NASA Technical Memorandum 100982

Monitoring Biological Impacts Of Space Shuttle Launches From Vandenberg Air Force Base: Establishment Of Baseline Conditions

(NASA-TM-100982) MONITORING BIOLOGICAL IMPACTS OF SPACE SHUTTLE LAUNCHES FROM VANDENBERG AIR FORCE BASE: ESTABLISHMENT OF BASELINE CONDITIONS (NASA) 100 p CSCL 06C N88-25133
Unclas
G3/51 0148174

December 1987

National Aeronautics and
Space Administration

NASA Technical Memorandum 100982

Monitoring Biological Impacts Of Space Shuttle Launches From Vandenberg Air Force Base: Establishment Of Baseline Conditions

Paul A. Schmalzer, Ph. D.
G. Ross Hinkle, Ph. D.
The Bionetics Corporation, Kennedy Space Center, Florida

December 1987

National Aeronautics and
Space Administration

John F. Kennedy Space Center

TABLE OF CONTENTS

SECTION		PAGE
TABLE OF CONTENTS		i
ABSTRACT		ii
LIST OF FIGURES		iii
LIST OF TABLES		iv
ACKNOWLEDGEMENTS		viii
PRODUCT DISCLAIMER		viii
INTRODUCTION		1
METHODS		7
RESULTS		12
DISCUSSION		16
RECOMMENDATIONS		23
LITERATURE CITED		26
Appendix I:	Vegetation Composition of the Permanent Transects	34
Appendix II:	Environmental and Soils Data from the Permanent Transects	70
Appendix III:	Photodocumentation of Vegetation Transects and Vegetation Overviews in the SLC-6 Area	83

ABSTRACT

Space Shuttle launches produce environmental impacts resulting from the formation of an exhaust cloud containing hydrogen chloride aerosols and aluminum oxide particulates. Studies at John F. Kennedy Space Center (KSC) have shown that most impacts occur near-field (within 1.5 km) of the launch site while deposition from launches occurs far-field (as distant as 22 km). In order to establish baseline conditions of vegetation and soils in the areas likely to be impacted by Shuttle launches from Vandenberg Air Force Base (VAFB), vegetation and soils in the vicinity of Space Launch Complex 6 (SLC-6) were sampled and a vegetation map prepared.

The areas likely to be impacted by launches were determined considering the structure of the launch complex, the prevailing winds, the terrain, and predictions of the Rocket Exhaust Effluent Diffusion Model (REEDM). Fifty vegetation transects (15 m length) were established and sampled in March 1986 (wet season) and resampled in September 1986 (dry season). A vegetation map was prepared for the six Master Planning maps surrounding SLC-6 (1:9600) using LANDSAT Thematic Mapper imagery as well as color and color infrared aerial photography. Soil samples were collected from the 0-7.5 cm layer at all transects in the wet season and at a subsample of the transects (10) in the dry season and analyzed for pH, organic matter, conductivity, cation exchange capacity, exchangeable Ca, Mg, Na, K, and Al, available NH_3-N, NO_3-N, PO_4-P, Cu, Fe, Mn, Zn, and TKN.

Vegetation in the expected impact areas is primarily annual grassland (grazed) and coastal sage scrub with lesser amounts of chaparral. Composition of annual grassland changes greatly between the wet and dry seasons. Some changes in vegetation cover occur seasonally in the coastal sage scrub. Changes in soil chemistry also occur. Cations, pH, conductivity, organic matter, cation exchange capacity, TKN, and ammonia-nitrogen increase from the wet season to the dry season while certain available metals (Al, Cu, Fe) decrease.

Launches from SLC-6 will probably have impacts to vegetation within an area of about 1 km in the direction of the initial movement of the exhaust cloud. Damage to shrubs and loss of sensitive species may occur. Erosion is likely in areas losing vegetation cover. Species of the annual grassland and coastal sage scrub will probably be moderately to very sensitive while chaparral species are likely to be more resistant to launch deposition. Impacts and time required for recovery will vary seasonally with the phenology of the vegetation. Vegetation recovery at VAFB will be slower than at KSC because of the low rainfall and extended dry season. Impacts to populations of special interest plants will probably be minimal. Seasonal variation in soil parameters will complicate detection of soil impacts of launches.

In response to the delay in Shuttle launches, recommendations are made to update the data base prior to launch.

LIST OF FIGURES

Page

Figure 1. Location of vegetation sampling transects in the SLC-6 area 8

LIST OF TABLES

		Page
Table 1.	Chemical characteristics of the 0-7.5 cm layer of soils of plots sampled in the wet and dry seasons	17
Table 2.	Concentrations of cations in the 0-7.5 cm layer of soils of plots sampled in the wet and dry seasons	17
Table 3.	Concentrations of phosphorus and nitrogen species in the 0-7.5 cm layer of soils of plots sampled in the wet and dry seasons	18
Table 4.	Concentrations of selected metals in the 0-7.5 cm layer of soils of plots sampled in the wet and dry seasons	19
Table I-1.	Composition (percent cover) of transect #1 in March and September 1986	35
Table I-2.	Composition (percent cover) of transect #2 in March and September 1986	35
Table I-3.	Composition (percent cover) of transect #3 in March and September 1986	36
Table I-4.	Composition (percent cover) of transect #4 in March and September 1986	36
Table I-5.	Composition (percent cover) of transect #5 in March and September 1986	37
Table I-6.	Composition (percent cover) of transect #6 in March and September 1986	38
Table I-7.	Composition (percent cover) of transect #7 in March and September 1986	39
Table I-8.	Composition (percent cover) of transect #8 in March and September 1986	40
Table I-9.	Composition (percent cover) of transect #9 in March and September 1986	41
Table I-10.	Composition (percent cover) of transect #10 in March and September 1986	41
Table I-11.	Composition (percent cover) of transect #11 in March and September 1986	42

LIST OF TABLES
(continued)

Page

Table I-12. Composition (percent cover) of transect #12 in March and September 1986 43

Table I-13. Composition (percent cover) of transect #13 in March and September 1986 44

Table I-14. Composition (percent cover) of transect #14 in March and September 1986 45

Table I-15. Composition (percent cover) of transect #15 in March and September 1986 46

Table I-16. Composition (percent cover) of transect #16 in March and September 1986 47

Table I-17. Composition (percent cover) of transect #17 in March and September 1986 48

Table I-18. Composition (percent cover) of transect #18 in March and September 1986 48

Table I-19. Composition (percent cover) of transect #19 in March and September 1986 49

Table I-20. Composition (percent cover) of transect #20 in March and September 1986 49

Table I-21. Composition (percent cover) of transect #21 in March and September 1986 50

Table I-22. Composition (percent cover) of transect #22 in March and September 1986 51

Table I-23. Composition (percent cover) of transect #23 in March and September 1986 52

Table I-24. Composition (percent cover) of transect #24 in March and September 1986 53

Table I-25. Composition (percent cover) of transect #25 in March and September 1986 54

Table I-26. Composition (percent cover) of transect #26 in March and September 1986 54

Table I-27. Composition (percent cover) of transect #27 in March and September 1986 55

LIST OF TABLES
(continued)

		Page
Table I-28.	Composition (percent cover) of transect #28 in March and September 1986	56
Table I-29.	Composition (percent cover) of transect #29 in March and September 1986	57
Table I-30.	Composition (percent cover) of transect #30 in March and September 1986	57
Table I-31.	Composition (percent cover) of transect #31 in March and September 1986	58
Table I-32.	Composition (percent cover) of transect #32 in March and September 1986	59
Table I-33.	Composition (percent cover) of transect #33 in March and September 1986	60
Table I-34.	Composition (percent cover) of transect #34 in March and September 1986	60
Table I-35.	Composition (percent cover) of transect #35 in March and September 1986	61
Table I-36.	Composition (percent cover) of transect #36 in March and September 1986	62
Table I-37.	Composition (percent cover) of transect #37 in March and September 1986	63
Table I-38.	Composition (percent cover) of transect #38 in March and September 1986	63
Table I-39.	Composition (percent cover) of transect #39 in March and September 1986	64
Table I-40.	Composition (percent cover) of transect #40 in March and September 1986	64
Table I-41.	Composition (percent cover) of transect #41 in March and September 1986	65
Table I-42.	Composition (percent cover) of transect #42 in March and September 1986	65
Table I-43.	Composition (percent cover) of transect #43 in March and September 1986	66

LIST OF TABLES
(continued)

Page

Table I-44. Composition (percent cover) of transect #44 in March and September 1986........................ 66

Table I-45. Composition (percent cover) of transect #45 in March and September 1986........................ 67

Table I-46. Composition (percent cover) of transect #46 in March and September 1986........................ 67

Table I-47. Composition (percent cover) of transect #47 in March and September 1986........................ 68

Table I-48. Composition (percent cover) of transect #48 in March and September 1986........................ 68

Table I-49. Composition (percent cover) of transect #49 in March and September 1986........................ 69

Table I-50. Composition (percent cover) of transect #50 in March and September 1986........................ 69

Table II-1. Selected environmental variables for the study transects.. 71

Table II-2. Chemical composition of soils collected in March 1986.. 75

Table II-3. Chemical composition of soils collected in September 1986.................................... 81

Table III-1. Slides of SLC-6 vegetation transects and overviews of vegetation in the area - March 1986...................................... 84

Table III-2. Slides of SLC-6 vegetation transects and overviews of vegetation in the area - September 1986...................................... 87

ACKNOWLEDGMENTS

This project was conducted under the direction of Dr. Albert M. Koller, Jr., Chief, Programs and Planning Office, and Dr. William M. Knott, III, Biological Sciences Officer, Life Sciences Research Office, Biomedical Operations and Research Office, John F. Kennedy Space Center under NASA contract NAS10-10285. Work at Vandenberg Air Force Base was directed by Mr. Paul Toft, SD/DEC.

Chuck Pergler and Donna Elias, Martin Marietta Corporation, Environmental Protection, provided field and logistical assistance. Teresa Hughes, The Bionetics Corporation, conducted the chemical analyses of soils with laboratory assistance by Lee Maull. Terry Layer of EG&G Florida, Inc. provided graphics assistance. From The Bionetics Corporation, we thank Mark Provancha for field assistance, Resa Reddick for data analysis, and Diana Hickson for reviewing an earlier draft of this report.

PRODUCT DISCLAIMER

INTRODUCTION

Shuttle Effects - Brief Overview

Launches of the Space Shuttle produce environmental impacts to terrestrial and aquatic systems resulting from the formation of an exhaust cloud (Bowie 1981, Knott et al. 1983). Major constituents of the exhaust cloud are carbon dioxide (CO_2), water (H_2O), aluminum oxide (Al_2O_3), and hydrogen chloride (HCl) (NASA 1979). The formation of the exhaust cloud occurs as a result of the combined effects of the ignition of the Solid Rocket Motors (SRM), the Space Shuttle Main Engines (SSME), and the simultaneous dumping of several thousand kiloliters of sound suppression and cooling water onto the launch pad. In the turbulence of the rocket exhausts, atomization of the deluge water occurs; these droplets coagulate with aluminum oxide particulates and rapidly scavenge hydrogen chloride gas producing acidic deposition (Anderson and Keller 1983).

At John F. Kennedy Space Center (KSC), this ground cloud is directed northward by the structure of the flame trench and begins to rise as the horizontal velocity decreases (Knott et al. 1983). As the cloud rises it entrains ambient air until reaching a stabilization height (Bjorklund et al. 1982). This exhaust cloud is then carried by prevailing winds. Wind direction is variable at KSC (NASA 1979) and direction of cloud movement has varied (Schmalzer et al. 1986).

Near-field acute effects are produced by the ground cloud sweeping turbulently across the ground, vegetation, and lagoonal waters. Generally near-field effects occur within 0.5 km of the launch pad although they have extended up to 1.0 km away (Knott et al. 1983, Schmalzer et al. 1985). Since the pH of droplets in this cloud can be <0.5 (Anderson and Keller 1983), near-field effects can be severe and include acute vegetation damage (Bowie 1981, Knott et al. 1983, Schmalzer et al. 1986) and fish kills (Knott et al. 1983, Milligan and Hubbard 1983, Hawkins et al. 1984).

Far-field effects are produced after the exhaust cloud rises and moves with the prevailing winds. Deposition from this cloud occurs as spotting on vegetation and structures; spotting may include acid burns from "wet" deposition or may be dry residue, primarily Al_2O_3 (Knott et al. 1983, Anderson and Keller 1983). Deposition has been detected up to 22 km from the launch site (Schmalzer et al. 1986).

In the near-field study area of 12.6 ha north of Pad 39A, deposition rates of up to 127 g/m^2 of chlorides have been measured for several launches (Dreschel and Hall 1985). Repeated launches produced cumulative vegetation changes in this area including loss of sensitive species, loss of plant community structure, reduction in total cover, and replacement of some species by weedy invaders (Schmalzer et al. 1985). As launch frequency increased, less vegetation recovery occurred between launches and bare ground increased in the most severely impacted areas (Schmalzer unpublished).

Plant species vary greatly in their sensitivity to the acid deposition from Shuttle launches (Schmalzer et al. 1985). Nearly all plants in the near-field zone receiving 25 g - 127 g/m^2 of chloride deposition are completely or partially defoliated; most plants receiving 1 g - 25 g/m^2 of chlorides are obviously damaged. Sensitive species can be damaged by about 100 mg/m^2 of chloride deposition (Schmalzer et al. 1986). Sensitivities are partially predictable based on laboratory studies (Heck et al. 1980), but sensitivities to gaseous HCl and to an aqueous aerosol of HCl (hydrochloric acid) in the field differ (Schmalzer et al. 1985).

Acid deposition from Shuttle launches also has the potential to affect soils. Soil microcosm studies in the near-field impact zone north of Pad 39A indicate a decline in the pH of leachate collected from exposed microcosms along with an increase in the concentrations of aluminum (Al), copper (Cu), iron (Fe), and zinc (Zn). Trends in cation concentrations (calcium [Ca], magnesium [Mg], potassium [K]) indicate a decline in the buffering capacity of the soil (Hinkle et al. 1986).

The Rocket Exhaust Effluent Diffusion Model (REEDM) was developed to predict launch cloud deposition. Earlier versions of this model (Bjorklund et al. 1982) predicted gaseous hydrogen chloride concentration and aluminum oxide concentration. Post-launch observations for many launches showed that this model correctly predicted direction of launch deposition but typically placed these effects much farther from the launch site than they actually occurred. In 1984, the model was modified to predict gravitational HCl deposition (Bowman et al. 1984). Results from the modified model predict higher deposition near the launch pad declining with distance. Comparisons of REEDM predictions to measurements and estimates of chloride and aluminum deposition have been made (Schmalzer et al. 1986). There is general agreement between the model and observations with the exceptions that: 1) REEDM does not predict the near-field plume zone where deposition of >100 g/m^2 chloride occurs; and 2) the predicted isopleth of 25 mg/m^2 chloride often cannot be detected on the ground.

Considerations for Vandenberg Air Force Base

The facilities and environment for Shuttle launches at Vandenberg Air Force Base differ in a number of ways from those at KSC that may effect launch cloud behavior and its impacts on terrestrial systems. At KSC, both Solid Rocket Boosters (SRB's) exhaust into a single flame trench that opens to the north and has a flat bottom; the main engines exhaust into a separate flame trench that opens to the south. At the Vandenberg Shuttle launch site, Space Launch Complex 6 (SLC-6), each SRB exhausts into a separate flame trench, one faces north and the other south, and the openings of the flame trenches angle sharply upward (USAF 1983). The main engines exhaust into a third flame trench that also faces south.

The water deluge system at SLC-6 will use about twice the amount of water as the system at KSC. This additional water may affect exhaust cloud properties (Compton 1983b), but acid deposition is still expected to occur (Anderson and Keller 1983, USAF 1986).

Wind directions at SLC-6 on Vandenberg are predominately from the northwest (USAF 1978, Compton 1983a, Bowman et al. (1985). A risk assessment based on the REEDM program as modified for Vandenberg and meterological data predicts the most frequent direction for the 5000 mg/m^2 isopleth to be from east-southeast to south-southeast (65.8%) during daytime hours and from south-southeast to southwest (54.8%) at night (Bowman et al. 1985).

Vegetation and climate at Vandenberg are considerably different than at KSC. Vandenberg has a Mediterranean-type climate with distinct wet and dry seasons. Growth of most grasses, forbs, and shrubs is concentrated in the wet season, extending into the dry season until soil moisture levels decline. Annual species are important, dominating the annual grasslands. Many of the shrubs in the coastal sage scrub are drought-deciduous or partially so. In contrast, most of the flora at KSC is comprised of perennial plants; although some cease growth or die-back in the winter, others continue growing year-round. Vegetation recovery is likely to be much slower at Vandenberg than at KSC. For example, following a launch at the end of the wet season (April-May), vegetation regrowth might not begin until the fall rains (November-December).

Zammit and Zedler (1988) recently examined the effects of single treatments of simulated acid deposition similiar to that expected from Shuttle launches on seedling survivorship and yield, seed germination response, and seedling emergence under controlled conditions for species native to the SLC-6 area. They found that no seedlings of Mimulus aurantiacus, Artemisia californica, or Baccharis pilularis survived 30 days after treatment with ph 0.5 or 1.0 solutions; at ph 2.5 there were species differences and effects from different soils. In the seed germination experiment, germination of six of seven species was reduced by ph 1.0 treatment, but the magnitude varied with species, seed moisture level, and soil type. These results suggest that Shuttle launches have the potential to reduce seedling survival and seed germination in the near-field environment.

Approach

This project was undertaken to provide baseline data needed to monitor biological impacts of Shuttle launches on Vandenberg. The approach taken was based on experience gained from monitoring launch effects on KSC with modifications as appropriate for the Vandenberg situation; the program was implemented by some of the personnel involved in launch monitoring at KSC.

There are two major parts to this approach. The first is a set of permanent vegetation transects located within the expected zone of near-field impacts; soil samples were also collected with these transects. These transects establish baseline data to which acute launch-induced changes could be compared. The second part of the program is a vegetation map for the six Master Planning map units around SLC-6. These maps document vegetation patterns and form a data set to which changes caused by the more diffuse far-field effects could be compared. Complementary data would be collected by the Vandenberg Bioenvironmental Engineer (AFR 19-7). Post-launch surveys would also be conducted to determine the path of the launch cloud deposition and assess launch impacts near-field and far-field, as has been done at KSC.

METHODS

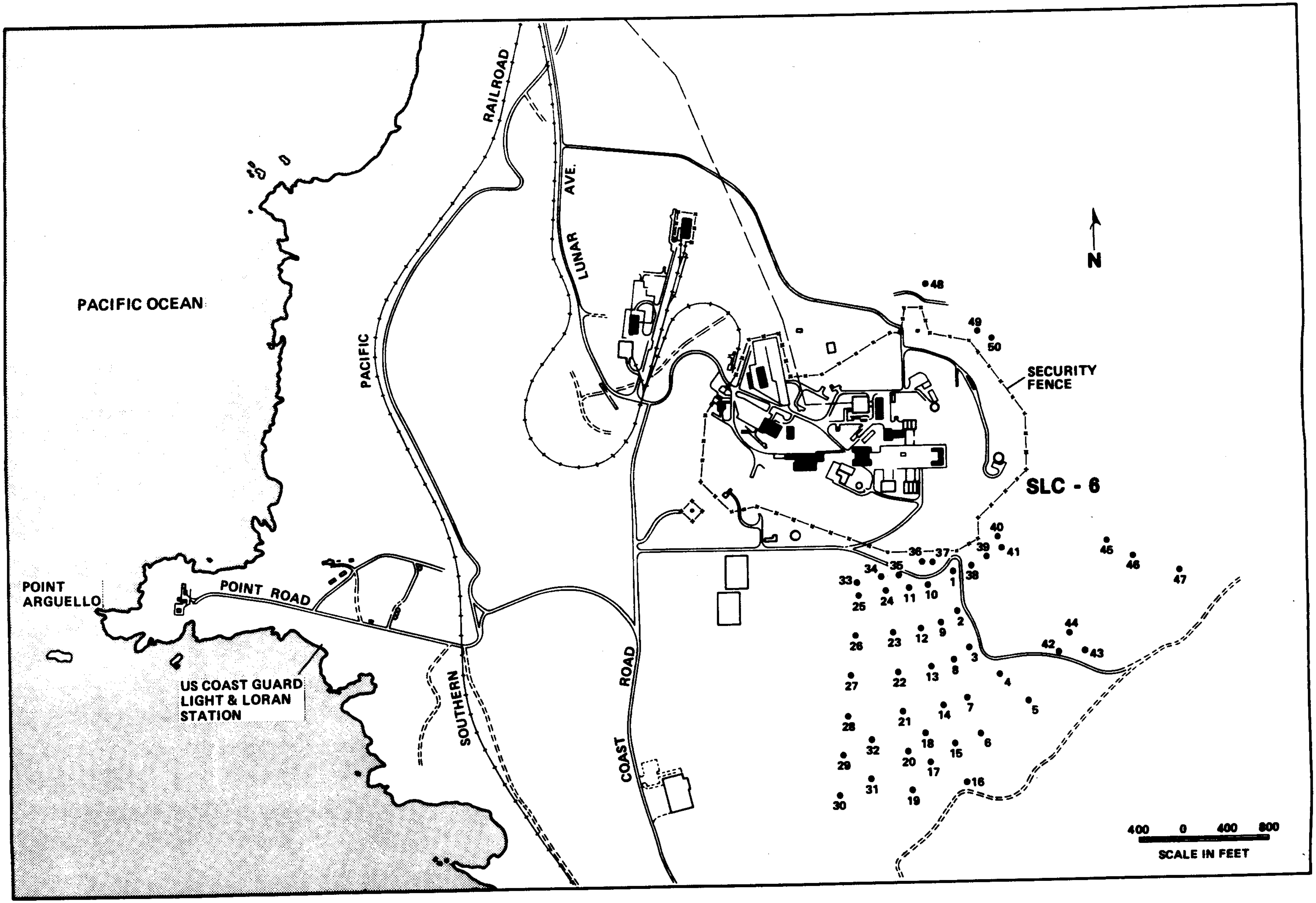
Vegetation Sampling

Vegetation sampling was concentrated within a 1.5 km region south of SLC-6. Sampling was concentrated in this region because: 1) the initial thrust of the south-facing flame trench will direct that exhaust to the south; 2) the main engine flame trench also exhausts to the south and this may combine with the SRB exhaust; 3) the prevailing winds will most probably move the launch cloud in this direction; 4) experience at KSC indicates that acute, near-field impacts will occur within 1.0 to 1.5 km of the launch pad.

Thirty-two vegetation transects were placed in the annual grassland-pasture south of SLC-6, three transects were placed between the pasture fence and the road, and two were placed between the road and the SLC-6 security fence (Figure 1). Transects were placed approximately 100 m apart on five lines; from east to west these lines were at compass headings of 125°, 140°, 155°, 170°, and 185°. Four transects were placed between the main lines of transects to fill gaps in the coverage.

Three transects were placed on the north side of SLC-6. The north-facing SRB flame trench may possibly direct its cloud onto this area. In most cases, the northern ground cloud will have

Figure 1. Location of vegetation sampling transects in the SLC-6 area.



impacts within the pad security fence and adjacent areas of buildings and then be pushed southward by the prevailing winds.

Four transects were placed at the lower end of two canyons on the southeast side of SLC-6. Under some conditions the launch cloud may be channelled into these canyons. Six transects were placed at the upper ends of these canyons to determine if acute launch impacts would extend that far.

This sampling should define the most probable areas of acute launch impacts under most launch conditions. Some transects will probably be impacted by every launch. A gradient of declining launch deposition with distance is likely in the pasture south of SLC-6 where sampling was concentrated. Some transects may seldom or never receive heavy launch deposition. For a launch, data from these permanent transects would be supplemented by data from a network of copper plates, pH paper, and bulk collectors (AFR 19-7, Annex E), and post-launch ground surveys to determine near-field and far-field deposition patterns on vegetation and structures (AFR 19-7, Annex E-2). Deployment of bulk collectors on the posts marking the vegetation sampling transects would provide quantification of launch deposition and allow comparison of deposition amount to vegetation damage. The pre-launch vegetation map of the six Master Planning maps in the SLC-6 vicinity provides baseline conditions to which more diffuse launch-induced changes could be compared.

Vegetation transects were 15 m in length. Both ends of the transects were marked by metal fence posts. A numbered aluminum tag was placed on one of the posts. Transects were established and initially sampled in March 1986 (wet season) and resampled in September 1986 (dry season). Vegetation was sampled in 0-0.5 m and >0.5 m height classes using line-intercept methods (Mueller-Dombois and Ellenberg 1974). Percent cover was recorded by taxa. Species were identified using standard manuals (Hoover 1970, Munz and Keck 1973, Smith 1976). In the dry season, ground cover in the annual grassland-pasture was often thatch (dead grass and herbs). Each transect was photographed at the wet season sampling and again in the dry season.

Vegetation Mapping

Vegetation of the area covered by the six Master Planning maps around SLC-6 (#53, 54, 57, 58, 60, 61) was mapped. Maps were prepared using LANDSAT Thematic Mapper imagery and color infrared and true color aerial photography (flown April 1986 and December 1986) and ground truthing the resulting maps. Final maps were prepared at the scale of the Master Planning maps (1:9600) in digital format using the ERDAS geographical information system. Final maps are in the same format as those prepared for the rest of Vandenberg under a separate project.

Soil Sampling and Analysis

Soil samples were collected from the 0-3 inch (0-7.5 cm) layer at all transects in the wet season sampling (March 1986). At four transects, soils were collected from the 6-12 inch (15-30 cm) layer for comparison purposes. In the dry season, soils were collected from the 0-3 inch layer of 10 transects to compare wet and dry season soil characteristics.

Soil samples were air dried. Subsamples were taken and ovendried (50°C) for nitrate-nitrogen and ammonia-nitrogen analyses. Analyses of all parameters except organic matter were made in the NASA/KSC Environmental Chemistry Laboratory. pH was determined on a 1:1 soil to water slurry (McLean 1982) using an Orion pH meter. Conductivity was measured on a 1:5 soil to water solution using a conductivity meter (Rhoades 1982). Exchangeable cations, Ca, Mg, Na, and K, were extracted in 1N ammonium acetate (Knudsen et al. 1982, Lanyon and Heald 1982) and analyzed by atomic absorption spectrophotometer using methods #20.1 (Ca), #12.1 (Mg), #11.1 (Na), and #19.1 (K) (Perkin-Elmer Corporation 1982).

Available metals, Cu, Fe, Mn, and Zn, were extracted in diethylenetriaminepentaacetic acid (DTPA) (Olson and Ellis 1982, Gambrell and Patrick 1982, Baker and Amacher 1982) and analyzed by atomic absorption spectrophotometer using methods #29.1 (Cu), #26.1 (Fe), #25.2 (Mn), and #30.1 (Zn). Exchangeable aluminum was extracted in 1N potassium chloride (Barnhisel and Bertsch 1982) and analyzed by atomic absorption spectrophotometry using method #13.1 (Perkin-Elmer Corporation 1982).

Exchangeable nitrate-nitrogen (NO_3-N) and ammonia-nitrogen (NH_3-N) were extracted in 2N potassium chloride (Keeney and Nelson 1982) and then analyzed on a Technicon Autoanalyzer using methods 100-70W (NO_3-N) (Technicon Industrial Systems 1973) and 696-82W (NH_3-N) (Technicon Industrial Systems 1983a). Total Kjeldahl nitrogen (TKN) was determined by digestion (Schuman et al. 1973) followed by analysis on a Technicon Autoanalyzer using method 696-82W (Technicon Industrial Systems 1983b).

Available phosphorus was determined by extraction in deionized water (Olsen and Sommers 1982) followed by analysis on a Technicon Autoanalyzer using method 696-82W (Technicon Industrial Systems 1983c).

Cation exchange capacity was determined by the ammonium saturation method (Chapman 1965) followed by determination of ammonium by using a Technicon Autoanalyzer (method 696-82W) (Technicon Industrial Systems 1983a).

Organic matter was determined by the combustion method (Nelson and Sommers 1982). Organic matter determinations were made by Post, Buckley, Schuh, and Jernigan, Inc., Orlando, Florida.

RESULTS

Location of sample transects is given in Figure 1. Vegetation composition of the transects in the wet and dry season is given in Appendix I, Tables I-1 through I-50.

Selected environmental variables are summarized in Appendix II, Table II-1. Soil chemical characteristics are given in Appendix II, Table II-2 for the wet season samples and in Appendix II, Table II-3 for the dry season. Lists of the slides taken to photodocument the vegetation sampling are given in Appendix III, Tables III-1 and III-2. Slides are archived at the Vandenberg SD/DEC office.

In the immediate vicinity of the SLC-6 facility, the predominant vegetation is annual grassland and coastal sage scrub. Chaparral occurs on slopes north of the pad and is a minor element in the pasture south of SLC-6. Vegetation changes between the wet season and the dry season in the annual grassland are great. The annual grasses and forbs present in the spring die back in the dry season and are either completely absent or present only in minor quantities. Much of the live cover in the wet season is transformed into thatch in the dry season. Some fall-flowering species occur that are absent or inconspicuous in the spring. Bare ground increases from the wet season to the dry season. Grazing probably increases the amount of bare ground.

Changes also occur in shrub communities, particularly coastal sage scrub, between the wet season and the dry season. These changes include shrubs growing in height so that they are present in the >0.5 m class rather than the <0.5 m class, increase in cover by horizontal canopy growth of shrubs, and loss of leaves (and cover) by shrubs that are drought deciduous.

Several special interest plants were reported from the SLC-6 area by Beauchamp and Oberbauer (1977) including _Arctostaphylos viridissima_, _Castilleja mollis_, _Ceanothus impressus_, and _Scrophularia atrata_. Several of these populations were in areas since cleared for facilities associated with SLC-6.

Arctostaphylos viridissima was reported from slopes west of the SLC-6 area apparently outside of what is now the security fence (Beauchamp and Oberbauer 1977). These populations may still be extant but were not encountered in the present study. From the range descriptions in Smith (1976), this taxon is more likely to be _A. purissima_ or _A. refugioensis_. These manzanitas are listed by the California Native Plant Society (CNPS) (Smith and York 1984) but have not been proposed for federal listing.

Castilleja mollis occurred both inside and outside construction areas near SLC-6 (Beauchamp and Oberbauer 1977) and scattered populations probably still exist. No major populations were encountered during this study. The taxon has been proposed for federal listing (Category 2) and is considered rare and endangered in California and elsewhere by the CNPS (List 1B) (Smith and York 1984).

Ceanothus impressus occurred in several areas in the SLC-6 vicinity (Beauchamp and Oberbauer 1977). It is present in the pasture south of SLC-6 (transect #30) in an area which could receive acid deposition from Shuttle launches. This taxon does not presently have any formal protection status. It was considered for listing by the CNPS but is presently considered too common to list (Appendix I, Smith and York 1984).

Scrophularia atrata was reported in several areas near SLC-6 (Beauchamp and Oberbauer 1977). _S. atrata_ has been proposed for federal listing (Category 2); it has been placed on List 3 (plants about which more information is needed) by the CNPS (Smith and York 1984). Taxonomic uncertainty exists about this species since it hybridizes extensively with _S. californica_ (Smith 1983). _Scrophularia_ was encountered in this study in the canyon bottoms directly southeast of SLC-6. These plants have tentatively been assigned to _S. californica_, but ongoing taxonomic work may clarify the situation (Chuck Pergler, pers.

comm.).

Cirsium rhothophilum, considered rare and endangered in California (List 1B) and proposed for federal listing (Category 2) (Smith and York 1984), occurs on Point Arguello (Chuck Pergler, pers. comm.). This population is unlikely to be impacted by Shuttle launches given its distance (>2 km) from the launch site and that it is west of SLC-6, while the most likely initial direction of cloud movement is to the south or southeast.

Monardella crispa occurs in scattered populations in disturbed areas in the vicinity of SLC-6 (Chuck Pergler, pers. comm.). Monardella crispa and the related Monardella undulata var. frutescens have both been proposed for federal listing (Category 2) and are considered rare and endangered in California (List 1B, Smith and York 1984). Some taxonomic confusion exists as to the proper nomenclature of the two perennial species of Monardella in this area (Smith 1983), but both have the same status as regards protection. Since only small scattered populations are present near SLC-6, and the taxon is abundant in other parts of the base (Henningson, Durham and Richardson 1979) impacts of Shuttle launches to it would be minor.

The vegetation map has been prepared to be compatible with the map for the entire base.

Comparisons of the chemical characteristics of soils from the plots sampled in both the wet and dry seasons are given in Tables 1 through 4. Soils in the sampling area vary greatly in chemical characteristics; therefore, only general comparisons of the trends of increase or decrease of certain parameters between statistical comparisons. There are, however, seasonal trends in many of the soil parameters.

Cations (Ca, Mg, K, Na) generally increase from the wet season to the dry season (Table 2). Probably as a result of the increase in cations, pH and conductivity also generally increase (Table 1).

Organic matter and cation exchange capacity generally increase from the wet to dry season (Table 1). Total Kjeldahl nitrogen and ammonia-nitrogen concentrations generally increase from the wet to dry season while nitrate-nitrogen generally decreases (Table 3). Phosphate-phosphorus does not show a clear seasonal trend (Table 3).

Available concentrations of certain metals (Al, Cu, Fe) decline from the wet season to the dry season while others (Mn, Zn) are variable, without definite seasonal trends (Table 4).

DISCUSSION

What impacts are likely from Shuttle launches from SLC-6 to terrestrial systems? Acid deposition of sufficient intensity to cause significant vegetation damage is most likely in the area south of the launch complex. Within about 1 km of the launch site, acid deposition will probably kill sensitive species and damage shrubs. Repeated launches will probably result in the loss of the shrub layer in the area of repeated severe impact. Erosion is likely on slopes where vegetation cover is lost. Vegetation areas within the SLC-6 security fence in line with the south SRB flame trench will probably be denuded and cause erosion

Table 1. Chemical characteristics of the 0-7.5 cm layer of soils of plots sampled in the wet and dry seasons.

Plot #	pH		Conductivity (umho/cm)		OM (%)		CEC (meq/100g)	
	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
3	5.87	5.88	193.7	152.1	15.4	17.2	31.3	36.0
13	5.65	5.74	100.0	129.0	6.2	7.8	11.4	15.7
21	5.58	5.67	106.5	210.6	9.3	12.6	15.9	21.5
24	6.04	6.00	94.4	178.5	4.6	6.5	8.0	13.3
26	5.77	6.13	71.4	140.4	6.8	10.5	11.5	20.9
36	5.67	5.65	56.9	280.8	5.7	9.9	8.4	17.4
38	5.44	5.75	101.6	114.7	7.6	13.0	15.2	35.6
42	4.73	4.78	197.8	222.3	28.7	26.0	38.4	37.8
46	5.13	5.60	92.8	131.2	5.5	6.9	11.1	11.9
48	6.52	6.54	78.9	131.0	7.0	11.0	13.7	21.5

Table 2. Concentrations of cations in the 0-7.5 cm layer of soils of plots sampled in the wet and dry seasons.

Plot #	Ca+ (mg/kg)		Mg+ (mg/kg)		K+ (mg/kg)		Na+ (mg/kg)	
	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
3	1964.0	1722.0	1048.0	1014.0	1068.0	1088.0	145.4	312.3
13	624.0	818.0	286.4	268.0	488.0	830.0	135.5	170.6
21	1000.0	1364.0	483.2	582.0	616.0	890.0	173.8	221.7
24	880.0	990.0	276.0	298.2	912.0	964.0	77.2	138.6
26	936.0	1340.0	384.8	484.0	736.0	862.0	110.4	157.3
36	680.0	1182.0	268.8	456.4	352.0	672.0	94.0	308.9
38	856.0	1676.0	781.6	839.6	512.0	1208.0	283.5	227.8
42	872.0	1192.0	751.2	958.4	320.0	564.0	188.4	235.4
46	608.0	754.0	492.0	453.6	560.0	773.0	82.8	123.1
48	1752.0	1864.0	365.6	383.2	1336.0	880.0	80.4	167.9

Table 3. Concentrations of phosphorus and nitrogen species in the 0-7.5 cm layer of soils of plots sampled in the wet and dry seasons.

	PO_4-P (mg/kg)		TKN (mg/kg)		NO_3-N (mg/kg)		NH_3-N (mg/kg)	
Plot #	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season
3	3.09	2.16	5396	6011	65.1	3.20	10.20	14.80
13	2.06	1.26	2761	3957	18.6	11.6	9.85	9.88
21	2.42	5.55	4346	5578	25.6	23.0	7.07	15.80
24	5.68	1.61	1770	2726	10.6	19.6	8.64	15.45
26	1.69	2.18	2561	4647	26.1	13.9	7.69	14.70
36	.98	1.30	2204	4020	8.1	12.7	5.88	20.00
38	.59	1.28	2610	3210	3.6	3.1	9.85	10.20
42	1.87	2.19	11752	11380	53.8	26.0	23.20	20.60
46	1.91	1.83	2437	2761	22.7	14.8	5.25	12.35
48	1.63	2.41	3887	2266	16.1	3.1	12.20	12.60

Table 4. Concentrations of selected metals in the 0-7.5 cm layer of soils of plots sampled in the wet and dry seasons.

Plot #	Al (mg/kg) Wet Season	Al (mg/kg) Dry Season	Cu (mg/kg) Wet Season	Cu (mg/kg) Dry Season	Fe (mg/kg) Wet Season	Fe (mg/kg) Dry Season	Mn (mg/kg) Wet Season	Mn (mg/kg) Dry Season
3	.40	.00	.72	.50	166.96	110.60	19.0	26.6
13	.80	.00	.40	.24	102.24	78.40	17.9	20.2
21	2.00	.00	.48	.28	142.24	81.80	23.0	21.7
24	1.60	.00	.44	.33	113.84	91.50	7.7	13.1
26	1.20	.00	.56	.40	91.60	59.20	27.7	21.1
36	1.20	.00	.48	.48	137.20	118.40	11.7	19.3
38	6.00	.00	1.28	.42	193.84	95.20	14.5	10.0
42	18.80	3.40	.36	.46	292.80	217.40	1.8	28.2
46	4.40	.10	.72	.41	106.08	60.00	18.4	20.8
48	0.00	.00	.26	.32	35.60	26.00	14.4	19.1

Plot #	Zn (mg/kg) Wet Season	Zn (mg/kg) Dry Season
3	77.6	69.3
13	10.1	15.4
21	6.8	13.0
24	3.8	13.9
26	35.2	12.8
36	9.7	115.2
38	22.0	72.1
42	23.5	18.4
46	3.7	3.9
48	2.1	4.8

problems. Launches at SLC-6 are not projected to be as frequent as those from Pad 39A at KSC that produced cumulative impacts (Schmalzer et al. 1985). However, vegetation recovery is likely to be slower at Vandenberg than at KSC because of the low rainfall and extended dry season. Effects of desposition on seedling survival and germination may also influence recovery.

Species of the annual grassland and coastal sage scrub communities are likely to be moderately to very sensitive to launch deposition based on their leaf morphology. The species most resistant to launch deposition at KSC are those with heavily cutinized leaves such as saw palmetto (Serenoa repens) and evergreen oaks (Quercus spp.) or perennial grasses adapted to salt spray (e.g., sea oats [Uniola paniculata]) (Schmalzer et al. 1985). Similar differences in species sensitivities have been shown in experimental tests with gaseous hydrogen chloride and hydrochloric acid mists (Heck et al. 1980, Granett 1984). The grasses and forbs in the annual grassland have thin, relatively uncutinized leaves. The drought-deciduous shrubs of the coastal sage scrub are also likely to be relatively sensitive to launch impacts. Baccharis pilularis ssp. consanguinea, an important coastal sage scrub species, has leaves resembling Baccharis halimifolia, one of the more sensitive shrub species at KSC (Schmalzer et al. 1985). Chaparral shrub species are likely to be more resistant to launch deposition than coastal sage scrub shrubs but, except for one slope to the north of SLC-6 and some patches of shrubs in the pasture south of SLC-6, are not likely to be exposed to heavy deposition. Zammit and Zedler (1988) showed differences in species sensitivity to acid deposition for seedling survival and germination among several native species.

It might be possible in some areas to replace sensitive species with those more resistant to launch deposition. At KSC, grasses (and graminoids) persist longer in the launch impact zone than shrubs. However, these are perennial species with underground organs (e.g., rhizomes) from which they sprout when defoliated. For sea oats, resistance to acid deposition is probably a consequence of adaptation to a salt spray environment. The common grasses at Vandenberg are Eurasian annuals and may lack the ability to sprout after defoliation.

Whether native perennial grasses such as Stipa pulchra (purple needle grass) or Elymus condensatus (giant rye) would be resistant to launch deposition is not known.

The phenology of the vegetation at the time of launch is likely to influence the resulting impacts. A launch in the dry season would have little direct impact on annual grasses and herbs that were already dormant or on shrubs that had lost their leaves, but might impact shrubs such as Baccharis pilularis that retain their leaves. For a dry season launch, deposition may accumulate on the soil surface and on dead grasses and herbs until there is sufficient rainfall to leach it into the soil. A launch early in the growing season might be followed by recovery from sprouting shrubs and herbs and germinating seeds, but for a launch late in the growing season, recovery might be delayed until the fall rains. Seedlings may be more sensitive to deposition than adult plants. At KSC, new growth of many shrubs is more sensitive than older foliage.

Launch impacts to special interest plants are likely to be minimal. Ceanothus impressus is in an area that could receive launch deposition but is sufficiently distant that it would probably not be eliminated. It is also present in many other areas on the base. Scrophularia does occur in an area likely to receive launch deposition and these plants could be eliminated by repeated launches. The taxonomic status of this population is uncertain, as previously noted. If it is S. atrata rather than S. californica, then S. atrata would have to be considered rather abundant on Vandenberg and the loss of the small population near SLC-6 would be a minor impact. Other species are present in small numbers (Castilleja mollis) or not in the area likely to receive acid deposition (Cirsium rhothophilum).

Seasonal trends in soil characteristics occur in relation to the extended dry season. Cations accumulate in the surface soil in the absence of leaching from heavy rainfall. Cations may be added to the surface soil from dry deposition, salt spray, fog, or mineralization of organic matter. Increasing cation concentrations probably account for the increase in pH and conductivity. The increase in pH, in turn, may decrease the availability of certain metals.

Soil organic matter increases from the wet season to the dry season. Decomposition may be limited during the dry season, so that litter or root biomass added to the soil during the growing season is not completely degraded while the soil reamins dry. Increases in organic matter may also account for the increase in cation exchange capacity and total Kjeldahl nitrogen.

Since seasonal trends in many soil characteristics do occur, these would have to be considered in interpreting the impacts of Shuttle launches on the soils. Soil conditions previous to a launch in the wet season will differ from those previous to a dry season launch. Trends that might be attributed to launch impacts, decreased pH, decreased cations, and increases in available Al, Cu, and Fe, actually occur as seasonal patterns going from the dry season to the wet season.

RECOMMENDATIONS

Current plans call for Shuttle launches to begin from Vandenberg not before 1992, a delay of six years from the sampling of baseline conditions. These plans could be subject to changes that would result in Shuttle launches before this intended date or a longer delay. What actions should be taken to maintain the validity of the data base or to reestablish baseline conditions before the initial Shuttle launch from SLC-6?

Several observations indicate that vegetation in the SLC-6 area changes on various time scales. Comparison of spring and fall samples of the same transects indicate changes due to shrub growth as well as seasonal die-back of annual and drought-deciduous species. Vegetation type boundaries have changed since the preparation of the San Diego State University (SDSU) study vegetation map (1974-75) to the present, particularly along the boundaries between shrublands and grasslands. Since the SDSU study, the area near SLC-6 was subject to a wildfire in 1977 and part of it to a controlled burn in 1983 (Vandenberg Fire Protection Branch records). Cattle grazing also occurs in the pasture south of SLC-6.

In order to maintain the existing set of permanent plots and to reestablish baseline conditions, we recommend the following:

1) A subset of the plots should be established by survey in order to have fixed, permanent locations marked. Ten transects (#3, 13, 21, 24, 26, 36, 38, 42, 46, 48) would be a reasonable sample.

2) All permanent transects should be visited once a year after grazing is completed in the pasture south of SLC-6 for the year. At this time, posts should be checked to make sure they remain in place and tags should be examined and replaced if necessary. (Cattle rubbing against the posts removed several tags between March and September 1986.) Transects should be photographed at this time and the slides archived. Notes of any obvious disturbances such as fires or overgrazing should be made. It should be possible to complete this survey in one to two days.

3) If Shuttle launches from SLC-6 do not occur before 1992, permanent transects should be resampled, at least in the wet season, to determine the baseline conditions prior to initiating launches. If launches occur at an earlier date, at least a subset of the transects should be examined to determine the magnitude of changes that have occurred and a decision made as to whether it is necessary to resample all of them.

4) It is probably not necessary to resample soils from all

transects prior to a Shuttle launch from SLC-6. In the absence of major disturbance, soils would not be expected to change rapidly and the soils in the SLC-6 impact area are relatively well-buffered. However, seasonal differences in soil characteristics do occur. If a more detailed understanding of the seasonal patterns of soil properties is required, then more intensive sampling of soils in the dry season within a particular soil type (or types) would be required.

5) One year previous to Shuttle launches from Vandenberg the vegetation map for the SLC-6 area should be spot checked to determine if major changes in vegetation boundaries have occurred and if updating is necessary. Since the vegetation map should be available in digitized format in a geographic information system, revision of the map should be less demanding than its original preparation.

6) When Shuttle launches begin at SLC-6, cattle should be permanently excluded from the pasture directly south of SLC-6 in the area in which heavy deposition is expected due to the potential for bioaccumulation of deposition products.

7) The potential for erosion from slopes that lose vegetation cover from launch impacts should be considered when planning launches from SLC-6.

LITERATURE CITED

Anderson, B.J. and V.W. Keller. 1983. Space Shuttle exhaust cloud properties. NASA Technical Paper 2258. Marshall Space Flight Center, Alabama.

Baker, D.E. and M.C. Amacher. 1982. Nickel, copper, zinc, and cadmium. In: A.L. Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, part 2. Chemical and microbial properties. Agronomy 9:323-346. American Society of Agronomy, Inc., Madison, Wisconsin.

Barnhisel, R. and P.M. Bertsch. 1982. Aluminum. In: A.L. Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, part 2. Chemical and microbial properties. Agronomy 9:275-300. American Society of Agronomy, Inc., Madison, Wisconsin.

Beauchamp, R.M. and T.A. Oberbauer. 1977. Appendix: Survey of the botanical resources in the Space Shuttle construction zone, Vandenberg Air Force Base, California. In: Wooten R.C., Jr., D. Strutz, and R. Hudson. Impact of Space Shuttle support facilities construction on special interest plant species (Vandenberg AFB, CA). CEEDO-TR-77-33. Tyndall AFB, Florida. 59 pp.

Bjorklund, J.R., R.K. Dumbauld, C.S. Cheney, and H.V. Geary. 1982. Users manual for the REEDM (Rocket Exhaust Effluent Diffusion Model) computer program. H.E. Cramer Co. NASA Contractor Report 3646. Marshall Space Fight Center, Alabama.

Bowie, W.H. 1981. Environmental effects of the STS-1 flight readiness firing and launch. Medical Directorate, NASA, Kennedy Space Center, Florida.

Bowman, C.R., J.R. Bjorklund, and J.E. Rafferty. 1984. User's manual for the revised REEDM (Rocket Exhaust Effluent Diffusion Model) computer program for launches at Kennedy Space Center. Volume 1. TR-84-157-02. Prepared by H.E. Cramer Co., Inc. Salt Lake City, Utah. Contract No. F08606-83-C-0014.

Bowman, C.R., G.C. Dodd, and H.G. Geary, Jr. 1985. Final risk assessment. TR-85-157-02. Prepared by H.E. Cramer Co., Inc., Salt Lake City, Utah. Contract no. F08606-83-C-0014.

Chapman, H.D. 1965. Cation exchange capacity. In: C.A. Black (ed.), Methods of soil analysis, part 2. Chemical and microbial properties. Agronomy 9:891-901. American Society of Agronomy, Inc., Madison, Wisconsin.

Compton, J. 1983a. Ground cloud microphysical terrain effects. Pp. 247-255. In: A. Potter (ed.), Space Shuttle environmetal effects: the first five flights. NASA, Lyndon B. Johnson Space Center. Houston, Texas.

Compton, J. 1983b. The 6.4-percent scale model of the Space Shuttle. Pp. 221-227. In: A. Potter (ed.), Space Shuttle environmental effects: the first five flights. NASA, Lyndon B. Johnson Space Center. Houston, Texas.

Dreschel, T.W. and C.R. Hall. 1985. Near-field deposition patterns of chlorides and particulates resulting from launches of the Space Transportation System at the John F.

Kennedy Space Center. NASA Technical Memorandum 89194. John F. Kennedy Space Center, Florida. 21 pp.

Gambrell, R.P. and W.H. Patrick, Jr. 1982. Manganese. In: A.L. Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, part 2. Chemical and microbial properties. Agronomy 9:313-322. American Society of Agronomy, Inc., Madison, Wisconsin.

Granett, A.L. 1984. The phytotoxicity of designated pollutants on plant species. Third Annual Report, ARAMRL-TR-83-96, Aerospace Medical Research Laboratory, Wright-Patterson AFB, Ohio. 81pp.

Hawkins, W.E., R.M. Overstreet, and M.J. Provancha. 1984. Pathological effects of Space Shuttle exhaust plumes on gills of some estuarine fish: a light and electron microscopic study of acute environmental stress. Gulf Research Reports 7:297-309.

Heck, W.W., W.M. Knott, E.P. Slahel, J.T. Ambrose, J.N. McCrimmon, M. Engle, L.A. Romanov, A.G. Sawyer, and J.D. Tyson. 1980. Response of selected plant and insect species to simulated solid rocket exhaust mixtures and to exhaust components from solid rocket fuels. NASA Technical Memorandum 74109. John F. Kennedy Space Center, Florida. 146 pp.

Henningson, Durham and Richardson. 1979. Biological assessment for proposed MX flight test program, Vandenberg Air Force Base, California. Volume I and II. Technical Report ETR-158R. Henningson, Durham and Richardson (HDR). Santa

Barabara, California.

Hinkle, C.R., T.L. Hughes, and P.A. Schmalzer. 1986. Evaluation of the effects of acidification on coastal soils. Abstract of poster presentation in: Program of the IV International Congress of Ecology. State University of New York and Syracuse University, Syracuse, New York. Pp. 179.

Hoover, R.F. 1970. The vascular plants of San Luis Obispo County, California. University of California Press. Berkeley. 350 pp.

Keeney, S.R. and S.W. Nelson. 1982. Nitrogen-inorganic forms. In: A.L. Page, L.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, part 2. Chemical and microbial properties. Agronomy 9:643-698. American Society of Agronomy, Inc., Madison, Wisconsin.

Knott, W.M., III, A.M. Koller, Jr., and J.R. Puleo. 1983. Environmental effects of STS-1 through STS-4 launches: comprehensive report. Pp. 1-30. In: A. Potter (ed.), Space Shuttle environmental effects: the first five flights. NASA, Lyndon B. Johnson Space Center, Houston, Texas.

Knudsen, D., G.A. Peterson, and P.F. Pratt. 1982. Lithium, sodium, and potassium. In: A.L. Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, part 2. Chemical and microbial properties. Agronomy 9:225-246. American Society of Agronomy, Inc., Madison, Wisconsin.

Lanyon, L.E. and W.R. Heald. 1982. Magnesium, calcium, strontium, and barium. In: A.L. Page, R.H. Miller, and

D.R. Keeney (eds.). Methods of soil analysis, part 2. Chemical and microbial properties. Agronomy 9:247-262. American Society of Agronomy, Inc., Madison, Wisconsin.

McLean, E.O. 1982. Soil pH and lime requirement. In: A.L. Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, part 2. Chemical and microbiological properties. Agronomy 9:199-224. American Society of Agronomy, Inc., Madison, Wisconsin.

Milligan, J.E. and G.B. Hubbard. 1983. STS-5 fish kill, Kennedy Space Center, Florida. Pp. 59-80. In: A. Potter (ed.), Space Shuttle environmental effects: the first five flights. NASA, Lyndon B. Johnson Space Center, Houston, Texas.

Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley & Sons, New York. 547 pp.

Munz, P.A. and D.D. Keck. 1973. A California flora (with supplement by P.A. Munz). University of California Press. Berkeley. 1681 and 224 pp.

NASA. 1979. Final environmental impact statement for the Kennedy Space Center. NASA, John F. Kennedy Space Center, Florida.

Nelson, D.W. and L.E. Sommers. 1982. Total carbon, organic carbon, and organic matter. In: A.L. Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, part 2. Chemical and microbial properties. Agronomy 9:539-579. American Society of Agronomy, Inc., Madison, Wisconsin.

Olsen, S.R. and L.E. Sommers. 1982. Phosphorus. In: A.L.

Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, part 2. Chemical and microbial properties. Agronomy 9:403-430. American Society of Agronomy, Inc., Madison, Wisconsin.

Olson, R.V. and R. Ellis, Jr. 1982. Iron. In: A.L. Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, part 2. Chemical and microbial properties. Agronomy 9:301-312. American Society of Agronomy, Inc., Madison, Wisconsin.

Perkin-Elmer Corporation. 1982. Analytical methods for atomic absorption spectrophotometry. Perkin-Elmer Corporation. Norwalk, Connecticut.

Rhoades, J.D. 1982. Soluble salts. In: A.L. Page, R.H. Miller, and D.R. Keeney (eds.). Methods of soil analysis, part 2. Chemical and microbial properties. Agronomy 9:167-179. American Society of Agronomy, Inc., Madison, Wisconsin.

Schmalzer, P.A., C.R. Hinkle, and D. Breininger. 1985. Effects of Space Shuttle launches STS-1 through STS-9 on terrestrial vegetation of John F. Kennedy Space Center, Florida. NASA Technical Memorandum 83103. John F. Kennedy Space Center, Florida. 39 pp.

Schmalzer, P.A., C.R. Hinkle, and T.W. Dreschel. 1986. Far-field deposition from Space Shuttle launches at John F. Kennedy Space Center, Florida. NASA Technical Memorandum 83104. John F. Kennedy Space Center, Florida. 37 pp.

Schuman, G.E., M.A. Stanley, and D. Knudsen. 1973. Automated total nitrogen analysis of soil and plant samples. Soil Science Society of America Proceedings 37:480-481.

Smith, C.F. 1976. A flora of the Santa Barbara region, California. Santa Barbara Museum of Natural History. Santa Barbara, California. 331 pp.

Smith, D.M. 1983. Field study of candidate threatened or endangered plant species at Vandenberg Air Force Base. Report to U.S. Dept. of the Interior, Fish and Wildlife Service. Contract no. 11310-0133-81. 10 pp. and addendum.

Smith, J.P., Jr. and R. York. 1984. Inventory of rare and endangered plants of California (3rd ed.). Special Publication no. 1. California Native Plant Society. Berkeley, California. 174 pp.

Technicon Industrial Systems. 1973. Nitrate and nitrite in water and wastewater. Industrial method no. 100-70W. Technicon Industrial Systems. Tarrytown, New York.

Technicon Industrial Systems. 1983a. Ammonia in water and wastewater. In: Multi-test cartridge method no. 696-82W:1D-4D. Technicon Industrial Systems, Tarrytown, New York.

Technicon Industrial Systems. 1983b. Nitrogen, total Kjeldahl, in water and wastewater. In: Multi-test cartridge no. 696-82W:1C-5C. Technicon Industrial Systems. Tarrytown, New York.

Technicon Industrial Systems. 1983c. Ortho-phosphorus. In: Multi-test cartridge no. 696-82W:1B-4B. Technicon Industrial Systems, Tarrytown, New York.

U.S. Department of the Air Force. 1978. Final environmental impact statement MX: Milestone II. Volume III. Missile Flight Testing.

U.S. Department of the Air Force. 1983. Environmental impact analysis process: Supplement to final environmental impact statement, Space Shuttle program, Vandenberg AFB, California.

U.S. Department of the Air Force. 1986. Environmental planning factors, Space Shuttle program, Vandenberg AFB, California. Headquarters Space Division, Directorate of Civil Engineering, Environmental Planning Division. Los Angeles AFB, California.

Zammit, C.A. and P.H. Zedler. 1988. Germination response to extreme acidity: impact of simulated acid deposition from a single Shuttle launch. Environmental and Experimental Botany 28:73-81.

Appendix I

Vegetation Composition of the Permanent Transects

Table I-1. Composition (Percent Cover) of Transect #1 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	22.0	23.3	30.7	34.7
Chenopodium californicum	.	.	15.7	.
Artemisia californica	.	14.0	7.0	.7
Vulpia myuros/bromoides	.	.	9.7	.
Pterostegia drymarioides	.	.	6.0	.
Bromus rubens	.	.	6.0	.
Erodium botrys	.	.	4.3	.
Viola pedunculata	.	.	2.7	.
Oxalis albicans	.	.	2.0	.
Achillea millefolium	.	.	1.3	.
Ranunculus californicus	.	.	.7	.
Stipa pulchra	.	.	.7	.
Thatch	.	.	.	40.7
Bare ground	.	.	.	4.0
Anagallis arvensis	.	.	.	.7
Total live cover	22.0	37.3	86.8	36.1

Table I-2. Composition (Percent Cover) of Transect #2 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Artemisia californica	28.3	34.7	4.0	3.3
Baccharis pilularis ssp. consanguinea	27.3	40.0	2.0	2.7
Chenopodium californicum	2.7	.	23.0	.
Claytonia perfoliata	.	.	13.3	.
Cotula australis	.	.	3.3	.
Anagallis arvensis	.	.	2.0	1.0
Stachys bullata	.	.	2.0	.
Stellaria media	.	.	2.0	.
Pterostegia drymarioides	.	.	1.7	.
Erodium botrys	.	.	.3	.
Viola pedunculata	.	.	.3	.
Bare ground	.	.	.	27.3
Litter	.	.	.	3.3
Brassica nigra	.	.	.	2.0
Total live cover	58.3	74.7	53.9	9.0

Table I-3. Composition (Percent Cover) of Transect #3 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	8.3	18.0	31.7	29.3
Artemisia californica	3.7	4.0	9.7	13.0
Stipa pulchra	2.7	.	6.0	.
Pterostegia drymarioides	.	.	15.0	.
Claytonia perfoliata	.	.	11.0	.
Bromus rubens	.	.	10.3	.
Stachys bullata	.	.	5.0	.
Calystegia macrostegia ssp. cyclostegia	.	.	4.0	.
Bare ground	.	.	4.0	23.3
Festuca sp.	.	.	3.3	.
Erodium cicutarium	.	.	2.7	.
Chenopodium californicum	.	.	2.3	.
Solanum umbelliferum	.	.	1.3	.
Stellaria media	.	.	1.3	.
Vulpia myuros/bromoides	.	.	.7	.
Galium nutallii	.	.	.7	.
Thatch	.	.	.	18.0
Litter	.	.	.	1.3
Total live cover	14.7	22.0	105.0	42.3

Table I-4. Composition (Percent Cover) of Transect #4 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	30.0	41.3	5.3	4.7
Lupinus chamissonis	12.7	13.3	.	.
Bare ground	.	.	16.7	37.3
Solanum umbelliferum	.	.	13.3	.
Mirabilis californica	.	.	7.3	.
Scrophularia californica	.	.	5.4	.
Artemisia californica	.	.	4.7	3.3
Calystegia macrostegia ssp. cyclostegia	.	.	1.7	.
Chenopodium californicum	.	.	1.3	.
Descurainia pinnata	.	.	.3	.
Total live cover	42.7	54.6	39.3	8.0

Table I-5. Composition (Percent Cover) of Transect #5 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Claytonia perfoliata	34.3	.
Pteridium aquilinum	21.0	15.3
Rubus ursinus	13.7	5.0
Eriogonum parvifolium	9.0	20.7
Amsinckia intermedia	8.7	.
Mimulus aurantiacus	7.0	6.0
Bare ground	7.0	20.0
Baccharis pilularis ssp. consanguinea	1.3	1.3
Vulpia myuros/bromoides	1.3	.
Galium aparine	.7	.
Stachys bullata	.7	.
Toxicodendron diversilobum	.7	.
Poaceae - unknown	.7	.7
Eriophyllum confertiflorum	.	1.3
Thatch	.	29.3
Total live cover	99.1	50.3

Table I-6. Composition (Percent Cover) of Transect #6 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	.7	3.3	33.3	42.0
Vulpia myuros/bromoides	.	.	34.0	.
Achillea millefolium	.	.	17.7	.
Eriogonum parvifolium	.	.	10.7	11.3
Artemisia californica	.	.	7.7	8.0
Pterostegia drymarioides	.	.	7.0	.
Bromus carinatus	.	.	3.7	.7
Stachys bullata	.	.	3.3	.
Calystegia macrostegia ssp. cyclostegia	.	.	2.7	.
Marah fabaceus	.	.	2.3	.
Erodium cicutarium	.	.	2.0	.
Solanum sp.	.	.	1.7	.
Stellaria media	.	.	1.7	.
Claytonia perfoliata	.	.	1.3	.
Viola pedunculata	.	.	1.3	.
Poaceae - unknown	.	.	1.3	.
Bare ground	.	.	1.3	5.3
Chenopodium californicum	.	.	.7	.
Corethrogyne filaginifolia	.	.	.7	.
Unknown herb	.	.	.7	.
Asteraceae - unknown	.	.	.3	.
Calandrinia ciliata var. menziesii	.	.	.3	.
Cirsium occidentale	.	.	.3	.
Unknown herb	.	.	.3	.
Thatch	.	.	.	35.3
Lotus cf. scoparius	.	.	.	4.0
Aster radulinus	.	.	.	2.0
Elymus condensatus	.	.	.	.7
Total live cover	.7	3.3	135.0	68.7

Table I-7. Composition (Percent Cover) of Transect #7 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	22.0	20.0	13.0	23.3
Melica imperfecta	4.7	.	4.7	.7
Elymus condensatus	2.3	.	.	2.0
Artemisia californica	.	2.7	4.0	3.3
Vulpia myuros/bromoides	.	.	25.7	.
Claytonia perfoliata	.	.	13.3	.
Bromus carinatus	.	.	10.0	.
Achillea millefolium	.	.	6.3	.
Sanicula crassicaulis	.	.	5.0	.
Stachys bullata	.	.	5.0	.7
Mimulus aurantiacus	.	.	3.3	2.7
Stellaria media	.	.	2.0	.
Viola pedunculata	.	.	1.7	.
Eriophyllum confertifolium	.	.	1.3	1.3
Toxicodendron diversilobum	.	.	1.3	.7
Astragalus sp.	.	.	.7	.
Conium maculatum	.	.	.7	.
Eriogonum parvifolium	.	.	.7	.
Erodium cicutarium	.	.	.7	.
Pterostegia drymarioides	.	.	.7	.
Dichelostemma pulchellum	.	.	.3	.
Thatch	.	.	.	52.7
Bare ground	.	.	.	8.0
Rubus ursinus	.	.	.	.7
Lupinus sp.	.	.	.	.3
Total live cover	29.0	22.7	100.4	35.7

Table I-8. Composition (Percent Cover) of Transect #8 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	8.7	9.3	9.3	12.0
Artemisia californica	3.3	6.0	.	.
Eriogonum parvifolium	2.3	4.0	8.0	8.0
Erodium botrys	.	.	24.0	.
Stipa pulchra	.	.	18.3	.
Erodium cicutarium	.	.	10.0	.
Bromus carinatus	.	.	8.7	.
Achillea millefolium	.	.	6.3	.
Stachys bullata	.	.	5.3	.
Viola pedunculata	.	.	5.0	.
Bromus diandrus	.	.	5.0	.
Stellaria media	.	.	3.3	.
Galium nuttallii	.	.	2.3	.
Calystegia macrostegia ssp. cyclostegia	.	.	1.7	.
Calandrinia cilliata var. menziesii	.	.	1.3	.
Oxalis albicans	.	.	1.3	.7
Sonchus asper	.	.	1.3	.
Claytonia perfoliata	.	.	1.0	.
Rumex angiocarpus	.	.	1.0	.
Amsinckia intermedia	.	.	.7	.
Brassica nigra	.	.	.7	.
Corethrogyne filaginifolia	.	.	.7	.
Vulpia myuros/bromoides	.	.	.7	.
Haplopappus venetus ssp. veronioides	.	.	.7	4.7
Pterostegia drymarioides	.	.	.7	.
Unknown moss	.	.	.7	.
Spergula arvensis	.	.	.3	.
Thatch	.	.	.	45.3
Bare ground	.	.	.	12.7
Bromus sp.	.	.	.	2.0
Aster radulinus	.	.	.	1.3
Lotus cf. scoparius	.	.	.	1.3
Unknown herb	.	.	.	1.3
Stachys bullata	.	.	.	.7
Total live cover	14.3	19.3	118.3	32.0

Table I-9. Composition (Percent Cover) of Transect #9 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Haplopappus venetus ssp. vernonioides	.	3.3	2.7	7.3
Bromus carinatus	.	.	43.0	.
Erodium botrys	.	.	16.7	.
Layia platyglossa	.	.	14.3	.
Vulpia myuros/bromoides	.	.	10.3	.
Hordeum leporinum	.	.	10.3	.
Erodium cicutarium	.	.	7.7	.
Asteraceae - unknown	.	.	4.0	.
Avena barbata	.	.	3.3	.
Medicago polymorpha	.	.	2.3	.
Rumex angiocarpus	.	.	2.0	1.0
Calandrinia ciliata var. menziesii	.	.	1.3	.
Capsella bursa-pastoris	.	.	1.3	.
Oxalis albicans	.	.	1.3	.
Bromus diandrus	.	.	.7	.
Calystegia macrostegia ssp. cyclostegia	.	.	.7	.
Sonchus asper	.	.	.7	.
Bare ground	.	.	.7	14.7
Thatch	.	.	.	66.0
Hemizonia paniculata ssp. increscens	.	.	.	16.0
Bromus sp.	.	.	.	1.3
unknown herb	.	.	.	1.7
Total live cover	.	3.3	122.6	27.3

Table I-10. Composition (Percent Cover) of Transect #10 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Bromus diandrus	58.0	.
Erodium botrys	48.7	.3
Hordeum leporinum	24.0	.
Bromus carinatus	10.7	1.0
Cirsium occidentale	.7	.
Silybum marianum	.7	.
Thatch	.	85.3
Bare ground	.	10.0
Artemisia californica	.	1.3
Total live cover	142.8	2.6

Table I-11. Composition (Percent Cover) of Transect #11 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	3.3	3.3	2.0	4.7
Erodium botrys	.	.	31.3	.
Vulpia myuros/bromoides	.	.	24.0	.
Bromus diandrus	.	.	20.7	.
Hordeum leporinum	.	.	14.3	.
Bromus carinatus	.	.	4.7	.
Juncus sp.	.	.	3.3	1.3
Brassica nigra	.	.	2.7	.
Erodium sp.	.	.	1.7	.
Capsella bursa-pastoris	.	.	1.3	.
Rumex angiocarpus	.	.	1.3	2.3
Spergula arvensis	.	.	1.3	.
Erodium cicutarium	.	.	.7	.
Oxalis albicans	.	.	.7	.
Medicago polymorpha	.	.	.3	.
Thatch	.	.	.	92.7
Bare ground	.	.	.	1.3
Brassica nigra	.	.	.	1.0
Hemizonia paniculata ssp. increscens	.	.	.	.7
Haplopappus venetus ssp. vernonioides	.	.	.	.3
Total live cover	3.3	3.3	110.3	10.3

Table I-12. Composition (Percent Cover) of Transect #12 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Hapolopappus venetus ssp. vernonioides	.	2.0	1.7	4.7
Bromus carinatus	.	.	51.3	4.3
Erodium botrys	.	.	43.3	.3
Hordeum leporinum	.	.	14.0	.
Layia platyglossa	.	.	8.0	.
Rumex angiocarpus	.	.	6.7	5.0
Oxalis albicans	.	.	2.7	.7
Amsinckia intermedia	.	.	2.3	.
Capsella bursa-pastoris	.	.	1.7	.
Sonchus asper	.	.	1.7	.
Erodium sp.	.	.	1.3	.
Silybum marianum	.	.	1.3	.
Chenopodium californicum	.	.	.7	.
Eschscholzia californica	.	.	.7	.
Medicago polymorpha	.	.	.7	.
Thatch	.	.	.	78.0
Bare ground	.	.	.	12.3
Unknown herb	.	.	.	4.3
Festuca sp.	.	.	.	1.0
Total live cover	.	2.0	138.1	20.3

Table I-13. Composition (Percent Cover) of Transect #13 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Bromus carinatus	30.7	.
Bromus diandrus	15.3	.
Eschscholzia californica	11.7	2.0
Silybum marianum	11.3	.
Rumex angiocarpus	10.7	4.7
Erodium botrys	9.7	.
Erodium cicutarium	9.7	.
Layia platyglossa	8.3	.
Calandrinia ciliata var. menziesii	4.0	.
Hordeum leporinum	4.0	.
Stachys bullata	4.0	.7
Sonchus asper	2.7	.
Capsella bursa-pastoris	2.0	.
Haplopappus venetus ssp. vernonioides	1.3	2.7
Asteraceae - unknown	2.0	.
Vulpia myuros/bromoides	.7	.7
Marah fabaceus	.7	.
Medicago polymorpha	.3	.
Thatch	.	74.0
Bare ground	.	10.7
Bromus sp.	.	4.7
Total live cover	129.8	15.5

Table I-14. Composition (Percent Cover) of Transect #14 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Stipa pulchra	29.3	.
Bromus carinatus	21.3	.
Vulpia myuros/bromoides	15.0	.
Baccharis pilularis ssp. consanguinea	13.3	19.0
Avena barbata	6.7	.
Erodium botrys	5.7	.
Calystegia macrostegia ssp. cyclostegia	4.3	.
Haplopappus venetus ssp. vernonioides	4.0	3.0
Layia platyglossa	3.7	.
Hordeum leporinum	2.7	.
Bare ground	2.7	5.3
Ranunculus californicus	2.7	.
Erodium cicutarium	2.3	.
Rumex angiocarpus	2.3	.
Stellaria media	2.0	.
Calandrinia ciliata var. menziesii	1.0	.
Dichelostemma pulchellum	.7	.
Asteraceae - unknown	.7	.
Oxalis albicans	.3	.
Thatch	.	71.3
Hemizonia paniculata ssp. increscens	.	6.7
Total live cover	120.7	34.0

Table I-15. Composition (Percent Cover) of Transect #15 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	9.3	10.0	2.7	6.0
Bromus carinatus	.	.	21.0	.
Vulpia myuros/bromoides	.	.	17.0	.
Toxicodendron diversilobum	.	.	12.3	8.7
Bromus diandrus	.	.	11.0	.
Stachys bullata	.	.	10.0	1.3
Claytonia perfoliata	.	.	9.3	.
Elymus condensatus	.	.	4.7	8.0
Stellaria media	.	.	4.3	.
Achillea millefolium	.	.	4.0	.
Hordeum leporinum	.	.	2.7	.
Rumex angiocarpus	.	.	2.7	2.0
Cirsium occidentale	.	.	2.3	.
Lupinus chamissonis	.	.	2.3	.3
Chenopodium californicum	.	.	1.3	.
Melica imperfecta	.	.	1.3	.
Sanicula crassicaulis	.	.	1.0	.
Capsella bursa-pastoris	.	.	.7	.
Dichelostemma pulchellum	.	.	.7	.
Solanum douglasii	.	.	.7	.
Pterostegia drymarioides	.	.	.7	.
Thatch	.	.	.	68.0
Bare ground	.	.	.	6.0
Solidago californica	.	.	.	.7
Bromus sp.	.	.	.	.3
Total live cover	9.3	10.0	112.7	27.3

Table I-16. Composition (Percent Cover) of Transect #16 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	36.0	42.7	.7	8.0
Elymus condensatus	17.3	10.0	2.0	18.7
Chenopodium californicum	2.7	.	7.3	.
Toxicodendron diversilobum	.	2.7	3.3	3.0
Conium maculatum	2.0	.	20.0	.
Achillea millefolium	.	.	18.3	.3
Vulpia myuros/bromoides	.	.	14.0	.
Claytonia perfoliata	.	.	10.7	.
Bromus diandrus	.	.	3.3	.
Artemisia douglasii	.	.	2.7	.
Stellaria media	.	.	2.0	.
Bromus carinatus	.	.	1.3	.
Bromus rubens	.	.	1.3	.
Thatch	.	.	.	29.3
Bare ground	.	.	.	6.7
Rubus ursinus	.	.	.	1.3
Bromus sp.	.	.	.	.7
Total live cover	58.0	55.4	86.9	32.0

Table I-17. Composition (Percent Cover) of Transect #17 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Stipa pulchra	25.3	.
Layia platyglossa	16.3	.
Hordeum californicum	12.7	.
Erodium botrys	12.3	.
Vulpia myuros/bromoides	10.0	.
Hordeum leporinum	8.7	.
Spergula arvensis	6.3	.
Achillea millefolium	4.3	.
Capsella bursa-pastoris	4.0	.
Stachys bullata	4.0	.7
Rumex angiocarpus	3.7	1.0
Bromus carinatus	2.7	.
Erodium cicutarium	2.7	.
Erodium sp.	2.0	.7
Haplopappus venetus ssp. vernonioides	1.7	8.3
Calandrinia ciliata var. menziesii	1.3	.
Bromus diandrus	.7	.
Lotus scoparius	.7	.7
Amsinckia intermedia	.3	.
Oxalis albicans	.3	.3
Thatch	.	83.3
Bare ground	.	8.0
Poaceae - unknown	.	2.3
Hemizonia paniculata ssp. increscens	.	.7
Total live cover	120.0	14.7

Table I-18. Composition (Percent Cover) of Transect #18 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Silybum marianum	71.3	.
Hordeum leporinum	27.3	.
Bromus carinatus	6.7	.
Stellaria media	5.3	.
Cirsium occidentale	1.3	.
Erodium botrys	1.3	.
Brassica nigra	.7	.
Rumex angiocarpus	.7	.
Thatch	.	96.7
Bare ground	.	3.3
Total live cover	114.6	0.0

Table I-19. Composition (Percent Cover) of Transect #19 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Salvia mellifera	59.3	54.0	.	.
Baccharis pilularis ssp. consanguinea	28.0	28.0	.	.
Ceanothus impressus	17.3	24.0	.	.
Rhamnus californica	10.7	15.3	.	1.3
Marah fabaceus	5.3	.	.	.
Calystegia macrostegia ssp. cyclostegia	1.3	.	.	.
Rubus ursinus	1.3	7.3	1.3	.7
Stellaria media	.	.	5.3	.
Claytonia perfoliata	.	.	2.0	.
Pterostegia drymarioides	.	.	2.0	.
Total live cover	123.2	128.6	10.6	2.0

Table I-20. Composition (Percent Cover) of Transect #20 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Artemisia californica	5.3	14.0	5.7	3.3
Baccharis pilularis ssp. consanguinea	12.7	11.3	2.0	6.7
Hordeum californicum	.	.	20.3	.
Stipa pulchra	.	.	20.0	.
Layia platyglossa	.	.	10.7	.
Erodium botrys	.	.	4.3	.
Vulpia myuros/bromoides	.	.	4.0	.
Eschscholzia californica	.	.	3.3	.
Lotus scoparius	.	.	3.3	4.7
Erodium sp.	.	.	3.0	.
Bromus carinatus	.	.	2.7	.
Haplopappus venetus ssp. vernonioides	.	.	2.3	2.0
Rumex angiocarpus	.	.	2.3	.
Erodium cicutarium	.	.	2.0	.
Lupinus bicolor	.	.	1.3	.
Oxalis albicans	.	.	1.3	.
Chenopodium californicum	.	.	.7	.
Medicago polymorpha	.	.	.7	.
Viola pedunculata	.	.	.7	.
Calandrinia ciliata var. menziesii	.	.	.3	.
Asteraceae - unknown	.	.	.3	.
Thatch	.	.	.	64.0
Hemizonia paniculata ssp. increscens	.	.	.	14.0
Bare ground	.	.	.	2.0
Total live cover	18.0	25.3	91.2	30.7

Table I-21. Composition (Percent Cover) of Transect #21 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Layia platyglossa	40.3	.
Hordeum leporinum	21.3	.
Erodium botrys	14.3	.
Eschscholzia californica	10.7	4.0
Bromus carinatus	8.7	5.3
Hordeum californicum	7.3	.
Medicago polymorpha	3.0	.
Lupinus bicolor	2.3	.
Sonchus asper	2.3	.
Asteraceae - unknown	2.3	.
Brassica nigra	1.7	.
Capsella bursa-pastoris	1.3	.
Stellaria media	1.3	.
Baccharis pilularis ssp. consanguinea	1.0	.
Cirsium occidentale	1.0	.3
Erodium cicutarium	1.0	.
Amsinckia intermedia	.7	.
Calandrinia ciliata var. menziesii	.7	.
Vulpia myuros/bromoides	.7	.3
Malva parviflora	.7	.
Rumex angiocarpus	.7	.7
Spergula arvensis	.7	.
Anagallis arvensis	.3	.
Thatch	.	52.7
Bare ground	.	26.7
Hemizonia paniculata ssp. increscens	.	8.7
Total live cover	124.0	19.3

Table I-22. Composition (Percent Cover) of Transect #22 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Halopappus venetus ssp. vernonioides	.	4.7	.7	5.3
Bromus carinatus	.	.	33.0	.
Hordeum leporinum	.	.	28.7	.
Eschscholzia californica	.	.	12.3	4.3
Erodium cicutarium	.	.	9.3	.
Sonchus asper	.	.	7.3	.
Vulpia myuros/bromoides	.	.	6.0	.3
Erodium botrys	.	.	4.7	.3
Capsella bursa-pastoris	.	.	3.0	.
Asteraceae - unknown	.	.	3.0	.
Spergula arvensis	.	.	2.7	.
Medicago polymorpha	.	.	2.0	.
Rumex angiocarpus	.	.	1.7	1.3
Stachys bullata	.	.	1.7	.
Cirsium occidentale	.	.	1.3	.7
Amsinckia intermedia	.	.	.7	.
Calystegia macrostegia ssp. cyclostegia	.	.	.7	.
Oxalis albicans	.	.	.3	.3
Stellaria media	.	.	.3	.
Thatch	.	.	.	64.0
Bare ground	.	.	.	26.7
Poaceae - unknown	.	.	.	3.3
Total live cover	.	4.7	119.4	15.8

Table I-23. Composition (Percent Cover) of Transect #23 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Bromus carinatus	21.3	.
Hordeum leporinum	16.7	.
Stachys bullata	14.7	1.0
Erodium cicutarium	9.0	.
Baccharis pilularis ssp. consanguinea	8.7	11.3
Eschscholzia californica	8.3	2.7
Chenopodium californicum	6.3	.
Hordeum californicum	6.3	.
Bromus diandrus	6.0	.
Asteraceae - unknown	5.3	.
Erodium botrys	5.0	.
Brassica nigra	2.7	.
Vulpia myuros/bromoides	2.7	.
Medicago polymorpha	1.7	.
Rumex angiocarpus	1.7	1.0
Calystegia macrostegia ssp. cyclostegia	1.3	.
Haplopappus venetus ssp. vernonioides	1.3	8.0
Layia platyglossa	1.0	.
Lupinus bicolor	.7	.
Oxalis albicans	.7	.3
Sonchus asper	.7	.
Amsinckia intermedia	.3	.
Thatch	.	69.3
Bare ground	.	5.3
Hemizonia paniculata ssp. increscens	.	1.3
Poaceae - unknown	.	2.0
Total live cover	122.4	27.6

Table I-24. Composition (Percent Cover) of Transect #24 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Vulpia myuros/bromoides	29.7	.
Brassica nigra	23.3	8.3
Erodium botrys	13.0	.
Hordeum leporinum	12.0	.
Bromus diandrus	9.3	.
Bromus carinatus	8.0	.
Chenopodium californicum	7.3	.
Silybum marianum	4.0	.
Cirsium occidentale	1.3	.
Claytonia perfoliata	1.3	.
Anagallis arvensis	1.0	.
Erodium cicutarium	.7	.
Rumex angiocarpus	.7	.
Medicago polymorpha	.3	.
Thatch	.	74.0
Bare ground	.	9.3
Juncus sp.	.	2.0
Total live cover	111.9	10.3

Table I-25. Composition (Percent Cover) of Transect #25 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	24.0	33.3	10.0	6.7
Artemisia californica	3.3	5.3	8.3	15.7
Chenopodium californicum	.	.	24.3	.
Vulpia myuros/bromoides	.	.	12.0	.
Bare ground	.	.	12.0	24.0
Anagallis arvensis	.	.	8.0	1.0
Rumex angiocarpus	.	.	1.0	.
Eschscholzia californica	.	.	.7	.
Calandrinia ciliata var. menziesii	.	.	.3	.
Claytonia perfoliata	.	.	.3	.
Oxalis albicans	.	.	.3	.
Pterostegia drymarioides	.	.	.3	.
Stellaria media	.	.	.3	.
Thatch	.	.	.	12.7
Total live cover	27.3	38.6	65.8	23.4

Table I-26. Composition (Percent Cover) of Transect #26 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Artemisia californica	14.0	38.7	19.7	17.0
Chenopodium californicum	1.3	.	10.7	.
Haplopappus venetus ssp. vernonioides	.	1.3	3.3	.7
Vulpia myuros/bromoides	.	.	17.7	.
Eschscholzia californica	.	.	15.7	.
Hordeum californicum	.	.	12.0	.
Erodium botrys	.	.	9.0	.
Calystegia macrostegia ssp. cyclostegia	.	.	8.7	.3
Bromus carinatus	.	.	7.3	.
Bromus mollis	.	.	5.3	.
Marah fabaceus	.	.	4.0	.
Oxalis albicans	.	.	2.3	.3
Rumex angiocarpus	.	.	1.7	.
Brassica nigra	.	.	1.3	.
Erodium cicutarium	.	.	1.0	.
Cirsium occidentale	.	.	.3	.
Thatch	.	.	.	70.0
Bare ground	.	.	.	2.0
Bromus sp.	.	.	.	.7
Total live cover	15.3	40.0	120.0	19.0

Table I-27. Composition (Percent Cover) of Transect #27 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	.	9.3	10.7	6.7
Artemisia californica	.	6.7	16.0	9.3
Haplopappus venetus ssp. vernonioides	.	1.3	4.7	3.0
Vulpia myuros/bromoides	.	.	17.3	.
Hordeum californicum	.	.	15.3	.
Bromus carinatus	.	.	13.3	.
Calystegia marcostegia ssp. cyclostegia	.	.	12.0	.
Layia platyglossa	.	.	10.3	.
Lupinus bicolor	.	.	7.7	.
Chenopodium californicum	.	.	7.0	.
Eschscholzia californica	.	.	7.0	.
Erodium botrys	.	.	2.0	.
Erodium cicutarium	.	.	1.3	.
Cirsium occidentale	.	.	1.0	.
Amsinckia intermedia	.	.	.7	.
Ranunculus californicus	.	.	.7	.
Capsella bursa-pastoris	.	.	.3	.
Thatch	.	.	.	49.3
Hemizonia paniculata ssp. increscens	.	.	.	18.7
Bare ground	.	.	.	4.0
Rumex angiocarpus	.	.	.	.3
Total live cover	.	17.3	127.3	38.00.

Table I-28. Composition (Percent Cover) of Transect #28 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Layia platyglossa	20.3	.
Erodium botrys	18.7	.
Vulpia myuros/bromoides	18.3	.
Eschscholzia californica	10.0	.3
Haplopappus venetus ssp. vernonioides	8.3	6.0
Artemisia californica	7.0	9.3
Erodium cicutarium	6.0	.
Chenopodium californicum	5.7	.
Bromus diandrus	3.3	.
Asteraceae - unknown	3.3	.
Trifolium hirtum	3.0	.
Spergula arvensis	1.7	.
Bare ground	1.3	8.7
Cirsium occidentale	1.0	.
Calystegia macrostegia ssp. cyclostegia	1.0	.
Dichelostemma pulchellum	.7	.
Rumex angiocarpus	.7	.
Sonchus asper	.7	.
Stellaria media	.7	.
Amsinckia intermedia	.3	.
Thatch	.	59.3
Hemizonia paniculata ssp. increscens	.	30.7
Lamiaceae - unknown	.	.3
Total live cover	110.7	46.6

Table I-29. Composition (Percent Cover) of Transect #29 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Artemisia californica	17.3	22.0	19.3	18.7
Baccharis pilularis ssp. consanguinea	.	1.3	.	1.3
Solidago californica	.	.	16.7	10.3
Vulpia myuros/bromoides	.	.	12.0	.
Lotus scoparius	.	.	8.0	7.3
Rubus ursinus	.	.	8.0	11.3
Erodium botrys	.	.	5.7	.
Taraxacum officinale	.	.	5.7	.
Erodium cicutarium	.	.	4.7	.
Cardionema ramosissimum	.	.	3.3	.
Layia platyglossa	.	.	2.7	.
Marah fabaceus	.	.	2.0	.
Pterostegia drymarioides	.	.	2.0	.
Calandrinia ciliata var. menziesii	.	.	1.3	.
Oxalis pes-caprae	.	.	1.3	.
Eschscholzia californica	.	.	1.0	.
Unknown herb	.	.	1.0	.
Dichelostemma pulchellum	.	.	.7	.
Haplopappus venetus ssp. vernonioides	.	.	.3	1.0
Claytonia perfoliata	.	.	.3	.
Thatch	.	.	.	23.3
Hemizonia paniculata ssp. increscens	.	.	.	8.7
Bare ground	.	.	.	4.7
Total live cover	17.3	23.3	96.0	58.6

Table I-30. Composition (Percent Cover) of Transect #30 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Ceanothus impressus	68.0	84.0	.	.
Baccharis pilularis ssp. consanguinea	22.7	12.7	.	4.7
Marah fabaceus	12.0	.	4.7	.
Chenopodium californicum	3.3	.	1.3	.
Claytonia perfoliata	.	.	16.7	.
Stellaria media	.	.	13.3	.
Pterostegia drymarioides	.	.	4.7	.
Stachys bullata	.	.	.7	.
Bare ground	.	.	.	2.0
Total live cover	106.0	96.7	41.4	4.7

Table I-31. Composition (Percent Cover) of Transect #31 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Artemisia californica	22.7	28.7	18.0	22.7
Baccharis pilularis ssp. consanguinea	7.3	9.3	2.0	2.7
Salvia spathaceae	.	.	33.0	12.7
Bromus diandrus	.	.	6.7	.
Eschscholzia californica	.	.	5.7	.
Viola pedunculata	.	.	3.7	.
Erodium cicutarium	.	.	3.3	.
Chenopodium californicum	.	.	2.3	.
Vulpia myuros/bromoides	.	.	1.3	.
Layia platyglossa	.	.	1.3	.
Rumex angiocarpus	.	.	1.3	.
Anagallis arvensis	.	.	1.0	1.0
Erodium botrys	.	.	1.0	.
Cirsium occidentale	.	.	.7	.
Dichelostemma pulchellum	.	.	.7	.
Haplopappus venetus ssp. vernonioides	.	.	.7	.
Unknown herb	.	.	.7	.
Hemizonia paniculata ssp. increscens	.	.	.3	3.3
Oxalis albicans	.	.	.3	.
Stellaria media	.	.	.3	.
Taraxacum officinale	.	.	.3	.
Thatch	.	.	.	28.0
Bare ground	.	.	.	2.0
Total live cover	30.0	38.0	85.6	42.4

Table I-32. Composition (Percent Cover) of Transect #32 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Layia platyglossa	33.0	.
Hordeum californicum	23.3	.
Bromus carinatus	20.3	.
Erodium botrys	9.7	.3
Vulpia myuros/bromoides	8.3	.
Stipa pulchra	4.0	.
Asteraceae - unknown	4.0	.
Calystegia macrostegia ssp. cyclostegia	3.7	.
Erodium cicutarium	3.7	.
Haplopappus venetus ssp. vernonioides	3.0	4.3
Eschscholzia californica	2.0	.
Medicago polymorpha	2.0	.
Bromus diandrus	1.7	.
Chenopodium californicum	1.3	.
Rumex angiocarpus	1.0	1.7
Erodium sp.	.7	.
Lupinus bicolor	.7	.
Sonchus asper	.7	.
Trifolium sp.	.7	.
Capsella bursa-pastoris	.3	.
Thatch	.	65.3
Hemizonia paniculata ssp. increscens	.	41.3
Bare ground	.	2.7
Oxalis albicans	.	.3
Poaceae - unknown	.	.3
Total live cover	124.1	48.2

Table I-33. Composition (Percent Cover) of Transect #33 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Claytonia perfoliata	51.3	.
Brassica nigra	29.0	8.3
Chenopodium californicum	11.7	.
Vulpia myuros/bromoides	9.3	.
Calandrinia ciliata var. menziesii	9.0	.
Silybum marianum	7.3	.
Erodium cicutarium	5.7	.
Cirsium occidentale	2.0	.
Erodium botrys	1.7	.
Anagallis arvensis	1.3	4.3
Stachys bullata	1.3	.
Hordeum californicum	1.0	.
Stellaria media	.7	.
Erodium sp.	.3	.
Medicago polymorpha	.	.
Thatch	.	77.3
Bare ground	.	7.3
Total live cover	131.9	12.6

Table I-34. Composition (Percent Cover) of Transect #34 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Claytonia perfoliata	27.0	.
Vulpia myuros/bromoides	25.3	.
Brassica nigra	21.0	4.0
Chenopodium californicum	14.3	.
Erodium cicutarium	12.7	.
Erodium botrys	11.7	.
Cirsium occidentale	10.0	.
Amsinckia intermedia	6.3	.
Bromus diandrus	6.0	.
Calandrinia ciliata var. menziesii	3.3	.
Asteraceae - unknown	3.3	.
Medicago polymorpha	2.0	.
Sonchus asper	1.3	.
Erodium sp.	1.0	.
Layia platyglossa	.7	.
Rumex angiocarpus	.7	.
Spergula arvensis	.3	.
Thatch	.	77.3
Bare ground	.	8.0
Stephanomeria sp.	.	1.3
Total live cover	146.9	5.3

Table I-35. Composition (Percent Cover) of Transect #35 in March and September 1986

TAXA	< 0.5m March	< 0.5m September
Vulpia myuros/bromoides	64.3	.
Bromus diandrus	12.7	.
Erodium botrys	11.0	.
Amsinckia intermedia	10.3	.
Cirsium occidentale	10.3	.
Calandrinia ciliata var. menziesii	8.3	.
Brassica nigra	6.7	.
Silybum marianum	6.3	.
Sonchus asper	6.3	.
Anagallis arvensis	2.0	.
Medicago polymorpha	2.0	.
Bare ground	2.0	9.3
Spergula arvensis	1.3	.
Stellaria media	1.0	.
Asteraceae - unknown	1.0	.
Rumex angiocarpus	.7	.
Thatch	.	87.3
Total live cover	144.2	0.0

Table I-36. Composition (Percent Cover) of Transect #36 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	20.3	20.7	9.0	7.0
Artemisia californica	.	2.0	4.0	2.0
Bromus diandrus	.	.	27.3	.
Vulpia myuros/bromoides	.	.	22.3	.
Stellaria media	.	.	15.7	.
Anagallis arvensis	.	.	6.0	.
Erodium botrys	.	.	4.7	.
Claytonia perfoliata	.	.	4.7	.
Stipa pulchra	.	.	4.3	.
Chenopodium californicum	.	.	2.7	.
Bromus sp.	.	.	2.7	.
Oxalis albicans	.	.	2.3	.
Brassica nigra	.	.	2.0	.
Erodium cicutarium	.	.	2.0	.
Medicago polymorpha	.	.	1.7	.
Spergula arvensis	.	.	1.7	.
Amsinckia intermedia	.	.	.3	.
Calandrinia ciliata var. menziesii	.	.	.3	.
Layia platyglossa	.	.	.3	.
Unknown herb	.	.	.3	.
Thatch	.	.	.	68.7
Hemizonia paniculata ssp. increscens	.	.	.	6.7
Total live cover	20.3	22.7	114.3	15.7

Table I-37. Composition (Percent Cover) of Transect #37 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	85.3	70.3	2.0	6.7
Vulpia myuros/bromoides	.	.	27.0	.
Stachys bullata	.	.	19.3	.
Stellaria media	.	.	16.0	.
Bromus sp.	.	.	11.0	.
Oxalis albicans	.	.	4.7	.
Anagallis arvensis	.	.	2.0	.
Calandrinia ciliata var. menziesii	.	.	2.0	.
Gnaphalium microcephalum	.	.	1.7	.
Bare ground	.	.	1.7	.
Rumex angiocarpus	.	.	1.3	.
Unknown herb #2	.	.	1.3	.
Castilleja sp.	.	.	.7	.
Moss	.	.	.7	.
Achillea millefolium	.	.	.3	.
Unknown herb #1	.	.	.3	.
Thatch	.	.	.	29.3
Total live cover	85.3	70.3	90.3	6.7

Table I-38. Composition (Percent Cover) of Transect #38 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	52.7	67.3	4.0	3.3
Mimulus aurantiacus	18.7	20.0	5.3	8.7
Galium nuttallii	2.0	.	5.7	.
Melica imperfecta	1.3	.	22.7	.
Vicia sp.	1.3	.	.	.
Haplopappus venetus ssp. vernonioides	.7	.7	.	.
Eriogonum parvifolium	.	2.7	4.7	.
Pteridum aquilinum	.	.	4.7	.7
Achillea millefolium	.	.	2.0	.
Salvia spathacea	.	.	2.0	.7
Sanicula crassicaulis	.	.	.7	.
Thatch	.	.	.	18.0
Bare ground	.	.	.	1.3
Total live cover	76.7	90.7	51.8	13.4

Table I-39. Composition (Percent Cover) of Transect #39 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	49.3	55.3	.	.
Artemisia californica	22.7	42.0	.	.
Salvia spathacea	20.0	.	10.7	14.7
Sanicula crassicaulis	9.3	.	2.7	.
Elymus condensatus	7.3	9.3	.	.
Solanum umbelliferum	5.3	.	.	.
Galium nuttallii	2.0	.	.	.
Claytonia perfoliata	.	.	7.3	.
Stellaria media	.	.	2.0	.
Chenopodium californicum	.	.	1.3	.
Pterostegia drymarioides	.	.	1.3	.
Urtica urens	.	.	1.3	.
Thatch	.	.	.	16.7
Total live cover	115.9	106.6	26.6	14.7

Table I-40. Composition (Percent Cover) of Transect #40 in March and September 1986

TAXA	> 0.5m March	> 0.5m September
Salvia leucophylla	86.0	88.0
Artemisia californica	21.3	26.0
Encelia californica	9.3	4.7
Baccharis pilularis ssp. consanguinea	2.7	6.7
Marah fabaceus	.7	.
Total live cover	120.0	125.0

Table I-41. Composition (Percent Cover) of Transect #41 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Elymus condensatus	54.7	37.3	.	.
Rubus ursinus	10.7	3.3	.	12.7
Artemisia douglasiana	10.0	2.0	.7	.
Baccharis pilularis ssp. consanguinea	9.3	8.0	.	.
Toxicodendron diversilobum	6.7	.	9.3	4.7
Salvia spathacea	4.7	.	5.0	9.7
Pteridium aquilinum	3.3	.	.	9.3
Sanicula crassicaulis	3.3	.	2.7	.
Vicia sp.	1.7	.	2.0	.
Stachys bullata	.	.	3.7	.
Stellaria media	.	.	3.0	.
Scrophularia californica	.	.	2.0	.
Urtica urens	.	.	2.0	.
Claytonia perfoliata	.	.	1.0	.
Thatch	.	.	.	49.3
Bare ground	.	.	.	.7
Total live cover	104.4	50.6	31.4	36.4

Table I-42. Composition (Percent Cover) of Transect #42 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	9.3	6.0	8.3	14.0
Lotus scoparius	.	8.0	10.7	2.0
Eriogonum parvifolium	.	4.7	15.3	9.0
Melica imperfecta	.	.	20.7	.
Pteridium aquilinum	.	.	19.7	10.7
Claytonia perfoliata	.	.	13.7	.
Elymus condensatus	.	.	4.0	.7
Pterostegia drymarioides	.	.	3.3	.
Achillea millefolium	.	.	2.7	.
Chenopodium californicum	.	.	1.3	.
Rubus ursinus	.	.	1.7	2.7
Coreopsis gigantea	.	.	1.3	.
Mimulus aurantiacus	.	.	1.3	1.3
Solanum douglasii	.	.	1.3	1.0
Stellaria media	.	.	1.0	.
Amsinckia intermedia	.	.	.7	.
Stachys bullata	.	.	.7	.
Thatch	.	.	.	42.7
Aster radulinus	.	.	.	.3
Total live cover	9.3	18.7	107.7	41.7

Table I-43. Composition (Percent Cover) of Transect #43 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	11.3	15.3	16.0	12.0
Vulpia myuros/bromoides	.	.	32.7	.
Achillea millefolium	.	.	10.7	.
Bromus diandrus	.	.	8.0	.
Melica imperfecta	.	.	8.0	.
Eriogonum parvifolium	.	.	4.0	4.7
Calystegia macrostegia ssp. cyclostegia	.	.	2.7	.
Salvia spathacea	.	.	2.3	.7
Stipa pulchra	.	.	2.0	.
Horkelia cuneata	.	.	1.7	2.0
Claytonia perfoliata	.	.	1.7	.
Anagallis arvensis	.	.	1.3	.
Artemisia californica	.	.	1.3	2.0
Pterostegia drymarioides	.	.	1.3	.
Ranunculus californicus	.	.	1.3	.
Rumex angiocarpus	.	.	1.3	.
Bare ground	.	.	1.3	5.3
Plantago erecta	.	.	1.0	.
Amsinckia intermedia	.	.	.3	.
Dichelostemma pulchellum	.	.	.3	.
Galium nuttallii	.	.	.3	.
Oxalis albicans	.	.	.3	.
Thatch	.	.	.	72.0
Total live cover	11.3	15.3	98.5	21.4

Table I-44. Composition (Percent Cover) of Transect #44 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Artemisia californica	45.3	48.7	.7	.
Baccharis pilularis ssp. consanguinea	32.7	30.0	7.7	6.7
Mimulus aurantiacus	20.7	18.7	4.7	3.3
Calystegia macrostegia ssp. cyclostegia	8.7	.	1.0	.
Salvia spathacea	.	.	6.3	.
Chenopodium californicum	.	.	2.7	.
Lotus scoparius	.	.	.7	.
Stellaria media	.	.	.3	.
Rubus ursinus	.	.	.	3.3
Thatch	.	.	.	3.3
Bare ground	.	.	.	3.3
Total live cover	107.4	97.4	24.1	13.3

Table I-45. Composition (Percent Cover) of Transect #45 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	24.7	22.0	5.3	20.0
Mimulus aurantiacus	12.0	15.3	5.3	7.3
Elymus condensatus	.7	2.0	.	.
Eriogonum parvifolium	.	.	16.7	18.0
Salvia spathacea	.	.	15.0	5.3
Claytonia perfoliata	.	.	13.7	.
Achillea millefolium	.	.	3.7	.
Stellaria media	.	.	3.7	.
Pterostegia drymarioides	.	.	2.7	.
Amsinckia intermedia	.	.	2.0	.
Stachys bullata	.	.	2.0	.
Bare ground	.	.	2.0	6.0
Solanum umbelliferum	.	.	1.7	.
Galium aparine	.	.	1.3	.
Coreopsis gigantea	.	.	.7	.
Lotus scopairus	.	.	.7	.
Erodium cicutarium	.	.	.3	.
Vulpia myuros/bromoides	.	.	.3	.
Total live cover	37.4	39.3	75.1	50.6

Table I-46. Composition (Percent Cover) of Transect #46 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	37.3	42.7	1.3	5.7
Mimulus aurantiacus	17.3	14.0	4.3	8.0
Artemisia californica	4.0	4.7	.3	.
Chenopodium californicum	.	.	9.3	.
Marah fabaceus	.	.	.7	.
Bare ground	.	.	24.7	18.7
Total live cover	58.6	61.4	15.9	13.7

Table I-47. Composition (Percent Cover) of Transect #47 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	33.3	41.3	5.3	2.7
Artemisia californica	12.7	36.7	5.0	.7
Chenopodium californicum	.	.	8.7	.
Marah fabaceus	.	.	.7	.
Pterostegia drymarioides	.	.	.3	.
Bare ground	.	.	30.7	18.0
Scrophularia californica	.	.	.	1.3
Total live cover	46.0	78.0	20.0	4.7

Table I-48. Composition (Percent Cover) of Transect #48 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Ceanothus ramulosus	39.0	31.3	2.3	2.7
Salvia mellifera	16.7	18.7	14.7	12.7
Rhus integrifolia	12.7	14.0	.7	1.0
Erodium cicutarium	.	.	.3	.
Bare ground	.	.	16.3	15.3
Total live cover	68.4	64.0	18.0	16.4

Table I-49. Composition (Percent Cover) of Transect #49 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Baccharis pilularis ssp. consanguinea	53.3	50.0	4.0	2.7
Artemisia californica	18.0	22.7	2.3	2.7
Mimulus aurantiacus	9.7	8.0	1.3	1.3
Anagallis arvensis	.	.	4.7	4.0
Chenopodium californicum	.	.	4.7	.
Sanicula crassicaulis	.	.	4.3	.
Achillea millefolium	.	.	3.0	.
Claytonia perfoliata	.	.	1.7	.
Melica imperfecta	.	.	.7	.
Stellaria media	.	.	.7	.
Thatch	.	.	.	8.7
Bare ground	.	.	.	2.0
Total live cover	81.0	80.7	27.4	10.7

Table I-50. Composition (Percent Cover) of Transect #50 in March and September 1986

TAXA	> 0.5m March	> 0.5m September	< 0.5 March	< 0.5m September
Eriophyllus confertiflorum	23.3	20.0	31.0	21.3
Baccharis pilularis ssp. consanguinea	16.0	9.3	.	.7
Elymus condensatus	11.3	4.0	.	3.3
Thalictrum polycarpum	3.3	.	9.7	.
Eriogonum parvifolium	2.7	3.3	1.3	.7
Pteridium aquilinum	.	.	26.3	11.0
Toxicodendron diversilobum	.	.	4.0	.
Adiantum jordani	.	.	1.7	.
Galium nuttallii	.	.	1.7	.7
Rubus ursinus	.	.	1.7	2.3
Achillea millefolium	.	.	.7	.
Artemisia douglasiana	.	.	.7	.
Mimulus aurantiacus	.	.	.7	1.3
Bare ground	.	.	.7	3.3
Thatch	.	.	.	38.7
Lotus scoparius	.	.	.	1.3
Total live cover	56.6	36.6	79.5	42.6

Appendix II

Environmental and Soils Data from the Permanent Transects

Table II-1. Selected environmental variables for the study transects.

PLOT	ASPECT	SLOPE ANGLE UP (%)	SLOPE ANGLE DOWN (%)	SLOPE ANGLE RIGHT (%)
1	250	13	-8	-11
2	246	30	-28	-8
3	238	30	-25	-16
4	194	35	-40	-7
5	320	42	-50	7
6	330	24	-30	10
7	340	40	-38	5
8	220	14	-20	-8
9	256	12	-10	-8
10	240	7	-8	-4
11	240	4	-6	2
12	240	7	-5	-4
13	240	5	-4	-3
14	240	12	-10	-5
15	340	40	-38	4
16	350	42	-30	8
17	260	14	-13	-4
18	254	10	-10	3
19	260	10	-14	-8
20	260	8	-8	-5
21	260	6	-7	3
22	260	9	-8	0
23	248	5	-7	-4
24	254	6	-7	0
25	254	4	-6	-2

Table II-1. (continued).

PLOT	ASPECT	SLOPE ANGLE UP (%)	SLOPE ANGLE DOWN (%)	SLOPE ANGLE RIGHT (%)
25	254	4	-6	-2
26	250	8	-7	0
27	260	4	-8	3
28	260	5	-8	3
29	282	8	-9	2
30	280	5	-8	-5
31	260	5	-8	2
32	250	4	-12	2
33	260	4	-5	0
34	260	4	-5	2
35	254	5	-8	3
36	240	8	-6	-5
37	252	3	-5	-18
38	50	28	-40	15
39	220	38	-25	-10
40	160	28	-20	-4
41	314	35	-28	10
42	340	0	-14	-15
43	330	2	-8	8
44	208	18	-30	-8
45	260	30	-38	15
46	200	25	-55	-30
47	180	28	-60	-18
48	192	30	-20	4
49	360	20	-25	5
50	320	45	-38	-9

Table II-1. (continued).

PLOT	SLOPE ANGLE LEFT (%)	PLOT SHAPE	MOST RECENT FIRE	MOST RECENT GRAZING
1	10	flat	1983	1986
2	8	flat	1983	1986
3	8	flat	1983	1986
4	5	flat	1983	1986*
5	-10	flat	1983	1986*
6	-11	flat	1983	1986
7	-7	flat	1983	1986
8	4	flat	1983	1986
9	2	flat	1983	1986
10	3	flat	1983	1986
11	0	flat	1983	1986
12	4	flat	1983	1986
13	2	flat	1983	1986
14	8	flat	1983	1986
15	-3	flat	1983	1986
16	-9	flat	1983	1986
17	10	flat	1983	1986
18	0	flat	1983	1986
19	4	flat	1983	1986
20	4	flat	1983	1986
21	-1	flat	1983	1986
22	2	flat	1983	1986
23	4	flat	1983	1986
24	4	flat	1983	1986
25	2	flat	1983	1986

* Grazing in area, apparently not on transect
** Fire in area, apparently not on transect
*** nr - Not recent

Table II-1. (continued).

PLOT	SLOPE ANGLE LEFT (%)	PLOT SHAPE	MOST RECENT FIRE	MOST RECENT GRAZING
25	2	flat	1983	1986
26	4	flat	1983	1986
27	-1	flat	1983	1986
28	-4	flat	1983	1986
29	0	flat	1983	1986
30	2	flat	1983**	1986*
31	0	flat	1983	1986
32	-3	flat	1983	1986
33	2	flat	1977?	nr***
34	-3	flat	1977?	nr
35	-2	flat	1977?	nr
36	4	flat	1977?	nr
37	4	flat	1977?	nr
38	-22	flat	1977	nr
39	8	flat	1977	nr
40	5	flat	1977	nr
41	-5	flat	1977	nr
42	-15	convex	1977	nr
43	-7	flat	1977	nr
44	7	flat	1977	nr
45	-18	flat	1977	nr
46	18	flat	1977	nr
47	10	flat	1977	nr
48	-4	flat	1977	nr
49	3	flat	1977	nr
50	5	flat	1977	nr

* Grazing in area, apparently not on transect
** Fire in area, apparently not on transect
*** nr - Not recent

Table II-2. Chemical composition of soils collected in March 1986

PLOT	DEPTH*	PH	CONDUCTIVITY (umho/cm)	ORGANIC MATTER (%)	AVAILABLE PHOSPHORUS (mg/kg)	TOTAL KJELDAHL NITROGEN (mg/kg)
1	1.00	5.80	121.0	7.5	4.20	3926
2	1.00	5.83	169.9	8.2	1.55	3398
3	1.00	5.87	193.7	15.4	3.09	5396
4	1.00	5.27	193.6	12.6	4.40	4919
5	1,00	4.96	205.7	17.4	2.68	15152
6	1.00	5.11	169.8	12.8	1.79	6300
7	1.00	5.43	157.3	11.3	4.53	6495
8	1.00	5.40	97.1	4.0	1.76	2799
9	1.00	5.42	119.8	5.2	1.93	3060
10	1.00	5.67	145.2	7.6	3.30	2966
11	1.00	5.90	106.5	5.5	1.02	2322
12	1.00	5.49	104.1	7.0	1.97	2641
12	2.00	5.66	83.2	5.2	1.52	2024
13	1.00	5.65	100.2	6.2	2.06	2761
14	1.00	5.24	77.4	6.8	1.46	2896
15	1.00	5.29	145.7	17.6	2.53	6208
15	2.00	5.40	89.5	11.8	1.27	4138
16	1.00	5.52	211.8	18.3	14.55	6713
16	2.00	5.34	181.5	15.4	12.00	6519
17	1.00	5.51	77.4	8.0	1.03	3053
18	1.00	5.80	121.0	6.4	1.81	3910
19	1.00	6.00	80.8	5.5	1.65	2655
20	1.00	5.53	56.3	4.7	.73	2055
21	1.00	5.58	106.5	9.3	2.42	4346
22	1.00	5.47	122.2	8.6	2.24	3957
23	1.00	5.67	104.1	7.4	3.16	3968
24	1.00	6.04	94.4	4.6	5.68	1770
25	1.00	5.87	91.5	3.8	2.29	2757

* - Depth 1.00=0 - 7.5 cm, 2.00=15 - 30 cm

Table II-2. (cont.)

PLOT	DEPTH*	PH	CONDUCTIVITY (umho/cm)	ORGANIC MATTER (%)	AVAILABLE PHOSPHORUS (mg/kg)	TOTAL KJELDAHL NITROGEN (mg/kg)
26	1.00	5.63	92.6	7.5	1.91	2835
26	2.00	5.77	71.4	6.8	1.69	2561
27	1.00	5.85	65.6	5.1	2.03	2195
28	1.00	5.72	83.2	5.1	1.88	1997
29	1.00	6.23	53.9	3.2	1.52	1470
30	1.00	5.26	181.5	9.7	2.79	3299
31	1.00	5.65	84.7	4.6	.90	1782
32	1.00	5.55	96.2	8.2	2.19	2792
33	1.00	6.21	111.3	6.3	1.20	2876
34	1.00	5.59	77.7	3.1	1.30	1519
35	1.00	5.64	77.4	5.0	.79	1871
36	1.00	5.67	56.9	5.7	.98	2204
37	1.00	5.44	106.7	6.1	.61	2251
38	1.00	5.44	101.6	7.6	.59	2610
39	1.00	6.73	145.2	14.2	9.90	5078
40	1.00	7.57	5452.0	17.1	68.70	8232
41	1.00	6.36	139.4	9.6	86.80	5079
42	1.00	4.73	197.8	28.7	1.87	11752
43	1.00	5.40	78.9	6.1	1.29	3010
44	1.00	5.66	124.1	11.6	2.59	4779
45	1.00	4.86	116.3	6.1	.25	1906
46	1.00	5.13	92.8	5.5	1.91	2437
47	1.00	4.58	233.7	6.6	.11	2546
48	1.00	6.52	78.9	7.0	1.63	3887
49	1.00	5.43	74.3	5.9	1.03	3110
50	1.00	5.79	78.9	10.8	2.24	4422

* - Depth 1.00=0 - 7.5 cm, 2.00=15 - 30 cm

Table II-2. (cont.)

PLOT	DEPTH*	NITRATE-NITROGEN (mg/kg)	AMMONIA-NITROGEN (mg/kg)	CATION EXCHANGE CAPACITY (meq/100g)	ALUMINUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)
1	1.00	40.10	9.73	14.80	.80	.54	76.16
2	1.00	29.10	6.93	17.60	.40	.38	75.04
3	1.00	65.10	10.20	31.30	.40	.72	166.96
4	1.00	34.20	10.10	21.70	1.60	.84	140.72
5	1.00	61.00	70.50	42.70	13.20	.28	219.92
6	1.00	41.30	7.33	29.90	4.40	.38	171.28
7	1.00	17.60	14.50	30.40	1.20	.56	90.60
8	1.00	17.60	11.70	13.70	.80	.52	202.96
9	1.00	31.10	8.92	11.80	.80	.66	109.92
10	1.00	42.10	9.43	11.00	.40	.60	199.92
11	1.00	11.20	5.11	7.14	.40	.52	295.68
12	1.00	18.00	6.29	9.86	.80	.44	104.16
12	2.00	15.90	5.70	9.58	.60	.51	108.20
13	1.00	18.60	9.85	11.40	.80	.40	102.24
14	1.00	18.50	9.19	11.80	2.80	.40	119.92
15	1.00	38.90	30.60	24.40	2.40	.42	226.32
15	2.00	14.90	4.42	21.20	5.60	.32	220.32
16	1.00	48.65	13.30	38.60	.80	.88	313.04
16	2.00	36.00	16.50	23.30	1.60	.90	332.48
17	1.00	16.20	10.50	12.80	3.20	.30	113.68
18	1.00	31.20	10.40	11.70	.80	.34	92.72
19	1.00	20.00	9.82	6.87	.80	.28	38.08
20	1.00	11.55	6.86	6.95	1.80	.23	108.72
21	1.00	25.60	7.07	15.90	2.00	.48	142.24
22	1.00	38.00	18.20	14.80	1.60	.86	95.20
23	1.00	19.80	9.15	15.90	1.20	.52	104.32
24	1.00	10.60	8.64	8.01	1.60	.44	113.84
25	1.00	16.15	11.45	11.15	1.20	.47	75.12

* - Depth 1.00=0 - 7.5 cm, 2.00=15 - 30 cm

Table II-2. (cont.)

PLOT	DEPTH*	NITRATE-NITROGEN (mg/kg)	AMMONIA-NITROGEN (mg/kg)	CATION EXCHANGE CAPACITY (meq/100g)	ALUMINUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)
26	1.00	26.10	10.50	11.30	.40	.50	106.96
26	2.00	12.20	7.69	11.50	1.20	.56	91.60
27	1.00	10.20	17.10	8.53	1.20	.44	84.08
28	1.00	13.40	5.93	7.57	1.60	.38	83.36
29	1.00	7.10	7.56	4.25	.80	.35	38.28
30	1.00	59.60	17.20	11.10	.80	.44	53.92
31	1.00	22.40	9.83	5.84	.40	.36	70.88
32	1.00	24.80	11.80	11.40	1.60	.44	124.64
33	1.00	28.00	13.40	8.32	.40	.54	259.52
34	1.00	12.05	6.31	5.11	.40	.59	136.04
35	1.00	15.10	9.87	7.15	2.80	.46	168.80
36	1.00	8.14	5.88	8.35	1.20	.48	137.20
37	1.00	16.60	8.60	11.00	4.00	.58	289.76
38	1.00	3.63	9.85	15.20	6.00	1.28	193.84
39	1.00	33.55	4.92	32.05	.20	1.69	57.76
40	1.00	30.00	16.50	32.60	.40	3.90	9.36
41	1.00	37.50	9.67	31.30	0.00	1.66	66.80
42	1.00	53.80	23.20	38.40	18.80	.36	292.80
43	1.00	16.20	7.92	12.70	2.40	.40	168.80
44	1.00	21.20	8.55	18.70	.60	.69	136.20
45	1.00	8.26	4.49	9.42	54.80	.78	93.52
46	1.00	22.70	5.25	11.10	4.40	.72	106.08
47	1.00	45.50	13.70	14.90	67.20	1.14	192.32
48	1.00	16.10	12.20	13.70	0.00	.26	35.60
49	1.00	15.35	12.05	11.60	1.40	.43	84.96
50	1.00	18.30	11.10	20.90	.40	.36	84.64

* - Depth 1.00=0 - 7.5 cm, 2.00=15 - 30 cm

Table II-2. (cont.)

PLOT	DEPTH*	MANGANESE (mg/kg)	ZINC (mg/kg)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)
1	1.00	18.38	60.43	1168	440.0	776	96.96
2	1.00	11.32	22.99	1224	673.6	1736	171.36
3	1.00	19.00	77.58	1964	1048.8	1068	145.36
4	1.00	21.84	21.86	1320	896.8	560	142.92
5	1.00	7.74	21.95	1088	958.4	760	197.48
6	1.00	17.60	16.26	1000	712.0	768	212.28
7	1.00	22.88	9.40	1752	868.8	648	199.88
8	1.00	14.71	5.39	828	387.2	764	133.92
9	1.00	20.32	13.34	728	294.4	344	132.96
10	1.00	11.96	34.78	904	421.6	600	110.84
11	1.00	3.68	13.51	640	256.0	496	87.48
12	1.00	13.70	7.35	768	300.0	608	91.64
12	2.00	11.42	4.16	712	320.0	628	101.10
13	1.00	17.92	10.08	624	286.4	488	135.52
14	1.00	13.90	5.33	680	279.2	560	87.84
15	1.00	19.10	16.22	1232	700.8	816	164.60
15	2.00	4.06	2.81	1008	587.2	632	181.68
16	1.00	19.42	26.24	2268	1036.4	1580	166.46
16	2.00	10.64	8.20	2408	1006.4	1792	206.92
17	1.00	11.02	3.11	864	322.4	416	112.40
18	1.00	17.10	9.39	984	370.4	912	122.08
19	1.00	9.96	.93	696	196.0	288	25.60
20	1.00	11.11	.93	460	130.8	352	54.08
21	1.00	22.98	6.84	1000	483.2	616	173.84
22	1.00	23.18	8.22	976	450.4	808	122.48
23	1.00	19.00	5.22	1136	452.8	968	129.40
24	1.00	7.70	3.81	880	276.0	912	77.20
25	1.00	12.32	4.97	956	355.6	744	93.40

* - Depth 1.00=0 - 7.5 cm, 2.00=15 - 30 cm

Table II-2. (cont.)

PLOT	DEPTH*	MANGANESE (mg/kg)	ZINC (mg/kg)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)
26	1.00	27.70	35.19	936	384.8	736	110.44
26	2.00	14.82	1.00	864	359.2	720	133.32
27	1.00	14.82	1.80	672	234.4	704	67.56
28	1.00	16.84	1.49	576	216.8	552	83.12
29	1.00	8.89	.82	504	143.2	284	29.14
30	1.00	38.74	7.42	904	236.8	160	46.48
31	1.00	12.50	1.42	696	133.6	400	44.28
32	1.00	18.76	3.71	760	325.6	648	142.80
33	1.00	9.12	12.74	1048	427.2	512	64.08
34	1.00	15.26	4.14	500	111.2	452	62.96
35	1.00	9.94	5.32	576	186.4	456	76.20
36	1.00	11.72	9.65	680	268.8	352	94.04
37	1.00	13.44	8.17	488	265.6	296	165.96
38	1.00	14.52	21.95	856	781.6	512	283.52
39	1.00	22.63	81.23	3356	1242.4	1080	249.10
40	1.00	8.58	22.42	4208	1647.2	1584	231.64
41	1.00	21.98	34.16	3960	1376.8	496	205.56
42	1.00	1.84	23.52	872	751.2	320	188.36
43	1.00	11.12	1.27	688	368.0	456	96.88
44	1.00	23.90	7.37	2768	1616.0	1152	171.50
45	1.00	11.50	.96	368	434.4	480	164.84
46	1.00	18.38	3.72	608	492.0	560	82.76
47	1.00	13.90	2.29	776	678.4	504	187.32
48	1.00	14.40	2.09	1752	365.6	1336	80.44
49	1.00	17.13	3.45	488	252.8	340	73.22
50	1.00	21.52	3.95	1200	694.4	488	116.00

* -Depth 1.00=0 - 7.5 cm, 2.00=15 - 30 cm

Table II-3. Chemical composition of soils collected in September 1986.

PLOT	DEPTH*	PH	CONDUCTIVITY (umho/cm)	ORGANIC MATTER (%)	AVAILABLE PHOSPHORUS (mg/kg)	TOTAL KJELDAHL NITROGEN (mg/kg)
3	1.00	5.88	152.1	17.2	2.16	6011
13	1.00	5.74	129.0	7.8	1.26	3957
21	1.00	5.67	210.6	12.6	5.55	5578
24	1.00	6.00	178.5	6.5	1.61	2726
26	1.00	6.13	140.4	10.5	2.18	4647
36	1.00	5.65	280.8	9.9	1.30	4020
38	1.00	5.75	114.7	13.0	1.28	3210
42	1.00	4.78	222.3	26.0	2.19	11380
46	1.00	5.60	131.2	6.9	1.83	2761
48	1.00	6.54	131.0	11.0	2.41	2266

* - Depth 1.00=0 - 7.5 cm, 2.00=15 - 30 cm

PLOT	DEPTH*	NITRATE-NITROGEN (mg/kg)	AMMONIA-NITROGEN (mg/kg)	CATION EXCHANGE CAPACITY (meq/100g)	ALUMINUM (mg/kg)	COPPER (mg/kg)	IRON (mg/kg)
3	1.00	3.17	14.80	36.00	0.00	.50	110.60
13	1.00	11.60	9.88	15.70	0.00	.24	78.40
21	1.00	23.00	15.80	21.50	0.00	.28	81.80
24	1.00	19.60	15.45	13.25	0.00	.33	91.50
26	1.00	13.90	14.70	20.90	0.00	.40	59.20
36	1.00	12.70	20.00	17.40	0.00	.48	118.40
38	1.00	3.08	10.20	35.60	0.00	.42	95.20
42	1.00	26.00	20.60	37.80	3.40	.46	217.40
46	1.00	14.80	12.35	11.91	.10	.41	60.00
48	1.00	3.08	12.60	21.50	0.00	.32	26.00

* -Depth 1.00=0 - 7.5 cm, 2.00=15 - 30 cm

Table II-3 . (cont.)

PLOT	DEPTH*	MANGANESE (mg/kg)	ZINC (mg/kg)	CALCIUM (mg/kg)	MAGNESIUM (mg/kg)	POTASSIUM (mg/kg)	SODIUM (mg/kg)
3	1.00	26.58	69.30	1772	1014.0	1088	312.30
13	1.00	20.20	15.40	818	268.0	830	170.60
21	1.00	21.74	13.04	1364.	582.0	870	221.70
24	1.00	13.09	13.87	990	298.2	964	138.60
26	1.00	21.10	12.84	1340	484.0	862	157.30
36	1.00	19.32	115.18	1182	456.4	672	308.90
38	1.00	9.98	72.12	1676	839.6	1208	227.80
42	1.00	28.18	18.40	1192	958.4	564	235.40
46	1.00	20.76	3.94	754	453.6	773	123.10
48	1.00	19.10	4.76	1864	383.2	880	167.90

*- Depth 1.00=0 - 7.5 cm, 2.00=15 - 30 cm

Appendix III

Photodocumentation of Vegetation Transects and Vegetation Overviews in the SLC-6 Area

Table III-1. Slides of SLC-6 vegetation transects and overviews of vegetation in the area - March 1986.

Slide #	Date	Subject
1	3/14/86	Vegetation - Plot 1
2	3/14/86	Vegetation - Plot 2
3	3/14/86	Vegetation - Plot 3
4	3/23/86	Vegetation - Plot 4
5	3/14/86	Vegetation - Plot 5
6	3/14/86	Vegetation - Plot 6
7	3/19/86	Vegetation - Plot 7
8	3/19/86	Vegetation - Plot 8
9	3/19/86	Vegetation - Plot 9
10	3/19/86	Vegetation - Plot 10
11	3/19/86	Vegetation - Plot 11
12	3/19/86	Vegetation - Plot 12
13	3/19/86	Vegetation - Plot 13
14	3/19/86	Vegetation - Plot 14
15	3/19/86	Vegetation - Plot 15
16	3/21/86	Vegetation - Plot 16
17	3/20/86	Vegetation - Plot 17
18	3/20/86	Vegetation - Plot 18
19	3/20/86	Vegetation - Plot 19
20	3/20/86	Vegetation - Plot 19
21	3/20/86	Vegetation - Plot 20
22	3/20/86	Vegetation - Plot 21
23	3/20/86	Vegetation - Plot 22
24	3/20/86	Vegetation - Plot 23
25	3/19/86	Vegetation - Plot 24
26	3/20/86	Vegetation - Plot 25
27	3/20/86	Vegetation - Plot 26
28	3/23/86	Vegetation - Plot 27
29	3/23/86	Vegetation - Plot 28
30	3/23/86	Vegetation - Plot 29
31	3/23/86	Vegetation - Plot 30
32	3/23/86	Vegetation - Plot 31
33	3/23/86	Vegetation - Plot 32
34	3/18/86	Vegetation - Plot 33
35	3/18/86	Vegetation - Plot 34
36	3/18/86	Vegetation - Plot 35
37	3/18/86	Vegetation - Plot 36
38	3/18/86	Vegetation - Plot 37
39	3/23/86	Vegetation - Plot 38
40	3/23/86	Vegetation - Plot 39
41	3/23/86	Vegetation - Plot 40
42	3/23/86	Vegetation - Plot 41
43	3/21/86	Vegetation - Plot 42
44	3/21/86	Vegetation - Plot 43
45	3/21/86	Vegetation - Plot 44
46	3/21/86	Vegetation - Plot 45

Table III-1. (Continued.)

Slide #	Date	Subject
47	3/21/86	Vegetation - Plot 46
48	3/21/86	Vegetation - Plot 47
49	3/24/86	Vegetation - Plot 48
50	3/24/86	Vegetation - Plot 49
51	3/24/86	Vegetation - Plot 50
52	3/18/86	Overview south of SLC-6
53	3/18/86	Overview south of SLC-6
54	3/18/86	Overview south of SLC-6
55	3/18/86	Overview south of SLC-6
56	3/18/86	Overview south of SLC-6
57	3/18/86	Overview south of SLC-6
58	3/18/86	View canyon southeast of SLC-6
59	3/18/86	View slope southeast of SLC-6
60	3/18/86	View slope southeast of SLC-6
61	3/20/86	Eschscholzia californica
62	3/20/86	Eschscholzia californica
63	3/20/86	Small canyon south of SLC-6
64	3/20/86	Small canyon south of SLC-6
65	3/21/86	Upper end south canyon
66	3/21/86	Lupinus chamissonis
67	3/21/86	Lupinus chamissonis
68	3/21/86	Coreopsis gigantea
69	3/21/86	View from water tower
70	3/21/86	Red Roof Canyon from top
71	3/21/86	Red Rood Canyon top
72	3/21/86	View from Tranquillon Peak
73	3/21/86	View from Tranquillon Peak
74	3/21/86	View from Tranquillon Peak
75	3/21/86	View from Tranquillon Peak
76	3/21/86	View from Tranquillon Peak
77	3/21/86	View from Tranquillon Peak
78	3/21/86	Canyon below Plot 42
79	3/23/86	Gorge near Plot 39
80	3/23/86	Scrophularia cf. californica south canyon bottom
81	3/23/86	Scrophularia cf. californica south canyon bottom
82	3/23/86	South canyon from bottom
83	3/23/86	South canyon from bottom
84	3/23/86	Mimulus aurantiacus
85	3/23/86	Mimulus aurantiacus
86	3/23/86	Oxalis pes-caprae
87	3/24/86	Slope above Plot 48
88	3/24/86	Eriophyllum confertiflorum
89	3/24/86	Thalictrum polycarpum female flower (Plot 50)
90	3/24/86	Thalictrum polycarpum male flower (Plot 50)
91	3/24/86	Eriophyllum confertiflorum (Plot 50)
92	3/24/86	Red Roof Canyon

Table III-1. (Continued.)

Slide #	Date	Subject
93	3/24/86	Red Roof Canyon
94	3/24/86	Red Roof Canyon
95	3/24/86	*Lupinus bicolor*

Table III-2. Slides of SLC-6 vegetation transects and overviews of vegetation in the area - September 1986.

Slide #	Date	Subject
1	9/26/86	Vegetation - Plot 1
2	9/30/86	Vegetation - Plot 2
3	9/30/86	Vegetation - Plot 3
4	9/30/86	Vegetation - Plot 4
5	9/30/86	Vegetation - Plot 5
6	9/29/86	Vegetation - Plot 6
7	9/29/86	Vegetation - Plot 6
8	9/29/86	Vegetation - Plot 7
9	9/29/86	Vegetation - Plot 8
10	9/29/86	Vegetation - Plot 9
11	9/29/86	Vegetation - Plot 10
12	9/29/86	Vegetation - Plot 11
13	9/29/86	Vegetation - Plot 12
14	9/29/86	Vegetation - Plot 13
15	9/29/86	Vegetation - Plot 14
16	9/29/86	Vegetation - Plot 15
17	9/29/86	Vegetation - Plot 16
18	9/29/86	Vegetation - Plot 17
19	9/29/86	Vegetation - Plot 18
20	9/27/86	Vegetation - Plot 19
21	9/29/86	Vegetation - Plot 20
22	9/29/86	Vegetation - Plot 21
23	9/29/86	Vegetation - Plot 22
24	9/29/86	Vegetation - Plot 23
25	9/26/86	Vegetation - Plot 24
26	9/26/86	Vegetation - Plot 25
27	9/27/86	Vegetation - Plot 26
28	9/27/86	Vegetation - Plot 27
29	9/27/86	Vegetation - Plot 28
30	9/27/86	Vegetation - Plot 29
31	9/27/86	Vegetation - Plot 30
32	9/27/86	Vegetation - Plot 31
33	9/27/86	Vegetation - Plot 32
34	9/26/86	Vegetation - Plot 33
35	9/26/86	Vegetation - Plot 34
36	9/26/86	Vegetation - Plot 35
37	9/26/86	Vegetation - Plot 36
38	9/26/86	Vegetation - Plot 37
39	9/29/86	Vegetation - Plot 38
40	9/29/86	Vegetation - Plot 39
41	9/30/86	Vegetation - Plot 40
42	9/30/86	Vegetation - Plot 41
43	9/30/86	Vegetation - Plot 42
44	9/30/86	Vegetation - Plot 43
45	10/1/86	Vegetation - Plot 44
46	9/30/86	Vegetation - Plot 45

Table III-2. (Continued.)

Slide #	Date	Subject
47	9/30/86	Vegetation - Plot 46
48	9/30/86	Vegetation - Plot 47
49	10/1/86	Vegetation - Plot 48
50	10/1/86	Vegetation - Plot 49
51	10/1/86	Vegetation - Plot 50
52	9/29/86	Pasture south of SLC-6 - Deer
53	9/29/86	Pasture south of SLC-6 - Deer
54	9/29/86	Pasture south of SLC-6 - Deer
55	9/27/86	*Ceanothus impressus* - south of SLC-6
56	9/27/86	*Ceanothus impressus* - south of SLC-6
57	9/27/86	*Ceanothus impressus* - south of SLC-6
58	9/29/86	Canyons southeast of SLC-6
59	9/29/86	Canyons southeast of SLC-6
60	9/29/86	Canyons southeast of SLC-6
61	9/29/86	Canyons southeast of SLC-6
62	10/1/86	Canyons above SLC-6
63	10/1/86	Canyons above SLC-6
64	10/1/86	Canyons above SLC-6
65	10/4/86	Honda Canyon Road, slopes on north side
66	10/4/86	Honda Canyon Road, slopes on south side
67	10/4/86	Honda Canyon Road
68	10/4/86	Honda Canyon Road
69	10/4/86	Honda Canyon Road
70	10/4/86	Honda Canyon Road
71	10/4/86	Honda Canyon Road
72	10/4/86	Honda Ridge Road
73	10/4/86	Honda Ridge Road
74	10/4/86	Honda Ridge Road
75	10/4/86	Honda Ridge Road
76	10/4/86	Road to Tranquillon Peak
77	10/4/86	Road to Tranquillon Peak
78	10/4/86	Road to Tranquillon Peak
79	10/4/86	View from Tranquillon Peak
80	10/4/86	View from Tranquillon Peak
81	10/4/86	View from Tranquillon Peak
82	10/4/86	View from Tranquillon Peak
83	10/4/86	View from Tranquillon Peak
84	10/4/86	View from Tranquillon Peak
85	10/4/86	View from Tranquillon Peak
86	10/4/86	View from Tranquillon Peak
87	10/4/86	View from Tranquillon Peak
88	10/4/86	View from Tranquillon Peak
89	10/4/86	View from Tranquillon Peak

 C-2

NASA

Report Documentation Page

1. Report No. TM 100982	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Monitoring Biological Impacts of Space Shuttle Launches from Vandenberg Air Force Base: Establishment of Baseline Conditions		5. Report Date December 1987
		6. Performing Organization Code BIO-1
7. Author(s) Paul A. Schmalzer and C. Ross Hinkle (1) Editors: A.M. Koller, Jr., and W.M. Knott, III (2)		8. Performing Organization Report No.
		10. Work Unit No.
9. Performing Organization Name and Address (1) The Bionetics Corp. John F. Kennedy Space Center KSC, FL 32899 (2) NASA/Biomedical Office John F. Kennedy Space Center KSC, FL 32899		11. Contract or Grant No. NAS10-10285
		13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address NASA/John F. Kennedy Space Center, Florida		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

Space Shuttle launches produce environmental impacts resulting from the formation of an exhaust cloud containing hydrogen chloride aerosols and aluminum oxide particulates. Studies at John F. Kennedy Space Center (KSC) have shown that most impacts occur near-field (within 1.5 km) of the launch site while deposition from launches occurs far-field (as distant as 22 km). In order to establish baseline conditions of vegetation and soils in the areas likely to be impacted by Shuttle launches from Vandenberg Air Force Base (VAFB), vegetation and soils in the vicinity of Space Launch Complex 6 (SLC-6) were sampled and a vegetation map prepared.

The areas likely to be impacted by launches were determined considering the structure of the launch complex, the prevailing winds, the terrain, and predictions of the Rocket Exhaust Effluent Diffusion Model (REEDM). Fifty vegetation transects (15 m length) were established and sampled in March 1986 (wet season) and resampled in September 1986 (dry season). A vegetation map was prepared for the six Master Planning maps surrounding SLC-6 (1:9600) using LANDSAT Thematic Mapper imagery as well as color and color infrared aerial photography. Soil samples were collected from the 0-7.5 cm layer at all transects in the wet season and at a subsample of

17. Key Words (Suggested by Author(s)) Space Shuttle Launch, Hydrochloric Acid, Vegetation, Environmental Effects, Soils	18. Distribution Statement Unlimited National Technical Information Services Subject Category 51

19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of pages 97	22. Price

NASA FORM 1626 OCT 86

16. Abstract (continued).

the transects (10) in the dry season and analyzed for pH, organic matter, conductivity, cation exchange capacity, exchangeable Ca, Mg, Na, K, and Al, available NH_3-N, PO_4-P, Cu, Fe, Mn, Zn, and TKN.

Vegetation in the expected impact areas is primarily annual grassland (grazed) and coastal sage scrub with lesser amounts of chaparral. Composition of annual grassland changes greatly between the wet and dry seasons. Some changes in vegetation cover occur seasonally in the coastal sage scrub. Changes in soil chemistry also occur. Cations, pH, conductivity, organic matter, cation exchange capacity, TKN, and ammonia-nitrogen increase from the wet season to the dry season while certain available metals (Al, Cu, Fe) decrease.

Launches from SLC-6 will probably have impacts to vegetation within an area of about 1 km in the direction of the initial movement of the exhaust cloud. Damage to shrubs and loss of sensitive species may occur. Erosion is likely in areas losing vegetation cover. Species of the annual grassland and coastal sage scrub will probably be moderately to very sensitive while chaparral species are likely to be more resistant to launch deposition. Impacts and time required for recover will vary seasonally with the phenology of the vegetation. Vegetation recovery at VAFB will be slower than at KSC because of the low rainfall and extended dry season. Impacts to population of special interest plants will probably be minimal. Seasonal variation in soil parameters will complicate detection of soil impacts of launches.

In response to the delay in Shuttle launches, recommendations are made to update the data base prior to launch.