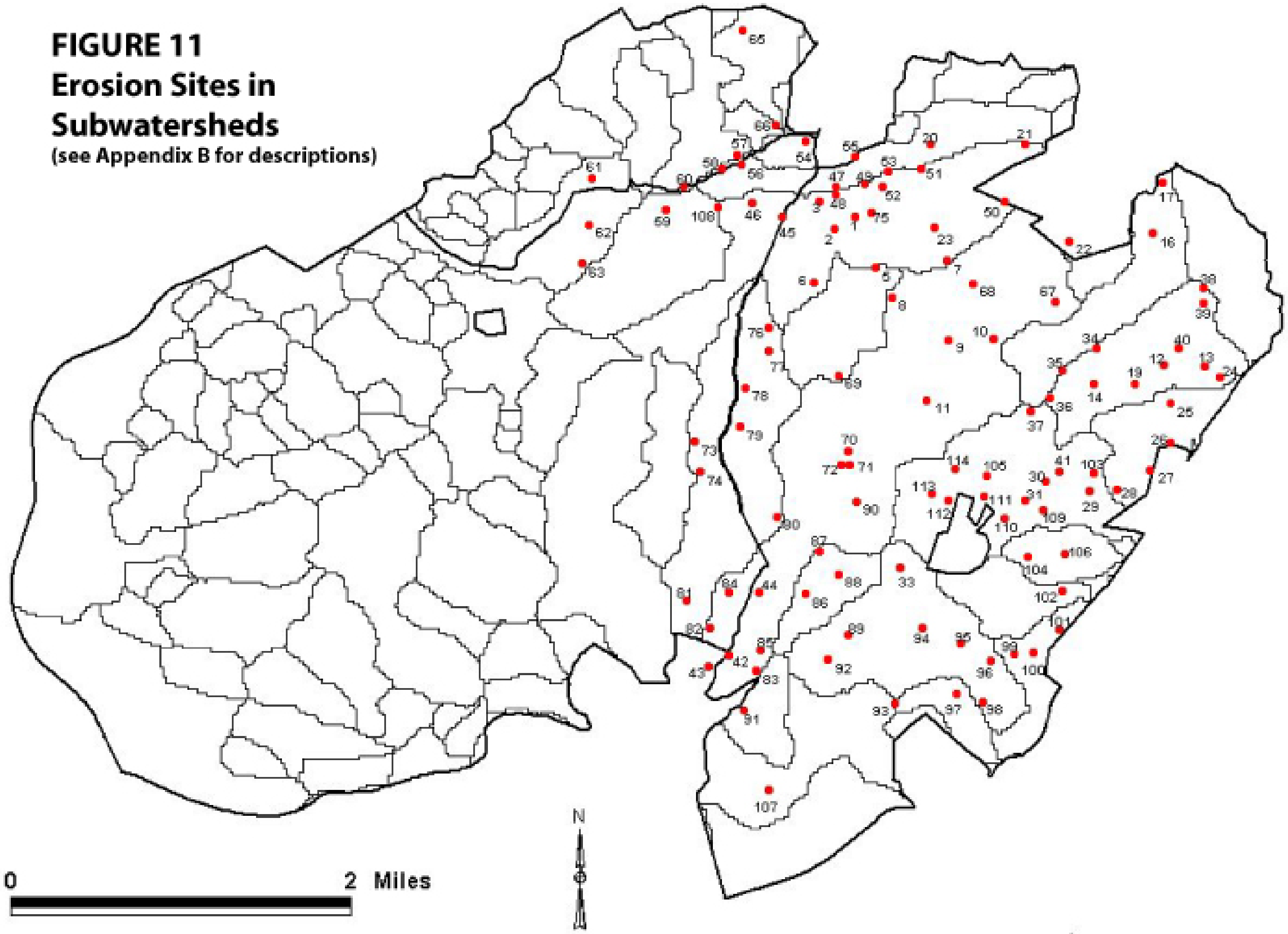


FIGURE 12: Erosion Sites on Aerial Photograph

(see Appendix B for descriptions)

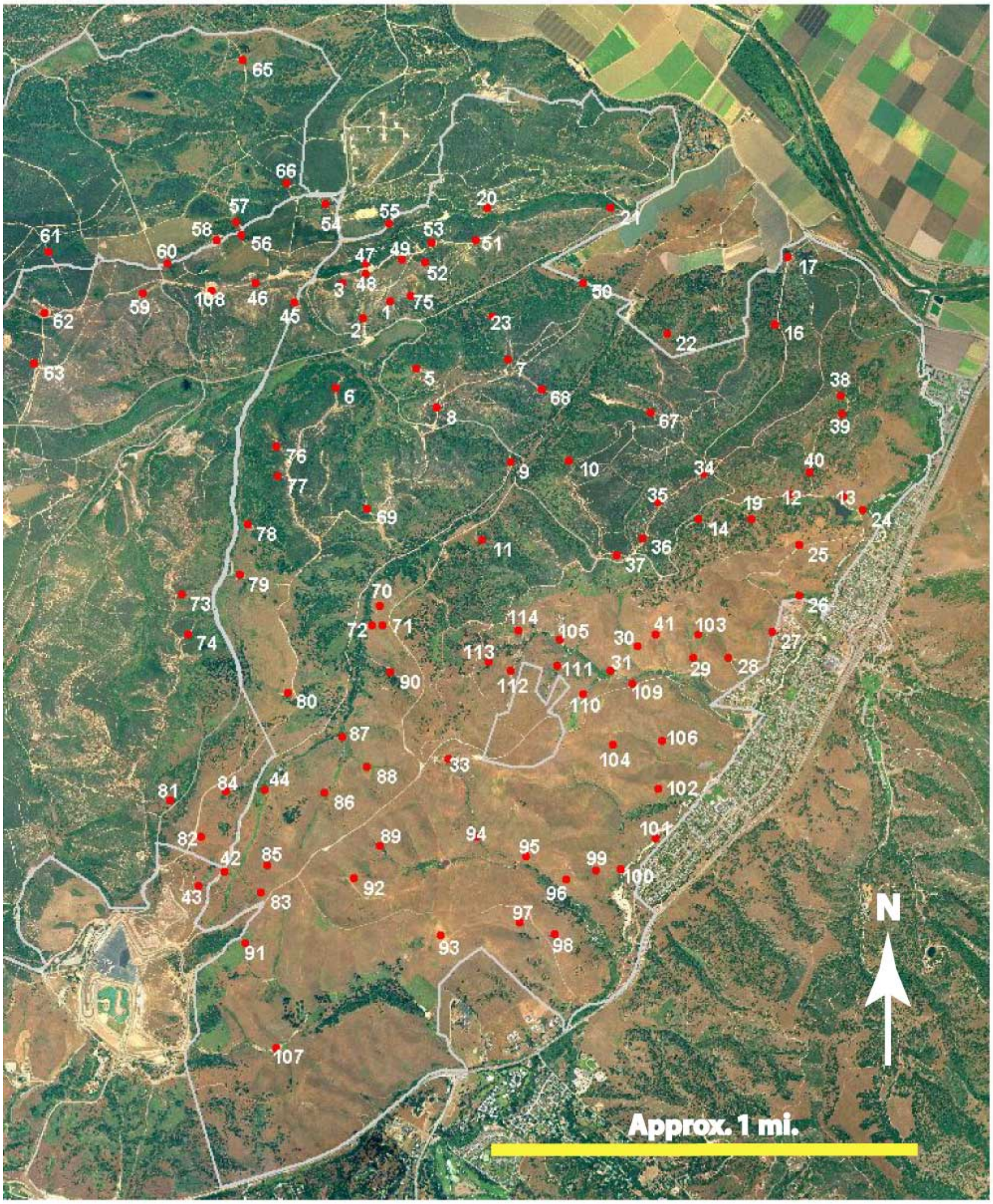
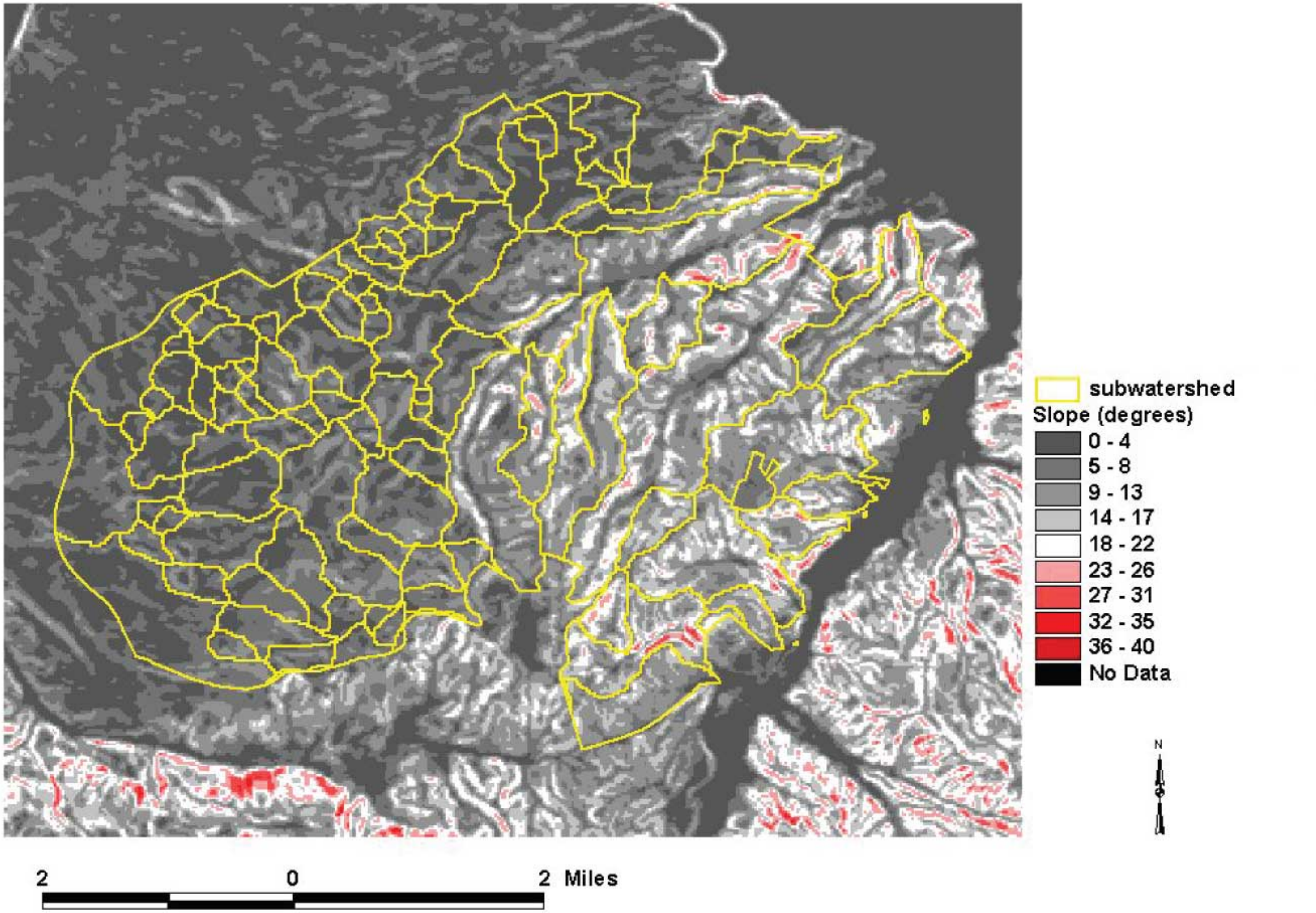


FIGURE 13
Slope within Watersheds



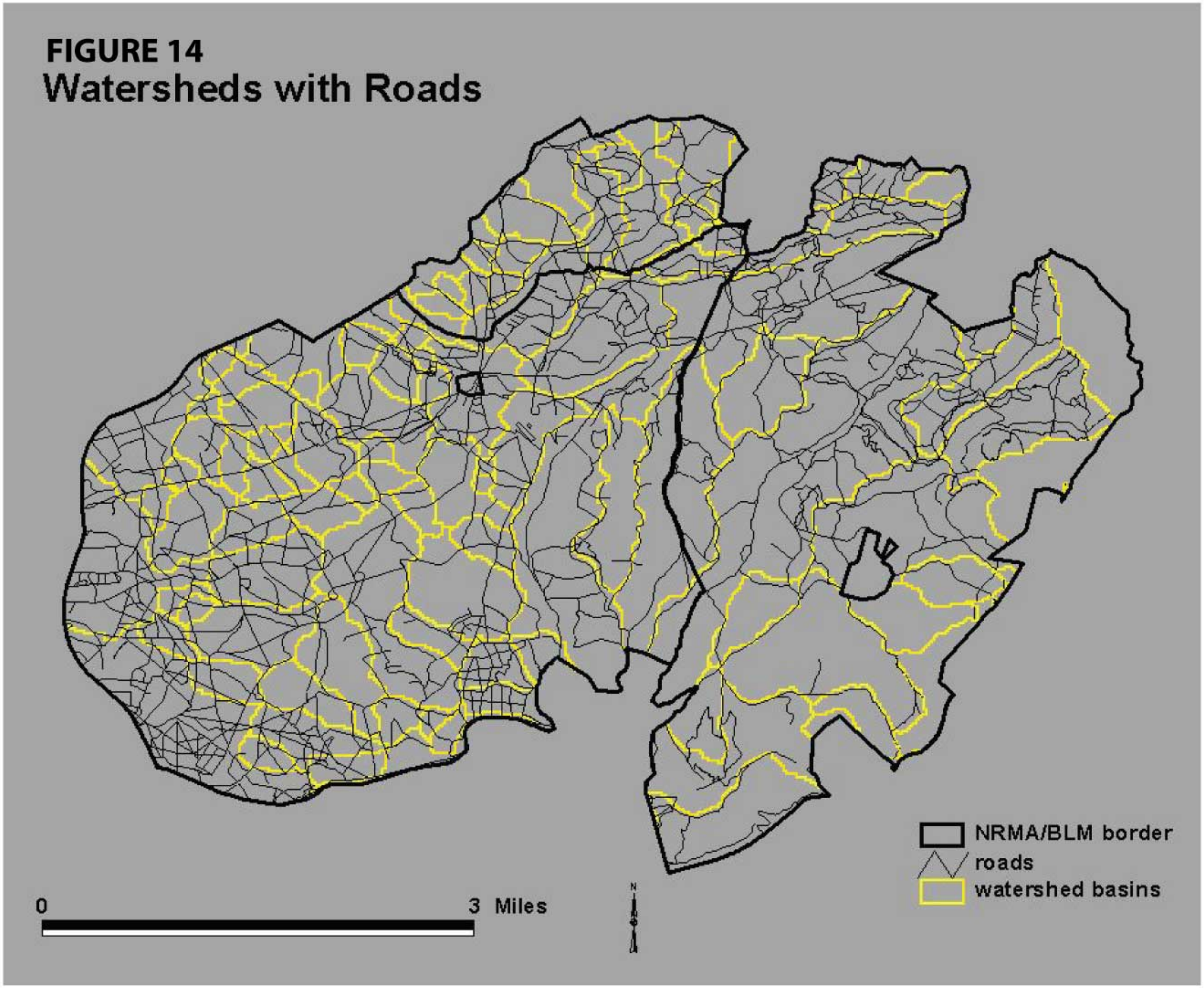


FIGURE 14
Watersheds with Roads
NRMA/BLM border
roads
watershed basins
0
3 Miles
N

FIGURE 15: Annual Grassland of Toro Creek Watershed

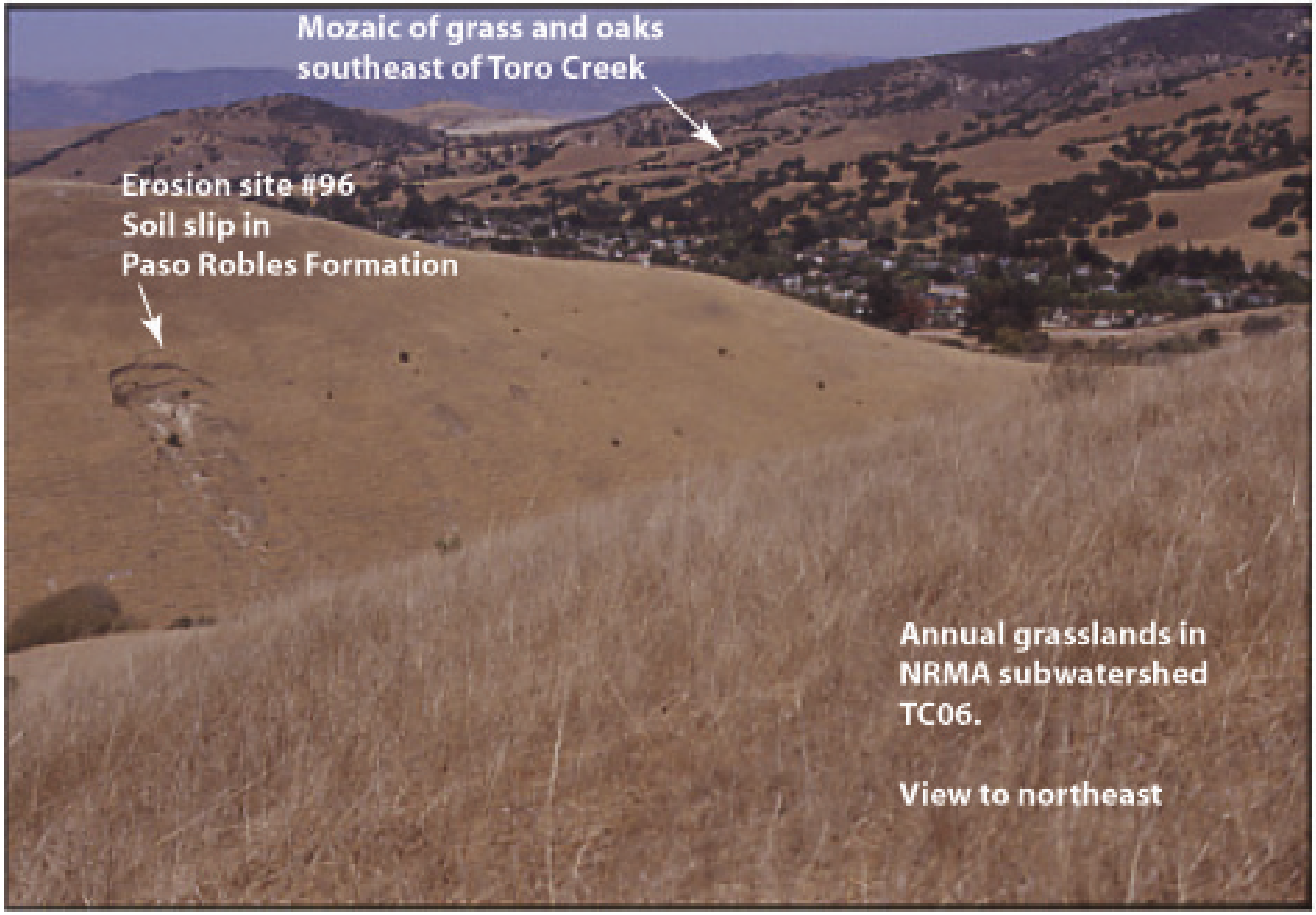


FIGURE 16

Watershed Ecology(vegetation)

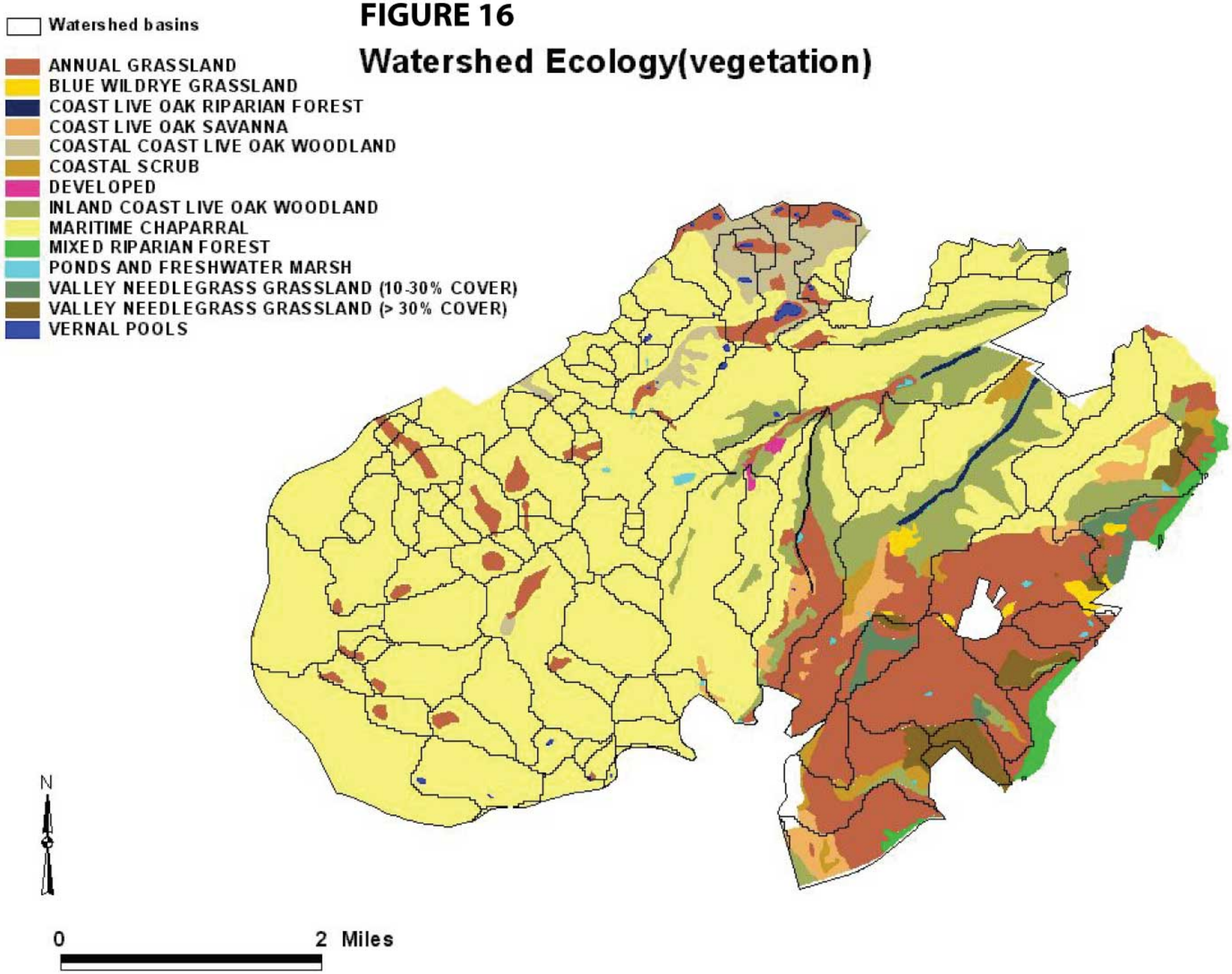


FIGURE 17: Parker Flats and Erosion Site #63

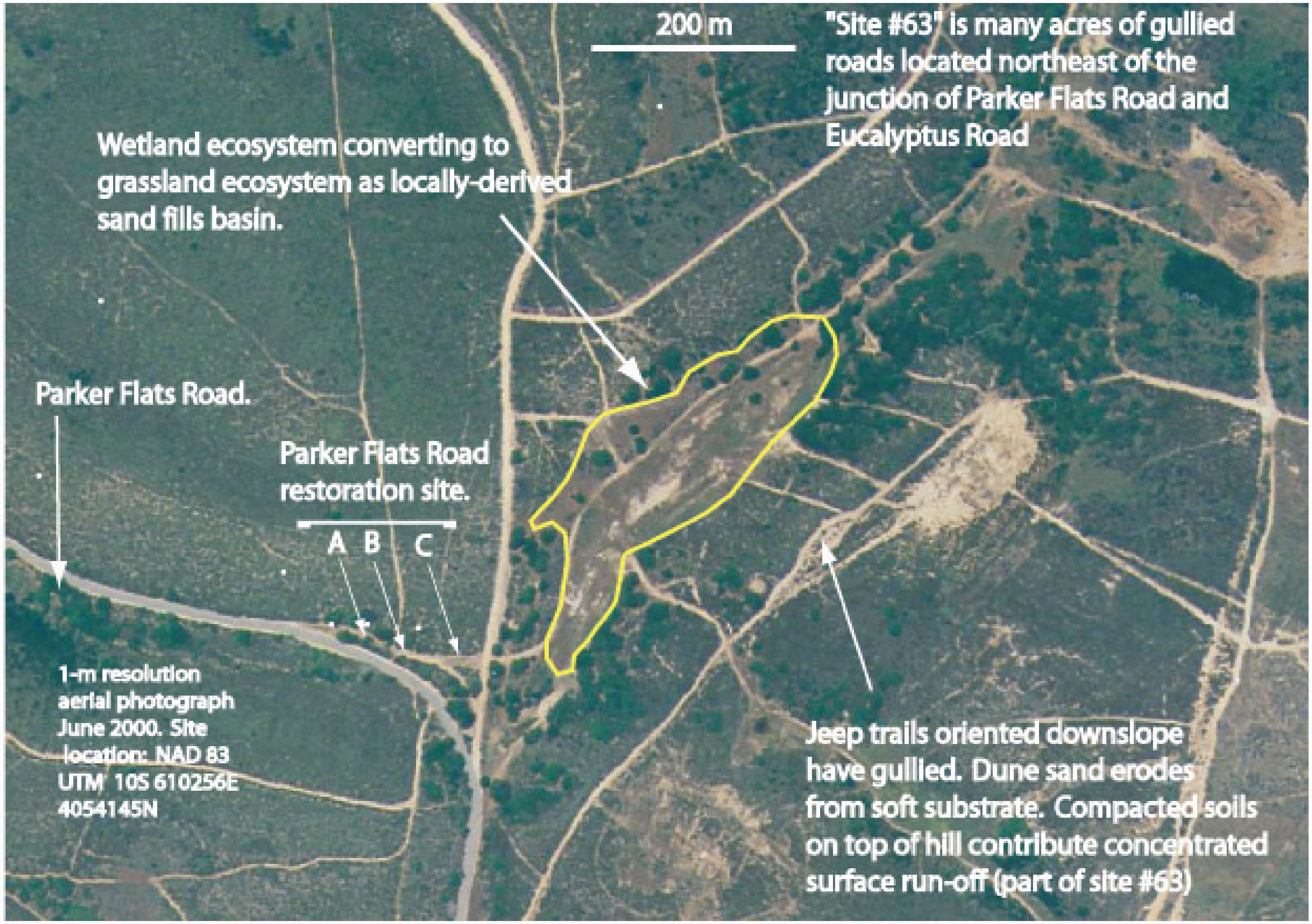


FIGURE 18: "The Chasm" Gully formed during intense rains of 1998 (Erosion site # 67)

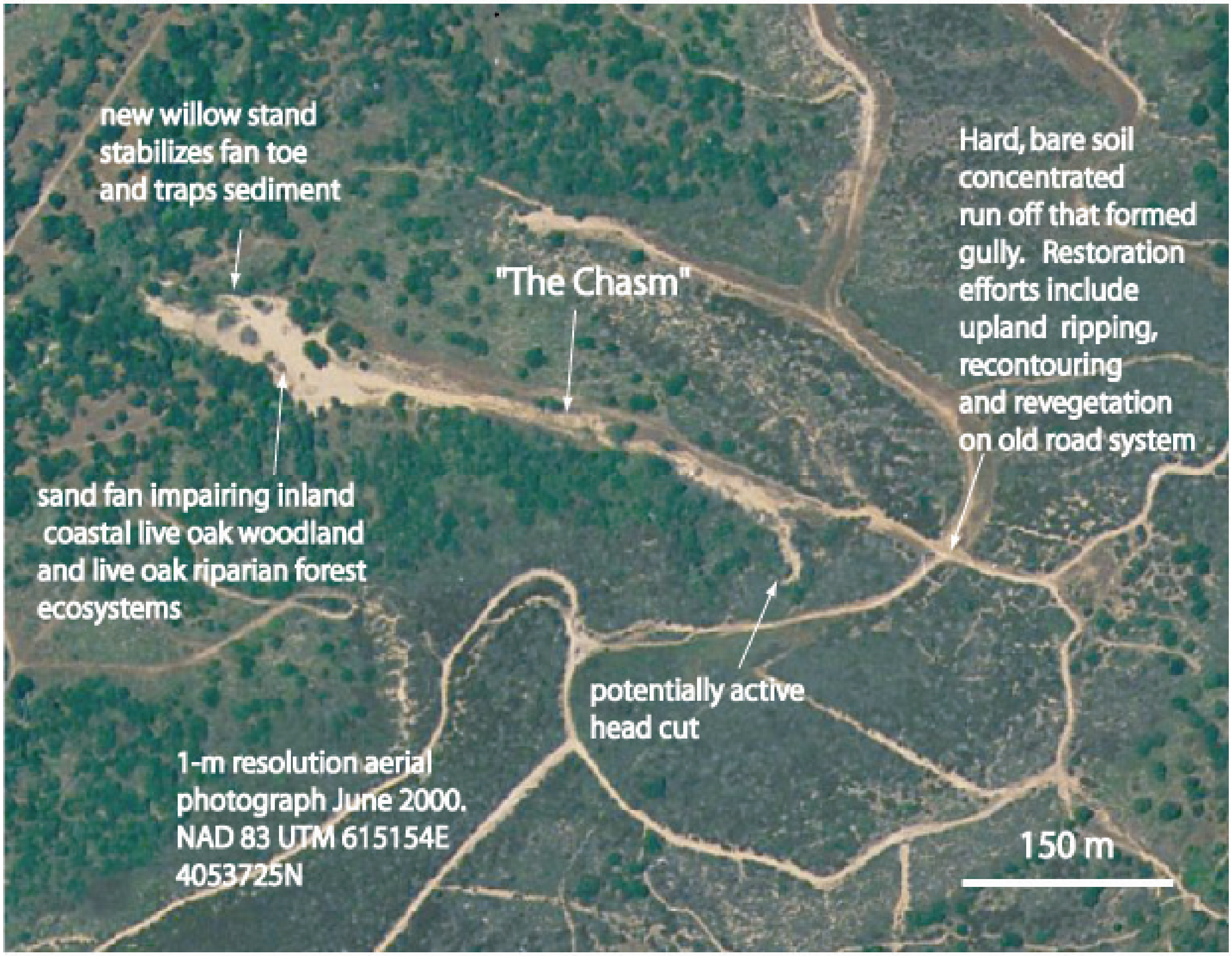


FIGURE 19: "Skyline Gully" System in subwatershed TC06 (erosion site # 33)

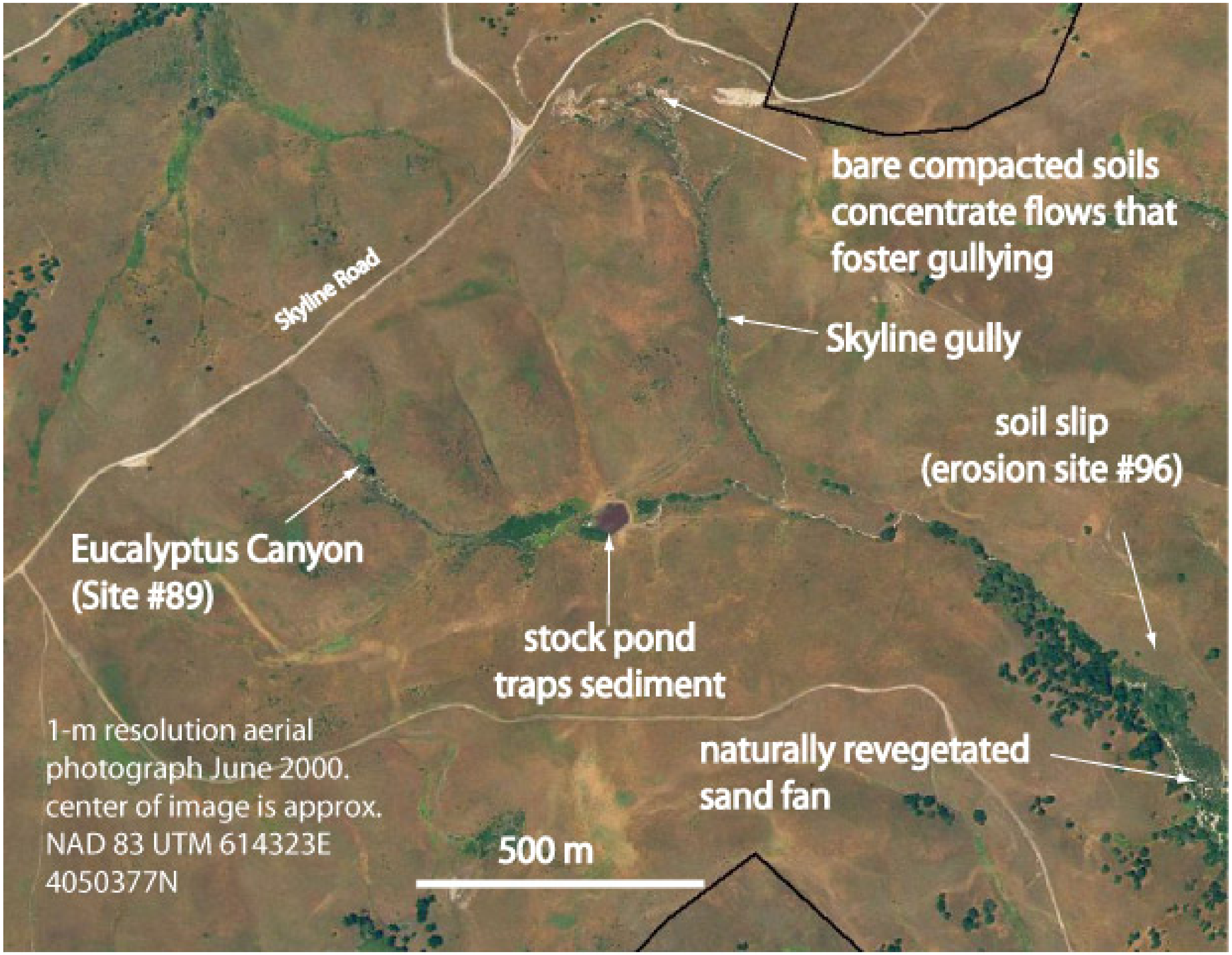


FIGURE 20: Impaired Riparian Forest at Mouth of Pilarcitos Canyon

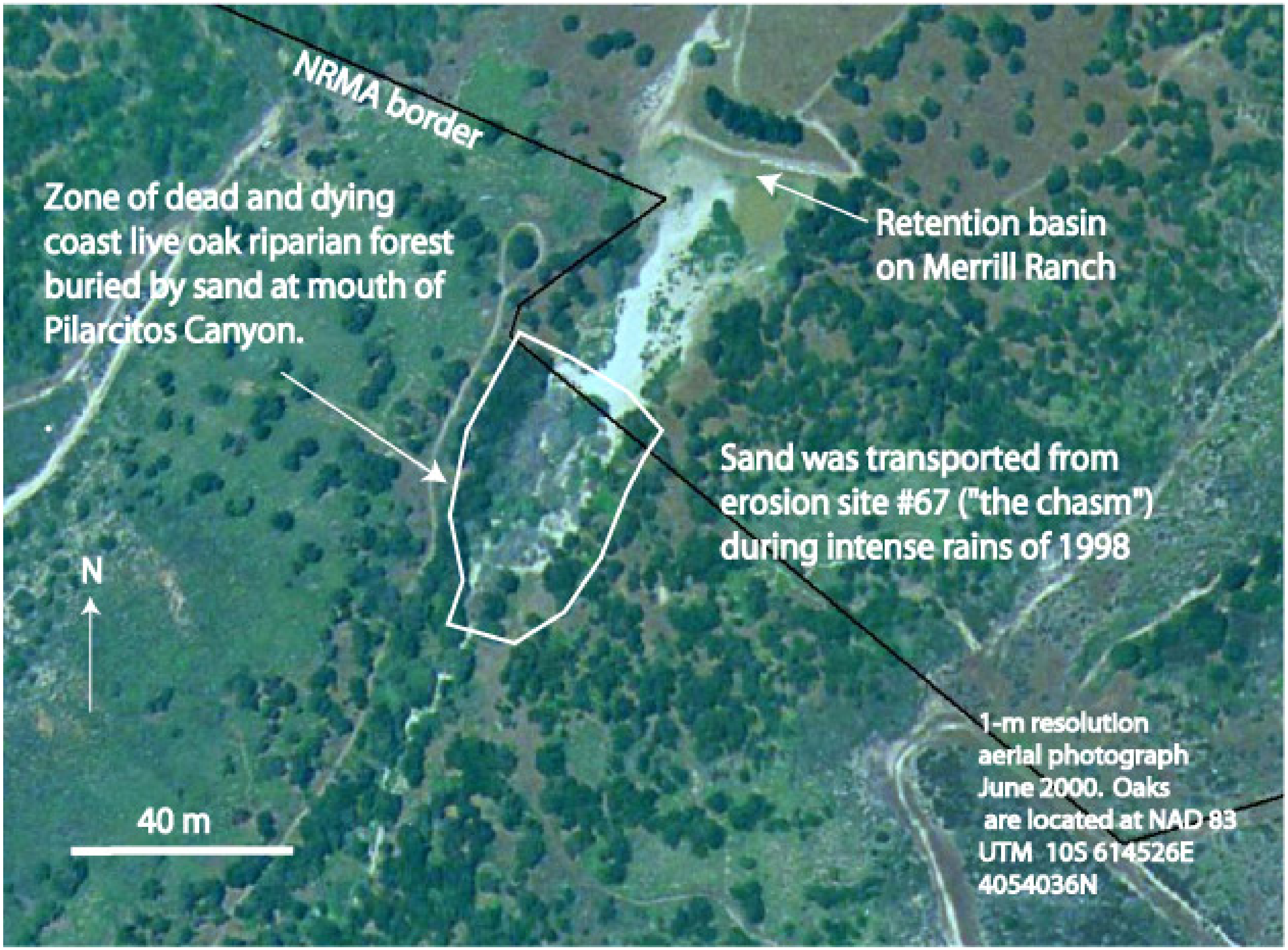


FIGURE 21: "Laguna Seca" gully in subwatershed TC09 (erosion site # 107)

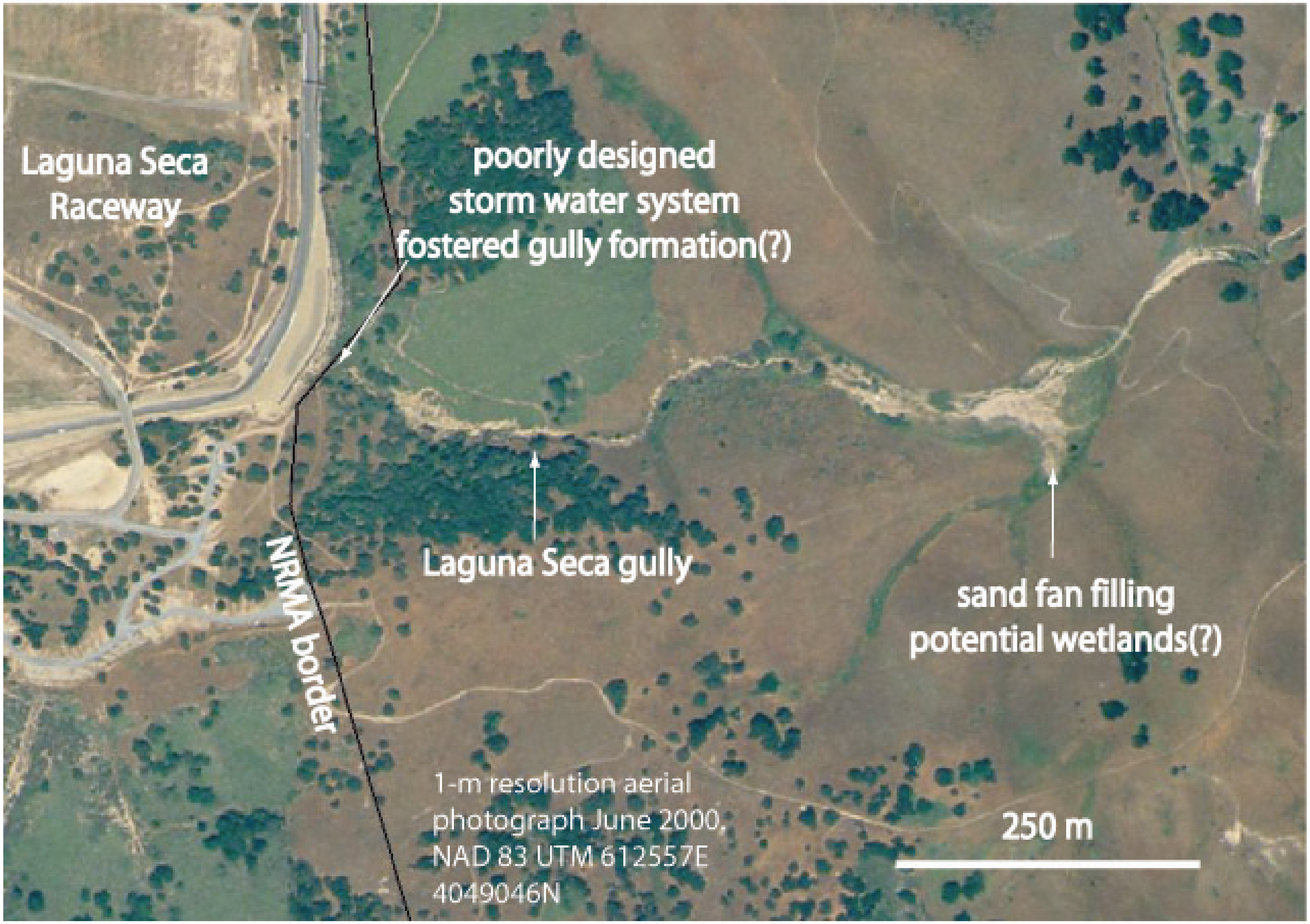


FIGURE 22
Weeds by Watershed

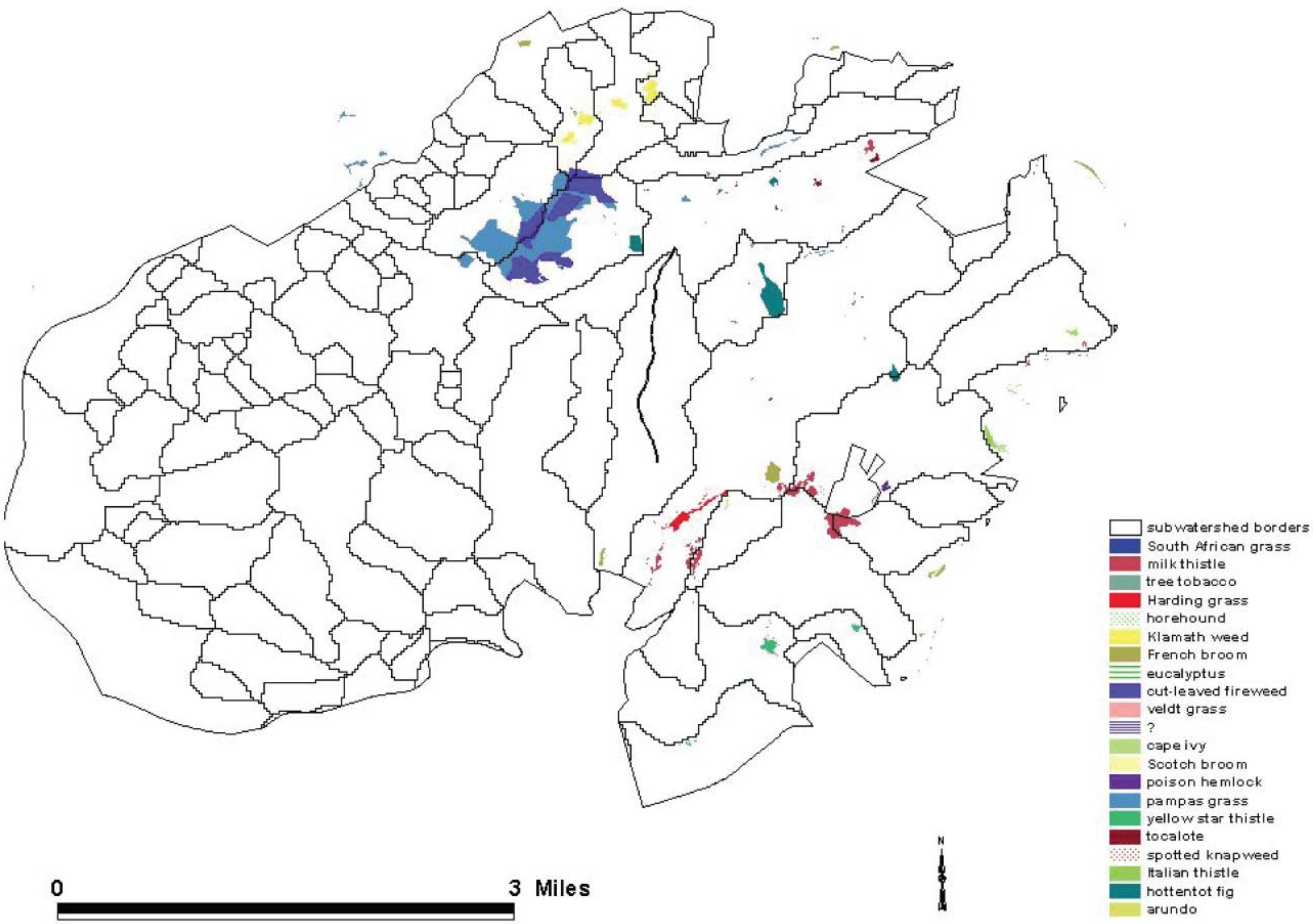
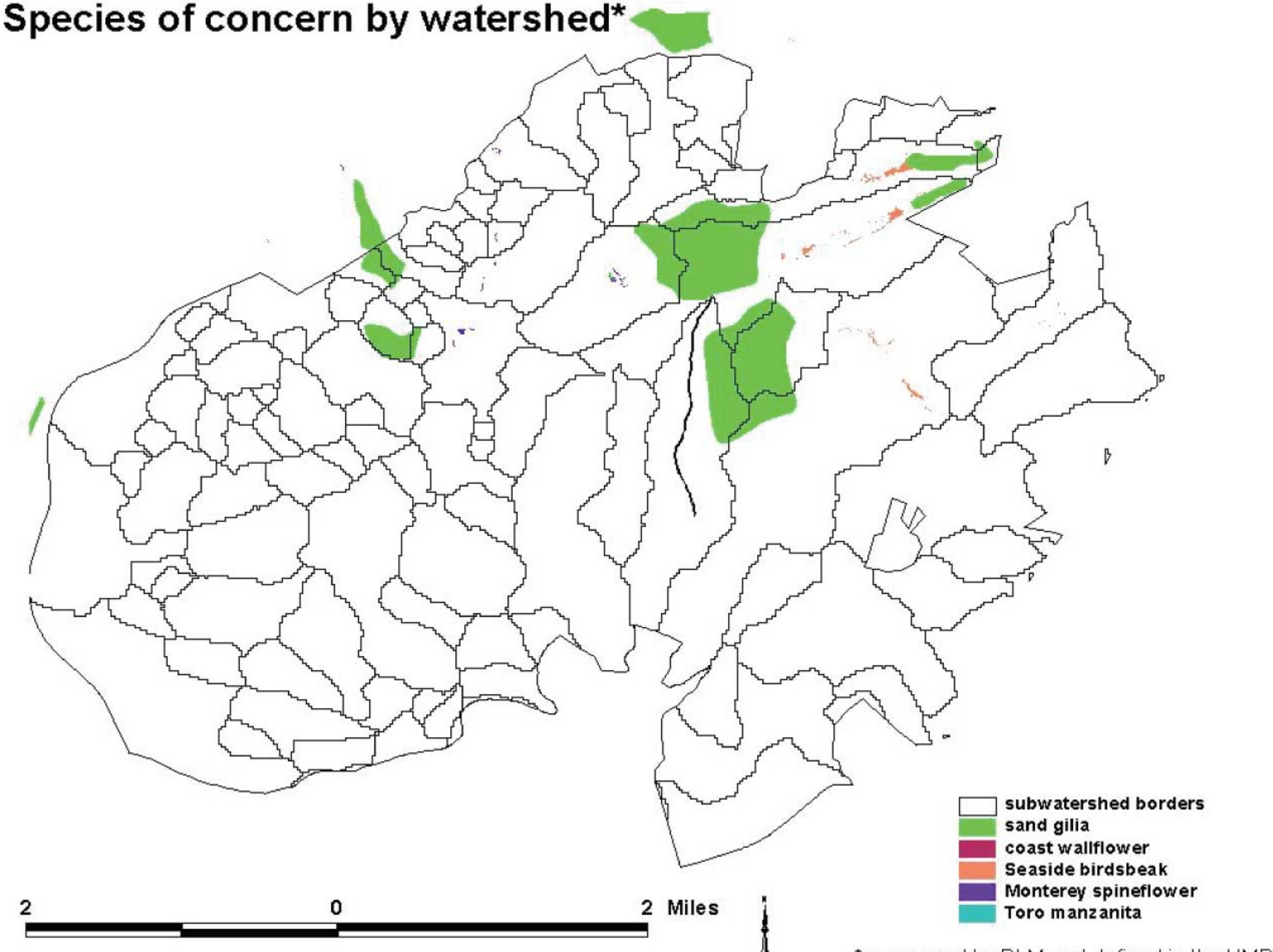


FIGURE 23

Species of concern by watershed*



*as mapped by BLM and defined in the HMP

FIGURE 24: Skyline Gully (Site# 33)

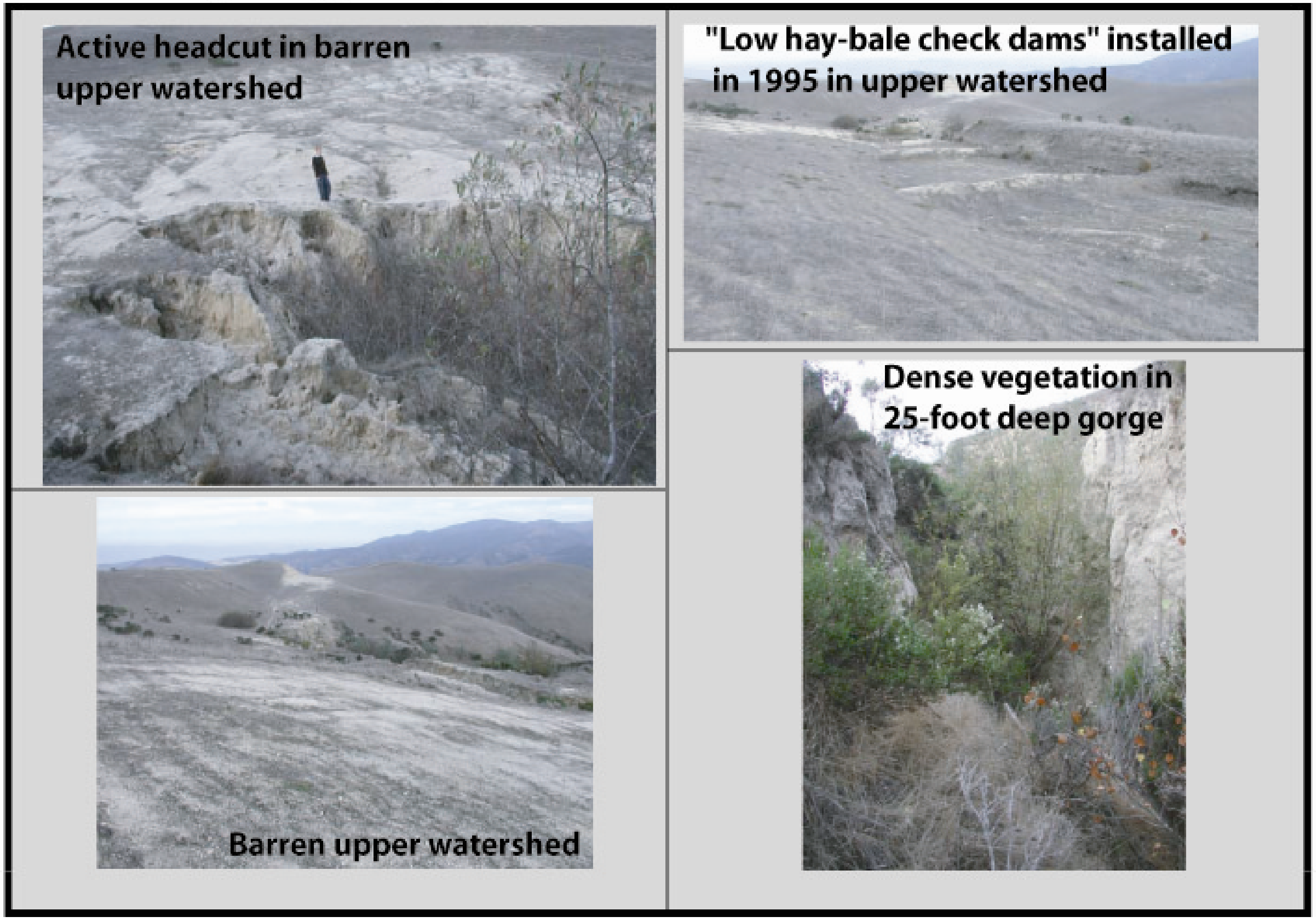


FIGURE 25
Established Restoration Sites

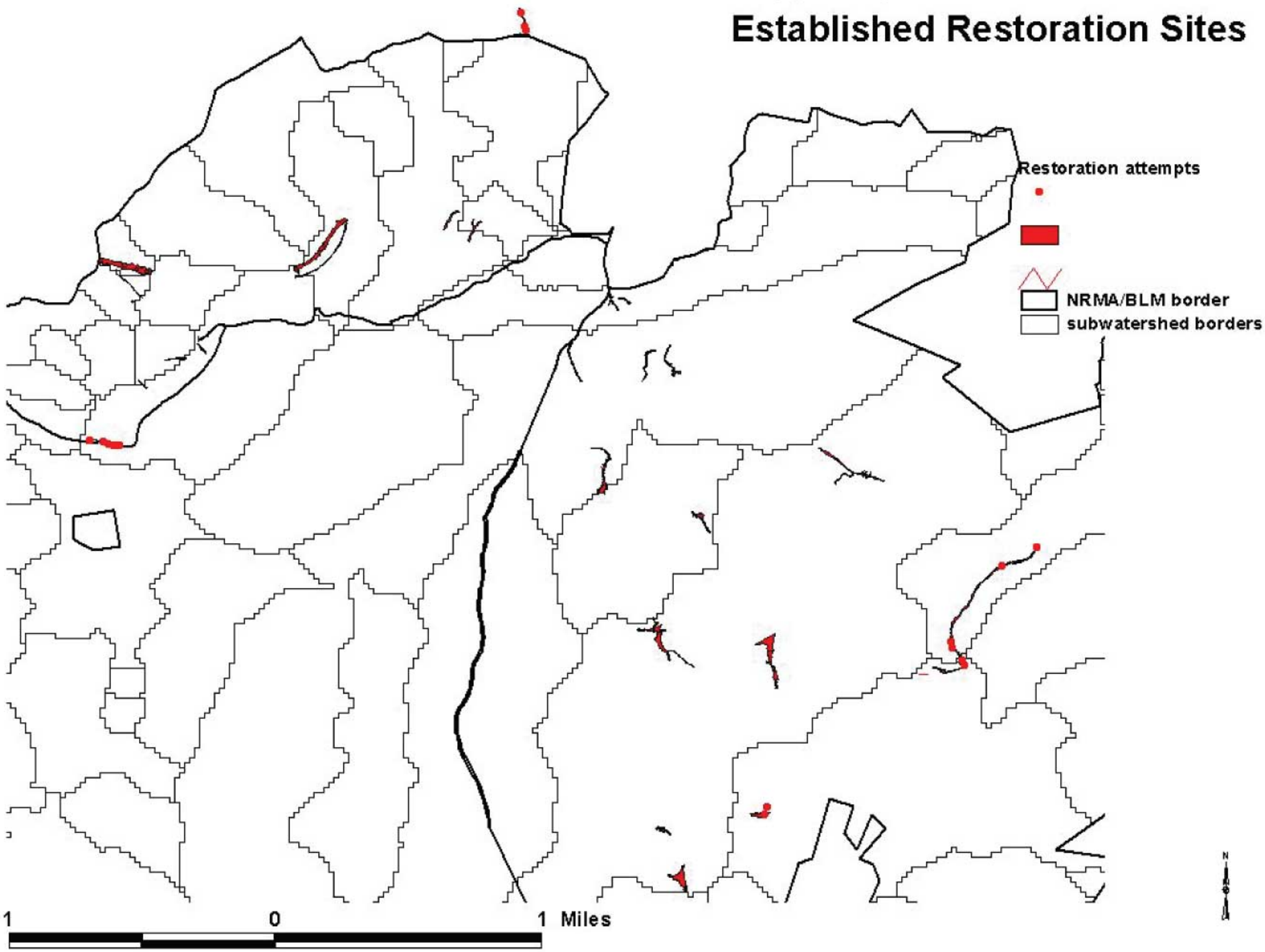


FIGURE 26: Map Comparison of Trails #67 and #26

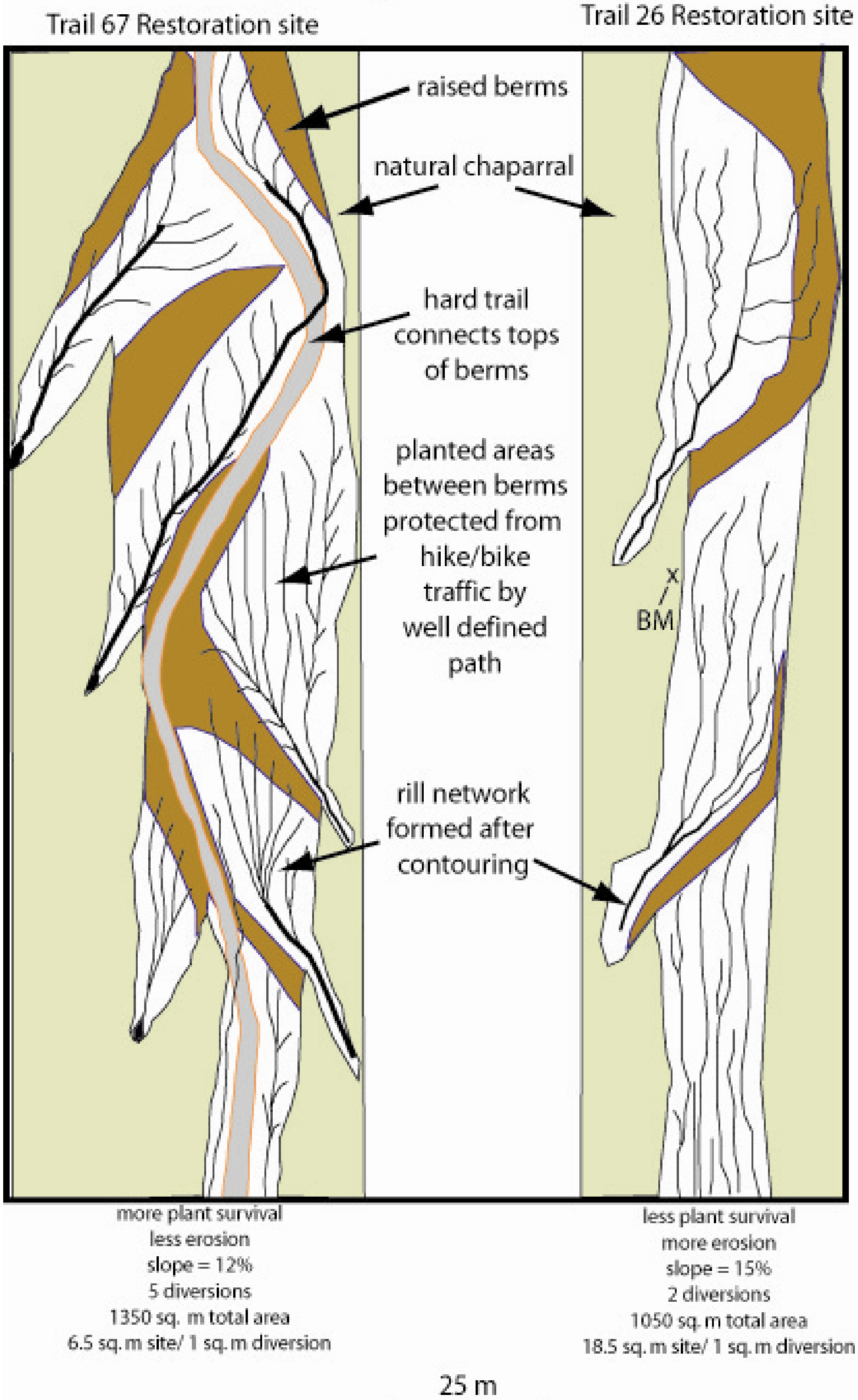


FIGURE 27
Typical Natural Cycle of Arroy/Gully Erosion and Valley Fill

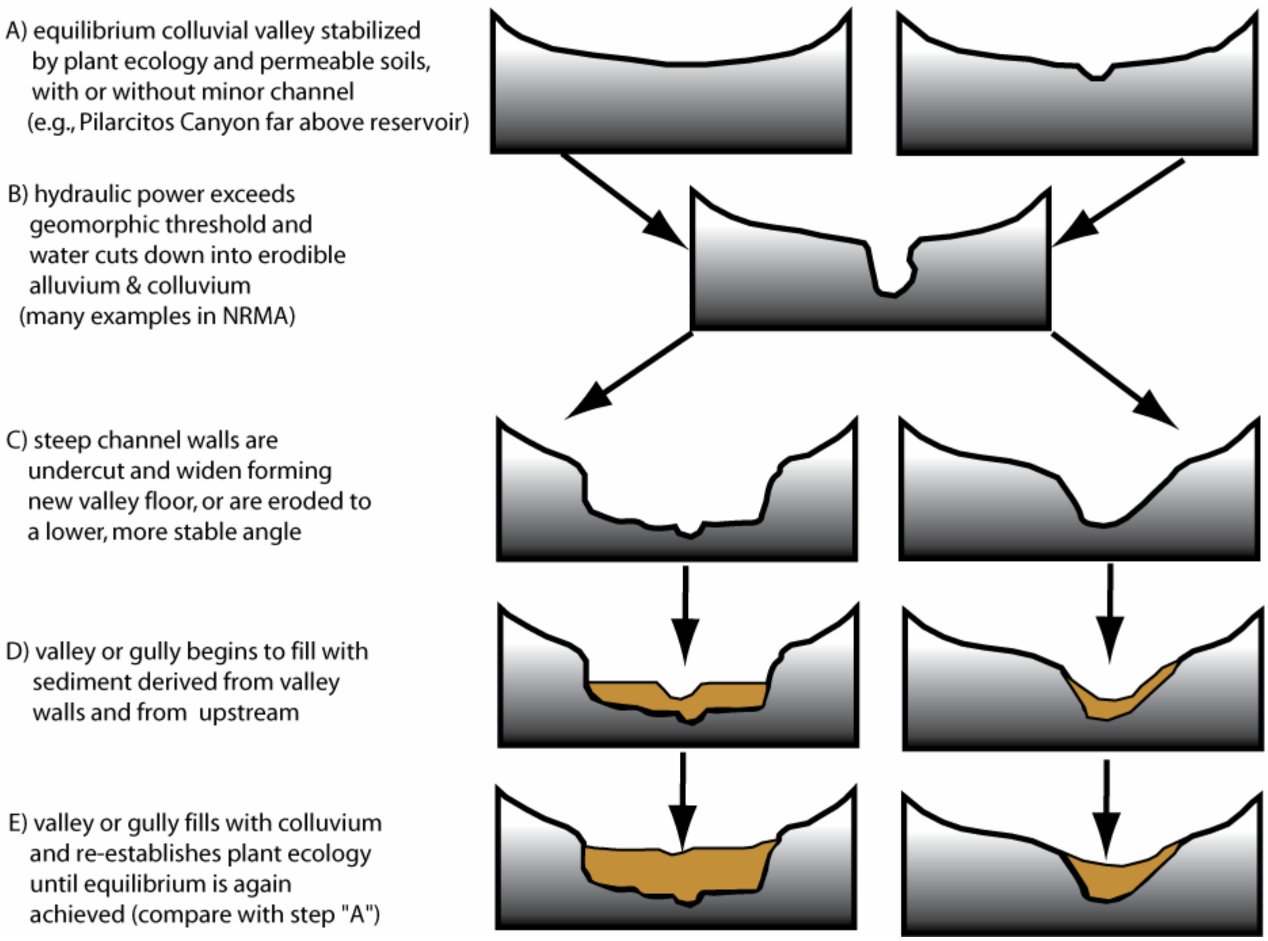
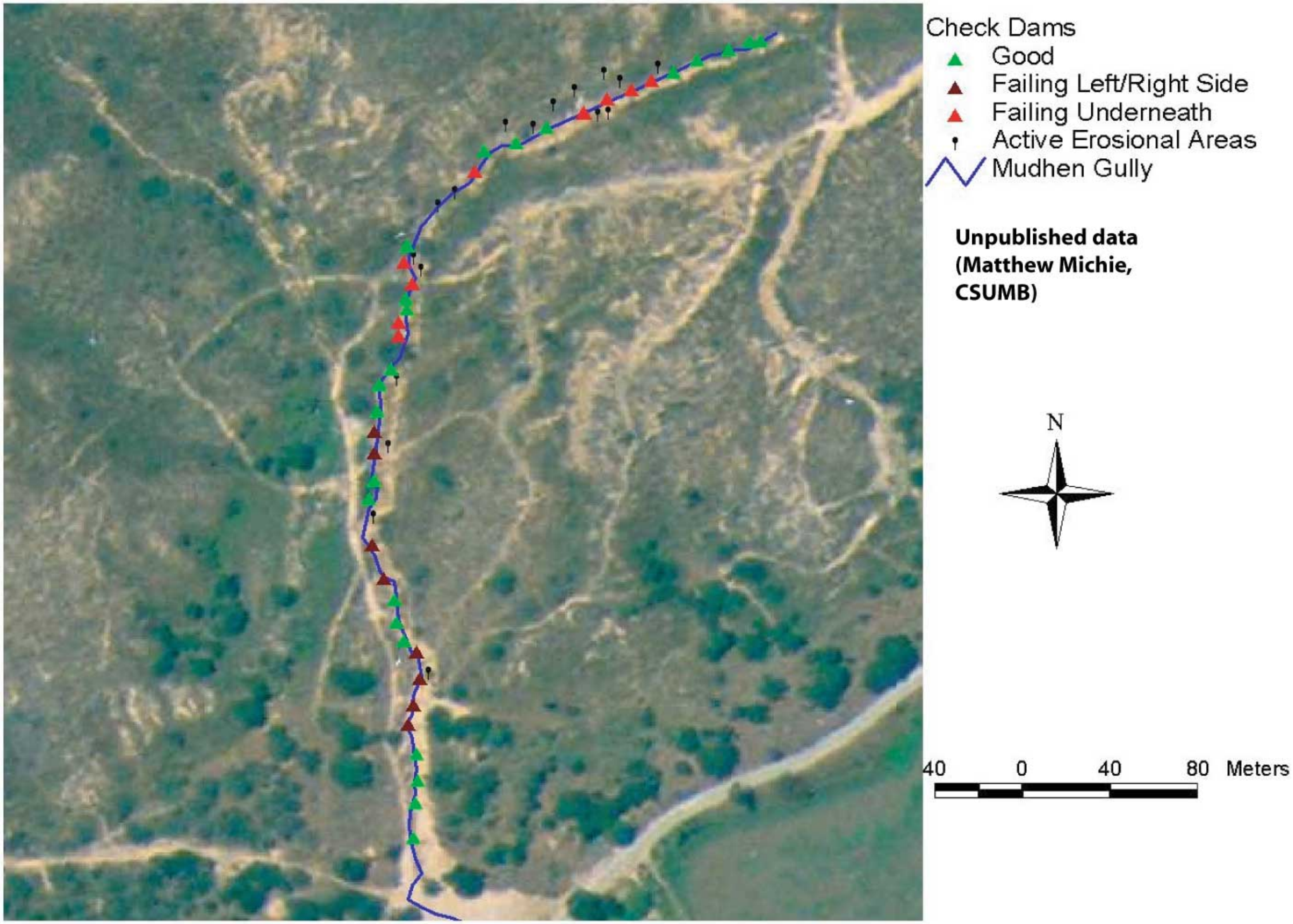
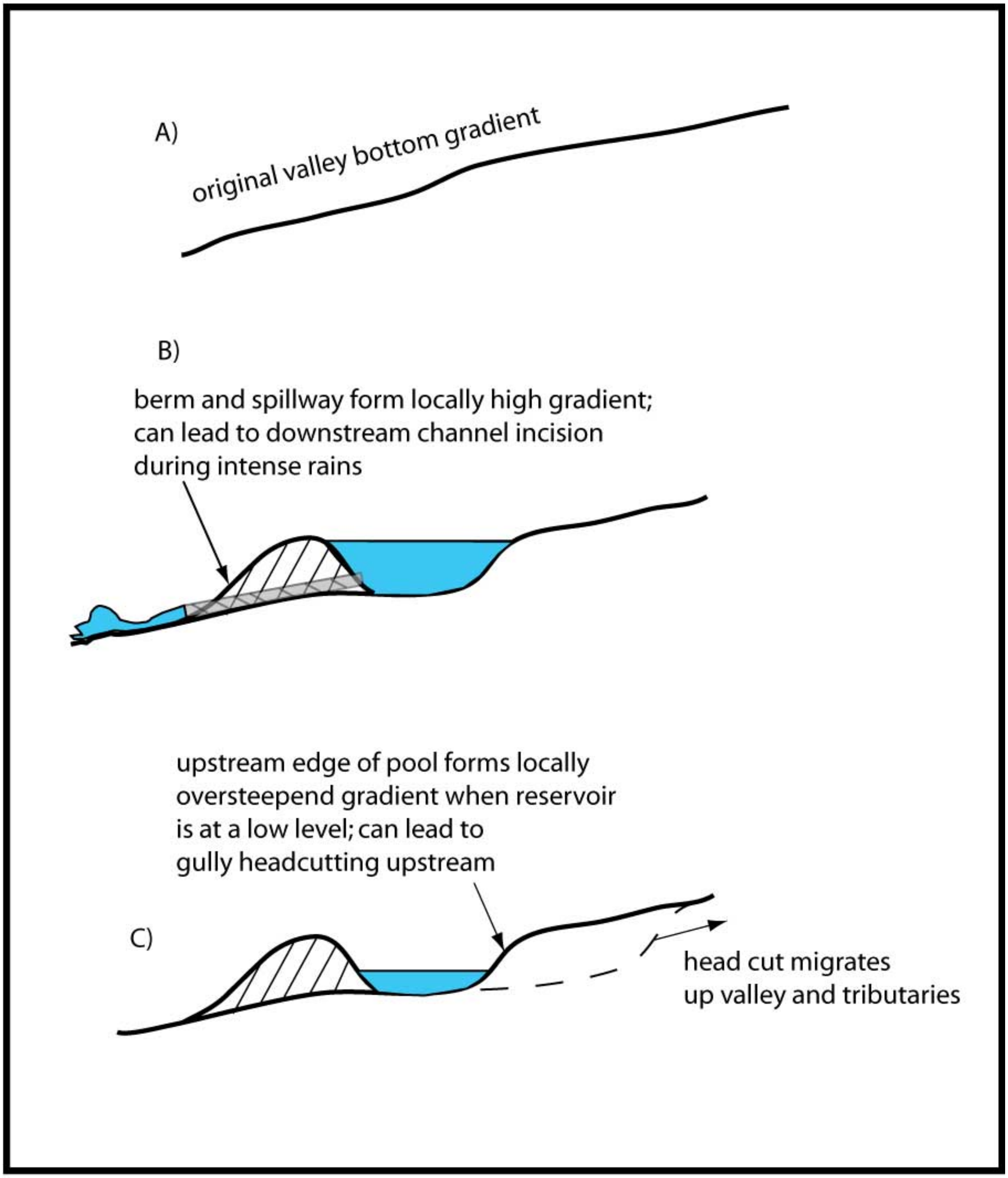


FIGURE 28: **Assessment of 42 check dams in Mudhen Lake Gully (Site #2)**



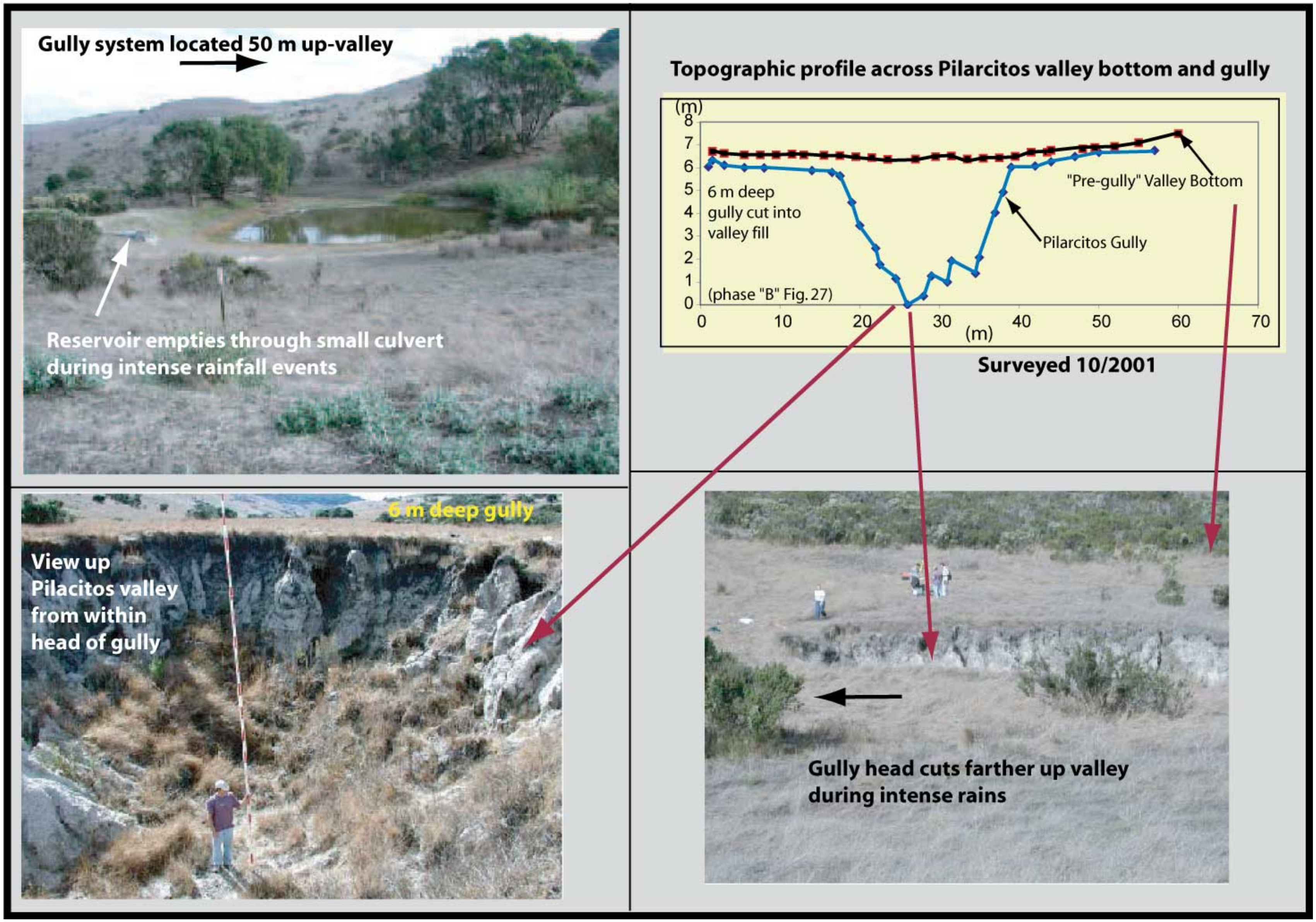
Unpublished data (Matthew Michie, CSUMB)

FIGURE 29
Potential Negative Effects of Reservoirs within NRMA



Based upon observations of the upper reservoir in Pilarcitos Canyon
See Figure 30

FIGURE 30: Features of the Upper Reservoir in Pilarcitos Canyon (Site# 44)



M. Appendicies

Appendix A: Physiography and Ownership

Map ID	Local name	Ownership	Area (hec)	Area (acres)	Relief (m)	Relief (ft)	Slope (max, degrees)	Perimeter (m)
	Salinas Watershed							
SA 01	-	BLM	8	19	34	110	9-13	1358
SA 02	-	BLM	10	24	34	110	9-13	1767
SA 03	Vernal pool # 24	BLM	10	25	12	40	5-8	1500
SA 04	Vernal pool # 21	BLM	18	45	18	60	9-13	2280
SA 05	Vernal pool # 20	BLM	46	113	55	180	9-13	3664
SA 06	Hennekin Lake	BLM	60	149	66	215	9-13	5192
SA 07	Vernal pool # 16	BLM & P	51	126	73	240	5-8	4500
SA 08	Vernal pool # 13	BLM	18	46	27	90	9-13	2160
SA 09	Machinegun Flats	BLM & P	79	194	59	195	9-13	6867
SA 10	-	BLM & P	24	59	67	220	14-17	3692
SA 11	Trail 23	BLM & P	109	270	152	500	23-26	9568
SA 12	Impossible Cyn, MOUT, Mudhen drainage	BLM & P	542	1340	299	980	32-35	26964
SA 13	Elliot Hill	P	137	338	104	340	18-22	6420
SA 14	Picnic Cyn	BLM	84	207	134	440	23-26	5100
SA 15	Barloy Cyn	BLM & P	232	574	201	660	27-31	15101
SA 16	Wildcat Cyn	P	86	213	171	560	23-26	6600
SA 17	-	P	72	178	67	220	14-17	5640
SA 18	-	P	35	86	67	220	14-17	3240
SA 19	Wolf Hill	P	52	129	79	260	9-13	7884
SA 20	Pilarcitos Cyn	BLM & P	514	1270	262	860	27-31	18181
SA 21	Trail 05&55	BLM	20	48	104	340	23-26	3213
SA 22	Engineer Cyn	BLM	119	294	140	460	27-31	8247
SA 23	Pilarcitos tributary	BLM	51	125	134	440	23-26	4200
SA 24	-	BLM	19	46	52	170	14-17	1860
SA 25	-	BLM	31	76	91	300	14-17	3729
SA 26	-	BLM	23	56	134	440	14-17	3654
SA 27	Vernal pool # 18	BLM	13	32	21	70	9-13	2160
SA 28	Vernal pool # 04	BLM	59	146	64	210	9-13	4804
SA 29	Vernal pool # 05	BLM	4	10	5	15	0-4	971
SA 30		BLM	3	8	21	70	9-13	950
	Toro Creek Watershed							
TC 01, A	-	BLM	101	251	122	400	27-31	5101
TC 01, B	Oilwell Rd	BLM	76	187	122	400	23-26	5329
TC 01, C	-	BLM	57	142	98	320	27-31	6261
TC 02	Boyscout Pond	BLM	137	338	128	420	23-26	7247
TC 03	Parking Lot Cyn	BLM & P	195	482	171	560	23-26	11305
TC 04	-	BLM	45	112	110	360	23-26	3648
TC 05	-	BLM	60	147	146	480	27-31	4630
TC 06	Skyline Gully	BLM	188	464	213	700	27-31	9182

TC 07	Guidotti Ranch	BLM	35	86	122	400	18-22	3711
TC 08	-	BLM	8	21	128	420	18-22	2125
TC 09	Laguna Seca	BLM	136	337	177	580	32-35	9193
TC 10	Laguna Seca tributary	BLM	42	104	116	380	23-26	3565
TC 11	-	BLM	116	286	165	540	18-22	7426

Appendix A (continued)

Map ID	Local name	Ownership	Area (hec)	Area (acres)	Relief (m)	Relief (ft)	Slope (max, degrees)	Perimeter (m)
	Seaside Watershed							
SE 01	-	BLM	18	44	29	95	9-13	2669
SE 02	-	BLM	7	17	23	75	9-13	1380
SE 03	-	BLM	13	31	24	80	9-13	1800
SE 04	Leary Hill	BLM & P	102	251	49	160	9-13	5880
SE 05	-	BLM	11	27	32	105	5-8	1860
SE 06	Parker Flats	BLM & P	23	56	38	125	9-13	3209
SE 07	-	P	13	33	43	140	14-17	1997
SE 08	-	P	9	22	5	15	9-13	1560
SE 09	-	P	5	14	9	30	5-8	1200
SE 10	BLM office	BLM & P	94	232	55	180	14-17	6840
SE 11	-	P	12	30	NE	NE	9-13	1740
SE 12	-	P	26	64	NE	NE	9-13	2580
SE 13	-	P	19	46	NE	NE	9-13	2160
SE 14	-	P	56	138	NE	NE	9-13	4676
SE 15	-	P	9	23	NE	NE	5-8	1440
SE 16	-	P	80	199	NE	NE	14-17	5400
SE 17	-	P	59	145	NE	NE	9-13	4920
SE 18	-	P	4	9	NE	NE	5-8	840
SE 19	-	P	5	12	NE	NE	9-13	1020
SE 20	-	P	29	72	NE	NE	9-13	2940
SE 21	-	P	20	50	NE	NE	14-17	2580
SE 22	-	P	17	42	NE	NE	9-13	2280
SE 23	-	P	10	25	NE	NE	9-13	1560
SE 24	-	P	47	117	NE	NE	14-17	3600
SE 25	-	P	4	10	NE	NE	9-13	960
SE 26	-	P	36	89	NE	NE	9-13	3360
SE 27	-	P	18	45	NE	NE	9-13	2460
SE 28	-	P	10	24	NE	NE	9-13	1620
SE 29	-	P	106	261	NE	NE	9-13	7814
SE 30	-	P	8	19	NE	NE	5-8	1380
SE 31	-	P	30	75	NE	NE	5-8	2940
SE 32	-	P	19	48	NE	NE	5-8	2520
SE 33	-	P	10	25	NE	NE	9-13	1620
SE 34	-	P	13	31	NE	NE	14-17	2100
SE 35	-	P	13	31	NE	NE	9-13	2040
SE 36	-	P	32	79	NE	NE	9-13	3000
SE 37	-	P	175	433	NE	NE	14-17	9300
SE 38	-	P	105	260	NE	NE	14-17	5520

Map ID	Local name	Ownership	Area (hec)	Area (acres)	Relief (m)	Relief (ft)	Slope (max, degrees)	Perimeter (m)
SE 39	-	P	30	75	NE	NE	9-13	3540
SE 40	-	P	83	206	NE	NE	5-8	4740
SE 41	-	P	40	98	NE	NE	9-13	3600
SE 42	-	P	61	150	NE	NE	9-13	4320
SE 43	-	P	11	26	NE	NE	5-8	1620
SE 44	-	P	12	30	NE	NE	5-8	1800
SE 45	west end	P	155	382	NE	NE	9-13	7705
SE 46	-	P	12	30	NE	NE	5-8	2280
SE 47	-	P	10	24	NE	NE	9-13	1740
SE 48	-	P	83	205	NE	NE	14-17	5400
SE 49	-	P	78	192	NE	NE	9-13	5460
SE 50	-	P	22	54	NE	NE	9-13	2700
SE 51	-	P	8	21	NE	NE	5-8	1860
SE 52	-	P	12	31	NE	NE	9-13	1977
SE 53	-	P	33	81	NE	NE	9-13	6940
SE 54	-	P	44	108	NE	NE	14-17	3720
SE 55	-	P	54	133	NE	NE	9-13	4800
SE 56	-	P	26	65	NE	NE	9-13	3630
SE 57	-	P	17	43	NE	NE	9-13	2160
SE 58	west end	P	212	524	NE	NE	9-13	9438
SE 59	-	P	31	77	NE	NE	9-13	2760
SE 60	-	P	21	52	NE	NE	9-13	2580
SE 61	-	P	19	47	NE	NE	14-17	2520
	Total Area		6065	14987				

NOTES

Map ID -- See Figure 4 for location

Ownership-- BLM = present BLM land, P = land pending transfer to BLM

Relief-- NE = not evaluated

Slope = the range of the maximum slope in the subwatershed (Fig. 13)

Local Name-- "-" = no local name

Appendix B: Select Erosion Sites---Key to Figures 11 & 12

Map number and Description	Subwat	Easting	Northing	Figure
1: gully, road concentrating flow on old restoration site	SA12	613382	4054473	
2: Mudhen Lake gully	SA12	613183	4054356	28, H
3: gully is a tributary to Mudhen Lake gully	SA12	613040	4054610	
5: small gully at end of Jeep road off Trail 8	SA14	613575	4053982	
6: gully	SA12	612985	4053848	H
7: badly gullied steep Jeep road	SA12	614244	4054049	H
8: minor gullies	SA20	613729	4053703	
9: badlands forming in roadcut	SA20	614263	4053303	H
10: badly gullied, steep, Jeep road	SA20	614688	4053317	
11: minor steep new mountain bike tracks	SA20	614057	4052737	
12: small gullies in Paso Robles Formation	TC02	616302	4053071	H
13: incipient gullied hollow in Paso Robles Formation	TC02	616691	4053051	
14: gully in valley bottom	TC02	615633	4052892	H
16: incipient erosion on old singletrack trail	SA22	616186	4054307	
17: badlands forming in roadcut	SA22	616284	4054796	
19: gullied road	TC02	616020	4052892	
20: Canyon #23 channel is incised, has headcut	SA11	614092	4055153	
21: end of ridge has eroding bike tracks	SA12	614991	4055153	
22: bad gully through capstone ridge	SA20	615401	4054239	
23: top of Trail #40 is bad gully	SA12	614131	4054363	
24: small gully in short section of old road	TC02	616826	4052953	
25: incipient gully, good kindergarten project, like #13	TC01B	616361	4052698	
26: wetland could be vegetated with HMP species of concern	TC01B	616361	4052334	
27: hillside oversteepened by road, landslide potential	TC01B	616168	4052071	
28: example of self-healing gully(?)	TC01B	615850	4051885	
29: gullying and soil slip	TC03	615595	4051877	
30: several soil slips	TC03	615184	4051965	
31: entire subwatershed below Trail 10 is badly gullied	TC03	614991	4051787	H
33: Skyline gully	TC06	613805	4051142	19,24
34: gullied road, easy access, on Trail 36	TC02	615666	4053217	H
35: gullied road	TC02	615339	4053012	
36: rutted road	TC02	615221	4052753	
37: gullied road	TC03	615034	4052623	
38: minor gullied road	TC02	616666	4053789	
39: steep section of trail 2, minor gullies	TC02	616674	4053656	
40: road needs gully control in roadside ditches	TC02	616438	4053229	
41: minor soil slips and gullying	TC03	615316	4052055	
42: gully	SA20	612180	4050321	H
43: gully	SA20	611986	4050220	
44: Pilarcitos Canyon gully head	SA20	612474	4050917	30
45: minor gullies in roadcut	SA12	612691	4054463	H
46: minor gullies in roadcut	SA12	612404	4054603	

47: several steep, parallel, eroded Jeep roads	SA11	613202	4054750	
48: old restoration site has incipient gully	SA12	613202	4054672	H
49: old restoration site needs mulch & more plants	SA12	613473	4054773	
50: hillside gully south of Merrill Ranch	SA12	614789	4054611	
51: gully head threatens Trail #22	SA12	614007	4054920	
52: hillside gully	SA12	613643	4054758	

Appendix B (continued)

Map number and Description	Subwatershed	Easting	Northing	Image
53: minor road drainage off Trail 22 triggering new gully	SA11	613690	4054897	
54: highly erosive road in sand	SA10	612915	4055184	H
55: gully in road	SA11	613372	4055044	
56: minor gully in old road	SA11	612304	4054959	
57: gullies in road	SA09	612265	4055052	
58: minor road erosion	SA11	612118	4054920	
59: gullied roads	SA13	611576	4054564	H
60: gullied roads	SA09	611762	4054750	H
61: gullied roads	SE04	610894	4054835	
62: erosional scarp & gullied roads	SE04	610863	4054394	
63: several acres of sandy hills with very gullied roads	SE04	610794	4054022	17, H
65: roadside gully on trail 19	SA28	612311	4056229	
66: minor gullying	SA27	612629	4055338	
67: "the Chasm," deeply gullied road	SA20	615277	4053666	18
68: well restored drainage, needs chaparral vegetation	SA20	614487	4053836	
69: Picnic Canyon, big gully needs flow control at head	SA14	613217	4052969	
70: gully in grass,south side of Pilarcitos Canyon	SA20	613310	4052257	
71: soil slip in grass, south side of Pilarcitos Canyon	SA20	613326	4052117	
72: gully in grass,south side of Pilarcitos Canyon	SA20	613248	4052117	
73: gullied steep road	SA15	611862	4052342	
74: gullied steep road	SA15	611909	4052055	
75: redo drainage work in old restoration site, add mulch	SA12	613535	4054510	
76: minor gully cutting capstone ridge	SA12	612559	4053418	
77: gullied road	SA12	612567	4053201	
78: minor gully in road	SA12	612342	4052853	
79: gullied road w/natural revegetation	SA12	612288	4052481	
80: gullied hillside	SA12	612637	4051629	
81: roadside drain initiates gully	SA12	611785	4050840	
82: gullied hillside	SA20	612009	4050584	
83: headwall of minor soil slip	SA20	612443	4050174	H
84: headcutting valley	SA20	612188	4050909	
85: stabilized(?) headwall scarp of landslide	SA20	612489	4050375	
86: headcutting gully above lower reservoir	SA23	612908	4050901	
87: headcutting gully above lower reservoir	SA23	613039	4051304	
88: gully	SA23	613217	4051087	
89: Eucalyptus gully	TC06	613310	4050514	H
90: gully in valley bottom	SA20	613388	4051776	
91: hillside gully	TC10	612327	4049802	H
92: healed(?) soil slips	TC06	613124	4050274	
93: old quarry may be unstable	TC07	613752	4049864	

94: lower Skyline gully system	TC06	614015	4050576	19
95: soil slip and gravure?	TC06	614379	4050437	
96: soil slip	TC06	614665	4050266	15
97: headcutting gully	TC07	614332	4049957	
98: headcutting gully	TC06	614580	4049872	
99: gully in steep hollow	TC01C	614882	4050336	
100: unstable(?) erosion cut in Santa Margarita Fm.	TC01C	615068	4050344	
101: Toro Creek streambank erosion	TC01C	615316	4050568	

Appendix B (continued)

Map number and Description	Subwatershed	Easting	Northing	Image
102: minor soil slips	TC05	615339	4050932	
103: gullying & soil slip	TC03	615633	4052047	
104: incipient gullies	TC04	615006	4051250	
105: large gully system	TC03	614619	4052016	H
106: hillside gully	TC04	615362	4051281	
107: Laguna Seca gully system	TC09	612557	4049046	21
108: 2.4 acre bare region	SA13	612079	4054555	
109: Oil Well Road culvert causing steep gully	TC03	615150	4051695	
110: large gully network	TC03	614786	4051619	
111: large gully network	TC03	614603	4051820	
112: large gully network	TC03	614261	4051784	
113: large gully network	TC03	614103	4051853	
114: large gully network	TC03	614319	4052076	

1. Easting and Northing are UTM NAD 83
2. Trail number designations are from Fort Ord BLM trail guide
3. Subwat = subwatershed. Locations in Figure 4
4. Figure = figure number of photo documentation of site. "H" = Appendix H
5. Many roads and trails within the NRMA are slated to be decommissioned. They will require restorative revegetation, but they are too numerous to list and assess individually within the scope of this report. A separate road and trail assessment is recommended to catalog those potential erosion sites

Appendix C: Watershed Erosion Geology, and Soils

Map ID	**Local name**	**Erosion sites**	**Geology**	**Soil**
	Salinas Watershed			
SA 01	-	-	Qoe?	Ar
SA 02	-	-	Qoe?	Ar
SA 03	Vernal pool # 24	-	Qoe?	Ar
SA 04	Vernal pool # 21	-	Qoe?	Ar
SA 05	Vernal pool # 20	-	Qoe?	Ar & Oc
SA 06	Hennekin Lake	-	Qoe?	Ar & Oc
SA 07	Vernal pool # 16	-	Qoe? Qal?	Ar, Ant & Oc
SA 08	Vernal pool # 13	-	Qoe? Qal?	Ar, Ant & Oc
SA 09	Machinegun Flats	60, 57	Qoe? Qal?	Ar, Ant & Oc
SA 10	-	54	Qoe?	Ar & X
SA 11	Trail 23	58, 56, 47, 55, 20, 53	Qoe?	Ar, Ant & X
SA 12	Impossible Cyn, MOUT, Mudhen drainage	21, 50, 51, 23, 7, 52, 75, 49, 1, 48, 3, 2, 6, 45, 46,	Qc, Qal, Qls, Qoe	Ar, X & SY
SA 13	Elliot Hill	59, 108	Qal? Qoe, Qc	Ar & X
SA 14	Picnic Cyn	5, 69	Qoe, Qc, Qal, Qls	Ar, X & SY
SA 15	Barloy Cyn	81, 80, 74, 73, 79, 78, 77, 76	QTc, Qoe, Qal, Qls	Ar, X & SY
SA 16	Wildcat Cyn	NE	Qoe, Qc	Ar & X
SA 17	-	NE	Qoe	Ar & X
SA 18	-	NE	Qoe, Qc	Ar & X
SA 19	Wolf Hill	NE	Qoe, Qc	Ar & X
SA 20	Pilarcitos Cyn	67, 68, 22, 8, 10, 9, 11, 70, 71, 72, 90, 44, 84, 85, 82, 83, 42, 43	Qc, Qal, Qls, Qoe, QTc	Ar, X & SY
SA 21	Trail 05&55	-	Qal? Qoe	Ar & X
SA 22	Engineer Cyn	16, 17	Qal, Qoe	Ar, X & D
SA 23	Pilarcitos tributary	88, 87, 86	QTc, Qc, Qal	SY & X
SA 24	-	-	Qoe?	Ar & X
SA 25	-	-	Qoe?	Ar & X
SA 26	-	-	Qoe?	Ar
SA 27	Vernal pool # 18	66	Qoe? Qal?	Ar & Ant
SA 28	Vernal pool # 04	65	Qoe? Qal?	Ar, Ant & Oc
SA 29	Vernal pool # 05	-	Qoe? Qal?	Ant & Oc
	Toro Creek Watershed			
TC 01, A	-	-	Qls, QTc, Qoe, Qyf, Qof, Qal?	Ar, X, SY & D
TC 01, B	Oilwell Rd	26, 25, 27, 28	Qls, Qal, Qyf, Qof, QTc	SY, X & D
TC 01, C	-	101, 100, 99,	Qt, Qyf, Qof, QTc, Qal	SY, X & D
TC 02	Boyscout Pond	38, 39, 24, 13, 40, 12, 19, 34, 14, 35, 36,	Qoe, QTc, Qc, Qal, Qls, Qyf	Ar, X, SY & D
TC 03	Parking Lot Cyn	37, 114, 113, 112, 111, 105, 110, 31, 109, 30, 41, 29, 103	Qoe, **QTc,** Qls, Qal, Qt	Ar, X, SY & D
TC 04	-	104, 106,	QTc, Qls, Qal, Qt, Qyf	SY & D
TC 05	-	102,	QTc, Qls, Qal	SY & D
TC 06	Skyline Gully	33, 89, 92, 94, 95, 96, 98,	QTc, Qal, Qls, Tsm, Qoe	SY, X & D
TC 07	Guidotti Ranch	97, 93,	QTc, Tsm, Qal, Qyf	SY & D
TC 08	-	-	QTc	SY

TC 09	Laguna Seca	107,	QTc, Tsm, Qal	Ar & SY
TC 10	Laguna Seca tributary	91	QTc, Qal, Tsm	Ar & SY

Appendix C (continued)

Map ID	Local name	Erosion sites	Geology	Soil
TC 11	-	NE	QTc, Qyf, Qc, Qls, Qal,Tsm, Qof	SY
	Seaside Watershed	-		
SE 01	-	-	Qoe?	Ar
SE 02	-	-	Qoe?	Ar
SE 03	-	-	Qoe?	Ar
SE 04	Leary Hill	61, 62, 63	Qoe	Ar & Ant
SE 05	-	-	Qoe?	Ar
SE 06	Parker Flats	-	Qeo	Ar
SE 07	-	NE	Qoe?	Ar & Oce
SE 08	-	NE	Qoe	Ar
SE 09	-	NE	Qoe	Ar
SE 10	BLM office	NE	Qoe	Ar
SE 11	-	NE	Qoe	Ar
SE 12	-	NE	Qoe	Ar
SE 13	-	NE	Qoe	Ar
SE 14	-	NE	Qoe, Qod	Ar & Bay
SE 15	-	NE	Qoe	Ar
SE 16	-	NE	Qoe	Ar
SE 17	-	NE	Qoe	Ar & X
SE 18	-	NE	Qoe	Ar
SE 19	-	NE	Qoe	Ar
SE 20	-	NE	Qoe	Ar
SE 21	-	NE	Qoe	Ar
SE 22	-	NE	Qoe	Ar
SE 23	-	NE	Qoe	Ar
SE 24	-	NE	Qoe	Ar
SE 25	-	NE	Qoe	Ar
SE 26	-	NE	Qoe	Ar & Bay
SE 27	-	NE	Qoe, Qod	Ar & Bay
SE 28	-	NE	Qod, Qoe	Ar & Bay
SE 29	-	NE	Qod, Qoe	Bay & Ar
SE 30	-	NE	Qoe, Qod	Ar & Bay
SE 31	-	NE	Qoe, Qod	Ar & Bay
SE 32	-	NE	Qoe	Ar
SE 33	-	NE	Qoe	Ar
SE 34	-	NE	Qoe	Ar
SE 35	-	NE	Qoe	Ar
SE 36	-	NE	Qoe	Ar
SE 37	-	NE	Qoe	Ar & X
SE 38	-	NE	Qoe	Ar & X
SE 39	-	NE	Qoe	Ar & X
SE 40	-	NE	Qoe	Ar
SE 41	-	NE	Qoe, Qod	Ar & Bay
SE 42	-	NE	Qod, Qoe	Ar & Bay

SE 43	-	NE	Qod, Qoe	Ar & Bay
SE 44	-	NE	Qod	Bay

Appendix C (continued)

Map ID	Local name	Erosion sites	Geology	Soil
SE 45	west end	NE	Qod, Qoe	Ar & Bay
SE 46	-	NE	Qoe	Ar & Bay
SE 47	-	NE	Qoe	Ar
SE 48	-	NE	Qoe	Ar
SE 49	-	NE	Qoe	Ar
SE 50	-	NE	Qoe	Ar
SE 51	-	NE	Qoe	Ar
SE 52	-	NE	Qoe	Ar
SE 53	-	NE	Qoe	Ar
SE 54	-	NE	Qoe	Ar
SE 55	-	NE	Qoe	Ar
SE 56	-	NE	Qoe	Ar
SE 57	-	NE	Qoe	Ar
SE 58	west end	NE	Qoe, Qod	Ar & Bay
SE 59	-	NE	Qoe	Ar
SE 60	-	NE	Qoe, Qod	Ar & Bay
SE 61	-	NE	Qoe	Ar

Notes:

1. Map ID locations are found on Fig. 4.
2. Erosion sites are found on Figures 11 & 12 and Appendix B.
3. Geology symbol key is same as for Figure 3.
4. Soil symbol key is same as for Figure 9.

APPENDIX D: HMP Species of Concern

HMP Ecosystem	HMP Species of Concern	Weeds
MarCh	spineflower	-
MarCh	spineflower	-
MarCh, Pond	spineflower	-
MarCh, VP	spineflower	-
MarCh, C.OakWood, VP	spineflower	coma
MarCh, C.OakWood, AnGrass, VP	spineflower	gemo, hype
MarCh, C.OakWood, VP, AnGrass,	-	ergl, coju, hype,coma,gemo
AnGrass, C.OakWood, VP	-	hype
C.OakWood, AnGrass, MarCh, VP	-	hype,ergl, caed, coju
MarCh, C.OakWood, AnGrass, Dev	spineflower, birdsbeak	-
MarCh, AnGrass, In.OakWood	sandgilia, birdsbeak	caed, coju
MarCh, AnGrass, In.OakWood, OakRip, Pond, Dev, OakSav	sandgilia, birdsbeak, spineflower	sima, ceme, trac, caed, coju, ceso, gemo
MarCh, VP, In.OakWood	sandgilia, spineflower	ergl, coju, caed
MarCh, AnGrass, In.OakWood	birdsbeak, sandgilia	gemo, caed, coju
MarCh, Angrass, In.OakWood, OakSav, Pond, VP	sandgilia	gemo,hype, difu
MarCh, In.OakWood, Dev.	-	-
MarCh, Pond	-	-
March	-	-
March, OakSav	-	-
MarCh, C.Scrub, In.OakWood, OakRip, BluGrass, OakSav, AnGrass	sandgilia, birdsbeak	coju, coma, caed, capy, nigl, sima, ardo, phaq, gemo
MarCh, AnGrass	-	-
MarCh	birdspeak	caed
MarCh, V.NeedGrass10-30%, V.NeedGrass>30%	-	ardo, sima, mavu
MarCh, In.OakWood	sandgilia	-
MarCh, In.OakWood	-	-
MarCh, In.OakWood, Dev	-	peus, gemo
MarCh, AnGrass, VP	-	hype

HMP Ecosystem	HMP Species of Concern	Weeds
MarCh, C.OakWood, AnGrass, VP	-	hype
AnGrass, C.OakWood, VP	-	-
MarCh, AnGrass, In. Oakwood, C.Scrub, V.NeedGrass>30%, MixRip	-	caed, gemo
MixRip, AnGrass, V.NeedGrass10-30%, In.OakWood, BluGrass, V.NeegGrass>30%	-	sima, capy
MixRip, AnGrass	-	gemo
MarCh, AnGrass, In.OakWood, OakSav, V.NeedGrass>30%, Pond, MixRip	birdsbeak	cima, capy, coma
AnGrass, MarCh, V.NeedGrass>30%, V.NeedGrass10-30%, BluGrass, Pond, C.Scrub	birdsbeak	caed, coma, sima, mavu
AnGrass, BluGrass, Pond	-	-
AnGrass, V.NeedGrass>30%, In.OakWood	-	sima
AnGrass, In.OakWood, V.NeedGrass10-30%, C.Scrub, Ponds	-	sima, mavu
V.NeedGrass>30%, AnGrass	-	ceso
V.NeedGrass>30%	-	-
AnGrass, C.Scrub, V.NeedGrass>30%, In.OakWood, OakSav, Pond	-	ceso
AnGrass, C.Scrub	-	ceso
AnGrass, MixRip, In.OakWood, OakSav, C.Scrub	-	ceso

HMP Ecosystem	HMP Species of Concern	Weeds
	-	-
MarCh	spineflower	coju, hype (but outside blm border)

MarCh	-	-
MarCh	spineflower	-
MarCh, AnGrass, C.OakWood, Ponds, VP	spineflower	coju, ergl
MarCh	-	-
MarCh	-	coju
MarCh, C.OakWood	sandgilia, spineflower	-
MarCh, C.OakWood	sandgilia	-
MarCh	sandgilia	-
MarCh, AnGrass, Ponds	spineflower, birdsbeak	coju
MarCh, AnGrass	sandgilia	-
MarCh, AnGrass	sandgilia	-
MarCh, C.OakWood	-	-
MarCh	-	-
MarCh	-	-
MarCh, AnGrass	sandgilia	-
MarCh	-	-
MarCh	-	-
MarCh	-	-
MarCh	-	-
MarCh	-	-
MarCh, AnGrass	-	-
MarCh, AnGrass	-	-
MarCh, AnGrass	-	-
MarCh	-	-
MarCh, AnGrass	-	-
MarCh, AnGrass	-	-
MarCh, AnGrass	-	-
MarCh, AnGrass	-	-
MarCh	-	-
MarCh	-	-
MarCh	-	-
MarCh	-	-
MarCh	-	-
MarCh, AnGrass	-	-
MarCh, AnGrass	-	-
MarCh, AnGrass, C.OakWood	-	-
MarCh	-	-
MarCh, AnGrass	-	-
MarCh	-	-

HMP Ecosystem	**HMP Species of Concern**	**Weeds**
MarCh, AnGrass	**-**	**-**
MarCh, AnGrass	-	-
MarCh	-	-
MarCh	-	-
MarCh, AnGrass	-	-

MarCh, AnGrass	-	-
MarCh, AnGrass	-	-
MarCh, AnGrass	-	-
MarCh	-	-
MarCh, VP	-	-
MarCh	-	-
MarCh, AnGrass, VP	-	-
MarCh, AnGrass	-	-
MarCh, AnGrass	-	-
MarCh	-	-
MarCh, VP	-	-
MarCh, VP	-	-
MarCh, AnGrass	-	-
MarCh, AnGrass	-	-
MarCh, AnGrass	-	-
MarCh	-	-

<u>BLM Vascular Plant Keys</u>

Key to ecosystem abbreviations in Appendix D

symbol	system
AnGrass	Annual Grassland
BluGrass	Blue Wildrye Grassland
OakRip	Coast Live Oak Riparian Forest
OakSav	Coast Live Oak Savanna
C.OakWood	Coastal Coast Live Oak Woodland
C.Scrub	Coastal Scrub
Dev	Developed
In.OakWood	Inland Coast Live Oak Woodland
MarCh	Maritime Chaparral
MixRip	Mixed Riparian Forest
Pond	Ponds and Freshwater Marsh
V.NeedGrass10-30%	Valley Needlegrass Grassland (10-30% cover)
V.NeedGrass>30%	Valley Needlegrass Grassland (>30% cover)
VP	Vernal Pools

Key to weed abbreviations in Appendix D

symbol	scientific name	common name

ardo	Arundo donax	giant reed
caed	Carpobrotus edulis	hottentot fig
capy	Carduus pycnocephalus	Italian thistle
cebi	Centaurea biebersteinii	spotted knapweed
ceme	Centaurea melitensis	tocalote
ceso	Centaurea solstitialis	yellow star thistle
coju	Cortaderia jubata	pampas or jubata grass
coma	Conium maculatum	poison hemlock
cysc	Cytisus scoparius	scotch broom
deod	Delairea odorata	cape ivy
ehca	Ehrharta calycina	veldt grass
ergl	Erechtites glomerata	cut-leaved fireweed
peus	Eucalyptus spp	eucalyptus
gemo	Genista monspessulana	French broom
hype	Hypericum perforatum	Klamath weed
mavu	Marrubium vulgare	horehound
nigl	Nicotiana glauca	tree tobacco
phaq	Phalaris aquatica	harding grass
sima	Silybum marianum	milk thistle
trac	Tribolium obliterum	S. African grass

Appendix E: HMP Species of Concern that occur, or have habitat, within the NRMA (After Church and Kane, 2001)

Scientific name	Common name	Acreage	Status (a)	CNPS RED code	Typical Habitat
Plants					
Gilia tenuiflora arenaria	sand gilia	2,288	FE/ST/1B	3-2-3	Sandy openings in coastal dunes, scrub and maritime chaparral
Lasthenia conjugens	Contra Costa goldfields		FE/--/1B	3-3-3	Mesic valley and foothill grasslands. Known from vernal pool habitat in three locations on Fort Ord.
Piperia yadonii	Yadon's piperia		FE/--/1B	3-3-3	Sandy soil in maritime chaparral, coastal scrub, and closed-cone coniferous forest
Chorizanthe p. pungens	Monterey spineflower	5,176	FT/--/1B	2-2-3	Colonizes recently disturbed sandy sites in coastal dune, coastal scrub, grassland, and maritime chaparral habitats
Cordylanthus rigidus littoralis	Seaside bird's-beak	1,046	FSC/SE/1B	2-3-3	Sandy soils of stabilized dunes, maritime chaparral, coastal scrub, and closed-cone coniferous forest
Arctostaphylos montereyensis	Toro manzanita	5,261	FSC/--/1B	3-2-3	Stabilized sandy soils and badlands in maritime chaparral
Arctostaphylos pumila	sandmat manzanita	5,453	FSC/--/1B	3-2-3	Sand hills of maritime chaparral and coast live oak woodland
Ceanothus cuneatus rigidus	Monterey ceanothus	8,223	FSC/--/4	1-2-3	Sand hills and flats of maritime chaparral, closed-cone coniferous forests, and coastal scrub
Ericameria fasciculata	Eastwood's goldenbrush	4,194	FSC/--/1B	3-3-3	Coastal dune and scrub, maritime chaparral, and closed-cone coniferous forest
Arctostaphylos h. hookeri	Hooker's manzanita	4,499	--/--/1B	2-2-3	Sand Hill and Aromas Formations, maritime chaparral and closed-cone coniferous forest

Appendix E continued

Scientific name	Common name	Acreage	Status (a)	CNPS RED code	Typical Habitat
Reptile					
Anniella pulchra nigra	California black-legless lizard	935	--/--/CSC	NA	Moist, warm habitat with loose soil and prostrate plant cover located on beaches and chaparral with sandy soils
Amphibians					
Rana aurora draytonii	California red-legged frog	23	FT/--/CSC	NA	Lowlands, foothills woodland, grasslands near marshes, lakes ponds or other permanent water sources with extensive emergent vegetations
Ambystoma californiense	California tiger salamander	56	FC/--/CSC	NA	Grassland and oak woodland with scattered ponds, intermittent streams or vernal pools, upland habitat with rodent burrows required in summer
Invertebrate					
Linderiella occidentalis	California linderiella	56	--/--/--	NA	Low lying areas, temporary water sources, vernal pools and ponds

Footnotes for Appendix E

Footnotes	
(a) Status (Plants: Federal/State/CNPS: Wildlife: Federal/State/ California Department of Fish and Game)	
STATUS CODES	
Federal	
FE	Listed as endangered under the Federal Endangered Species Act (16 U.S.C. 1531 *et seq.)*
FT	Listed as threatened under the Federal Endangered Species Act (16 U.S.C. 1531 et seq.)
FC	Federal Candidate for listing by the Federal Government (Former Category 1 Candidate for listing)
FSC	U.S. Fish and Wildlife Service designated "Species of Concern" (Former Category 2 candidate for listing)
State	
SE	Listed as endangered under the California Endangered Species Act (California Fish and Game Code Division 3, Chapter 1.5, Article 2)
ST	Listed as threatened under the California Endangered Species Act (California Fish and Game Code Division 3, Chapter 1.5)
CSC	California Species of Special Concern
CNPS	
List	1B Plants considered by CNPS as rare in California and elsewhere
List	4 Plants CNPS considers to have limited distributions-a watch list
CNPS R-E-D Code	
R (rarity)	
1	Rare, but found in sufficient numbers and distributed widely enough that the potential for extinction is low at this time
2	Distributed in a limited number of occurrences, occassionally more if each occurrence is small
3	Distributed in one to several highly restricted occurences, or present in such small numbers that is seldom reported
E (endangerment)	
2	Endangered in portion of its range
3	Endangered throughout its range
D (distribution)	
3	Endemic to California

Appendix F: BLM Restoration Sites in Electronic Database (June 2001)

Local name	Map Index	BLM Description of restored sites
Salinas Watershed		
-	SA 1	site lower 18, restoration site 19
-	SA 2	site lower 18, site upper 18, site 18 plot c, restoration site 19
Vernal pool # 24	SA 3	1998-1999 rest. site 21 w/ plots a, b & c
Vernal pool # 21	SA 4	Site 26, restoration site 19,
Vernal pool # 20	SA 5	Site 26
Hennekin Lake	SA 6	-
Vernal pool # 16	SA 7	Site 26, A, B; site NR4, plot A & B
Vernal pool # 13	SA 8	-
Machinegun Flats	SA 9	site 16, site 16 rocks
-	SA 10	-
Trail 23	SA 11	site 6 west 2, site 6 west, site 6 plot a, site 6 plot b, site 6 plot c
Impossible Cyn, MOUT, Mudhen drainage	SA 12	site 5, site 23, site 59, plot a site 59, plot b site 59, omit, site 12, site 12 plots a,b, c & d,
Elliot Hill	SA 13	-
Picnic Cyn	SA 14	site 8 1997-1998, site 8 plot a, site 8 plot b, site 8 plot c, site 12
Barloy Cyn	SA 15	-
Wildcat Cyn	SA 16	-
-	SA 17	-
-	SA 18	-
Wolf Hill	SA 19	-
Pilarcitos Cyn	SA 20	cell 5, cell 6, cell 7, Skyline road FY2000 rest.site, rest site 7/9 early primter, rest site 49/11 cell 1, rest site 49/11 cell 2, rest site perimiter, site 14 2
Trail 05&55	SA 21	-
Engineer Cyn	SA 22	trail 39 junc, trail 37 junc, PP4, PP3, rest. site 37 perimeter, rest site trail 37 cell 1
Pilarcitos tributary	SA 23	site 24
-	SA 24	-
-	SA 25	-
-	SA 26	-
Vernal pool # 18	SA 27	site 16
Vernal pool # 04	SA 28	1998 1999 rest. Site gs plots a-c, 1998 1999 rest site gs
Vernal pool # 05	SA 29	-

Appendix F (continued)

Local name	**Map Index**	**restored sites**
Toro Creek Watershed		
-	TC 1, A	-
Oilwell Road	TC 1, B	-
-	TC 1, C	-
Boyscout Pond	TC 2	-
Parking Lot Cyn	TC 3	wb, cl rock/cloth, PP1, PP2, trl 10, jacks rd bdry, trail no 10 bdry, southeast bdry, sandy south, sandy north, no fert west, no fert east, no fert north, high fert north, top east, cell no 1, trail 10 side gully, rest. site 37 perimeter, rest site trail 37 cell 1, site NR7
-	TC 4	-
-	TC 5	-
Skyline Gully	TC 6	-
Guidotti Ranch	TC 7	-
-	TC 8	-
Laguna Seca	TC 9	-
Laguna Seca tributary	TC 10	-
-	TC 11	-
Seaside Watershed		-
-	SE 1	-
-	SE 2	-
-	SE 3	-
Leary Hill	SE 4	PP 1-7 1997-1998 REST. SITE 1, restoration_2000_site66_north, restoration_2000_site66_south, 1998-1999 rest. site 21, site one, site 1 plots a, b & c, site NR4
-	SE 5	-
Parker Flats	SE 6	-
-	SE 7	-
-	SE 8	-
-	SE 9	-
BLM office	SE 10	-
-	SE 11	-
-	SE 12	-

-	SE 13	-
-	SE 14	-

Apendix F (continued)

Local name	Map Index	restored sites
-	SE 15	-
-	SE 16	-
-	SE 17	-
-	SE 18	-
-	SE 19	-
-	SE 20	-
-	SE 21	-
-	SE 22	-
-	SE 23	-
-	SE 24	-
-	SE 25	-
-	SE 26	-
-	SE 27	-
-	SE 28	-
-	SE 29	-
-	SE 30	-
-	SE 31	-
-	SE 32	-
-	SE 33	-
-	SE 34	-
-	SE 35	-
-	SE 36	-
-	SE 37	-
-	SE 38	-
-	SE 39	-
-	SE 40	-
-	SE 41	-
-	SE 42	-
-	SE 43	-
-	SE 44	-

west end	SE 45	-
-	SE 46	-
-	SE 47	-
-	SE 48	-

Appendix F (continued)

Local name	**Map Index**	**restored sites**
-	SE 49	-
-	SE 50	-
-	SE 51	-
-	SE 52	-
-	SE 53	-
-	SE 54	-
-	SE 55	-
-	SE 56	-
-	SE 57	-
west end	SE 58	-
-	SE 59	-
-	SE 60	-
-	SE 61	-

Appendix G: Erosion Sites Ranked by Restoration Priority

Ranking Criteria Weights						
A	B	C	D	Score	Priority	Map number and Description
4	3	_	_	7	1	101: Toro Creek stream bank erosion
4	3	2	1	10	2	33: Skyline gully
4	3	2	1	10	3	89: Eucalyptus gully
4	3	2	1	10	4	107: Laguna Seca gully system
4	3	2	1	10	5	67: "the Chasm," deeply gullied road
4	3	_	_	7	6	NA: Unstable banks in many places along Pilarcitos Creek
4	3	_	_	7	7	NA: Unstable banks in SA11 stream channel
4	3	2	1	10	8	110: large gully network
4	3	2	1	10	9	91: hillside gully
4	3	2	1	10	10	63: several acres of sandy hills with very gullied roads
4	3	2	_	9	11	47: several steep, parallel, eroded Jeep trails
4	3	_	1	8	12	44: Pilarcitos Canyon gully head
4	3	_	1	8	13	20: Canyon #23 channel is incised, has headcut
4	3	_	1	8	14	90: gully in valley bottom
4	3	_	1	8	15	22: bad gully through capstone ridge
4	3	_		7	16	49: old restoration site needs mulch & more plants
4	_	2	1	7	17	51: gully head threatens Trail #22
4	_	2	1	7	18	10: badly gullied, steep, Jeep road
4	_	2		6	19	23: top of Trail #40 is bad gully
_	3	2	1	6	20	31: entire subwatershed below trail 10 is badly gullied
_	3	2	1	6	21	114: large gully network
_	3	2	1	6	22	111: large gully network
_	3	2	1	6	23	112: large gully network
_	3	2	1	6	24	113: large gully network
_	3	2	1	6	25	105: large gully system
_	3	2	1	6	26	3: gully is a tributary to Mudhen Lake gully
_	3	2	1	6	27	2: Mudhen Lake gully
_	3	2	1	6	28	14: gully in valley bottom
_	3	2	1	6	29	45: minor gullying in roadcut
_	3	2	1	6	30	59: gullied roads
4	_	_	1	5	31	94: lower Skyline gully system
4	_	_	1	5	32	13: incipient gullied hollow in Paso Robles Formation
4	_	_	1	5	33	106: hillside gully
4	_	_	1	5	34	97: headcutting gully
4	_	_	1	5	35	98: headcutting gully
4	_	_	1	5	36	103: gullying & soil slip
4	_	_	1	5	37	104: incipient gullies
4	_	_	1	5	38	50: hillside gully south of Merrill Ranch
_	3	2	_	5	39	48: old restoration site has incipient gully
4	_	_	_	4	40	29: gullying and soil slip
4	_	_	_	4	41	41: minor soil slips and gullying
4	_	_	_	4	42	100: unstable(?) erosion cut in Santa Margarita Fm.
_	3		1	4	43	84: headcutting valley

_	3	_	1	4	44	86: headcutting gully above lower reservoir

Appendix G (continued)

Ranking Criteria Weights						
A	B	C	D	Score	Priority	Map number and Description
_	3	_	1	4	45	87: headcutting gully above lower reservoir
_	3	_	1	4	46	60: gullied roads
_	3	_	_	3	47	1: gully, road concentrating flow on old restoration site
_	3	_	_	3	48	6: gully
_	3	_	_	3	49	54: highly erosive road in sand
_	3	_	_	3	50	61: gullied roads
_	3	_	_	3	51	62: erosional scarp & gullied roads
_	3	_	_	3	52	68: well restored drainage, needs chaparral vegetation
_	3	_	_	3	53	73: gullied steep road
_	3	_	_	3	54	74: gullied steep road
_	3	_	_	3	55	80: gullied hillside
_	3	_	_	3	56	108: 2.4 acre bare region
_	_	2	1	3	57	53: minor road drainage off Trail 22 triggering new gully
_	_	2	1	3	58	109: Oil Well Road culvert causing steep gully
_	_	2	1	3	59	69: Picnic Canyon, big gully needs flow control at head
_	_	2	1	3	60	82: gullied hillside
_	_	_	1	1	61	7: badly gullied steep Jeep road
_	_	_	1	1	62	12: small gullies in Paso Robles formation
_	_	_	1	1	63	34: gullied road, easy access, on Trail 36
_	_	_	1	1	64	40: road needs gully control in roadside ditches
_	_	_	1	1	65	42: gully
_	_	_	1	1	66	43: gully
_	_	_	1	1	67	70: gully in grass,south side of Pilarcitos Canyon
_	_	_	1	1	68	72: gully in grass,south side of Pilarcitos Canyon
_	_	_	1	1	69	75: redo drainage work in old restoration site, add mulch
_	_	_	1	1	70	88: gully
_	_	_	1	1	71	99: gully in steep hollow
_	_	_	_	_	72	5: small gully at end of Jeep road off Trail 8
_	_	_	_	_	73	8: minor gullies
_	_	_	_	_	74	9: badlands forming in roadcut
_	_	_	_	_	75	11: minor steep new mountain bike tracks
_	_	_	_	_	76	16: incipient erosion on old singletrack trail
_	_	_	_	_	77	17: badlands forming in roadcut
_	_	_	_	_	78	19: gullied road
_	_	_	_	_	79	21: end of ridge has eroding bike tracks
_	_	_	_	_	80	24: small gully in short section of old road
_	_	_	_	_	81	25: incipient gully, good kindergarten project, like #13
_	_	_	_	_	82	26: wetland could be vegetated with HMP species of concern
_	_	_	_	_	83	27: hillside oversteepened by road, landslide potential
_	_	_	_	_	84	28: example of self-healing gully(?)
_	_	_	_	_	85	30: several soil slips
_	_	_	_	_	86	35: gullied road

_	_	_	_	_		87	36: rutted road
_	_	_	_	_		88	37: gullied road
_	_	_	_	_		89	38: minor gullied road
_	_	_	_	_		90	39: steep section of trail 2, minor gullies
_	_	_	_	_		91	46: minor gullies in roadcut
_	_	_	_	_		92	52: hillside gully

Appendix G (continued)

Ranking Criteria Weights						
A	B	C	D	Score	Priority	Map number and Description
_	_	_	_	0	93	56: minor gully in old road
_	_	_	_	0	94	57: gullies in road
_	_	_	_	0	95	58: minor road erosion
_	_	_	_	0	96	65: roadside gully on trail 19
_	_	_	_	0	97	66: minor gullying
_	_	_	_	0	98	71: soil slip in grass, south side of Pilarcitos Canyon
_	_	_	_	0	99	76: minor gully cutting capstone ridge
_	_	_	_	0	100	77: gullied road
_	_	_	_	0	101	78: minor gully in road
_	_	_	_	0	102	79: gullied road w/natural revegetation
_	_	_	_	0	103	81: roadside drain initiates gully
_	_	_	_	0	104	83: headwall of minor soil slip
_	_	_	_	0	105	85: stabilized(?) headwall scarp of landslide
_	_	_	_	0	106	93: old quarry may be unstable
_	_	_	_	0	107	95: soil slip and gravure(?)
_	_	_	_	0	108	96: soil slip
_	_	_	_	0	109	102: minor soil slips
_	_	_	_	0	110	92: healed(?) soil slips

Notes

1. Ranking Criteria Weights

A (4 points) =site has the potential to convey water and sediment off BLM property during extreme events

B (3 points)=further erosion of site will impact species of concern or habitat of interest

C (2 points)=site threatens BLM roads, trails, or other infrastructure

D) (1 point)=gully has potential to rapidly grow, branch, or develop significant "badlands" topography

2. Score=sum of weights in columns A, B, C, and D
3. Priority=priority for restoration based upon score and best professioanl judgement
4. See Appendix B and Figure 11 for locations.
5. Many roads and trails within the NRMA are slated to be decommissioned. They will require restorative revegetation, but they are too numerous to list and assess individually within the scope of this report. A separate road and trail assessment is recommended to catalog those potential erosion sites

APPENDIX H: Photographs of miscellaneous erosion sites

Site # 2: Mudhen Gully with checkdams

Site # 6: Rutted jeep road southwest of Mudhen Lake

Site # 7: Gullied jeep road

Site # 9: Minor rills and gullies in roadcut of Pilarcitos Canyon Road

Site # 12: Gullies in Paso Robles Formation

Site # 14: Deep gully on low-gradient valley bottom

Site # 31: Deep gully below future Laguna Seca parking lot

Site # 34: Rutted jeep road near Trail 36

Site # 42: Active gully threatens Pilarcitos Canyon Road

Site # 45: Gullies in roadcut of Barloy Canyon Road

Site # 45: Gullies in roadcut of Barloy Canyon Road

Site # 48: Barren uplands of Mudhen Lake Gully fosters overland flow to gully system

Site # 54: Unstable sandy road west of Barloy Canyon Road

Site # 59: Gullied Roads

Site # 60: rutted road

Site # 63: Example of rutted road that feeds sand to infilled vernal pool (Fig. 17)

Site # 63: Example of rutted road in generally unstable region northwest of BLM office


Site # 83: Example of headwall of minor soil slip in Pilarcitos Canyon headwaters

Site # 89: Eucalyptus Gully receives runoff concentrated by road ditch. Piping pervasive.

Site # 91: Head wall of large gully system. Note person for scale

Site # 91: Close up shot shows inclined strata of old dunes that migrated past the divide of Barloy canyon and down toward Toro Creek These old eolian sands are exceptionally prone to gullying.

Site #105: Very unstable large gully system in watershed TC03.

Appendix I: WRAR Geographic Information System Arcview Project

GIS Arcview Project Prepared by the
Watershed Institute, CSUMB December, 2001

The written and electronic WRAR report is supported by a set of GIS layers presented to the BLM in an Arcview 3.2 project format. The project includes layers and data sourced from the BLM, U.S.Geological Survey, U.S. Army Corps of Engineers, AirPhotoUSA, and the Watershed Institute (CSUMB). The following section summarizes the data structure and data sources in the GIS project.

Arcview GIS data/file structure & contents

UTM NAD 83 Z 10, meters

File Structure: folders are bold

BLM_WRAR_01

BLM_WRAR_01.apr (arcview project file)
DATA (folder with all accompanying data)

AERIAL PHOTOS

blm_color_1m.tif, tfw (~1m resolution color aerial photo of NRMA & immediate surrounding lands) (source: cut from 2 aerial photos obtained from AirPhotoUSA, photo date: June 2000)

ECOLOGY

FLORA (folder of gis data on various flora in the NRMA & nearby areas) (source: BLM GIS folder, June 2001)
species_of_concern.dbf, shp, shx (derived from FLORA, these are defined (by HMP)species of concern (soc) or interest)
veg_ecology.avl, dbf, shp, shx (plant communities of the NRMA) (source: BLM, Item id: 14792, Name: vegpfo, updated: 1-24-2001; June 2001)
weeds.dbf, shp, shx (derived from FLORA, these are noxious plants)

GEOLOGY

SLOPE (folder of slope grid info) (source: created from 30 meter DEM in TNTmips, Watershed Institute, July 2001)
SLOPEGRD & INFO (folders necessary for the grid that produces the slope image)
Slopelegend.avl (legend format for slopegrd)
N_GEO.dbf, sbn, sbx, shp, shx (geology of northern NRMA region) (source: hand-drawn interpretation by Watershed Institute from various map sources, July 2001)
N_geo_PR.avl, dbf, sbn, sbx, shp, shx (Paso Robles geological formation w/in northern NRMA region) (hand-drawn interpretation by Watershed Institute from maps and ground truthing)
S_geo.avl, dbf, shp, shx (geology of southern NRMA region) (source: fusion of Seaside and Spreckles quadrangles from

USGS electronic data source website //geopubs.wr.usgs.gov/. June, 2001)

soils.avl, dbf, shp, shx (soil classifications of the NRMA region) (source: BLM, item id 172200, name: slspfo, updated: 01-24-2000; June 2001) The soils layer was modified to conform with the Soils baseline study of Fort Ord (USACE, 1992)

HYDROGRAPHY

ephemeral_streams.dbf, shp, shx (derived by Watershed Institute from TNTmips computer model of stream flow paths from 30m DEM, July 2001)

flodirs.tif (source: Watershed Institute image (TNTmips) of modeled flow drainage, used for shaded relief, July 2001)

maj_watershed_divide.dbf, sbn, sbx, shp, shx (line dividing the three major watershed regions, hand drawn by Watershed Institute, July 2001)

ponds_&_pools.dbf, shp, shx (vernal pools & ponds of NRMA & outer areas) (source: BLM, item id: 145868, name: hydp019, updated: 5-16-2000; June 2001)

streams_&_rivers.dbf, shp, shx (streams & rivers of the greater Monterey area) (source: BLM, item id: 172199, name: hydlfo, updated: 1-24-2000; June 2001)

subwatershed_basins.dbf, shp, shx (modeled (TNTmips) drainage basins of NRMA from 30 meter DEM, July 2001)

subwatersheds.avl, dbf, sbn, sbx, shp, shx (modeled (TNTmips) drainage basins of NRMA & surrounding area, 30 meter DEM, July 2001)

LANDS_BORDERS (files in this folder were made from source: BLM, item id: 172182, name: ownpfo, updated 01-24-2000; June 2001)

NRMA_BLM_border.avl, dbf, sbn, sbx, shp, shx (NRMA border lines)

parcel_class.dbf, met, shp, shx (land classifications of former FO land parcels)

surround_class.dbf, met, shp, shx (land classifications of former FO land parcels adjacent to NRMA)

RANGE_MGMT

BLM_RESTOSITES (folder of gis info on various restoration sites on NRMA, from BLM, used to create areamerge, linemerge, pointmerge, and plotmerge files, June 2001)

areamerge.dbf, shp, shx (restoration sites, areas)

erosion.avl, dbf, shp, shx (gps'd locations of identified erosion problems or potentials, WRAR derived)

linemerge.dbf, shp, shx (restoration sites, lines)

plotmerge.dbf, shp, shx (restoration sites, plots)

pointmerge.dbf, shp, shx (restoration sites, points)

TOPOS

blm_topo_10ft.avl, dbf, shp, shx (10ft contour topographic map of NRMA) (source: Army Corp of Engineers, numerous CAD files from1995, June 2001)

TRANSPO

roads_blm.dbf, shp, shx (roads & trails of the NRMA, from roads_trails)

roads_trails.dbf, sbn, sbx, shp, shx (roads & trails of NRMA & surrounding area (source: BLM, item id: 172196 name: rtslfo, updated 01-24-2000; June 2001)