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Annual Review October 16, 1996

Threatened and Endangered Species Habitat Management Plan

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Agenda

Threatened and Endangered Species
Habitat Management Plan

Annual Review
October 16, 1996

8:30–8:45	Welcome and General Overview	Teralene Foxx, Project Manager
	Threatened and Endangered Species Programs of Other DOE Sites	
8:45–9:15	Ecosystems Management at Savannah River	Beth Le Master, Savannah River Site, South Carolina
9:15–9:45	The GIS and NERP in Sensitive Species Management at ORNL	Pat Parr, Oak Ridge National Laboratory, Tennessee
9:45–10:00	Break	
	Why a Management Plan and Some Resource Issues	
10:00–10:15	Facility Management Perspectives	Tom Alexander, DX-DO
10:15–10:30	Wildfire and Threatened and Endangered Species	Charisse Sydoriak, NPS
10:30–10:45	Threatened and Endangered Species in Forest Service Planning	Buck Sanchez, USFS
10:45–11:00	Evaluation of a Proposal to Re-establish Bighorn Sheep	Leslie Hansen, ESH-20
	LANL Program	
11:00–11:15	Mexican Spotted Owl and Willow Flycatcher Surveys	David Keller, ESH-20
11:15–11:40	Bat Surveys in the Jemez Mountains	Mike Bogan, NBS
11:40–12:00	Peregrine Falcon and Bald Eagle Status, A Regional View	Terrell Johnson, Consultant
12:00–1:00	Lunch	

Agenda
(Cont'd)

1:00–2:00	Ecological Risk	Wayne Hansen, EES-15 Anthony Gallegos, EES-15 Gilbert Gonzales, ESH-20
2:00–2:15	Break	
2:15–2:45	Preliminary Land Cover Maps and Vegetation Classification	Steven Koch, ESH-20 Teralene Foxx, ESH-20 Randy Balice, ESH-20
2:45–3:00	Predicting Jemez Mountains Salamander Habitat	Louise Tribbe, Consultant Tim Haarmann, ESH-20
3:00–3:30	GIS Phase and an ArcView Application	Kathryn Bennett, ESH-20
3:30–4:00	Pilot Demonstration of a Project Evaluation	Todd Haagenstad, ESH-20 Kathryn Bennett, ESH-20
4:00–4:30	Discussions and Wrap-up	

Thursday, October 17

8:30–10:00	FY97 Activities and FY96 Lessons Learned	Teralene Foxx, Facilitator
10:00–	Break and Tours for Out of Town Guests	

ERRATA

In Section 4, "Preliminary Land Cover Map for Los Alamos National Laboratory," Page 6, please change the fourth sentence to read:

In other words, although 100% of the mixed conifer pixels identified by the satellite are actually mixed conifer (Table 2), only 57% of the mixed conifer plots visited have been correctly identified as mixed conifer.

The last line of the first column on page 6 should read:

This modification resulted in the accuracy calculation increasing from 0.32 to 0.64

Tables 4 and 5 on page 7 should be replaced with the following:

Table 4. "Accuracy Assessment" using 47 plots, with some original categories grouped

Satellite	MixCon	Aspen	Pipo	Grasses	PJ	
Reference	2	4	3+5	6+7	8+9	Sums
Mixed Conifer	4	1	2			7
Aspen		3	1			4
Ponderosa Pine			12	3		15
Grasses/Shrubs			3	6	2	11
Piñon/Juniper				5	5	10
Sums	4	4	18	14	7	47

Total correct = 30 Overall Accuracy = 0.64

Table 5. Breakdown of Table 4 by cover type and error type.

Cover Type	Producer's Accuracy [Omission Error]	User's Accuracy [Commission Error]
Mixed Conifer	0.57	1.00
Aspen	0.75	0.75
Ponderosa Pine	0.80	0.67
Grasses/Shrubs	0.55	0.43
Piñon/Juniper	0.50	0.71

Please replace Table 3, page 5, with the following:

Table 3. Breakdown of Table 2 by cover type and error type.

Cover Types	Producer's Accuracy [Omission Error]	User's Accuracy [Commission Error]
Mixed Conifer	0.57	1.00
Pipo/Mixed	-	0.00
Aspen	0.75	0.75
Ponderosa Pine	0.33	0.56
Turf Grasses	-	0.00
Grasses	0.17	0.08
Piñon/Juniper /grass	0.50	0.29
Piñon/Juniper /rock	0.00	-

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Ecology Group, ESH-20

October 1996

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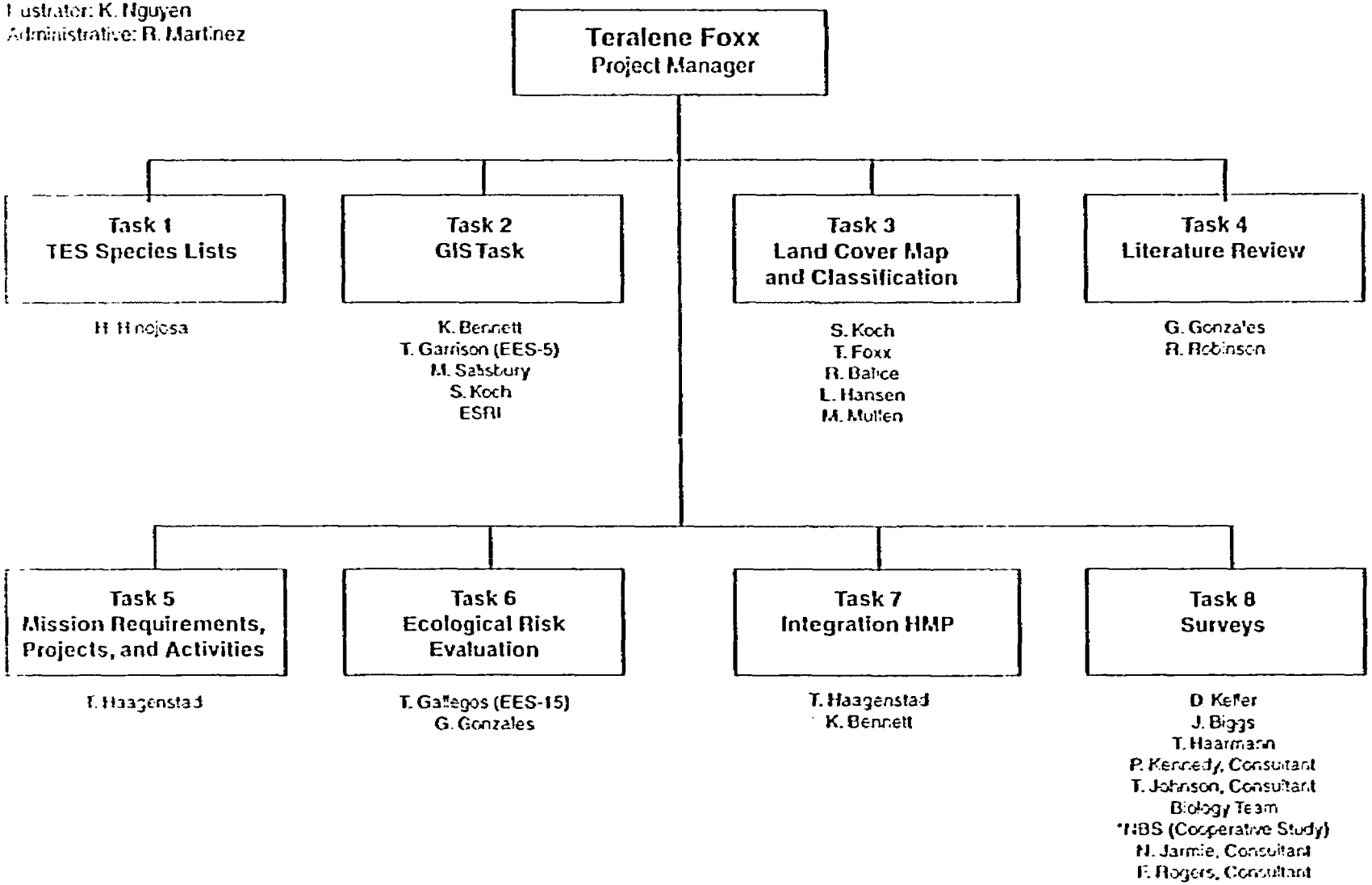

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Papers in this notebook are products of the first year of effort toward development of a Threatened and Endangered Species Habitat Management Plan at Los Alamos National Laboratory. With the exception of the papers related to management issues, all reports are related to tasks outlined in the April 1996 Work Plan. These papers are interim reports and are considered drafts. The notebook is not intended for wide distribution.

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Section 2: Species Descriptions

H.A. Hinojosa and L.K. Nguyen, "Threatened, Endangered, and Sensitive Species Profile," Los Alamos National Laboratory draft report LA-UR-96-1269.

Section 3: Surveys

D.C. Keller, J.R. Biggs, and T.H. Johnson, "Threatened and Endangered Species Surveys and Habitat Management at Los Alamos National Laboratory (National Environmental Research Park)," Los Alamos National Laboratory draft report LA-UR-96-3444.

- D.C. Keller, "Mexican Spotted Owl."
- D.C. Keller, "Southwestern Willow Flycatcher."
- J.R. Biggs, "Goat Peak Pika, Black-Footed Ferret, and New Mexico Meadow Jumping Mouse."
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- T.H. Johnson, "Golden Eagle Habitat Management in the Los Alamos National Environmental Research Park."
- T.H. Johnson, "Peregrine Falcon Habitat Management in the Los Alamos National Environmental Research Park."

L. Trippe and T.K. Haarmann, "Evaluation of the Use of Satellite Imagery as a Tool to Predict Habitat of the Jemez Mountains Salamander, *Plethodon neomexicanus*," Los Alamos National Laboratory draft report LA-UR-96-3392.

M.A. Bogan, T.J. O'Shea, P.M. Cryan, A.M. Ditto, W.H. Schneider, and L. Ellison, "Status and Trends of Bat Populations at Los Alamos National Laboratory and Bandelier National Monument, Jemez Mountains, New Mexico," Annual Report to Los Alamos National Laboratory and Bandelier National Monument, Sept[illegible] 1996, Los Alamos [illegible]

Section 4: Plant Overstory Map

S.W. Koch, T.K. Budge, S.G. Ferran, L.F. Sandoval, M.A. Mullen, K.D. Bennett, and R.G. Balice, "Preliminary Land Cover Map for Los Alamos National Laboratory," Los Alamos National Laboratory draft report LA-UR-96-3362.

T.S. Foxx, R.G. Balice, and M.E. Salisbury, "Preliminary Land Cover Classification for Los Alamos National Laboratory and Los Alamos County, New Mexico," Los Alamos National Laboratory draft report LA-UR-96-3525.

T.S. Foxx, L. Pierce, G. Tierney, and L.A. Hansen, "Annotated Checklist and Database for Vascular Plants of the Jemez Mountains," Los Alamos National Laboratory draft report LA-UR-96-3542.

N. Jarmie and F.J. Rogers, "A Survey of Los Alamos County and Bandelier National Monument for Macroscopic Fungi," Los Alamos National Laboratory draft report LA-UR-96-3581.

Section 5: GIS/Database Activities

K.D. Bennett, T.E. Garrison, M.E. Salisbury, and S.W. Koch, "Threatened and Endangered Species Plan, GIS Phase," Los Alamos National Laboratory draft report LA-UR-96-3527.

Section 6: Ecological Risk

A.F. Gallegos, G.J. Gonzales, K.D. Bennett, and L.E. Pratt, "Preliminary Ecological Risk Assessment of the Mexican Spotted Owl at the Los Alamos National Laboratory," Los Alamos National Laboratory draft report LA-UR-96-3361.

Section 7: Mission Requirements

T.S. Foxx, K.D. Bennett, H.T. Haagenstad, S.W. Koch, and M.E. Salisbury, "Integrating Mission Requirements with Threatened and Endangered Species Habitat Requirements, A Pilot Demonstation," Los Alamos National Laboratory report LA-UR-96-3616.

Section 8: Literature Review

G.J. Gonzales, R. Robinson, S. Cross, H. Nottleman, and T.S. Foxx, "Literature Review and Species Habitat Use Documentation," Los Alamos National Laboratory draft report LA-UR-96-3526.

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Species Descriptions

Surveys

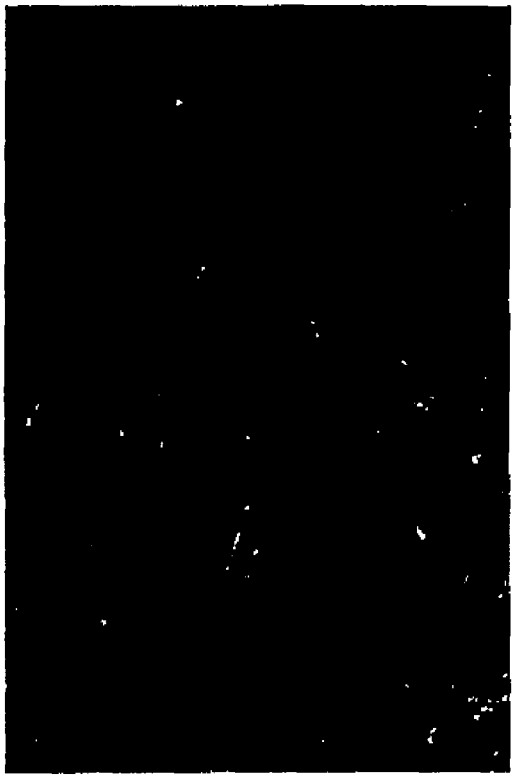
4 Plant Overstory Map

5 GIS/Database Activities

6 Ecological Risk

Mission Requirements

Literature Review



Threatened and Endangered Species Habitat Management Plan Summary of Tasks Completed in FY96

Teralene S. Foxx

Threatened and Endangered Species Habitat Management Plan Summary of Tasks Completed

Teralene S. Foxx, Project Manager*

*Ecology Group, Los Alamos National Laboratory

1.0 Introduction

This notebook contains the information gathered toward preparation of a Habitat Management Plan (HMP) for species of concern (SOC) and those threatened and endangered species (TES) that may occur on or utilize the 43 square miles of Los Alamos National Laboratory (LANL). The Record of Decision (ROD) for the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility Environmental Impact Statement (EIS) (October 1995) mandates completion of the HMP by October 10, 1998. The papers presented in this notebook represent the studies and the products from those studies for the first year of activity, FY96.

The data reported here represents the combined efforts of personnel within LANL, including individuals in the Ecology Group (ESH-20), Environmental Sciences Group (EES-15), Facility for Informaton Management, Analysis, and Display (FIMAD) (EES-5), Facilities Management Unit 67 (FMU-67), and Computing, Information, and Communications Group (CIC-1). The effort also represents collaboration between National Biological Service (NBS), LANL, and Bandelier National Monument (BNM) for the study of bats and rare bat species. Various consultants supplemented the internal Laboratory expertise in supplying information about specific species: Terrell Johnson for bald eagle, peregrine falcon and Mexican spotted owl; Nelson Jarmie and Fran Rogers for fungi; David Hafner (Museum of Natural History) for Goat Peak pika; and Louise Trippe, US Forest Service, for salamanders. The papers in this notebook are draft interim reports of on-going studies.

The HMP effort covers species that are considered threatened or endangered under the Endangered Species Act (ESA). Additionally, we considered all "species of concern," previously known as candidate species (C1 and C2), and species listed by the State of New Mexico as sensitive, threatened, or endangered. In this document "species of concern" and state listed species will collectively be called species of concern (SOC). For definitions of terms used in this report see Appendix A. See Appendix B for a list of acronyms.

2.0 Background

The Department of Energy (DOE) published a Final EIS on the DARHT Facility at LANL (DOE/EIS-0228, August 1995). The U. S. Environmental Protection Agency (EPA) published a Notice of Availability of this EIS in the Federal Register on September 8, 1995 (60 FR 46833). The Final EIS identifies and discusses measures that DOE considered in order to mitigate potential adverse effects resulting from the various alternatives promulgated in the Draft EIS.

DOE issued a ROD on the DARHT proposal on October 10, 1995, and published the ROD Monday, October 16, 1995 (60 FR 53588), pursuant to regulations of the Council of Environmental Quality (40 CFR 1500-1508). Among other things, the ROD states that DOE will develop several mitigation actons to protect soils, water, and biotic resources. In these mitigation measures, DOE will take special precautions to protect the Mexican spotted owl (*Strix occidentalis lucida*), will prepare a laboratory-wide HMP for all TES species occurring at LANL, and

will implement mitigation measures discussed in section 5.11, Volume 1 of the DARHT Final EIS. The Mitigation Action Plan for the DARHT, published January 23, 1996, provides additional information on how DOE and LANL will meet the commitments made in the DARHT ROD. The HMP must be completed within 3 years of the ROD or by October 10, 1998.

In addition to the mandate resulting from the DARHT ROD, the Endangered Species Act of 1973 (16 USC 1531 et seq.) (ESA 1973) mandates protection, conservation, and perpetuation of species. This law was enacted to help prevent the extinction of animals and plants considered TES. Under the law, the Secretary of the Interior, acting through the U.S. Fish and Wildlife Service (USFWS), is granted broad powers to protect and conserve terrestrial and nonmarine wildlife and plants in serious jeopardy of extinction. Noncompliance with the ESA can result in fines and jail terms.

Under the ESA it is illegal to kill, collect, remove, harass, import, or export a TES. The Act also calls for interagency cooperation and imposes three requirements on all federal agencies through Section 7: 1) the Act directs federal agencies to utilize their authorities to carry out conservation programs for listed species; 2) every federal agency is required to ensure that its activities or programs will not jeopardize the continued existence of a listed species; and 3) Section 7 directs all federal agencies to ensure their activities or programs do not result in the destruction or adverse modification of a critical habitat.

Section 4 (F) (1) of the ESA of 1973 requires the Secretary of the Interior (usually delegated to the Director of the USFWS) to "... develop and implement (recovery) plans for the conservation of endangered species and threatened species ... unless he finds that such a plan will not promote the conservation of the species. Recovery teams, composed of specialists on a species, develop recommendations on steps necessary to remove a species from the List of TES Wildlife and Plants." Federal agencies may be involved in implementation of recovery plans.

Beyond the federal protection under the ESA, New Mexico's Wildlife Conservation Act and New Mexico's Endangered Plant Species Act (EPSA) are state laws designated to protect the plant and animal resources of the State of New Mexico. The HMP will also consider species listed as TES under state law and will coordinate with state authorities in an effort to identify and conserve these species. Although state listed species are not protected under the ESA, they may be protected under other federal laws such as the Migratory Bird Treaty Act, the Bald Eagle Protection Act, and other regulations protecting biota (see Appendix C). Additionally, state listed species are generally prime candidates for federal listing if populations decline and may be considered SOC by USFWS. The inclusion of these species in the HMP will also help to avoid future project delays.

3.0 Description of the area

3.1 Geographic Setting

LANL is situated in Los Alamos County in north-central New Mexico, approximately 100 km (60 miles) north-northeast of Albuquerque and 40 km (25 miles) northwest of Santa Fe (Figure 1). The county is approximately 283 km^2 (109 mi^2) and is situtated in the Jemez Mountains. The western boundary encompasses some peaks of the Sierra de Los Valles, the mountainous rim of the Valles Caldera, and portions of the table-like extension on the eastern slopes, known as the Pajarito Plateau. This plateau extends approximately 16 km (10 miles) from the base of the mountain slopes and ends at the Rio Grande. It is dissected by narrow precipitous canyons separated by finger-like mesas. LANL is located at the base of the Sierra de Los Valles and on portions of the plateau. It comprises 112 km^2 (43 mi^2) of the lands within the county. Because of the rugged topography, most of the facilities are confined to the mesa tops and concentrated in developed technical areas. The remoteness, the lack of development, and the rugged topography provide habitat for a variety of plant and animal species including species listed as endangered or threatened and SOC under the ESA.

3.2 Geologic Setting

The Jemez Mountains are a remnant of a massive volcano that erupted 1.4 to 1.1 million years ago. Ash from the eruptions laid down 300 m (985 ft) of welded and nonwelded tuff on the eastern flanks. The rim of the collapsed volcano is called the Sierra de Los Valles. The rim has nine peaks including Cerro Grande, Pajarito Mountain, and Caballo Mountain. The tops of the mountains range from 2895 m (9500 ft) to over 3353 m (11,000 ft) in elevation. On the eastern flank of the mountains, an apron-like plateau, the Pajarito Plateau, is formed from a consolidated ash tuff. The plateau is dissected into canyons and mesas (Burton 1982).

4.0 Methods

As stated in the Work Plan (April 1996), the development of a TES HMP will require a systematic step-by-step approach based on ecosystems management. TES populations (both current and goal) will have to be assessed, TES habitats (present and future) must be identified, and LANL mission requirements (present and future) for the identified areas will be defined. Detailed analyses of the above factors and the interrelationships will be developed. The data gathering for the HMP must span three years to provide the necessary survey data required by USFWS protocols for determination of species presence and population levels. Additionally, the extensive work needed to develop the Geographic Information Systems (GIS) applications, to model the individual species for ecological risk, to develop monitoring plans, and to understand Laboratory activities will require the first 2 years. The third year will be devoted to integration of all information into a tool that can be used for proactive assessment of impact of activities to TES and SOC.

Table 1 provides a general overview of the three-year schedule outlined in the 1996 Work Plan.

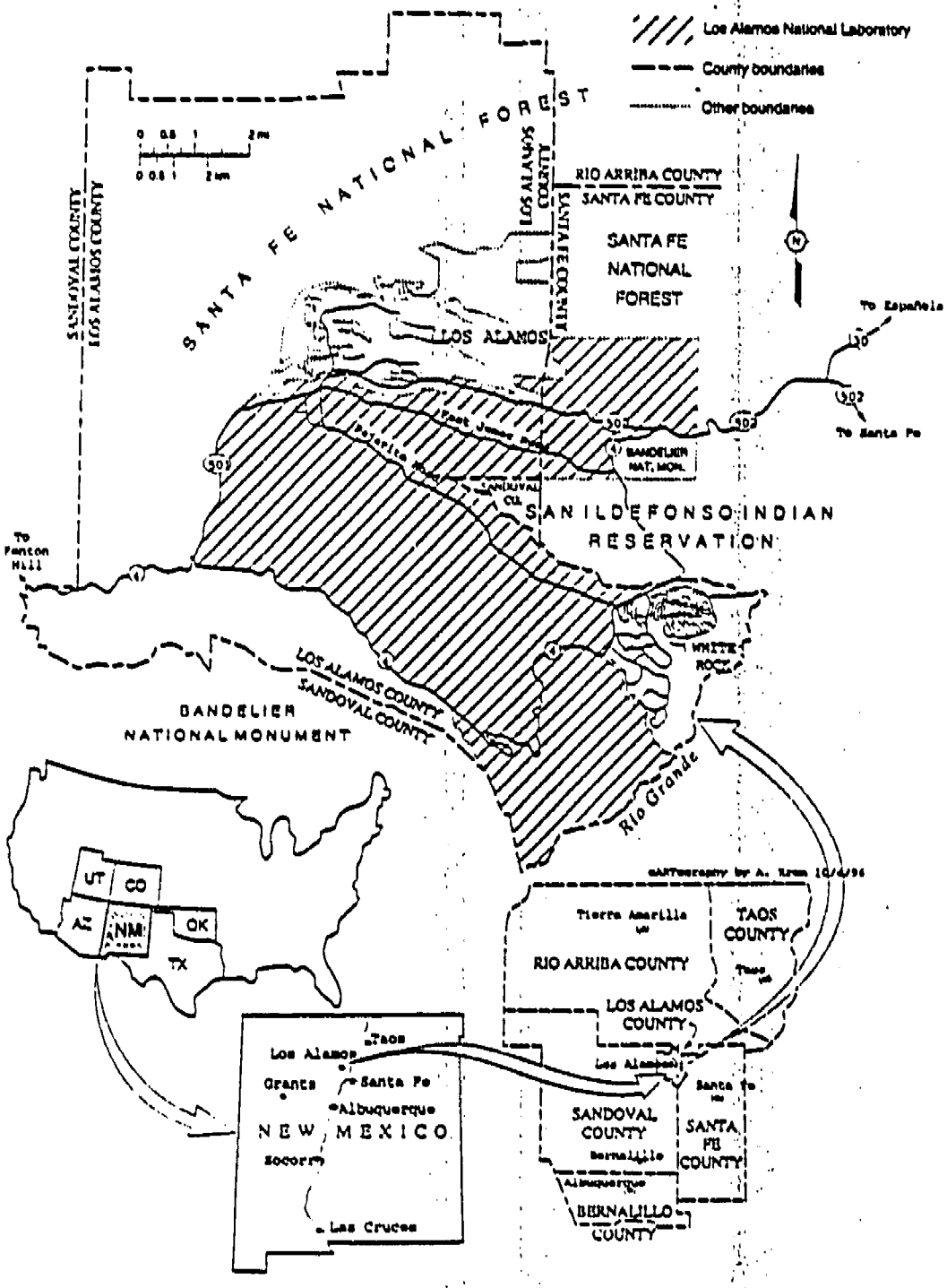


Figure 1. Locations of Los Alamos County and Bandelier National Monument.

Table 1: TES HMP, General Overview.

Year 1	Year 2	Year 3	Subsequent Years
Data Acquisition and Integration of Data (Tasks 1, 2, 3, and 4)	Modeling of Habitats	HMP	Annual Review of Plan
Determining Laboratory Projects and Activities related to Mission (Tasks 5)	Determining Laboratory Projects and Activities related to Mission (Tasks 5)	Determining Laboratory Projects and Activities related to Mission (Tasks 5,6, and 7)	On-going through project review
Integrating project and species requirements (6,7)	Development of Species Monitoring Plans/ Ecological Risk	Development of NEPA Documentation	
Surveys (Task 8)	Surveys	Surveys	Surveys

5.0 Results

There are 8 tasks with subtasks that were defined for FY96. The products resulting from activities related to each task and subtask are presented as a separate paper in this notebook. Although each paper stands alone, the information is integrated into a beginning GIS application to evaluate projects.

The results of the activities for FY96 are presented in the following order in this overview. The task number as presented in the 1996 Work Plan is in parentheses.

Threatened, endangered, and species of concern lists (Task 1).
Surveys for species (Task 8).
Development of a land cover map (Task 3).
Database Design: Database Structure/ Naming Convention/Data Entry (Task 2).
Assessing toxicological and ecological risk (Task 6).
Determining Mission Requirements (Task 5).
Integration of Mission and TES requirements (Task 7).
Literature review (Task 4).

5.1 Threatened, Endangered, and Sensitive Species Profile

The most recent listings for TES and SOC were obtained from the USFWS and the State of New Mexico. From these listings the species that were reported to occur, or potentially could occur in Los Alamos County were extracted and species profiles were developed. This information is reported in "Threatened, Endangered, and Sensitive Species Profile" (Hinojosa 1996; Section 2).

This profile is intended to provide a thumbnail description of various plant and animal species on state and federal lists. Additionally, we have begun a listing of species we call "local concern". These species are ones that are rarely found in the area and are often associated with unique habitats. Under state and federal regulations they are not protected but they often occur in areas such as wetlands that are considered sensitive or they are found in habitats that are disappearing because of urbanization.

We have eliminated black hawk (*Buteogallus anthracinus*) from our list at the recommendation of Terrell Johnson and Sandy Williams (State of New Mexico, Endangered Species Unit). We have added zone-tailed hawk (*Buteo albonotatus*) to our list, also at their recommendation.

5.2 Field Surveys and Studies to Determine the Status of TES and SOC on LANL and in Los Alamos County

Field surveys were conducted for Mexican spotted owl, peregrine falcon (*Falco peregrinus anatum*), and southwestern willow flycatcher (*Empidonax traillii extimus*) during FY96. The results of these surveys are reported by Keller (1996). Johnson (1996) has studied bald eagle (*Haliaeetus leucocephalus*) and golden eagle (*Aquila chrysaetos*) along the Rio Grande. He has also monitored the status of peregrine falcon in the Jemez for many years. Trippe and Haarmann (1996) did an evaluation of the use of satellite imagery as a tool to predict Jemez Mountains salamander (*Plethodon neomexicanus*). No systematic surveys were conducted for this organism. The NBS surveyed for bat species on the Pajarito Plateau including the *Myotis* bats (SOC) and spotted bat (*Euderma maculatum*) (Bogan et al. 1996). Experts were contacted and literature was surveyed for information about Goat Peak pika (*Ochotona princeps nigrescens*), black-footed ferret (*Mustela nigripes*), and New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) (Biggs 1996). Surveys for sensitive plant species were not conducted because of the extreme drought condition during the normal blooming time, which would have invalidated the surveys. Studies on macroscopic fungi have been conducted over the past five years by Jarmie and Rogers (1996).

5.2.1 Surveys for Mexican Spotted Owl

For the past 3 years, three primary areas at LANL were surveyed for Mexican spotted owl. The surveys revealed a nesting pair of owls that subsequently fledged a pair of young during two of the years (Keller 1996; Section 3).

5.2.2 Surveys for Southwestern Willow Flycatcher

During 1995 and 1996, two primary areas were surveyed for the southwestern willow flycatcher. The southwestern willow flycatcher was not found (Keller 1996; Section 3).

5.2.3 Goat Peak Pika, Black-footed Ferret, and New Mexico Meadow Jumping Mouse

Three mammals species, other than bats, are on state and federal lists for the County of Los Alamos. They are the Goat Peak pika, the black-footed ferret, and the New Mexico meadow jumping mouse. No surveys were done for these three species during FY96. Once the land cover map is completed, an assessment of potential habitat will be done. Experts were queried for further information about these species. Species such as the New Mexico meadow jumping mouse have been surveyed for at LANL in past years but have not been found (Biggs 1996; Section 3). Black-footed ferret has not been reported in New Mexico since 1934 and LANL does not have extensive prairie dog towns. Goat Peak pika has been found in Los Alamos County but only on the high mountain peaks.

5.2.4 Bald Eagle Habitat Management in the Los Alamos National Environmental Research Park

Bald eagles winter along the Rio Grande but are not known to nest in the area. Most wintering bald eagles congregate downstream from LANL, but LANL contains winter foraging and roosting habitat and potential nesting habitat. Potential nest and roost trees in White Rock Canyon have been mapped and will be monitored for signs of use. Sensitive zones around these trees have been mapped to trigger review of potentially disturbing activities. Interagency coordination will increase the effectiveness of the bald eagle habitat management in the area (Johnson 1996; Section 3).

5.2.5 Golden Eagle Habitat Management in Los Alamos National Environmental Research Park

Golden eagles regularly breed in White Rock Canyon and have nested in LANL. A sensitive zone around an historic nesting cliff has been mapped to trigger review of potentially disturbing activities (Johnson 1996; Section 3).

5.2.6 Peregrine Falcon Habitat Management in the Los Alamos National Environmental Research Park

Suitable breeding habitat for the American peregrine falcon is located in and around LANL. The entire area is suitable foraging habitat. Suitable breeding areas in and around LANL have been identified, and the most important sensitive zones have been mapped to trigger review of potentially disturbing activities. A habitat management plan has been drafted for some suitable breeding habitat, which will require interagency cooperation to complete (Johnson 1996; Section 3).

5.2.7 Jemez Mountains Salamander

Trippe and Haarman (1996; Section 3) designed a study to determine the accuracy and feasibility of using satellite imagery technology to locate and predict specific habitat, using the Jemez Mountains salamander as a model species. The satellite imagery did not prove successful in predicting the habitat sites but proved to be a good first-cut tool in predicting areas of potential habitat. Additionally, informal surveys provided the researchers with experience and information as to the types of conditions in which the animals live.

5.2.8 Bats in the Jemez Mountains

The second year of a multiyear study for bats was completed. The goals of the study were to assess the current status of bats (particularly SOC), elucidate distribution and relative abundance, and obtain information on sites used by bats as roosts. Thus far 828 bats of 15 species have been captured and released. In 1995 the first spotted bats were captured at BNM and in 1996 they were heard at several locations on LANL. General searches of cliffs in canyons revealed active night roosts and recently-used day roosts of several species, including an unknown colony of over 500 free-tailed (*Tadarida* bats). Eight SOC were netted in the Jemez. Many of these bats (*Myotis evotis*, *M. thysanodes*, and *M. volans*) were frequently captured and a fourth (*E. maculatum*) was captured occasionally and heard frequently (Bogan et al. 1996; Section 3). Additonally, from this study a video on bats is being produced for Bradbury Science Museum as part of their natural resources display.

5.2.9 Survey for the Woodlily, Helleborine Orchid, Yellow Lady's Slipper, and Grama Grass Cactus

Surveys for the woodlily (*Lilium philadelphicum* var. *andinum*), helleborine orchid (*Epipactis gigantea*), and yellow lady's slipper (*Cypredium calceolus* var. *pubescens*) were not conducted. Until July 1996, New Mexico was in extreme drought conditions. Preliminary surveys of vegetation indicated that common species were not blooming, stream beds were dry, and environmental conditions were not acceptable for valid surveys. Spot checks of species such as the grama grass cactus (*Toumeya papyracantha*) showed that there was drought stress and many of the smaller cacti had died. In FY97, we will do surveys if normal rain patterns exist.

5.3 Development of a Land Cover Map and Land Cover Classification

This task resulted in 4 products. Two of the products were directly related to the land cover map; two products were the completion of long-term data bases related to vascular and nonvascular species. Data about vascular and nonvascular plants will be used for the basis of vegetation classification for the land cover map. A systematic use of naming conventions will be used for the GIS data bases.

5.3.1 The Land Cover Map

The HMP calls for identifying areas on LANL property which are suitable or potentially suitable habitat for TES. The production of a land cover map is the first step necessary to meet that goal. Landsat Thematic Mapper (TM) images were classified into 50 classes using an ISODATA clustering technique in an unsupervised classification. This process resulted in a land cover map with 10 classes. Classification of the forest and woodland areas had the highest accuracy, however, the differentiation of grasslands/shrublands/savanna was not well determined and will require additional field study to give the map a more accurate definition in those cover classes (Koch et al. 1996; Section 4).

5.3.2 Preliminary Land Cover Classification

Major land cover types were identified by using the satellite imagery. To describe the land cover types and to further classify them into community types, a Working Draft Key was developed. The land cover types found in the area were classified according to physiognomic and floristic characteristics. The hierarchical classification is modeled from the New Mexico Natural Heritage Program (NMNHP) New Mexico Gap Analysis Map Legend. We identified the following cover types: mixed conifer, ponderosa pine, pinon-juniper, and juniper woodlands. The grassland and shrubland classes were not classfied into cover types at this time. We also will do additional classification of the riparian/wetland areas (Foxx et al. 1996; Section 4).

5.3.3 Annotated Checklist of Vascular Plants of the Jemez Mountains

Basic to a classification for land cover and habitat modeling is an understanding of the species that occur in an area. Therefore, we have completed an update of a checklist that was developed by Foxx and Tierney (1985). The information presented for this review builds on the checklist done in the 1980s. We have annotated the checklist with information about biology and ecology of each species. The checklist is annotated with taxonomic information, geographic and biological information, economic uses, wildlife cover, revegetation potential, and ethnographic uses. There are nearly 1000 species that have been noted for the Jemez Mountains (Foxx et al. 1996; Section 4).

5.3.4 Survey of Los Alamos County and Bandelier National Monument for Macroscopic Fungi

Fungi are ecologically important to forest systems. Therefore, a knowledge of the fungal flora is important in developing a HMP. Additionally, rare fungi have been found in association with the Jemez Mountains salamander.

In 1991, we began a survey of the macroscopic fungi living within the ecosystems of the Pajarito Plateau. During FY96, we completed the data base for the specimens collected. A species list has been generated. Although most of the work was done prior to 1996, the information is useful to this project and will become part of the data bases developed and maintained on the GIS. To date we have catalogued 1048 specimens and identified 241 species. Fifty-one species are new to the State of New Mexico mycology lists. Six species are considered rare (Jarmie and Rogers 1996; Section 4).

5.4 The GIS Phase, Development of a Database Design.

This task is essential to identifying habitats, locations of species, population sizes and dynamics, and long term management of species. Personnel within ESH-20 began development of a GIS data base for the TES HMP. The data base is used to store ecological data, both spatial and tabular, and the GIS can be used to query, analyze, model, and display data. In FY96 we developed a GIS data dictionary, a data base design, and have imported data into the design.

Four subtasks were completed: development of a draft data dictionary, data inventory/data base design/naming conventions, data entry/conversion, and map production.

Currently the database contains over 12,000 records. The data that have been imported into the data base can be queried, displayed, and analyzed. An ArcView application that can demonstrate these abilities has been developed. With the development of this application, we can assess project interactions with known TES habitats (Bennett et al. 1996; Section 5).

5.5 Preliminary Ecological Risk Assessment of the Mexican Spotted Owl at Los Alamos National Laboratory

Special measures must be taken to protect certain species that are considered TES. To do so, risk to species from any radiological or nonradiological contaminants must be evaluated. During FY96 a preliminary ecological risk assessment on the Mexican spotted owl in two Ecological Exposure Units was performed using a modified EPA Quotient method, the FORTRAN model "ECORSK3" and a geographic information system. Estimated doses to the owl were compared against reference doses generating hazard indices for three risk source types.

Hazard Quotient results, based on modeling assumptions and conditions, indicated no unacceptable risk to the owl, including a measure of cumulative effects from multiple contaminants that assumes a linear additive toxicity type. Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, owl habitat, facility siting, and facility operations in order to maintain risk from contaminants to acceptably low levels (Gallegos et al. 1996; Section 6).

5.6 The Mission of the Laboratory and Threatened and Endangered Species and Species of Concern

A key element of the TES HMP is the mission requirement task. This task identified and considered the current and future DOE and University of California "mission" for LANL as part of the plan. In the management of the TES and SOC, the goal is to evaluate the relationship between activities done toward the mission and the requirements for protection, conservation, and recovery of TES and SOC (Haagenstad 1996; Section 7).

During FY96, we have developed a pilot ArcView application that is used to identify and evaluate the interactions between mission-related activities and TES, SOC, and their habitats. This FMU is located in the central portion of the Laboratory, involves many types of activities, and has documented TES and SOC concerns. Information was gathered about activities, data availability, and proposed projects. (Haagenstad 1996; Section 7).

5.7 The Development of a GIS Application as a Tool in Project Assessment; an Integration Task

As the ecological data bases are transferred to the GIS, the task to integrate the ecological data with the mission-related activities is possible. Information residing in the various databases (ecological and informational) and map layers (roads, land cover, topography, sensitive areas) can be used for

for the purpose of evaluating the potential impacts of a project to a species. The integration tasks relies on information gathered in all other tasks including the GIS Phase (Task 2), development of the land cover map (Task 3), mission information (Task 5), and survey information (Task 8).

During FY96 we have developed an ArcView Program Application which allows the user to query the data bases to determine the location of a hypothetical project at the Laboratory. During FY97, the application will be refined and additional look-up tables developed. Figure 2 is a simplistic diagram of the application (Bennett et al. 1996, Foxx et al. 1996; Section 5 and 7).

5.8 Survey of the Literature

Essential to understanding the habitat requirements of TES and SOC is information gathered from other researchers. Background information is needed for toxicological modeling and ecological risk studies, developing Habitat Evaluation Procedures (HEP), conducting TES surveys, developing monitoring plans, and understanding habitat requirements. During FY96, we did a systematic search of the literature to find information about TES and SOC. To date, we have entered references related to these species into a bibliographic data base called ProCite. From the literature, we have developed habitat use and feeding habits tables for 10 of the species (Gonzales et al. 1996; Section 8).

6.0 Conclusion

This project received funding in mid-year. We have accomplished all the tasks set forth in the Work Plan for FY96. We have a draft land cover map with preliminary classification of the land cover classes, and we have successfully surveyed TES species and developed an ecological risk model for Mexican spotted owl. Data from biological surveys have been entered into the GIS making it possible to access information that was previously buried in files. We have integrated information about TES and mission activites demonstration project into an ArcView application. This application will become the basis for project reviews and will integrate Laboratory activities and TES and SOC habitat requirements.

Although we have accomplished a great deal in this first year, much work still needs to be done. The second year will be used to provide additional information needed for the HMP. We anticipate further refinement of the land cover map and classification. Modeling of habitats for species difficult to survey will begin. Habitat Evaluation Procedures (HEP) will be used to determine if nonchemical impacts (e.g., tree cutting) will alter habitats. Monitoring plans will be written for each species. Toxicological and ecological risk analyses will be conducted for the bald eagle, peregrine falcon, and SOC. We will broaden the scope and use of the GIS ArcView application for other types of activities at the Laboratory.

Accomplishing the tasks for FY96 set out in the Work Plan will assure that we meet all the milestones to provide a Habitat Management Plan by October 1998.

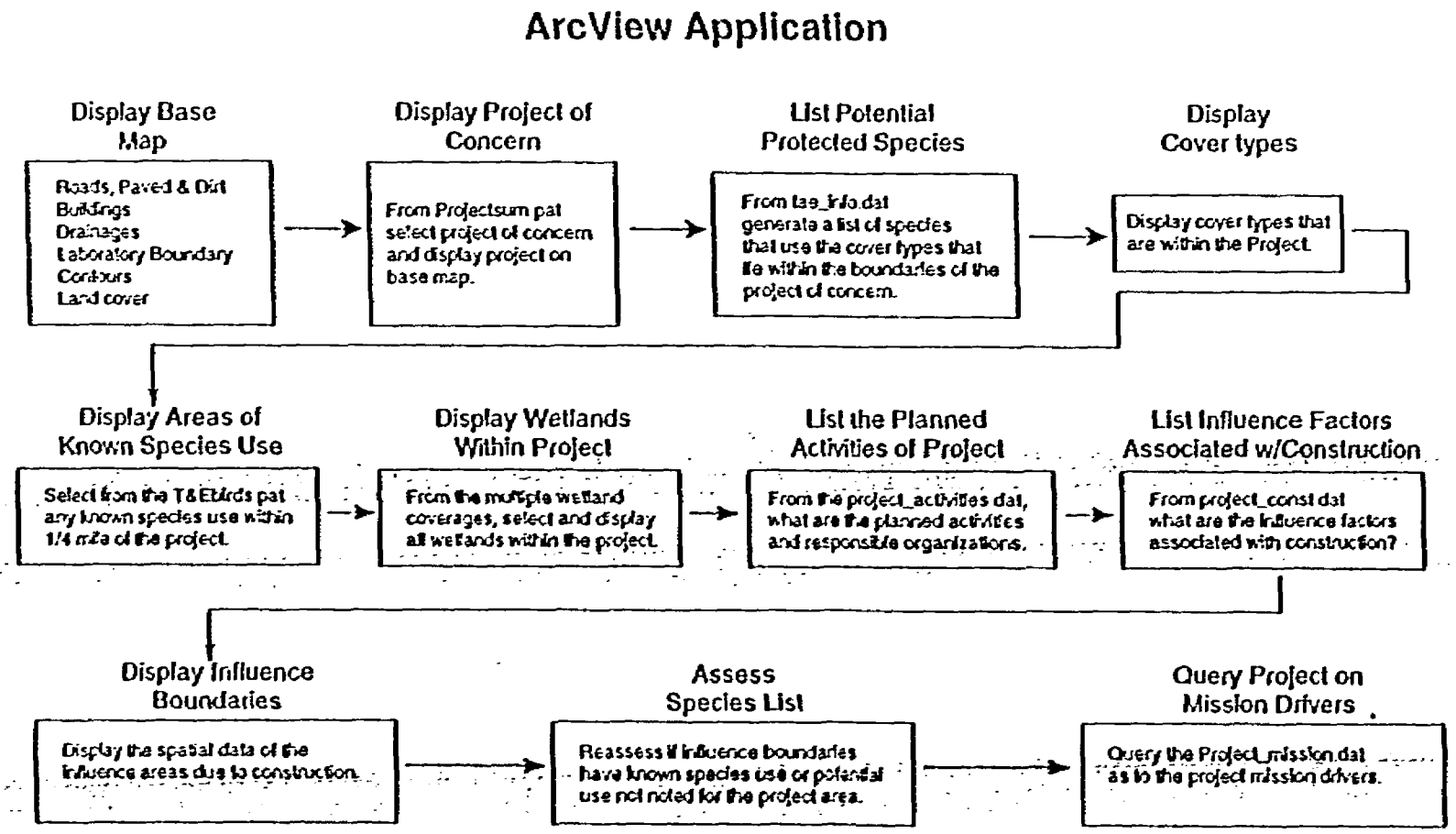


Figure 2. Simplistic Diagram of the Application.

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APPENDIX A
DEFINITIONS

The following definitions are used in this Work Plan.

Endangered Plant Species Act: A New Mexico state statute which provides the designation and protection of plant species which are in danger of becoming extinct.

Endangered Species Act: A federal statute which provides for designation and protection of wildlife, fish, and plant species which are in danger of becoming extinct and to the ecosystems on which species depend.

Federal Candidate Species: This designation has been formerly called a C1 or C2 species. Because of changing concerns in Congress, the USFWS recommends these species be called species of concern (SOC) (personal information from USFWS to T. Foxx and D. Keller, 2/16/96).

Federally Endangered Species: Any species which is in danger of extinction throughout all or a significant portion of its range.

Federally Threatened Species: Any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

Formal Consultation: Is initiated with USFWS when a federal agency determines a proposed project is likely to impact a TES or critical habitat.

SOC: See Federal Candidate Species. In the context of this Plan it will also designate state sensitive species and federal candidate species.

State Endangered Plant: A plant which has been listed on New Mexico's state endangered list. The plant is rare in numbers and/or occurrences and its further existence in the state is threatened without protection.

State Group 1 and 2 Species: Group 1 and 2 are animal species considered to be TES in the state of New Mexico. Group 2 species are those species whose prospects of survival or recruitment within the state are likely to become jeopardized in the near future.

Threatened and Endangered Species (TES): In the context of this plan, TES shall represent both Federal and State TES.

Wildlife Conservation Act: A state statute which became effective on July 1, 1974. This Act provides for the protection of all animal species which are threatened or endangered within the state.

APPENDIX B
LIST OF ACRONYMS

ARC INFO	A Geographic Information System developed by Environmental Systems Research Institute, Inc.
BNM	Bandelier National Monument
CEQ	Council on Environmental Quality
DARHT	Dual Axis Radiographic Hydrodynamic Test Facility

DOE	Department of Energy
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency
EPSA	Endangered Plant Species Act
ESA	Endangered Species Act
ESH	Environment, Safety, and Health Division
ESH-20	Ecology Group
FIMAD	Facility for Information Management, Analysis, and Display
GIS	Geographic Information System
HMP	Habitat Management Plan
LANL	Los Alamos National Laboratory
NBS	National Biological Service
NEPA	National Environmental Policy Act
NM	New Mexico
NWI	National Wetland Inventory
ROD	Record of Decision
SOC	Species of Concern
TES	Threatened and Endangered species
TM	Thematic Mapper
USFWS	United State Fish and Wildlife Service
UTM	Universal Transverse Mercator

APPENDIX C
REGULATORY DRIVERS

Bald and Golden Eagle Protection Act (16 USC 668)

Clean Water Act (33 U.S.C. 1251 et seq.)

Endangered Species Act (16 USC 1531 et seq.)

Executive Order 11988, Floodplains Management, also 10 CFR 1022

Executive Order 11990, Wetlands Management, also 10 CFR 1022

Fish and Wildlife Conservation Act (P.L. 96-366, 16 USC 2901)

Fish and Wildlife Coordination Act (16 USC 661 et seq.)

Migratory Bird Treaty Act (16 USC 703 et seq.)

National Environmental Policy Act (42 USC 4341), and also 40 CFR 1500–1508 (Compliance with NEPA, Council on Environmental Quality [CEQ] and 20 CFR 1022)

Wildlife Conservation Act (NMSA 17-2-37 through 17-2-46, July 1, 1974)

New Mexico Endangered Plant Species Act (NM 75-6-1) of 1985 and attendant regulation NRD Rule 85-3.

Bighorn Re-establishment Assessment-Significant Issues, Concerns, and Questions to be Answered for Department of Energy (DOE)/ Los Alamos National Laboratory (LANL)

An Introduction to: Bighorn Re-establishment Assessment-Significant Issues, Concerns, and Questions to be Answered for Department of Energy (DOE)/Los Alamos National Laboratory (LANL)

Leslie A. Hansen

The New Mexico Department of Game and Fish (NMDGF) has proposed re-establishing Rocky Mountain bighorn sheep in White Rock Canyon. This re-establishment is part of a long-term plan for restoring and maintaining at least 7 populations of bighorns of over 100 individuals each in New Mexico. Landowning agencies, and Pueblos involved in the White Rock Canyon project include the National Park Service, the U.S. Forest Service, the Department of Energy, Cochiti Pueblo, San Ildefonso Pueblo, Santa Clara Pueblo and Los Alamos County. Because federally-owned lands are affected, the proposal for re-establishment of the bighorn sheep must go through the National Environmental Policy Act environmental assessment process.

The plan of NMDGF to expand the range of the Rocky Mountain bighorn sheep in New Mexico represents the type of proactive efforts that are required to prevent species from becoming threatened or endangered in this state. There are some obvious economic as well as biological benefits to keeping species off the threatened and endangered species (TES) lists. Right now, Rocky Mountain bighorn sheep do not require federal protection or regulation, do not require the intensive surveying and management associated with TES, provide some hunting opportunities, and may generate economic benefits through tourism. By restoring bighorn populations in the state, NMDGF is helping to restore a missing ecosystem component and to secure present and future human options.

However, the Environmental Assessment process already is revealing some of the conflicting social values which make management of TES, and of all species, such a challenge. This area is richly endowed with archeological sites, which federal agencies are legally mandated to protect. What effects might bighorns have in causing damage and erosion to these sites? Landowning agencies would like to determine the impacts of the bighorns on their environment by monitoring soil erosion rates, range condition, bighorn movements, and population dynamics. This information is necessary to prevent adverse effects resulting from bighorn population growth and to properly manage the herd. Yet, in this era of budgetary austerity, where will the money come from to monitor these environmental impacts? Private landowners may have concerns that bighorns will become garden pests as the re-established elk have.

What is the appropriate course of action? Which values should take precedence? Hopefully, through involving landowners and the public in the environmental assessment process, we will be able to identify and resolve these types of issues in the best long-term interests of humans and our environment. Issues identified by landowning agencies were evaluated by DOE/UC and are presented below.

Bighorn Re-establishment Assessment-Significant Issues, Concerns, and Questions to be Answered for Department of Energy (DOE)/Los Alamos National Laboratory (LANL)

Instructions: Answer questions, citing sources and justifying reasoning; provide background information. Identify possible consequences if the issue is ignored. Propose an impacts mitigation action that would eliminate an adverse effect finding and evaluate the consequences of the proposed mitigation. Please note additional issues and concerns that arise as a result of your addressing these questions and conversing with members of your agency or an effected entity. If possible, address these concerns in the same manner as described above.

Summary: We collected information to evaluate issues and concerns involved with the proposed re-establishment of bighorn sheep in White Rock Canyon. Four issues are judged to be critical to the re-establishment effort: (1) degradation of natural and cultural resources caused by activities of bighorn sheep, (2) property damage and/or consumption of residential landscape vegetation by bighorn sheep, (3) the scope and funding of monitoring activities, and (4) actions to be taken if problems are identified. Mitigation actions for issues are proposed.

Prescribed fire is recognized as a valuable tool to improve bighorn sheep habitat. NPS and USFWS policies support the use of prescribed fire, but can DOE/LANL and the County of Los Alamos support prescribed fire? If so, when and how? What are the DOE and LANL and LA County Plans relative to fire and fuels management over the next 5-50 years?

(John Huchton, Elizabeth Withers, and John Powers)

DOE/LANL is currently developing a program to reduce risks of wildfire at live-firing ranges with some limited prescribed burns. The primary aim of the fuels management program on LANL at this time is to protect facilities. A LANL-wide fuels management program is being developed. Because of the dangerous nature of materials stored at some facilities on the lab (radioactive materials, explosives, and hazardous chemicals), and concern for the protection of humans and property, LANL will probably implement prescribed burning very conservatively. It is unlikely that LANL will support prescribed burning on LANL property to improve bighorn habitat in the near future unless it also serves the function of protecting LANL facilities from wildfire.

Consequences if issue is ignored: New Mexico Department of Game and Fish has evaluated the suitability of this area for re-establishment of bighorn sheep in an unburned condition, and feels the habitat is suitable. Burning would be a desirable tool for habitat improvement but is not necessary for the re-establishment.

Impacts mitigation: No mitigation is necessary.

What is the value of bighorn sheep re-establishment in terms of the human condition? Will re-establishment have a social impact and, if so, in what manner and form?

(Amy Fisher and M. Diana Webb, Group Leader, ESH-20, LANL, MS-M887)

Evidence indicates that bighorn sheep were important to prehistoric human populations in this region. When the minimum number of individual animals present (as identified from bone fragments) were calculated from ungulate remains at 45 archeological sites in the Jemez Mountains, bighorn sheep was the second most common species, following mule deer (Allen, in press). Wild sheep were the most prevalent animal depicted in Southwest prehistoric rock art (Brown 1993, as cited in Edgar 1994).

In our time, bighorn sheep have become a valued wildlife resource, primarily for viewing (Lewis 1995, Reel 1990, Stumpf 1988), but also for hunting (New Mexico Department of Game and Fish 1995). Dunn (1996) stated that Rocky Mountain bighorn sheep are "one of New Mexico's more majestic wildlife species." Some communities have realized economic benefits from tourism associated with bighorn sheep (Lewis 1995). Problems associated with bighorn herds have included occasional traffic hazards (Reel 1990) and conflicts between bighorn sheep management and other uses of natural resources such as livestock grazing and timber harvesting (Lewis 1995). (Also see section on attraction of bighorn sheep to residential areas.)

It has been estimated that the current population of bighorn sheep in the United States is one-tenth of its level prior to European settlement in the Rockies. Bighorn sheep are threatened by poaching, diseases (primarily transmitted from domestic sheep), livestock competition, and continuing human encroachment on bighorn habitat. The restoration strategy of New Mexico Department of Game and Fish for Rocky Mountain bighorns is to establish 7 populations of over 100 animals each in the state (Dunn 1996). Re-establishment of bighorn sheep into White Rock Canyon would help to secure present and future human options by maintaining biological diversity and restoring a missing ecosystem component (Mangel et al. 1996).

Related issues: (1) Possible effects of water level manipulation in Cochiti Reservoir on bighorn movements (which may affect human-bighorn interactions) need to be considered. (2) Possible damage to archeological sites (see section on damage to archeological sites).

Consequences if issue is ignored: All environmental manipulations, whether deliberate or an unintended consequence of other actions, have the potential for direct and indirect impacts on the human environment. Restoration of bighorn sheep to White Rock Canyon appears to be a manipulation with relatively low foreseeable negative impacts, while offering large benefits in the areas of maintaining biological diversity, providing recreational opportunities for wildlife viewing, and restoring native ecosystems. Public perception of the relative costs and benefits will determine public response to the re-establishment proposal.

Impacts mitigation: Since there is little economic use of resources in White Rock Canyon itself (except for cattle grazing permits along the eastern rim), no conflicts are anticipated. Traffic hazards can be minimized by appropriate signing along roads and construction of bighorn viewing areas (Reel 1990). (Also see sections on attraction of bighorn sheep to residential areas, damage to archeological sites.)

Will the bighorn sheep be attracted to residential landscape vegetation, livestock feed, or gardens? (Bill Dunn, John Huchton, and Charisse Sydoriak)

Bighorns normally forage on forbs, shrubs, and grasses. Potential forage species in our area include: sagebrush, mountain-mahogany, cliffrose, blackbrush, saltbush, Mormon tea, mountain lover, ricegrass, mountain muhly, sedges, fescues, wheatgrass, and willow (Klingel 1996, Todd 1975).

Bighorn sheep may well be attracted to residential gardens and landscaped areas, particularly in White Rock, Pajarito Acres, La Senda, the Cochiti golf course, and the Cochiti apple orchard. In Boulder City, Nevada, bighorn sheep learned to graze in residential yards and city parks (Stumpf 1988). In addition, bighorn sheep are attracted to sources of salt (New Mexico Department of Game and Fish & USDA Forest Service 1993), and hence may be attracted by salt and mineral licks put out for livestock.

Related issues: Bighorn rams in the 3-5 year age classes may suffer injury or mortality while trying to cross barbed wire fences (Helvie 1971). Mature rams (250 lb.) measure approximately 3' at the shoulder, with ewes (150 lb.) and lambs being proportionally shorter (New Mexico Department of Game and Fish 1996, Helvie 1971). Bighorn sheep do not normally cross fences by jumping; they cross under or between lower rails or wires (Helvie 1971). Therefore, residents with woven wire fences or chain link fences probably will not suffer any depredations.

Consequences if issue is ignored: Resident elk depredations of gardens and landscape vegetation are currently perceived to be a serious problem by some residents of Pajarito Acres (Shankland 1996). Fears of bighorn sheep also becoming a problem may cause local residents to oppose the re-establishment.

Impacts Mitigation: Depending on funding and authorization, LANL is proposing to conduct a survey in Pajarito Acres to determine the types of livestock resident in the area, the types of fences, and the number of salt licks. This survey should help further define the potential problems. In the scoping process and press releases, the participating agencies should educate local residents about the much smaller size of bighorns (than elk), the fact that they are primarily diurnal, their inability to cross certain types of fences, and techniques residents can use to avoid depredation problems. Users of public lands and private landowners should be strongly discouraged from habituating bighorn sheep to humans (see sections on trails and the Ramsey Wildlife Center). New Mexico Game and Fish should be prepared to promise to respond to long-term depredation complaints by: (1) removing selected problem individuals through net-gunning or other techniques, or (2) responding to an population problem (as defined in the operational constraints section).

What operational constraints can the affected agencies anticipate if the bighorn sheep are reintroduced? (All)

DOE/LANL

Monitoring of bighorn sheep after the re-establishments is not expected to cause any operational constraints (see Monitoring issue). Since Rocky Mountain bighorn sheep are regulated as a game species by the State of New Mexico, we do not anticipate any operational constraints due to their legal status. Our primary concerns are the possibility of environmental or cultural resources degradation, contaminants uptake by bighorns, property damage, and bighorn-vehicle interactions as the bighorn sheep population grows. TA-33, one of the technical areas which would provide bighorn habitat on LANL (Dunn 1993), contains areas of tritium contamination.

Consequences if issue is ignored: DOE/LANL would like measures to be put in place prior to the re-establishment to deal with these issues if they should occur.

Impacts Mitigation: We suggest that DOE/LANL, New Mexico Department of Game and Fish, and other affected entities agree on monitoring methods and action levels in the following areas: range condition, resource damage, property damage, bighorn-vehicle interactions, and contaminants levels. A

monitoring program for range condition, soil erosion, and Southwestern Willow Flycatcher habitat should be implemented prior to a release of bighorns. We also suggest that a committee be formed with representatives from all affected entities to resolve unanticipated problems that may occur and to reevaluate action levels and monitoring methods at appropriate intervals.

If an action level is exceeded due to the behavior of an individual bighorn, we suggest that New Mexico Department of Game and Fish either relocate or remove the individual using net-gunning or another technique, or allow the affected agency to remove the individual using lethal means. If the action level is exceeded due to general population growth and animal movement, we suggest that the committee declare that portion of the bighorn range where action levels are exceeded to have a population problem. A population problem would then be alleviated by (1) a legal hunt which effectively reduces the problem to below the action level (note: because of legal constraints or security considerations, USFS is likely to be the only agency which can allow hunting), (2) a relocation effort or other action by New Mexico Department of Game and Fish which effectively reduces the problem to below the action level, or (3) action by the affected agency, not limited to but including culling, which effectively reduces the problem to below the action level.

To mitigate the effects of contaminants moving into the human food chain, we suggest than New Mexico Department of Game and Fish require that all animals harvested either in a legal hunt or as part of response to an action level, or killed by a vehicle, have a tissue sample submitted to LANL for contaminants analysis. We would also recommend that if Pueblo residents kill a bighorn on their property that they submit a tissue sample for contaminants analysis. Results of analyses would be reported to individual hunters and would be published in Laboratory reports.

Will the presence of bighorn sheep have any affect on the Southwestern willow flycatcher, peregrine falcon, bald eagles, or any other sensitive animals? (Stephen Fettig and Terry Foxx)

We do not anticipate that bighorn sheep will affect any sensitive animal. Browsing of willows along the Rio Grande by bighorn sheep may contribute to an unknown cumulative effect of ungulate browsing (primarily by trespass cattle and somewhat by elk) on the availability of habitat for Southwestern Willow Flycatcher. This habitat is also impacted by management of water levels at Cochiti Reservoir. During the winter bald eagles roost within the anticipated range of the bighorn sheep, however, we do not foresee any impacts of the re-establishment on bald eagles.

Consequences if issue is ignored: Agencies are legally and administratively mandated to protect sensitive species.

Impacts mitigation: Because of its riparian nature, Southwestern Willow Flycatcher habitat is subject to natural periodic change caused by flooding, drought and other events. We do not anticipate that bighorn sheep will be a primary cause of problems. However, recognizing the cumulative effects of natural and man-caused activities, including browsing by bighorn sheep, is important for effective management of this habitat type for Southwestern Willow Flycatcher. Agencies currently monitor suitable habitat for the presence of Southwestern Willow Flycatchers. We recommend expanding current monitoring of this habitat type within the bighorn sheep range to identify a problem if it should occur. If funding is available, a study of the impacts of water level changes and browsing by different ungulates on willow habitat should be conducted in conjunction with the Cochiti Biological Group.

How would sheep monitors/researchers access the sheep once they are re-established? Would monitoring activities have an adverse effect on the sheep? How would monitors and researchers prevent environmental impacts? (Stephen Fettig, Bill Dunn, Amy Fisher, and John Huchton)

New Mexico Department of Game and Fish personnel are planning on monitoring released bighorn sheep using VHF radiocollars and aerial telemetry (Bill Dunn, NMDGF, pers. comm.). Collars which are detected with a mortality signal are then radiotracked on the ground to find the animal. DOE/LANL strictly limits flyovers of Laboratory property for security reasons. It is possible to adequately radiotrack bighorns without flying over LANL property as long as flyovers are permitted on USFS and Bandelier National Monument property (Bill Dunn, NMDGF, pers. comm.). New Mexico Department of Game and Fish personnel could then be escorted by LANL personnel for ground telemetry if a mortality is detected on LANL property. Any long-term population monitoring would also be done using aerial surveys without flyovers of LANL property. Periodic aerial telemetry and ground walk-ins on mortalities are not expected to have an adverse impact on the sheep or the environment.

Consequences if issue is ignored: Agencies included in the re-establishment effort need to be aware of DOE/LANL policies regarding flyovers so (1) New Mexico Department of Game and Fish personnel can follow these policies in conducting aerial surveys and telemetry, and (2) all agencies involved can make appropriate plans for monitoring.

Impacts mitigation: No impacts are expected, so no mitigation is necessary.

Where, when, and how will monitoring and research be conducted to insure the continued health of the ecosystem? Who will pay for it? (Bill Dunn, Amy Fisher, Stephen Fettig, and John Huchton)

Monitoring and research are needed to determine if the bighorn sheep re-establishment is successful, if bighorn sheep are contributing to erosion in sensitive areas, to determine if range condition remains adequate, and to determine if bighorn sheep are harming Southwestern Willow Flycatcher habitat. New Mexico Department of Game and Fish will monitor the re-establishment of the bighorn sheep herd. Landowning agencies can conduct monitoring and research activities on erosion rates, range condition, and Southwestern Willow Flycatcher habitat, if methods and funding sources for this monitoring are identified and agreed upon cooperatively among the participating agencies.

Consequences if issue is ignored: Monitoring and evaluation are necessary components of a re-establishment effort. Agencies are legally and administratively mandated to manage their properties to maintain healthy functioning ecosystems.

Impacts mitigation: Funding for monitoring efforts is difficult to acquire, yet monitoring is essential to the re-establishment effort. Funding sources need to be identified and confirmed during the assessment process.

Where would accelerated erosion cause cultural resource losses and how likely is it that the sheep could be contributing elements? (Bev Larson, Bill Dunn/Amy Fisher, & Stephen Fettig)

We are in the process of trying to contact resource specialists at Mesa Verde to determine what effects bighorn sheep are having in a similar area.

Would re-establishment affect traditional uses and/or the cultural significance of affected lands? If so, would the effect be positive or negative? (Bev Larson and Pueblo Councils)

The bighorn re-establishment will be discussed at the August working group meeting, and points arising during that meeting will be transmitted to Charisse Sydoriak as soon as possible.

Are bighorn sheep likely to uptake contaminants and, if they do, would sheep become a contaminants pathway for humans? (Elizabeth Withers and Mat Johansen)

We do not anticipate that bighorn sheep will become significantly contaminated. Monitoring of radioactive contaminants in elk suggests that elk are not accumulating greater levels of contaminants on LANL than they are in control areas, and that elk are not a significant transport pathway of radioactive contaminants to humans (Fresquez 1994). Bighorn sheep food habits are similar to those of elk (Lawson and Johnson 1982), and their movements on the lab are anticipated to be much more limited than those of elk (Dunn 1993). The status of nonradioactive contaminants in elk has not been documented, but is not likely to be different than that of radioactive contaminants.

Consequences if issue is ignored: The possibility of contamination is likely to be a significant public concern.

Impacts mitigation: See operational constraints section. LANL can test bighorn sheep for contamination.

Could any existing or potential trails (i.e. those associated with the proposed Ramsey Wildlife Center) in the identified bighorn habitat cause harm to the bighorn? When, where, and how? (Stephen Fettig and Elizabeth Withers)

Habituation of bighorns to humans is undesirable because it makes the bighorns more vulnerable to poachers, it increases the chances of bighorns becoming nuisances around residential areas, it may increase the chance of traffic hazards, and it may increase the potential for exposure of bighorns to diseases from domestic livestock in other areas. Habituation of bighorns may occur along frequently-used trails in bighorn habitat.

Consequences if issue is ignored: Allowing bighorns to become habituated would have adverse consequences for bighorns and humans.

Impacts mitigation: Users of public lands and private landowners should be strongly discouraged from approaching bighorns or offering food or other attractants to them through education concerning the adverse consequences of habituation.

How likely is it that the Ramsey Wildlife Center will be built and where would it be located? (Elizabeth Withers)

DOE has agreed in principle to lease DOE land east of State Road 4 in Water Canyon for the construction of the Ramsey Wildlife Center. However, Dr. Ramsey has not provided information needed by DOE/LANL to further evaluate and initiate the lease. The process is inactive at this time, and its future progress depends on Dr. Ramsey's actions.

Consequences if issue is ignored: Depending on the movements of the bighorns after re-establishment, there might be human-bighorn interactions at the Ramsey Wildlife Center. This could create traffic hazards, potentially expose bighorns to diseases of other animals, and habituate the bighorns to humans, increasing their vulnerability to poachers and potentially causing problems in other areas.

Impacts mitigation: We suggest that the Ramsey Wildlife Center be restricted from putting out attractants to bighorns, such as a water source or salt licks, as a condition of the lease.

How likely is it that human trespass in the Water Canyon tract will affect DOE/LANL security? Where would trespass be problematic? (Elizabeth Withers)

Public access is already allowed by DOE in the Water Canyon tract of LANL (parts of TA-70 and TA-71) for hiking, picnicking, and horseback riding. Bighorn sheep viewing would be consistent with these allowed activities. DOE has an Interagency Agreement with the National Park Service to provide field services to enforce authorized use restrictions in this area. The IA does not include search and rescue functions which would be managed by the DOE Emergency Management Center.

However, public access is not allowed at Technical Area-33 which has specific controls for access and is also within the likely proposed habitat area. Although small, the potential for bighorn sheep to act as an attraction for unauthorized public access to TA-33 is a concern.

Consequences if issue is ignored: Public exposure to the natural hazards at TA-33, and potentially to any facility hazards, could increase.

Impacts mitigation: Any increase in unauthorized access at TA-33 may require increased management controls such as more fencing or signs.

Where and how could bighorn sheep become entangled in DOE/LANL equipment, fall into sumps, and defecate in pollution sensitive area? (Elizabeth Withers)

LANL security and operations staff were contacted and they concluded that bighorn sheep would be no more of a problem than the present elk population. Given their experience with the relatively large population of elk, they do not consider this a significant concern even though the potential for incidents exist.

Is the water quality and quantity in the habitat adequate for the sheep? (Bill Dunn and Mat Johansen)

The bighorn sheep will have access to the Rio Grande in White Rock Canyon as well as seasonal and some permanent water sources in tributary canyons. Water quantity in the habitat is adequate. LANL monitors surface water quality at off-site regional stations, off-site perimeter stations, and many sites on Laboratory property. DOE/LANL is evaluating reducing the number of on-site effluent outfalls to better comply with the Clean Water Act. In 1994, all radiochemical analyses of surface water were below DOE Derived Concentration

Guide safety limits for humans (Los Alamos National Laboratory 1996). New Mexico General Stream Standards for Livestock and Wildlife Watering were exceeded at a limited number of stations for aluminum, arsenic, and cadmium in 1994; these exceedences were believed to reflect natural environmental conditions (Los Alamos National Laboratory 1996).

Consequences if issue is ignored: Exposure of bighorns to water contamination may be perceived as a significant issue by the public. Limited exposure to contaminants in water sources is not likely to harm the bighorn population.

Impacts mitigation: New Mexico Department of Game and Fish will monitor the success of the re-establishment, and identify a population-level problem if it occurs. Bighorn sheep which are killed by hunters or in response to action levels can be tested for contaminants. LANL will continue its Environmental Surveillance reporting and will identify any changes in its water monitoring results.

What are DOE's plans in terms of land transfers and development in the areas where bighorn sheep are likely to occupy or roam? Would a change in land ownership affect a bighorn re-establishment and management plan, if approved? (Elizabeth Withers)

Land in the White Rock/Pajarito Acres area is on the list of areas being considered for transfers. Land transfers must go through the NEPA process, so there will be no decisions on land transfers for at least 3 years. The impact of land transfers depends on who receives the land. Los Alamos County, San Ildefonso Pueblo, and Bandelier National Monument have all expressed interest in receiving land within potential bighorn habitat.

Consequences if issue is ignored: Development of transferred land could impact bighorn habitat quality and the level of human-bighorn interactions.

Impacts mitigation: If the decision is made to release bighorns in White Rock Canyon in 1998, the re-establishment will predate land transfers. In that case, the presence of bighorns will be considered in the NEPA process. Potential effects of the transfer on bighorns can be more closely considered with more information at that time.

One further clarification: The term "LANL" needs some clarification for future use. Although it is often used to mean a variety of things, LANL is strictly the name of a facility. This facility is owned by DOE and operated by the University of California under contract with DOE. Formal organization lists should include DOE and UC but not LANL as it is not an organization.

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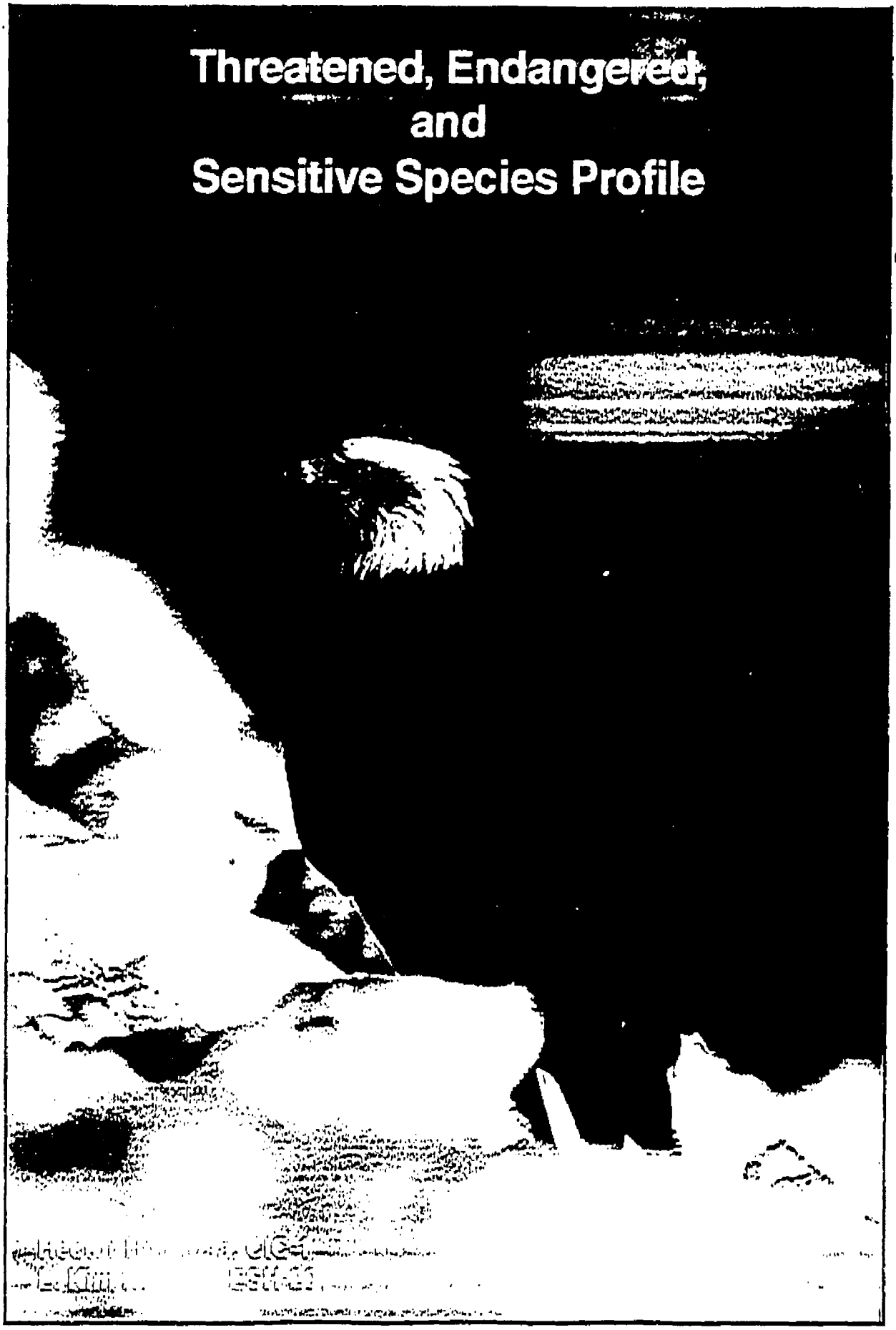
Threatened, Endangered, and Sensitive Species Profile



FOREWORD

This document is intended to provide a thumbnail description of various plant and animal species that are included in lists on the federal, state, or local level proclaiming them to be at risk to some degree and that may inhabit or potentially inhabit areas in and around Los Alamos National Laboratory lands.

At the top of each profile is the category for the current status of each organism. This status will range from federal endangered, which designates the most serious condition for an organism, to species of local concern, which identifies an organism that is noted to be rare on a local level. The different labels of status are defined as follows:

- **Federal endangered** — Any species that is in danger of extinction throughout all or a significant portion of its range.

- **Federal threatened** — Any species that is likely to become endangered within the foreseeable future throughout all or a significant portion of its range.

- **Federal species of concern** — Any species whose population numbers are declining or whose range is diminishing to the point where it may become threatened in the near future.

- **State endangered** — Any species listed in the New Mexico state endangered list because it is rare in numbers and/or occurrences and, without protection, its further existence in the state is in serious jeopardy.

- **State threatened** — Any species whose prospects of survival or recruitment within the state are likely to become jeopardized in the near future.

- **Species of local concern** — Any species known to exist or potentially exist within the proximity of Los Alamos National Laboratory lands and surrounding areas that are rare in numbers and/or occurrences and whose habitat requirements are very specific, rare to this area, or threatened in any way.

The nature of this document allows for updates to be made to species that are already included in this list as new information becomes available. At the same time we will be able to add new species to this profile as they become a part of a category listed in the status section and delete any species that have been removed from any of these designations.

Mexican Spotted Owl

Strix occidentalis lucida

Status:
Federal threatened.

Description:
The Mexican spotted owl is one of three subspecies of spotted owl—Mexican, California, and Northern. This strictly nocturnal bird is fairly large, 42 to 53 cm (16.5 to 21 in.) tall. It is dark brown with a puffy head and has white spots on its head, back, and chest and barred underparts. Unlike most other owls, the Mexican spotted owl is dark-eyed rather than yellow-eyed.

Habitat:
Mixed Conifer, Ponderosa Pine. The Mexican spotted owl prefers tall, old-growth forests in canyons and moist areas for breeding. It will forage for woodrats and mice in forests, woodlands, and rocky areas.

Occurrence:
The Mexican spotted owl is a resident and has been confirmed on Los Alamos National Laboratory, Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands. Critical habitat has been designated in Santa Fe National Forest.

Courtesy of New Mexico Game and Fish

Black-Footed Ferret

Mustela nigripes

Status:
Federal endangered.

Description:
The weasel family, of which the black-footed ferret is a member, is the smallest of a group of predators that are different sizes but are similar in shape and habits. The black-footed ferret has a long body, 38 to 46 cm (15 to 18 in.), with a 13- to 15-cm (5- to 6-in.) long tail. This weasel can be identified by its yellowish brown to darker colored fur, black forehead, black-tipped tail, and black feet.

Habitat:
Prairie. The main prey of the black-footed ferret is the praine dog. Hence, this weasel-like animal will not stray far from a prairie dog town. However, it may also occur in other areas where other rodents, small enough to be taken, abound.

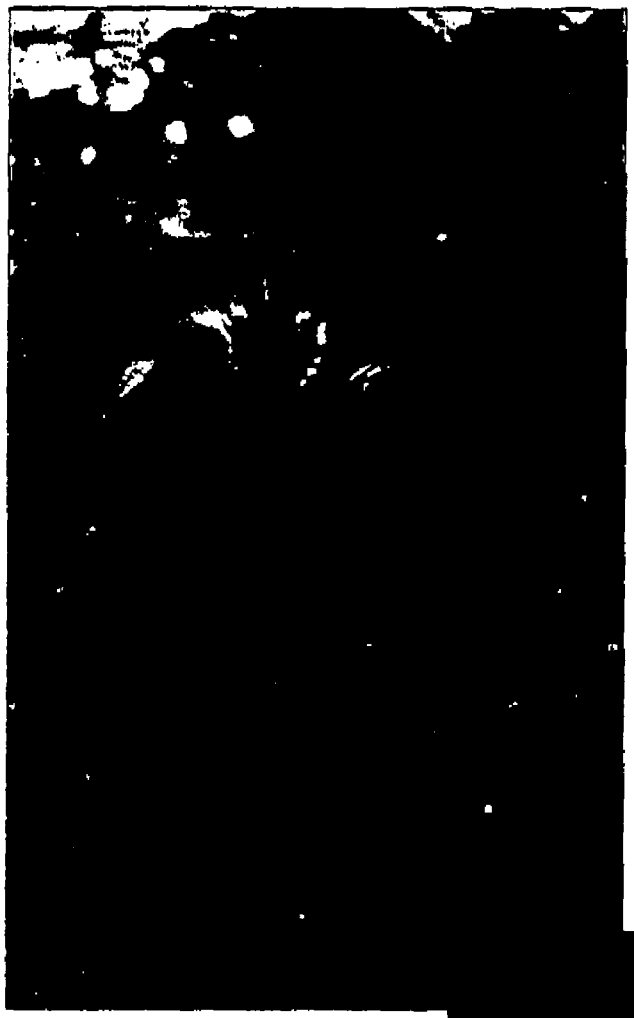
Occurrence:
The presence of the black-footed ferret on Los Alamos National Laboratory and Los Alamos County lands or surrounding uplands is believed to be highly unlikely.

Courtesy of US Fish and Wildlife Service

Wood Lily

Lilium philadelphicum var. *andinum*

Status:
Species of concern, State endangered.



Courtesy of Terralene Foxx, LANL

Description:
On a slender stalk, the wood lily stands to 40 cm (15 in.). Six petals that are yellowish in the center, changing to bright orange on the outside, make up the flower that adorns the top. At regular intervals down the length of the stalk, grow numerous slender leaves.

Habitat:
Riparian, Ponderosa Pine, Mixed Conifer, Spruce/Fir. The wood lily can be found in canyons above 2,285 m (7,500 ft) and usually occurs in areas of old growth conifers.

Occurrence:
The presence of the wood lily has been confirmed on Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands.

Yellow Lady's Slipper

Cyprepedium calceolus var. *pubescens*

Status:
State endangered.

Description:
The yellow lady's slipper orchid will stand from 15 to 60 cm (6 to 23.5 in.) tall, topped by one or two large, yellow flowers. The lower segment of the flower is a pouch and resembles a lady's slipper. Three to five yellowish green, elliptic-shaped leaves ascend the stalk, growing out and over at regular intervals.

Courtesy of Teralene Foxx, LANL

Habitat:
Riparian, Mixed Conifer. The yellow lady's slipper grows in a variety of moist habitats including bogs, humid woodlands, and rocky slopes in open woods.

Occurrence:
The presence of this orchid has been confirmed on Bandelier National Monument lands only.

Grama-Grass Cactus

Toumeya papyracantha

Status:
Species of local concern.

Description:
The stems of grama grass cactus are solitary, ribbed, and 2.5 to 20 cm (1 to 8 in.) tall. Central spines elongate, resembling dry grass blades that are flattened, grooved, and flexible. Radial spines are short and straight. Flowers are white and fruit is round, tan, and dry when mature.

Habitat:
Juniper Savanna, Piñon/Juniper. Grama grass cactus can be found from 1,530 to 2,225 m (5,000 to 7,300 ft) in the Jemez Mountains, usually where soil is sandy, and is associated with basalt outcrops.

Occurrence:
The presence of grama grass cactus has been confirmed on Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands. This cactus has recently been dropped from the list but is still rare in Los Alamos County.

Courtesy of Teralene Foxx, LANL

SOUTHWESTERN WILLOW FLYCATCHER

Empidonax traillii extimus

Status:
Federal endangered, State endangered.

Description:
The southwestern willow flycatcher has a whitish throat, pale olive breast, pale yellow belly, and brownish olive upper parts. This bird can be distinguished from peewees, a bird that is similar in appearance, by the upward flicking of the tail feathers.

Habitat:
Riparian. The southwestern willow flycatcher requires cottonwoods or willows. It is generally found in dryer habitat, but near water, than the habitat of the closely related alder flycatcher.

Occurrence:
The presence of the southwestern willow flycatcher has been confirmed in the Jemez Mountains, and there may be possible breeding habitat on Los Alamos National Laboratory and Bandelier National Monument lands.

Courtesy of W. Maynard, New Mexico Game and Fish

GIANT HELLEBORINE

Epipactis gigantea

Status:
Species of local concern.

Description:
The giant helleborine will stand from 20 cm to 1 m (8 to 40 in.) on a single stem. From a rounded base to a tapered point, four to twelve leaves grow in alternating directions along the stem. The greenish-yellow flowers will grow in clusters with up to fifteen flowers on one stem. This plant will flower from March to August.

Habitat:
Riparian, Juniper Savanna, Piñon/Juniper. The giant helleborine can be found on sandbars of rivers and streams and in areas around springs and seeps.

Occurrence:
The presence of the giant helleborine has been confirmed on Los Alamos County lands but not on Los Alamos National Laboratory lands.

Courtesy of Teralene Foxx, LANL

New Mexico Meadow Jumping Mouse

Zapus hudsonius luteus

Status:
Species of concern, State threatened.

Description:
As with all species of jumping mice, the New Mexico meadow jumping mouse is equipped for jumping with long black feet and a long tail. However, it prefers to crawl from place to place under leaves and other vegetation. If hurried, it will run by making a quick series of short hops. Other characteristics of this species are grooved upper incisors and a colorful fur, exhibiting various shades of brown.

Habitat:
Riparian, Mixed Conifer, Spruce/Fir. The meadow jumping mouse prefers to live on ground surface in lush grassy or weedy meadows. By day it hides under heavy vegetation and by night in nests placed in protective areas such as hollow logs or short burrows. The meadow jumping mouse hibernates over the winter.

Occurrence:
The presence of New Mexico meadow jumping mouse has been confirmed on Los Alamos County and Santa Fe National Forest lands and may be possible on Los Alamos National Laboratory lands.

Courtesy of Joan Morrison

Goat Peak Pika

Ochotona princeps

Status:
Species of concern.

Description:
As with all pikas, the Goat Peak pika is a small rodent, 15 to 22 cm (6 to 8.5 in.) in length and weighing from 4 to 6.5 oz. Its grayish buff or brown coloring helps it to blend into the favorite habitat of talus slopes. It has short ears that are broad and rounded and no visible tail.

Habitat:
Mixed Conifer, Spruce/Fir. The Goat Peak pika forages during the early morning, late afternoon, and nighttime hours close to talus slopes, rock slides, or boulder piles that afford protection and nesting areas. Pikas appear to utilize whatever plants are close to their burrows. They eat the leaves, stalks, and flowers of grasses, shrub twigs, and mosses and lichens.

Occurrence:
The presence of the Goat Peak pika has been confirmed on Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands but not on Los Alamos National Laboratory lands.

Courtesy of James R. des Lauriers

Bald Eagle

Haliaeetus leucocephalus

Status:
Federal threatened, State threatened.

Courtesy of New Mexico Game and Fish

Description:
The bald eagle is a huge raptor with a wingspan of 2.0 to 2.4 m (6.5 to 7.5 ft). The body plumage is dark, and the head and tail are white. The iris, cere, bill, and legs are yellow. An immature bald eagle is dark, usually with some white under the wings, and gradually develops a white head and tail.

Habitat:
Riparian and adjacent areas. The bald eagle prefers to inhabit areas near rivers and lakes with tall trees and cliffs that are protected from the wind. It eats fish, waterfowl, carrion, and rabbits.

Occurrence:
The bald eagle is a migrant and a winter resident along the Rio Grande and on adjacent Los Alamos National Laboratory, Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands.

Myotis Bats

Family Vespertilionidae

Status:
At least seven species of Myotis bats occur in this area—California myotis, fringed myotis, long-eared myotis, long-legged myotis, small-footed myotis, Yuma myotis, and occult little brown bat. All but the California myotis are considered species of concern, and all but the occult little brown bat have been documented on Los Alamos National Laboratory lands.

Description:
The Myotis bats form the largest group of bats and are widely distributed. They are all relatively small in size, some sort of brown in color, and have simple snouts. Some of the differences in physical characteristics of the Myotis bats in this area can be surmised by their names.

Habitat:
Ponderosa Pine, Piñon/Juniper, Mixed Conifer. The long-eared and long-legged myotis roost in snags of ponderosa pine or mixed conifer and in rock crevices. The others roost in cliffs or caves with occult little brown bat and Yuma myotis needing water close by.

Occurrence:
The presence of all species except the occult little brown bat has been confirmed on Los Alamos National Laboratory, Bandelier National Monument, and Santa Fe National Forest lands. Occult little brown bat has only been seen on Santa Fe National Forest lands.

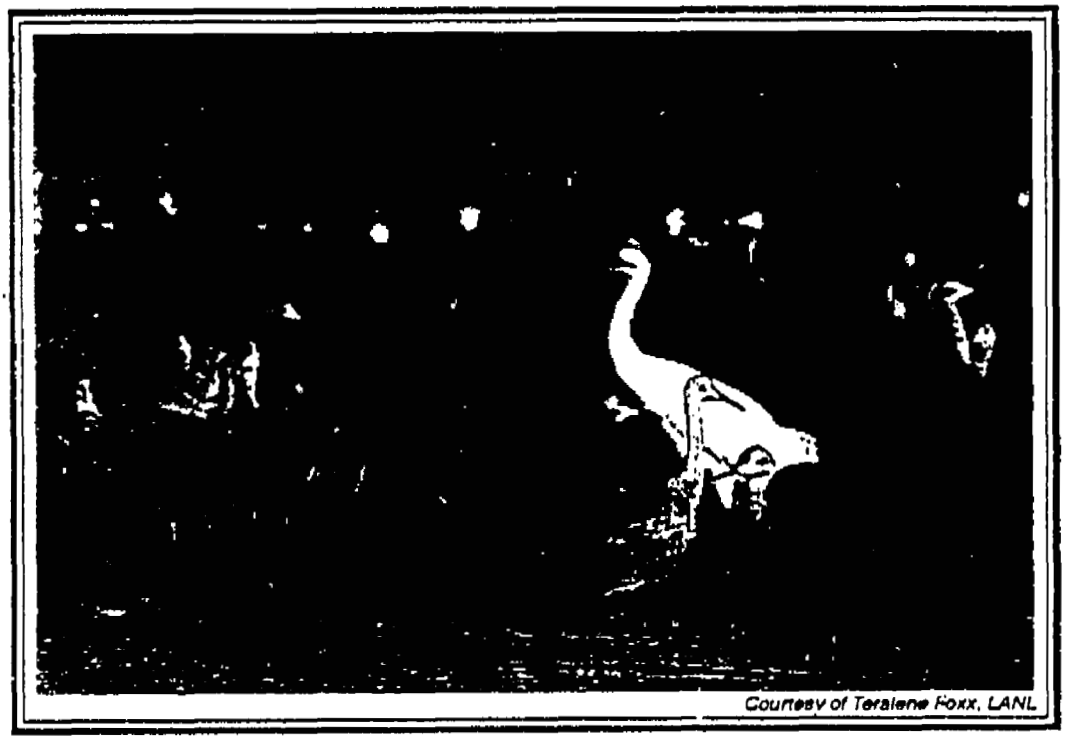
Courtesy of Teralene Foxx, LANL

WHOOPING CRANE

Grus americana

Status:

Federal endangered, State endangered.



Courtesy of Teralene Foxx, LANL

Description:

An adult whooping crane has an all-white plumage with black wingtips and red plumage on the forehead. With long legs and neck, an adult stands at about 132 cm (52 in.). The immature whooping crane is whitish with a reddish-brown head and neck.

Habitat:

River/Streams. The whooping crane roosts on sand bars, often returning to the same location year after year.

Occurrence:

The few remaining whooping cranes migrate along the Rio Grande and Cochiti Reservoir en route to southern New Mexico among flocks of sandhill cranes. These flocks are known to roost overnight in openings on mesas and on sand bars along their route. They are known to fly over but have not been confirmed to stop on Los Alamos National Laboratory lands.

JEMEZ MOUNTAINS SALAMANDER

Plethodon neomexicanus

Status:
Species of concern, State threatened.

Description:
The Jemez Mountains salamander is elongated, from 50 to 110 mm (2 to 5 in.), is brown with fine brassy striping, and has small fore and hind limbs. It can be identified by a hairline furrow that extends from the nostril to the edge of the upper lip.

Habitat:
Mixed Conifer. The Jemez Mountains salamander requires shaded and moist wooded canyon slopes with loose, rocky soils that are at elevations from 2,200 to 2,820 m (7,225 to 9,250 ft.).

Occurrence:
The presence of the Jemez Mountains salamander has been confirmed on Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands and is believed to be on Los Alamos National Laboratory lands as well.

Courtesy of Teralene Foxx, LANL

Peregrine Falcon

Falco peregrinus

Status:
Federal endangered, State endangered.

Description:
The peregrine falcon is a swift-flying raptor with gray and white plumage and a black nape and crown. The crown extends wedge shaped below the eyes, forming a distinctive helmet. An immature peregrine is dark brownish above and heavily streaked below.

Habitat:
Piñon/Juniper, Ponderosa Pine, Mixed Conifer, Riparian, Grassland. The peregrine falcon inhabits canyons with cliffs that are required for breeding. It ranges widely and preys on birds that are captured in flight.

Occurrence:
The peregrine falcon is a migrant and summer resident and has been confirmed on Los Alamos National Laboratory, Bandelier National Monument, Santa Fe National Forest, and Los Alamos County lands.

Corel Professional Photos

LOGGERHEAD SHRIKE

Lanius ludovicianus

Status:
Species of concern.

Description:
The loggerhead shrike resembles a mockingbird in size and appearance but is more bluish grey than the grey of a mockingbird. This bird is big-headed and slim-tailed with a black mask, an all-dark bill, and white, faintly barred underparts. A juvenile acquires adult coloring by the first fall but is paler and barred overall with brownish grey upperparts early on.

Habitat:
Juniper Savanna, Piñon/Juniper, Ponderosa Pine. Loggerhead shrikes prefer areas where they can hunt in fairly open or brushy terrain, diving from a low perch and swooping upward to another perch.

Occurrence:
The presence of the loggerhead shrike has been confirmed on Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands but not on Los Alamos National Laboratory lands.

Corel Professional Photos

SPOTTED BAT

Euderma maculata

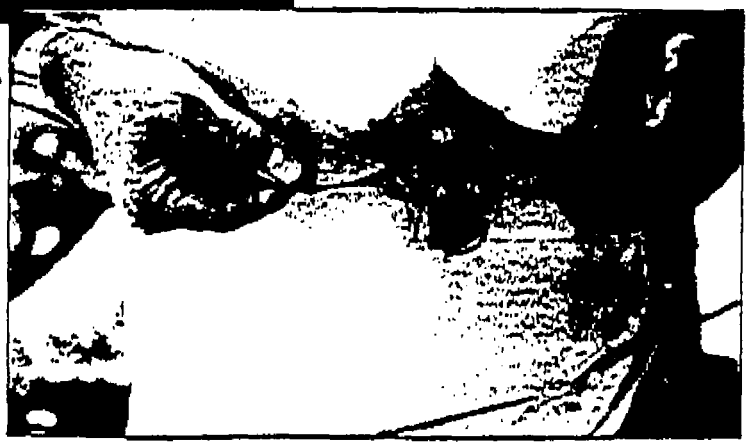
Status:
Species of concern, State threatened.

Description:
The spotted bat carries a unique white spot on its rump and each shoulder. It has huge pink ears and is dark sepia in color.

Habitat:
Riparian, Mixed Conifer, Piñon/Juniper, Ponderosa Pine. The spotted bat roosts in cliff crevices and other situations, often near water with an abundance of moths and other insects in the area.

Occurrence:
The presence of the spotted bat has been confirmed by capture at watering sites on adjacent lands of Bandelier National Monument and Santa Fe National Forest. Habitat and plant communities favored by the spotted bat are well represented within Los Alamos National Laboratory boundaries, and its distinctive echolocation calls have been heard on Los Alamos National Laboratory lands. The spotted bat has also been observed foraging in mixed Ponderosa Pine and Piñon/Juniper communities in Pueblo Canyon on Los Alamos County property.

Courtesy of Mike Bogan, National Biological Service



Big Free-Tailed Bat

Nyctinomops macrotis

Status:
Species of concern.

Description:
The big free-tailed bat is pale brown to black with a tail that extends beyond the tail membrane and ears that join at the midline of the forehead. With a wingspan of up to 42.5 cm (17 in.), this animal can be a swift, powerful flyer.

Habitat:
Piñon/Juniper, Ponderosa Pine, Mixed Conifer. This bat prefers canyon country that is rocky. It will roost in crevices of cliff faces and in rock hollows.

Occurrence:
The big free-tailed bat is a confirmed migrant on Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands.

Flathead Chub

Platygobio gracilis

Status:
Species of Concern.

Description:
The flathead chub is a fish that, in New Mexico, typically does not exceed 145 mm (inches) in length. This fish is scaled with an olivaceous colored back and sides that are silver. The head is broad in relation to its slender body and looks somewhat flattened. The dorsal and pectoral fins are sickle-shaped and the anal and pelvic fins are triangular.

Habitat:
The flathead chub can be found in rivers and larger streams with areas of highly turbid waters in moderate to strong currents. This fish is omnivorous but seems to prefer terrestrial insects.

Occurrence:
The flathead chub can be found in portions of the Rio Grande.

Gray Vireo

Vireo vicinior

Status:
State threatened.

Description:
The plumage of the gray vireo is gray above and white below. There is a white ring around the eye and two bars along the wings. Short wings give this bird the appearance of having a long tail.

Habitat:
Juniper Savanna, Piñon/Juniper, especially on rocky slopes. This bird will forage through the undergrowth, flitting restlessly from place to place and flicking its tail feathers.

Occurrence:
The presence of the gray vireo has been confirmed on Los Alamos County, Bandelier National Monument, and Santa Fe National Forest lands but not on Los Alamos National Laboratory lands.

Zone-Tailed Hawk

Buteo albonotatus

Status:
Species of local concern.

Description:
The zone-tailed hawk is a long-winged raptor that is black to dark grey in body. When perched, this bird's wingtips will extend back as far as the tail feathers. The wings are also dark in color but with a silvery tint, giving the underwing a two-tone appearance. In flight, it strongly resembles the turkey vulture (*Cathartes aura*). On the tail feathers the male has one wide and one slender whitish band and the female has two slender bands. The legs and the cere are bright yellow.

Habitat:
This buteo is relatively uncommon, but is widely distributed in Latin America and in the southwestern United States. In the US, it is most commonly found in the southern and central portions of Arizona and New Mexico. The zone-tailed hawk prefers mesa or mountain country where there are rivers or streams. Swooping down from a low glide, this hawk will prey upon rodents, lizards, fish, frogs, and small birds.

Occurrence:
The presence of the zone-tailed hawk has been confirmed on Los Alamos National Laboratory and Bandlier National Monument lands.

Information for profiles was derived from *Field Guide to the Birds of North America*, Scott, Ed., 2nd ed., (National Geograghic Society, Washington, D. C. 1985); *Western Birds*, Peterson, Ed., 3rd ed., (Houghton Mifflin Company, Boston 1990); *Mammals*, Peterson, Ed., 3rd ed., (Houghton; Mifflin Company, Boston 1980); *Field Guide to Orchids of North America*, Williams and Williams, (Universe Books, New York 1983); *The Encyclopedia of Mammals*, Macdonald, Ed., (Facts on File Publications, New York 1984); *Flowering Plants of the Southwestern Woodlands*, Foxx and Hoard, (Otowi Crossing Press, Los Alamos, New Mexico 1984); ESH-20 field notes; and first-person knowledge from the Ecological Studies Team members of ESH-20.

Threatened and Endangered Species Surveys and Habitat Management at Los Alamos National Laboratory

(National Environmental Research Park)

David C. Keller
James R. Biggs
Terrell H. Johnson

LA-UR-96-3444

Mexican Spotted Owl

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Abstract

During the 1994, 1995, and 1996 field seasons, three primary areas at Los Alamos National Laboratory were surveyed for the Mexican spotted owl (*Strix occidentalis lucida*). The surveys revealed a nesting pair of owls that subsequently fledged a pair of young during two of the years.

1.0 Introduction

The Mexican Spotted owl was designated a federally threatened species on April 15, 1993. Mexican spotted owls are between 41 to 48 cm (16 to 19 in.) in length with white spots on the head and back and white horizontal stripes on the chest and no ear tuffs. This owl is one of two species, the other being the flammulated owl (*Otus flammeolus*), in the southwest that has completely dark eyes (National Geographic Society 1983).

The Mexican spotted owl inhabits mixed-conifer and ponderosa pine-Gambel oak forests in mountains and canyons in the southwestern United States and northern Mexico. High canopy closure, high stand diversity, multilayered canopy resulting from an uneven-aged stand, large, mature trees, downed logs, snags, and stand decadence as indicated by the presence of mistletoe are characteristic of Mexican spotted owl habitat. This owl requires approximately 800 ha (2000 acres) of suitable habitat to insure reproductive success. In addition, spotted owls favor narrow, steep canyons where there is little light penetration and cool temperatures. They tend to prefer north-facing slopes and to nest in trees, crevices, or small caves (USDI Fish and Wildlife Service 1995, Travis 1992).

During the 1994, 1995, and 1996 breeding seasons, I surveyed the canyons in the western portion of Los Alamos National Laboratory (LANL) as part of the mitigation measures for the construction of the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility and as part of the development of the Threatened and Endangered Species Habitat Management Plan. During the course of these surveys, a pair of Mexican spotted owls was located in 1995 and in 1996. In both years, nests were found, each with two young that ultimately fledged. Based on the proximity of each nest location, it is reasonable to assume that this is the same pair of owls. They continue to be the only pair utilizing LANL lands for breeding.

Terrell Johnson (1994), a recognized spotted owl authority, developed a topographic model of potential spotted owl habitat in New Mexico and is in the process of developing a similar model to be used for LANL. Results from initial modeling indicate three areas within Laboratory boundaries that could have potential owl habitat. All of the areas indicated in this model have been monitored for at least two years and occupied habitat will continue to be monitored on a yearly basis.

2.0 Methodology

Surveying for the Mexican spotted owl follows the USDA Forest Service protocol. Once an area of potential habitat is identified based on habitat type, a survey route is planned. A route is designed to cover all of the available habitat within 0.8 km (0.5 mi) of the calling route. From approximately 2 AM until sunrise, surveys are performed by broadcasting the call of the spotted owl and waiting for an owl to respond. The surveyor will walk a canyon edge or bottom and play the call to cover the habitat in the area of the survey. The area is covered completely in one survey outing. Once an owl is found, the preliminary surveys can be discontinued and more intensive nest location surveys can begin. All owl species detected during the survey are recorded. Table 1 shows the results of the surveys conducted in 1994, 1995, and 1996. The biologist records the time, species, and the location of each owl detected.

Once a Mexican spotted owl is located, the next step is to discover if there is a pair of owls and if they have a nest in the location of interest. The owl, after detected during a night survey, is usually followed until dawn, and a physical description of the area where the owl quit calling and the location are recorded. The area where the owl is near dawn is the most likely roost location. If a pair has young, the owl is usually near the nest location. Once a roost location is suspected, the next day the biologist searches the area for any evidence of nests or a pair of owls. Droppings, pellets, and the remains of dead prey can be a clue to the nest location. The next step is for the biologist to give the owl under surveillance a mouse. In the mousing process one or both owls are given a mouse and the biologist follows an owl to determine the fate of the mouse. Only male mice are used to ensure that a non-native mouse species is not introduced to the study area. When the female owl is given a mouse, she will then usually take this mouse to a nest, revealing its location. The male owl will often give the mouse to the female and the nest can be located. If the mouse is consumed or stored by the owl, nesting might not be taking place but further mousing is conducted to confirm that the pair is not nesting. Once several mousing attempts, noting male and female owl behavior, result in no nest being located, it is reasonable to assume that a pair is not nesting. If an area is surveyed and no owls are found, a series of 4 or more surveys per breeding season is required for two years before a site can be cleared for disturbance activities during the spotted owl breeding season.

3.0 Results

During the 1994, 1995, and 1996 field seasons, 22 regular call broadcast surveys were conducted at LANL. Of these surveys, 7 of them resulted in the detection of a Mexican spotted owl. All of these located endangered owls were in or near the same canyon complex. Following the identification of the roosting locations, two or three additional field outings were required to locate the owl pair and the nestlings. The first and second trip to the nest area revealed a pair of adult owls and chicks on the nest. The third visit revealed the adult owl pair and two chicks out on a tree away from the nest. Once the nest location was confirmed, physical measurements were established as to the makeup of the nest location. Castings, owl pellets, are collected at the site to determine the prey abundance and characteristics of the owls diet.

Date of Survey	Location of Survey	Result of Survey
6/30/94	Study Site (SS) 1	None
7/18/94	SS 1	None
8/3/94	SS 1	None
8/23/94	SS 1	None
5/10/95	SS 2	Great Horned Owl (4) Flammulated Owl (1)
5/16/95	SS 2	Mexican Spotted Owl (1) Great Horned Owl (1)
5/18/95	SS 3	Mexican Spotted Owl (2) Great horned Owl (2) Flammulated Owl (1)
5/23/95	SS 2	Flammulated Owl (1)
5/25/95	SS 3	Flammulated Owl (1) Great horned Owl (1)
6/2/95	SS 2	Great Horned Owl (2) Flammulated Owl (1)
6/8/95	SS 3	Mexican Spotted Owl (2)
6/15/95	SS 3	Northern Pygmy-Owl (1) Mexican Spotted Owl (1) Great Horned Owl (1)
6/22/95	SS 1	Great Horned Owl (1)
7/6/95	SS 1	None
7/27/95	SS 1	None
8/9/95	SS 1	None
4/26/96	SS 3	Great Horned Owl (2) Mexican Spotted Owl (1)
5/1/96	SS 2	Northern Pygmy-Owl (1)
5/7/96	SS 3	Great Horned Owl (1) Mexican Spotted Owl (1) Northern Pygmy-Owl (1)
5/17/96	SS 2	None
6/5/96	SS 2	Northern Pygmy-Owl (1)
6/25/96	SS 2	Mexican Spotted Owl (1)

Table 1. Results of the three years of Mexican spotted owl surveys.

4.0 Conclusions

For the second year in a row a pair of Mexican spotted owls at LANL have successfully reared and fledged a pair of chicks. The environment is currently protected from major disturbance and continued protection of this environment will ensure that LANL will play a role in the conservation and recovery of the Mexican spotted owl. The lands of LANL are capable of supporting more than one pair of Mexican spotted and an aggressive monitoring program will ensure that biologists know the location of nesting birds and are able to assist in the planning of projects that could be impacted by the location of these birds. The continued monitoring of owl nest locations will be a valuable tool to planners to ensure that owls and the mission of the Laboratory can coexist.

Acknowledgments

I wanted to thank Rhonda Robinson, Saul Cross, Kathy Bennett, Dan Dunham, and Terry Foxx for getting up early and stumbling around in the dark to see if we could hear some owls.

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Southwestern Willow Flycatcher

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Abstract

During the 1995 and 1996 field seasons, two primary areas were surveyed for the southwestern willow flycatcher (*Empidonax traillii extimus*). The areas searched were Pajarito Canyon and the Rio Grande near Buckman Crossing. The southwestern willow flycatcher was not found.

1.0 Introduction

The southwestern willow flycatcher is listed as federally and state endangered, making the federal list on March 29, 1995. This species has experienced extensive loss and modification of its habitat and is also endangered by nest parasitism by the brown-headed cowbird (*Molothrus ater*).

The southwestern willow flycatcher is a small insectivorous bird, approximately 15 cm (5.75 in.) long. It has a grayish-green back and wings, whitish throat, light gray-olive breast, and light yellowish belly. Two wingbars are visible and an eye ring is faint or absent. The upper beak is dark and the lower is light. The song is a wheezy "fitz-bew" or "fit-za-bew," the call a repeated "whitt."

The breeding range of the southwestern willow flycatcher includes southern California, southern Nevada, southern Utah, Arizona, New Mexico, western Texas, and northern Mexico. The southwestern willow flycatcher winters in Mexico, Central America, and northern South America.

The nest is a compact cup of bark and grass with feathers on the rim lined with a layer of grass or silky plant material. It is located in a fork or on a horizontal tree branch 1 to 4.5 m (3.2 to 15 ft) above ground in a medium-sized bush or small tree, with dense vegetation all around the nest.

Southwestern willow flycatchers inhabit areas near water with 4- to 7-m- (13- to 23-ft-) high thickets of willow (*Salix* spp.), buttonbush (*Cephalanthus occidentalis* var. *pubescens*), seepwillow (*Baccharis glutinosa*), and tamarisk (*Tamarix pentandra*) (Tibbitts et al. 1994). There is occasionally a sparse overstory of cottonwoods (*Populus* spp.) associated with this species. At some nest sites surface water may be present early in the breeding season but only damp soil is present by late June or early July. Habitat patches as small as 0.5 ha (1.2 ac) can support one or two nesting pairs. This species has not previously been found on Los Alamos National Laboratory (LANL) property or Los Alamos County. Areas in lower Pajarito Canyon near Pajarito wetlands contain marginal southwestern willow flycatcher habitat.

The southwestern willow flycatcher is present and singing on breeding territories by mid-May. This flycatcher builds nests and lays eggs in late May and early June and fledges young in early to mid-July. During the 1995 and 1996 breeding seasons, monitoring of the potential southwestern willow flycatcher habitat did not reveal the presence of any of this protected species. To date, in two consecutive years of surveys, this flycatcher has not been found on LANL lands.

2.0 Methodology

The following steps are taken in a southwestern willow flycatcher survey. Once an area of potential habitat is identified, a survey route is planned. A route is designed to cover all of the available habitat. The survey for the southwestern willow flycatcher begins at dawn and continues until the survey area is completed. Surveys are performed by broadcasting the call of this flycatcher and waiting for it to respond. The surveyor walks a wetland area and plays the call enough to cover the habitat in the area of the survey. Preliminary surveys can be discontinued once a flycatcher is found. More intensive nest location surveys can then begin. The physical description of the site and the nest location are recorded but the nest site is not disturbed.

If an area is surveyed and no flycatchers are found, a series of 4 or more surveys per breeding season is required. Only then is a site cleared for disturbance activities during the breeding season.

3.0 Results

During the 1995 and 1996 field seasons, 10 regular call broadcast surveys were conducted at LANL and adjacent lands. Of these surveys none of them resulted in the location of a southwestern willow flycatcher. Table 1 shows the results of the surveys conducted in 1995 and 1996.

4.0 Conclusions

For the second year in row no southwestern willow flycatchers were located at LANL. Although the existing habitat at LANL is marginal at best, I believe it should be periodically monitored for future colonization by this species. The land cover mapping will provide a tool to define potential habitat (Koch et al. 1996). Once habitat is established on a map, any potential conflicts between LANL activities and endangered species can be dealt with very early in the planning stages of a habitat disturbing activity.

Date of Survey	Location of Survey	Result of Survey
6/14/95	Pajarito Canyon	None
6/22/95	Rio Grande	None
7/13/95	Pajarito Canyon	None
7/19/95	Rio Grande	None
5/30/96	Pajarito Canyon	None
5/31/96	Rio Grande	None
6/13/96	Rio Grande	None
6/14/96	Pajarito Canyon	None
7/17/96	Pajarito Canyon	None
7/18/96	Rio Grande	None

Table 1. Results of 1995 and 1996 southwestern willow flycatcher surveys.

Acknowledgments

I wanted to thank Rhonda Robinson, Saul Cross, Dan Dunham, and John Huchton for getting up early and battling the mosquitoes to try and find this bird.

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Goat Peak Pika, Black-Footed Ferret, and New Mexico Meadow Jumping Mouse

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Abstract

Potentially endangered mammal species of concern for Los Alamos National Laboratory (LANL) include Goat Peak pika (*Ochotona princeps nigrescens*), black-footed ferret (*Mustela nigripes*), and New Mexico meadow jumping mouse (*Zapus hudsonius*). Pikas commonly occur within the Jemez Mountains including Frijoles Canyon, the Cerro Grande, and Pajarito Mountain. This species is more common in this area than previously recognized. New activities by the Laboratory are expected to result in a low potential for impact to suitable habitat for this species. Meadow jumping mice are found close to permanent water and wet meadows. Suitable habitat for this species is limited on LANL property. Several surveys have been conducted since 1990 with no specimens having been captured to date. Black-footed ferrets usually inhabit large prairie dog towns which serve as a food source. However, no expansive prairie dog towns have been found on LANL property, therefore, the potential for this species to occur here is low. Suitable habitat on LANL property for Goat Peak pika and meadow jumping mouse will need to be evaluated following the development of a detailed vegetation map of this area. Appropriate surveys can then be conducted to determine presence/absence.

1.0 Introduction

Other than some bat species, three species of mammals listed as threatened, endangered, or species of concern (SOC) may occur in habitats in the Los Alamos National Laboratory (LANL) area or in the east Jemez Mountains. These species are the Goat Peak pika (*Ochotona princeps nigrescens*), black-footed ferret (*Mustela nigripes*), and New Mexico meadow jumping mouse (*Zapus hudsonius*).

1.1 Goat Peak Pika (SOC)

The Goat Peak pika is generally nocturnal. Pikas occur commonly within the Jemez Mountains on patches of large talus slopes on higher peaks, small rocky areas at the head of Frijoles Canyon, older talus slopes of Cerro Grande, and exposed ski slopes of Pajarito Mountain (Swickard et al., 1971; Hafner, pers. obs.). Areas most heavily populated by pikas are the Tschicoma Mountain and eastern rim of the Valles Caldera, Rabbit Mountain, Redondo Peak, and Cerros del Abrigo. Disturbance activities exposing talus such as logging and ski slope construction have also produced suitable habitat for pikas.

1.2 New Mexico Meadow Jumping Mouse (SOC, State Threatened)

Known populations of meadow jumping mouse in New Mexico have been found close to permanent free-flowing water, in riparian zones of streams and ditches, and in wet meadows near cattail marshes associated with major rivers (Morrison 1990, 1992). Dry higher ground near waterways that provide locations for nesting and hibernation are typical of habitat where jumping mice have been found.

1.3 Black-Footed Ferret (Federal Endangered)

Black-footed ferrets are most commonly associated with prairie dog towns (*Cynomys* spp.) in the western U.S. Prairie dogs serve as the main food source for black-footed ferrets. During winter months black-footed ferrets move from burrow to burrow feeding on hibernating prairie dogs. Prairie dog towns, none of which have been found within or near LANL, vary in size but are usually found in relatively open terrain where vegetation does not hinder the line of sight to predators.

2.0 Methodology

2.1 Goat Peak Pika

No formal surveys have been conducted on LANL property for the Goat Peak pika. However, numerous surveys in the Jemez Mountains, including the eastern portion, have revealed localized high numbers of this species (Hafner, pers. com.; Hafner 1993, 1994, 1995; Swickard et al. 1971). Specific methodology for surveying this species will be based on evaluations of cover and community types at LANL. Once suitable habitat has been identified, a site evaluation will be made and, if deemed necessary, formal surveys for this species will be performed. The need to perform surveys and the type of survey used for Goat Peak pikas will depend on the presence and extent of suitable open talus and rocky areas on LANL property. This information will be obtained from land cover maps that will be produced during the FY '97 scope of work.

2.2 New Mexico Meadow Jumping Mouse

The major activity period for meadow jumping mice in the Jemez Mountains-Espanola area is June through September, with breeding occurring between May and September (NMDGF 1988). Since 1990, areas of potential habitat have been surveyed using a snap trap protocol developed by Morrison (1990). These surveys took place at locations that were evaluated as being the most suitable habitat available on LANL property. A minimum of four consecutive nights of snaptrapping was used. Traps were spaced at 10-m (33-ft) intervals with three traps per station along a stream channel or within other appropriate habitat. Aluminum

Sherman live traps with the dimensions 22.5 x 7.5 x 30 cm (9 x 3 x 12 in.) and baited with sweet feed were also used. Traps were baited in late afternoon and set on a level surface under cover for protection from exposure to heat and precipitation. Traps were left open overnight to capture animals, then checked early the next morning.

2.3 Black-Footed Ferret

No surveys have been conducted on LANL property for black-footed ferrets due to an apparent lack of suitable habitat. Preliminary surveys will be conducted to determine if prairie dog towns exist on or adjacent to LANL property. Formal surveys for black-footed ferrets are conducted on towns that are greater than 80 acres in size or a complex of towns greater than 80 total acres that are less than 5 miles apart from one another (WCFW 1988). Survey methodology differs from warmer months to cooler months. During periods of snow cover, surveys consist of daytime surveys where tracks, scat, and burrowing activity are the primary focus of search. Burrows have a distinct formation unique to this species. During periods of non-snow cover, a series of surveys are conducted over three consecutive nights. The surveys consist of a complete check of the prairie dog town by use of spotlighting and burrow checks. Activities resulting in disturbance of any part of a prairie dog town, or any part of a complex of towns, will require an indepth survey.

3.0 Results

3.1 Goat Peak Pika

This is a common species within its desired habitat and is more common than previously recognized for this area (Hafner, pers. comm.). Loss of appropriate habitat can occur by increasing moisture in dry areas which promotes invasion of vegetation that fills the talus slopes. If new activities around the Laboratory result in disturbance of presently undisturbed ground, there will likely be a low potential for impact to habitat to this species.

3.2 New Mexico Meadow Jumping Mouse

Meadow jumping mouse surveys were conducted in habitat on LANL property evaluated to likely support this species. Although no individuals were found to date, more extensive and thorough evaluation of potential habitat will be conducted following the development of a detailed land cover map.

3.3 Black-Footed Ferret

The presence of the black-footed ferret has not been reported in New Mexico since 1934. During various vegetation surveys performed in and around LANL property over the last 20 years, no prairie dog towns have been observed. No formal surveys for the presence of prairie dogs have been conducted on LANL property. If prairie dog towns are identified, a more extensive survey will be done.

4.0 Conclusions

Three of the threatened, endangered, or SOC mammal species identified as potentially occurring in the LANL area, the Goat Peak pika, meadow jumping mouse, and black-footed ferret have not been found on LANL property. However, the Goat Peak pika and the meadow jumping mouse are known to inhabit this region in habitats similar to what is found on or around LANL property. Additional surveys will be needed to determine presence/absence of these species on LANL property. The black-footed ferret is extremely rare and likely does not occur in this area, however, surveys will be necessary to determine if extensive prairie dog towns (>80 acres) occur in or near LANL. If so, more extensive surveys will need to be conducted to determine presence/absence of this species.

Surveys for any of these species will not be conducted until completion of the land cover map. This map will aid in identifying and delineating the extent of potential habitat that could support these species.

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Bald Eagle Habitat Management in the Los Alamos National Environmental Research Park

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Abstract

Bald eagles *(Haliaeetus leucocephalus)* winter along the Rio Grande but are not known to nest in the area. Most wintering bald eagles congregate downstream from the Los Alamos National Environmental Research Park (LA/NERP), but the LA/NERP contains winter foraging and roosting habitat and potential nesting habitat. As bald eagles become more numerous and the river delta above Cochiti Lake expands, bald eagle use of LA/NERP is expected to increase. Potential nest and roost trees in White Rock Canyon have been mapped and will be monitored annually for signs of use. Sensitive zones around these trees have been mapped to trigger review of potentially disturbing activities. Interagency coordination will increase the effectiveness of bald eagle habitat management in the area.

1.0 Introduction

The bald eagle is federally listed as threatened throughout the lower 48 states and equivalently listed by the state of New Mexico as endangered (group 2). Bald eagles winter along the Rio Grande, including Department of Energy (DOE) land in and around White Rock Canyon, and several dozen often congregate downstream near Cochiti Lake. Some are resident from November through March, but others move about, and peak numbers usually occur in January or early February. Bald eagles forage for fish and waterfowl along the river and lake and for carrion and rabbits over land. While they forage most often in the vicinity of Cochiti Lake, they use all of White Rock Canyon regularly and the entire Pajarito Plateau occasionally. Bald eagles roost overnight in canyons that offer weather protection, security, and convenience to foraging areas, usually in tall ponderosa pines in lower portions of tributary canyons. Bald eagles around Cochiti Lake behave as if they are hunted, weaving and dodging in flight to avoid people. Evacuation of foraging and roosting areas in response to human presence within 200 to 800 meters (660 to 2640 ft) is typical behavior. Because few bald eagles nest in New Mexico, their nesting habitat is not well characterized, but a secure tree or cliff nest site near suitable aquatic habitat is probably required.

Several agencies have funded or conducted studies of bald eagles in this area. Johnson (1993) has monitored bald eagle winter population and diet near Cochiti Lake since 1979, funded by the National Park Service, US Army Corps of Engineers (COE), US Forest Service (USFS), and US Bureau of Reclamation. The USFS funded a study of bald eagles by Dodd (1979) in White Rock Canyon, and Public Service Company of New Mexico funded a study by Stahlecker (EES 1986) in the upper portion of White Rock Canyon. The New Mexico Department of Game and Fish has performed mid-winter fixed-wing aerial counts of bald eagles almost every year since 1978, and the COE has performed helicopter counts most years since 1984. LANL funded a survey for roosting and potential nesting habitat on the LA/NERP in 1992.

2.0 Methodology

Roosting counts provide the most effective way to census wintering bald eagles, which tend to congregate at regular roosts (Johnson 1993). Late afternoon and early morning counts along flyways to and from roosts are more effective than counts of eagles at roosts, where growing darkness and the distance required to avoid disturbance limit visibility. Aerial counts cover more ground and sample aquatic foraging areas, but tend to detect relatively fewer immature eagles. Collection of castings and other prey remains under roost trees provide the most comprehensive picture of diet, but underrepresent the absolute proportion of fish in the diet. Late winter surveys of suitable roost trees for accumulated castings, feathers, and droppings have proven to be the most efficient method of documenting occasional use of trees for roosting and perching.

3.0 Results

Winter roosting counts of bald eagles in the Cochiti area have generally increased over the years (Johnson 1993), as have the statewide aerial counts (S.O. Williams III, pers. comm.). Since 1979, average winter counts near Cochiti have doubled (Figure 1). As total counts have increased, the number of bald eagles using areas farther upstream has also increased. Over the same period, the wetland habitat of the delta above Cochiti Lake has expanded to about 12 km (7.2 mi) of delta between Frijoles Canyon and the lake in the 20 years since the lake was filled. This delta provides diverse aquatic and wetland habitat for fish, wintering waterfowl, and bald eagles (Allen 1993). Castings indicate that wintering bald eagles consume fish, waterfowl, and significant amounts of carrion, especially deer and elk. Water management may affect bald eagle habitat (Johnson 1988), especially that of the delta wetlands.

A survey of potential roost trees near the mouths of Water, Ancho, and Chaquehui Canyons in March 1992, indicated occasional bald eagle use of trees near the mouth of Water and Chaquehui Canyons, as droppings but no castings or feathers were found. The same habitat has potential for nesting. Bald eagle use of the Pajarito Plateau is too sparse to study or to attract much attention, but a detailed report of an immature bald eagle in Los Alamos Canyon above the Omega reactor (A. Kron, pers. comm.) and a number of reports of bald eagles seen along State Highway 4 west of the Bandelier entrance illustrate that use does occur.

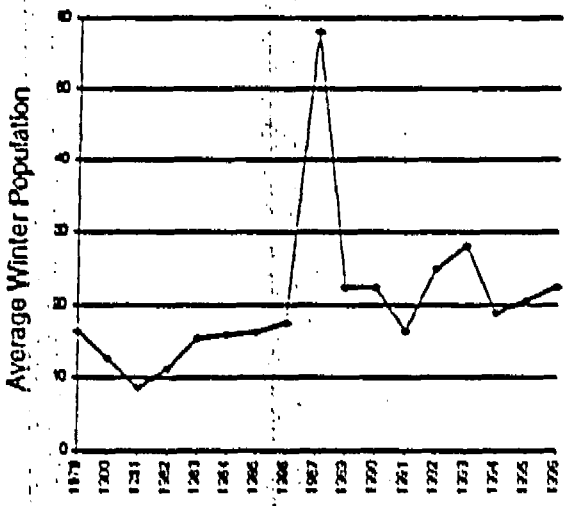


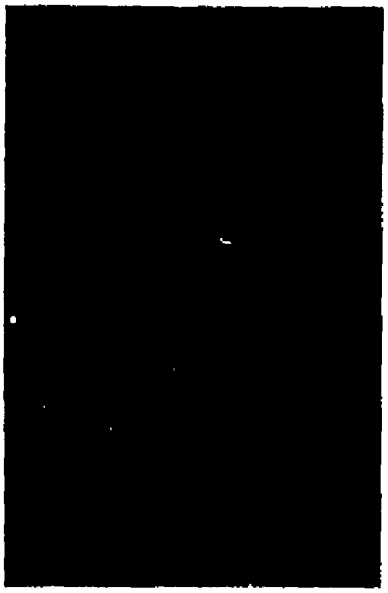
Figure 1. Average numbers of bald eagles roosting near Cochiti Lake during the winters of 1979–1996. An increasing trend underlies annual variations, which are dependent on water management and weather (Johnson 1993).

Fifteen suitable roost and five potential nest trees in the lower tributary canyons and sensitive zones extending up to 1700 m (5610 ft) from roost and 900 m (2970 ft) from potential nest trees were mapped in 1992 (Johnson 1992). Sensitive zones indicate an area in which LANL activities should be reviewed for potential impact on roosting (November 1 – March 31) or nesting (January 1 – July 31) bald eagles, and outside of which no effect is anticipated.

4.0 Conclusions

Bald eagle use of DOE land in White Rock Canyon should increase as the Cochiti Lake delta continues to expand upstream and numbers of wintering eagles increase. Indications of bald eagle use on DOE land in White Rock Canyon in 1992 were too slight to justify direct bald eagle counts, but annual surveys for signs of use is an appropriate method to monitor and document bald eagle winter use there. Infrequent and scattered use of terrestrial areas does not justify direct survey for bald eagles in terrestrial areas, but management planning should recognize that it does occur at low levels, and may be associated with elk or deer carrion. Likewise, bald eagle nesting in White Rock Canyon or adjacent areas is a possibility that should not be discounted.

Sensitive zones should be used to flag review of LANL activities to prevent disturbance of roosting or nesting bald eagles. Potentially disturbing activities should be scheduled outside of the sensitive season, unless non-occupancy has been determined at that time. These zones are mainly undeveloped and should remain so. LANL land-use planning should also recognize the contribution of terrestrial foraging areas, and cluster future developments to maintain large blocks of open land, especially near White Rock Canyon. Water management agencies have increasingly involved land and wildlife management agencies in water management decisions, and an interagency group has developed an ecological framework for managing the Cochiti delta wetlands (Allen 1993). The DOE and LANL should continue to participate in the Cochiti Lake Advisory Committee, which is now being organized to provide ongoing input into river and reservoir management.



Acknowledgments
S.O. Williams III of the New Mexico Department of Game and Fish has kindly provided summaries of mid-winter counts of bald eagles throughout New Mexico.

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Golden Eagle Habitat Management in the Los Alamos National Environmental Research Park

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Abstract

Golden eagles *(Aquila chrysaetos)* regularly breed in White Rock Canyon and have nested in the Los Alamos National Environmental Research Park (LA/NERP). A sensitive zone around an historic nesting cliff has been mapped to trigger review of potentially disturbing activities.

1.0 Introduction

The golden eagle is not federally or state listed but is uncommon in the area and is protected under the Bald Eagle Act, as amended in 1962. The Los Alamos breeding bird atlas acknowledged historic records of golden eagles breeding in Los Alamos County, but found none breeding during 1984–88 (POS 1992). Golden eagles are usually present in White Rock Canyon during the breeding season, which begins in early February and extends through the end of July and sometimes during the rest of the year. They forage primarily for small mammals such as rabbits and occasionally larger mammals or waterfowl. Golden eagles usually build stick nests on cliffs, sheltered by an overhang, and generally lay eggs in early March and fledge one young in late June. The narrow part of White Rock Canyon above the mouth of Frijoles Canyon appears to be a center of breeding activity, where nests have been found on two different cliffs, one of which was located in the LA/NERP in 1979 (Johnson 1991). A breeding territory will typically contain several nest sites that are used periodically, but breeding does not occur every year.

2.0 Methodology

Observation of suitable nesting cliffs during the breeding season is the most effective way to determine use by golden eagles. Observation at a range of about 400 m (1320 ft) early in the season, especially early in the morning, provides the best opportunity of detecting activity at a cliff, which does not always lead to nesting. Scanning stick nests on cliffs with a powerful spotting scope from a high vantage point is an efficient method of discovering nesting eagles later in the season, but concluding that a nesting cliff is vacant requires observation at close range.

3.0 Results

Golden eagles have not been found breeding in the LA/NERP since 1979, but no consistent monitoring has occurred. The LA/NERP historic nesting cliff was checked but not found to be occupied in 1994. However, golden eagle use of the area continues, as an adult and immature golden eagle were seen separately in the area in August 1996 (B. Foy, pers. comm.).

A sensitive zone extending up to 900 m (2970 ft) from the historic nesting cliff was mapped in 1992 (Johnson 1992). The sensitive zone indicates an area in which LANL activities should be reviewed for potential impact on nesting golden eagles from February 1 – July 31, and outside of which no effect is anticipated.

4.0 Conclusions

Golden eagle use of Department of Energy land near White Rock Canyon can be expected to continue, with occasional nesting in the LA/NERP. Annual surveys for signs of use is an appropriate method to monitor and document golden eagle nesting. The sensitive zone should be used to flag review of LANL activities to prevent disturbance of nesting golden eagles. Potentially disturbing activities should be scheduled outside of the sensitive season, unless non-occupancy has been determined at that time. This zone is mainly undeveloped and should remain so. LANL land-use planning should also recognize the contribution of terrestrial foraging areas and cluster future developments to maintain large blocks of open land, especially near White Rock Canyon.

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Peregrine Falcon Habitat Management in the Los Alamos National Environmental Research Park

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Abstract

Suitable breeding habitat for the American peregrine falcon *(Falco peregrinus anatum)* is located in and around the Los Alamos National Environmental Research Park (LA/NERP), and the entire area is foraging habitat. Statewide, the peregrine population is increasing, but has experienced a recent decline in reproduction, which threatens to reverse this population trend. If peregrine falcons continue to increase in New Mexico, peregrine use of the LA/NERP is expected to increase. Suitable breeding areas in and around the LA/NERP have been identified, and the most important sensitive zones have been mapped to trigger review of potentially disturbing activities. A habitat management plan has been drafted for some suitable breeding habitat, which will require interagency cooperation to complete.

1.0 Introduction

The American peregrine falcon is federally and state listed as endangered. Peregrine falcons nest on cliffs with defensible and protected nest ledges that are in good foraging habitat. Peregrine breeding habitat occurs throughout the mountains of New Mexico, including lands in and around the Los Alamos National Environmental Research Park (LA/NERP). Peregrine falcons forage up to 20 km (12 mi) from nesting areas, almost entirely for birds, which are attacked and caught in the air. Avian prey is vulnerable when it is without cover, which may occur in a large gulf of air, as found over a canyon or over large grasslands or bodies of water. They are resident from early March through mid October. Breeding peregrine falcons have been increasing in New Mexico for more than a decade, but pesticides evidently continue to impair reproduction, and occupancy of breeding territories remains below recovery levels (Johnson 1995).

By agreement among the wildlife and major land management agencies in New Mexico, all suitable peregrine habitat is managed as if occupied, in the absence of a current determination of vacancy. Suitable habitat has been identified throughout much of the state, based on an objective evaluation of historic habitat. The suitable habitat approach has proven to be the most efficient and effective management strategy because it maintains the distinction between the relative permanence of habitat and transience of habitat use by individuals of the species. It maintains habitat for population expansion and protects peregrines wherever they may breed. At the same time, it permits coordination of other activities in a predictable manner. Attempts to coordinate activities based on occupancy in any given year have proven complicated and inefficient, and have usually disappointed expectations and resulted in more disclosure than predetermined habitat management.

Observations have shown how peregrines respond to human activity (Johnson 1988). Disturbance can prevent birds from occupying habitat or cause mortality of young by interrupting essential parental care. Nesting areas in New Mexico with frequent human activity are generally occupied irregularly, and peregrines in areas with occasional disturbance suffer reproductive failure more often than those in undisturbed areas (Johnson 1994a). While pesticide impacts on reproduction result from national or international factors, local management of peregrine habitat focuses on minimizing disturbance and maintaining habitat quality. Preserving the confidentiality of nesting areas is essential to minimizing disturbance because the peregrine has such notoriety that disclosure inevitably results in disturbance.

In cooperation with the US Fish and Wildlife Service and federal land management agencies, the New Mexico Department of Game and Fish takes the lead in monitoring and compiling information on peregrine falcons in New Mexico. LANL has been coordinating peregrine habitat management with state and federal wildlife agencies for two decades, supporting habitat monitoring and ensuring that activities do not impact habitat, individuals, or the species.

2.0 Methodology

Suitable nesting areas are monitored for occupancy and nesting activity by observing with binoculars and spotting scope from a distance of typically 450 meters (495 yds). This allows complete aural and visual observation of nesting activity and resolution of individual plumage characteristics with minimal disturbance (Johnson 1988b). Nesting areas are visited at least twice every year, but as often as necessary to determine occupancy and reproduction. Results have been standardized by having four highly experienced observers do nearly all the peregrine monitoring in the state. Individual plumages can be used to determine identity, and are recorded whenever possible.

Habitat identification is based on analysis of foraging and nesting topography and cliff characteristics associated with peregrine falcon breeding areas (Johnson 1993). Factors of elevation and slope model prey abundance, diversity, and vulnerability to index the suitability of breeding territories, and factors of cliff size, structure, position, and temperature index the suitability of nesting cliffs. Four sensitive zones around each suitable nesting area have been defined relative to peregrine responses to disturbance and extend from 900 m (990 yd) up to 3400 m (3740 yd) from suitable nesting cliffs (Johnson 1983). These zones are used to evaluate and schedule activities occurring in the zones, to prevent disturbance (Johnson 1994).

3.0 Results

Sensitivity of the information precludes disclosure of local monitoring data, which are not statistically significant by themselves but are consistent with statewide data. Occupancy of breeding habitat in New Mexico has increased since 1980, but reproduction has declined since 1988 (Figure 1). Recent reproduction has been just above the level required to maintain the population, and if it continues to decline, the population will soon begin to decline (Johnson 1995).

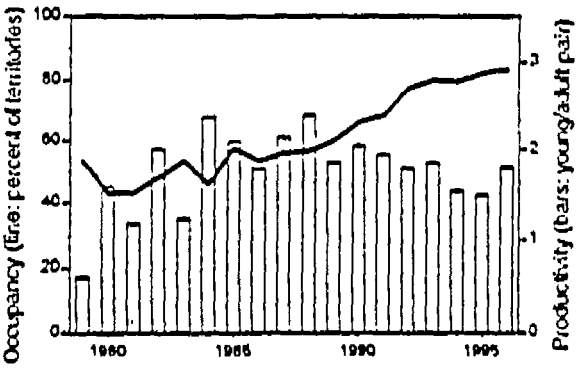

Figure 1. Occupancy of historic breeding territories by any peregrine (line) and reproduction by adult pairs (bars) in New Mexico during 1979–1996. Occupancy represents population, and has been increasing, but the trend depends on prior reproduction, which has recently declined close to the minimum maintenance level (Johnson 1995).

Habitat identification in and around the LA/NERP began in 1979 and has continued as habitat criteria have been refined since. A number of suitable breeding areas have been identified in and around the LA/NERP, all of which involve shared responsibility with other land management agencies. The Department of Energy (DOE) has primary federal responsibility for some of these areas, but needs only to ensure that LANL activities do not impact others. Sensitive zones and a habitat management plan were drafted for one suitable nesting area in 1992, and a sensitive zone was delineated in 1992 where LANL activities within the LA/NERP are most likely to have an effect on nearby habitat. The entire LA/NERP is peregrine foraging habitat.

4.0 Conclusions

Peregrine falcon breeding activity in and around the LA/NERP should increase if the peregrine population continues to increase. Annual monitoring of habitat for which the DOE has primary responsibility provides useful management information and should continue. Revision and expansion of the draft habitat management plan to cover all habitat for which the DOE has primary federal responsibility should be completed, which will require careful cooperation with other agencies. Sensitive zones should be used to flag review of LANL activities to prevent disturbance of breeding peregrine falcons in or near the LA/NERP. As a rule, all potentially disturbing activities should be scheduled outside of the breeding season, but biological monitoring information may be used to evaluate critical activities within the breeding season. LANL land-use planning should also recognize the contribution of terrestrial

foraging areas and cluster future developments to maintain large blocks of open land. Cooperation with adjacent land management and wildlife agencies is essential to the successful habitat management for this species.

Acknowledgments

S.O. Williams III of the New Mexico Department of Game and Fish has kindly provided data summarizing the status of the peregrine falcon throughout New Mexico.

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Evaluation of the Use of Satellite Imagery as a Tool to Predict Habitat of the Jemez Mountains Salamander, *Plethodon neomexicanus*

Louise Trippe and Timothy K. Haarmann

LA-UR-96-3392

Evaluation of the Use of Satellite Imagery as a Tool to Predict Habitat of the Jemez Mountains Salamander, *Plethodon neomexicanus*

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Abstract

A study to determine the accuracy and feasibility of using satellite imagery technology to locate or predict specific habitat, using the Jemez Mountains salamander (*Plethodon neomexicanus)* as a model species, was conducted. It appears that a satellite imagery map, based solely on a small suite of physical characteristics (elevation, vegetation, and gradient), was not successful in predicting habitat for Jemez Mountains salamander. Inclusion of additional habitat features would be required to strengthen the predictive power of the map. It is possible that information obtained through geological maps, soil conservation units, and vegetation data bases could be entered into the Geographic Information System to strengthen the predictive value of these maps. It was determined that satellite imagery could be used as an initial screening process to determine potential salamander habitat.

1.0 Introduction

The Record of Decision for the Dual Axis Radiographic Hydrodynamic Test Facility Environmental Impact Statement (1995) mandates the completion of a Habitat Management Plan (HMP) for Species of Concern (SOC) and those species considered threatened and endangered that occur on, or utilize, the 43 square miles of the Los Alamos National Laboratory (LANL). One of the objectives in developing the HMP is to gather data pertaining to the habitat requirements of both threatened and endangered species (TES) and SOC in an effort to delineate the area used by a particular species.

A study to determine the accuracy and feasibility of using satellite imagery technology to locate or predict specific habitat, using the Jemez Mountains salamander (*Plethodon neomexicanus)* as the model species, was initiated by LANL in May 1996. This species was selected on the basis that it is currently listed by the State of New Mexico as threatened, is considered a federal SOC, and has a range which encompasses those lands owned and administered by LANL. The purpose of this study was to provide habitat and distributional data for Jemez Mountains salamander based on satellite imagery. Work discussed in this report was carried out by Louise Trippe and Timothy Haarmann as a part of the development of the LANL TES HMP.

1.1 Study Objectives

- Assess the feasibility of using satellite imagery as a tool to locate Jemez Mountains salamander habitat and populations.

- Evaluate stand level characteristics in targeted areas in order to ground truth satellite imagery based maps.

- Consult with LANL personnel in field surveys to identify any suitable Jemez Mountains salamander habitat on LANL property.

The following information is presented in this report:

- a written assessment explaining the accuracy and feasibility of using satellite imagery to predict suitable Jemez Mountains salamander habitat,

- a satellite imagery map based on selected habitat variables submitted to Earth Data Analysis Center (EDAC), and

- a list of Jemez Mountains salamander sites visited within the Jemez Mountains.

1.2 Geographic Distribution, Habitat Associations, and Natural History of Jemez Mountains Salamander

Jemez Mountains salamander is a member of the lungless salamanders family, Plethodontidae. It is described as a small (total length = 55 mm [2.2 in.]), slender salamander, uniformly brown with shiny, brassy flecking along the back, sooty to pale gray below, and paler on the throat and tail (Stebbins and Riemer 1950). The fifth hind toe is absent or reduced. This species represents a biological anomaly as it is the only representative of this family and genus found in the southern Rocky Mountains. It is a terrestrial salamander endemic to north-central New Mexico, where it inhabits high-elevation coniferous forests and associated habitats within the Jemez Mountains. The entire range of this species extends for less than 1,632 square kilometers (1,011 square miles) located in Sandoval, Rio Arriba, and Los Alamos Counties. Within its range, Jemez Mountains salamander appears to exist as a series of disjunct populations, separated by geophysical and vegetational features (Painter unpub. report, 1993). Populations are found primarily on land administered by the USDA Forest Service, Santa Fe National Forest, although it has been reported to occupy land owned by the Santa Clara Indian Pueblo, Bandelier National Monument, LANL, and private individuals. This species has been recorded from 2190 m (7183 ft) to 3290 m (10,791 ft). A site located on LANL property represents the lowest known elevation (2190 m [7183 ft]) that this salamander has been found (Ramotnik 1986).

Jemez Mountains salamander is most often found under decaying logs and under rocks in mixed coniferous forests (Reagan 1967, Ramotnik 1986). The most common tree species associated with Jemez Mountains salamander are white fir *(Abies concolor)*, Engelmann spruce *(Picea engelmanii)*, blue spruce *(Picea pungens)*, quaking aspen *(Populus tremuloides)*, Douglas fir *(Pseudotsuga menziesii)*, ponderosa pine *(Pinus ponderosa)*, and Rocky Mountain maple *(Acer glabrum)* (Reagan 1967, Ramotnik 1986). Other tree species found in Jemez Mountains salamander habitat include subalpine fir *(Abies lasiocarpa)*, Gambel oak *(Quercus gambelii)*, wavyleaf oak *(Quercus undulata)*, and several species referred to as non-oak deciduous (Painter unpub. report, 1989). Shrub and forb species associated with these forested areas include: Colorado blue columbine (*Aquilegia caerulea*), Richardson's geranium (*Geranium richardsonii*), dwarf juniper (*Juniperus communis*), pinesap (*Monotropa latisquama*), Virginia creeper (*Parthenoeissus inserta*), New Mexico locust (*Robinia neomexicana*), thimbleberry (*Rubus parviflorus*), and Canada violet (*Viola canadensis*) (Reagan 1972). Although studies are currently underway to determine the

impact of timber harvesting on Jemez Mountains salamander (Painter, unpub. report, 1993), no conclusive evidence exists to date describing the impact of timber harvesting, fire, or mining on this species. Ramotnik (1988) found no significant difference in size classes of fir and spruce between transects with salamanders (10 total) and those transects without (33 total). Reagan (1972) also reports locating five salamanders at the edge of meadows.

The most consistent and perhaps the most important component of Jemez Mountains salamander habitat is thought to be the presence of fragmented rock in the soil profile (substrate) (Painter, personal comm.). Reagan (1972) describes the presence of remnant talus at all locations where salamanders were found. This type of substrate, in which extrusive rhyolite is broken down to produce a talus slope, stems from the volcanic origin of the Jemez Mountains. Talus is known to be an important feature for several *Plethodon* species. Given the narrow range of climatic conditions that are necessary for *Plethodons* to exist, it is believed that these animals move through the permeable talus interstices during unfavorable surface conditions to seek preferred temperature and moisture regimes. Reagan (1972) and references therein have suggested that the talus, which provides open channels to the subterranean environment, may account for the survival of this species in the harsh environment of the Rocky Mountains (Ramotnik 1986). During periods of prolonged precipitation, animals move up from their talus retreats to the surface where cover objects such as downed woody debris are widely used. Ramotnik (1986) located all salamanders in her 1985 survey period in downed logs. Downed woody material, however, comprised >94% of the 800 cover objects searched, and logs contributed to 95% of this downed woody material (Ramotnik 1985). Jemez Mountains salamander has been found using other surface objects, such as talus and fine woody debris for cover (Reagan 1972).

Several studies have suggested that slope is an important factor in suitable Jemez Mountains salamander habitat (Ramotnik 1986, Reagan 1972). Ramotnik. (1988) identified slope as the most useful variable in determining the presence of Jemez Mountains salamander. It was speculated that, due to the combined effects of gravity and movement of water and soil, steep slopes may be less compacted and contain more interstitial spaces in the soil. Subsequent investigations, however, have found Jemez Mountains salamander to exist at a wide range of slopes (from 0 to 100% gradient) (Painter unpub. report 1993, Scott et al. unpub. report 1987).

Although the salamander does not appear to be confined to slopes of a particular aspect, much of the published data suggests that suitable habitat is most often found on north-facing slopes or sheltered canyons. Because a north-facing slope is more protected from direct solar radiation, evaporation and sublimation occur at a slower rate (West 1959). Gradual snow melt enables water to soak into substrates rather than being lost by sublimation or runoff (Anderson 1963). Differences in available moisture may vary between north- and south-facing slopes as much as 21% (West 1959). Narrow canyon walls also provide protection from wind and direct solar radiation, thus allowing for similar

conditions with respect to snow accumulation. Ramotnik (1986), however, found that elevation had a greater effect on microhabitat variables such as ground cover, temperature, and moisture of logs than either slope or aspect.

Moisture is an important component of Jemez Mountains salamander habitat. This species is a lungless salamander which requires that its skin be in contact with moist surfaces for respiration (Goin et al. 1978). Observations of Jemez Mountains salamander on the surface are typically during the summer months following periods of heavy rain. This species may be opportunistically responding to suitable surface conditions such as moisture and temperature (Ramotnik 1986, Reagan 1972). Reagan (1972) reports that salamanders were only seen active on the surface at night when litter and foliage were "dripping wet" from afternoon thundershowers or night storms. All salamanders he found during the day were inactive in the coiled position. Dietary analysis of 39 specimens further suggests that these animals are nocturnal foragers (Reagan 1972). Because important data is lacking for the 39 individuals used in Reagan's dietary analysis, a more rigorous study is currently underway (Painter unpub. report, 1993). It is known, however, that Jemez Mountains salamander preys on a wide array of invertebrates such as mites, spiders, crickets and other orthopterans, flies, and ants (Painter unpub. report, 1993). Both research carried out by Reagan (1972) and Painter (1993 unpub.) found that ants were the most frequently consumed prey item.

2.0 Methodology

2.1 Establishing Criteria/Variables

An extensive literature review was conducted in order to obtain all available published information describing the natural history, ecology, and habitat associations of Jemez Mountains salamander. Additional information and recommendations were obtained through personal communication with Marilyn Altenbach, New Mexico Natural Heritage Program, and Charles Painter, New Mexico Department of Game and Fish, both of whom are currently conducting studies of Jemez Mountains salamander. Information was then evaluated and those elements most consistent in descriptions of the salamander's habitat were prioritized. Once a list of habitat parameters had been defined, a meeting with EDAC representatives took place to review the preferred variables. Of the original seven preferred variables, only three could be parameterized by EDAC for the production of a Jemez Mountains salamander habitat-based map (Table 1). It was decided that both Frijoles and Guaje Mountain U.S. Geological Survey (USGS) Quadrangle (7.5 min. series) maps would be used, as they encompass the areas directly north and south of LANL.

2.2 Ground Truthing of Satellite Imagery Maps and Consultation of LANL Personnel in Identifying Suitable Jemez Mountains Salamander Habitat

In order to characterize the habitat features of Jemez Mountains salamander, 12 locations were visited in Sandoval and Los Alamos Counties where populations of Jemez Mountains salamander are known to exist (Appendix A). At each site, information on stand structure and composition, gradient (%

slope), aspect, elevation, and substrate was recorded. Gradient was measured using a clinometer, and elevation was taken from a USGS topographical map. The habitat data from sites known to support Jemez Mountains salamander was used as a reference to validate the specific spectral classes depicted on the satellite imagery maps (Figure 1). An additional 13 sites were visited in an effort to ground truth (qualitatively) and assess stand level characteristics of those areas identified on the maps as potential Jemez Mountains salamander habitat. Of the 13 sites visited, four had been targeted in prior years as suitable habitat likely to support populations of this salamander. No amphibian field surveys were conducted due to inappropriate weather conditions.

Maps of locations where Jemez Mountains salamander surveys had been conducted were provided by the New Mexico Natural Heritage Program. These maps were superimposed on to the satellite imagery map to determine if there were any correlations between the targeted area on the satellite imagery map and the areas where Jemez Mountains salamander had been found.

3.0 Results

Seven habitat attributes were identified as being important to the mapping project (Table 1). Because data for three of the attributes were not available, the selected list of habitat features to be used in generating the satellite maps included (1) all mixed coniferous stands, (2) elevation range of 2000–3300 m (6560–10824 ft), and (3) a gradient > than 5%.

Table 1. List of preferred and selected habitat variables used in the development of a habitat-based map for Jemez Mountains salamander.

Preferred Variables	Selected Variables
Geological material	Elevation
Elevation	Vegetation
Moisture	Gradient
Vegetation	
Cover Objects	
Aspect	
Gradient	

A gradient of >5% was used as a means of eliminating mesa tops from the resulting map and should not be interpreted as a specific variable for Jemez Mountains salamander. Habitat-based maps, including elevational contours, major drainages, and roads were generated, using the three selected habitat attributes, for Guaje Mountain and Frijoles USGS quadrangles (7.5 min. series).

Information on stand structure and composition, gradient, aspect, elevation, and substrate was recorded at 12 known Jemez Mountains salamander sites (Table 2). Five of these sites are located in Frijoles and Guaje Mountain Quadrangles, and provided reference data which verified the spectral classes targeted as potential Jemez Mountains salamander habitat.

Table 2. List of known locations of Jemez Mountains salamander visited. Definitions of substrate, forest structure, and composition are given in Appendix B.

Site Name	Elevation m (ft)	Gradient(% Slope)	Aspect	Forest Composition	Forest Structure	Substrate
Pony Canyon	2543 (8480)	55	N	MixCon	Mature	Rock
Ont Canyon	2472 (8240)	55	N	MixCon	Mature	Rock
Unnamed Canyon	2472 (8240)	~57*	N	MixCon	Mature	Rock
Bear Canyon	2608 (8606)	57	N	Mix Con	Mature	Rock
Bear Canyon	2590 (8547)	69	S	MixCon	Mature	Rock
Barley Canyon	2575 (8497)	45	S	PinPon	Mature	Rock
Ski Hill	2745 (9150)	Flat	N**	Mix Con	Pole	No Rock
u. Water Canyon	2548 (8408)	68	W	MixCon	Mature	Rock
u. Water Canyon	2560 (8448)	60	N	MixCon	Mature	Rock
Pueblo Canyon	2160 (7200)	~60*	N	PinPon	Mature	Rock
Acid Canyon	2160 (7200)	~55	N	MixCon	Mature	Rock
Los Alamos Canyon	2133 (7039)	~50	N	MixCon	Mature	Rock

* Slope was estimated due to disfunctional clinometer. Gradient values for Bear Canyon, Barley Canyon, and upper Water Canyon were obtained through site descriptions included in Ramotnik (1986).

** The aspect listed for the Ski Hill Site refers to the slope above location where the salamander was found.

We visited 13 sites in order to qualitatively ground truth the satellite imagery maps (Table 3). These sites were selected on the basis that they were depicted as the same spectral classes as known Jemez Mountains salamander sites. It was found that, at this level of resolution, there was no distinction drawn between ponderosa pine-dominated stands and mixed-coniferous stands. In Guaje Canyon, certain portions of the canyon that actually contained habitat attributes, as defined by the list of variables, were not included in the same spectral class as other areas meeting the same set of variables. These areas and their spectral class were subsequently located on another higher-resolution satellite imagery map of the same quadrangle, and all areas delineated by this spectral class were added to the final map produced by EDAC. Due to time constraints on the project, a more quantitative and systematic ground truthing process was not possible.

When the map of selected survey sites was superimposed on to the satellite imagery based map, all locations of these surveys were included in the same spectral classes. The habitat-based satellite imagery map did not differentiate between those sites where salamanders had been found and those areas where survey efforts had not resulted in locating salamanders.

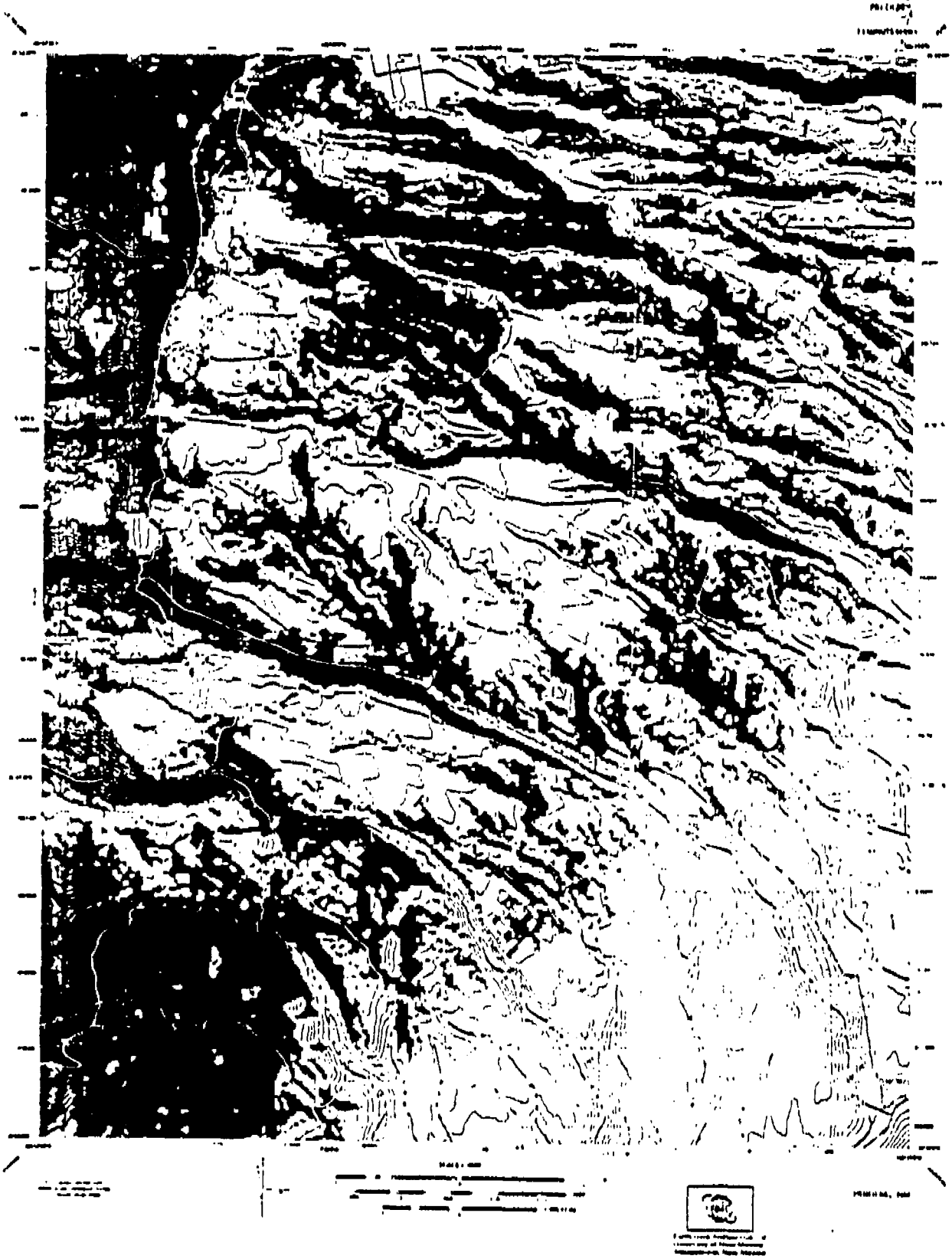

Figure 1. The colored areas show the predicted Jemez Mountains salamander habitat.

Table 3. List of areas visited for ground truthing of satellite imagery maps. Forest composition is defined in Appendix B.

LOCATION	PRIOR SURVEY YES/NO	RESULTS CLASS	SPECTRO-COMP.	FOREST HABITAT	POTENTIAL
Water Canyon 1	YES	POS	DG	MIX CON	YES
Water Canyon 2	YES	NEG	DG	MIX CON	YES
Water Canyon 3	YES	NEG	DG	MIX CON	YES
2 Mile Canyon	NO------	DG	MIX CON		YES
Ancho Canyon	NO------	DG	PINPON	NO	
Canada del Buey	NO------	DG	PINPON	NO	
Mortandad Canyon	NO------	DG	MIX CON		YES
Bayo/Barranca	NO------	DG	PINPON	NO	
Rendija Canyon 1	NO------	DG	PINPON	NO	
Rendija Canyon 2	NO------	DG	PINPON	NO	
Rendija Canyon 3	NO------	DG	PINPON	NO	
Pueblo Canyon	NO------	DG	MIXCON	YES	
Guaje Canyon	YES	NEG	DG	MIXCON	YES

4.0 Conclusions

Satellite imagery technology is one of many remote sensing tools available to resource managers or researchers from a variety of disciplines. This technology can prove to be extremely useful. However, careful consideration needs to be given to determine whether or not it will provide the information needed to fulfill certain project requirements. Evaluating certain factors such as the level of required detail and the size of the targeted area can serve to facilitate this decision-making process. Additional factors include the spatial, temporal, and radiometric resolutions of certain satellite imaging types, as each can greatly influence the feasibility of producing a satellite image classification. In assessing the success of employing satellite imagery technology for the purpose of predicting and delineating habitat of Jemez Mountains salamander, each of these elements have been considered.

The spectral and radiometric resolution of these maps did not discern between mixed coniferous stands and those dominated by ponderosa pine. Since the salamander has been found in stands where ponderosa pine is the dominant canopy species (Painter personal comm.), it is in fact an asset that these areas were not effectively ruled out. The resulting maps, however, show an extremely large area highlighted as potentially suitable to support populations of Jemez Mountains salamander.

It appears that the satellite imagery map, based solely on a small suite of physical characteristics, was not successful in predicting habitat for Jemez Mountains

salamander. This was made apparent when a map of surveyed areas was superimposed onto the satellite imagery map. Each of the locations targeted for survey were selected based on overall appearance as suitable habitat after visual inspections. Each of these locations were included in the same spectral classes, whether or not salamanders were found in the survey. Although the satellite imagery map included all areas recognized as "potential" after visual inspections, it did not preferentially tease out those areas where salamanders had been found.

Due to limitations in both available data (Geographic Information System [GIS] layers, ancillary data), important components of Jemez Mountains salamander habitat such as soil characteristics, moisture qualities, and surface cover objects were omitted, and a much coarser set of habitat variables was used. Inclusion of additional habitat features would be required to strengthen the predictive power of the map. It is possible that information obtained through geological maps, soil conservation units, and vegetation databases could be entered into the GIS. In this way, these features that are now unmappable could, in turn, be layered onto the more spatial data already available.

In addition to the technological limitations of using satellite imagery for this purpose, there are elements of this species' natural history that contribute to the difficulty in predicting or locating actual habitat occupied by the salamander. Populations may be small and isolated, existing in only one small section of a drainage or slope. Factors other than habitat suitability may preclude the existence of Jemez Mountains salamander in a given area. Ramotnik (1988) suggests that unsuitability of the surrounding area may prevent access to more optimal habitat, or that climatic events could also have eliminated salamanders from an area without sufficient time to recolonize.

Logistical data constraints discussed above hinder the success of employing satellite imagery as a tool to locate suitable Jemez Mountains salamander habitat. However, the entire process could be "fine-tuned" using additional data which would yield more accurate results. As an initial screening process to determine which locations might be field surveyed, satellite imagery works well. Finally, a visual inspection, as outlined in Painter (1989), remains the most practical method for Jemez Mountains salamander habitat assessment. In using this method, an area is first located on a USGS quad or orthro-quad map in order to determine the elevation of the site. If the area is at an elevation of 2440 m (8052 ft) or greater, the area is considered potential Jemez Mountains salamander habitat and is visited for an on-ground assessment. The assessment focuses on dominant tree species, percent cover, slope, aspect, and "overall conditon of the site." If the habitat appears to be suitable salamander habitat, than a high-grade search is carried out. In the absence of a more inclusive data base from which specific habitat based classifications can be defined, this technique remains the most practical method for identifying and assessing Jemez Mountains salamander habitat.

Appendix A: Twelve locations where Jemez Mountains salamander are known to exist.

Location	Date	County	Quad
Pony Canyon	01-5-96	Sandoval	Seven Springs
Oat Canyon	01-5-96	Sandoval	Seven Springs
Unnamed Canyon	01-5-96	Sandoval	Seven Springs
Bear Canyon	01-5-96	Sandoval	Seven Springs
Bear Canyon	01-5-96	Sandoval	Seven Springs
Barley Canyon	01-5-96	Sandoval	Seven Springs
Ski Hill	02-5-96	Los Alamos	Valle Toledo
U. Water Canyon	02-5-96	Los Alamos	Frijoles
U. Water Canyon	02-5-96	Los Alamos	Frijoles
Pueblo Canyon	02-5-96	Los Alamos	Guaje Mt.
Acid Canyon	02-5-96	Los Alamos	Guaje Mt.
Los Alamos Canyon	02-5-96	Los Alamos	Guaje Mt.

Appendix B: Definitions of substrate, forest structure, and composition.

Forest Structure: Defined by the dominant canopy species. Categories included

1) Mixed coniferous (MixCon),
2) Ponderosa pine dominated (PinPon),
3) Mixed coniferous-deciduous, and
4) Deciduous.

Forest Structure: Defined by the seral class at the specific location visited.

Substrate: Recorded the presence of rock within the substrate.

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Status and Trends of Bat Populations at Los Alamos National Laboratory and Bandelier National Monument, Jemez Mountains, New Mexico

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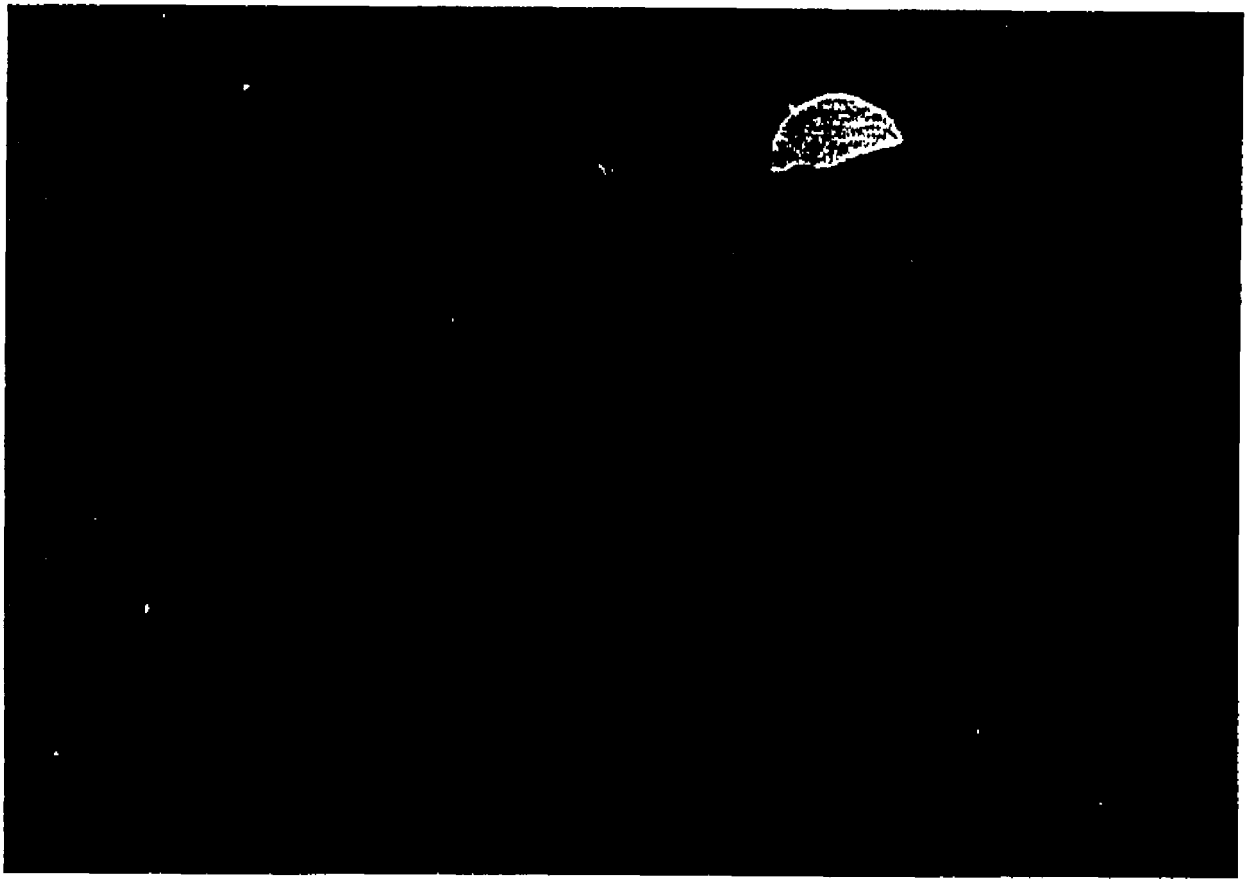

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Status and Trends of Bat Populations at Los Alamos National Laboratory and Bandelier National Monument, Jemez Mountains, New Mexico

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Abstract

In 1995, Los Alamos National Laboratory (LANL), Bandelier National Monument (BAND), and the Midcontinent Ecological Science Center (MESC) initiated a multiyear study of bats in the eastern Jemez Mountains. Although some previous bat research has been conducted here, our goals were to assess the current status of bats (particularly species of concern), elucidate distribution and relative abundance, and obtain information on sites used by bats as roosts. We finished our second year of study in 1996. We captured and released over 828 bats of 15 species. Netting sites were located in a variety of habitats from piñon-juniper through mixed coniferous forest. Species captured to date include *Myotis californicus*, *M. ciliolabrum*, *M. evotis*, *M. thysanodes*, *M. volans*, *M. yumanensis*, *Lasionycteris noctivagans*, *Lasiurus cinereus*, *Pipistrellus hesperus*, *Eptesicus fuscus*, *Euderma maculatum*, *Corynorhinus townsendii*, *Antrozous pallidus*, *Tadarida brasiliensis*, and *Nyctinomops macrotis*. The most abundant species were: *L. noctivagans*, *M. evotis*, *E. fuscus*, *M. volans*, *A. pallidus*, *M. ciliolabrum*, and *M. thysanodes*. Most of these species are typical of ponderosa pine-mixed coniferous forests. The abundance of *L. noctivagans* (nearly all males) is a function of their migration through the area; they are relatively uncommon at other times. Males outnumber females for most species. Only four species (*M. californicus*, *M. thysanodes*, *M. yumanensis*, and *C. townsendii*) have about equal numbers of both sexes. Reasons for the observed distribution of sexes are unknown but climatic and elevational influences or sites chosen for netting may be involved. In 1995 we captured the first *Euderma* known for BAND and in 1996 we heard them at several locations at LANL. In 1996 we initiated radiotracking studies in which selected bats were equipped with miniaturized radios (ca. 0.6g) and followed to roosts. Several female *M. thysanodes* were instrumented and were found to be using small cavities in south-facing cliffs of Bandelier tuff. A male *M. thysanodes* roosted in a north-facing cliff. A female *E. fuscus* used a large dead ponderosa pine as a roost and we observed an exit flight of 35 (presumed) *E. fuscus* leaving this tree. General searches of cliffs in canyons also revealed active night roosts and recently-used day roosts of several species, including an unknown colony of over 500 *Tadarida*. We netted all eight bat species of concern in the Jemez. Three of these (*M. evotis*, *M. thysanodes*, and *M. volans*) were frequently captured and a fourth (*Euderma*) was captured occasionally and heard frequently. We captured a few individuals of two species (*M. ciliolabrum* and *C. townsendii*) that are agile fliers and that may be difficult to net. *M. yumanensis* is known to roost at BAND and tends to occur at elevations lower than where we netted; it is probably relatively common. *N. macrotis* was netted in low numbers both at BAND and on the Santa Fe National Forest.

1.0 Introduction

It is generally believed that bat populations have declined in recent decades in the United States and elsewhere. Several species are listed as endangered or threatened by the U.S. Fish and Wildlife Service (FWS) and additional species were listed as Category 1 and 2 Candidates for listing. In 1995, the FWS stopped maintaining a list of Category 2 Candidate Species in order to concentrate on higher-priority listing needs (memorandum, Director, FWS, July 1995). It is hoped that other entities and individual states will assist in maintaining lists and acquiring information on these species of concern.

Many states now protect bats, and rank various species among taxa of special concern. The public has developed an increased interest in this diverse group of mammals, as exemplified by support for Bat Conservation International and bat societies in several states (e.g., Colorado). Federal land management agencies also have responsibilities relative to bat inventory, monitoring, and conservation, and carry out surveys in areas under their jurisdiction (see, for example, Green et al. 1994, Lacki et al. 1993, Thomas 1988). Despite this increasing attention and concern for bat populations, considerable work remains to be done to obtain detailed basic information on the distribution, abundance, and natural history of bats in specific areas.

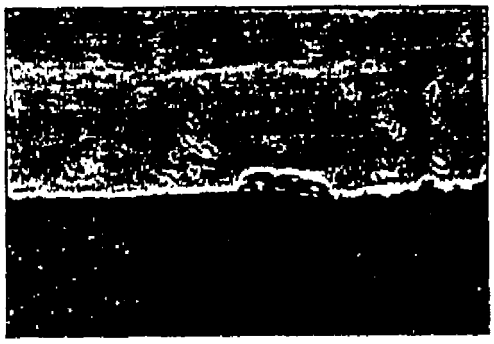
Pursuant to the agreements between the Midcontinent Ecological Science Center (MESC), National Biological Service (NBS) and both Los Alamos National Laboratory (LANL) and Bandelier National Monument (BAND), a three-year project to determine the occurrence, distribution, and habitat use of bat species in the Jemez Mountains, Sandoval and Los Alamos counties, New Mexico, was initiated in late summer of 1995 and continued in 1996. Considerable progress has been made toward assessing the current status of the bat species inhabiting the eastern portion of the Jemez Mountains.

The Jemez Mountains support a diverse community of bats. Fifteen species are currently known from the Jemez Mountains in north central New Mexico, including eight species of concern (former Category 2 Candidate Species). Most of these species also are known from Bandelier National Monument (BAND) and Los Alamos National Laboratory (LANL). One additional species (*Myotis lucifugus*), known from elsewhere in northern New Mexico (Findley et al. 1975), also may occur in the Jemez Mountains, at least at lower elevations. Previous work has been conducted on LANL and at BAND by several investigators. Tyrell and Brack (1992) mistnetted three sites at LANL and one on BAND. Guthrie and Large (1980) used mist nets to sample several sites at BAND for bats, whereas both Arganbright (1987, 1991) and Judson (1990) concentrated on roosting colonies of *Tadarida brasiliensis* and *Myotis yumanensis* on BAND. Cryan (1993) conducted echolocation surveys for bats in the Santa Fe National Forest. Other investigators have netted bats on the Santa Fe National Forest in the Jemez Mountains, including the East Fork of the Jemez River, near BAND (files, Museum of Southwestern Biology, University of New Mexico). However, much remains to be learned of bats in this topographically and biologically diverse area, especially in terms of providing information for land managers so that bats remain a functional part of the Jemez Mountain ecosystem.

There are seven major objectives to the proposed multiyear study. These are to: (1) compile and review available information on bats in the Jemez Mountains; (2) identify major information gaps for the area; (3) collect original field data on occurrence, distribution, roosting sites, and habitat use of bats in the Jemez; (4) provide samples of common bat species to assess impacts of potential environmental contamination; (5) analyze and synthesize all data gathered; (6) provide recommendations for maintaining bats as part of the Jemez Mountain ecosystem; and (7) provide a baseline that will serve as a foundation for future bat inventory and monitoring programs. This report provides a preliminary summary of information obtained through early September 1996 in attempting to reach these objectives.

2.0 Methods

Bats were captured in mist nets during the summers of 1995 and 1996 as they foraged over and drank from water sources. Capture, handling, and radio-tagging of bats followed a written protocol approved by the NBS Animal Care and Use Committee at MESC. All personnel associated with the project, and actively handling bats, were vaccinated against rabies prior to field work. We followed netting methods outlined by Kunz and Kurta (1988). Mist nets of varying sizes were deployed shortly after sunset and attended continuously until closure. Time of net closure varied for numerous reasons, such as inclement weather or radio-transmitter attachment and tracking, but most often we netted until bat activity diminished significantly (30 - 45 min after the last bat was captured).



For each netting episode we recorded investigators' names, site location, date, number and size of nets, times nets were opened and closed, starting and ending temperature, cloud cover, wind speed, and brief habitat description. We removed bats upon capture and promptly processed them before release. We recorded the species, sex, age (adult or young-of-the-year based on epiphyseal fusion; Anthony 1988), reproductive condition (testes or cauda epididymides visible in males, females pregnant, lactating, postlactating, or non-reproductive; Racey 1988), and time of capture for all bats mistnetted. Additional comments on parasites, wing damage, and the like were made as necessary. All data were recorded on standardized data sheets; completed data sheets are on file at the Albuquerque office of Midcontinent Ecological Science Center.

In addition to capturing and releasing bats after examination, one of us (Ellison) documented the call signatures of bat species in the Jemez Mountains with an ANABAT ultrasonic detector and software and a laptop computer. This work is summarized in Appendix A*.

*Tables, Figures, and Appendices are at the end of this report.

We netted bats at 11 sites on LANL, 9 sites at BAND, and 2 sites on the Santa Fe National Forest. Most such sites were over pools of water of varying sizes where bats came to forage and drink. Site locations and descriptions are given in Appendix B. Not all sites were netted in both years, primarily due to variations in water levels due to differing climate conditions among years.

Selected individual bats captured by mist net were marked with miniature radiotransmitters (Model BD-2, 0.6 g, Holohil Systems Ltd., Woodlawn, Ontario) for roosting studies. Radiotelemetry techniques followed the methods of Wilkinson and Bradbury (1988). Transmitters were attached to the interscapular region of the dorsal fur with a non-irritant medical adhesive (Skin Bond ©). Bats were held for about 30 minutes before release in order to insure secure adhesion. After release, the nocturnal movements of transmittered individuals were monitored with hand-held, 3-element Yagi antennae and portable receivers (Model TRX 1000-S, Wildlife Materials, Carbondale, Illinois, 62901) until radio contact was lost. A truck-mounted 4-element Yagi receiver was used to search for radio signals from tagged bats while driving road networks in the area. Bats were located on subsequent days in their daytime retreats. Information on location, orientation, elevation, and general structure of each day roost was recorded. Roosts were observed during evening emergence to determine if the marked bat roosted alone or communally. Bats with transmitters were located on a daily basis until radio contact was lost.

In addition to following radio-tagged bats, we attempted to discover bat roosts during the day by systematically searching the bases of cliffs and shallow caves for droppings, and by reflecting sunlight into likely rock crevices and cavities in cliff faces. Searches were conducted in the rugged terrain at cliff bases, and took about 90 min or more per kilometer of cliff face. In the interests of safety, no climbing was involved. Roosts thus discovered were classified as diurnal retreats (occupied by bats during the daytime) or as night roosts (sheltered overhangs and grottos used by bats only at night for resting or handling prey between foraging bouts. During 1996 we searched for roosts while hiking along sections of the south-facing cliffs of Kwage Mesa (about 1.5-km search path), Otowi Mesa (about 2-km search path), and an unnamed mesa east of Otowi Ruins (about 2-km search path), all in Pueblo Canyon. We also searched south-facing cliffs along lower Los Alamos Canyon above State Road 4 (about 1.5-km search path), and cliffs and boulders along both sides of a 3-km stretch of Cañon de Valle above State Road 4.

Roost sites were categorized as currently active (occupied by bats), recent (fresh droppings indicating use in current season but bats not present), or old (droppings present but probably deposited prior to 1996). Freshness of droppings was judged subjectively based on darkness of color and apparent moisture content. When possible, droppings were also judged to be likely from pallid bats (large, often accompanied by culled insect parts in night roosts), big brown bats (large, no culled insect parts), *Myotis* species (small), or free-tailed bats (small to medium sized, about 3-6 mm long, sometimes with distinctive odor at the roost). Many roost locations were

identified by UTM coordinates using Global Positioning System (GPS) receivers. Most roosts were also documented photographically. Photographic and GPS documentation of roosts and netting sites is continuing.

3.0 Results

We mistnetted a total of 67 nights at 20 different locations in the Jemez Mountains during 1995 and 1996 (Tables 1 & 2, Appendices B, C, D). We captured a total of 828 bats of 15 species (Table 3, Figure 1, Appendix C) including the first known records of *Euderma maculatum* for BAND and the first records of *Pipistrellus hesperus* for BAND and LANL. We spent additional days and nights in the field actively looking for bat roosts or tracking instrumented bats to diurnal roosts.

Los Alamos National Laboratory

During 1995 and 1996 we mistnetted for 33 nights at 10 LANL sites (2 nights in 1995, 31 in 1996). We captured 392 bats of 12 different species (Table 4, Figure 2). The most frequently captured species was *Lasionycteris noctivagans* (48% of LANL captures), followed by *Eptesicus fuscus* (13%), *Antrozous pallidus* (9%), and *Myotis volans* (9%). Most bats captured at LANL were male (81%). Species with the most even sex ratios were *M. californicus* (50% male), *M. evotis* (54%), *M. thysanodes* (58%), and *E. fuscus* (44%). Female *L. cinereus*, *P. hesperus*, *C. townsendii*, *A. pallidus*, and *T. brasiliensis* were not captured at LANL.

We captured an average of 14 bats per night at LANL (range 1-60). The greatest mean numbers of bats captured per night were at Icehouse Pond (mean=24), Pueblo Canyon Effluent Stream (mean=13), and the Pueblo Canyon Waste Facility (mean=11). These three sites also showed the highest species diversity; 9 species were captured at Icehouse Pond, 7 at Pueblo Canyon Effluent Stream, and 7 at the Pueblo Canyon Waste Facility. The highest number of species captured in a single night was 6 at Icehouse Pond on 5 September 1995. Male and female *M. evotis* and *M. thysanodes* were captured at more sites, on average, than any other species (mean=4). Male *L. noctivagans* were captured at the greatest number of sites and *T. brasiliensis* were captured at the least. Female *M. ciliolabrum*, *M. evotis* and *E. fuscus* were all captured at three sites and female *M. volans* were only captured at one site (Table 5, Figure 3, Appendix D).

Bandelier National Monument

We netted for 34 nights at 9 sites on Bandelier and an additional site in the adjacent Santa Fe National Forest. We captured 435 bats of 15 species (Table 6, Figure 4). The most frequently captured species was *L. noctivagans* (52%), followed by *M. evotis* (12%), *M. thysanodes* (7%), and *Myotis volans* (7%). Most bats captured at BAND were male (87%). Species with the most even sex ratios were *M. yumanensis* (50% male), *M. thysanodes* (47%), and *M. californicus* (67%). Male *E. maculatum*, *C. townsendii*, and *N. macrotis* were not captured at BAND, nor were female *L. cinereus*, *L. noctivagans*, or *P. hesperus*.

We captured an average of 16 bats per night at BAND sites (range 1-89). The greatest mean numbers of bats captured per night were at Dome Pond (mean=23), Ski Pond (mean=22), and Meadow Pond (mean=15). The most species were captured at Meadow Pond (12), Ski Pond (9), and Frijoles Creek at the Rainbow House Crossing (8). The greatest number of species captured on a single night during the study was 7 at Ski Pond on 6 June 1996. The mean number of sites of capture for both sexes of *M. thysanodes* and *M. volans* were highest (mean=8), followed by *E. fuscus* (mean=6). Male *M. volans* were captured at more BAND sites (7) than males of any other species. We captured male *L. noctivagans* at 6 sites, and male *M. evotis*, *M. thysanodes*, and *E. fuscus* at 5 sites each. Female *Myotis thysanodes* were captured at more BAND sites (6) than females of any other species. There were more female than male *M. thysanodes* capture sites on BAND. Female *M. californicus*, *M. evotis*, *L. noctivagans*, *C. townsendii*, *A. pallidus*, and *T. brasiliensis* were each captured at single sites (Table 7, Figure 5).

Combined Sites and Years

We captured an average of 12.3 bats per night (range 1-89) in the Jemez Mountains over two years of study. The bats captured most frequently were *L. noctivagans*, *M. volans*, *M. thysanodes*, *M. evotis*, *E. fuscus*, and *M. ciliolabrum* (Table 3, Figure 6). We rarely captured *P. hesperus*, *N. macrotis*, *E. maculatum*, *C. townsendii*, or *M. yumanensis*. The species captured at the most sites were *M. thysanodes*, *E. fuscus*, *L. noctivagans*, *M. volans*, and *M. evotis*, while *P. hesperus*, *E. maculatum*, and *N. macrotis* were captured at the fewest (Table 8, Figure 7). Males were captured at more sites than females for all species except *M. thysanodes*, *M. yumanensis*, and *E. fuscus* (Figure 8). Females of *M. thysanodes* and *M. yumanensis* were captured at more sites than males. Males and females of *E. fuscus* were captured at the same number of sites. Eighty-four percent of all bats captured during both years were male.

The total number of bats captured during 1996 was higher than 1995 for 10 species, but the mean number of bats captured per night during 1996 was lower than 1995 for two of those species (*M. thysanodes* and *M. volans*; Figure 10). The mean numbers of males and females of *M. evotis*, *M. thysanodes*, *M. volans*, and *M. yumanensis* were all higher in 1995 than 1996 (Figures 11 and 12). Females of *C. townsendii*, *A. pallidus*, and *T. brasiliensis* were captured during 1995 and not 1996, while female *M. californicus*, *L. noctivagans* and *N. macrotis* were captured during 1996 and not during 1995. Female *L. cinereus* or *P. hesperus* have not been captured during the study. The number and proportion of females exhibiting observable signs of reproduction varied across species and years (Figures 13 and 14). In 1995, we captured reproductive females of 9 species; in 1996 we captured reproductive females of 7 species. Among all species, *L. noctivagans*, *M. volans*, *M. evotis* and *M. yumanensis* exhibited the lowest percentages of reproductive females (Table 9 and 10, Figure 15). No obviously reproductive female *L. noctivagans* have been captured. The species we captured that had higher ratios of reproductive to non-reproductive females were *M. californicus*, *M. ciliolabrum*, *M. thysanodes*, *E. fuscus*, *E. maculatum*, and *N. macrotis*. All female *C. townsendii*, *A. pallidus*, and *T. brasiliensis*

captured appeared reproductive. During 1995, 75% of all male bats captured appeared scrotal, while in 1996 only 13% appeared scrotal.

Juvenile bats of 4 species were captured during the study period: *M. thysanodes* (2), *M. volans* (1), *E. fuscus* (2), and *T. brasiliensis* (1). With the exception of the 2 juvenile *E. fuscus*, all were captured during 1995. The earliest date of juvenile bat capture was 24 July. The two juvenile *E. fuscus* were both captured at Pueblo Canyon Waste Facility, while the two *M. thysanodes* were captured on Frijoles Creek near the Bandelier Visitor Center. No site yielded juveniles of more than one species. The *M. volans* juvenile was female, both *M. thysanodes* were male, the *T. brasiliensis* was male, and *E. fuscus* juveniles had an even sex ratio.

The average elevations of capture for *A. pallidus* and *P. hesperus* were lowest and mean elevations for *M. evotis*, *E. maculatum*, *L. noctivagans*, and *L. cinereus* were highest (Table 11, Figure 16). Many species show differences in the mean elevation of capture between reproductive females and males (Table 12, Figure 17). A test for no difference in the mean elevation of capture between reproductive female and male bats was significant at the 5% level for *E. fuscus* and *M. evotis* ($p < 0.001$ and 0.02, two-sample, unequal variance t-test) (Table 13).

Radiotelemetry

During 1996 we deployed a total of seven transmitters on three species of bats (*M. evotis*, *M. thysanodes*, and *E. fuscus*). On 10 June we instrumented (frequency 164.237) an adult male *M. thysanodes* captured at Ski Trailhead Pond (P 5) at BAND. This bat was released at 2300 h and was tracked in the immediate vicinity and across the road (Route 4) from the pond in mixed coniferous-aspen forest. This bat was located the following day from mile marker 46 on Route 4 at 2030 h; the signal appeared to be coming from the north-facing cliff face in upper Frijoles Canyon. At about 2100 h the bat left the roost and was tracked as it flew up Frijoles Canyon to the general area where it was captured and released, south of Cerro Grande. On 12 June we hiked to the vicinity of the day roost, specifically to the base of a boulder field on the north-facing cliff at 65° 15'N, 72° 20'E. We were unable to climb closer due to the steep nature of the cliff face. On 13 June the bat appeared to be roosting 0.5 mi. upcanyon and the signal was coming from the eastern branch of the canyon, below the Dome Ski Trail. At 2100 h we heard the bat flying south of Cerro Grande just before a rainstorm commenced. On 14 June, signals were emanating from a stand of pine and aspen south of Cerro Grande. The signals were still coming from this area as late as 2130 h on 17 June (by which time the bat should have flown) and again at 1730h on 19 June. We suspect the transmitter was shed and left in the tree. On 28 June we were still getting signals from the transmitter and determined that it was in a large ponderosa pine south of Cerro Grande. The radio has not been recovered.

On 18 June we deployed a transmitter (164.164) on a pregnant female *M. evotis* captured at Icehouse Pond. The bat was released at 2330 h and immediately flew north; we lost the signal within 15 min. We searched extensively by road and on foot the next day but could not find the bat. We did

pick up a faint signal that night (19 June) from 2140 - 2155 h. This transmitter was not subsequently relocated, despite extensive efforts, and its fate is unknown.

We next placed transmitters on 3 lactating female *M. thysanodes* captured in Frijoles Canyon at Rainbow House Crossing. The first two bats were instrumented late on 18 July and very early 19 July. Both bats flew upcanyon on release. The third bat was tagged the following night (19 July) and was heard for about 20 min around the point of release, near the BAND Visitor Center. The first transmitter (164.100) was located more or less continuously from 19 July to 5 August (18 days). This bat roosted in several small "solution pit" cavities in the south-facing cliffs of Bandelier tuff, including one or more in a small circular alcove where she was first found. All pits where she roosted were within 0.25 mi. of where she was originally captured and were approximately 20-30 m from the ground; they were not accessible to us. We also located her leaving the roosts several times, once with four other bats. On 27 July she emerged at 2044 and flew a short distance upcanyon where she appeared to be foraging for at least 25 min. On 1 August the signal seemed weaker and did not move by 2140 h. By 5 August it appeared that the transmitter had been shed as the signal still was coming from the roost at 2150 h.

The second female *M. thysanodes* (164.253) was re-located on 19 July high up on the south-facing cliff of Bandelier tuff, near a rocky prominence. This area was shaded in the mid-morning light. This bat moved at least once or twice to other sites, including the same roost used by one of the other *thysanodes* (164.278), but she was not detected reliably either during the day or night after 21 July. This transmitter may have failed.

The third *M. thysanodes* (164.278) was located on 20 July in the same general area of Bandelier tuff, just east of the turnout to the stable area. This bat also moved among several pits in the cliff and was detected flying over the riparian area on 25 July, near where she was captured. We were not successful in observing her exiting any roost, although bats were observed on 23 July entering and leaving a small crack in the cliff where her transmitter signal was strongest. The last date this transmitter was heard was 5 August (17 days). We hope to search for these roosting sites near the BAND Visitor Center, and recover the transmitters, by climbing the cliffs later in 1996.

On 24 July we tagged (164.637) a pregnant female *E. fuscus* captured at the Pueblo Canyon Sewage Treatment Plant. She flew, apparently foraging, in the general area of the sewage facility after release. On 26 July she was located in a large dead ponderosa pine in upper Pueblo Canyon, about 1.5 mi. from the capture site. The snag was on the south side of the canyon, slightly upslope from the canyon bottom. The roost cavity appeared to be about 4 - 6 ft below the broken top of the snag and 35 bats were observed leaving this snag between 2028 - 2040 h. This bat was heard in flight at 2025 h on 29 July and an exit flight of 37 bats was observed on 30 July. The transmitter was recovered on 5 August, still working, below another large old ponderosa pine snag, about 0.25 mi. east of the original roost site.

The last bat tagged (164.663) was a lactating female *E. fuscus* also captured at the sewage treatment plant on 14 August. This bat was heard flying near the treatment plant for about 10 min (2020-2030 h) on 19 August but we were unable to find her roost and did not hear the signal again.

In summary, we successfully tracked five bats of two species (*M. thysanodes*, *E. fuscus*) to their diurnal roosts and subsequently monitored movements among roosts in four cases. In two cases (*M. evotis*, *E. fuscus*) we could not locate roosts. Known transmitter life averaged 10.4 days (range 1 - 18 days). Roosts of reproductive female *M. thysanodes* were all in cavities in south-facing cliffs of Bandelier tuff. A male of this species roosted in rocks on a north-facing cliff. A pregnant *E. fuscus* roosted in a large ponderosa pine snag that was exposed to sunlight for most of the day. This bat also may have used an alternate roost. All roosts were within about 2 mi. of capture sites and three roosts of *M. thysanodes* were within 0.25 mi.

Roost Searches

We identified 10 locations with diurnal bat roosts in the limited areas searched (Table 9). Only one of these roosts was active. This roost was located on the south-facing cliffs of Kwage Mesa, and consisted of an estimated 540 presumed Brazilian free-tailed bats (*Tadarida brasiliensis*). The bats were identified and counted in flight during their emergence on 29 August 1996, the date the colony was discovered. A follow-up visit to this roost on 3 September revealed no exit flight. No bats were captured from the roost and efforts were made to minimize disturbance. The crevice is around 40 m above the ground in a relatively smooth, vertical section of cliff. The roost was in two large dark, vertical, circular chutes that form almost a figure eight when viewed from below. The algae on the cliff face below the roost was a brighter green than on immediately surrounding surfaces, and a noticeable amount of guano was dispersed on the soil surface below the roost at the base of the cliff.

Several other sites were also identified which previously had held colonies that were likely attributable to *T. brasiliensis* but were unoccupied on the day discovered (Table 10). These include two additional cliff crevices on Kwage Mesa, and one major and two minor sites elsewhere in Pueblo Canyon (two on Otowi Mesa and one on the unnamed mesa to the east of Otowi Ruins). These sites were notable for accumulations of guano below vertical crevices. Typically healthy Jimsonweed (*Datura* spp.) plants occurred at the bases of cliffs below crevice openings, and two of the roost sites on Kwage Mesa had green-stained lichen streaks on the cliffs below their openings. A strong odor, typical of that associated with free-tailed bats was notable at the major site on the cliffs of Otowi Mesa. Only one diurnal roost provisionally attributed to free-tailed bats was in one of the numerous grottos formed as Indian ruins; this roost was within an open overhang about 2 m above the cliff base in Pueblo Canyon.

Some vacant roosts were located which had housed species other than free-tailed bats. Droppings suggestive of pallid bats were found beneath a large, lengthy vertical crevice on the south-facing cliffs of Los Alamos Canyon and those suggestive of a *Myotis*

species were found beneath a small (about 10 cm diameter) round opening some 3 m high on a vertical cliff of Kwage Mesa (Table 11). Other, minor amounts of droppings were also located sporadically during cliff searches, but these could not be attributed to obvious roost sites of any seeming significance and were not recorded. No significant guano accumulations were found during the search of upper Cañon de Valle.

Night roosts were found in numerous grottos excavated by Indians in ancient times. However, many of the grottos had no significant accumulations of droppings or were not used at all. Droppings of a wide range of sizes were located on grotto floors, indicating that several species of bats used these excavations as night roosts. Particularly obvious were large-sized droppings accompanied by culled insect parts (wings of sphingid moths, elytra of beetles) in some of these roosts, which typifies night-roosting use by pallid bats. Those situations that seemed most favorable as night roosts were grottos with smaller openings than neighboring, unused grottos; higher ceilings (about 2 m above the floor); and bowl-like depressions or small vertical chutes in grotto ceilings. Droppings below some of the latter situations could also have been left by diurnally roosting bats. Current use of what were apparently favored night roosts in Los Alamos Canyon was verified on 26 August 1996, when a bat was observed exiting late at night as we walked past, and on 27 August 1996, when a pallid bat was captured attempting to enter a grotto blocked by a mist net. Sections of cliff with night roosts that seemed to be most heavily and recently used were identified in Pueblo and lower Los Alamos canyons and GPS/UTM coordinates were obtained for some of these sites (Table 14).

4.0 Discussion

Many factors can affect year-to-year mistnetting results and they should be considered in interpretation of our data. Due to the late project start in 1995, the results from the first year are biased towards late-season captures and their consequent reproductive status (e.g., more scrotal males and females in post-lactation) and distributional patterns. Additionally, most captures in 1995 were from sites on BAND, which tended to be at higher elevations. In 1996, an earlier start was made and a greater proportion of time was spent on LANL, where lower-elevation sites were frequently netted. The 1996 data can be expected to contain a greater number of females in earlier stages of reproduction and more non-scrotal males.

Although proportions of males and females and observed reproductive state of both males and females are important indices of general population status, several biases can affect our ability to discern or explain variation in such indices. Although female bats captured early in the season (May to mid-June 1996) may have been in the early stages of pregnancy, we were unable to determine this in the field without sacrificing individuals, which we chose not to do. Thus, all females that were not obviously pregnant early in the season, or in some phase of lactation later in the summer, were called non-reproductive. Likewise, early in the season, most males were not scrotal. Thus, our data may be biased towards apparent (and so-called) non-reproducing individuals. Bats captured early in the season are not distinguished from those captured later in figures and tables in this report. The date of earliest reproductive female capture varies from species to species and year to year; any bias associated with

these results is included in the discussion and individual species accounts (Appendix C). As noted in results, numbers of males and females varied across all sites (Appendix D).

The above sources of error may be termed "observer error." There is at least one other influence on our ability to capture bats and that is the effect of seasonal or yearly climatic fluctuations. Bat activity over a given water source seems to be inversely proportional to the amount of water dispersed across the landscape (Findley 1993, Geluso, pers. commun.); that is, the more water there is, the less concentrated the bat activity will be over a given site. During 1996, the Jemez Mountains experienced drought conditions during the winter, spring, and early summer months. Many of the water sources netted in 1995 were dry early in the 1996 season. This situation reversed itself in a remarkably short period in late June 1996 when early monsoonal rains began to fall. Following the commencement of summer rains, water sources were abundant and a consequent dispersal of bats across the landscape occurred. Both precipitation and its converse, drought severity, have varied considerably over the last three years (Appendix E). The winter and spring of 1995-96 were especially dry.

Climate also can affect mistnetting success through its effects on insects, upon which bats in the Jemez Mountains feed. During the breeding season, temperature and precipitation determine whether individuals forage or not (Grindal et al. 1992, Holroyd et al. 1994, Rydell 1989). Furthermore, most north temperate female bats remain homeothermic during pregnancy and lactation and may not be able to maintain homeothermy if regular feeding is not possible (Findley 1993). Thus, climate may affect localized aspects of bat distributions. In addition, females may not breed in some years (Holroyd et al. 1994) or may resorb or abort embryos during times of stress.

Recent work in the Jemez Mountains has added considerably to our understanding of bat abundance and distribution there. Species added specifically to LANL or BAND since Findley et al. (1975) include *M. californicus*, *M. ciliolabrum*, *P. hesperus*, *C. townsendii*, and *T. brasiliensis* (Arganbright 1987, Guthrie and Large 1980, Judson 1990, Sexton et. al. 1995, Tyrell and Brack 1992). Refinements in our understanding almost certainly are the result of increased research effort at specific sites rather than significant distributional changes in any of the bat species.

Most of the bat species captured during 1995 and 1996 in the Jemez Mountains are typical associates of ponderosa pine-mixed conifer forests (Findley et al. 1975). The average elevation of capture (Figure 16) generally reflects what is known about the elevational distributions of these species. Though some bats, such as *E. maculatum* which is known from Albuquerque, are known to have greater elevational ranges than the figure indicates, *Euderma* along with *M. evotis*, *M. volans*, *L. cinereus*, and *L. noctivagans* are bats commonly captured in mixed conifer-ponderosa pine forests. Species captured in ponderosa-pine forest that also range down to lower elevations are *E. fuscus*, *M. ciliolabrum*, *M. thysanodes*, and *M. yumanensis*. *M. volans* occurs at low elevations at least on a seasonal basis (Bogan, unpubl. data).

The mean elevation of BAND sites was higher (mean=7906') than that of LANL sites (mean=6687') and the bat captures from each area reflect the difference in elevation of sites. The four most commonly captured species at BAND were *L. noctivagans, M. evotis, M. thysanodes,* and *M. volans,* all species typical of pine-mixed conifer forests. On the other hand, the four most commonly captured species at LANL were *L. noctivagans, E. fuscus, A. pallidus,* and *M. volans*. Captures of *A. pallidus* at LANL reflect our work at low elevation sites.

Bat species common at lower elevations are *M. californicus, P. hesperus, T. brasiliensis,* and *A. pallidus*. We captured 3 *P. hesperus* and 47 *A. pallidus* during the study period, all at sites lower than 7000 feet. The earliest and only other record of *P. hesperus* from the Jemez Mountains is apparently an individual specimen reported by Bailey (1931) from "Jemez Canyon." It is likely that this specimen was taken at a site below 7000 feet. Captures of *P. hesperus* and more *A. pallidus* in 1996 than 1995 reflect the increased effort at lower elevation sites (LANL). The data of other researchers (e.g., Tyrell and Brack 1992) in the Jemez Mountains exhibit similar elevational species trends.

The overall frequency of species captured for both years likely reflects the preponderance of ponderosa pine-mixed conifer forest sites we netted. The two species that we captured most frequently were *L. noctivagans* and *M. evotis*; both are species typical of upper elevations. The most widespread species (Table 8) were *L. noctivagans, M. thysanodes,* and *E. fuscus*. These species exhibit relatively wide ranges of capture elevations (Table 11) but their occurrence at our netting sites is likely due to several factors, including how easy they may be to catch in nets. The lack of capture data for certain species may be the result of mistnetting bias rather than absence of the species in the area. For example, the distinct, audible calls of *E. maculatum* (Cryan 1993) were heard at all sites except Frijoles Canyon during the summer of 1996, yet they were captured at only one site. It is also interesting to note the small number of *T. brasiliensis* captured during 1995 and 1996, considering the presence of several large roosts within the study areas. *Tadarida* may be leaving their roosts and foraging and drinking in the valley of the Rio Grande.

Bats are long-lived mammals with relatively low fecundity and mortality rates and an extended period of maternal care (Findley 1991); undisturbed populations are not known to fluctuate greatly over short periods of time. Despite the increased netting effort during 1996, more *M. evotis, M. thysanodes, M. volans,* and *M. yumanensis* were captured per night during 1995. The reason for this decreased capture success is unknown, but may reflect the biases of current sampling techniques or short-term responses to climate, rather than actual population trends. The Jemez Mountains were under drought conditions during the first half of 1996 and then inundated with rain later in the summer (Appendix E). The lack of precipitation, either as snow or rain, dried up several sites we netted in 1995, leaving fewer suitable areas to capture bats. Later in the season, rainfall increased the amount of standing surface water throughout the study area. This may have led to the drop in capture success for several species during 1996.

Additional data from a year with precipitation closer to the long-term average is needed to tease these factors apart.

The ratios of reproductive to non-reproductive females over the past two years (Figures 13 and 14) reveal that during 1996 we observed a greater percentage of reproductive females to non-reproductive females than in 1995. If indeed reproductive females of some species are prone to inhabit lower elevations (Table 12, Figure 17), the greater total percentage of reproductive females captured in 1996 may be a consequence of netting more low elevation sites. The higher percentage of reproductive females captured in 1996 may also reflect an increased sample size during 1996. Overall, 9 out of 13 species exhibited more reproductive than non-reproductive females.

More non-reproductive than reproductive females were captured of *M. evotis*, *M. volans*, *M. yumanensis*, and *L. noctivagans*. Of these species, most of the non-reproductive female *M. ciliolabrum* and *M. volans* were captured on dates after reproductive females of each species had been caught. All of the non-reproductive *M. yumanensis* were captured late in the season (mid-July through August) and it is unlikely that signs of reproduction at this time would go undetected. The species with the lowest percentage of reproductive females was *M. volans*. Only 13 % of the 16 *M. volans* females captured in the past two years have been reproductive. Despite having the lowest observed percentage of reproductive females, one of the six juveniles captured in two years was of this species. The greater percentage of scrotal males captured in 1995 most likely is a result of a delayed study period (late summer), during which time reproductive males are more frequently encountered.

The relatively low numbers of observed reproductive female bats captured during the study period has confounded our efforts to locate maternity colonies of more than a few species. We assume that adequate maternity roosts are the most critical component for bats in the Jemez and should be the primary focus of research and management activities. Females often demonstrate high fidelity to such roosts, which have permanency and low availability (Lewis 1995). Non-reproductive females and males typically occupy multiple solitary roosts and may demonstrate low fidelity to such widespread roosts (Lewis 1995). Solitary roosts may be difficult to study or protect, other than in a landscape sense.

There are a number of possible explanations for the biased overall male sex ratio seen in the 1995 and 1996 capture data. Only 6 (1.5 %) of the most frequently captured species *(L. noctivagans)* were female. None of these females were grossly diagnosed as reproductive; all were captured between 23 April and 29 May 1996, probably as they were migrating though the area enroute to the north and east. Males and females of this species, and *L. cinereus*, are known to segregate during the breeding season and higher ratios of reproductive females are found elsewhere in these species ranges, beyond the immediate reach of the Jemez Mountains (Findley and Jones 1964, Kunz 1982). Females typically show an increased tendency to form colonies, often for thermoregulatory reasons. This may tend to

concentrate their distribution locally and make them more difficult to capture. Males may tend to wander greater distances in pursuit of mating opportunities.

In Europe, Kronwitter (1988) and other researchers report sexual segregation of bat populations on a local scale affecting capture results (Sluiter & van Heerdt 1966, Gaisler et. al. 1979). They found no female bats of the species they were studying (*Nyctalus noctula*) in their study area, despite 3 years of intensive survey, while colleagues in neighboring regions of Europe reported predominantly female populations. In the Jemez, all *N. macrotis* and *E. maculatum* captured to date were female and most were lactating, indicating they breed in the Jemez. *N. macrotis* makes long-distance migrations, yet we know far too little about the seasonal movement and distribution of the sexes to speculate on reasons for the capture of only females.

The elevational segregation of males and reproductive females (females being captured at lower elevations) also has been shown in other areas (Cryan and Bogan 1995). Temperature plays an important role in the reproductive physiology of bats (Studier and O'Farrell 1972) and females needing to remain homeothermic during pregnancy and lactation may be selecting lower elevation, warmer sites. Future research should incorporate more low elevation capture sites to determine if females are indeed selecting these areas, at least in some years.

The presence of suitable nursery roosts is believed to be the most important factor governing the distribution of temperate bats (Humphrey 1975). Typically, areas with the most topographic diversity also demonstrate the greatest bat species diversity. It is likely that an increased understanding of bat roosting habits in the Jemez Mountains will help us to explain the distribution and abundance data we are gathering. The location and characterization of maternity colonies should remain a primary focus of bat research in the Jemez Mountains.

We found tracking of tagged bats to their roost to be a challenging task in the broken and complex terrain of the eastern Jemez Mountains. Two of seven bats that were tagged with radios were not tracked to roosts, although we did locate them in flight for brief periods. In general, the roosting habits of *M. thysanodes* that we discerned were similar to observations made elsewhere in their range. Female *M. thysanodes* roosted in cavities on south-facing cliffs that we presume provided warm microclimates for females needing to maintain homeothermy. Additionally, they appeared to move daily, at least slightly, which is consistent with observations in the Black Hills (Cryan and Bogan 1995). Lewis (1995) discusses several reasons why bats would move frequently among roosts, and such lability is characteristic of bats that occupy roosts that are abundant in the landscape, as the pits in Bandelier tuff appear to be. Male bats tend to remain heterothermic even in summer and the choice of a north-facing cliff as a roosting site by a male *M. thysanodes* is consistent with this thermoregulatory strategy.

Eptesicus fuscus is known to form maternity roosts in a variety of structures, including trees and buildings. We found that one *E. fuscus* was using a large ponderosa pine snag as a roost, along with at least 35 other (presumed) conspecifics. We have some evidence that this bat later moved to another such snag nearby; reasons for this move are unclear to us. Trees in forests that are used by reproductive females tend to be large old, often dead, snags. Furthermore, such roost trees are frequently located so that they are well insulated. Use of such trees by homeothermic females would be predicted.

Our experience in tracking bats in the eastern Jemez Mountains suggests that in 1997 some changes in technique would be useful. In 1997, we intend to use fixed-wing aircraft to help us initially locate tagged bats, after which ground searches would be made. We also will use additional personnel for a more concentrated effort during the peak reproductive season.

We have netted all eight bat species of concern in the Jemez. A majority of females of the species of concern captured to date were reproductive. Three species (*M. evotis*, *M. thysanodes*, and *M. volans*) were frequently captured and a fourth (*Euderma*) was captured occasionally and heard frequently. The roosts chosen by *M. thysanodes* suggests that there is no immediate threat to their reproductive populations, as such structures are common in the Jemez Mountains. We captured low numbers of two species (*M. ciliolabrum* and *C. townsendii*). These bats are agile fliers and their capture numbers may reflect netting bias rather than relative abundance. *M. yumanensis* is known to roost, and reproduce, at BAND and tends to occur at elevations lower than where we netted; it is probably relatively common. Tracking the local status of *M. yumanensis* could best be done by monitoring the roosts at BAND. *N. macrotis* was netted in low numbers both at BAND and the Santa Fe National Forest.

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Table 1. Dates bats were mistnetted in the Jemez Mountains during 1995 and 1996. BAND = Bandelier National Monument and LANL = Los Alamos National Laboratory.

LANL DATES		BAND DATES
09/05/95		07/18/95
09/06/95		07/19/95
04/24/96		07/20/95
04/25/96		07/26/95
05/21/96		07/27/95
05/22/96		07/31/95
05/23/96		08/01/95
05/29/96		08/02/95
05/30/96		08/03/95
06/01/96		08/07/95
06/02/96		08/08/95
06/05/96		08/09/95
06/18/96		08/10/95
06/25/96		08/14/95
06/27/96		08/16/95
06/28/96		08/17/95
07/02/96		05/15/96
07/09/96		05/20/96
07/10/96		05/31/96
07/11/96		06/06/96
07/17/96		06/10/96
07/18/96		06/24/96
07/22/96		07/15/96
07/23/96		07/16/96
07/24/96		07/21/96
07/30/96		07/29/96
08/06/96		07/31/96
08/13/96		08/08/96
08/14/96		08/09/96
08/28/96		08/12/96
09/04/96		08/27/96
09/05/96		08/28/96
09/10/96		09/06/96
		09/11/96
33	TOTAL	34

Table 2. Sites netted in the Jemez Mountains during 1995 and 1996.
BAND = Bandelier National Monument, LANL = Los Alamos National Laboratory and SFNF = Santa Fe National Forest.

1995	1996	Both Years Combined	
Site	Site	Site	Code
Dome Pond (P 2)	East Fork of Jemez River	Dome Pond	BAND
Frijoles Creek @ R.H. Crossing	Frijoles Creek @ R.H. Crossing	East Fork of Jemez River	SFNF
Frijoles Creek @ Visitor Center	Icehouse Pond	Frijoles Creek @ R.H. Crossing	BAND
Icehouse Pond	Los Alamos Canyon - Otowi Well 4	Frijoles Creek @ Visitor Center	BAND
Lower Pond (P 4)	Los Alamos Canyon - Upper Puddle	Icehouse Pond	LANL
Meadow Pond (P 1)	Los Alamos Canyon CLF	Los Alamos Canyon - Otowi Well 4	LANL
Mortandad Canyon	Los Alamos Canyon Reservoir	Los Alamos Canyon - Upper Puddle	LANL
North Upper Pond (P 7)	Meadow Pond	Los Alamos Canyon CLF	LANL
Sewage Lagoons (L 1-3)	Pajarito Wetland	Los Alamos Canyon Reservoir	LANL
Ski Pond (P 5)	Pueblo Canyon Effluent	Lower Pond	BAND
Upper Pond (P 3)	Pueblo Canyon Waste Facility	Meadow Pond	BAND
	Ski Pond	Mortandad Canyon	LANL
	Tech. Area 15 Cement Pond	North Upper Pond	BAND
		Pajarito Wetland	LANL
		Pueblo Canyon Effluent	LANL
		Pueblo Canyon Waste Facility	LANL
		Sewage Lagoons	BAND
		Ski Pond	BAND
		Tech. Area 15 Cement Pond	LANL
		Upper Pond	BAND
11 Sites	13 Sites	20 Sites	

Table 3. Number and species of bats captured during 1995 and 1996 at sites in the Jemez Mountains. F = female; M = male; Sub = subtotal captured each year. Asterisks denote Federal Species of Concern status, "E" indicates State Endangered status.

	Species	F (1995)	M (1995)	Sub (1995)	F (1996)	M (1996)	Subtotal (1996)	Total F	Total M	TOTAL
	M. californicus	0	2	2	5	4	9	5	6	11
*	*M. ciliolabrum*	2	4	6	7	30	37	9	34	43
*	*M. evotis*	4	40	44	11	24	35	15	64	79
*	*M. thysanodes*	8	8	16	13	13	26	21	21	42
*	*M. volans*	5	18	23	12	29	41	17	47	64
*	*M. yumanensis*	3	5	8	2	0	2	5	5	10
	L. cinereus	0	2	2	0	19	19	0	21	21
	L. noctivagans	0	91	91	6	315	321	6	406	412
	P. hesperus	0	0	0	0	3	3	0	3	3
	E. fuscus	2	5	7	33	34	67	35	39	74
* (E)	*E. maculatum*	3	0	3	2	0	2	5	0	5
*	*C. townsendii*	2	0	2	0	2	2	2	2	4
	A. pallidus	1	1	2	0	45	45	1	46	47
	T. brasiliensis	1	4	5	0	1	1	1	5	6
*	*N. macrotis*	0	0	0	7	0	7	7	0	7
	TOTALS	31	180	211	98	519	617	129	699	828

Table 4. Bats netted at LANL sites during 1995 and 1996. Asterisks denote species of concern.

	Species	Male	Female	Total	% Male	% Frequency
	M. californicus	4	4	8	50	2
*	*M. ciliolabrum*	22	7	29	76	7
*	*M. evotis*	15	13	28	54	7
*	*M. thysanodes*	7	5	12	58	3
*	*M. volans*	24	11	35	69	9
*	*M. yumanensis*	0	0	0	0	0
	L. cinereus	3	0	3	100	1
	L. noctivagans	182	5	187	97	48
	P. hesperus	1	0	1	100	0
	E. fuscus	22	28	50	44	13
*	*E. maculatum*	0	0	0	0	0
*	*C. townsendii*	2	0	2	100	1
	A. pallidus	36	0	36	100	9
*	*T. brasiliensis*	1	0	1	100	0
	N. macrotis	0	0	0	0	0
	TOTAL	319	73	392	81	100

Table 5. Number of LANL sites at which each species was netted. Asterisks denote species of concern.

	Species	Female	Male
	M. californicus	2	2
*	*M. ciliolabrum*	3	3
*	*M. evotis*	3	2
*	*M. thysanodes*	2	3
*	*M. volans*	1	2
*	*M. yumanensis*	0	0
	L. cinereus	0	2
	L. noctivagans	2	4
	P. hesperus	0	0
	E. fuscus	3	2
*	*E. maculatum*	0	0
*	*C. townsendii*	0	2
	A. pallidus	0	3
	T. brasiliensis	0	1
*	*N. macrotis*	0	0

Table 6. Bats netted at BAND sites during 1995 and 1996. Asterisks denote species of concern.

	Species	Male	Female	% Male	Total	% Frequency
	M. californicus	2	1	67	3	1
*	*M. ciliolabrum*	12	2	86	14	3
*	*M. evotis*	49	2	96	51	12
*	*M. thysanodes*	14	16	47	30	7
*	*M. volans*	23	6	79	29	7
*	*M. yumanensis*	5	5	50	10	2
	L. cinereus	18	0	100	18	4
	L. noctivagans	224	1	100	225	52
	P. hesperus	2	0	100	2	0
	E. fuscus	17	7	71	24	6
*	*E. maculatum*	0	5	0	5	1
*	*C. townsendii*	0	2	0	2	0
	A. pallidus	9	1	90	10	2
	T. brasiliensis	4	1	80	5	1
*	*N. macrotis*	0	7	0	7	2
	TOTAL	379	56	87	435	100

Table 7. Number of BAND sites at which each species was netted. Asterisks denote species of concern.

	Species	Female	Male
	M. californicus	1	2
*	*M. ciliolabrum*	2	3
*	*M. evotis*	1	5
*	*M. thysanodes*	6	5
*	*M. volans*	3	7
*	*M. yumanensis*	3	2
	L. cinereus	0	4
	L. noctivagans	1	6
	P. hesperus	0	2
	E. fuscus	3	5
*	*E. maculatum*	2	0
*	*C. townsendii*	1	0
	A. pallidus	1	2
	T. brasiliensis	1	4
*	*N. macrotis*	2	0

Table 8. Number of sites at which each species was captured and number of nights each species was captured during 1995 and 1996.

Species	# Sites	# Nights
M. californicus	5	7
M. ciliolabrum	7	23
M. evotis	9	24
M. thysanodes	12	24
M. volans	9	25
M. yumanensis	4	5
L. cinereus	6	10
L. noctivagans	10	31
P. hesperus	2	2
E. fuscus	10	23
E. maculatum	2	3
C. townsendii	3	3
A. pallidus	6	11
T. brasiliensis	6	6
N. macrotis	2	2

Table 9. Reproductive status of bats captured at LANL and BAND during 1995.
NR = non-reproductive; S = scrotal; J = juvenile; P = pregnant; L = lactating; PL = postlactating.

1995	FEMALE					MALE		
Species	NR	P	L	PL	J	NR	S	J
M. californicus	0	0	0	0	0	1	1	0
M. ciliolabrum	0	0	0	2	0	2	2	2
M. evotis	3	0	0	1	0	14	26	0
M. thysanodes	2	0	2	4	0	3	3	0
M. volans	4	0	0	0	1	5	13	1
M. yumanensis	2	0	0	1	0	1	4	0
L. cinereus	0	0	0	0	0	2	0	0
L. noctivagans	0	0	0	0	0	12	79	0
E. fuscus	1	0	0	1	0	1	4	0
E. maculatum	0	0	2	1	0	0	0	0
C. townsendii	0	0	2	0	0	0	0	0
A. pallidus	0	0	0	1	0	0	1	0
T. brasiliensis	0	0	0	1	0	3	0	0
TOTAL	12	0	6	12	1	44	133	3

Table 10. Reproductive status of bats captured at LANL and BAND during 1996.
NR = non-reproductive; S = scrotal; J = juvenile; P = pregnant; L = lactating; PL = postlactating.

1996	FEMALE					MALE		
Species	NR	P	L	PL	J	NR	S	J
M. californicus	1	1	2	0	0	1	3	0
M. ciliolabrum	2	3	2	0	0	23	7	0
M. evotis	5	4	2	0	0	22	2	0
M. thysanodes	7	1	5	0	0	12	1	0
M. volans	10	0	2	0	0	28	1	0
M. yumanensis	2	0	0	0	0	0	0	0
L. cinereus	0	0	0	0	0	19	0	0
L. noctivagans	6	0	0	0	0	305	8	0
P. hesperus	0	0	0	0	0	1	2	0
E. fuscus	13	15	4	0	1	32	1	1
E. maculatum	2	0	0	0	0	0	0	0
C. townsendii	0	0	0	0	0	2	0	0
A. pallidus	0	0	0	0	0	4	41	0
N. macrotis	2	0	5	0	0	0	0	0
TOTAL	50	24	22	0	1	449	66	1

Table 11. Average elevation (in feet) of capture for bat species, standard error and range of capture elevations.

Species	Mean Elevation	Standard Error	Range (ft.)
A. pallidus	6391	31	5700-6600
P. hesperus	6453	127	6200-6580
M. californicus	6783	368	5750-7700
M. ciliolabrum	7083	147	6020-8950
M. thysanodes	7461	200	5750-9100
E. fuscus	7552	100	6020-8950
T. brasiliensis	7820	508	6080-8930
M. yumanensis	7882	432	6020-8950
M. volans	8003	107	6020-9100
N. macrotis	8090	143	7977-8950
C. townsendii	8093	634	6470-9100
L. noctivagans	8245	38	6080-8950
L. cinereus	8335	198	6020-8950
M. evotis	8436	81	6470-9100
E. maculatum	8938	5	8930-8950

Table 12. Average elevation of capture (in feet) for bat species according to sex. For each species average elevation of capture is shown for; M = male; F = female; NRF = non-reproductive female; RF = reproductive female. Totals are the average elevation of both years combined.

Species	M (1995)	M (1996)	Total M.	F (1995)	F (1996)	Total F	NRF (1995)	NRF (1996)	Total NRF	RF (1995)	RF (1996)	RF Total
M. californicus	7485	6027	6756		7000	7000	*	*	*	*	7000	7000
M. ciliolabrum	7593	7052	7322	7340	6853	7096	*	7700	7700	7340	6525	6933
M. evotis	8853	8289	8571	8400	7373	7886	8167	7268	7687	9100	7558	8329
M. thysanodes	7784	7292	7538	8563	6697	7630	7485	6641	7063	8585	6675	7780
M. volans	8173	7917	8045	8110	7905	8008	7905	7823	7864		8315	8315
M. yumanensis	8938	*	8938	7363	6020	6692	7745	6020	6883	6600	*	6600
L. cinereus	8930	8272	8601	*	*	*	*	*	*	*	*	*
L. noctivagans	8722	8127	8424	*	6902	6902	*	6902	6902	*	*	*
P. hesperus	*	6453	6453	*	*	*	*	*	*	*	*	*
E. fuscus	8572	8014	8293	6050	6987	6518	6020	6767	6393	6080	7126	6603
E. maculatum	*	*	*	8943	8930	8937	*	8930	8930	8940	*	8940
C. townsendii	*	7085	7085	9100	*	9100	*	*	*	9100	*	9100
A. pallidus	6080	6385	6233	6600	*	6600	*	*	*	6600	*	6600
T. brasiliensis	7843	8950	8396	6600	*	6600	*	*	*	6600	*	6600
N. macrotis	*	*	*	*	8090	8090	*	7947	7947		8143	8148

Table 13. P - values produced from a two sample, two tailed, unequal variance t-test for no difference in mean capture elevation between reproductive females and males of each species for which adequate data exists.

Species	p-value
M. californicus	0.61
M. ciliolabrum	0.65
M. evotis	0.02
M. thysanodes	0.46
M. volans	0.71
E. fuscus	< 0.001
C. townsendii	0.19

Table 14. Locations of diurnal and night roosts identified during systematic searches at cliff bases in Los Alamos at Pueblo Canyons. NT = UTM coordinates not yet determined by GPS.

Characteristics of Roost	General Location	Date Observed	UTM Coordinates (elevation)
Large, inactive diurnal roost in vertical crevice overhang, significant guano accumulations, roost area with odor of free-tailed bats	Pueblo Canyon, Otowi Mesa, south-facing cliff, SW 1/4 of Section 7, T 89E, R 70N	27-Jun-96	NT
Inactive, diurnal roost in bowl-shaped depression in open grotto 2 m above cliff base. About 1000 c.c. accumulation of small droppings, probably less than 1 year old.	Pueblo Canyon, unnamed mesa, south-facing cliff, NE 1/4 of Section 17, T 89E, R 70N	26-Jun-96	NT
Transient diurnal roosts (3), *Myotis*-sized droppings, near and inside grottos.	Pueblo Canyon, west end of unnamed mesa, south-facing cliff, NW 1/4 of Section 17, T 89E, R 70N	26-Jun-96	NT
Night roosts (3), *Antrozous*-sized droppings	Pueblo Canyon, west end of unnamed, south-facing cliff, NW 1/4 of Section 17, T 89E, R 70N	26-Jun-96	NT
Night roosts (2), *Antrozous*-sized droppings	Pueblo Canyon, Otowi Mesa, south-facing cliff, NE 1/4 of Section 18, T 89E, R 70N	27-Jun-96	NT
Transient diurnal roosts (3), including *Myotis*-sized droppings	Pueblo Canyon, Otowi Mesa, south-facing cliff, NE 1/4 of Section 18, T 89E, R 70N	27-Jun-96	NT
Inactive, diurnal roost in bowl-shaped depression in grotto, medium sized, older droppings	Pueblo Canyon, Otowi Mesa, south-facing cliff, SW 1/4 of Section 7, T 89E, R 70N	27-Jun-96	
Small, cylindrical chute (7-10 cm diameter) in vertical cliff, 3 m above cliff base. About 100 *Myotis*-sized pellets. Very recently used diurnal roost.	Pueblo Canyon, Kwage Mesa, west end, south-facing cliffs	26-Aug-96	13 386403, S 3971817 (2068 m)
Diurnal roost, large vertical crevice about 10 m above tuff layer, numerous scattered *Tadarida*-sized pellets at base of cliff	Pueblo Canyon, Kwage Mesa, south-facing cliffs	26-Aug-96	NT

Table 14. (continued)

Characteristics of Roost	General Location	Date Observed	UTM Coordinates (elevation)
Diurnal roost, large vertical chute, about 40 m above cliff base, numerous scattered *Tadarida*-sized pellets at base of cliff	Pueblo Canyon, Kwage Mesa, south-facing cliffs	26-Aug-96	13 386830, S 3971734 (2052 m)
Night roosts (3), one with *Antrozous*-sized droppings, two smaller, in group of about 12 grottos, fresh for 1996.	Pueblo Canyon, Kwage Mesa, south-facing cliffs	28-Aug-96	13 387059, S 3971661 (2052 m)
Active diurnal roost, 540 *Tadarida* counted at emergence. Large, double vertical chutes about 40 m above cliff base	Pueblo Canyon, Kwage Mesa, south-facing cliffs	28-Aug-96	13 387332, S 3971573 (2046 m)
Night roost with numerous *Antrozous*-sized droppings	Lower Los Alamos Canyon, south-facing cliffs, NW 1/4 of Section 20, T 19N, R 7E	27-Aug-96	13 389524, S 3969883 (1999 m)
Night roost with numerous *Antrozous*-sized droppings	Lower Los Alamos Canyon, south-facing cliffs, NW 1/4 of Section 20, T 19N, R 7E	27-Aug-96	13 389475, S 3969892 (1991 m)
Night roost with *Antrozous*-sized droppings, culled sphingid moth wings	Lower Los Alamos Canyon, south-facing cliffs, NW 1/4 of Section 20, T 19N, R 7E	27-Aug-96	13 389311, S 3969956 (2013 m)
Diurnal roost, vertical crevice about 8 m above cliff base, *Antrozous*-sized droppings	Lower Los Alamos Canyon, south facing cliffs, NW 1/4 of Section 20, T 19N, R 7E	27-Aug-96	13 388905, S 3970038 (2019 m)
Night roost in grotto with two internal vertical chutes, pellet size range indicates use by several species, including *Antrozous*. Verified active by net capture of *Antrozous* entering at night.	Lower Los Alamos Canyon, south-facing cliffs, NE 1/4 of Section 19, T 19N, R 7E	28-Aug-96	13 388617, S 3970178 (2006 m)

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Figures 13 & 14. Number of reproductive and non-reproductive female bats captured at all sites during 1995 and during 1996.

Figure 15. Combined year total number of reproductive and non-reproductive female bats captured during both 1995 and 1996 at all sites in the Jemez Mountains.

Figure 16. Average elevation of capture for each species during 1995 and 1996 in the Jemez Mountains. Bars represent standard error.

Figure 17. Average elevation of sexes for each species of bat captured in the Jemez Mountains in 1995 and 1996. Bars represent standard error.

Figure 1. Total number of bats captured during 1995 and 1996 in the Jemez Mountains.

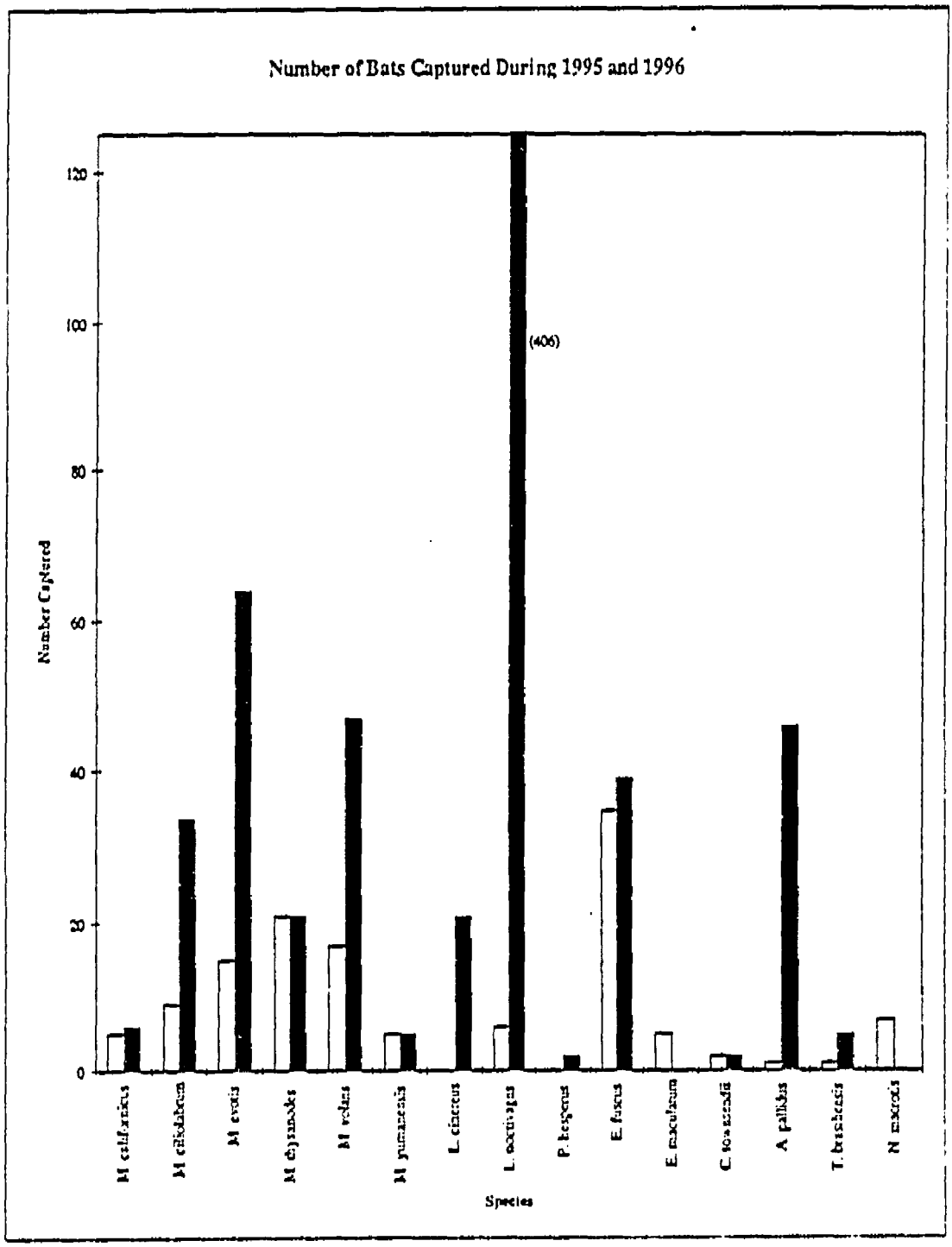


Figure 2. Total number of bats captured at LANL sites during 1995 and 1996.

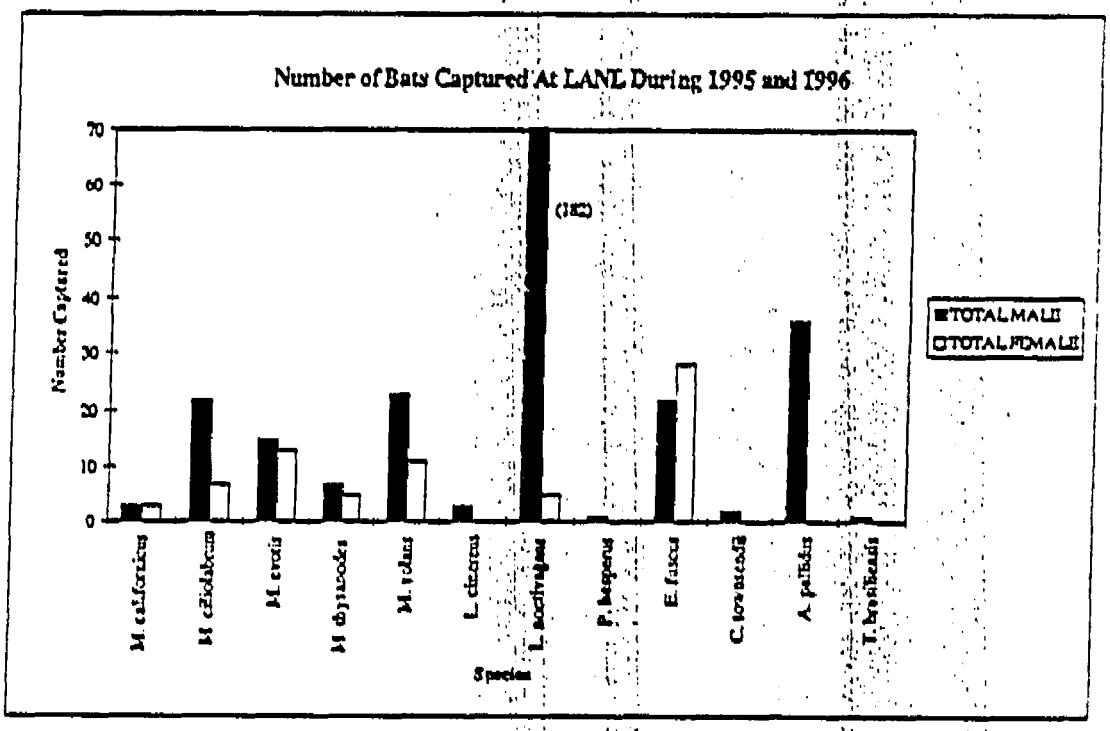


Figure 3. Number of sites bat species were captured at during 1995 and 1996 on LANL.

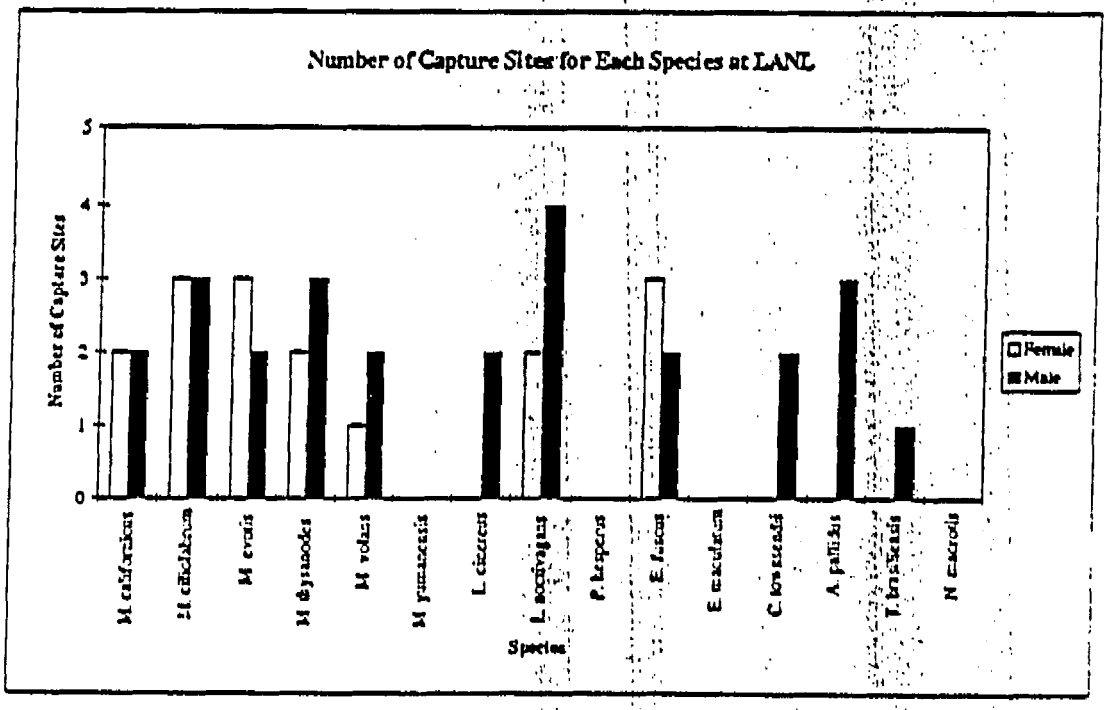


Figure 4. Total number of bats captured at BAND sites during 1995 and 1996.

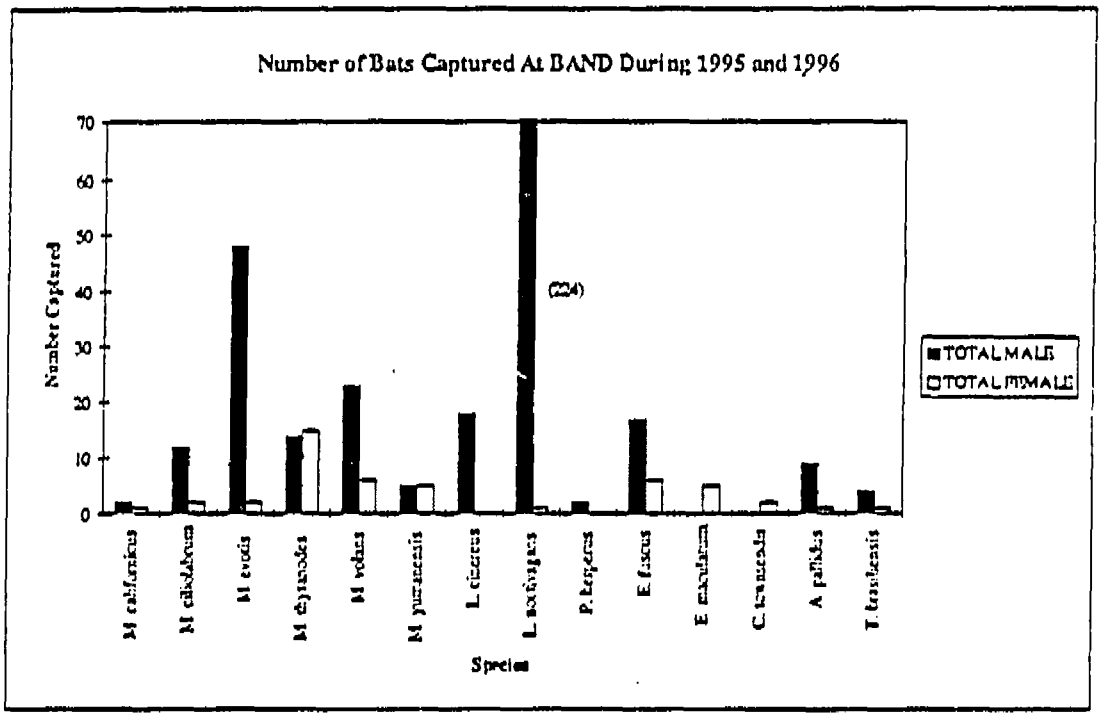


Figure 5. Number of sites bat species were captured at during 1995 and 1996 on BAND.

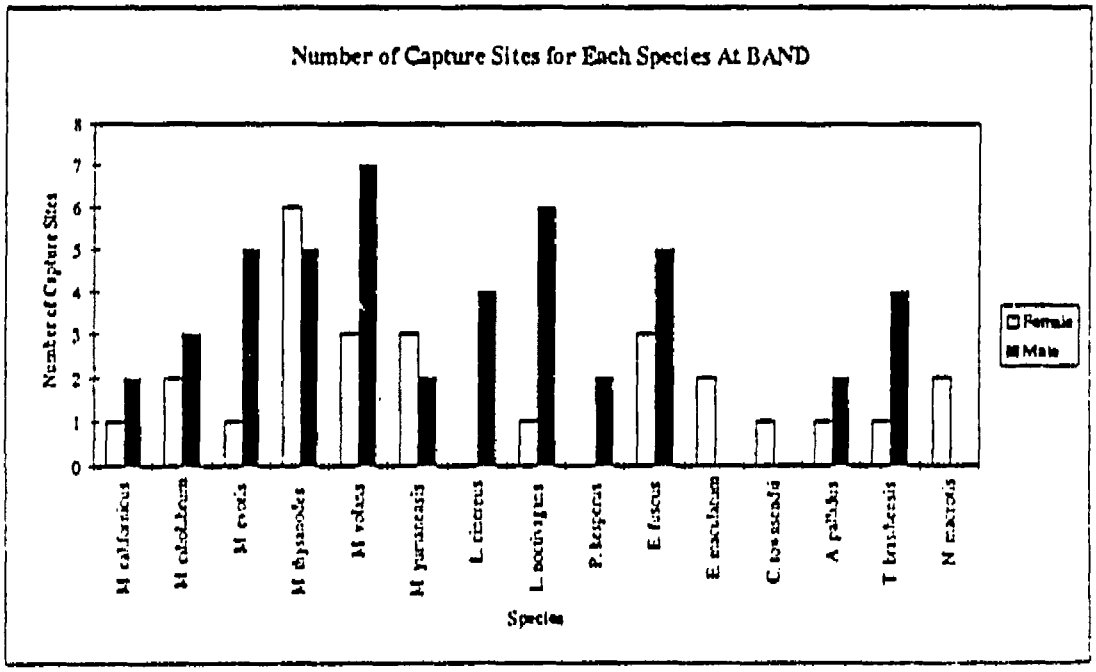


Figure 6. Number of nights that species were captured during 1995 and 1996 at all sites in the Jemez Mountains.

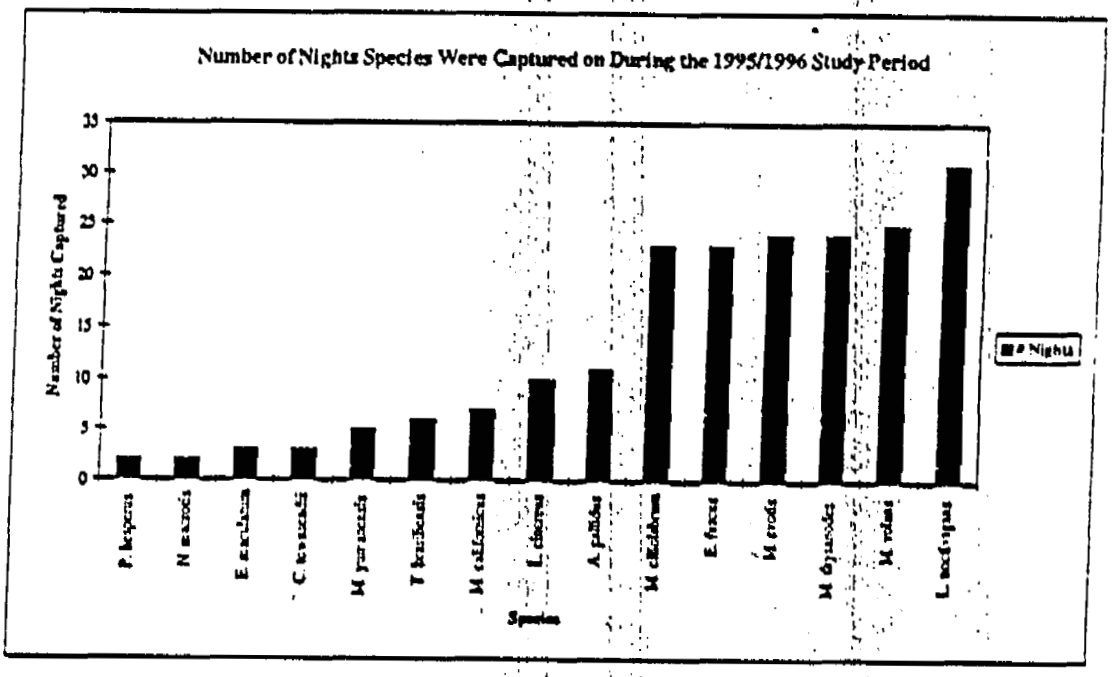


Figure 7. Number of sites at which species were captured during 1995 and 1996 including all sites.

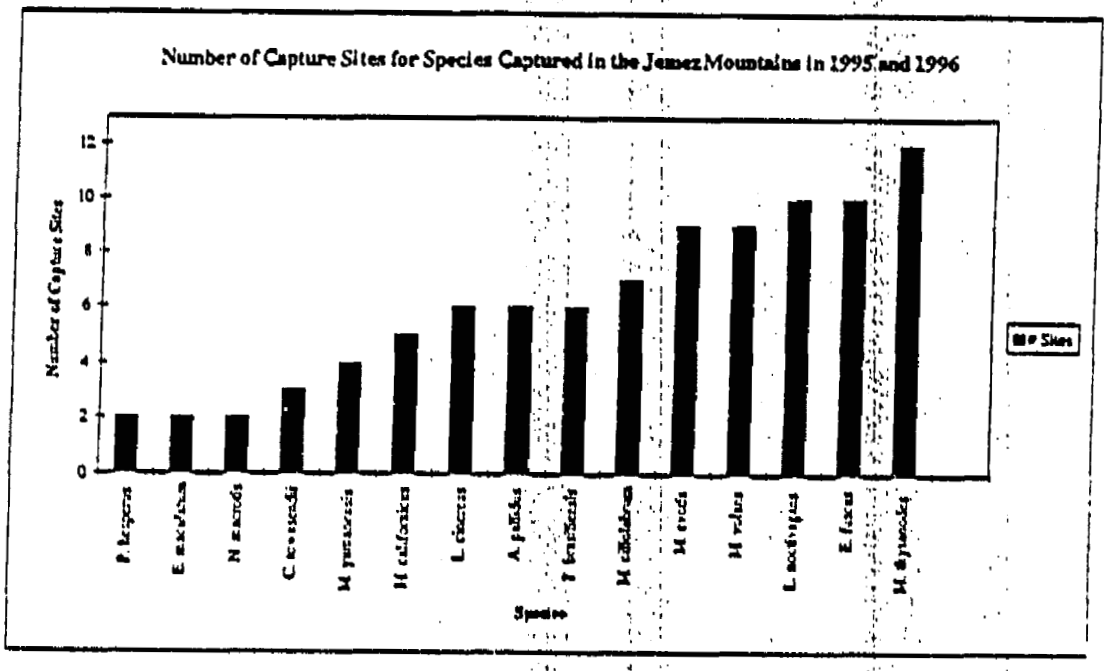


Figure 8. Number of capture sites at which males and females of each species were captured in the Jemez Mountains during 1995 and 1996.

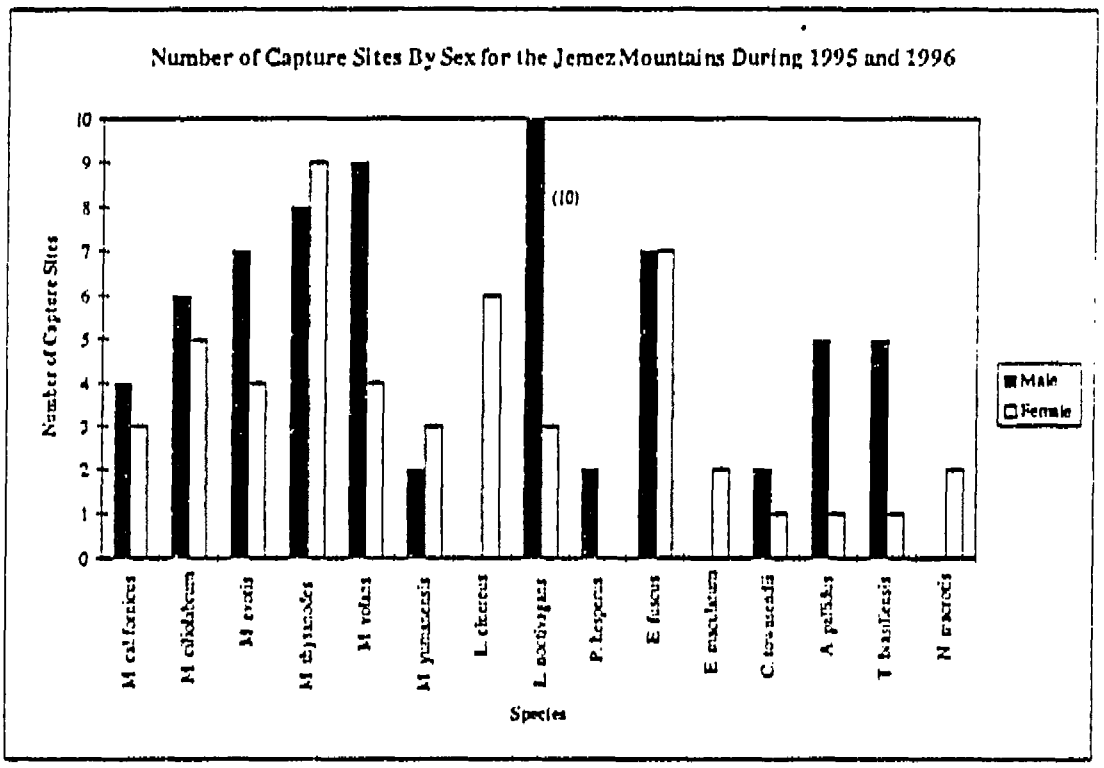


Figure 9. Total number of bats captured during 1995 and 1996 at all sites.

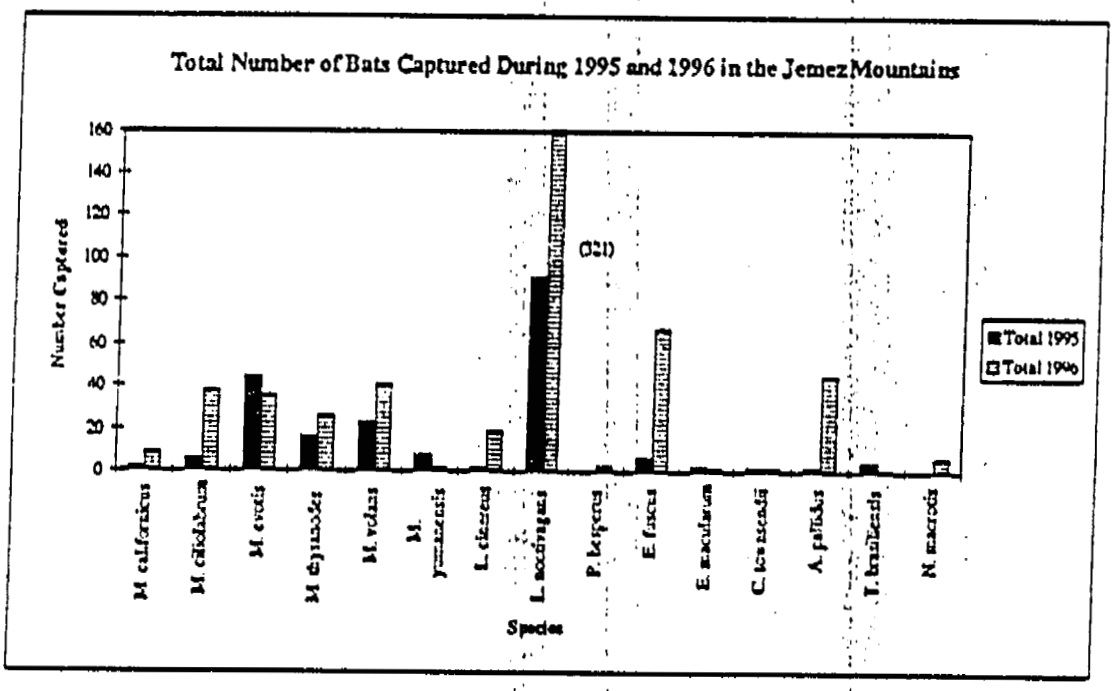
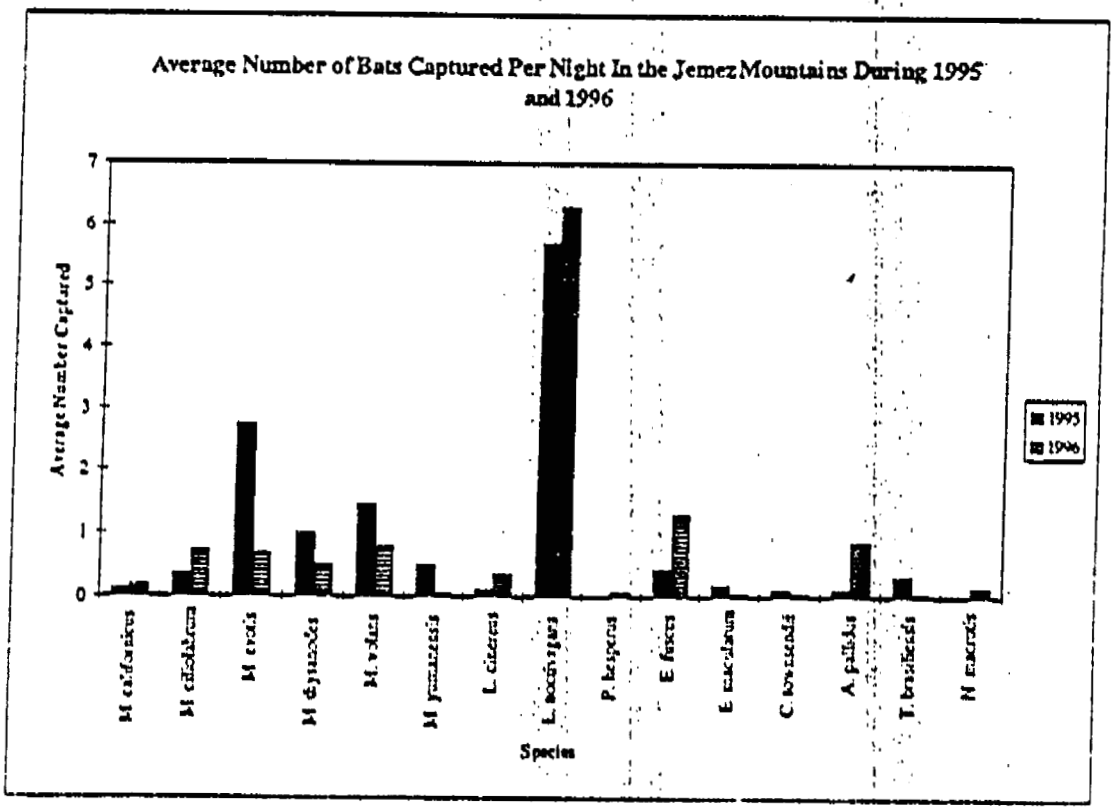
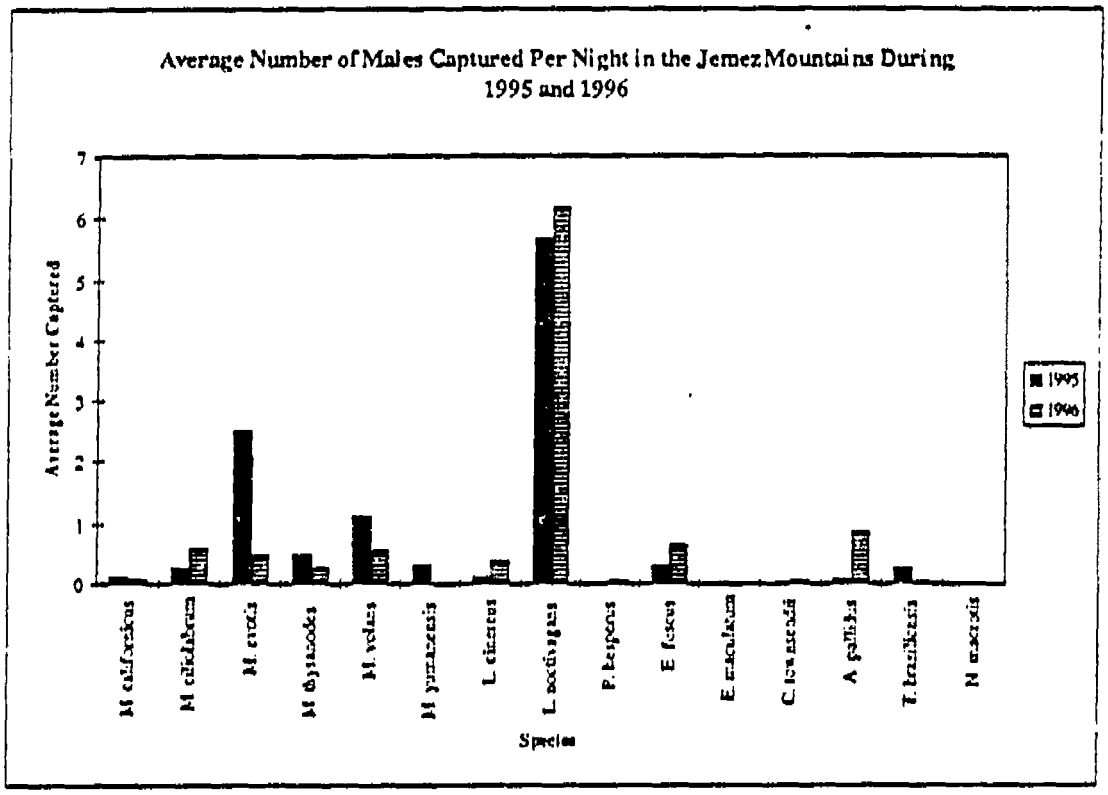
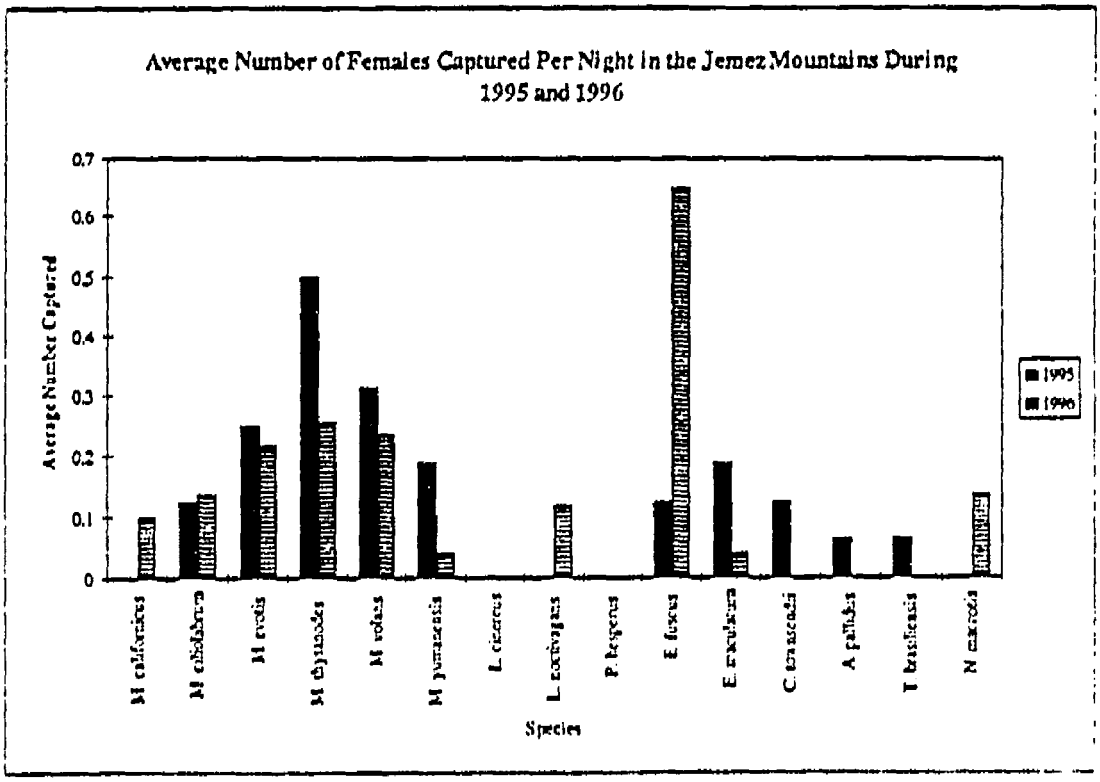


Figure 10. Mean number of bats captured during 1995 and 1996 at all sites.



Figures 11 & 12. Average number of male and female bats captured at all sites during 1995 and 1996.





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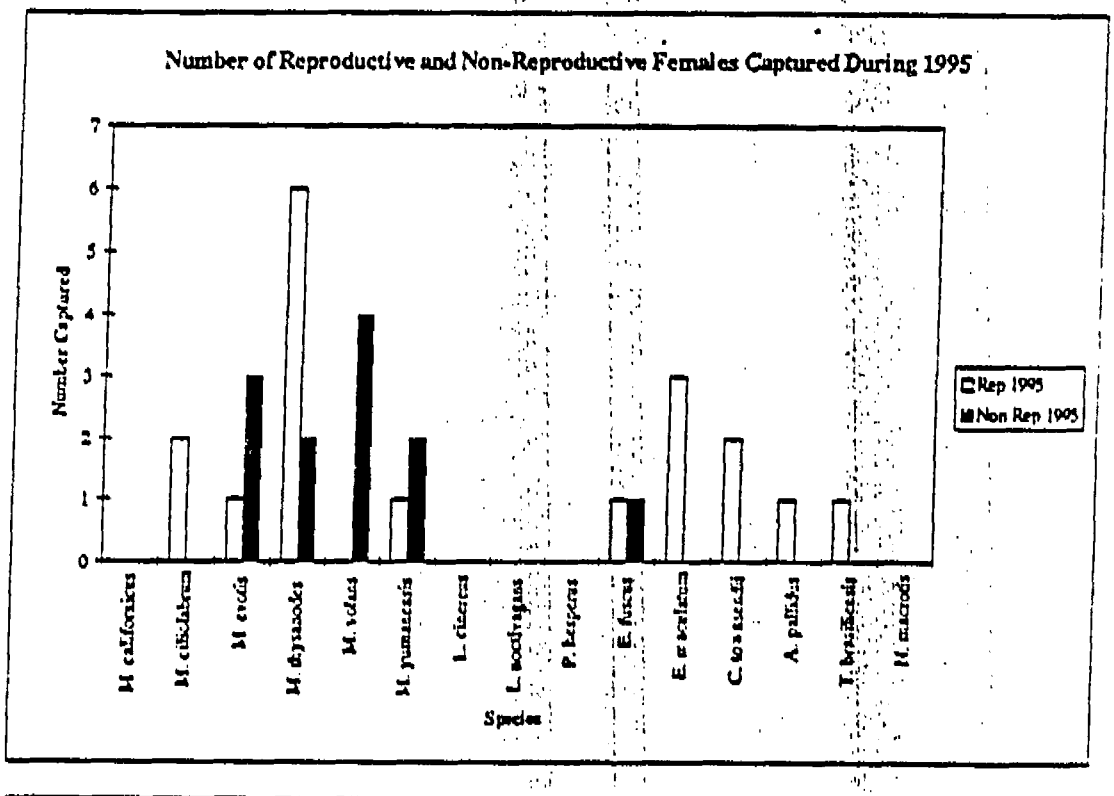


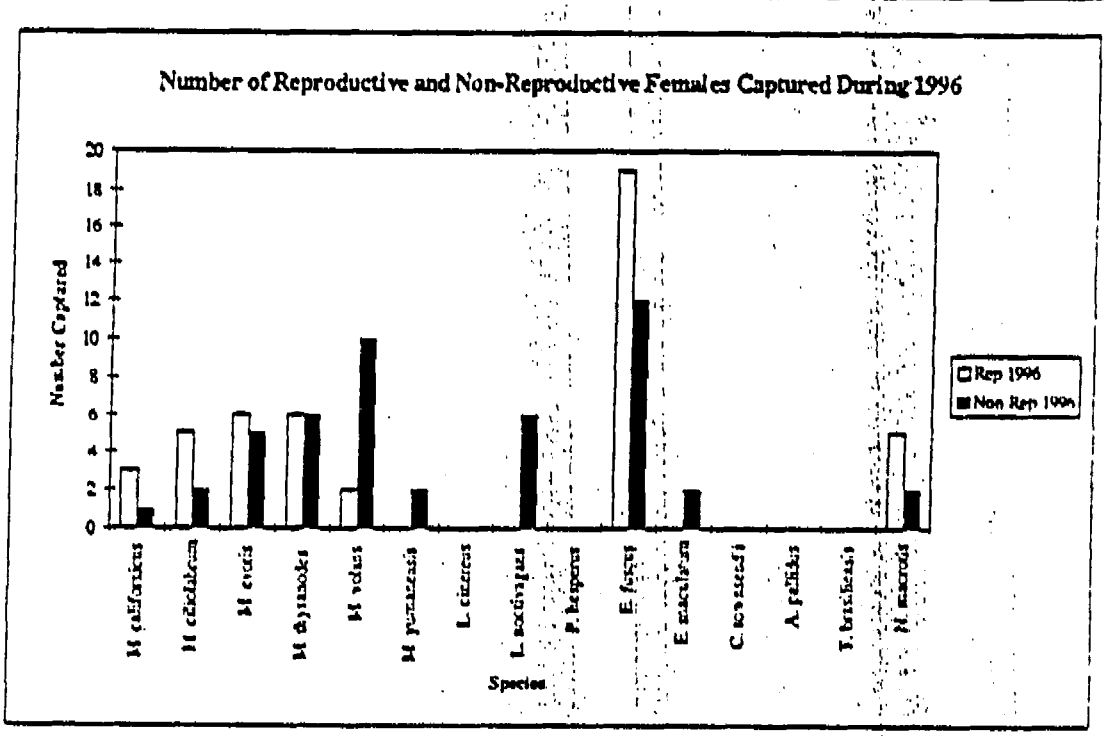


Figure 15. Combined year total number of reproductive and non-reproductive female bats captured during both 1995 and 1996 at all sites in the Jemez Mountains.

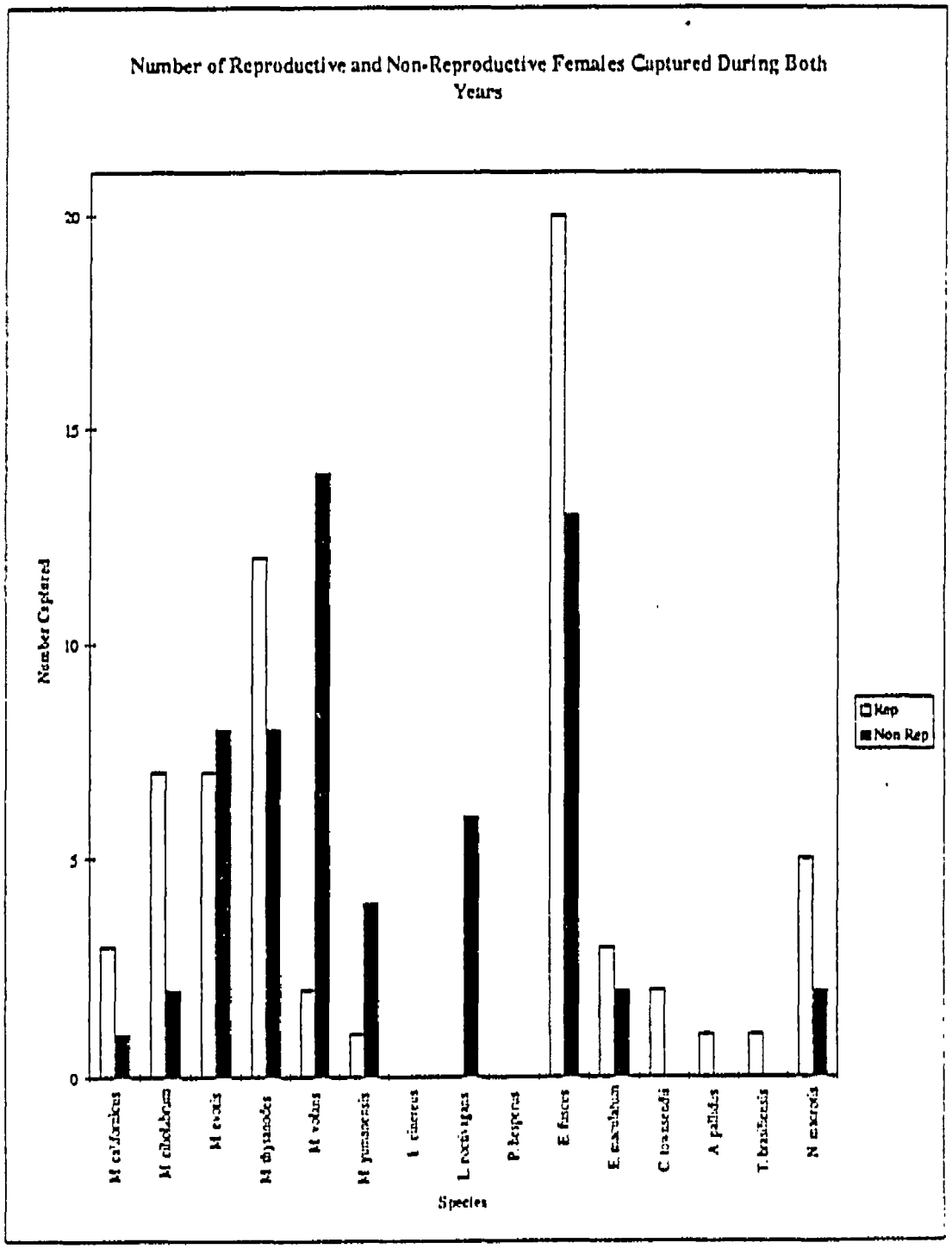


Figure 16. Average elevation of capture for each species during 1995 and 1996 in the Jemez Mountains. Bars represent standard error.

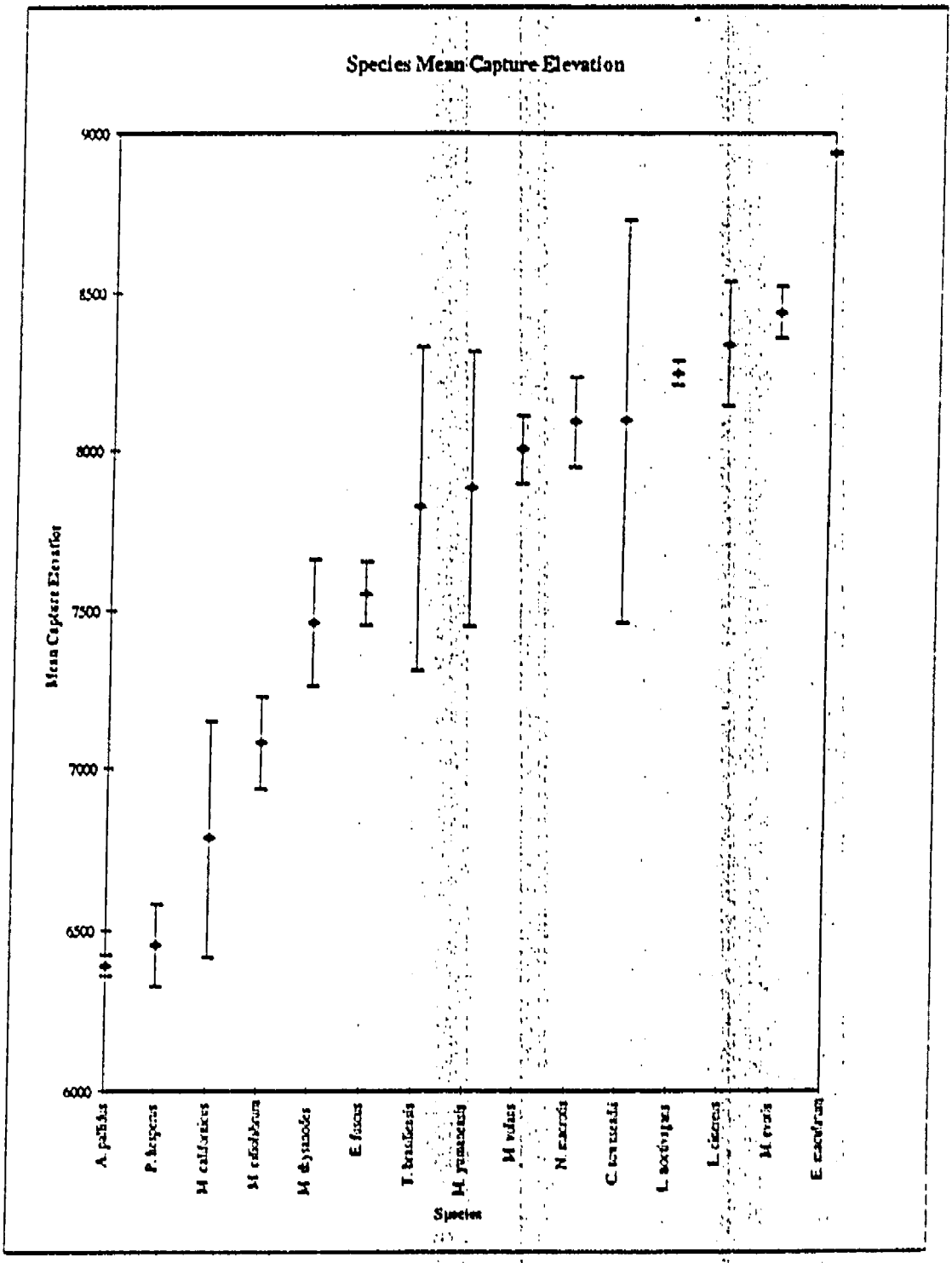
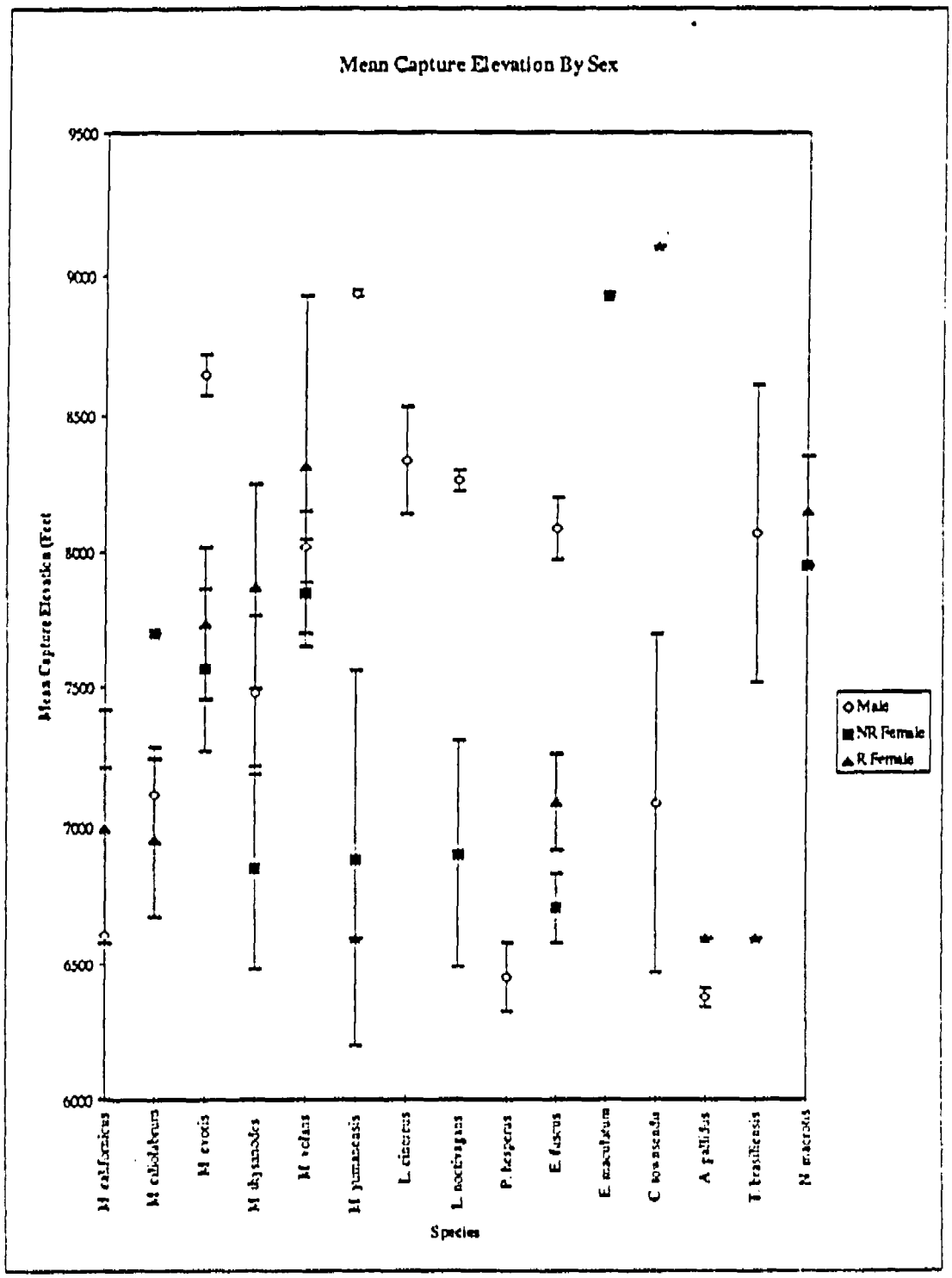


Figure 17. Average elevation of sexes for each species of bat captured in the Jemez Mountains in 1995 and 1996. Bars represent standard error.



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Appendix B. Descriptions of sites where bat nets were set during 1995 and 1996. Elevation of each site, in feet, is in brackets. Names in parentheses (e.g., P 1, L 1) are names used to describe water sources at BAND. We currently have photographs and GPS coordinates for most, but not all, of these sites. Sites are arranged generally by decreasing elevation.

Appendix C. Conservation status and species accounts of bats which are known from the Jemez Mountains.

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APPENDIX A

SUMMARY OF RESULTS OF ULTRASONIC SURVEYS FOR BATS AT BAND/LANL

By

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APPENDIX A. Summary of results of ultrasonic surveys for bats at BAND/LANL.

INTRODUCTION

Studies of bats using ultrasonic recording devices have become more common, as recording technology has developed and become less expensive (e.g., Fenton 1988). Bat surveys using ultrasonic recording devices have the potential to provide valuable information on the distribution, abundance, and ecology of bat species that complements the information gained through trapping and roost surveys. In particular, such surveys are not restricted to roost areas or the vicinity of water. They can be used to survey broad areas and a variety of habitats, and offer more complete information about overall distribution and habitats used by bats (Fenton 1988). Ultrasonic surveys are still in the development phase, however, and they have limitations. More work is needed in evaluating calls to determine whether species can be safely distinguished by their vocalizations.

I conducted surveys for bats in Bandelier National Monument (BAND) and Los Alamos National Laboratory (LANL) using ultrasonic detectors during the summer of 1996. My primary goals were to assess the utility of AnaBat detectors and point transect methodology for estimating bat activity, diversity, and habitat use and to develop a reference library of echolocation calls of known species from the Jemez Mountains. A secondary goal was to determine whether a density or volume of foraging bats could be estimated with the use of DISTANCE sampling theory in 3-dimensions.

METHODS

I used the AnaBat II bat detector, a unit designed specifically for identifying microchiropteran bats by their echolocation calls. AnaBat II detects the inaudible, high frequency sounds of bats and produces from them sounds which are audible to the unaided human ear. I interfaced the bat detector with a laptop computer in the field which enabled me to view the true frequency-time structure of echolocating bats at the time of detection. I could also record the vocalizations of bats directly onto the hard drive of the laptop with file header information such as date, location, species, and pertinent comments.

I developed the echolocation reference library by recording vocalizations from hand-released bats at 10 mist netting sites around BAND/LANL. A 500,000 candle-power spotlight was used to follow the bat as it flew from the hand. Approximately 2 recordings were made from every hand-released bat.

In conjunction with developing a call reference library, I also conducted 17 pilot transect surveys in 4 major habitat types in BAND/LANL: Riparian/Canyon bottom, Mixed Coniferous Forest, Pinyon-Juniper Woodland, and the 1977 La Mesa fire area. Encounter rates (number of "bat passes" detected/number of points along the transect) were calculated for each habitat type. A "bat pass" was defined as a continuous sequence of calls given by a single bat from when it is first detected until it travels beyond the range of detection. A bat pass usually lasts from 2-12 seconds.

Appendix A. *Continued.*

RESULTS

Echolocation library: Eleven species of bats were recorded from hand releases (common name and number of recordings in parentheses): *Myotis evotis* (Long-eared myotis, 23), *M. volans* (Long-legged myotis, 27), *M. ciliolabrum* (Western small-footed myotis, 19), *M. thysanodes* (Fringed myotis, 6), *M. californicus* (California myotis, 2), *Eptesicus fuscus* (Big brown bat, 53), *Antrozous pallidus* (Pallid bat, 31), *Corynorhinus townsendii* (Townsend's big-eared bat, 1), *Lasionycteris noctivagans* (Silver-haired bat, 24), *Lasiurus cinereus* (Hoary bat, 8), and *Nyctinomops macrotis* (Big free-tailed bat, 2). We made additional recordings of free-flying *Myotis yumanensis* (Yuma myotis), *Euderma maculatum* (Spotted bat), *Pipistrellus hesperus* (Western pipistrelle), and *Tadarida brasiliensis* (Brazilian free-tailed bat). Representative calls for 14 species in the Jemez Mountains are included in figures 1-14.

Point transects: Encounter rates varied dramatically among the four habitat types. Points with the highest average encounter rate were found along Riparian/Canyon bottom habitats (7.4). Mixed Coniferous Forest averaged 2.7 bat passes/point, Pinyon-Juniper Woodland 2.1 passes/point, and La Mesa Fire 2.7 passes/point. Due to the difficulty of estimating a distance to an individual foraging bat, I was not able to use DISTANCE sampling theory to determine foraging densities or volumes during the 1996 surveys.

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LITERATURE CITED

Fenton 1988: M. B. Fenton, "Detecting, Recording, and Analyzing Vocalizations of Bats," in *Ecological and Behavioral Methods for the Study of Bats*, T.H. Kunz (ed.), Smithsonian Institution Press, Washington, D.C., pp. 91-104.

Appendix A

Figure 1 a.

TAPE: computer DATE: 07/18/96 LOC: Frijoles Canyon
SP: Myotis californicus SPEC: female
NOTES: lactating; 4 grams

Compressed 0 to 80 kHz Div = 16 Cal = 40000 67182327.30#
DUR = 3.55 ms TBC = 157 ms FRE = 49.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 110 Buff = 0 % F 7

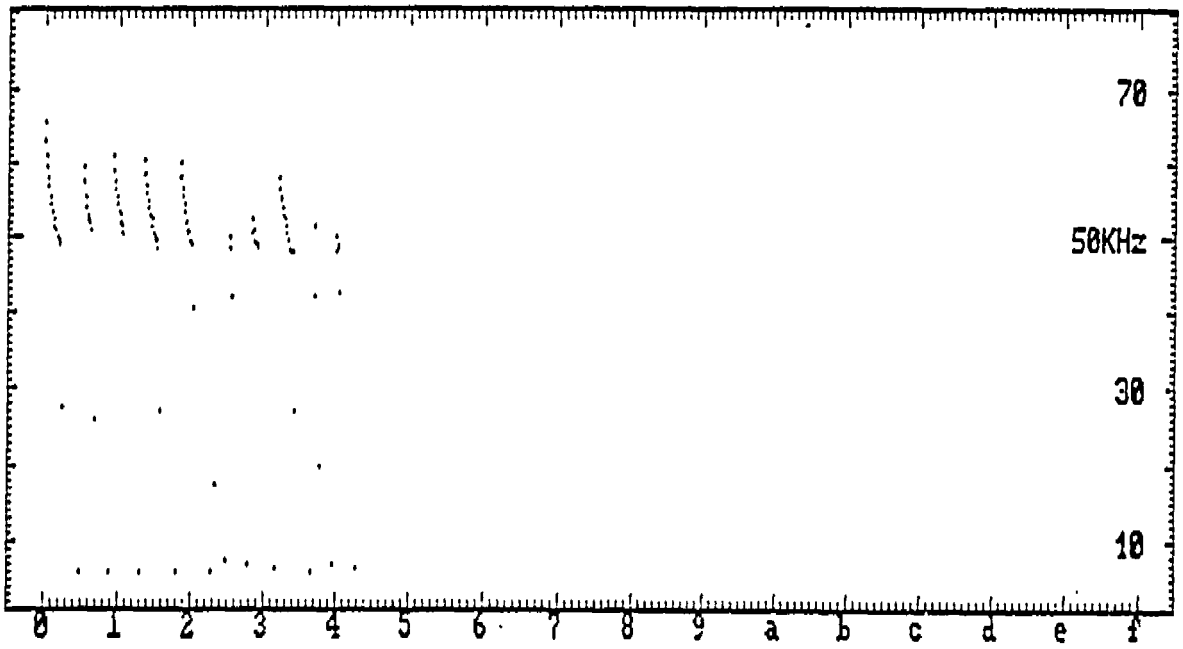
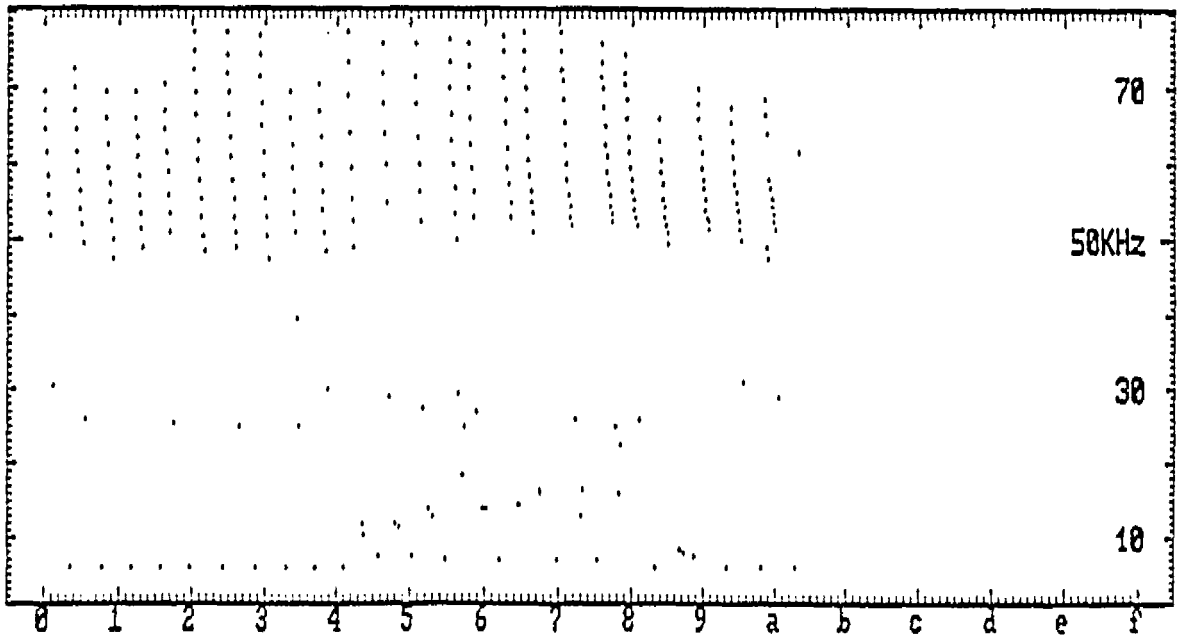


Figure 1 b.

TAPE: computer DATE: 07/18/96 LOC: Frijoles Canyon
SP: Myotis californicus SPEC:
NOTES: Hand release; female; 4 grams; still in hand, not flying.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 67182327.27#
DUR = 3.77 ms TBC = 92.4 ms FRE = 35.5 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 301 Buff = 3 % F 7



Appendix A

Figure 2a.

TAPE: Computer DATE: 05/21/96 LOC: Pueblo Canyon Effluent Area
SP: Myotis ciliolabrum SPEC:
NOTES: Hand release.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65210944.16#
DUR = 4.88 ms TBC = 166 ms FRE = 42.5 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 250 Buff = 1 % F 7

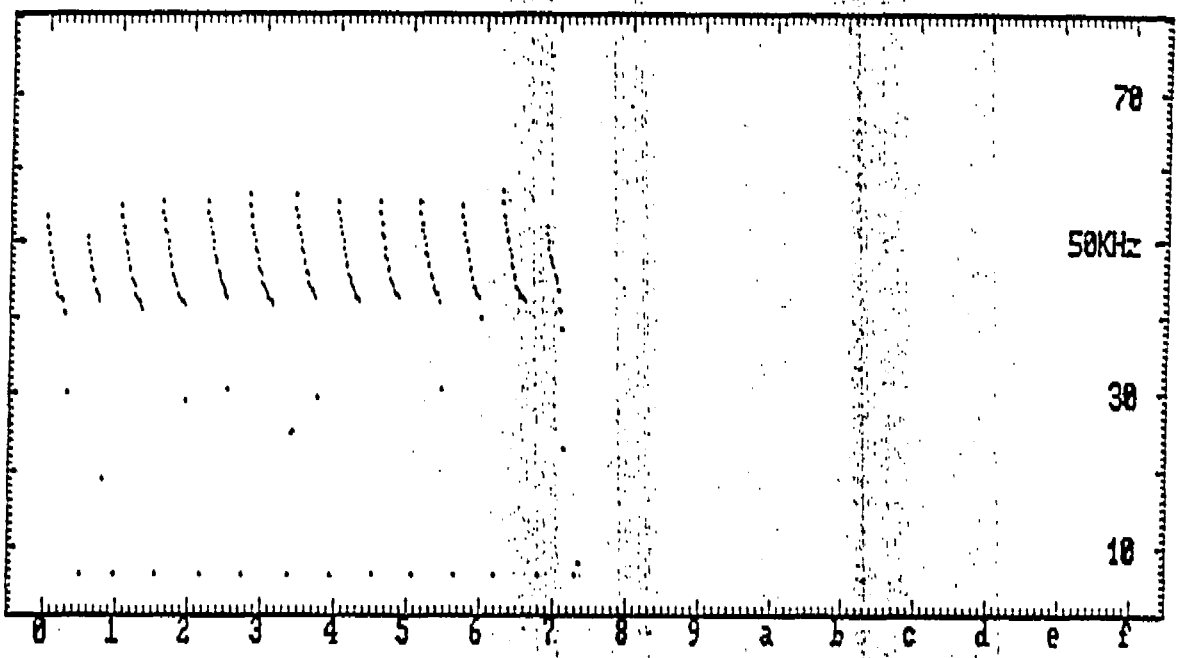
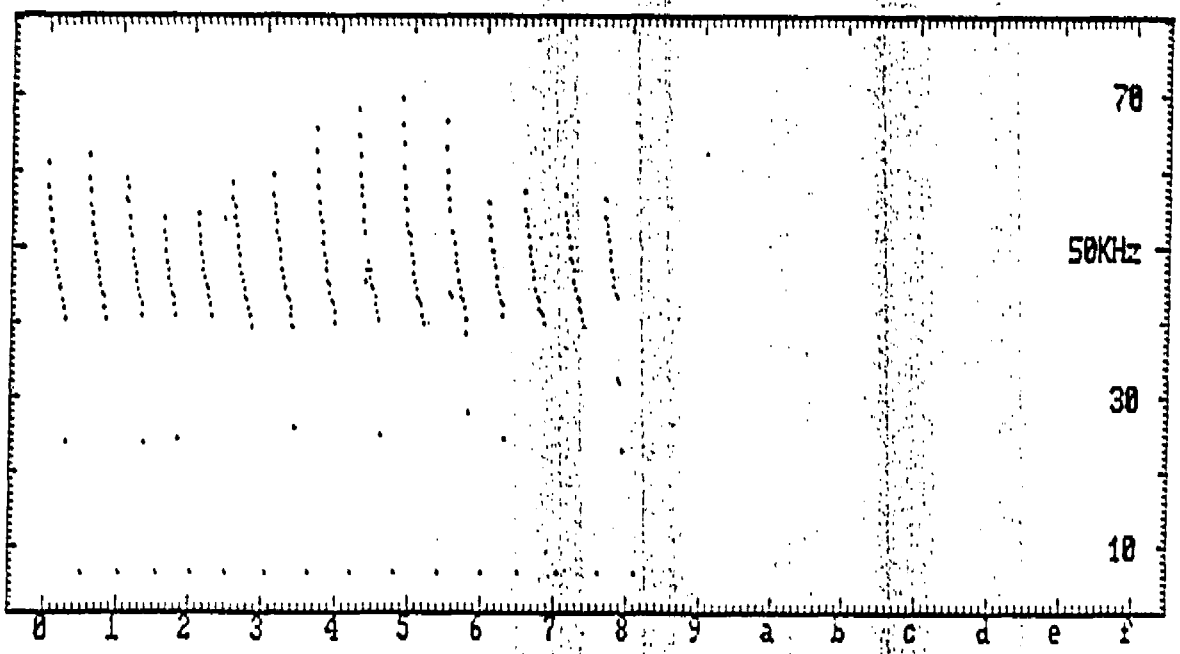


Figure 2b.

TAPE: Computer DATE: 05/21/96 LOC: Pueblo Canyon Effluent Area
SP: Myotis ciliolabrum SPEC:
NOTES: Hand release.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65211149.27#
DUR = 5.07 ms TBC = 112 ms FRE = 41.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 274 Buff = 1 % F 7



Appendix A

Figure 3 a.

TAPE: computer DATE: 06/25/96 LOC: Icehouse Pond, LANL, Los Alamos Co, NM
SP: Myotis evotis SPEC:
NOTES: Hand release; female.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 66251141.43#
DUR = 3.72 ms TBC = 156 ms FRE = 29.5 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 109 Buff = 0 % F 7

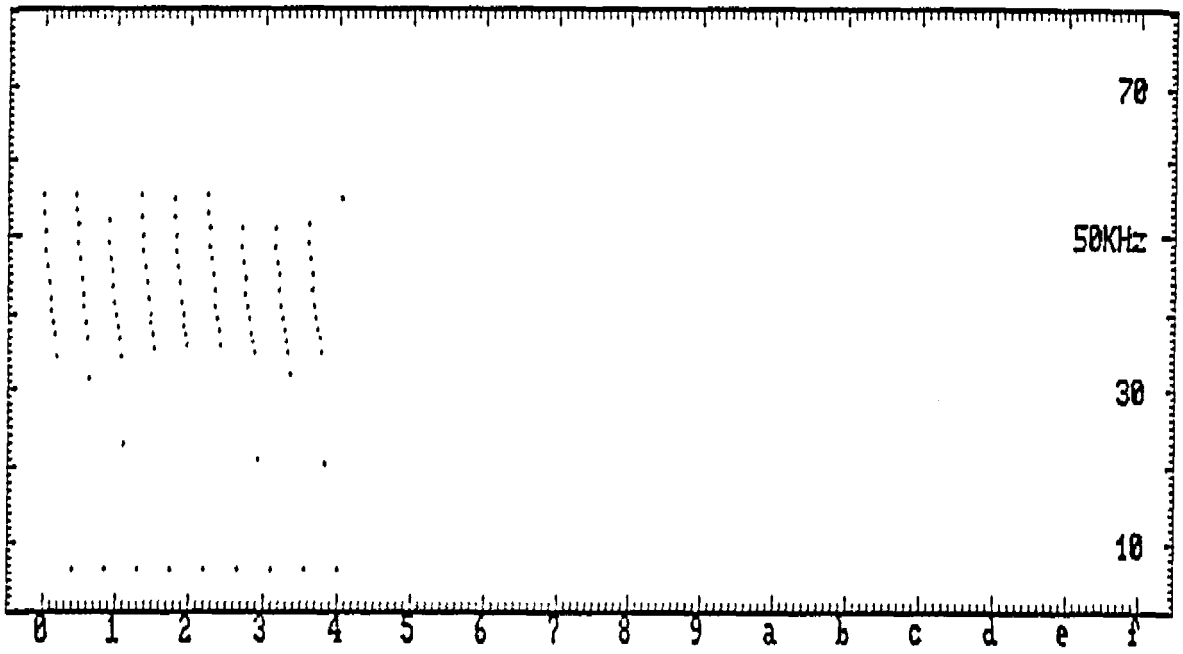
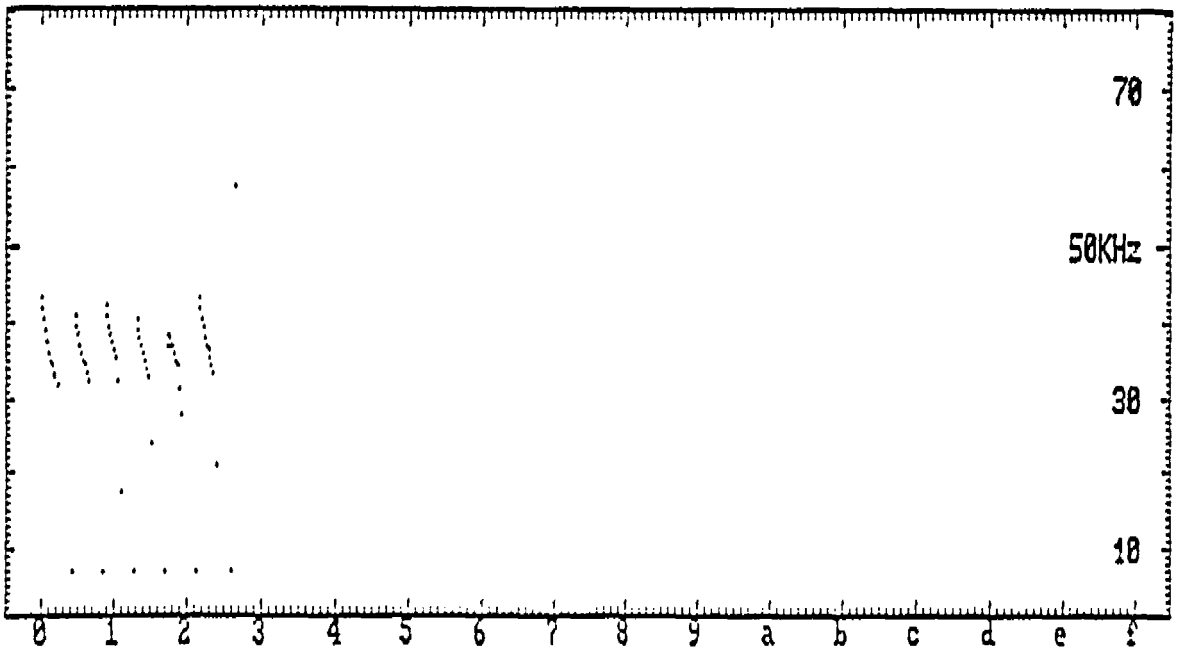


Figure 3 b.

TAPE: computer DATE: 06/03/96 LOC: Pajarito Wetland, 6200 ft., Biomonitsite
SP: Myotis evotis SPEC:
NOTES: Hand release.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 66032156.24#
DUR = 3.43 ms TBC = 744 ms FRE = 33.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 65 Buff = 0 % F 7



Appendix A

Figure 3 c.

TAPE: computer DATE: 06/03/96 LOC: Pajarito Wetland, 6200 ft., Biomonitsite
SP: Myotis evotis SPEC:
NOTES: Hand release.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 66032156.19#
DUR = 3.80 ms TBC = 191 ms FRE = 34.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 99 Buff = 1 % F 7

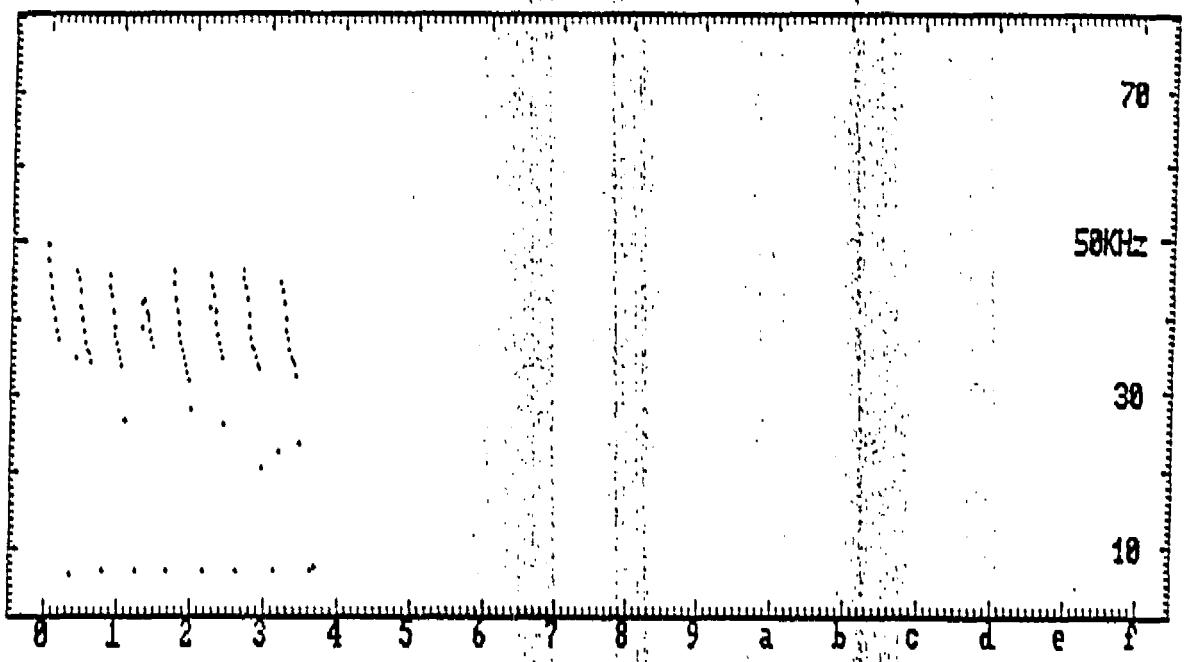
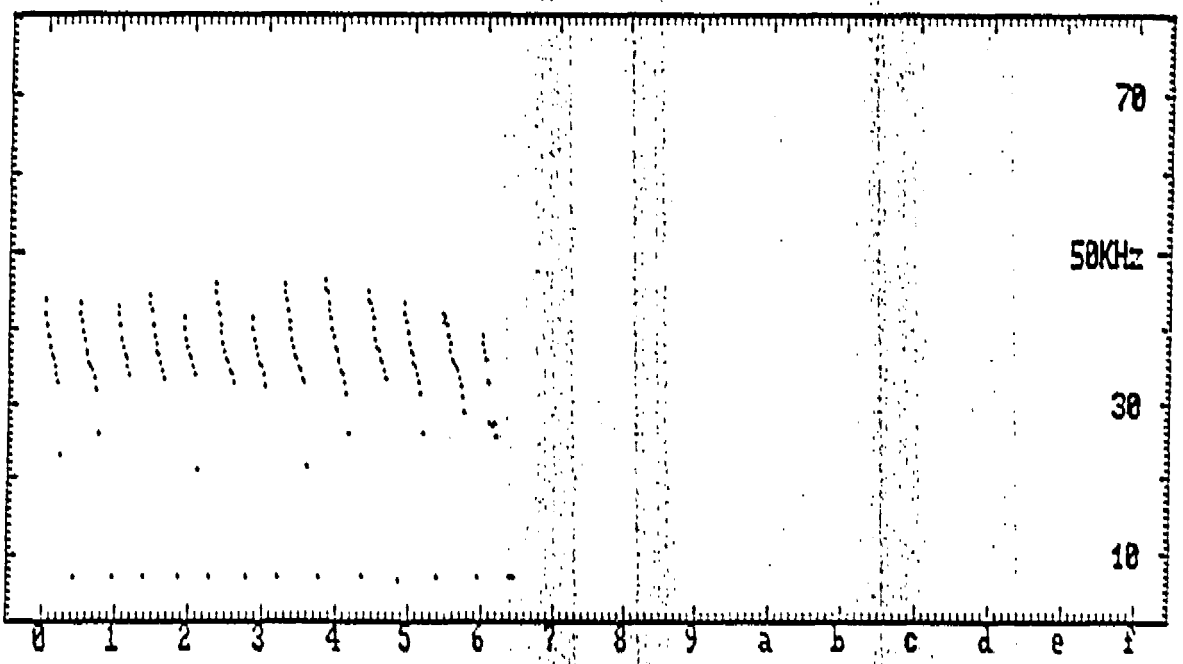


Figure 3 d.

TAPE: computer DATE: 07/15/96 LOC: stockpondski trailhead, 8930'; P.5
SP: Myotis evotis SPEC:
NOTES: male; hand realease

Compressed 0 to 80 kHz Div = 16 Cal = 40000 67150912.48#
DUR = 4.22 ms TBC = 188 ms FRE = 33.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 171 Buff = 1 % F 7



Appendix A

Figure 4 a.

TAPE: Computer DATE: 05/21/96 LOC: Pueblo Canyon Effluent Area
SP: Myotis thysanodes SPEC:
NOTES: Hand release.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65211010.23#
DUR = 5.14 ms TBC = 104 ms FRE = 23.5 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 358 Buff = 2 % F 7

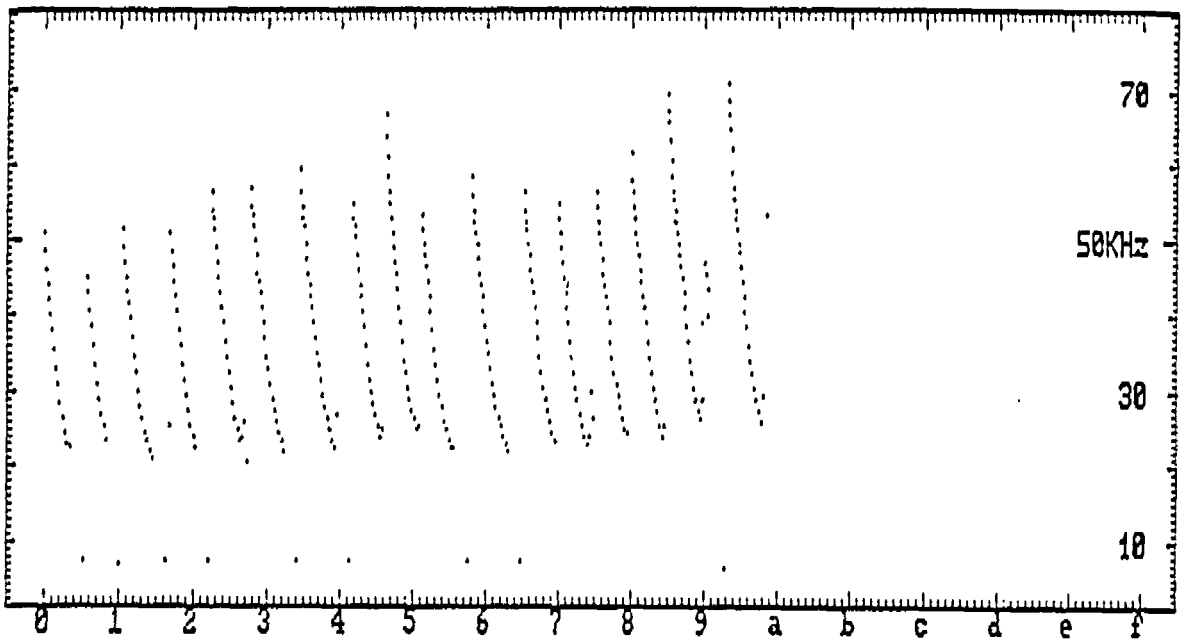
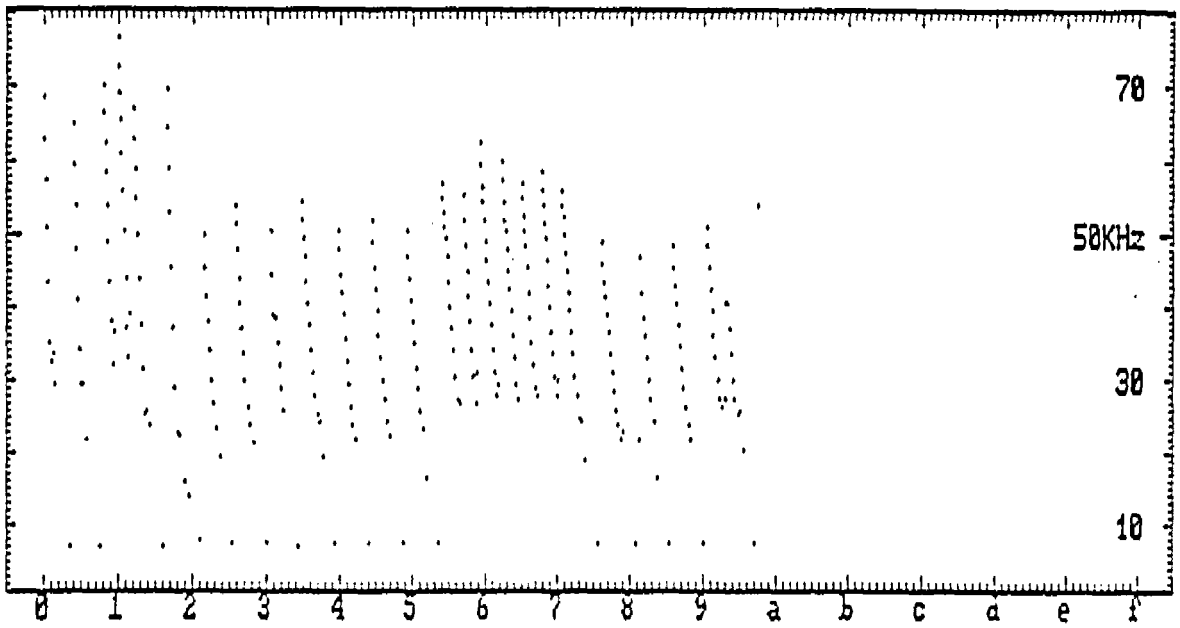


Figure 4 b.

TAPE: Computer DATE: 05/21/96 LOC: Pueblo Canyon Effluent Area
SP: Myotis thysanodes SPEC:
NOTES: Hand release.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65210919.46#
DUR = 3.41 ms TBC = 502 ms FRE = 24.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 297 Buff = 2 % F 7



Appendix A

Figure 4 c.

TAPE: Computer DATE: 05/21/96 LOC: Pueblo Canyon Effluent Area
SP: Myotis thysanodes SPEC:
NOTES: Hand release.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65211010.26#
DUR = 6.49 ms TBC = 132 ms FRE = 23.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 445 Buff = 2 % F 7

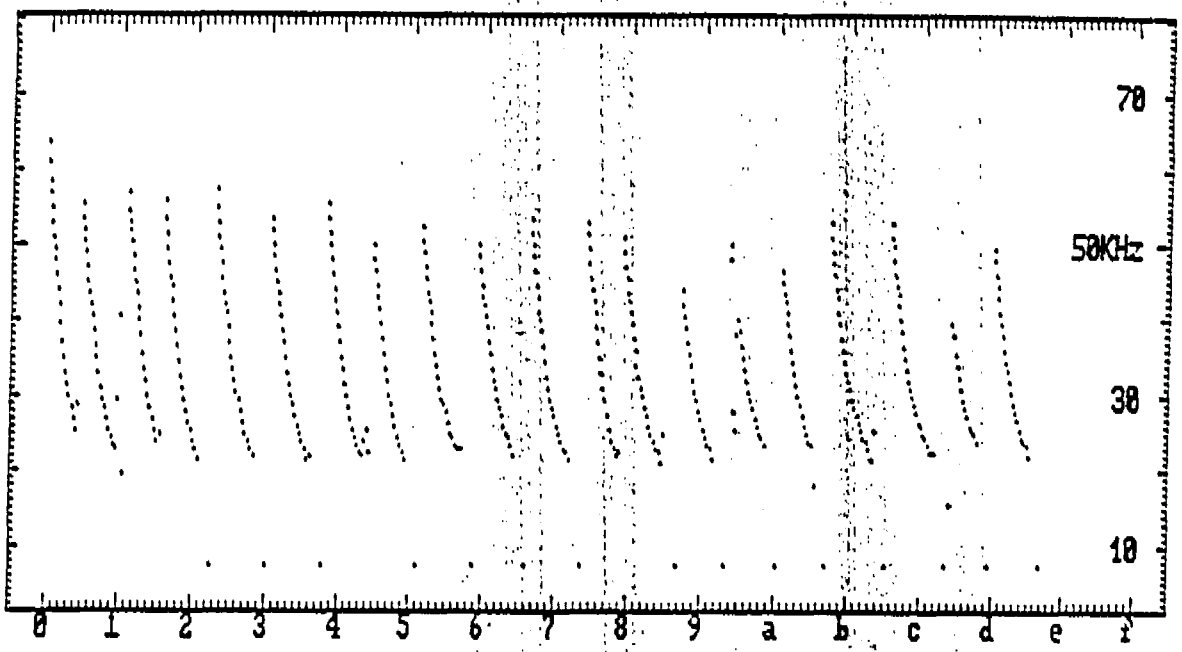
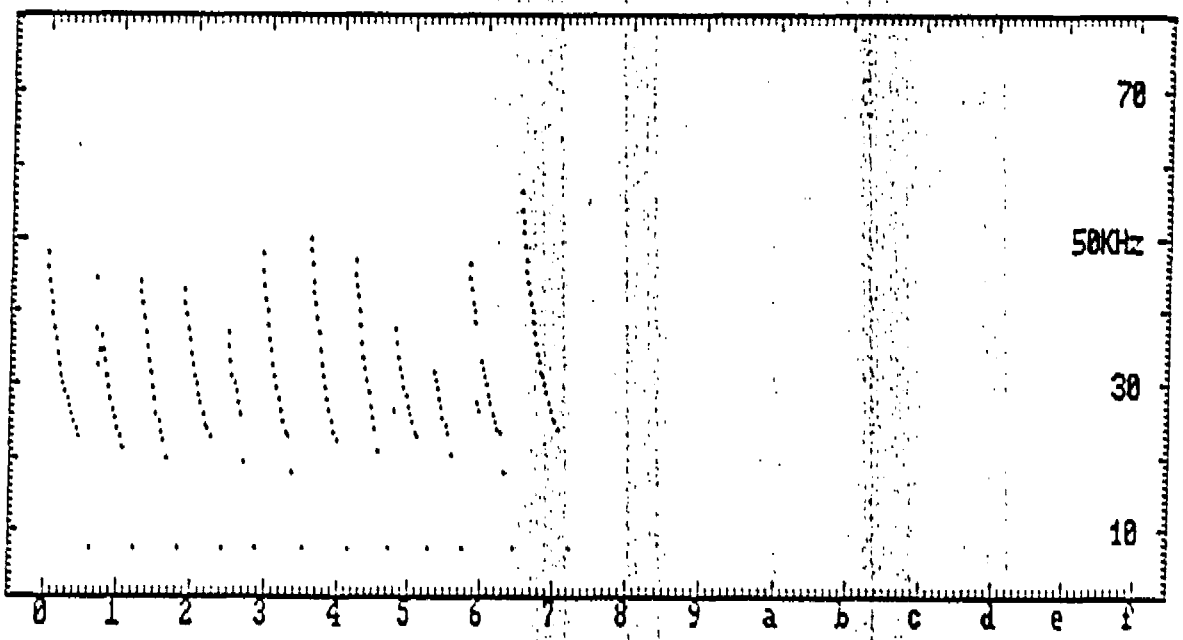


Figure 4 d.

TAPE: Computer DATE: 05/21/96 LOC: Pueblo Canyon Effluent Area
SP: Myotis thysanodes SPEC:
NOTES: Hand release; Low?

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65211010.28#
DUR = 5.70 ms TBC = 146 ms FRE = 21.5 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 200 Buff = 1 % F 7



Appendix A

Figure 5 a.

TAPE: computer DATE: 08/12/96 LOC: Frijoles Canyon below VC (across creek)
SP: Myotis volans SPEC:
NOTES: Hand release; interference with EPFU? first part of call is a EPFU, then MYVO last part; male adult.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 68122233.06#
DUR = 5.43 ms TBC = 136 ms FRE = 40.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 392 Buff = 12 % F 7

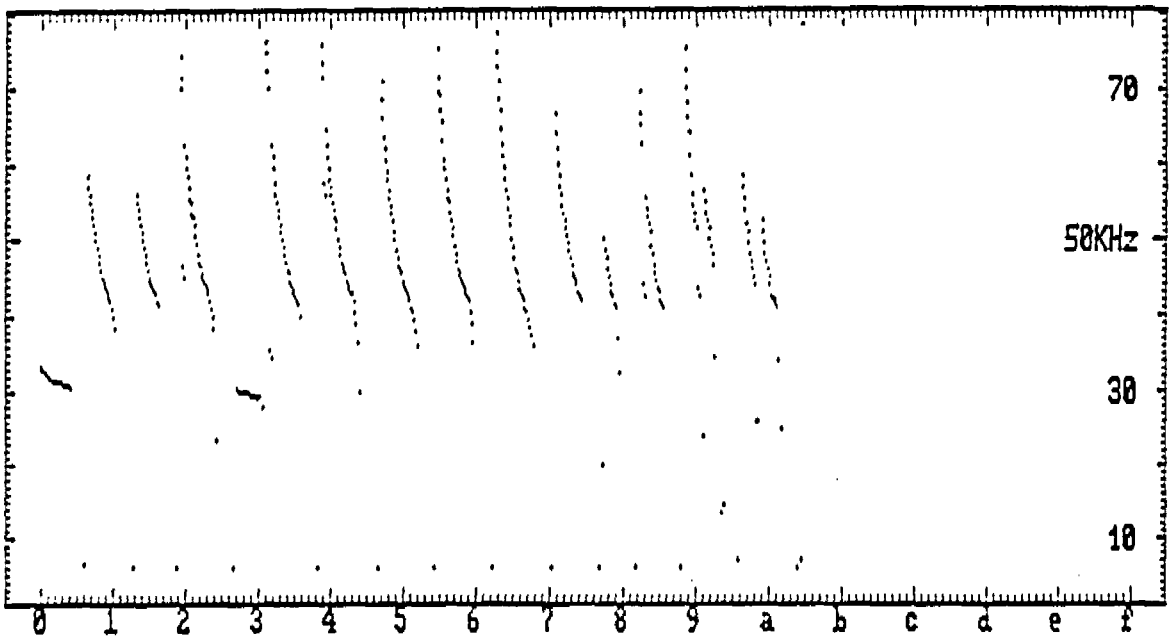
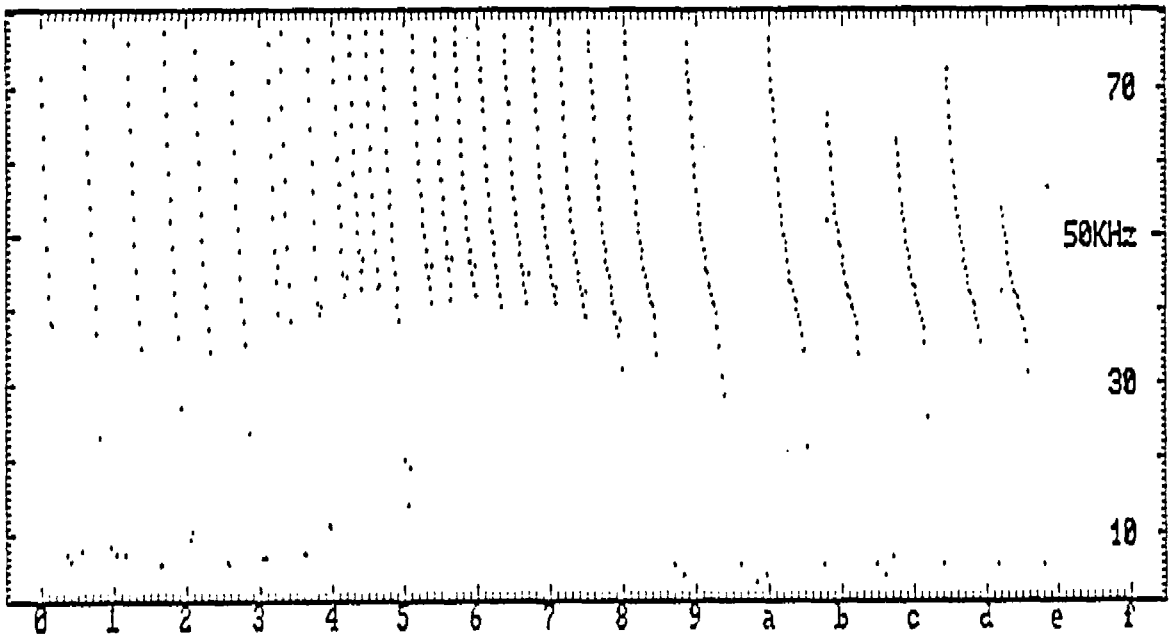


Figure 5 b.

TAPE: computer DATE: 07/24/96 LOC: Pueblo Cyn Sewage Trtment facility
SP: Myotis volans SPEC: male
NOTES: 7 grams: hand release

Compressed 0 to 80 kHz Div = 16 Cal = 40000 67242255.56#
DUR = 4.42 ms TBC = 76.6 ms FRE = 32.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 573 Buff = 9 % F 7



Appendix A

Figure 6

TAPE: Computer DATE: 05/20/96 LOC: Stock Pond at Ski Trailhead, 8,930 ft.
SP: Lasiurus cinereus SPEC:
NOTES: Hand release.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65202133.27#
DUR = 6.60 ms TBC = 748 ms FRE = 24.5 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 219 Buff = 1 % F 7

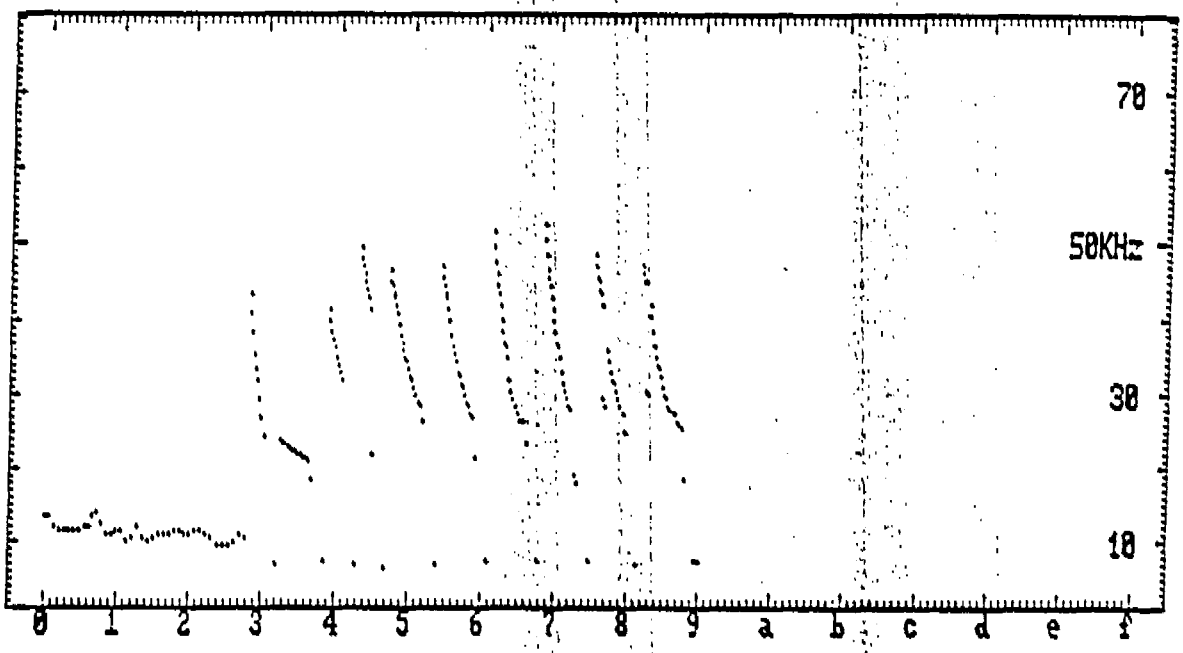
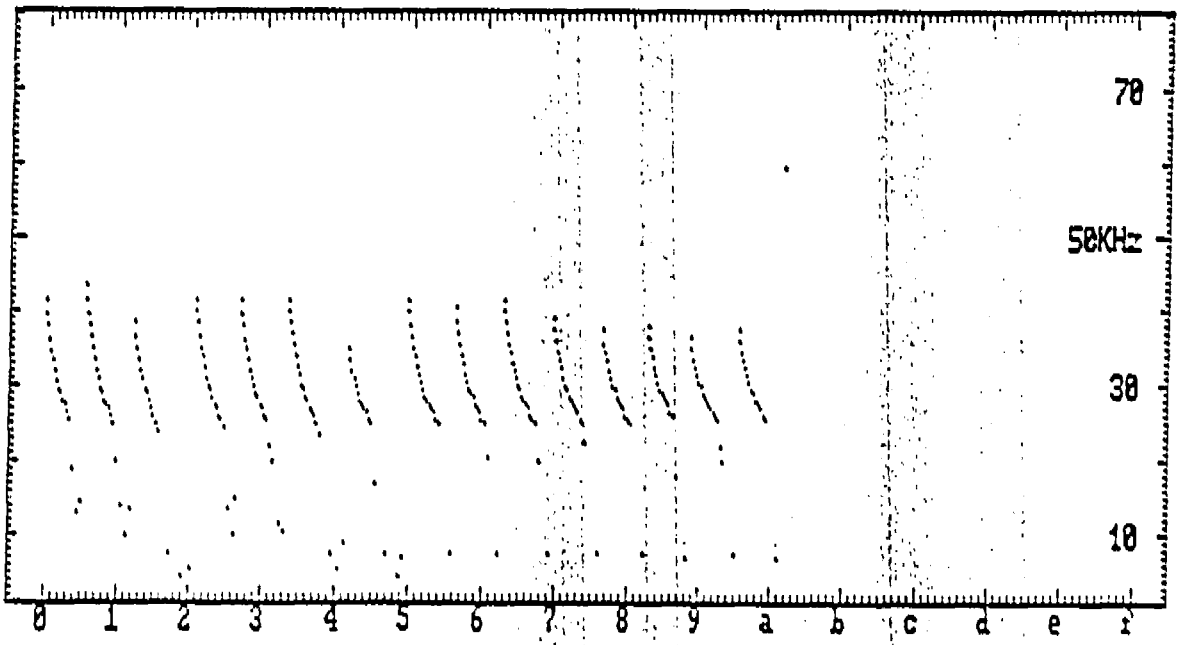


Figure 7 a.

TAPE: computer DATE: 05/31/96 LOC: Stock Pond @ Ski Trailhead, 8930'.P.5
SP: Lasionycteris noctivagans SPEC:
NOTES: male; hand release

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65310906.08#
DUR = 6.01 ms TBC = 135 ms FRE = 25.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 268 Buff = 2 % F 7



Appendix A

Figure 7 b.

TAPE: computer DATE: 06/03/96 LOC: Pajarito Wetland, 6200 ft., Biomonitsite
SP: Lasionycteris noctivagans SPEC:
NOTES: Not a hand release; bat foraging around during mist net set-up.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 66032052.49#
DUR = 11.3 ms TBC = 243 ms FRE = 26.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 450 Buff = 3 % F 7

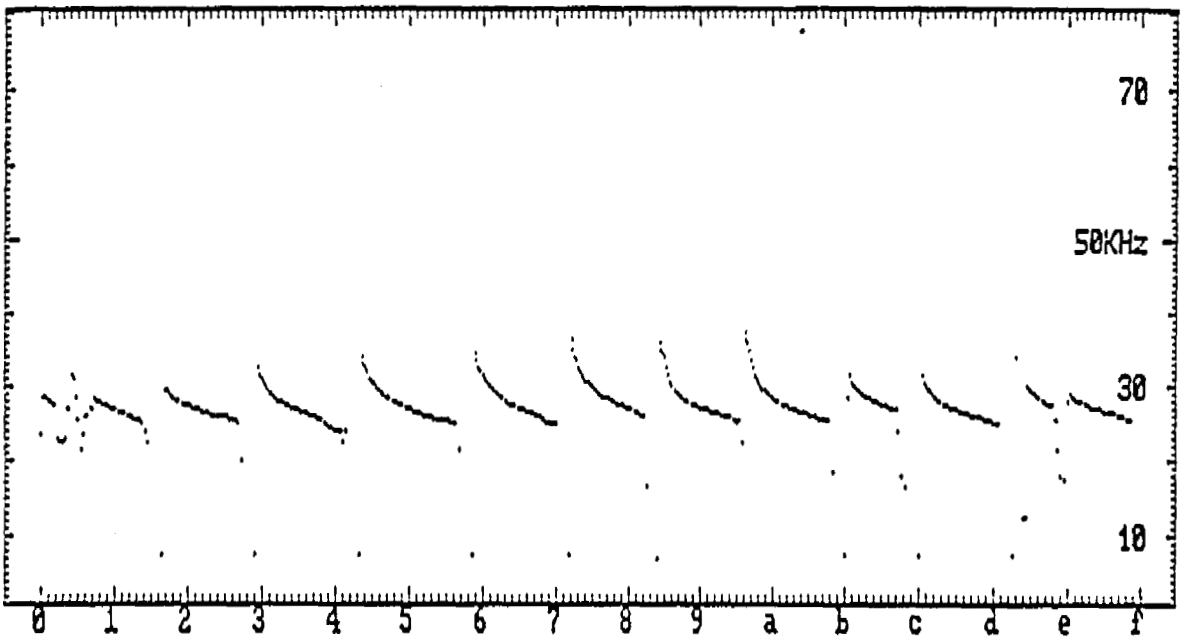
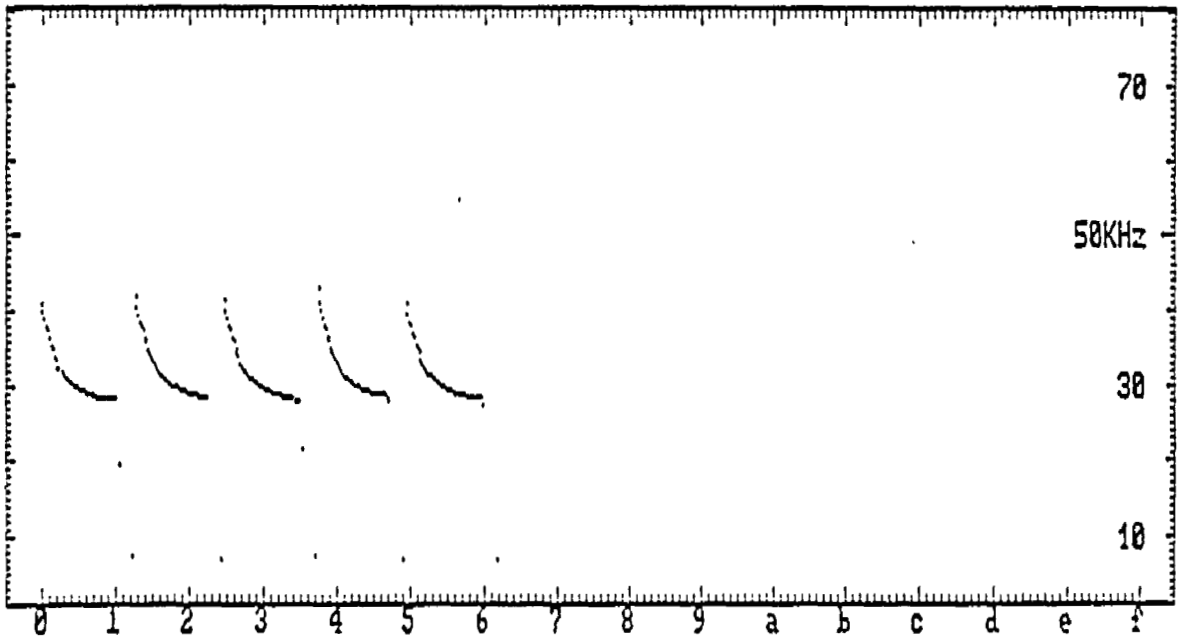


Figure 7 c.

TAPE: Computer DATE: 05/20/96 LOC: Stock Pond at Ski Trailhead, 8,930 ft.
SP: Lasionycteris noctivagans SPEC:
NOTES: Hand release.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65202127.01#
DUR = 12.0 ms TBC = 284 ms FRE = 28.5 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 206 Buff = 1 % F 7



Appendix A

Figure 8 a.

TAPE: computer DATE: 05/23/96 LOC: Pueblo Canyon Sewage Plant
SP: Eptesicus fuscus SPEC:
NOTES: Hand release; female.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65232114.38#
DUR = 7.21 ms TBC = 120 ms FRE = 27.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 368 Buff = 2 % F 7

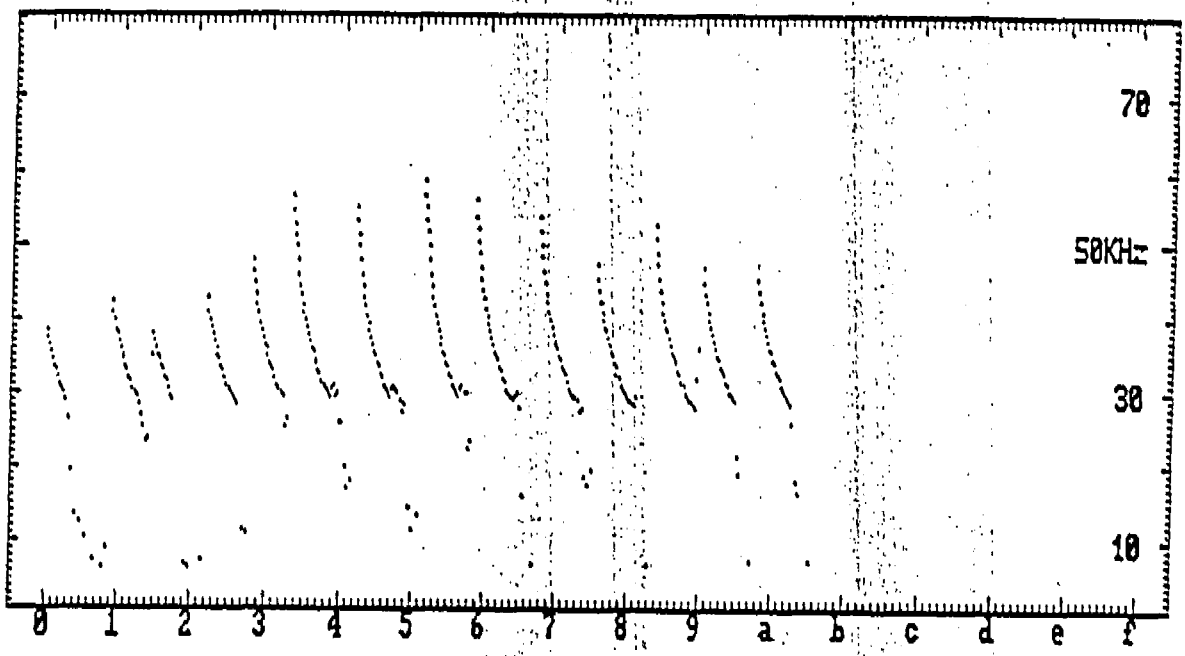
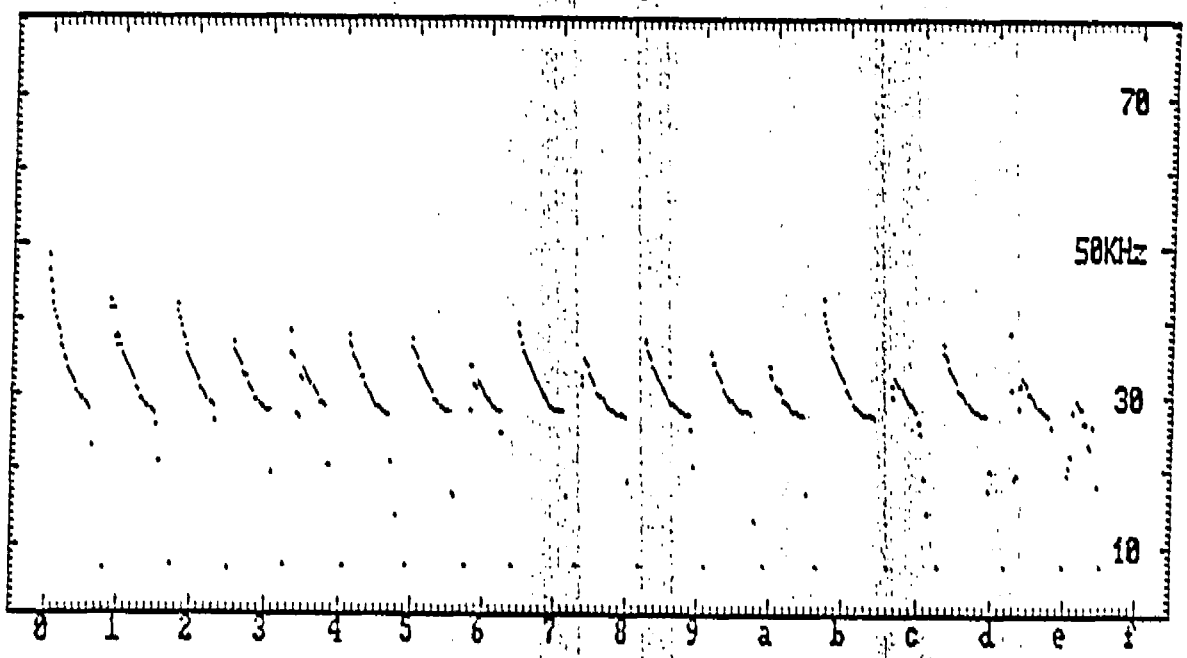


Figure 8 b.

TAPE: computer DATE: 05/23/96 LOC: Pueblo Canyon Sewage Plant
SP: Eptesicus fuscus SPEC:
NOTES: Hand release; female.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65232114.40#
DUR = 7.24 ms TBC = 124 ms FRE = 28.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 432 Buff = 2 % F 7



Appendix A

Figure 8 c

TAPE: computer DATE: 05/31/96 LOC: Stock Pond @ Ski Trailhead, 8930',P.5
SP: Eptesicus fuscus SPEC:
NOTES: hand release

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65310950.15#
DUR = 5.51 ms TBC = 159 ms FRE = 32.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 591 Buff = 15 % F 7

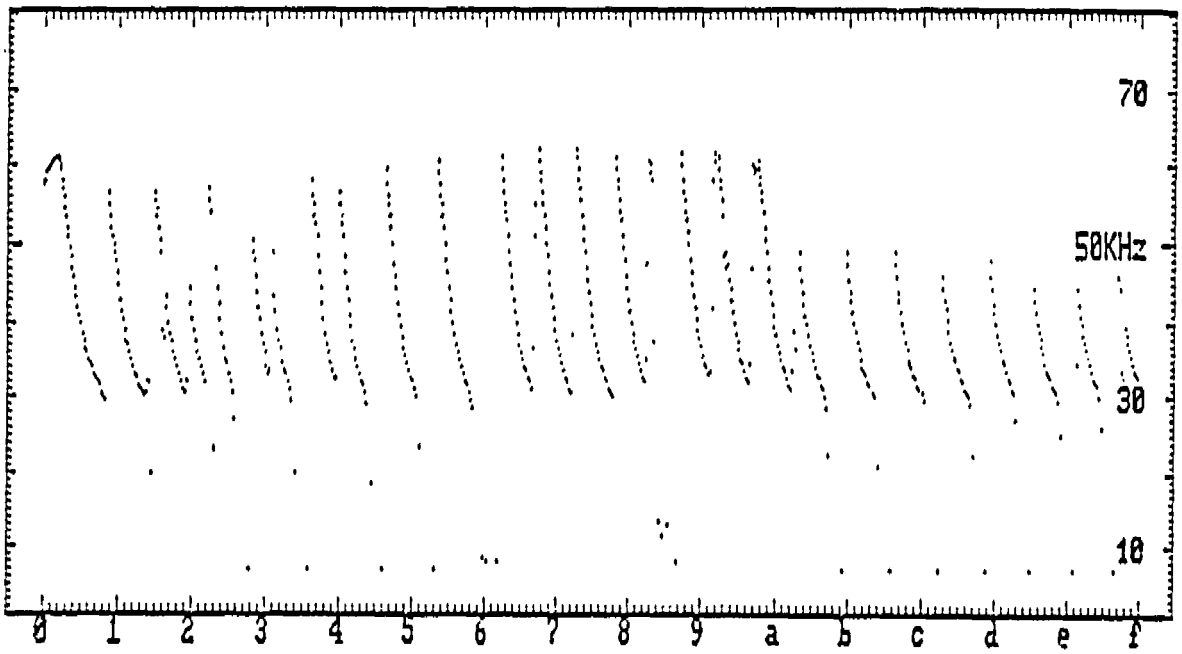
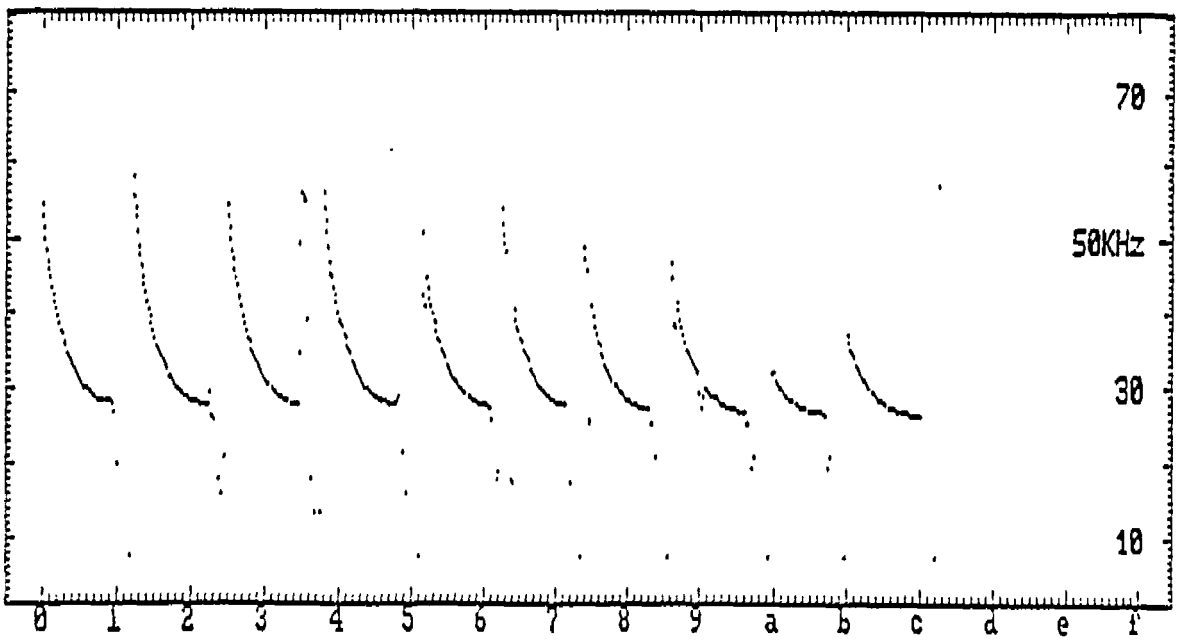


Figure 8 d

TAPE: computer DATE: 05/31/96 LOC: Stock Pond @ Ski Trailhead, 8930',P.5
SP: Eptesicus fuscus SPEC:
NOTES: hand release

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65310950.24#
DUR = 10.8 ms TBC = 268 ms FRE = 28.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 427 Buff = 2 % F 7



Appendix A

Figure 9 a

TAPE: computer DATE: 07/30/96 LOC: Lower Falls Trail Transect (pilot)
SP: Euderma maculatum SPEC:
NOTES: Recording of a free-flying foraging Euderma near the Rio Grande River.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 67302138.22#
DUR = 14.3 ms TBC = 188 ms FRE = 12.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 67 Buff = 0 % F 7

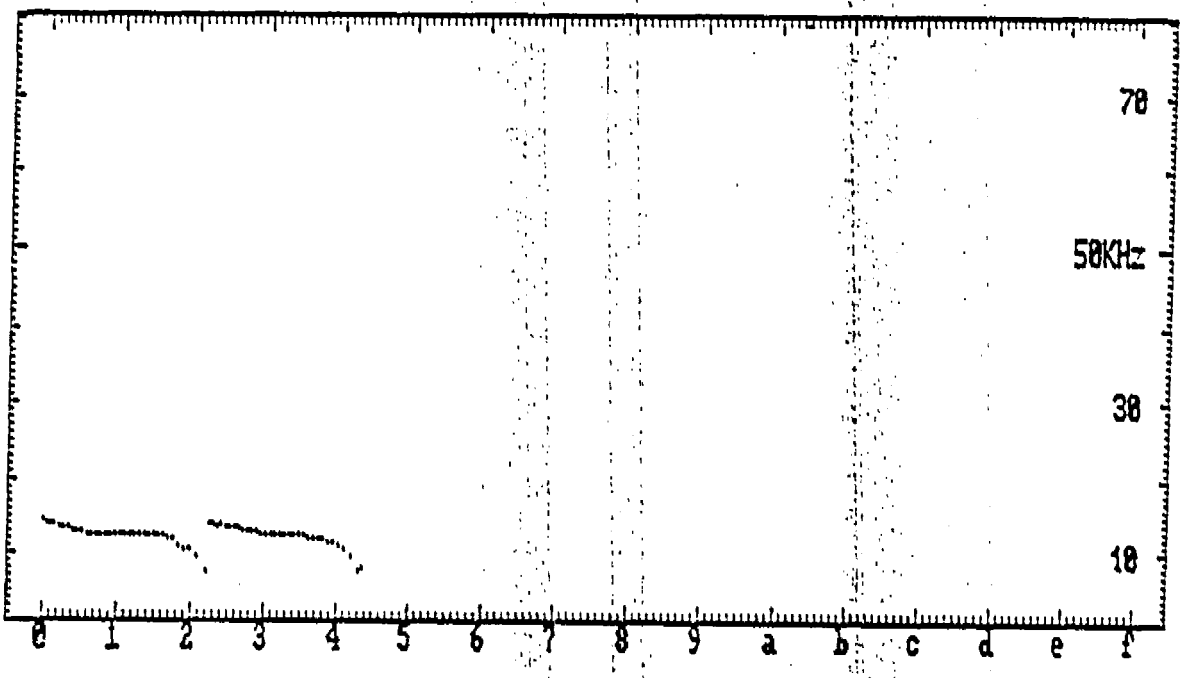
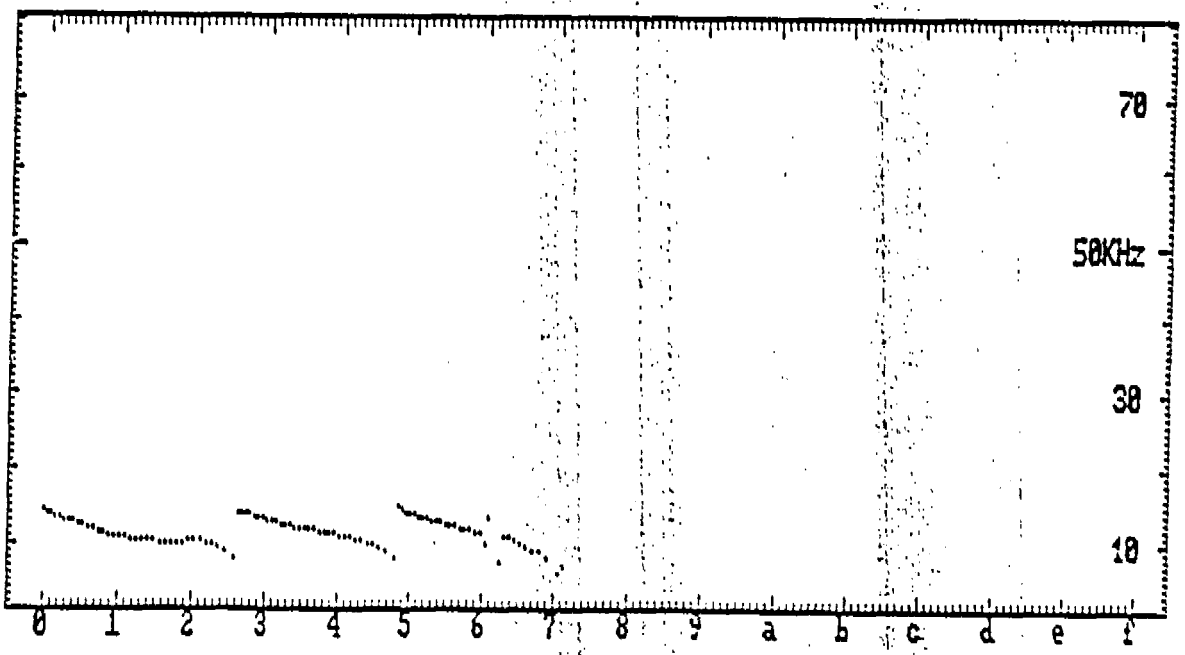


Figure 9 b.

TAPE: computer DATE: 07/30/96 LOC: Lower Falls Trail Transect (pilot)
SP: Euderma maculatum SPEC:
NOTES: Recording of a free-flying foraging Euderma near the Rio Grande River.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 67302138.33#
DUR = 17.6 ms TBC = 70.2 ms FRE = 10.5 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 100 Buff = 0 % F 7



Appendix A

Figure 10

TAPE: Computer DATE: 05/20/96 LOC: Stock Pond at Ski Trailhead, 8,930 ft.
SP: Corynorhinus townsendii SPEC:
NOTES: Hand release; distress calls from the hand.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65202043.54#
DUR = 6.62 ms TBC = 175 ms FRE = 28.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 510 Buff = 12 % F 7

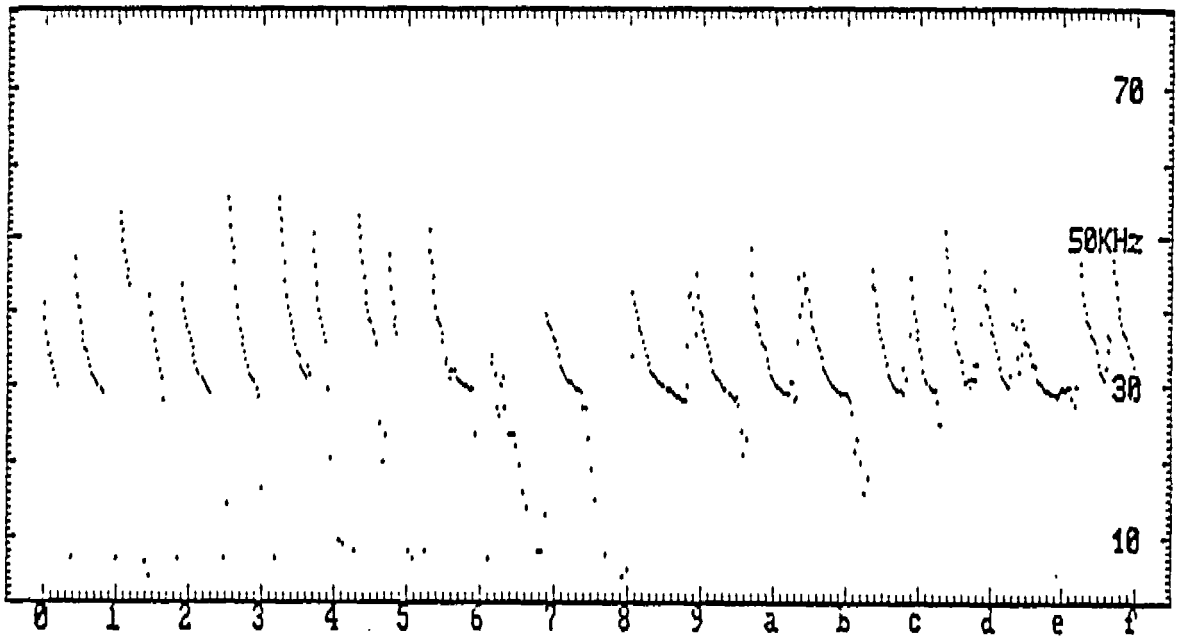
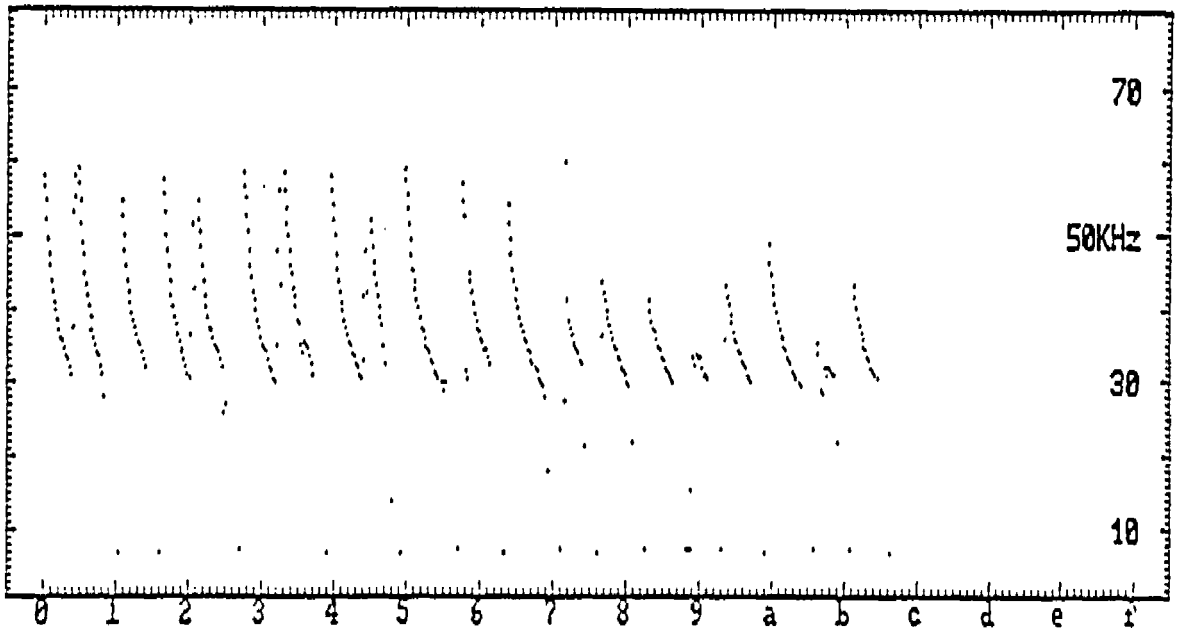


Figure 11 a

TAPE: Computer DATE: 05/21/96 LOC: Pueblo Canyon Effluent Area
SP: Antrozous pallidus SPEC:
NOTES: Hand release.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65211014.45#
DUR = 5.46 ms TBC = 91.6 ms FRE = 31.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 396 Buff = 3 % F 7



Appendix A

Figure 11 b

TAPE: Computer DATE: 05/21/96 LOC: Pueblo Canyon Effluent Area
SP: Antrozous pallidus SPEC:
NOTES: Hand release.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65211014.48#
DUR = 6.02 ms TBC = 135 ms FRE = 29.5 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 260 Buff = 1 % F 7

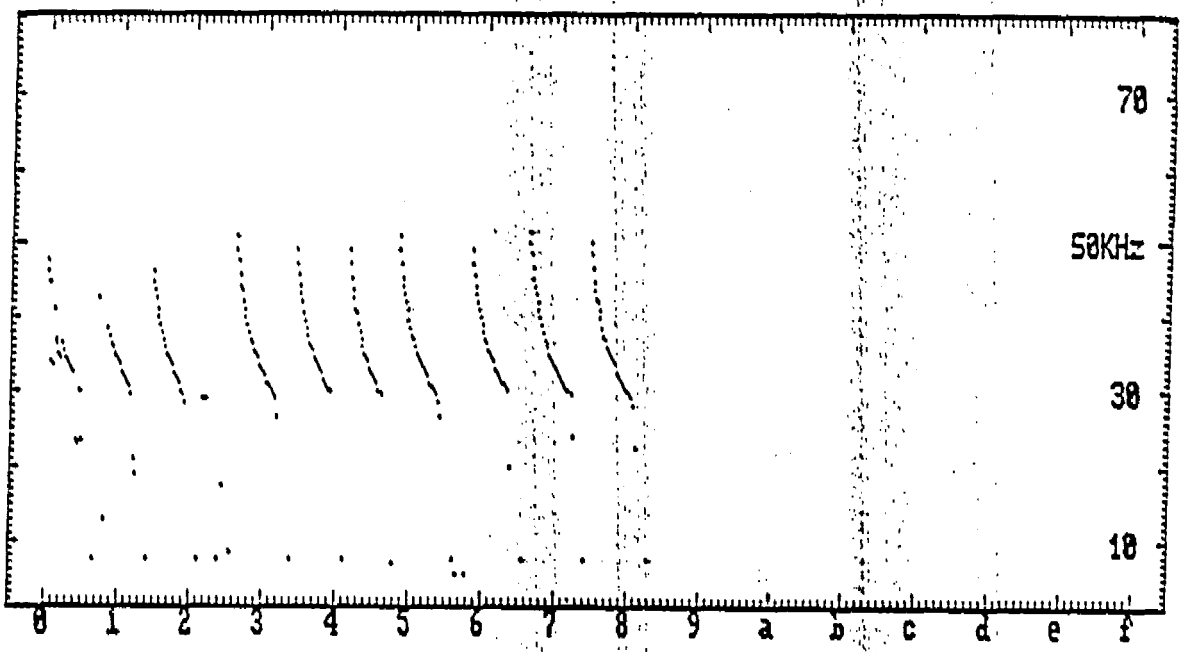
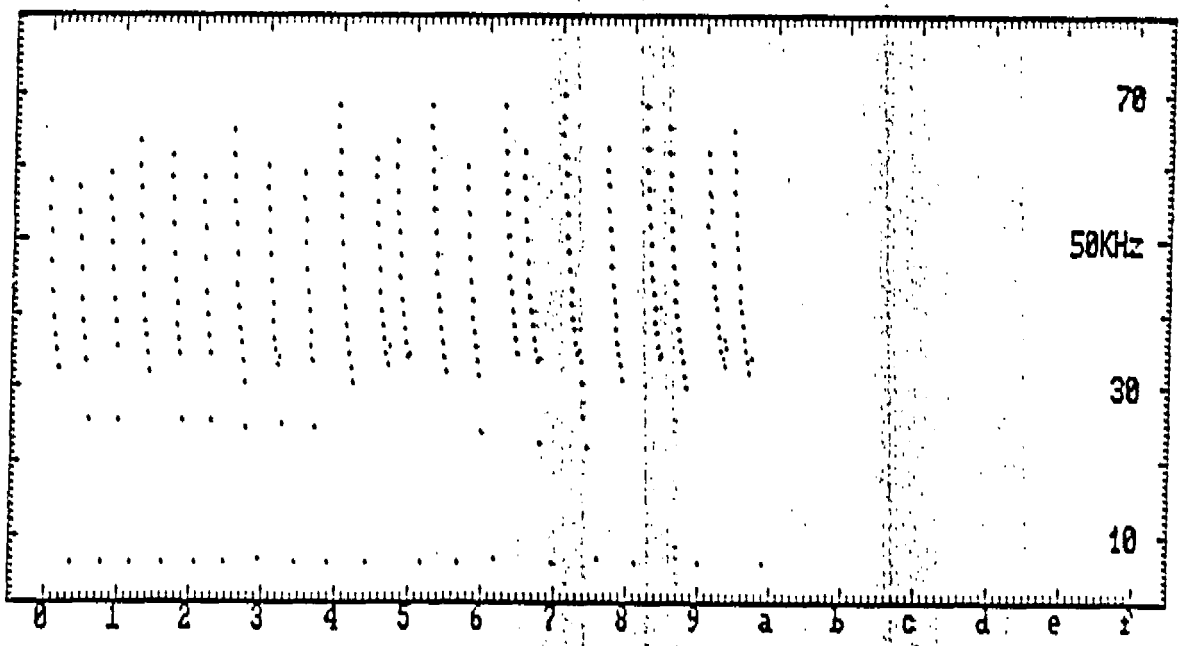


Figure 11 c

TAPE: Computer DATE: 05/21/96 LOC: Pueblo Canyon Effluent Area
SP: Antrozous pallidus SPEC:
NOTES: Hand release.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 65210956.31#
DUR = 4.16 ms TBC = 45.4 ms FRE = 31.5 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 316 Buff = 2 % F 7



Appendix A

Figure 12

TAPE: computer DATE: 07/30/96 LOC: Lower Falls Trail Transect (pilot)
SP: Tadarida brasiliensis SPEC:
NOTES: Recording of free-flying bat along Rio Grande.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 67302037.27#
DUR = 10.4 ms TBC = 569 ms FRE = 28.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 438 Buff = 2 % F 7

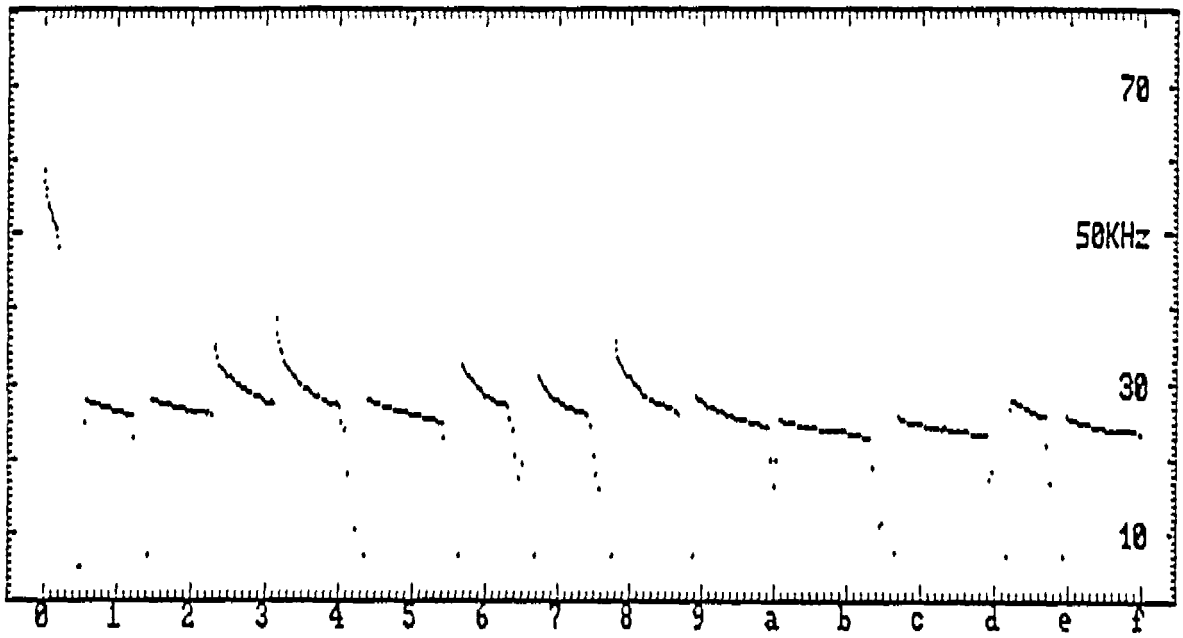
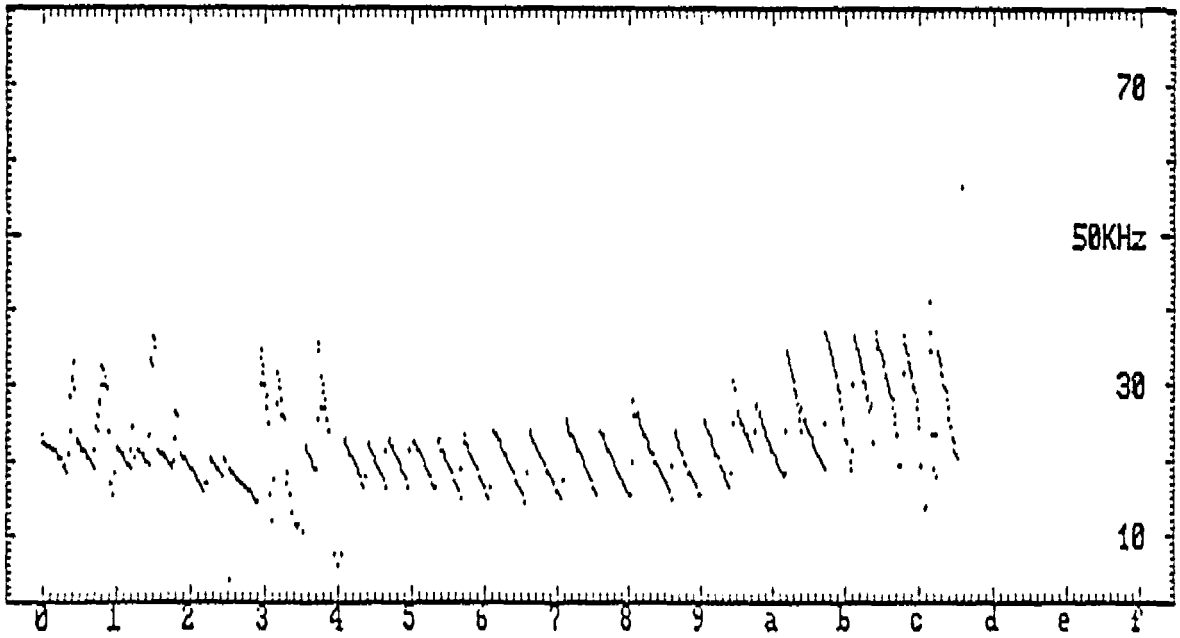


Figure 13

TAPE: computer DATE: 07/15/96 LOC: stockpond@ski trailhead; 8930; P.5
SP: Nyctinomops macrotis SPEC:
NOTES: female; lactating; hand release; captured at stockpond P.1

Compressed 0 to 80 kHz Div = 8 Cal = 40000 67151128.11#
DUR = 3.44 ms TBC = 231 ms FRE = 18.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 641 Buff = 11 % F 7



Appendix A

Figure 14 a.

TAPE: computer DATE: 08/11/96 LOC: Capulin Canyon
SP: Pipistrellus hesperus SPEC:
NOTES: Recording of free-flying foraging Pipistrellus in Capulin Canyon.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 68112200.06#
DUR = 6.06 ms TBC = 193 ms FRE = 42.5 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 573 Buff = 19 % F 7

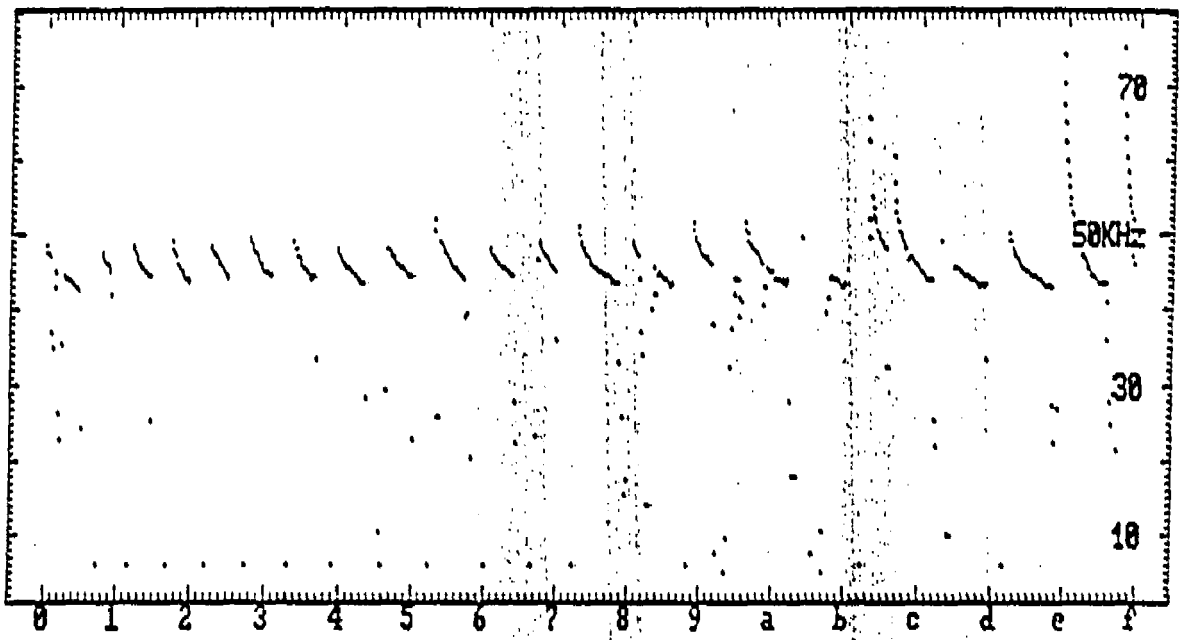
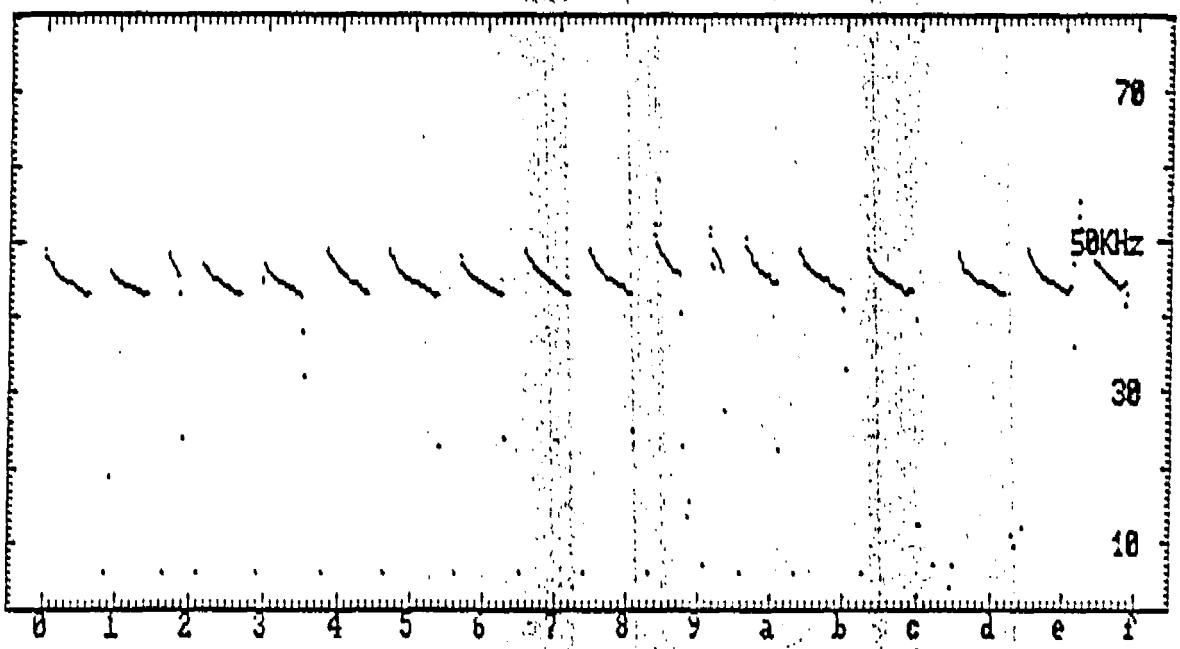


Figure 14 b.

TAPE: computer DATE: 08/11/96 LOC: Capulin Canyon
SP: Pipistrellus hesperus SPEC:
NOTES: Recording of a free-flying foraging Pipistrellus in Capulin Canyon.

Compressed 0 to 80 kHz Div = 16 Cal = 40000 68112200.24#
DUR = 7.95 ms TBC = 191 ms FRE = 44.0 kHz
TOTAL - 160 ms TICKS - 10 ms Npts = 599 Buff = 11 % F 7



APPENDIX B. Descriptions of sites where bat nets were set during 1995 and 1996. Elevation of each site, in feet, is in brackets. Names in parentheses (e.g., P 1, L 1) are names used to describe water sources at BAND. We currently have photographs and GPS coordinates for most, but not all, of these sites. Sites are arranged generally by decreasing elevation.

Sites at Los Alamos National Laboratory

Icehouse Pond [7700]: This is a perennial pond near the entrance to TA-16. This site was netted by Tyrell and Brack (1992), who called it Pond TA-16. The surrounding forest is predominantly *Pinus ponderosa* and mostly surrounds the pond. In 1995 the pond was approximately 15 m by 25 m and was one meter deep; during 1996 size and depth varied appreciably over the course of the season. The site is on USGS Frijoles, NM, 7.5 minute quadrangle, about two miles north of the intersection of routes 501 and 4; the pond is on the east side of Route 501. We netted this site on 5 September 1995. During 1996 this was the most frequently netted LANL location. We netted here on 22 and 30 May, 5, 18, 25, and 28 June, 2 and 18 July, and 6 and 13 August of 1996. During 1996, water levels in the pond varied considerably and after summer rains started it was almost too deep in work.

Technical Area 15 Cement Pond [7600]: We netted this large (approximately 45 m across) cement pond located in Technical Area 15 of LANL. The pond was surrounded by a forest of *Pinus ponderosa* with a large grassy meadow to the west. We netted this site on 17 July 1996.

Los Alamos Canyon Reservoir [7260]: This area includes two sites near the reservoir; one was an ephemeral pool approximately 5 m by 5 m and 25 cm depth; the other was a widened stream flow approximately 5 m across with a depth of 10 cm. Both sites were products of runoff from Los Alamos Reservoir in upper Los Alamos Canyon. The dominant vegetation here is *Pinus ponderosa*. The reservoir is shown on USGS Guaje Mountain 7.5 min quadrangle and is located on Forest Service land; permission was obtained from the Forest Service prior to netting. We netted this site on 11 and 15 September 1995 and 1 June 1996

Mortandad Canyon [7100]: We netted a shallow pool, approximately 2 m by 3 m, surrounded by cattails and part of a small wetland in the canyon. The surrounding forest consists of *Pinus ponderosa*. This are is shown on USGS Frijoles, NM, 7.5. minute quadrangle and is located southeast of Los Alamos on Pajarito Road. The site is accessed by taking the second left after the water tower. The pool is about 1.3 mi. downstream from the head of Mortandad Canyon. We netted this site on 6 September 1995.

Pajarito Wetland [6560]: This site is a small wetland just south of the Pajarito Canyon Road and about one-half mi. west of Route 4. Dominant vegetation species in the wetland include *Salix exigua*, *Populus* spp., *Carex* spp., and *Juncus* spp. Tree species in the surrounding forest include *Pinus edulis* and *Juniperus* spp. This site is bordered by a burn area to the immediate south and west. We netted this site on 3 June 1996.

Pueblo Canyon Waste Facility [6580]: This site is a sewage treatment plant located in Pueblo Canyon. Five sewage ponds, approximately 10 m in diameter, are surrounded by turf grass within the fenced facility enclosure. Nets were set over the sidewalks and grass near the tanks. Surrounding vegetation near the facility is predominantly *Pinus ponderosa* on the slopes of the canyon. We netted this site on 23 May, 24 July, 14 August, and 5 September 1996.

Pueblo Canyon Effluent [6470]: We netted the stream running from the Pueblo Canyon Waste Facility approximately 0.25 to 0.5 mi. down from the source. Nets were set in the meadow which had a dense cover of grasses and over the stream. Tree species included *Pinus ponderosa*, *P. edulis*, and *Juniperus* spp. We netted this site on 24 and 25 April, 21 and 29 May, 27 June, and 10 July 1996.

Los Alamos Canyon - Upper Puddle [6750]: This pond in the Lower Los Alamos Canyon road was filled from runoff and was about 3 m by 15 m in size. Surrounding vegetation was mostly *Pinus ponderosa*. We netted this site on 22 and 30 July 1996.

Los Alamos Canyon - Otowi Well 4 [6700]: This site was on the stream in Lower Los Alamos Canyon just east of the Otowi Pump House and reached by driving west of State Road 4 on the dirt road in the canyon. There are cliffs of Bandelier tuff to the north; the surrounding forest is mainly *Pinus ponderosa* and various shrub species. Sedges and grasses were present along the stream banks. We netted this site on 22 July 1996.

Los Alamos Canyon - County Line Fence [6560]: This site is on the road in the bottom of Lower Los Alamos Canyon, where Los Alamos and Santa Fe counties meet. Vegetation in the canyon bottom was mostly *Pinus ponderosa* and various shrub species. On 22 and 30 July 1996 we set one 18 ft net across the opening in the fence.

Los Alamos Canyon - Cliffs [6600]: These sites were against the cliffs in Lower Los Alamos Canyon where we found guano, likely from night-roosting bats, in excavations in the cliff walls. GPS readings were 389311e, 3969956n and 388617e, 3970178n. Vegetation consisted of *Pinus edulis* and *Juniperus spp.* We netted here on 27 and 28 August 1996.

Los Alamos Canyon, Lower [6500]: We netted over several small pools in the bottom of the canyon where the creekbed flattens out and runs through open forest of *Pinus ponderosa*. This location is on USGS White Rock, NM, 7.5 min quadrangle and, like those localities described immediately above, was accessed through a locked gate west off Route 4 in the canyon, about 0.75 mi south of the intersection of routes 4 and 502, as Route 4 heads south to White Rock. We netted here on 13 and 19 September 1995.

Sites at Bandelier National Monument

North Upper Stock Pond (P 7) [9100]: This perennial pond is 100 m directly north of Upper Stock Pond (P3) and was approximately 5 m in diameter with a depth of 50 cm. Its margins were thickly vegetated with grasses and sedges and this, plus its small size,

likely restricts bat use only to agile flyers. Grasses and herbaceous plants surrounding the pond and in the meadow included *Agoseris aurantiaca, Allium macropetalum, Arenaria* spp., *Bromus* spp., *Carex* spp., *Danthonia parryi, Geranium caespitosum, Iris missouriensis, Juncus* spp., *Poa* spp., and *Trifolum* spp. Trees and woody perennials surrounding the meadow included *Abies concolor, Juniperus scopulorum, Picea engelmanii, Pinus ponderosa, Populus tremuloides, Pseudotsuga menziesii, Quercus gambelii,* and *Ribes* spp. We netted this site on 8 August 1995.

Upper Stock Pond, (P 3) [9,070]: This is a perennial stock pond located at the southern base of Cerro Grande in the Upper East Fork of Frijoles Creek where the creek bed opens onto a narrow, sloping meadow north of State Route 4. The site was accessed by following the Upper East Fork 0.3 mi north from where it crosses Route 4 in the northwest extension of BAND. The pond was approximately 8 m by 12 m and at least one meter deep. Grasses and herbaceous plants surrounding the pond and in the meadow included *Agoseris aurantiaca, Allium macropetalum, Arenaria* spp., *Bromus* spp., *Carex* spp., *Danthonia parryi, Geranium caespitosum, Iris missouriensis, Juncus* spp., *Poa* spp., and *Trifolium* spp. Trees and woody perennials surrounding the meadow included *Abies concolor, Juniperus scopulorum, Picea engelmannii, Pinus ponderosa, Populus tremuloides, Pseudotsuga menziesii, Quercus gambelii,* and *Ribes* spp. We netted here on 19 July 1995.

Meadow Pond (P 1) [8950]: This large perennial pond is located approximately 200 m northwest of the intersection of State Route 4 and St. Peters Dome Road (Hwy 289), past the paved parking area. The pond was approximately 30 m by 70 m and at least one meter deep with a soft muddy bottom. It is in a large meadow which was surrounded by mixed conifers. Grasses and herbaceous plants near the pond and in the meadow included *Agoseris aurantiaca, Allium macropetalum, Alopecurus aequalis, Bromus* spp., *Carex* spp., *Cercium* spp., *Danthonia parryi, Elymus* spp., *Eragrostis* spp., *Geranium caespitosum, Iris missouriensis, Phleum alpinum, Phleum pratense, Poa* spp., and *Trifolium* spp. Trees and woody perennials surrounding the meadow include *Juniperus scopulorum, Picea engelmanii, Pinus ponderosa, Populus tremuloides, Pseudotsuga menziesii, Quercus gambelii,* and *Ribes* spp. We netted this site on 18 and 20 July and 14 August 1995 and 20 May and 15 July 1996. It appears to be an important resource for bats at BAND and held a large volume of water after the summer rains.

Ski Trailhead Pond (P 5) [8930]: This is a perennial stock pond 150 m south of the (cross-country) ski trailhead on the south side of State Route 4, 100 m east of the intersection of State Route 4 and Highway 289. The pond was approximately 10 m by 25 m and about 1 m deep. The pond faces an open field of *Phleum* spp. to the north and was surrounded by mixed conifer forest on all other sides consisting of *Quercus gambelii, Juniperus scopulorum, Picea engelmannii, Pinus ponderosa, Populus tremuloides, Pseudotsuga menziesii,* and *Ribes* spp. We netted this site on 7 July and 7 August 1995. This site was netted most frequently of all BAND locations during 1996 (31 May, 6, 10, and 24 June, 15 and 29 July, and 6 September).

Dome Road Stock Pond (P 2) [8890]: This is a small stock pond at the headwaters of the upper west fork of Frijoles Creek. It is located about 50 m east of St. Peter s Dome

Road (Hwy 289), and 0.1 mile southwest of the junction of State Route 4 and Highway 289. The pond is formed in a stone basin measuring approximately 5 m by 10 m, and 20 cm deep. The plant community surrounding the pond included *Picea engelmanii, Pinus flexilis, Pinus ponderosa, Populus tremuloides, Pseudosuga menziesii, Ribes* spp., and *Quercus gambelii* as well as grasses and annuals. We netted this site on 2 and 16 August 1995.

Lower Stock Pond - (P 4) [8660]: This is a large pond in the Upper East Fork of Frijoles Creek below State Route 4. Access is from the unpaved parking area on the north side of State Route 4, 0.1 mi. southeast of where the Upper East Fork of Frijoles Creek crosses State Route 4 in the northwest extension of BAND. The pond is approximately 0.5 mi. due south of the parking area on State Route 4. The pond was round, approximately 20 m in diameter, and had a depth of 50 cm. The water level fluctuated considerably here, as the pond margins were usually visible to a distance of 5 m beyond the water s edge. The plant community was a mixed conifer forest consisting of *Quercus gambelii, Juniperus scopulorum, Picea engelmanii, Pseudotsuga menziesii,* and *Ribes* spp. Grasses and herbaceous plants surrounding the pool included *Agoseris aurantiaca, Allium macropetalum, Alopecurus aequalis, Arenaria* spp., *Bromus* spp., *Carex* spp., *Elymus* spp., *Geranium caespitosum, Iris missouriensis, Juncus* spp., *Phleum alpinum, Phleum pratense, Poa* spp., and *Trifolium* spp. We netted this site on 19 July and 3 August 1995.

Bandelier Sewage Lagoons (L 1-3) [6500]: The sewage lagoons at Bandelier National Monument are formed by three large pools approximately 30 m by 100m; pool depths were unknown to us. The lagoons are on Frijoles Mesa about 0.5 mi. south of the Juniper Campground. From the BAND entrance, the lagoons were reached by turning right onto the Juniper Campground road, taking the first left turn, and following the left fork of this road to its end (ca. 0.5 mi.). The lagoons have mildly sloping plastic-covered banks that are devoid of vegetation. The dominant plant community surrounding the lagoons was piñon-juniper woodland (*Juniperus monosperma, Juniperus scopulorum,* and *Pinus edulis*). We netted this site on 1 August 1995 and on 16 July 1996.

Frijoles Creek at Bandelier Visitor Center [6080]: We netted Frijoles Creek at a point approximately 200 m northwest of the visitor center where it widens for about 20 m to form a flat, gently flowing stream, less than 30 cm deep. Riparian vegetation lined the creek , forming a potential flyway for bats. Trees and woody perennial plants in the canyon include *Acer negundo, Alnus tenuifolia, Betula occidentalis, Pinus ponderosa, Populus angustifolia, Populus fremontii, Ribes* spp.; and *Salix scouleriana.* In 1995 we netted this site on 26 and 27 July and 17 August.

Frijoles Creek at Rainbow House Crossing [6020]: We netted Frijoles Creek where it widens to form a flat, gentle stretch about 60 m long and less than 30 cm deep. This location is 0.1 mi. along the horse trail that descends from the stables at Frijoles Creek. Trees and woody perennial plants within the canyon include *Acer negundo, Alnus tenuifolia, Betula occidentalis, Pinus ponderosa, Populus angustifolia, Populus fremontii, Ribes* spp., and *Salix scouleriana.*. We netted this site 9 and 17 August 1995, 18 and 19 July 1996, and 12 August 1996.

Sites on Santa Fe National Forest

East Fork of Jemez River [7947]: We netted along the East Fork of the Jemez River about 50 m southeast of where it passes beneath State Road 4, south of the Baca land grant. There are two large culverts beneath the highway just west of where we placed nets over the river. Tree species in the surrounding forest include *Pinus ponderosa* and *Picea engelmanii* and short grasses were prevalent along the open banks. We netted this site on 21 July and 8 August 1996.

APPENDIX C. Species Accounts for Bats Known from the Jemez Mountains.

Conservation Status of Bat Species in the Jemez Mountains--Eight of the bat species known to inhabit the Jemez Mountains are former Federal Category 2 Candidate Species, now referred to as "species of concern." These species are *M. ciliolabrum, M. evotis, M. thysanodes, M. volans, M. yumanensis, E. maculatum, C. townsendii,* and *N. macrotis.* Population trends are unknown for all of these species. However, consensus among researchers is that western populations of *C. townsendii* have been declining in recent years. The eastern subspecies (Virginia and Ozark) of *C. townsendii* are listed as Endangered. Unlike many species with more secretive roosting habits, the generally conspicuous roosting sites of big-eared bats allow us to monitor their population levels more closely. The State of New Mexico lists *E. maculatum* as an endangered species, group 2, meaning that its "prospects of survival or recruitment in New Mexico are likely to be in jeopardy within the foreseeable future."

Myotis californicus (California Myotis).--California myotis were captured at Frijoles Creek near Rainbow House Crossing, Icehouse Pond, Los Alamos Canyon, and the Pueblo Canyon Waste Facility. These sites range between 5750 and 7700 feet in elevation. Most were in low elevation piñon-juniper habitats. This species ranks ninth in frequency of capture and tenth in distribution across sites. Males were captured at more sites than females during the study period and the average number of males captured during 1996 was higher than in 1995. Females were not captured during 1995, but a majority of the females captured during 1996 were reproductive indicating that breeding occurs in the Jemez Mountains. This species had the third lowest mean elevation of capture. Active roosts of this species have not yet been located in the Jemez Mountains, but elsewhere during the summer, these bats are known to inhabit lowland, rocky canyons and roost in trees, rock crevices, and various human-made structures (e.g. bridges, buildings, etc.). During the winter they have been found hibernating in caves, mines, and rock crevices. In some areas of its range this species may be sporadically active during the winter months.

Myotis ciliolabrum (Western Small-footed Myotis).--Small-footed myotis were captured at Frijoles Canyon near Rainbow House Crossing and the Bandelier Visitor Center, Icehouse Pond, Lower Pond, Meadow Pond, and in Pueblo Canyon. These sites range between 6020 and 8950 feet in elevation. This species ranks sixth in frequency of capture and sixth in distribution across sites. Males were captured at more sites than females and more bats were captured per night during 1996 than 1995. The mean number of females captured per night during 1995 was relatively equal to the mean number captured in 1996. A majority of females captured over both years have been reproductive, indicating that breeding occurs in the Jemez Mountains. *M. ciliolabrum* had the fourth lowest mean elevation of capture. Active roosts of this species have not yet been located in the Jemez Mountains, but elsewhere during the summer these bats are known to roost in small rock crevices, in trees, and in various human-made structures. During the winter they have been found hibernating in caves, mines, and rock crevices, usually in small numbers. This is the second most commonly encountered species wintering in abandoned mines in New Mexico.

Myotis evotis (Long-eared Myotis).--Long-eared myotis were captured at Dome Pond, Icehouse Pond, Lower Pond, North Upper Pond, Pajarito Wetland, Pueblo Canyon Effluent Stream, and Ski Pond. These sites range between 6470 and 9100 feet in elevation. Most of these sites are high-elevation mixed conifer forest, yet some are lower-elevation pine forest. This species ranked second in frequency of capture and fifth in distribution across sites. Males were captured at more sites than females and the mean number of bats captured during 1995 was higher than in 1996. A majority of females captured in 1995 were non-reproductive, but this trend reversed in 1996. Of all females captured during both years, more have been non-reproductive than reproductive, but this trend may be biased by early season captures when pregnancy is difficult to detect. Long-eared myotis ranked second highest in mean elevation of capture and there appears to be an elevational segregation of sexes (Table 17). Active roosts of this species have not yet been located in the Jemez Mountains. We placed a radiotransmitter on an adult female *M. evotis* on 18 June 1996 at Icehouse Pond. Subsequent attempts to locate this bat failed in spite of extensive ground searches. Long-eared bats are known to inhabit trees, rock crevices (including rocks and stumps low to the ground), and buildings in summer months. During the winter they have been found in mines and caves, but probably hibernate in rock crevices as well.

Myotis thysanodes (Fringed Myotis).--Fringed myotis were captured at Dome Pond, East Fork of the Jemez River, Frijoles Creek near the Bandelier Visitor Center and Rainbow House Crossing, Icehouse Pond, Los Alamos Canyon, Lower Pond, Meadow Pond, North Upper Pond, Pajarito Wetland, Pueblo Canyon Effluent Stream, and Ski Pond. These sites range between 5750 and 9100 feet in elevation and represent the greatest elevational range of any species captured. This species ranked seventh in frequency of capture and was caught at more sites than any other during the study period. Females were captured at more sites than males. The mean number of bats captured per night in 1995 was higher than in 1996 for both males and females. During 1995 a majority of females were reproductive, while in 1996 the ratio of reproductive to non-reproductive individuals was equal. This species had the fifth lowest mean capture elevation. Roosts of several *M. thysanodes* were located by radiotracking. All roosts were located in rocky situations. One male roosted in an extensive boulder field at the foot of a north-facing cliff in upper Frijoles Canyon. Several females roosted in small "solution pits" (likely made by wind and water) in south-facing cliffs of Bandelier tuff near the BAND visitor center. Elsewhere during the summer months, this bat is known to form small colonies in rock crevices, caves, mines, trees, and buildings. Bat colonies of this species in rock crevices are known to change roosts frequently, but usually remain within the same general vicinity. The winter habitat of these bats is virtually unknown.

Myotis volans (Long-legged Myotis).--Long-legged myotis were captured at Dome Pond, East Fork of the Jemez River, Frijoles Creek near the Bandelier Visitor Center and Rainbow House Crossing, Icehouse Pond, Los Alamos Canyon, Lower Pond, Meadow Pond, North Upper Pond, Pueblo Canyon Waste Facility, Pueblo Canyon Effluent Stream and Ski Pond. These sites range between 6020 and 9100 feet in elevation. This species ranked fourth in frequency of capture, and fourth in distribution across sites. Males were captured at more sites than females. The average number of males and females captured per night was higher in 1995 than 1996. No reproductive females were captured in 1995

and only 2 of the 14 females captured during both years were reproductive. Half of the non-reproductive females have been captured after mid-June, so this low reproductive rate may not entirely be the result of sampling bias, although total sample sizes are small. *M. volans* had the seventh highest mean elevation of capture. Active roosts of this species have not yet been located in the Jemez Mountains, but elsewhere long-legged bats are known to form summer colonies in rock crevices, trees, and buildings. These bats rarely use caves as day roosts, but frequently use them as night roosts. During the winter *M. volans* has been found hibernating in Jewel Cave, SD, but their winter distribution remains relatively unknown.

Myotis yumanensis (Yuma Myotis).--Yuma myotis were captured at Dome Pond, Frijoles Creek near Rainbow House Crossing, Meadow Pond, and the Bandelier Sewage Lagoons. These sites range between 6020 and 8950 feet in elevation. This species ranked tenth in frequency of capture and eleventh in distribution across sites. Females were captured at more sites than males. The average number of both males and females captured during 1995 was higher than during 1996. A majority of the females caught in 1995 and all of the females captured in 1996 were non-reproductive, but they raised young in a known roost in a cave at BAND (BAND staff, pers. comm.). We found the carcass of a young-of-the-year near the BAND visitor center. Low numbers of reproductive animals may be due to small sample sizes. This species had the eighth highest mean elevation of capture. Active roosts of this species have not yet been located in the Jemez Mountains, but elsewhere during the summer months these bats can be found roosting in caves, mines, buildings, and bridges. Of all the species of *Myotis*, this species and *M. lucifugus* are most frequently associated with permanent bodies of water. The winter retreats of these bats are unknown.

Lasiurus cinereus (Hoary Bat).--Hoary bats were captured at the East Fork of the Jemez River, Frijoles Creek near Rainbow House Crossing, Los Alamos Canyon Reservoir, Pueblo Canyon Effluent Stream, and Ski Pond. These sites range between 6020 and 8950 feet in elevation. This species ranked eighth in frequency of capture and ninth in distribution across sites. Females have not been captured during the study period and the mean number of males captured per night during 1996 was higher than in 1995. Females are known to occur primarily in the eastern U.S. during the summer. Hoary bats had the third highest mean elevation of capture. Roosts of *L. cinereus* are primarily in the foliage of trees and shrubs. They roost alone or in small family groups, usually not exceeding more than 3 or 4 individuals. As far as is known, these bats migrate to warmer latitudes during the winter months.

Lasionycteris noctivagans (Silver-haired Bat).--Silver-haired bats were captured at Dome Pond, the East Fork of the Jemez River, Frijoles Creek near the Bandelier Visitor Center, Icehouse Pond, Lower Pond, Meadow Pond, Pueblo Canyon Effluent Stream, Pueblo Canyon Waste Facility, Ski Area, and Tech. Area 15 Cement Pond. These sites range between 6080 and 8950 feet in elevation. This species was the most frequently captured and ranked third in distribution across sites. The mean number of bats captured per night during 1995 and 1996 were relatively equal (Figure 10). All females captured during the study were non-reproductive, but all of these bats were captured early in the season (24 April - 29 May) and may not have been showing signs of pregnancy. Silver-haired bats

are considered "tree bats" and are known to roost primarily beneath the bark and in cavities of trees. Studies have shown that maternity colonies are usually found roosting in areas of high snag densities within a forest. Sexes segregate geographically during the summer and females are typically found in eastern and northern parts of the range. These bats are assumed to be migratory but very little is known about their movements or winter habits. They have been found hibernating in dead trees, buildings, ships, and rock crevices. This species rarely enters mines and caves, although they have been found torpid in cave crevices.

Pipistrellus hesperus (Western Pipistrelle).--Western pipistrelles were captured at Frijoles Creek near the Bandelier Visitor Center, and along the cliffs of lower Los Alamos Canyon. These sites range between 6200 and 6580 feet in elevation. This species ranked last in frequency of capture and tied for last in distribution across sites. This species was only captured in 1996 and all 3 were male. *P. hesperus* had the second lowest mean capture elevation. Active roosts of this species have not yet been located in the Jemez Mountains, but elsewhere pipistrelles are commonly found roosting in rock crevices in areas of abundant, low elevation cliffs and canyons. They are never found roosting in large numbers and maternity colonies rarely number more than 12. They have also occasionally been found during the day in dense, low lying vegetation and beneath rocks on the ground. Some researchers have suggested that pipistrelles may occupy the burrows of kangaroo rats (*Dipodomys* spp.). *P. hesperus* is a species known to be active during the winter and to hibernate in caves, mines, and rock crevices where climatic conditions are very stable.

Eptesicus fuscus (Big Brown Bat).--Big brown bats were captured at Dome Pond, East Fork of Jemez River, Frijoles Creek near the Bandelier Visitor Center and Rainbow House Crossing, Icehouse Pond, Lower Pond, Meadow Pond, Pueblo Canyon Waste Facility, Ski Pond, and Tech Area 15 Cement Pond. These sites range between 6020 and 8950 feet in elevation. This species ranked third in frequency of capture and second in distribution across sites. Males and females were captured at the same number of sites and more males and females were captured in 1996 than 1995. Reproductive to non-reproductive ratio of females in 1995 was equal, yet in 1996 there were more reproductive than non-reproductive females. This species had the sixth lowest mean capture elevation and there was a statistical difference in mean elevation between males and reproductive females. One radiotagged female (captured at the Pueblo Canyon Waste Facility along with other reproductive females and volant young) was tracked to a roost near the top of a large ponderosa pine in upper Pueblo Canyon. Thirty-five bats were observed emerging from this roost, which was presumed to be a maternity colony of this species. A second bat of this species was tagged but we were unable to relocate this individual although it was located while foraging in Pueblo Canyon. Roosts of big brown bats are also frequently associated with human dwellings and structures. They are known to roost in trees, rock crevices, caves, and mines during the summer. During the winter these bats are found hibernating in caves, mines and buildings.

Euderma maculatum (Spotted Bat).--Spotted bats were captured at Meadow Pond and Ski Pond. These sites range between 8930 and 8950 feet in elevation and are both high elevation, mixed conifer forest. Though this species was only captured at these sites, its

audible calls were heard at nearly every site netted in 1996, including areas on LANL and BAND. Earlier research has indicated the presence of this bat at a majority of sites censused in the western Jemez Mountains (Cryan 1993). All spotted bats captured during the study period were female. Females captured in 1995 were all reproductive, all captured in 1996 were non-reproductive. However, the 2 captured in 1996 were caught early in the season (6 June) and signs of pregnancy may not have been apparent yet. The three females caught in 1995 were all captured in the late summer. *E. maculatum* had the highest mean capture elevation of any species studied. These bats are known to occupy crevices in high cliffs during the summer months and may form maternity colonies in inaccessible crevices or caves. The roosting habits of this species, as well as its winter habits, are virtually unknown.

Corynorhinus townsendii (Townsend s Big-eared Bat).--Townsend's big-eared bats were captured at Icehouse Pond, North Upper Pond, and Pueblo Canyon Effluent Stream. These sites range between 6470 and 9100 feet in elevation. Both *C. townsendii* captured in 1995 were reproductive females, while the two captured in 1996 were male. This species had the fifth highest mean capture elevation. Although this species is not found in abundance anywhere within its range, big-eared bats are perhaps the most commonly encountered bat in surveys of caves and mines in western North America. Active roosts of this species have not yet been located in the Jemez Mountains, but elsewhere in its range this species is extremely intolerant of disturbance in the roosts and often abandons a site after such disturbance. These bats have not been found entering crevices and are typically seen roosting on an exposed ceiling surface. With the exception of arid regions, they have been found occasionally roosting in undisturbed buildings during the summer.

Antrozous pallidus (Pallid Bat).--Pallid bats were captured at Frijoles Creek near the Bandelier Visitor Center and Rainbow House Crossing, Los Alamos Canyon - Otowi Well 4 and CLF, Pueblo Canyon Effluent Stream, and the Bandelier Sewage Lagoons. These sites range between 5700 and 6600 feet in elevation and are predominantly low-elevation, piñon-juniper habitat. This species ranked fifth in frequency of capture and eighth in distribution across sites. Males were captured at more sites than females and the mean number of bats captured per night during 1996 was higher than in 1995. All females captured in 1995 were reproductive, yet no females of this species were captured during 1996, despite the higher total number captured. This species is known to roost primarily in rock crevices, and one such roost site, likely attributed to pallid bats was located in lower Los Alamos Canyon. Numerous, recently-used pallid bat night roosts were discovered in grottos excavated by ancient residents of Pueblo and Los Alamos canyons. Maternity colonies typically range in size from approximately 12-200 individuals and frequently change roost locations, possibly in order to maximize thermal efficiency or reduce loads of external parasites. Winter habits are unknown though some researchers have suggested that they remain within the general summer range, but may make short migrations between summer and winter roosts. In some desert areas, pallid bats may arouse from hibernation to forage on warm winter nights.

Tadarida brasiliensis (Brazilian Free-tailed Bat).--This species was captured at Frijoles Creek near the Bandelier Visitor Center, Icehouse Pond, Sewage Lagoons, and Ski Pond. These sites range between 6080 and 8930 feet in elevation. The mean number of this

species captured during 1995 was higher than in 1996. All females captured during 1995 were reproductive, yet no females were captured during 1996. This species had the seventh lowest mean elevation of capture. These bats form colonies of great numbers in caves throughout southwestern North America. A large, well-known maternity colony of several thousand Brazilian free-tailed bats was active at Bandelier National Monument. Several previously used but inactive diurnal roosts likely attributed to this species were discovered in rock crevices in cliffs along Pueblo Canyon. One such crevice was found to house 540 bats in late August 1996. Colony size can range from a few individuals to 20 million or more. Colonies are also known from buildings and bridges. During the winter months some individuals remain in the summer range, while most migrate long distances to warmer latitudes.

Nyctinomops macrotis (Big Free-tailed Bat).--Big free-tailed bats were captured at the East Fork of the Jemez River and Meadow Pond. These sites range between 7977 and 8950 feet in elevation and are ponderosa pine-mixed conifer habitats. Much remains to be learned of the natural history and roosting habits of this species. Active roosts of this species have not been located on LANL or BAND, but elsewhere they are known to form maternity colonies in crevices high on cliff walls. The female from Meadow Pond was lactating, as were 3 of 6 females from East Fork of Jemez River. The winter habits are unknown, though this species is capable of making long-distance flights and is believed to migrate great distances.

APPENDIX D. Number of male and female bats captured at each site during 1995 and 1996.

LANL SITES

	SPECIES	FEMALE	MALE
Icehouse Pond	*M. californicus*	2	0
	M. ciliolabrum	2	10
	M. evotis	10	14
	M. thysanodes	0	2
	M. volans	11	22
	L. noctivagans	0	152
	E. fuscus	4	19
	C. townsendii	0	1
	T. brasiliensis	0	1
Los Alamos Canyon - Otowi Well 4	*A. pallidus*	0	1
Los Alamos Canyon - Upper Puddle	*M. californicus*	0	2
	M. thysanodes	0	1
Los Alamos Canyon CLF	*P. hesperus*	0	2
	A. pallidus	0	8
Los Alamos Canyon Reservoir	*L. cinereus*	0	2
Mortandad Canyon	*M. evotis*	0	1
Pajarito Wetland	*M. evotis*	1	0
	M. thysanodes	1	0
Pueblo Canyon Effluent	*M. ciliolabrum*	3	8
	M. evotis	2	0
	M. thysanodes	4	4
	L. cinereus	0	1
	L. noctivagans	4	24
	C. townsendii	0	1
	A. pallidus	0	28
Pueblo Canyon Waste Facility	*M. californicus*	2	2
	M. ciliolabrum	2	4
	M. volans	0	2

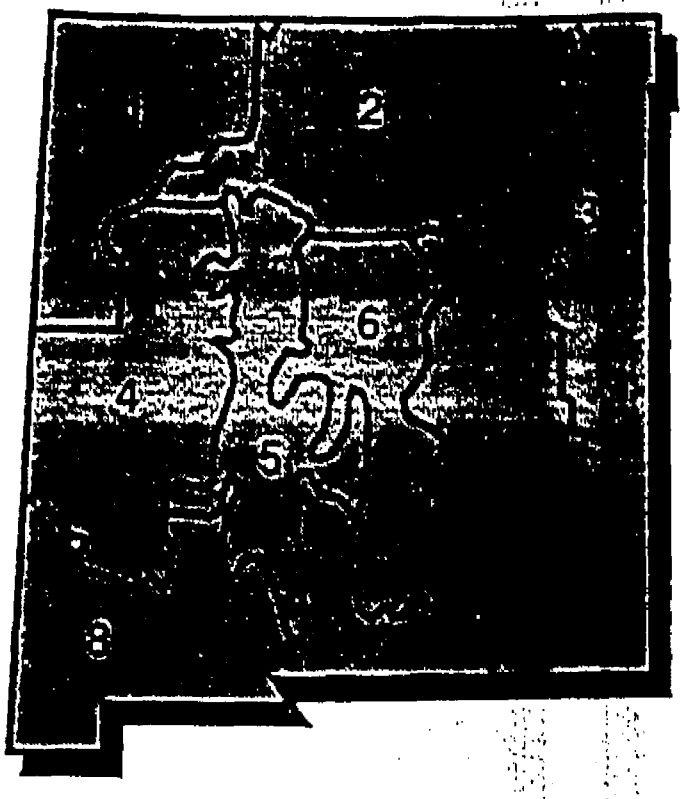
	L. noctivagans	1	5
	E. fuscus	21	3
	P. hesperus	0	1
Tech. Area 15 Cement Pond	*L. noctivagans*	0	1
	E. fuscus	3	0

BAND SITES

Dome Pond	*M. evotis*	0	13
	M. thysanodes	3	2
	M. volans	0	5
	M. yumanensis	1	1
	L. noctivagans	0	19
	E. fuscus	0	1
East Fork of Jemez River	*M. thysanodes*	3	0
	M. volans	0	1
	L. cinereus	0	4
	L. noctivagans	0	2
	E. fuscus	4	2
	N. macrotis	6	0
Frijoles Creek @ R.H. Crossing	*M. californicus*	1	1
	M. ciliolabrum	1	7
	M. thysanodes	5	2
	M. volans	1	3
	M. yumanensis	2	0
	L. cinereus	0	1
	E. fuscus	1	0
	A. pallidus	0	8
Frijoles Creek @ Visitor Center	*M. thysanodes*	0	3
	M. volans	0	1
	T. brasiliensis	0	1
	L. noctivagans	0	2
	E. fuscus	1	0
	A. pallidus	0	1

Lower Pond	*M. ciliolabrum*	1	0
	M. evotis	0	2
	M. thysanodes	1	2
	L. noctivagans	0	20
	E. fuscus	0	2
	T. brasiliensis	0	1
Meadow Pond	*M. californicus*	0	1
	M. ciliolabrum	0	3
	M. evotis	0	4
	M. thysanodes	1	0
	M. volans	2	1
	M. yumanensis	0	4
	L. cinereus	0	7
	L. noctivagans	1	49
	E. fuscus	0	1
	E. maculatum	2	0
	T. brasiliensis	0	1
	N. macrotis	1	0
North Upper Pond	*M. evotis*	2	13
	M. thysanodes	2	0
	M. volans	0	1
	C. townsendii	2	0
Sewage Lagoons	*M. yumanensis*	2	0
	A. pallidus	1	0
	T. brasiliensis	1	0
Ski Pond	*M. ciliolabrum*	0	2
	M. evotis	0	17
	M. thysanodes	1	5
	M. volans	3	11
	L. cinereus	0	6
	L. noctivagans	0	132
	E. fuscus	1	11
	E. maculatum	3	0
	T. brasiliensis	0	1

APPENDIX E. Map of New Mexico showing climate divisions and graphs of Palmer Drought Data for 1995-96 and Precipitation for 1994-96. Data obtained from National Climate Data Center, World Wide Web site (http://www.ncdc.noaa.gov/cgi-bin/ginterface.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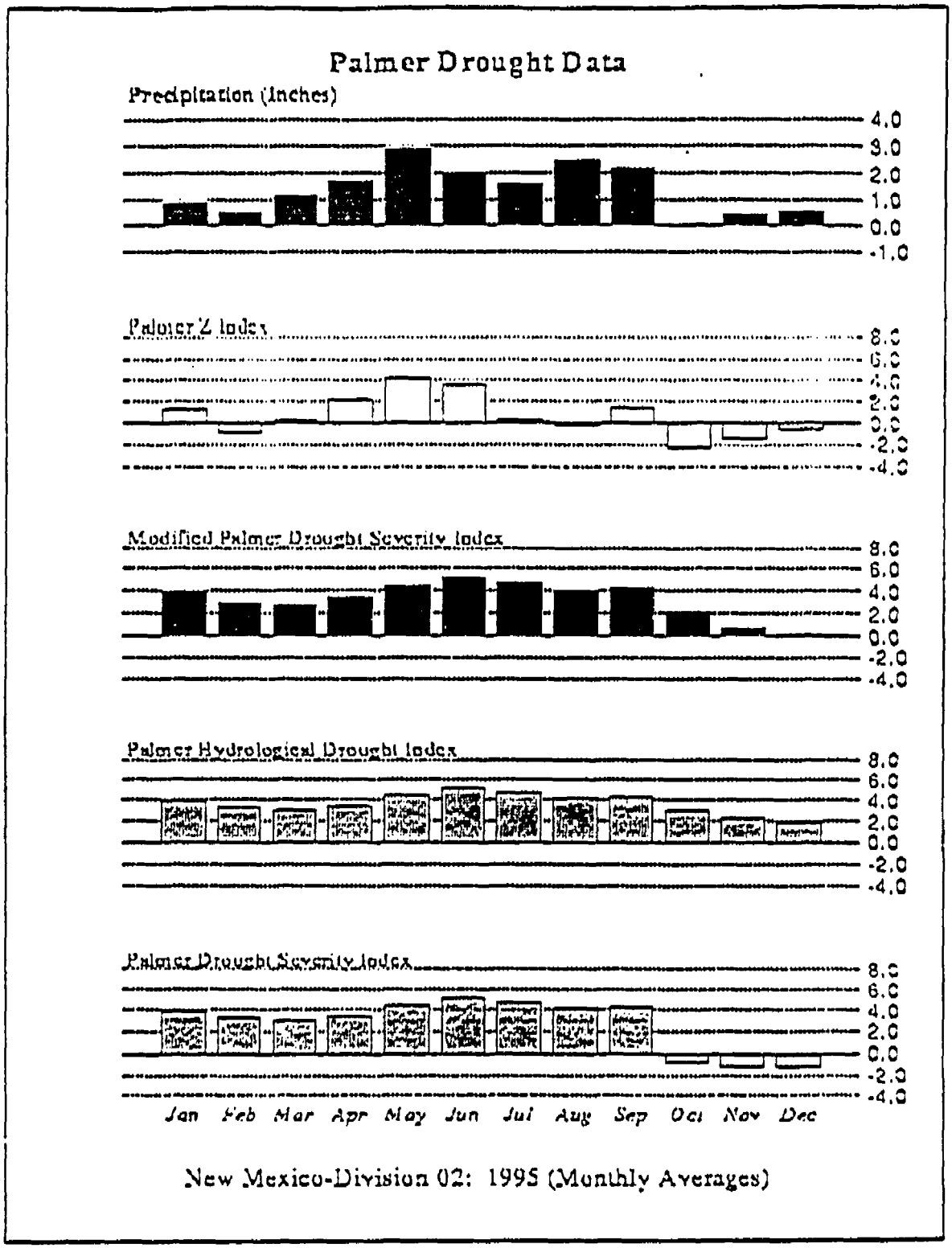
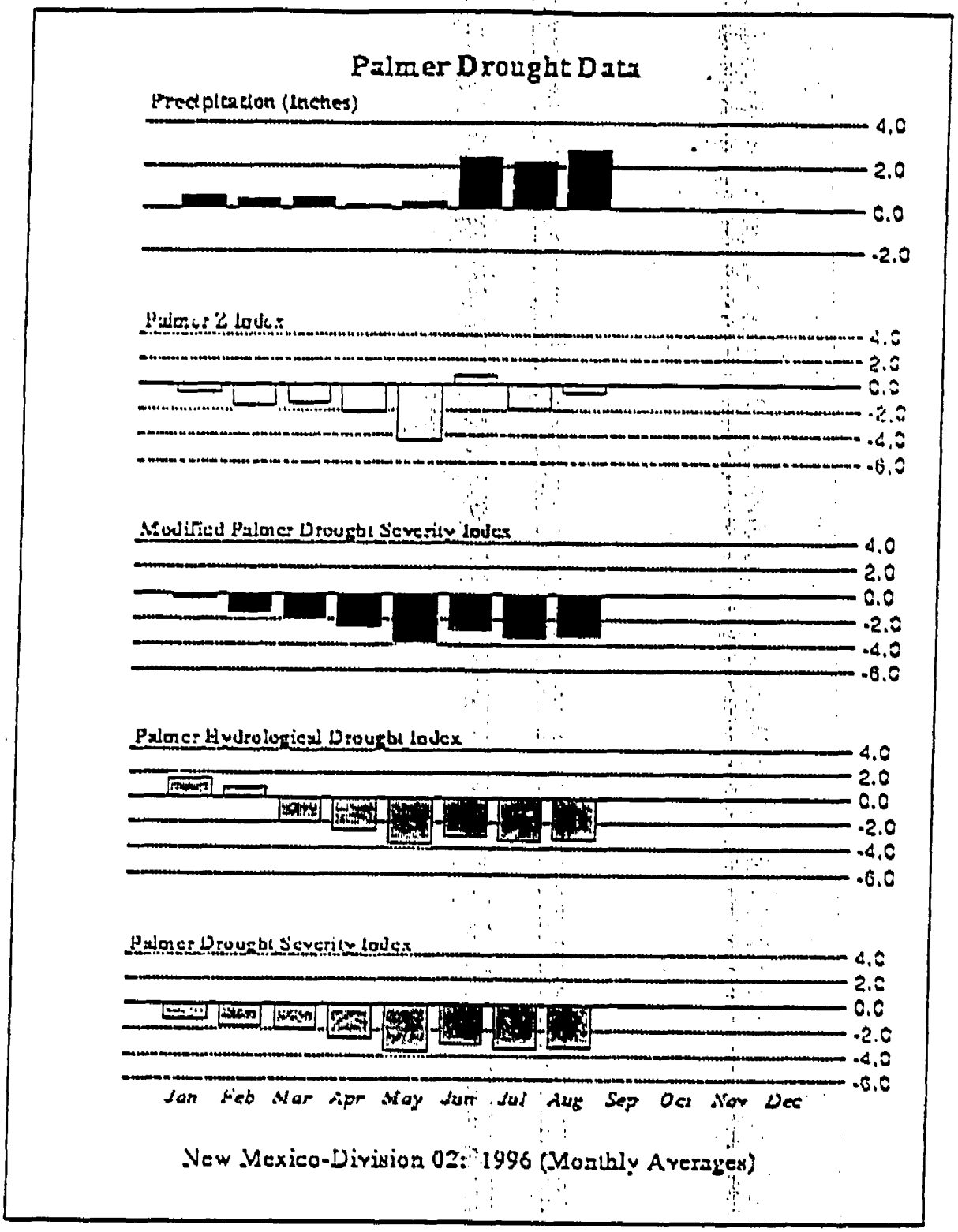


To Download the Data File Click Here!

To Download the Graph (GIF file), Click Anywhere On the Graph with the Mouse



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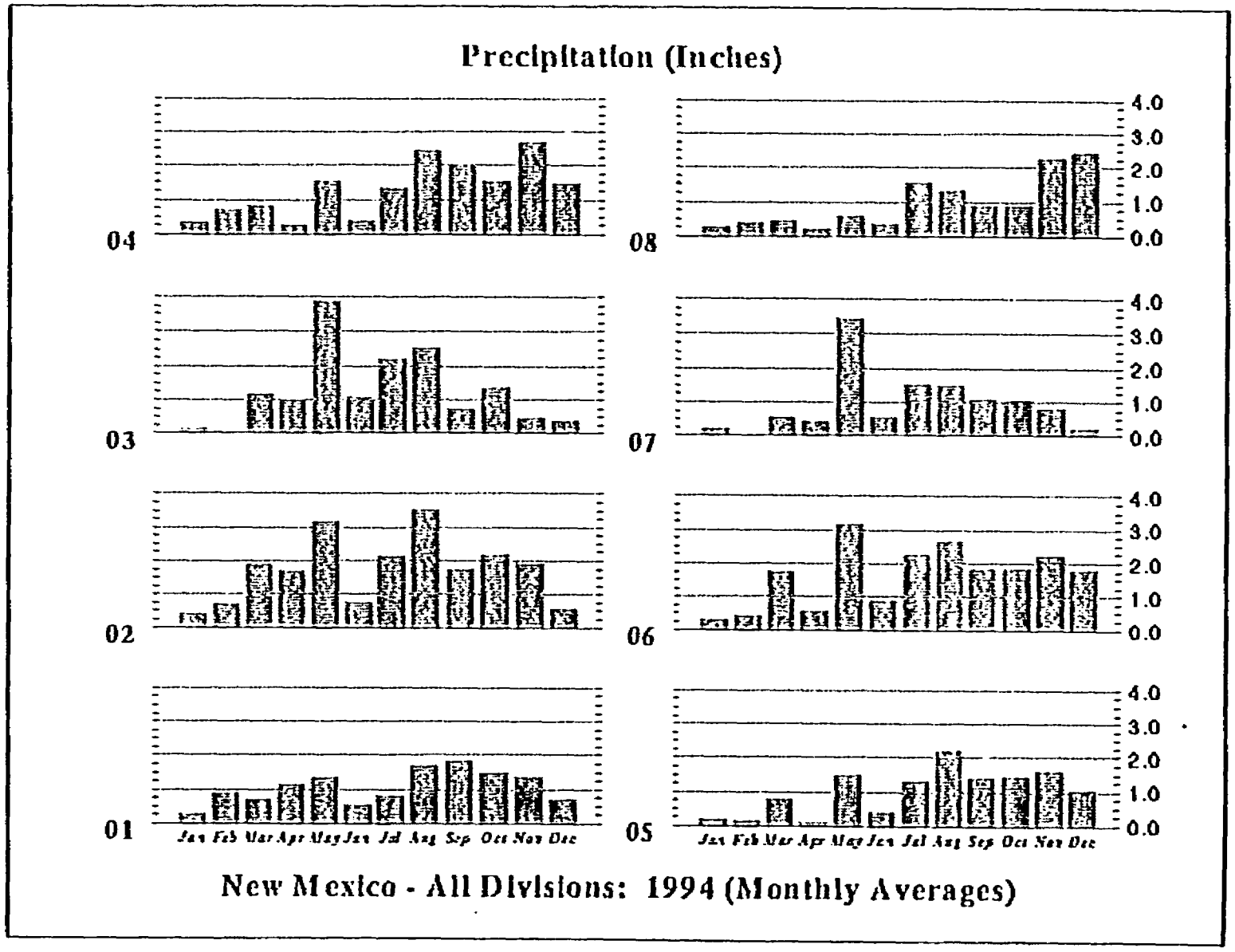
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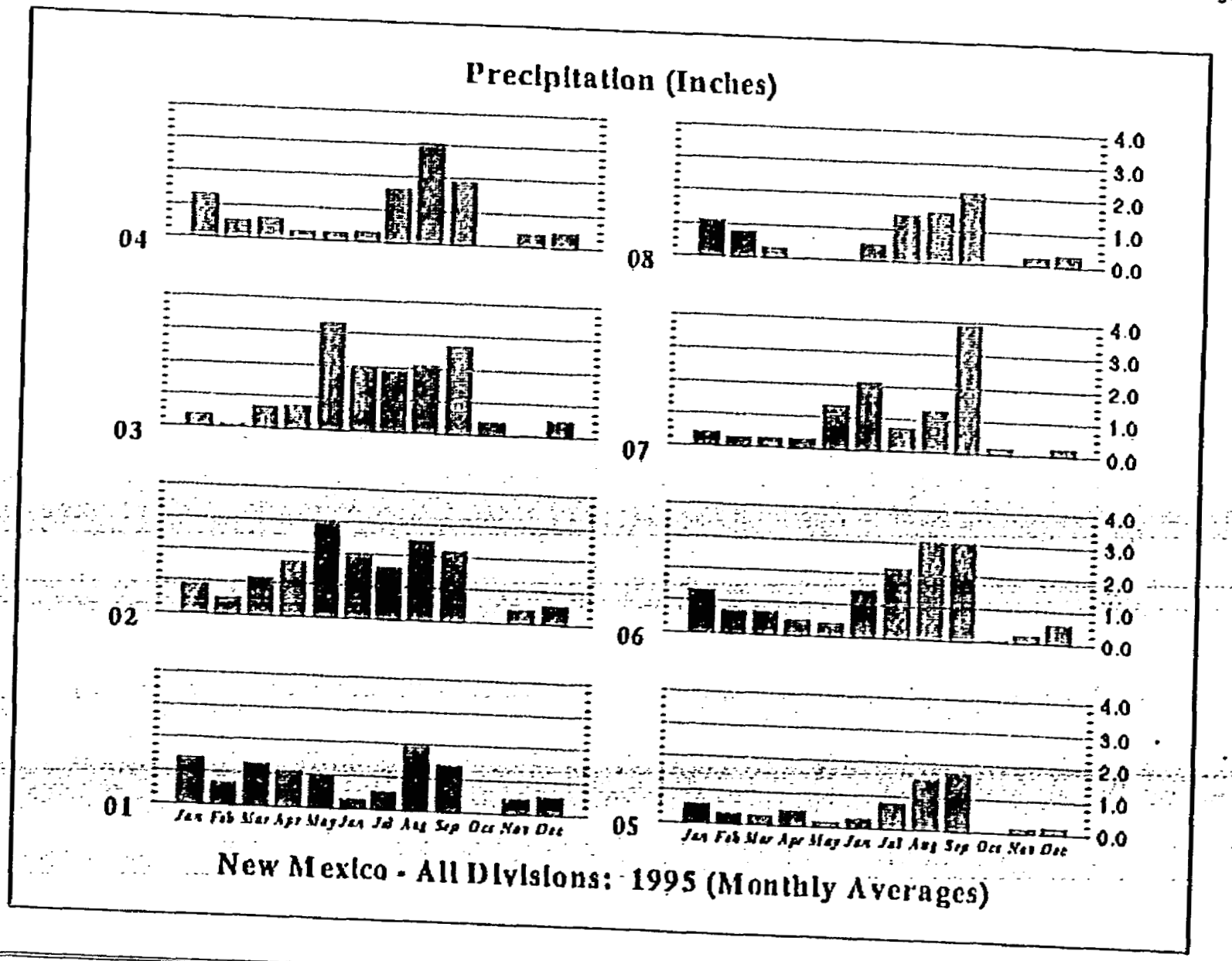
New Mexico - All Divisions: 1994 (Monthly Averages)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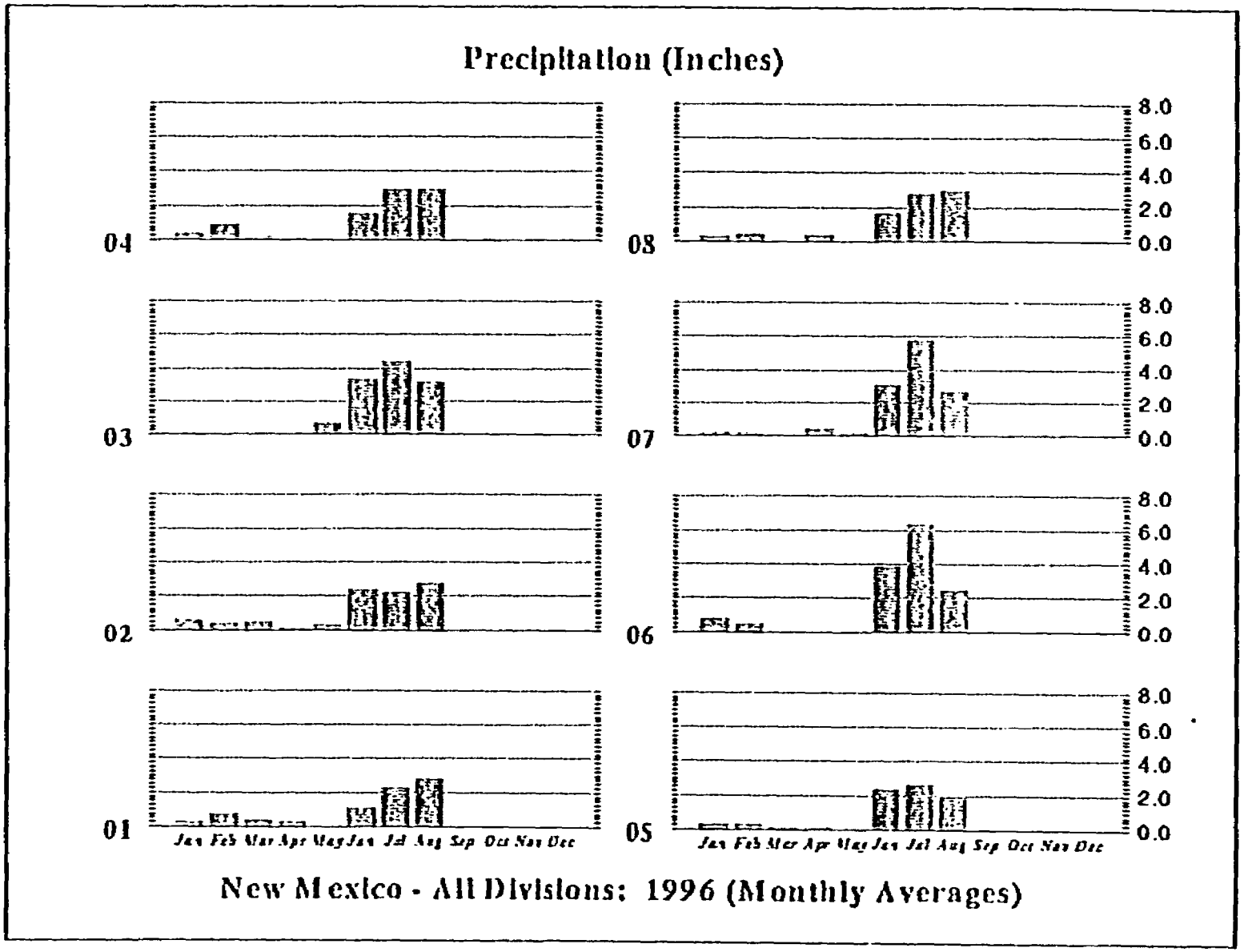
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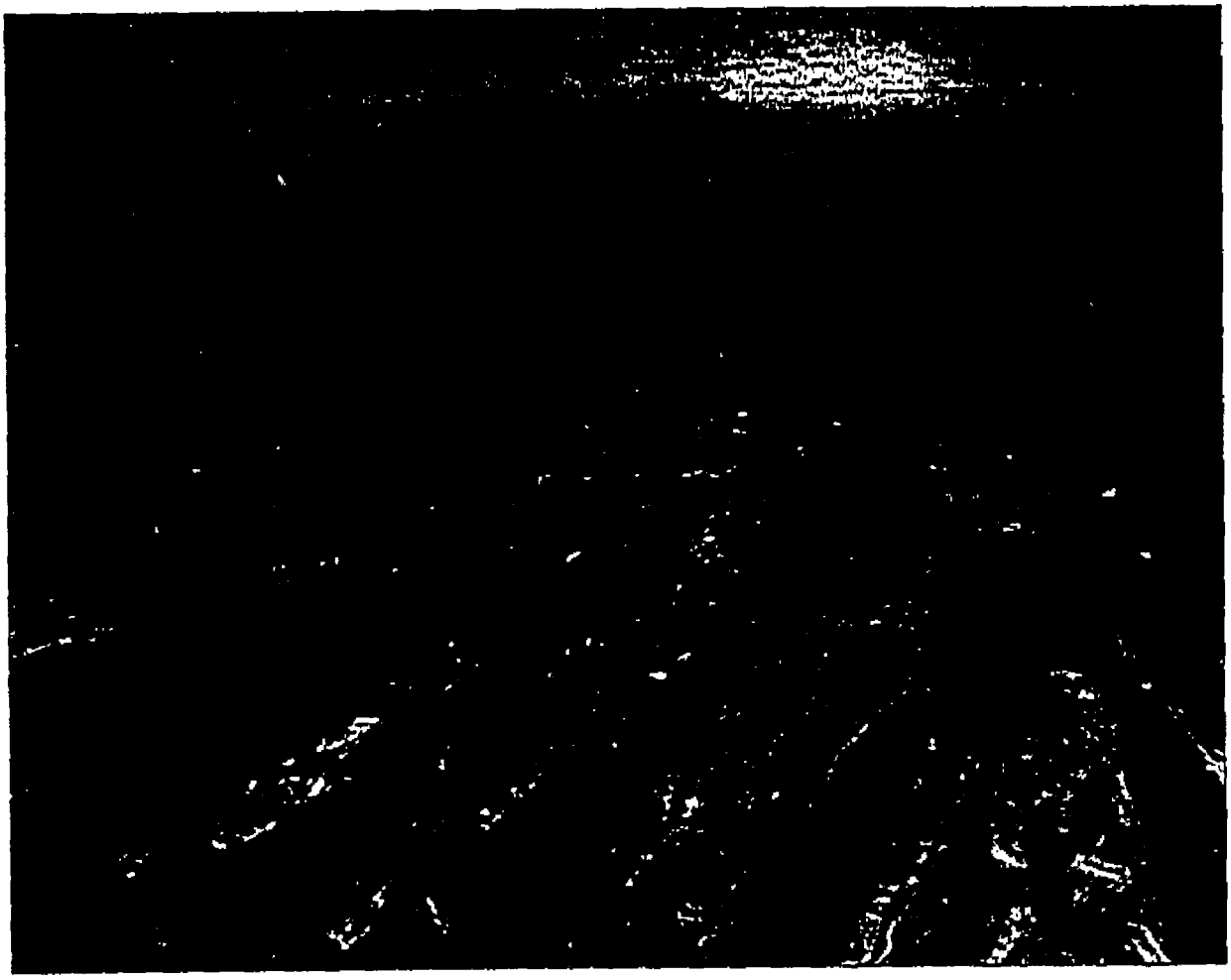
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
New Mexico - All Divisions: 1996 (Monthly Averages)

Preliminary Land Cover Map for Los Alamos National Laboratory

Steven W. Koch, Thomas K. Budge,
Scott G. Ferran, Leonard F. Sandoval, Mary A. Mullen,
Kathryn D. Bennett, and Randy G. Balice



LA-UR-96-3362

Preliminary Land Cover Map for Los Alamos National Laboratory

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Abstract

The Los Alamos National Laboratory's (LANL) Threatened and Endangered Species (TES) Habitat Management Plan calls for identifying areas on LANL property which are suitable or potentially suitable habitat for TES. The production of a land cover map is the first step necessary to meet this goal. Landsat Thematic Mapper images were classified into 50 classes using the Iterative Self-Organizing Data Analysis Technique. These 50 classes were aggregated in 10 land cover types by using field surveys. An analysis based on an informal accuracy assessment convinced us to group some classes which were apparently distinguishable in the field but which were indistinguishable in the image classification. Forested cover types were mapped fairly accurately, but nonforested areas will require additional work. Further work to improve the map includes: using a new classification scheme which more accurately represents actual communities and reclassifying the original TM data incorporating topographical information in the clustering processing and blockingout urban areas.

1.0 Introduction

The Los Alamos National Laboratory's (LANL) Threatened and Endangered Species (TES) Habitat Management Plan (HMP) calls for identifying areas on LANL property which are suitable or potentially suitable habitat for TES. A basic land cover map identifying areas by the dominant overstory vegetation must first be developed in order to begin locating this habitat. Once this map is completed, additional data specific to each species can be incorporated to identify species habitat.

In early 1996 a decision was made to use Landsat Thematic Mapper (TM) satellite imagery as the basis data for the land cover map. Of the various types of remotely-sensed data available for mapping the earth's vegetation, TM data is particularly suitable as it 1) is digital data; 2) has a high signal-to-noise ratio; 3) has high cartographic accuracy; and 4) has a high precision of radiometric data (Scott et al. 1993). TM sensors detect reflected radiation from the earth's surface in the visible and infrared (IR) wavelengths. The TM sensor has a spatial resolution of 28.5 m (94 ft) for the visible, near-IR, and mid-IR wavelengths and a spatial resolution of 120 m (396 ft) for the thermal-IR band. TM satellite data is widely used for producing land cover maps.

1.1 Geographic Setting

LANL is located in Los Alamos County in north-central New Mexico approximately 100 km (60 mi) north-northeast of Albuquerque and 40 km (25 mi) northwest of Santa Fe. The county is approximately 283 km^2 (109 mi^2) in area and is situated in the Jemez Mountains.

The county encompasses the mountainous rim of the Valles Caldera and portions of the table-like extension on the eastern slopes, known as the Pajarito Plateau. This plateau extends approximately 16 km (10 mi) from the base of the mountain slopes and ends at the Rio Grande. It is dissected by narrow precipitous canyons separated by finger-like mesas. LANL is located on the plateau and occupies 112 km^2 (43 mi^2) within Los Alamos County. Due to the rugged topography, most of the laboratory facilities are confined to the mesa tops.

2.0 Methods

The Earth Data Analysis Center (EDAC) of the University of New Mexico processed the raw TM images using the software ERDAS IMAGINE, ver. 8.2, on a Sun SparcStation 20.

2.1 Geocorrection

Two Landsat TM satellite images were acquired in order to cover the entire original study area. The eastern image was collected by Landsat on August 15, 1992, and the western image was collected on September 7, 1992. EDAC geocorrected, or registered, both images to the United States Geological Survey (USGS) 1:100,000 base map to an accuracy of approximately one pixel (about 28.5 x 28.5 meters [94 x 94 ft]). The geocorrection process consisted of identifying well-mapped locations on the base map, such as road intersections, and digitizing their coordinates. The coordinate system used was Universal Transverse Mercator (UTM) projection, zone 13, Clark 1866 spheroid, North American Datum of 1927 (NAD27). The line and column of the matching satellite image pixels were also obtained and the sets of coordinate pairs were entered into the computer. The ERDAS software then evaluated the fit of the coordinate match and provided the results as a root-mean-square (RMS) fit in pixel units. Each coordinate pair was evaluated for their fit, the worst pair was deleted, and the RMS fit was calculated again. The process was repeated until each coordinate pair was fit to within two pixels.

2.2 Contrast Matching

After the geocorrection was completed, the two images were contrast matched. Even though the acquisition dates were only three weeks apart, there were minor contrast differences due to subtle changes in vegetation greenness, in atmospheric conditions, and in the satellite viewing angle. Since the western image occupied the majority of the study area, the eastern image was matched to it. When the two images were joined together into a single image, the seam between the two was virtually invisible.

2.3 Classification

The spectral data collected by the Landsat TM contains no land cover information per se. The variety of spectral information must first be grouped into similar classes, and then these classes must be assigned to appropriate land cover categories based on data collected on the ground. This classification method is called unsupervised classification and the Iterative Self-Organizing Data Analysis Technique (ISODATA) (ERDAS 1994) was used. This procedure grouped the spectral data into 50 classes. This number was chosen because it is large enough to provide a good breakdown of differing vegetation without being so large that field checking the classes is overwhelming. For this classification six of

the seven TM spectral channels were used. The coarse resolution thermal band was excluded. However, a normalized vegetation difference image (NVDI) was used in its place. The NVDI is essentially a ratio of TM band 4 divided by TM band 3. This image is a good indicator of biomass or greenness. EDAC has found from previous mapping projects that the addition of the NVDI can further enhance the separation of vegetation classes.

With the classification completed to the 50 classes, a series of spectral plots was produced at the 1:24000 scale for field verification. Plots were generated for the six quadrangles overlaying Los Alamos County. Each plot consisted of either six or seven spectral classes per plot, each in a different color. Major roads, county boundary lines, and drainage lines were also plotted.

Homogenous polygons from each spectral class were selected on each plot. Field crews were sent to those polygons that were large enough to be easily located in the field and that were fairly accessible. The crews collected land cover data including overstory, understory, shrub, grass, and forb species types and percent covers, as well as ground surface type percent covers, downed wood quantities, numbers of snags, adjacent community types, and signs of animals or disturbance. The data sheets were grouped into apparent classes, based on percentages of dominant overstory and understory species. Ten land cover types were identified from these field surveys.

At this stage, five of the original 50 spectral classes could not be assigned to a land cover class. Using the statistics uniquely identifying each spectral class, EDAC placed these five problem classes into one of the remaining 45 classes. Once this was done, each of the 45 classes was aggregated into one of the ten land cover classes.

2.4 Reprojection

EDAC reprojected the classified image from UTM, NAD27, to State Plane, NAD83, so that the cartographic data available at LANL could be used.

2.5 Accuracy Assessment

Field crews then visited 47 plots based on selecting typical representatives of the various classes. These 47 plots were used for an informal accuracy assessment of the land cover map. Since the points were not randomly selected, and since less than 100 points were used, this accuracy assessment is being used as a tool to guide the refinement of the land cover map, not as an official assessment. The original ten land cover classes were evaluated using an error matrix adopted from Congalton (1991). The field data were reclassified based on a new land cover classification (Foxx et al. 1996) since this new classification more precisely reflects the vegetation classes we wish to use.

3.0 Results

A total of 128 plots were surveyed to provide the classification in Table 1. The 50 original satellite color classes were aggregated into ten land cover classes.

Foxx et al. (1996) describe the land cover categories in detail. They will be summarized in this section. In general, the mapping classes can be subdivided into forested types and nonforested types, that consist of woodlands, grasslands, nonvegetated areas, and open water.

The forested types can be subdivided into several groups based on overstory dominance. The Mixed Conifer Type is a high-elevation forest composed primarily of Douglas fir (*Pseudotsuga menziesii*), Engelmann spruce (*Picea engelmannii*), and white fir (*Abies concolor*). The Aspen Cover Type is also located in the high-elevation zone, but is dominated by quaking aspen (*Populus tremuloides*). The other components of the Mixed Conifer Type may also be present, but in lesser amounts. At middle elevations in the LANL region, the Ponderosa Pine/Mixed Conifer Type is found. As in the Aspen Cover Type, the Ponderosa Pine/Mixed Conifer Cover Type contains many of the species that are common to mixed conifer communities. However, ponderosa pine (*Pinus ponderosa*) is always a codominant species, and aspen is typically absent. As the elevation decreases to about 2034 m (7000 ft), the Ponderosa Pine cover type predominates. In this cover type, ponderosa pine is the dominant overstory species. Minor floristic components from higher-elevation zones, along with scattered piñon (*Pinus edulis*) or one-seed juniper (*Juniperus monosperma*), may also be present in these communities.

The nonforested types can be identified according to their physiognomic structures or according to their substrates. The Piñon-Juniper Woodland occupies much of the lower elevations on LANL. In addition to piñon and juniper trees, which are characteristically of short stature and relatively evenly spaced, this cover type also contains various combinations of grasses, shrubs, and bare ground. The remaining cover types can be found at a variety of elevational positions. The Grasslands Cover Type is a highly variable cluster of plant communities that are dominated by graminoid species. These range from parks and athletic fields to subalpine grasslands and abandoned homesteads. Nonvegetated areas are also highly variable. They consist of asphalt parking lots, tuffaceous cliffs, felsenmeers, talus slopes, and other upland, lithosolic areas that cannot support vegetation. The Open Water Cover Type includes lakes, reservoirs, rivers, and containment ponds.

The Foxx et al. (1996) land cover classification is more inclusive and robust than the classification in Table 1. Their scheme

Table 1. Original land cover classification.

Color class	Land Cover Category	Category #
1	Water	1
2–7	Mixed Conifer	2
8 and 10	Ponderosa Pine/Mixed	3
9	Aspen	4
11–15	Ponderosa Pine (Pipo)	5
16	unknown	
17	Turf Grass	6
18–21	unknown	
22–27, 32	Grasses	7
28–31, 37	Piñon/Juniper with grassy understory	8
34–40, 43	Open Piñon/Juniper, may have tuff	9
33, 41, 42, 44–50	Nonvegetated	10

more closely follows the Federal Geographic Data Committee standard for Vegetation Classification and Information (FGDC 1996). Therefore, the 47 additional assessment plots were assigned to Foxx et als land cover classes. Using these plots in an accuracy assessment with the satellite map based on the original classification, revealed a low thematic accuracy (Tables 2 and 3).

Table 2. "Accuracy Assessment" using 47 plots

Satellite	MixCon	Pipo/Mixed	Aspen	Pipo	Turf	Grasses	PJ/grass	PJ/rock	Shrublands	
Reference	2	3	4	5	6	7	8	9		Sums
MixCon	4	2	1							7
Pipo/Mixed										0
Aspen			3	1						4
Pipo		7		5		3				15
Turf										0
Grasses				2	2	1	1			6
PJ/grass						2	2			4
PJ/rock						3	3			6
Shrublands				1		3	1			5
Sums	4	9	4	9	2	12	7	0	0	47

Total correct = 15 Overall Accuracy = 0.32

Table 3. Breakdown of Table 2 into two types of error.

Cover Types	Omission Error Producer's Accuracy	Commission Error User's Accuracy
MixCon	1.00	0.57
Pipo/Mixed	0.00	–
Aspen	0.75	0.75
Pipo	0.56	0.33
Turf	0.00	–
Grasses	0.08	0.17
PJ/grass	0.29	0.50
PJ/rock	–	0.00
Shrublands	–	0.00

The overall accuracy is the sum of correctly classified plots divided by the total number of plots. The producer's accuracy is the total number of correct plots for a single category divided by the sum of plots for that category provided by the reference (field) data. The user's accuracy is the total number of correctly classified plots for a single category divided by the sum of plots for that category from the satellite map (Congalton 1991). In other words, although 100% of the mixed conifer areas in Table 2 have been correctly identified as mixed conifer, only 57% of the areas called mixed conifer are actually mixed conifer. The reference categories "Pipo/Mixed" and "Turf" have no plots in the tables as these categories do not exist in the Foxx et al. land cover classes. "Mixed Conifer" (MixCon) and "Aspen" had the highest accuracy, while "Grasses" and "Piñon/Juniper" (PJ) had the lowest. The Shrublands category does not exist on the satellite map, but based on field experience, the category Grasses contains areas of both shrublands and savanna. Based on this assessment, it is apparent that the category Pipo/Mixed should be grouped with "Pipo," the Turf category should be grouped with "Grasses," and the two Piñon/Juniper categories should be grouped together. Tables 4 and 5 repeat the assessment from Tables 2 and 3 after performing the aforementioned groupings. MixCon and "Aspen" again have the highest accuracy, and "Grasses" again has the lowest. This modification resulted in the accuracy calculation increasing from 0.32 to 0.57.

The land cover map for an eight-quad area surrounding LANL is presented in Figure A-1 in the appendix. On the left side of the map, the high-elevation aspen stands and mountain meadows are obvious. The Rio Grande runs northeast-southwest along the lower right side of the map. Figures A-2, A-3, and A-4 are land cover maps for each of the three quads overlaying LANL. In addition to land cover types, these maps include wetlands, hydrography, roads, and boundaries data produced at LANL. Fingers of mixed conifer run east along the south side of the plotted drainages. These areas are moist, shaded north-facing slopes. Based on experience, the forested cover types are mapped fairly accurately. The Grasses/Shrubs/Savanna cover type in Figures A-3 and A-4 will need additional work in order to separate these categories from each other.

The land cover classes for Los Alamos County are presented in Table 6, ranked by area. Ponderosa pine occupies the greatest area of the seven classes within Los Alamos County. Table 7 presents land cover classes for LANL ranked by area. Grasses/Shrubs occupy the greatest area within LANL, followed by Piñon/Juniper and Ponderosa Pine. Water is the least common land cover type.

Table 4. "Accuracy Assessment" using 47 plots, with some original categories grouped

Satellite	MixCon	Aspen	Pipo	Grasses	PJ	Shrublands	
Reference	2	4	3+5	6+7	8+9		Sums
MixCon	4	1	2				7
Aspen		3	1				4
Pipo			12	3			15
Grasses			2	3	1		6
PJ			5	5			10
Shrublands			1	3	1		5
Sums	4	4	18	14	7	0	47

Total correct = 27 Overall Accuracy = 0.57

Table 5. Breakdown of Table 4 into two types of error.

Cover Type	Omission Error Producer's Accuracy	Commission Error User's Accuracy
MixCon	1.00	0.57
Aspen	0.75	0.75
Pipo	0.67	0.80
Grasses	0.21	0.50
PJ	0.71	0.50
Shrublands	0.00	0.00

Table 6. Land cover classes by area for Los Alamos County.

Class	Area (acres)	Area (ha)	Area (mi^2)	%
Ponderosa Pine	21,693.05	8,782.61	33.90	31.0%
Grasses/Shrubs	19,712.47	7,980.76	30.80	28.2%
Mixed conifers	15,924.32	6,447.09	24.88	22.8%
Piñon/Juniper	8,776.33	3,553.17	13.71	12.6%
Nonvegetated	2,679.24	1,084.71	4.19	3.8%
Aspen	1,133.59	458.95	1.77	1.6%
Water	8.23	3.33	0.01	0.0%
Sums	69,927	28,310	109.26	100%

Table 7. Land cover classes by area for LANL.

Class	Area (acres)	Area (ha)	Area (mi^2)	%
Grasses/Shrubs	12,495.24	5,058.80	19.52	45.2%
Piñon/Juniper	6,440.70	2,607.57	10.06	23.3%
Ponderosa Pine	5,566.82	2,253.77	8.70	20.2%
Nonvegetated	2,432.17	984.68	3.80	8.8%
Mixed conifers	672.37	272.21	1.05	2.4%
Aspen	11.44	4.63	0.02	0.0%
Water	6.22	2.52	0.01	0.0%
Sums	27,625	11,184	43.16	100%

4.0 Conclusions

A land cover map is an essential component to managing TES at LANL. The first such map produced for the TES HMP identifies the closed canopy areas, such as Mixed Conifer Cover Type or the Ponderosa Pine Cover Type, fairly well. The map is much weaker in identifying grasslands and shrublands. These shortcomings will be addressed in the next iteration of the map production process. The following steps should greatly enhance the accuracy of the land cover map:

1. Have a classification scheme in place before map production. The land cover classification by Foxx et al. (1996) will provide the essential categories with which to classify the TM image. Having a classification scheme in place before attempting to classify a remotely-sensed image is critically important to the success of the mapping (Congalton 1991).

2. Reduce the spatial extent of the study area from 16 USGS 7.5-minute quadrangles to eight quadrangles. The original TM scene covered over 16 quads. The accuracy of the map should increase by limiting the area of the map to what can be realistically sampled in the field.

3. Remove or block out from the TM image those areas for which we already know the classification. In particular, mask out the urban areas. These areas typically add a wide range of spectral information to the satellite image, making the vegetated, nonurban areas harder to separate. We would not expect urban areas to be critical to TES.

4. Incorporate topographical data directly into the classification process. Since plant communities in the Southwest are highly correlated with elevation and slope and aspect, using this data should help separate unique communities and result in a more accurate map.

5. Use vegetation data and cover maps available from other agencies to check our map. Bandelier National Monument has completed a vegetation map based on aerial photography. The Santa Fe National Forest has vegetation transect data available. Information from these agencies would be useful for assessing the accuracy of the LANL land cover map.

Other projects at LANL will find the map to be a valuable resource as the map accuracy is improved. For example, Environmental Restoration has already expressed a strong desire for this map. Continued cooperation between groups and projects in the form of sharing data and resources will further enhance this product.

Acknowledgments

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Scott 1993: J.M. Scott, F. Davis, B. Csuti, R. Noss, B. Butterfield, C. Groves, H. Anderson, S. Caicco, F. D'Erchia, T.C. Edwards, Jr., J. Ulliman, and R.G. Wright, Gap analysis: A geographic approach to protection of biological diversity. Wildlife Monographs, No. 123, The Journal of Wildlife Management 57(1) supplement.

Figure A-1. Land Cover Map - TES Habitat Management Plan

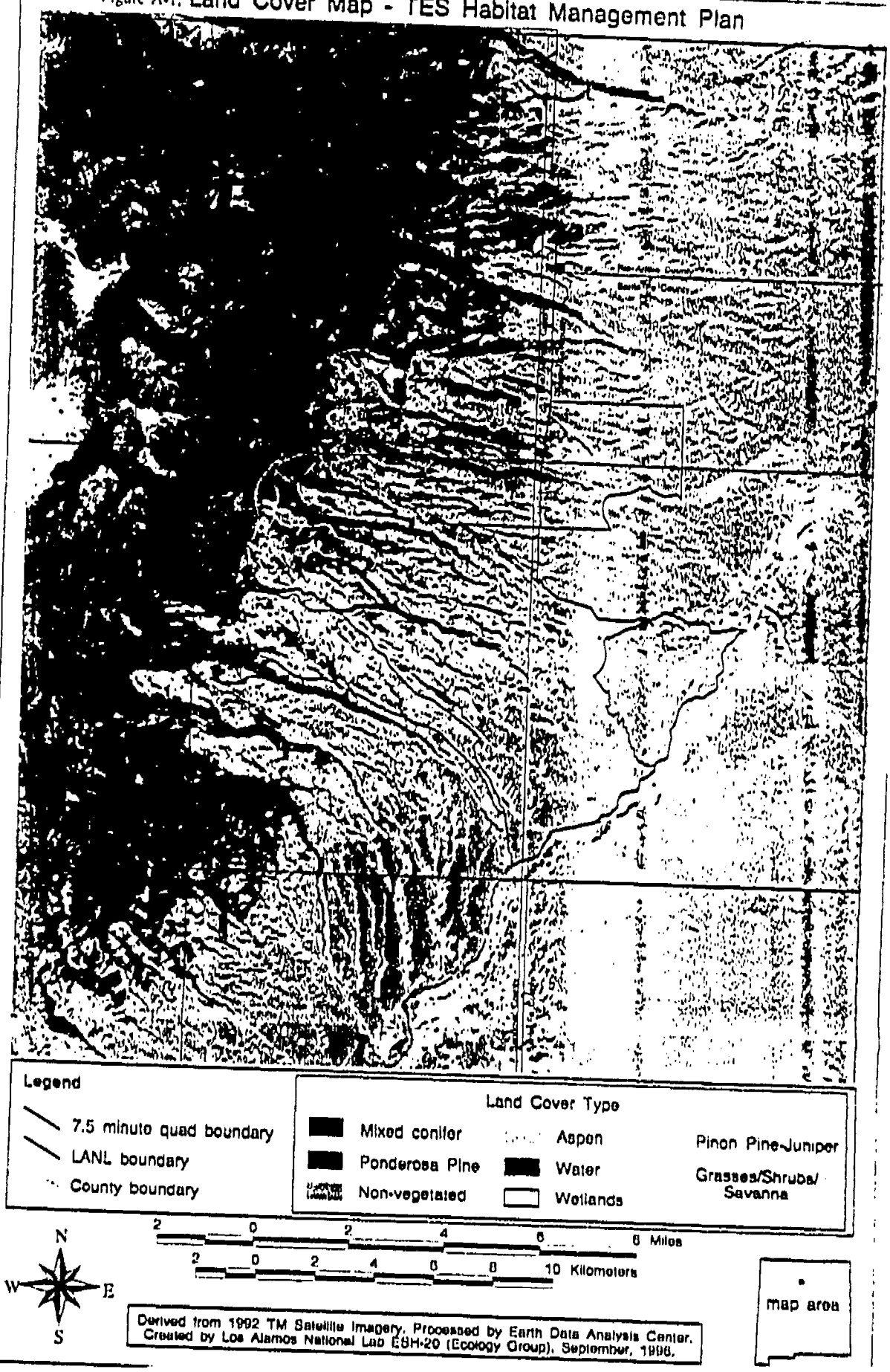


Figure A-2. Land Cover Map - Guaje Mountain quadrangle

Legend

- Paved roads
- LANL boundary
- Drainages

Land Cover Type

- Mixed conifer
- Ponderosa Pine
- Non-vegetated
- Aspen
- Water
- Wetlands
- Pinon Pine-Juniper
- Grasses/Shrubs/ Savanna

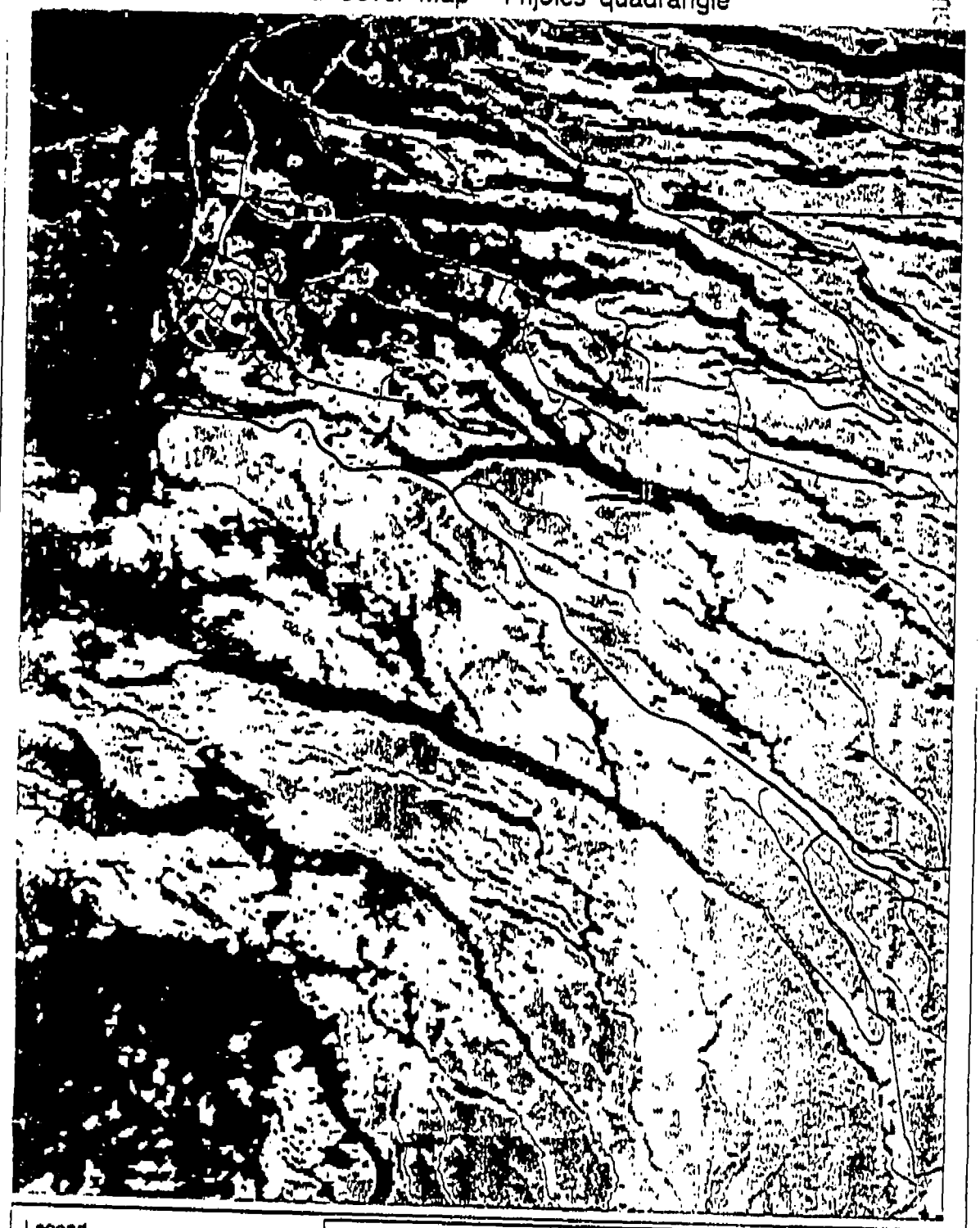
N W E S

2 0 2 4 6 Kilometers

1 0 1 2 3 4 Miles

Derived from 1992 TM Satellite Imagery. Processed by Earth Data Analysis Center. Created by Los Alamos National Lab ESH-20 (Ecology Group), September, 1998.

Figure A-3. Land Cover Map - Frijoles quadrangle



Legend

Paved roads

LANL boundary

Drainages

Land Cover Type

Mixed conifer

Ponderosa Pine

Non-vegetated

Aspen

Water

Wetlands

Pinon Pine-Juniper

Grasses/Shrubs/ Savanna

N W E S

2 0 2 4 6 Kilometers

1 0 1 2 3 4 Miles

Derived from 1992 TM Satellite Imagery. Processed by Earth Data Analysis Center. Created by Los Alamos National Lab ESH-20 (Ecology Group). September, 1996.

Figure A-4. Land Cover Map - White Rock quadrangle

Legend

Paved roads

LANL boundary

Drainages

Land Cover Type

Mixed conifer

Ponderosa Pine

Non-vegetated

Aspen

Water

Wetlands

Pinon Pine-Juniper

Grasses/Shrubs/
Savanna

N
W
E
S

2 0 2 4 6 Kilometers

1 0 1 2 3 4 Miles

Derived from 1992 TM Satellite Imagery. Processed by Earth Data Analysis Center.
Created by Los Alamos National Lab ESH-20 (Ecology Group). September, 1996.

Preliminary Land Cover Classification for Los Alamos National Laboratory and Los Alamos County, New Mexico

Teralene S. Foxx, Randy G. Balice, and Mary E. Salisbury

LA-UR-96-3525

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Appendix A. Working Draft "Keys to Major Land Cover Types in the LANL Vicinity."

Preliminary Land Cover Classification for Los Alamos National Laboratory and Los Alamos County, New Mexico

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Abstract

The major plant cover types of the Los Alamos County, Los Alamos National Laboratory (LANL), and surrounding area are distributed along topographic and moisture gradients. These cover types range from riparian areas along ephemeral streams to mountain grasslands at higher elevations. To date we have identified four terrestrial vegetation classes: forests, woodlands, shrublands, and grasslands. These classes have been further divided into subclasses, regional biomes, cover type groups, cover types, and community types. Cover types include mixed conifer, aspen, ponderosa pine, pinon- juniper woodlands, juniper woodlands, and Rocky Mountain subalpine grasslands. Additional study is needed to further define the cover types within grassland and shrubland classes. We have not yet classified wetland/riparian classes to a sufficient degree. Working Draft Keys also provide a classification for land used for human purposes.

This document provides for a discussion of the preliminary vegetation classification for the County of Los Alamos and LANL. The classification is a detailed description of the Cover Classes used on the draft land cover map that has been produced for LANL by Earth Data Analysis Center, University of New Mexico. This vegetation classification was based on previous qualitative and quantitative field studies, supervised and unsupervised classification for the land cover map, bibliographic references for the area, and 20 years experience with the vegetation of the Jemez Mountains.

This paper represents a preliminary classification that will be further tested through specific error-reduction techniques used in the land cover mapping. We believe that further refinement of this classification will provide a consistent terminology that can be used by researchers for describing the vegetation component of their study sites.

1.0 Introduction

A Habitat Management Plan (HMP) for threatened and endangered species (TES) is a proactive planning tool to provide information about TES to project planners. Such a planning tool is needed so that projects within a facility, such as Los Alamos National Laboratory (LANL), do not come into direct conflict with mandates of the Endangered Species Act of 1973. In the past, surveys for TES were done on a site by site basis and were dependent upon the location of maintenance and construction projects. There was no mechanism for annual surveys of the entire facility. The site by site approach resulted in project delays by last minute discovery of species not known to occur on the facility and by the consultation processes.

In 1995, the Record of Decision (ROD) for the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility Environmental Impact Statement (EIS) mandated development of a HMP for TES. This requires a site-wide rather than a site by site approach to conservation, protection, and identification of TES and those species of concern (SOC) that occur on or utilize the 112 km^2 (43 mi^2) of the LANL.

Additionally, LANL lands were designated a National Environmental Research Park (NERP) in 1976 based on the "legacy of parks" initiated by President Nixon's 1971 State of the Union Message and subsequent Presidential endorsements. The focus, as with other NERPs, is the "impact of man's activities on his environment; that is, the interaction between man-altered systems and adjacent natural ecosystems." To understand the impact of man's activities on his environment, ecological studies must be conducted.

These two mandates require an understanding of the ecological environments at LANL. Basic to this understanding is identification of the components of the habitats in which TES live. Vegetation components of the habitat influence the ability of organisms to successfully reproduce and forage on a site. Two types of information on vegetation are needed to determine the value of a habitat for a species:

1) plant and associated animal species present on the specific sites and

2) vegetation community patterns within the landscape. To provide these two types of information, the development of a land cover map and a vegetation classification has been one of the efforts of the first year in producing the HMP.

The task to develop a land cover map has resulted in completion of three products. The first is the development of the land cover map from satelite imagery (Koch et al. 1996) and the second is to provide an accompanying vegetation classification describing the homogeneous components within the land cover map extent. The third product is completion of a checklist of plants that are found in these components in the Jemez Mountains (Foxx et al. 1996).

The purpose of this paper is to describe the land use history that influences distribution of plants, to lay out a tentative hierarchial classification of the vegetation in the region based on the New Mexico Natural Heritage Program (NMNHP) classification, and to present a Working Draft Key to the various Cover and Community Types of Los Alamos County and immediate surrounding area.

2.0 Background

Since the early 1970s, vegetation studies at LANL have generally been conducted on a site by site basis and associated with construction projects (see References 7.2). Other studies done for old field succession, fire ecology, habitat typing and wetland monitoring have added to our knowledge (Foxx and Tierney 1996, Foxx and Potter 1979, Barnes 1983, Foxx and Blea-Edeskuty 1995). These studies have resulted in compilation of a list of species that occur in the Jemez Mountains and on the Pajarito Plateau (Foxx and Tierney 1985). This checklist has been revised and is included in this notebook under Foxx et al. (1996). The revised checklist has also been placed in the Geographic Information System (GIS) Database developed by Bennett et al. (1996).

Although much work has been done to compile species lists and to acquire quantitative data on cover, density, and frequency, there has not been a systematic classification of the landscape components of the vegetation within Los Alamos County. However, classification of the landscape components has been accomplished for Bandelier National Monument (BNM) (Allen 1989), and Forest Service personnel have done habitat typing and vegetation classification in portions of the county within the Santa Fe National Forest (Moir and Ludwig 1979).

To understand the vegetation patterns on a landscape level, LANL has worked with Earth Data Analysis Center (EDAC) at the University of New Mexico (UNM) to develop a land cover map (Koch et al. 1996). To understand the elements of the land cover map and the landscape patterns as related to the surrounding area and the State of New Mexico, we have developed this preliminary vegetation classification for Los Alamos County and LANL.

For the mapping and classification, we have extended the boundaries beyond the Laboratory and are using five US Geological Survey 7.5-min. quadrangles (Guaje, Frijoles, White Rock, Puye, and Valle Toledo) as our mapping units. Several studies, such as monitoring elk movements, include areas of BNM, the Santa Fe National Forests, and the privately owned Baca Location. Therefore, a wider view of the area is pertinent. For most of our discussion related to vegetation classification, we will use the county boundaries as our extent. We believe this is necessary because of the following factors: 1) the tops of the Sierra de Los Valles are the watershed sources for the Laboratory and therefore influence the ecology of the Laboratory; 2) land ownership boundaries are artificial and are not barriers to animal and plant movement; and 3) the influence between the Laboratory and its surrounding area is a reciprocal relationship.

3.0 Description of the Area

3.1 Geographic Setting

LANL is situated in Los Alamos County in north-central New Mexico, approximately 100 km (60 miles) north-northeast of Albuquerque and 40 km (25 miles) northwest of Santa Fe (Figure 1). The county is approximately 283 km^2 (109 mi^2) and is situated in the Jemez Mountains. The western boundary encompasses some peaks of the Sierra de Los Valles, the mountainous rim of the Valles Caldera, and portions of the table-like extension on the eastern slopes, known as

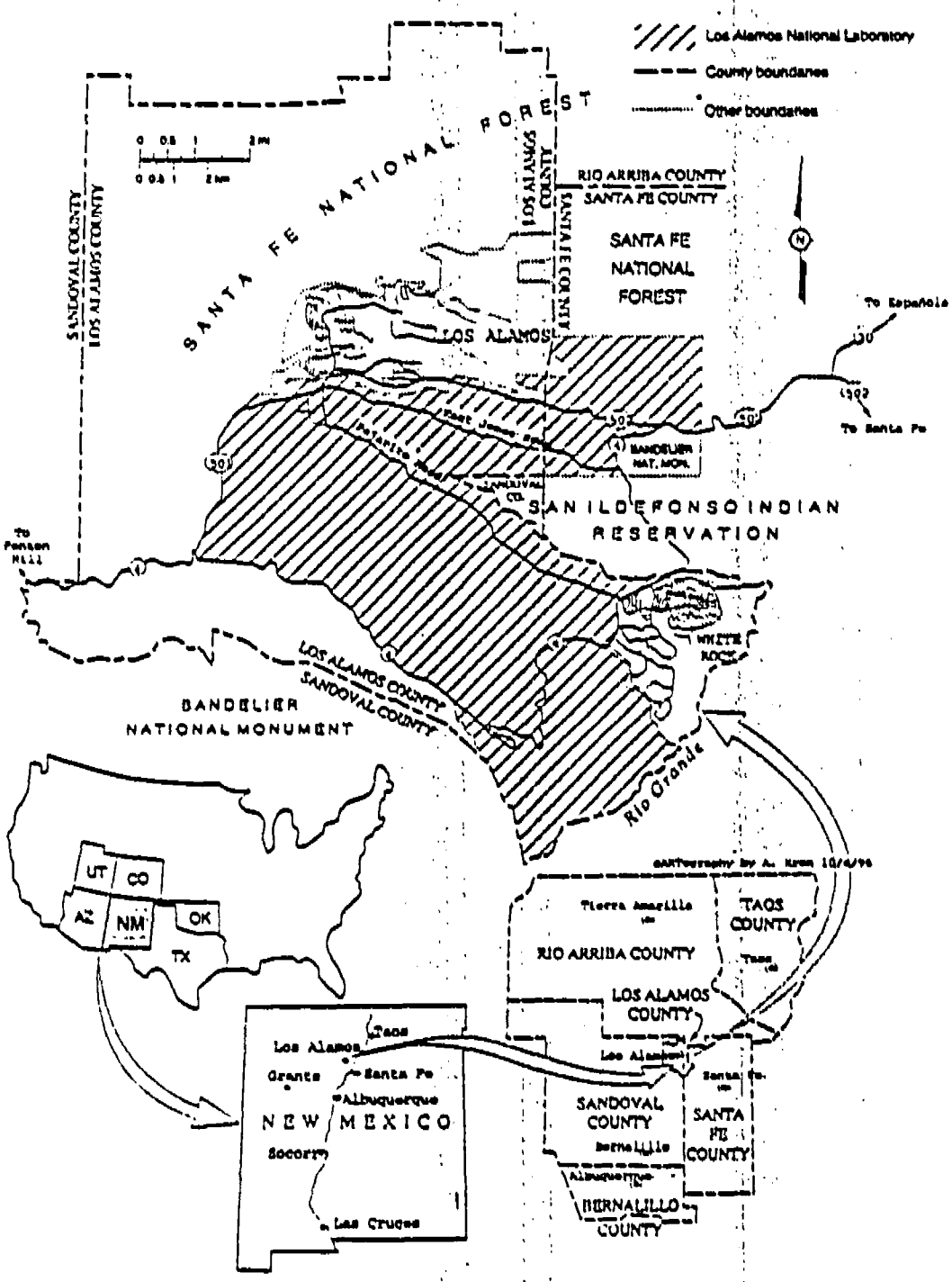


Figure 1. Location of Los Alamos National Laboratory.

the Pajarito Plateau. This plateau extends approximately 16 km (10 miles) from the base of the mountain slopes and ends at the Rio Grande. It is dissected by narrow precipitous canyons separated by finger-like mesas. LANL is located at the base of the Sierra de Los Valles and on portions of the plateau. It comprises 112 km^2 (43 mi^2) of the lands within the county. Because of the rugged topography, most of the facilities are confined to the mesa tops and concentrated in developed technical areas. The remoteness, the lack of development, and the rugged topography provide habitat for a variety of plant and animal species including species listed as endangered or threatened and species of concern under the Endangered Species Act.

Within Los Alamos County, land ownership includes LANL and the communities of Los Alamos and White Rock. Figure 2 shows the land ownership surrounding the Laboratory.

3.2 Geologic Setting

The Jemez Mountains are a remnant of a massive volcano that erupted 1.4 to 1.1 million years ago. Ash from the eruptions laid down 300 m (985 ft) of welded and nonwelded tuff on the eastern flanks. The rim of the collapsed volcano is called the Sierra de Los Valles. The rim has nine peaks including Cerro Grande, Pajarito Mountain, and Caballo Mountain. The tops of the mountains range from 2895 m (9500 ft) to over 3353 m (11,000 ft) in elevation. On the eastern flank of the mountains, an apron-like plateau, the Pajarito Plateau, is formed from a consolidated ash tuff (Burton 1982). Soils for the area have been classified by Nyhan (1979).

The plateau is dissected into canyons and mesas. Only the upper reaches of the canyons have permanent water sources. Below the Laboratory boundaries, the streams have only ephemeral water, flowing during spring snowmelt and during heavy rainstorms in the summer months. Springs and seeps can be found within the Laboratory boundaries and in White Rock Canyon. These water-rich areas, in an otherwise semiarid environment, often have a different and specific flora. Species such as helleborine orchid (*Epipactis gigantea*) are state SOC and others such as the cardinal lobelia (*Lobelia cardinalis*) are of local concern.

3.3 Climate

The area has a temperate mountain climate with four distinct seasons. Springs are dry and windy; summers, warm and often dry in June followed by a rainy season in July and August. July is the warmest month with an average daily high of 27.2 °C (81 °F) and an average daily low of 12.8 °C (55 °F). January is the coldest month with average temperature ranges of a daily high of 4.4 °C (40 °F) to a low of -8.3 °C (17 °F). There is solar heating during the day and rapid radiant cooling at night. The average annual preciptation is 17.6 cm (18.7 in.). Lower elevations near the Rio Grande receive 13 cm (5.1 in.) less and the higher elevations may receive 13 cm (5.1 in.) more. The peak rainfall months are July and August. Most of the winter precipitation falls as snow with an average of 150 cm (59 in.) (Bowen 1990, 1992)

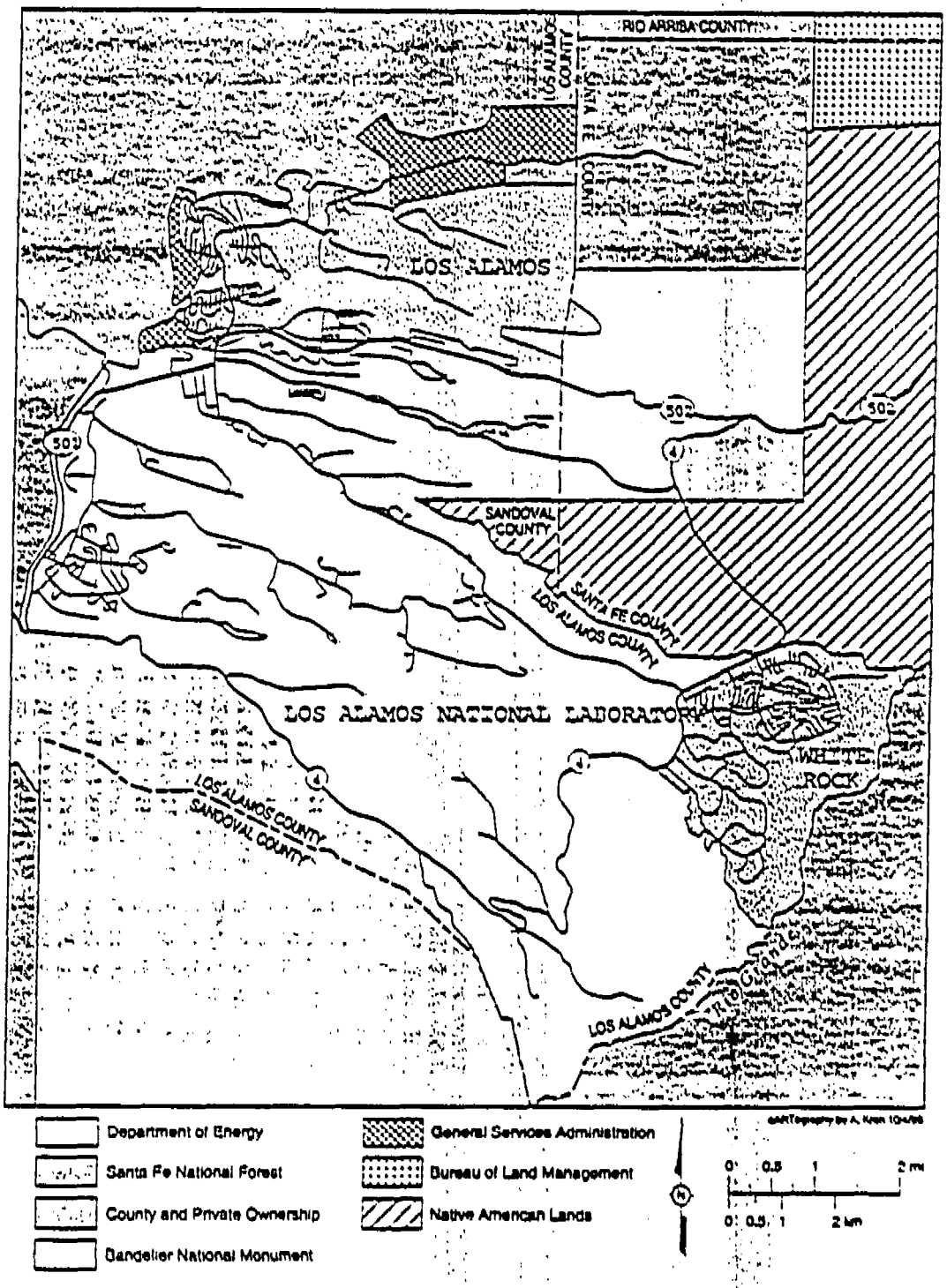


Figure 2. Landownership in the Los Alamos Area.

3.4 History of Land Use

To understand present vegetation patterns, it is important to understand the influence from past human activities. Certain plant species are characteristically found in areas of prehistoric disturbance that were introduced into the area as "camp followers" and are relics of manipulated native species or are part of an introduced ancient crop and weed complex (Yarnell 1958). Clearing areas for agriculture, by both prehistoric inhabitants and early homesteaders, has resulted in a system of abandoned agricultural fields dominated by disturbance species. (Foxx et. al, 1996). Extensive wildfires have turned many hectares of forested land into open grasslands or shrublands (Foxx and Potter 1979). Allen (1989) describes landscape changes throughout the Jemez from various forces, both man-caused and natural. He notes the changes to forests and woodlands brought by grazing, fire suppression, and insect outbreaks.

The history of the land use of the area is long and varied. Foxx and Tierney (1984) described the history of landuse of the Pajarito Plateau from prehistoric to historic times. Allen (1989) also studied the land use and landscape changes.

For our discussion we have divided the land-use changes and landscape modifications into four periods: prehistoric period from 1100 to 1598, the Spanish period from 1598 to1821, post-Spanish period from 1821 to 1940, and World War II (1940) to present. During each of these periods there have been unique influences on the vegetation patterns and the landscape.

3.4.1 Prehistoric Period (1100 to 1598)

According to the present archaeological record, northern New Mexico was inhabited by humans well before the Pajarito Plateau was first settled. After humans arrived in the region, at least several hundred years and several culture phases lapsed before the plateau region was occupied to any extent. Agriculture arrived about 1150 AD with the Pueblo III peoples and lasted until approximately 1500 AD. During this period there were extensive settlements and development of agricultural fields where corn, beans, and squash were grown. Today, remnants of these pueblos and garden plots are scattered throughout the region (Steen 1977, Lange 1959). Associated with these sites are often indicator species such as tomatillo (*Lycium pallidum*).

3.4.2 Spanish Period (1598 to 1821)

With the arrival of the Spanish in the mid-16th century came the introduction of domestic livestock. The impact of small subsistence farms from approximately 1742 through 1821 was primarily in sheep grazing and wood gathering. There is evidence from chronicles of the early explorers that the introduction of domestic livestock profoundly influenced the flora and ecology of the Southwest (Beck 1962, Carlson 1969, Grubbs 1958).

> *In records of his northern New Mexico travels of 1776, Dominguez, a Franciscan priest, mentions trading with Native Americans for several bushels of grass seed. (Chavez 1976).*

3.4.3 Post-Spanish Period (1821 to 1940)

Most of the Pajarito Plateau and the Jemez Mountains were not open to extensive European settlement until after 1821. Prior to that time the area contained only small herds of domestic stock and summer grazing. Two major factors opened the area up for settlement and use: 1) the coming of the narrow gauge railroad (the Chili Line) in 1879 and 2) the Homestead Act of 1882 (Gjevere 1978, Foxx and Tierney 1984).

The building of the railroad opened New Mexico to an influx of Easterners, provided a method of transportation to move goods such as livestock and lumber, and provided access to otherwise remote areas. With the development of the Chili line and the small town of Buckman on the Rio Grande, access roads were developed onto the Pajarito Plateau and large numbers of cattle were introduced into the area. From 1885 through 1887, the Ramon Vigil Grant (an area that basically corresponds to Laboratory lands), had over 3000 head of cattle on 32,000 acres.

The Los Alamos homestead era began in 1894 with the establishment of small subsistence farms, which grew beans, grain, and fruit under dry land conditions. The Alamo homestead was filed in 1911 by H. H. Brook. This homestead eventually reached the size of 2.5 km^2 (6.4 mi^2) and produced alfalfa, sorghum, wheat, and "trainloads" of pinto beans. By 1937, 35 farms occupied about 15 km^2 (38.9 mi^2) (Chambers 1974).

The logging industry clear-cut areas of the plateau during the early 1900s. In 1887 the owners of the Ramon Vigil Grant sold the timber rights to H. S. Buckman, who removed lumber from the area until 1903. A newspaper article of December 1903 speculated that Buckman cut 36,000,000 board feet on the 32,000 acre grant. Throughout the early 1900s and into the 1940s, areas adjacent to the Ramon Vigil Grant yielded 17,319,000 board feet of permitted saw log timber (Santa Fe New Mexican 1902).

Development of the plateau for recreation purposes began in 1914. Ashley Pond established the Los Alamos Ranch School in 1917. Areas such as Camp May were established as pack camps, and numerous trails were built for horseback riding (Chambers 1974).

3.4.4 World War II and Post World War II Period (1940 to Present)

Since 1942 the area known as LANL has been under Federal ownership. Since the Laboratory's establishment and the carving of Los Alamos County from Santa Fe and Sandoval Counties, the urban areas of Los Alamos and White Rock have developed. Allen (1989) estimated a 12-fold increase of roads in the Jemez Mountains from 1935 to 1981.

Other factors that have influenced vegetation patterns within the County are landscape changes due to wildfire and long-term fire suppression. Extensive wildfires have burned areas along the slopes of the Sierra de Los Valles and on the upper slopes of the plateau. In 1977, the La Mesa fire burned 6073 ha (15,000 acres) of BNM, Santa Fe National Forest, and LANL property.

Since LANL was removed from private ownership in the early 1940s, there has been little or no urban development, logging, or hunting on Laboratory lands. Essentially, much of the 43 mi^2 has become a natural reserve that supports many plant and animal species including 3 federally listed TES. Although the set-aside provides a unique diversity of plants and animals, active management of ungulate species, timber, and fire is important to sustaining these habitats over the long-term. The HMP is one step in the management of these resources.

3.4.5 Botanical History

Before the 20th century, the Pajarito Plateau and the east side of the Jemez Mountains were largely inaccessible to botanists. Early Spanish chronicler' accounts of the vegetation of the northern Rio Grande (Chavez 1976) seem to indicate that the native composition of the area was much the same as it is now, although the density of most of the species probably has changed greatly.

In 1841, the first trained naturalist entered New Mexico. William Gambel traveled to Santa Fe with a group of trappers and traders. Although he collected plants a few miles into the Santa Fe mountains, Gambel did not survey in the Jemez Mountains. After the American occupation in 1846, naturalists began to work in northern New Mexico. The first arrived with contingents of the US Army and others came later with the US Boundary Survey. Still, the Pajarito Plateau and Jemez Mountains were remote and not until the railroad came to the Rio Grande Valley in the early 1800s were plants collected there for scientific study. As far as we can determine, these first collections were made by Adolf Bandelier when he was living at Cochiti Pueblo. Bandelier's collections were shipped to Dr. George Engelmann, a physician-naturalist, in St. Louis, Missouri, for identification (Lange 1959). A number of plant names in the New Mexico flora have Gambel's or Engelmann's name attached to them.

The Jemez Range and Pajarito Plateau have seen many botanical collectors since the beginning of the 20th century. Among the earliest botanical explorers and authors of this century were E. O. Wooton and Paul Standley, authors of *A Flora of New Mexico* (1915). Later Howard Dittmer, Edward Castetter, and Ora M. Clark mention some plants from this area in their *The Fern and Fern Allies of New Mexico* (1954). Numerous specimens in the herbarium at Bandelier National Monument and the University of New Mexico were collected by Clark. Several students have written master's theses about the botany of our area, and have been mentioned earlier. The early collections and original data from more recent observations have been given in *Flora of New Mexico* by William C. Martin and Charles R. Hutchins (1980). These floristic studies have been summarized as a basic compilation of plant species that have been found in the Jemez Mountains (Foxx and Tierney 1985).

Only recently has there been classification of the landscape components. Other than Allen (1984, 1989), Barnes (1983), and Potter and Foxx (1981), few studies have been specific for the area. Barnes (1983) classified the habitat types in the pinon-juniper woodland of LANL and Bandelier National Monument. Allen (1984, 1989) conducted extensive

studies of the Jemez Mountains. Potter and Foxx (1981) mapped areas of the Cerro Grande. Most other studies are regional in nature. Moir and Ludwig (1979) classified the spruce-fir and mixed conifer habitat types of Arizona and New Mexico. Some of their work was done in the Espanola Ranger Distict of the Santa Fe National Forest.

On the state level, the New Mexico Natural Heritage Program (NMNHP) is engaged in development of a comprehensive classification of vegetation for the State of New Mexico. The purpose of their classification is for conserving and managing the states biological diversity (Muldavin 1994). The system used by the NMNHP incorporates the essential elements of the UNESCO framework with modifications for local characterization of ecosystem. Recently, the Federal Geographic Data Committee issued a standard for Vegetation Classification and Information. The overall objective of this standard was to support the production of uniform statistics on vegetation resources at the national level. The NMNHP can be cross-walked to all of these systems.

4.0 Methods

The proposed classification for LANL has been developed from a variety of sources. However, there are three informational sources that have been most important to the mapping and classification.

1) Previous surveys that have collected qualitative data as to species presence and absence.

2) Previous surveys that have been used to collect quantitative information using the standard vegetation measuring techniques.

3) Unsupervised classification of satellite imagery data for the land cover map (Koch et al. 1996).

4.1 Methods Used in Vegetation Surveys

At LANL, we have established 2 levels of surveys for project review: Level 1 and Level 2. One level is used to collect qualitative data and the other quantitative.

The Level 1 surveys are reconnaissance surveys. These are qualitative surveys that record observations and general species lists for the area. Most of the time the relative dominance of the species have been noted. Prior to the mid 1980s, a number of such surveys were conducted throughout the Laboratory. Generally, the dominant life forms (trees, shrubs, herbs, grasses) were identified by species and a percent cover of the dominant species noted. From species-specific data physiognomic attributes of the dominant vegetation (evergreen, deciduous) can be determined. Additional qualitative surveys were conducted to produce a land cover map (Koch et al. 1996).

Level 2 surveys are quantitative surveys using standard methods to determine vegetation cover, density, and frequency. Techniques have included line intercept methods and circular plots for the overstory component and Daubenmire plots for the understory.

Vegetation surveys have been conducted for Environmental Restoration Operable Units (ER-OU) using the line intercept techniques (Lindsey 1955, Woodin and Lindsey 1954) to measure the overstory components of coniferous forests. Researchers collected data

within 6-m- (20-ft-) wide strips centered on the transect line. Within the strip, the diameter breast heigh (DBH) of trees was measured and all shrub stems were counted. Data gathered included foliar cover, density (trees/acre), and frequency. From these data, an importance index was calculated.

Within the pinon-juniper and riparian areas, the circular plots technique was used to measure the overstory components. A 304.8-m (1000-ft) transect line was placed along the habitat that was to be evaluated. Three circular plots were established along the transect. Data was recorded for all trees within a 9.14-m (30-ft) radius of the center point. Data included species, height, crown diameter, condition, number of stems, diameter, and percent cover. All multistemmed species, such as pinon pine and juniper, were measured for basal diameter. All single-stemmed trees such as ponderosa pine were measured for DBH. Percentage cover for each species was determined by dividing the circle into four equal subplots (quarters) and estimating the cover within each of the subplots.

For the understory component of an area, the quadrat method with a Daubenmire plot of 20 x 50 cm (8 x 20 in.) (Daubenmire 1959) was used for measurement of cryptogamic and herbaceous vegetation, percentage of bare soil and litter, and shrubs with heights of less than 0.9 m (3 ft). We used visual estimates of foliar cover to determine percent cover and species composition, and read quadrats along the transect established for overstory evaluation at 3-m (10-ft) intervals. Quadrats were read until the number of species within the plots had not increased (the species area curve flattened) or a maximum of 100 quadrats had been read along a transect.

Figure 3 shows the locations for the quantitative surveys.

All plants were identified using Hitchcock (1950), Martin and Hutchins (1980), Foxx and Hoard (1984, 1995), Tierney and Foxx (1985), and Allred (1993). When necessary, voucher specimens were collected and archived in the herbarium at LANL. Any questionable identifications were confirmed at the University of New Mexico herbarium.

4.2 Methods Used in Development of Draft Terrestrial Classification

The development of a draft classification for LANL had four goals:

1) The classification must be applicable to habitat management.

2) The classification should be consistent with and complimentary to those used by organizations who have lands bordering LANL (e.g. US Forest Service, National Park Service).

3) The classification should be done by State and Federal standards.

4) The classification must represent what is currently present and not based on climax vegetation.

For these reasons, we decided to develop our classification based on the NMNHP system of hierarchical classification. This classification can be translated into the UNESCO system and the newly developed vegetation classification done by the Federal Geographic Data Committee (1996). This classification hierarchy draws upon the UNESCO Framework (Driscoll et al. 1984)

and other classifications from the Southwest including Donart, Sylvester, and Hickey (1978), Brown, Lowe, and Pace (1979), Dick-Peddie (1993) and many habitat type classifications produced by the Forest Service including Moir and Ludwig (1979), and Alexander et al. (1984, 1986). However, our classification is based on present vegetation not habitat types or climax vegetation.

Additionally, the advantage of the NMNHP system is that it has been developed in coordination with the New Mexico Gap Analysis Project and is specific for the ecosystems of the arid and semiarid Southwest. The hierarchical classification is as follows (Muldavin 1994):

I. Class — major physiognomic type (e.g., forest, grassland, etc.);
II. Subclass — moisture and temperature defined subformations;
III. Regional Biome — biogeographically related Series Groups;
IV. Cover Type Groups — sets of morphological, environmentally or floristically relatedcover types;
V. Major Cover Types — sets of Community Types related by at least a common dominant; more or less synonymous with Series without successional implications;
VI. Community Type — fundamental repeated assemblages of species; more or less synonymous with plant association without successional implications;
VII. Phase — floristic variants of Community Types—Typic Phase refers to the modal species composition of the Community Type.

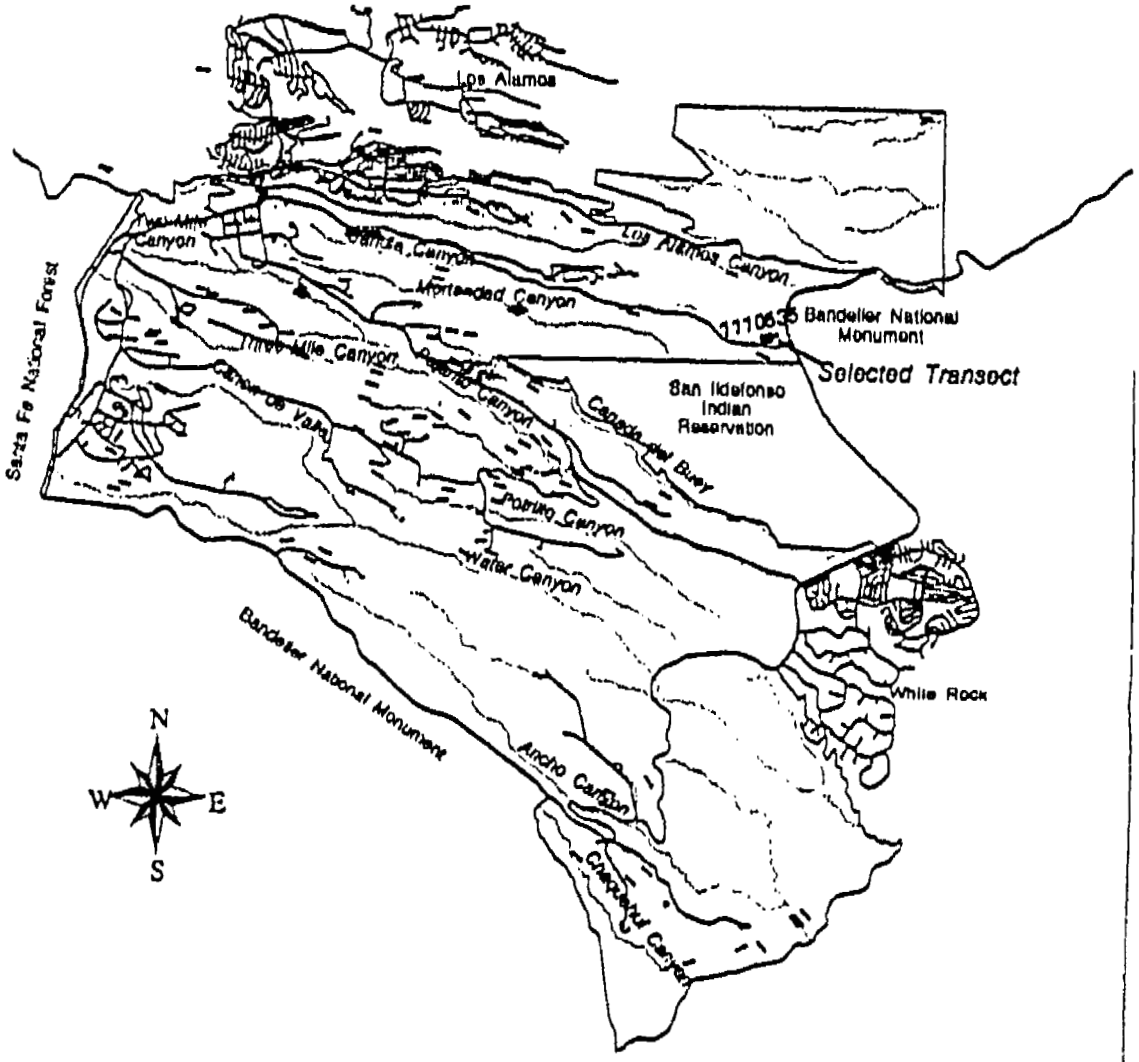
The upper 3 classifications are based on the physiognomic nature of the vegetation and the last two on the floristic nature. The upper 3 classifications are defined by temperature and moisture regimes. The lower levels of the classification are based on floristics. During FY96 we have concentrated on identifying the cover types and community types that are found on LANL and the surrounding area. The land cover map defines the cover types we identified from the spectral classes in satellite imagery. The Working Draft of "Keys to Major Land Cover Types in the LANL Vicinity" (Appendix A) defines the community types for the terrestrial ecosystems, provides a means of consistently identifying sites of human disturbance, and gives a preliminary classification for riparian/ wetland systems.

This Working Draft is to be used for guidance of major cover and community types within LANL and the surrounding areas. The keys were designed for homogenous areas of at least 0.405 ha (1 acre). These keys have been developed using information in Allen (1984), Moir and Ludwig (1979), USFW (1988), Muldavin (1994), and the survey data at Los Alamos. Selected quantitative survey data (104 plots), supervised and unsupervised classification data, and qualitative data were examined. Each plot was used to define the community types.

The draft classification contains 10 keys.

- Key A: Key A provides a guidance for classifying areas used for human purposes. Buildings, farms, parking lots, paved or dirt roads, utility corridors, or other man-made structures that are present or dominate the landscape can be classified using this key.

Map 1: Vegetation Transects



Legend

- Selected Transect
- Vegetation Transects
- LANL
- Paved Roads
- Drainages

1:72679

2 0 2 4 6 8 10 12 Kilometers

2 0 2 4 6 8 Miles

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BIOLOGY TEAM, HSH-20 ECOLOGY GROUP
PREPARED: SEPTEMBER, 1996

Figure 3. The locations of transects for the quantitative land cover surveys.

- Key B: Key B provides guidance to the classifying of land that is periodically flooded, supports facultative or obligate hydrophytic plants species, and is characterized by hydric soils. Key B incorporates the riparian/wetland classification (Cowardin 1979).

- Key C: Key C identifies areas that are rock outcrops, talus slopes, or other upland lithosolic areas that do not support vegetation.

- Keys D through J: All other keys are associated classifications of the terrestrial ecosystem on the floristic level including Cover Type and Community Type.

5.0 Results

5.1 Land Cover Classification and Mapping

Three products have contributed to the results presented in this paper. The first is the production of the land cover map (Koch et al. 1996). The second is the development of the preliminary vegetation classification reported in this paper. The third is the revised plant checklist for the Jemez Mountains by Foxx et al. (1996). The following is a detailed discussion of the preliminary classification. The land cover map and the checklist are discussed elsewhere.

5.2 Classification Description

The information in this section corresponds to the classification in Appendix A. There are three sections: Classification of areas of Land Used for Human Purposes which corresponds to Key A of the Working Draft Key, Riparian/Wetland System Classification which corresponds to Palustrine Systems in Muldavin (1994) and Key B of the Working Draft Key; and, Terrestrial System Classification of Vegetation which corresponds to Terrestrial System Classification in Muldavin (1994), the land cover map (Koch et al. 1996), and the Working Draft Keys C through J.

Below we have described each of these classifications.

5.2.1 Classification of Land Used for Human Purposes

To consistently define areas of human disturbance, Key A of the Working Draft has been developed. The land types include archaeological sites, buildings, farms, parking lots, paved and dirt roads, utility corridors, or other man-made structures.

Most of these areas of human disturbance can be pulled up as layers within the GIS ARC/INFO (e.g., road, utilities, residential). In some cases, they will be used to define habitats for TES. Areas of human disturbance generally will not support TES. However, some species such as the Goat Peak pika or bats may actually utilize areas that have undergone disturbance.

Roads: Roads are classified as paved, improved, and unimproved. Improved roads are generally gravel and are maintained by occassional blading. Unimproved roads are rarely bladed.

Utilities: These structures include pipelines, utility poles, and other structures used to supply gas, electricity, or water to facilities and homes. These structures can be aboveground or underground.

Abandoned farmlands: These are areas that have historically been used for agriculture. These areas usually have been cleared of the major cover type and are undergoing successional processes.

Waste ponds: These are water bodies associated with sanitary systems and collection of effluents. They are cement lined.

Industrial facilities: These are facilities within the Laboratory boundaries and are used for research or other activities.

Commercial areas: These are offices, restaurants, and other buildings used for commercial purposes.

Residential areas: These areas are homes, schools, and other buildings.

Archaeological/cultural sites: These areas were used for habitation, farming, ceremonial, or hunting by early residents of the Pajarito Plateau. Cultural sites can include homesteading and World War II sites. These sites are generally protected under the Historic Preservation Act.

5.2.2 Riparian and Wetland Systems

Riparian/Wetland ecosystems are directly associated with wetlands adjacent to rivers (riverine), riverbanks (palustrine) or lakes (lacustrine), e.g., mashes, bogs, and riverbank areas. These systems occur primarily in the canyon bottoms of the Pajarito Plateau and along the banks of the Rio Grande. The riparian/wetland ecosystems of the Plateau include springs, riverbanks, streambanks, outfalls, and marshes.

This classification corresponds to the information in Key B in the Working Draft Key (Appendix A). This key is very tentative and will need further refinement in FY97.

In 1990, the USFW classified the area in accordance with the National Wetlands Inventory 4. This mapping was based upon "The National Wetlands Inventory Classification of Wetlands and Deepwater Habitats of the United States," by Cowardin et al. (1979). The purpose of this inventory was to delineate and identify wetland. The classification was done primarily with infrared aerial photographs. In 1993 to 1995, wetland areas not identified by this survey (outfalls, springs, and small pools) were incorporated into maps by K. Bennett in the Ecology Group, ESH-20. The maps reside in ARC/INFO.

Using information from previous quantitative surveys done at the Laboratory, we have determined only a few riparian and wetland Cover and Community Types. Because of the narrowness of the canyons, spectral identification of the riparian zone was not possible. Therefore, this system will be separately classified. No map layer presently exists.

5.2.2.1 Characterization of Riparian Forests and Shrub Wetlands

From previous surveys, we have determined that Riparian Forest and Shrub Wetlands and Emergent Wetlands Classes are present within Los Alamos County (see References 8.2). For example, Foxx and Tierney (1980, 1984) surveyed Pajarito, Mortandad, Effluent, and Water Canyons. Foxx (1996) tested areas in Ancho and

Chaquehi Canyons for hydric soils and found hydrophytes made up 87.6% of the relative cover. The Riparian Forest and Shrub Wetlands are primarily in the canyons, along ephemeral streams. Emergent wetlands are in areas where canyon bottoms have been dredged, associated with outfalls, or natural springs

Riparian Forest and Shrub Wetlands are characterized by vegetation directly dependent on either ground water and/or flooding. The broadleaf forests are dominated by narrowleaf cottonwood (*Populus angustifolia*), boxelder (*Acer negundo*), alder (*Alnus oblogifolia, A. tenuifolia*). Evergreen forests include ponderosa pine (*Pinus ponderosa*), white fir (*Abies concolor*), and Douglas fir (*Psuedotsuga menziesii*).

5.2.2.2 Characterization of Emergent Wetlands

Emergent wetlands are dominated by herbaceous species, mostly grass-like species. These cover types may be characterized by cattail (*Typha latifolia*), rush (*Juncus* spp.), or other facultative or obligatory wetland species. Wetlands in Pajarito Canyon have been monitored for 6 years for changes in the species diversity. Other emergent wetlands have been found around outfalls (Foxx and Blea-Edeskuty 1995).

Below we describe some of the species found within the riparian and wetland habitats of these canyons.

Foxx and Tierney (1980, 1984) found understory species in the streamside habitats included Arizona valerian (*Valeriana arizonica*), black-eyed Susan (*Rudbeckia hirta*), cutleaf coneflower (*Rudbeckia laciniata*), western bracken fern (*Pteridium aquilinum*), and Canadian violet (*Viola canadensis*). Common grasses are melic grass (*Melica porteri*) and interior bluegrass (*Poa interior*). They also found a rare larkspur violet (*Viola pedadifida*) within the streamside and moist meadow areas.

Within Guaje and Los Alamos Canyon Banar (1995) found thinleaf alder (*Alnus tenuifolia*), Rocky Mountain maple (*Acer glabrum*), white fir, aspen (*Populus tremuloides*), Douglas fir, limber pine (*Pinus flexilis*), Engelmann spruce (*Picea engelmanni*), and water birch (*Betula occidentalis*). Shrub species in the understory included Gambel oak (*Quercus gambelii*), raspberry (*Rubus strigosus*), wild rose (*Rosa woodsii*), New Mexico locust (*Robinia neomexicana*), gooseberry (*Ribes inerme*)), serviceberry (*Amelanchier utahensis*), and cliffbush (*Jamesia americana*). Common understory species were Richardson's geranium (*Geranium richardsonii*), cutleaf coneflower, and meadow horsetail (*Equisetum arvense*).

Foxx and Tierney (1984) and Foxx (1996) did surveys along the Rio Grande. Within the County and LANL the riparian vegetation has been destroyed by the rising and falling of the backwaters of Cochiti Reservoir. A few netleaf hackberry (*Celtis reticulata*), one-seed juniper (*Juniperus monosperma*), tamarisk (*Tamarix pentandra*), and Russian olive (*Elaeagnus angustifolia*) are found at the edges of the maximum floodpool. Generally only weedy species such as Russian thistle (*Salsola kali*), cocklebur (*Xanthium strumarium*), field sandbur (*Cenchrus pauciflorus*), and summer cypress (*Kochia scoparia*) are found below the maximum floodpool.

Studies have shown that the following species generally occur in the Graminoid Wetlands of the area (Foxx and Tierney 1984, Banar 1995, and Foxx unpublished information). Common species of these wetlands include interior rush *(Juncus interior)* and cattail.

5.2.3 Unvegetated Lands

This information corresponds to Key C of the "Working Draft." Unvegetated lands are primarily associated with rock outcrops, talus slopes, and other upland lithosolic areas that cannot support vegetation. These include cliffs and outcrops of basalt or tuffaceous materials that impart many of the scenic splendors to the Los Alamos region. They also include felsenmeers and talus slopes.

Each of these classes represent specialty habitats to many of our threatened and endangered species and other species of concern, such as the American peregrine falcon, the Goat Peak pika, and the Jemez Mountains salamander.

5.2.4 Terrestrial Systems

Terrestrial systems are not directly associated with river channels (riverine), riverbanks (riparian), or lakes (lacustrine), e.g., marshes, bogs and riverbank areas, commonly referred to as riparian/wetlands. Nor are they heavily influenced by past or present human activity.

Keys D through J in the Working Draft Keys (Appendix A) are associated with the Cover and Community Type classification of the terrestrial systems.

Koch et al. (1996) found that the Forest and Woodland Classes were classified with the greatest accuracy from the supervised and unsupervised classifications of the spectral classes from satellite imagery. He found that the Shrubland and Grassland Classes were the least accurately identified. We believe further study will be required to adequately define the Shrubland and Grassland Cover and Community Types. Below we describe the classification for the Terrestrial Systems.

5.2.4.1 Hierarchical Classification for Terrestrial Forests

On the Pajarito Plateau, within the Sierra de Los Valles, and within the boundaries of LANL, terrestrial ecosystems are represented by forests, woodlands, shrublands, and grasslands. These are cold temperate forests and woodlands. Table 1 provides an outline of the hierarchical classification for the Forest Class after Muldavin (1994). Below we describe each element of the Forest Class we have defined for Los Alamos County.

Table 1. Hierarchical Classification for Terrestrial Forests.

I. Forest Class
II. Cold Temperate Forest Sub-Class
III. Rocky Mountain Subalpine Forest Regional Biome
IV. Subalpine Conifer Forest Cover Type Class
V. Cover Classes
Engelmann spruce (*Picea engelmannii*)
Subalpine fir (*Abies lasiocarpa*)

IV. Subalpine Broadleaf Forest
  V. Cover Class
    Aspen (*Populus tremuloides*)
III. Rocky Mountain Montane Forest
IV. Rocky Mountain Upper Montane Conifer Forest
  V. Cover Class
    Douglas fir (*Pseudotsuga menziesii*)
    White fir (*Abies concolor*)
IV. Rocky Mountain Lower Montane Conifer Forest
  V. Cover Class
    Ponderosa pine (*Pinus ponderosa*)

I. Forest Class

The forests of the region can be placed in the Rocky Mountain Montane Forest regional biome. These are forests of mid-elevations dominated by cold-tolerant species associated with the Rocky Mountain biogeographic province.

There are two major Cover Type Groups represented: The Rocky Mountain Upper Montane Conifer Forest and the Rocky Mountain Lower Montane Conifer Forests.

The Rocky Mountain Lower Montane Conifer Forest is dominated by rounded-crown conifers which form open to closed canopies. This Group is represented by the ponderosa pine Cover Type. Sometimes low-statured conifers such as pinon pine (*Pinus edulis*) and junipers and broad leaf shrubs or trees of Gambel oak can be found in the subcanopy.

II. Cold Temperate Forest Sub-Class

Forest of mid-elevations dominated by cold-tolerant species.

III. Rocky Mountain Montane Forests Regional Biome

Forests of mid-elevations dominated by cold-tolerant species associated with the Rocky Mountain biogeographic province.

IV. Rocky Mountain Upper Mountain Conifer Forests Cover Type Group

The Rocky Mountain Upper Montane Conifer Forests are dominated by conical crowned conifers which generally form closed canopies (occasional open canopies do occur). The major cover types within our area are Douglas fir and white fir. For the land cover map, we have called the varying mixtures of these cover types as a Mixed Conifer and have further classified them into various community types in our Working Draft Land cover key (Appendix A).

V. Mixed Conifer Cover Type

Mixed Conifer Cover Type comprises approximately 6449 ha (15, 924 acres) of Los Alamos County. The cover type primarily occurs at elevations of 2438 to 2896 m (8000 to 9500 ft). Within the Laboratory boundaries there are 31.8 ha (759 acres) most of which are along the stream channels within the canyons and along the north facing slopes of the upper canyons. Figure 4 is an example of the Mixed Conifer Cover Type.

This cover type is generally found on steep and rocky terrain. At these elevations, mean annual precipitation is 50.8 cm (20 in.), although, in favorable years, it may exceed 88.9 cm (35 in.) according to Tuan et al. (1973).

Within this cover type we have identified nine different community types. They include three Douglas fir, one Engelmann spruce, and three white fir dominated types.

Douglas fir types
Pseudotsuga menziesii/Populus tremuloides
Pseudotsuga menziesii/Quercus gambelii
Pseudotsuga menziesii/Muhlenbergia montana

Engelmann spruce types
Picea engelmanii/Populus tremuloides

White fir types
Abies concolor/Populus tremuloides
Abies concolor/Robinia neomexicana
Abies concolor/Quercus gambelii.

The mixed conifer forests within the county have been logged or burned. There is evidence of fire in the late 1800s and early 1900s (Allen 1989). A fire in 1954 on the eastern slopes of the Sierra de Los Valles was within both Ponderosa Pine and Mixed Conifer Cover Types. Allen (1989) found that the higher elevation mixed conifers on north-facing slopes have a 15 to 25 year surface fire regime, with patchy crown fires. South-facing slopes have a 10 to 8 year interval. The highest fire frequencies are 5 years with return intervals of 5 to 25 years.

Figure 4. An example of Mixed Conifer Cover Type.

Logging has been conducted within the Santa Fe National Forest during the Buckman era and also within the last 20 years. Pajarito Mountain Ski area was begun in 1957 and since that time has extended across the northern-facing slopes of the mountain in this cover type.

The following trees, shrubs, herbs, and grasses are found in this cover type.

Trees: Ponderosa pine, Douglas fir, limber pine, and white fir.

Shrubs: Common shrubs are ninebark (*Physocarpus monogynus*), wild rose, Gambel oak and cliff bush. Other shrubs include Utah serviceberry, bearberry (*Berberis repens*), red-osier dogwood (*Cornus stolonifera*), ocean spray (*Holodiscus dumosus*), inkberry (*Lonicera involucrata*), mock-orange (*Philadelphus microphyllus*), and western black chockcherry (*Prunus virginiana* var. *melanocarpa*).

Grasses and grass-like plants: western wheatgrass (*Agropyron smithii*), bearded wheatgrass (*A. subsecundum*), slender wheatgrass (A. *trachycaulum*), redtop (*Agrostis alba*), pine dropseed (*Blepharoneuron tricholepsis*), Arizona fescue (*Festuca arizonica*), sheep fescue (*F. ovina*), thurber fescue (*F. thurberi*), June grass (*Koeleria cristata*), common timothy (*Phleum pratense*), and inland bluegrass (*Poa interior*).

V. Aspen Cover Type

The Aspen Cover Type makes up approximately 459 ha (1, 134 acres) of Los Alamos County. Within the Laboratory boundaries there are only 7.2 ha (18 acres). Figure 5 is an example of the Aspen Cover Type.

At the higher elevations within the county, aspen is interspersed within the mixed conifer. At lower elevations, within Laboratory boundaries, it is found in the upper canyons, primarily where areas were burned by the 1977 La Mesa fire.

Aspen is considered a fire dependent species and is indicative of previous fire regimes within the mixed conifer type. Allen (1989) found aspen groves bordering the montane grasslands of the upper peaks of the Sierra de Los Valles. He found that the groves consisted of clones of large extent, covering several hectares. Many of the older decadent trees were found to be 80 to 120 years old. He also found damage from deer and elk browsing. In some stands Engelmann spruce was becoming dominant and in others white fir. On Cerro Grande, Allen (1984) found aspen regeneration within a single clone dated to 1847, 1908, and 1941. Aspen invades areas of disturbance such as along the slopes of the ski hill (Foxx and Tierney 1985).

We have identified three different Aspen Community Types. They include

Populus tremuloides/Athryrium filix-femina
Populus tremuloides/Bromus marginatus, and
Populus tremuloides/Bromus ciliatus.

Allen (1989) identified the soils beneath the aspens as thick mollisols.

Figure 5. An example of Aspen Cover Type.

IV. Rocky Mountain Lower Montane Conifer Forest Cover Type Group

The Rocky Mountain Lower Montane Conifer Forest is dominated by rounded-crown confiers which form open to closed canopies. This series group is represented by the Ponderosa Pine Cover Type. Sometimes low-statured conifers such as pinon pine and junipers and broad leaf shrubs or trees of Gambel oak can be found in the subcanopy.

V. Ponderosa Pine Cover Type

The Ponderosa Pine Cover Type comprises approximately 8,783 ha (21,693 acres) of Los Alamos County. This cover type is found primarly in elevational zones of 2134 to 2438 m (7000 to 8000 ft). Narrow bands of ponderosa-dominated areas are found in many canyon bottoms to 1981 m (6500 ft). Below 1981 m (6500 ft) scattered pines can be found in canyons to the Rio Grande at 1646 m (5400 ft).

Figure 6 is an example of the Ponderosa Pine Cover Type.

Within the Ponderosa Pine Cover Type we have identified 5 community types. They include

Pinus ponderosa/Quercus gambelii
Pinus ponderosa/Quercus undulata
Pinus ponderosa/Blephoneuron tricholepis
Pinus ponderosa/Bouteloua gracilis and
Pinus ponderosa/Muhlenbergia montana..

The ponderosa pine forest of the Pajarito Plateau and the Sierra de Los Valles has been influenced by factors of logging in the early 1900s, homesteading in the late 1800s, grazing from the 1600s to the 1940s, and development of Laboratory facilities.

Within the Laboratory boundaries, the Ponderosa Pine Cover Type was logged in the early 1900s and since the 1940s has had little or no timber management. Much of the lumbering activity by H. H. Buckman in the early 1900s was within the Laboratory boundaries. The presence of stumps, cleared areas, and the remnants of a sawmill, called the Phillips Mill, are all indicative of the lumbering activities.

Several large homesteads were established in the Ponderosa Pine Cover Type in the late 1800s. The Homestead Act of 1862 granted quarter sections of land to any bonafide settler who had occupied a site for 5 years. On the Laboratory, homesteads were most important after 1894. Homesteads claimed earlier in the 1800s were used mainly as summer grazing areas. Development of these homesteads required cutting trees and developing agriculture fields where they grew beans and hay. At the time the area was purchased for the Manhattan Project, the owners were forced to abandon these homesteads. These old fields have been invaded by ponderosa pine (Foxx and Tierney 1996) and are a plant community association within the Ponderosa Pine Cover Type.

Figure 6. An example of the Ponderosa Pine Cover Type.

Some portions of the Ponderosa Pine Cover Type were burned in the 1977 La Mesa fire. Much of that area is now a shrub/grassland cover type. However, small portions along State Route 502 were replanted in 2-year-old ponderosa pine stock.

The following shrubs, herbs, grasses, and grass-like plants characterize this cover type:

Shrubs: Bearberry (*Arctostaphylos uva-ursi*), buckbrush (*Ceanothus fendleri*), Colorado barberry (*Berberis fendleri*), and Gambel oak.

Herbs: Yarrow (*Achillea lanulosa*), Rocky Mountain nodding onion (*Allium cernuum*), pussytoes (*Antennaria parvifolia*), spreading dogbane (*Apocynum androsaemifolium*), wormwood (*Artemisia ludoviciana*), yellow ragweed (*Bahia dissecta*), Indian paintbrush (*Castilleja integra*), golden aster (*Chrysopsis villosa*), wavyleaf thistle (*Cirsium undulata*), and dayflower (*Commelina dianthifolia*).

Grasses and grasslike-plants: Slender wheatgrass, western wheatgrass, redtop, little bluestem (*Schizachyrium scoparium*), big bluestem (*A. gerardii*), blue grama (*Bouteloua gracilis*), yellow nutsedge (*Cyperus esculentus*), Junegrass, mountain muhly (*Muhlenbergia montana*), and Indian grass (*Sorghastrum nutans*).

Inclusions within the Ponderosa pine cover type include abandoned agricultural fields. Some plants typical of these grasslands are Harvard three-awn (*Aristida barbata*), wormwood (*Artemisia carruthii*), false tarragon (*Artemisia dracunculus*), yellow ragweed, golden aster, Bigelow rabbitbrush (*Chrysothamnus nauseosus* subs. *bigelovii*), Bermuda grass (*Cynodon dactylon*), trailing fleabane (*Erigeron flagellaris*), and evening-primrose (*Oenothera coronopifolia*).

5.2.4.2 Hierarchical Classification for Terrestrial Woodlands

The woodlands of the Pajarito Plateau are generally at elevations lower than 2100 m (7000 ft). The mesas near White Rock and Pajarito Acres are covered with pinon and juniper. Table 2 provides an outline of the hierarchical classification for terrestrial woodlands (Muldavin 1994). Below we describe each element of the Woodland Classes identified in Los Alamos County.

Table 2: Hierarchical Classification of Woodland Class (Muldavin 1994).

I. Woodland
II. Cold Temperate Woodland
III. Rocky Mountain/Great Basin Lower Montane—Foothill Woodland
IV. Rocky Mountain/Great Basin Closed Conifer Woodland
Pinon pine (*Pinus edulis*)
IV. Rocky Mountain/Great Basin Open Conifer Woodland (Savannah)
One-seed Juniper (*Juniperus monosperma*)

I. Woodland Class

Woodlands are characterized by trees less than 10 m (33 ft) tall, usually forming moderately closed to very open canopies (less than 60% canopy cover). This class may include some closed-canopied woodland types (greater than 60% canopy cover), but the tree species are low in stature (pgymy conifers such as pinon pine). The class excludes open-canopied vegetation dominated by species that are generally considered tall statured (for example, ponderosa pine forest).

The woodlands of the Plateau are considered Cold Temperate Woodlands. In our area the Rocky Mountain/Great Basin Lower Montane woods are associated with the Rocky Mountain biogeographic province. These woodlands are generally dominated by moderately cold-tolerant, drought-tolerant, evergreen needle-leaved conifer species.

There are two cover type groups that can be found in the area: Rocky Mountain/Great Basin Closed Conifer woodlands and Rocky Mountain/Great Basin Open Conifer Woodlands (Savannah).

II. Cold Temperate Woodland

Woodlands of mid and upper elevations of mountainous regions dominated by cold to very cold winters and generally cool to mildly warm summers.

III. Rocky Mountain/Great Basin Lower Montane Foothill Woodland

These woodlands exist in lower elevations of mountainous and hill regions primarily associated with Rocky Mountain biogeographic provice, but with some important elements from the Great Basin province. These woodlands generally are dominated by moderately cold-tolerant and drought-tolerant evergreen needle-leaved conifer species.

IV. Rocky Mountain/Great Basin Closed Conifer Woodland Cover Type Group

These woodlands are dominated by rounded-crown, low-statured conifers that form moderately closed to moderately open canopies (>60% canopy cover). The major cover type is pinon pine. One-seed juniper is a common canopy associate. Oaks such as Gambel oak, wavyleaf oak (*Q. undulata*), and gray oak (*Q. grisea*), or other shrubs such as mountain mahogany (*Cercocarpus montana*) and big sagebrush (*Artemisia tridentata*) are common. Common grasses are blue grama.

V. Pinon-Juniper Woodland Cover Type

The Pinon-Juniper Woodland Cover Type comprises 3,553 ha (8,776 acres) of Los Alamos County. The lower elevations of the LANL are dominated by this cover type with a total 2704 ha (6,762 acres). Figure 7 is an example of the Pinon-Juniper Woodland Cover Type.

Within this cover type we have identified seven community type associations. They include

Pinus edulis-Juniperus monosperma/ Chrysothamnus nauseosus, Fallugia paradoxa,
Pinus edulis-Junipers monosperma/ Cercocarpus montana,
Pinus edulis-Juniperus monosperma/ Artemisia tridentata,
Pinus edulis-Juniperus monosperma/ Bouteloua gracilis,
Pinus edulis-Juniperus monosperma/ Muhlenbergia montanus
Pinus edulis-Juniperus monosperma/ S. scropulorum and
Pinus edulis-Juniperus monosperma/bare.

Figure 7. An example of the Pinon-Juniper Woodland Cover Type.

These woodlands were influenced primarily by grazing and homesteading activities until 1942 when they were purchased for the Manhattan Project. Since that time there has been no logging, little influence from fire, and only small areas urbanized.

IV. Rocky Mountain/Great Basin Open Conifer Woodland (Savanna) Cover Type Group

These woodlands are dominated by rounded-crown, low-statured conifers that form moderately oepn to very open canopies (25% to 50% canopy cover). This type group can include very open canopied stand (10% to 25%) in the broad ecotone to grassland commonly referred to as savanna. Major cover types are one-seed juniper. The undergrowth is predominantly grass and dominated by warm season grasses such as blue grama. Shrub species such as wavyleaf oak, snakeweed (*Gutierrezia sarothrae*), big sage, and rabbitbrush (*Chrysothamnus nauseosus*) are well represented.

V. Juniper Woodlands Cover Type

The Juniper Woodland Cover Type is dominated by one-seed juniper. In the draft map we have not pulled-out this cover type, although from experience we know it exists and is primarly at the lower elevations below the scarp of White Rock Canyon at elevations from 1620 m to 1950 m (5400 ft to 6500 ft). During the next iteration of the map, we expect to have pulled this cover type out, probably primarily from the grassland cover type.

From previous survey data and data collected by Barnes, we have identified the following community type associations:

Juniperus monosperma/basalt scarp
Juniperus monosperma/tuff scarp
Juniperus monosperma/Chrysothamnus nauseosus-Fallugia paradoxa
Juniperus monopserma/Quercus undulata
Juniperus monosperma/Artemisia tridentata
Juniperus monosperma/Bouteloua curtipendula
Juniperus monosperma/Bouteloua eriopoda
Juniperus monosperma/Bouteloua gracilis.

This cover type is often found in relatively undisturbed locations, along the slopes of White Rock Canyon. Interspersed within this type are springs that provide ribbons of riparian vegetation. Much of the area was used prehistorically and has an abundance of petroglyphs (Lilienthal and Hoard 1995).

The following trees and shrubs have been found in this community (Foxx and Tierney 1984).

Trees and shrubs: Bigelow sage (*Artemisia bigelovii*),wormwood, sand sagebrush (*Artemisia filifolia*), fringed sagebrush (*A. frigida*), big sagbrush, fourwinged saltbush (*Atriplex canescens*), mountain mahogany, rabbitbrush, sticky rabbitbrush (*C. viscidiflorus*), green jointed-fir (*Ephedra viridis*), winterfat (*Eurotia lanata*), Apache plume (*Fallugia paradoxa*), cliff fendlerbush (*Fendlera rupicola*), wavyleaf oak, and skunkbush (*Rhus trilobata*), wax currant (*Ribes cereum*), New Mexico locust, wild rose.

Grasses and graminoids: A number of grass species have been identified from the slopes of White Rock Canyon including little bluestem, side-oats grama (*Bouteloua curtipendula*), black grama (*B. eriopoda*), blue grama, hairy grama (*B. hirsuta*), galleta (*Hilaria jamesii*), ring muhly (*Muhlenbergia torreyi*), false buffalo-grass (*Munroa squarrosa*), Indian rice-grass (*Oryzopsis hymenoides*), muttongrass (*Poa fendleriana*), inland bluegrass, spike dropseed (*Sporobolus contractus*), sand dropseed (S. *cryptandrus*), and needle-and-thread grass (*Stipa comata*).

Forbs: A variety of forbs have been identified including the plains blackfoot (*Melampodium leucanthum*), sego lily (*Calochortus nuttallii*), buffalo gourd (*Cucurbita foetidissima*), lark spur (*Delphinium virescens*), and Wright's verbena (*Verbena wrightii*).

Within the cover type there have been identified (Foxx and Tierney 1984) microhabitats, such as the talus-slopes, that support characteristic vegetation. This habitat is found in shallow sandy soils between piles of basalt rubble on steep slopes. The lip-fern (*Cheilanthus* sp.), cliff-brake fern (*Pellaea limitanea*), and the fringed sagebrush are common at the base of the cliffs. These rocky patches also support narrow leaf hoptree (*Ptelea trifoliata* subsp. *angustifolia*) and cliff fendlerbush (*Fendlera rupicola*). Within these talus slopes the *Oreohelix* spp. snail is found.

5.2.4.3 Hierarchical Classification of Shrubland Class.

The Shrubland Class was not well identified in the land cover map produced in FY96. Further accuracy assessments will be required to further define the large area we call grass/shrub/savannah.

Key I of the Working Draft Key (Appendix A) relates to the present information available on shrublands within the county.

In this section, we only describe the definitions of the shrubland and some of the elements of the shrublands, we believe occur on the Pajarito Plateau. Table 3 shows the hierarchical classification for shrubs developed by Muldavin for the State.

Table 3: Hierarchical Classification of Shrublands (Muldavin 1994).

I. Shrubland
II. Mesophytic Shrubland Sub-Class
III. Rocky Mountain Montane Shrub and Interior Chaparral Regional Biome
IV. Rocky Mountain Deciduous Scrub Cover Class Group
IV. Broadleaf Evergreen Interior Chaparral Cover Class Group
III. Plains-Mesa Sand Scrub Regional Biome
IV. Plains-Mesa Broadleaf Sand-Shrub Cover Type Group
II. Xerophytic Shrubland Regional Biome
III. Great Basin Desert Shrub
IV. Great Basin Microphyllous Desert Shrub Cover Class Group
IV. Great Basin Droadleaf Deciduous Desert Shrub Cover Class Group

I. Shrubland Class

Shrublands are dominated by shrubs 0.5 to 5 m (1.5 to15 ft) tall, forming canopies greater than 25%.

The shrublands within the area are within the Mesophytic or Xerophytic Shrublands subclasses. These shrublands are primarily dominated by moderately to very cold tolerant shrubs and moderately to very drought tolerant species including Gambel oak, mountain mahogany, and wavyleaf oak. Within the Mesophytic Shrubland subclass, the Rocky Mountain Montane Deciduous Scrub is the only cover type identified in this region. Xerophytic shrublands have two cover type groups applicable to the Plateau: The Great Basin Microphyllous Desert Shrub and the Great Basins Broadleaf Deciduous Desert Shrub.

II. Mesophytic Shrubland Sub-Class

We believe the Rocky Mountain Montane Deciduous Shrubs Cover Type groups are found in some of the burned areas and are primarly dominated by Gambel oak. More study will be required to better refine the cover type and/or inclusions of this type into the Ponderosa Pine and Pinon-Juniper Cover Types.

II. Xerophytic Shrubland Sub-Class

Xerophytic Shrublands are dominanted by very drought tolerant species. These species are generally found at lower elevations of the Plateau.

Xerophytic Shrublands are represented by Great Basin Desert Shrub Cover Type Group. Within that cover type group some Great Basin Microphyllous Desert Scrub cover types are found in the lower elevations near the community of White Rock and within White Rock Canyon. These shrubby areas are dominated by big sagebrush.

In general, shrublands within Los Alamos County and LANL are small and result from disturbance. In most cases they will be termed inclusions within the larger cover type (Pinon-Juniper or Juniper Woodlands). These shrubland inclusions may have resulted from disturbances such as fire, cultural and historic sites, and mechanical disturbances such as road building. Figure 8 shows a typical shrubland resulting from a wildfire.

We believe many of the shrubland types will be inclusions within the Forest or Woodland Cover Types. Additional study will be required to better define this class within the County.

5. 2. 4. 4 Hierarchical Classification of Grassland Class

Koch et al. (1996) found that the Grassland Class was not accurately identified from the satellite imagery. Additional field surveys are needed to better define the Cover and Community Types.

The information presently available has been incorporated into Key J of the Working Draft (Appendix A).

Figure 8. An example of typical shrubland resulting from a wildfire.

Table 4 shows the hiearchial classification for grasslands for the State of New Mexico (Muldavin 1994). Below we discuss elements of this grassland classification that appears to occur on the Pajarito Plateau. In FY97 we will further define the Grassland Class for the County of Los Alamos.

Table 4: Hiearchical Classification of Grasslands (Muldavin 1994).

I. Grassland
II. Mesophytic Grassland Subclass
III. Rocky Mountain Subalpine and Montane Grassland Regional Biome
IV. Rocky Mountain Subalpine Grassland
IV. Rocky Mountain Montane Grassland
III. Plains-Mesa-Foothill Grassland Regional Biome
IV. Short Grass Steppe Cover Class Group
IV. Mid-Grass Praire Cover Class Group
IV. Tall Grass Praire Cover Class Group
II. Xerophytic Grassland
III. Great Basin Desert Grassland Regional Biome
IV. Great Basin Foothill-Piedmont Grassland Cover Type Group
IV. Great Basin Lowland/Swale Grassland Cover Type Group

I. Grassland Class

Grasslands are dominated by herbaceous graminoid species. Shrubs comprise less than 25% canopy cover. Most of the grasslands of the Plateau are not grazed and are true to structural descriptions.

Grasslands of the Plateau and Sierra de Los Valles are in the Mesophytic Grassland Sub-Class. Mesophytic grasslands are dominated by cold tolerant and moderately drought-intolerant species. The grasslands are primarily found at high elevations, at the tops of the mountain tops and at low elevations within the pinon-juniper and juniper woodlands.

Those of the higher elevation are within the Rocky Mountain Subalpine Grasslands, Rocky Mountain Montane Grassland Formation. Those at lower elevations are within a Short Grass Steppe Formation.

IV. Rocky Mountain Subalpine Grassland cover Type Group

These high-elevation grasslands are dominated by dense stands of grasses, sedges and rushes, trees and shrubs are rare. This type of grassland is found primarily along the peaks of the Sierra de Los Valles. They are dominated by *Danthonia* spp. and various fescues and sedges.

This cover type was extensively studied by Allen (1989) and is called a Montane Grassland in his classification (Figure 9). It is confined to nine peaks of the Sierra de Los Valles, including Pajarito Mountain. These mountains are the sources of the watersheds extending on to LANL. The Subalpine Grasslands are found in a distinctive landscape pattern on the upper, south-facing slopes and their existence has been cited in local lore and references for several hundred years. He found that there has been extensive invasion of conifers, primarily ponderosa pine and Douglas fir. He attributes the invasion to fire suppression and the reduction of grasses by grazing of sheep in the late 19th and early 20th century.

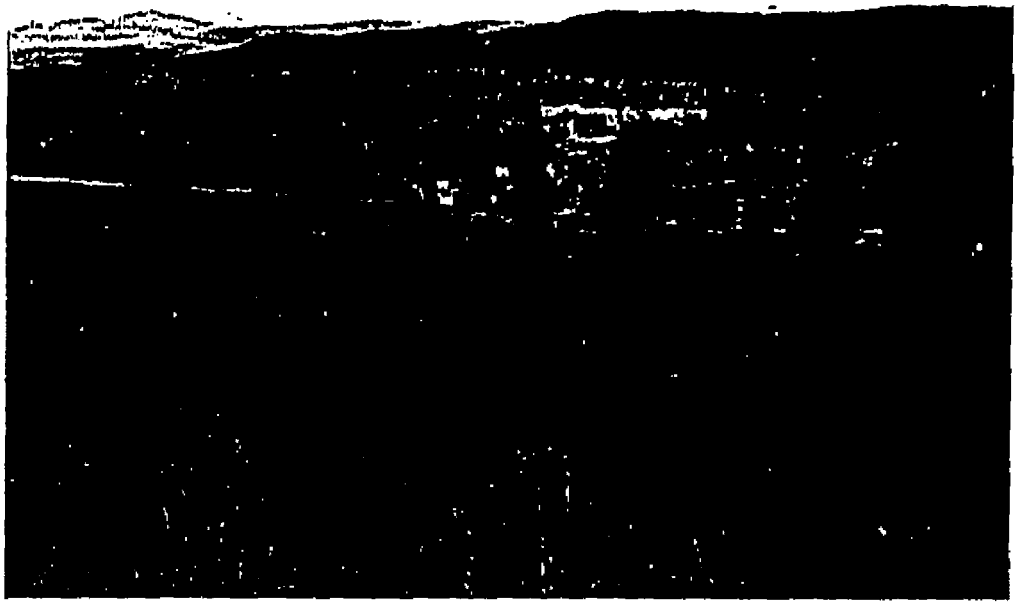

Figure 9. An example of Montane Grassland.

IV. Rocky Mountain Montane Grassland Cover Type Group

These are mid to high elevation grasslands dominated by dense stands of grasses, sedges, rushes, with few trees and shrubs. The major cover types include mountain muhly.

III. Plains-Mesa-Foothill Grassland Regional Biome

These grasslands are found on the mesas and lower slopes of the Sierra de Los Valles. The primary cover type is called a Short Grass Steppe.

IV. Short Grass Grassland cover Type Group

The short grass grasslands that occur at lower elevations will require additional field studies to determine community types. There are a variety of species that occur between 2400 m (8000 ft) and 1620 m (5400 ft). At upper elevations, associated with mixed conifer and ponderosa pine, mountain muhly, and pine dropseed are common. Little bluestem is scattered throughout. At lower elevations, within the Pinon-Juniper Woodland, blue grama is the dominant grass species.

Within these short grass grasslands, there are disburbance grasslands that have been created by extensive wildfires and restoration efforts. We have identified a sheep fescue *(Festuca ovina)* community type as a disturbance type resulting from reseeding after the La Mesa fire in 1977. This species is common in areas of high intensity crown fires that reduced the overstory canopy to zero

percent during the La Mesa fire (Foxx 1996). Within these fire disturbed areas species such as big bluestem have increased in abundance.

Another disturbance community type are old fields. These grasslands have developed in the abandoned and fallow fields of the early homesteaders (Foxx et al. 1996). They are primarily in the Ponderosa Pine Cover Type and are approximately 60 years fallow.

Considerable work and study must be done in the lower elevation grasslands to further determine if there are additional cover types and to determine the community type.

6.0 Conclusion and Discussion

To date we have tentatively identified the land cover types for Los Alamos County and LANL. We believe the classification for the forest and woodland types is more accurate and more representative of the area. However, further accuracy assessments must be done to better define the grassland and shrublands classes. A separate classification of riparian and wetland systems is necessary because of the narrowness of the canyons and lack of definition of spectral classes within the canyons for these systems. NMNHP is developing a classification for riparian areas that will be helpful in the classification of these canyon bottom systems (Muldavin personal communication).

Regardless of these limitations, this classification scheme will provide a consistent way of naming of the vegetation. Many TES and SOC occur within the Forest and Woodland Classes where we presently have the highest accuracy of classification. The land cover map, vegetation classification, and checklist of plants will enhance the use of the GIS and associated database for future Habitat Evaluation Procedures (HEP) and Eco-toxicological modeling.

In FY97, we will examine potential habitats for more defined characteristics such as downed woody components. The habitat definitions for species such as the Jemez Mountain Salamander and the Mexican spotted owl may include a downed woody component. Defining these characteristic will help identify actual and potential habitats.

7.0 Acknowledgements

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APPENDIX A
WORKING DRAFT

Keys to Major Land Cover Types in the LANL Vicinity

These keys are to be used as guidance for the identification of major types of land cover at the Los Alamos National Laboratory and the surrounding areas. They are designed for homogeneous areas that are at least 0.405 hectares (1.0 acre) in total area or are significant linear features.

1. Buildings, farms, pavement, paved or dirt roads, utility corridors, or other engineered structures are present and dominant components of the landscape.

- Use Key A (Land Used for Human Purposes)

1. Man-made structures are absent. Landscape is in a seminatural state, intrusions by man are relatively minor.

- Go to 2

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2. Land is at least periodically flooded, supports facultative or obligate hydrophytic plant species, is characterized by hydric soils; *or* the vegetation composition is influenced by nearby water; *or* the effects of past flooding are evident.

- Use Key B (Wetlands and Riparian Zones)

2. The land is variable but not as above.

- Go to 3

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3. Land is covered by <7 percent vegetation *or* ≥20 percent rock or bare ground.

- Use Key C (Unvegetated Lands)

3. Land is covered by ≥7 percent vegetation *and* <20 percent rock or bare ground.

- Go to 4

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4. Land is vegetated by an open woodland. *Juniperus monosperma* is the only tree species present, or *Pinus edulis* may be present with <7 percent coverage.

- Use Key D (*Juniperus monosperma* Woodlands)

4. Vegetation structures are variable. Combinations of tree species are not as above.

- Go to 5

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5. Land is forested or wooded. Trees are ≥5 m (16 ft) tall with coverage ≥12 percent.

- Go to 6

5. Land is not forested or wooded. Vegetation otherwise.

- Go to 9

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6. Dominant trees are *Pinus edulis* or *Juniperus monosperma*. Other tree species are <7 percent in combined coverage.

- Use Key E (*Pinus edulis-Juniperus monosperma* Woodlands)

6. Trees other than *Pinus edulis* or *Juniperus monosperma* are present with ≥7 percent combined coverage.

- Go to 7

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7. *Pinus ponderosa* is present with ≥7 percent coverage. *Pinus edulis* or *Juniperus monosperma* may be present, but other tree species are absent or are present with <7 percent coverage.

- Use Key F (*Pinus ponderosa* Forests)

7. Tree species other than *Pinus ponderosa*, *Pinus edulis*, or *Juniperus monosperma* are present with ≥7 percent cover.

- Go to 8

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8. *Pseudotsuga menziesii*, *Abies concolor*, or *Picea engelmannii* are present with ≥7 percent coverage. *Populus tremuloides* may be present or absent.

- Use Key G (Mixed Conifer Forests)

8. *Populus tremuloides* is present with ≥20 percent coverage. *Pseudotsuga menziesii*, *Abies concolor*, or *Picea engelmannii* are absent or present with <7 percent coverage.

- Use Key H (Aspen Forests)

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9. Shrub species with ≥12 percent cover are present.

- Use Key I (Shrublands)

9. Shrub species are absent *or* with <12 percent cover.

- Use Key J (Grasslands)

Key A: Land Used for Human Purposes. Buildings, farms, parking lots, paved or dirt roads, utility corridors, or other man-made structures are present and the dominant feature of the landscape. These features may essentially be linear in shape. Natural vegetational and geomorphic processes are secondary to man's activities.

1. Structure is a road or other transportation corridor, including road cuts and embankments.
   - Go to 2

1. Structure is not a road.
   - Go to 4

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2. Road is paved.
   - Paved road

2. Road is not paved.
   - Go to 3

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3. Road is improved.
   - Improved road

3. Road is not improved or is abandoned.
   - Unimproved road

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4. Structure is a powerline, pipeline, or other utility.
   - Go to 5

4. Structure is not a utility supply system.
   - Go to 6

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5. Utility system is above the ground surface.
   - Exposed utility

5. Utility is beneath the ground surface. Land is cleared regularly.
   - Buried utility

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6. Landscape is a farm, an agricultural system, or a prehistoric settlement.
   - Go to 7

6. Landscape is urban or industrial. Not agricultural.
   - Go to 9

7. Landscape is a prehistoric settlement.
   - Archaeological Site

7. Landscape is a farm or other agricultural systems
   - Go to 8

8. Farm is active.

- Active farm

8. Farm is inactive.

- Abandoned farm

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9. Land use is predominantly for industrial purposes, including LANL research facilities and other light industry.

- Go to 10

9. Land use is not predominantly industrial. Structures are for residential or commercial purposes.

- Go to 11

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10. Structure is a shallow water body with nonearthen walls.

- Waste pond

10. Structure is a building or other associated facility.

- Industrial facility

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11. Land use is predominantly for commercial purposes, including offices and restaurants.

- Commercial

11. Land use is predominantly for residential purpose.

- Residential

Key B: Wetlands and Riparian Zones. Land is at least periodically flooded, supports facultative or obligate hydrophytic plant species, is characterized by hydric soils; *or* the vegetation composition is influenced by nearby water; *or* the effects of past flooding are evident. These are marshes, lakes, rivers, streams, gallery forests, and other communities strongly influenced by the presence of water.

1. Land is vegetated with ≥30 percent cover.
   - Go to 2

1. Land is not vegetated or plant cover is <30 percent.
   - Go to 9

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2. Vegetation is dominated by *Acer negundo*, *Populus angustifolia*, *Populus fremontii*, or other riparian tree species.
   - Go to 3

2. Hydrophytic or riparian tree species are not present or present only as accidentals.
   - Go to 5

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3. Vegetation is dominated by *Populus angustifolia*.
   - POAN Riparian Forest

3. Vegetation is not dominated by *Populus angustifolia*.
   - Go to 4

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4. Vegetation is dominated by *Populus fremontii*.
   - POFR Riparian Forest

4. Vegetation is not dominated by *Populus fremontii*.
   - Other riparian forest

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5. *Salix* spp., *Tamarix* spp., *Alnus tenuifolia*, or other obligate or facultative hydrophyte shrub species are present with ≥30 percent cover.
   - Go to 6

5. Obligate or facultative hydrophyte shrub species are absent or present with <30 percent cover. *Carex* spp., *Typha* spp., *Scirpus* spp., or other obligate or facultative hydrophyte species are present with ≥30 percent cover.
   - Go to 8

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6. Vegetation is dominated by *Salix* spp.
   - Willow Wetland

6. Vegetation is various, but not dominated by *Salix* spp.
   - Go to 7

7. Vegetation dominated by *Tamarix* spp.

- Tamarisk Wetland

7. Vegetation is various, but not dominated by *Tamarix* spp.

- Shrub Wetland

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8. Vegetation is dominated by *Typha* spp.

- Cattail Meadow

8. Vegetation is dominated by *Carex* spp., *Scirpus* spp., or other species.

- Rush/Sedge Meadow

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9. Area is <75 percent stones, boulders or bedrock *and* is exposed for ≥50 percent of the year.

- Sandbars/mudflats

9. Substrate is various, but the land is covered by water >50 percent of the year.

- Go to 10

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10. Water is contained in a channel and flows, at least slowly.

- Go to 11

10. Water is not contained in a channel, and is standing or flows very slowly.

- Go to 13

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11. Water is relatively fast flowing over a high gradient. The substrate consists of rock, cobbles, or gravel with some patches of sand.

- Go to 12

11. Water is relatively slow moving over a low gradient. The substrate is mainly sand and mud.

- River

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12. The channel contains flowing water throughout the year.

- Permanent stream

12. The channel contains flowing water for only part of the year.

- Intermittent stream

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13. Water body is ≥2 m (6.6 ft) deep, *or* ≥8 ha (20 acres) in area.

- Lake

13. Water body is not as above.

- Go to 14

14. Substrate is sand, mud, gravel, or other natural material. Shoreline was not created or enhanced by man.

- Natural pond

14. Ultimate substrate is either a natural or synthetic material that was emplaced or improved by man. Shoreline was created or enhanced by man.

- Impoundment

Key C: Unvegetated Land. The land is covered by <7 percent vegetation *or* ≥20 percent rock, bare ground, or open water. The land is not developed for industrial, urban, agricultural, residential, or other cultural purposes.

1. Slopes are ≥70 percent.
   - Go to 2

1. Slopes are <70 percent.
   - Go to 3

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2. Substrate is a volcanic tuff.
   - Tuffaceous cliff

2. Substrate is a basalt.
   - Basalt cliff

---

3. Rocky substrate is relatively continuous rock.
   - Go to 4

3. Rocky substrate is cobbly or bouldery *or* soils may be present.
   - Go to 5

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4. Substrate is a volcanic tuff.
   - Tuffaceous outcrop

4. Substrate is a basalt.
   - Basalt outcrop

---

5. Land is above 2400 m (8000 ft) in elevation. Bouldery and cobbly outcrop is on a hillslope.
   - Felsenmeer

5. Land is below 2400 m (8000 ft) in elevation.
   - Go to 6

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6. Outcrop is on a lower-slope position.
   - Go to 7

6. Position is various. Soils or nonsoils may be present.
   - Unvegetated disturbed

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7. Substrate is a volcanic tuff.
   - Tuffaceous talus

7. Substrate is a basalt.
   - Basalt talus

Key D: *Juniperus monosperma* Woodlands. The landscape is a seminatural, open or closed woodland. The dominant tree species is *Juniperus monosperma*. Other tree species are <7 percent in combined coverage.

1. Slopes ≥15 percent and boulders or rock outcrop ≥20 percent.
   - Go to 2

1. Slopes and ground surface are otherwise.
   - Go to 3

---

2. Rock outcrops are predominantly basalt.
   - JUMO basalt scarp

2. Rock outcrops are tuffaceous or other than basalt.
   - JUMO tuff scarp

---

3. Shrub species with ≥7 percent cover are present.
   - Go to 4

3. Shrub species are absent *or* with <7 percent cover.
   - Go to 6

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4. Arroyos with *Chrysothamnus nauseosus* or *Fallugia paradoxa* present with ≥7 combined cover.
   - JUMO/CHNA-FAPA

4. *Chrysothamnus nauseosus* or *Fallugia paradoxa* absent or with <7 percent combined cover.
   - Go to 5

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5. *Quercus undulata* ≥7 percent cover. *Artemisia tridentata* may or may not be present.
   - JUMO/QUUN

5. *Quercus undulata* <7 percent cover. *Artemisia tridentata* ≥7 percent cover
   - JUMO/ARTR

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6. *Bouteloua curtipendula* ≥7 percent cover.
   - JUMO/BOCU

6. *Bouteloua curtipendula* absent or present with <7 percent cover.
   - Go to 7

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7. *Bouteloua eriopoda* ≥7 percent cover. *Bouteloua gracilis* may or may not be present.
   - JUMO/BOER

7. *Bouteloua eriopoda* is absent or with <7 percent cover. *Bouteloua gracilis* is present with ≥7 percent cover.
   - JUMO/BOGR

Key E: *Pinus edulis-Juniperus monosperma* Woodlands. The landscape is a seminatural, open or closed woodland. The dominant tree species are *Juniperus monosperma* and *Pinus edulis*. Other tree species are <7 percent in combined coverage.

1. Slopes are ≥15 percent and boulders or rock outcrops are ≥20 percent.
   - Go to 2

1. Slopes and ground surface otherwise.
   - Go to 3

---

2. Rock outcrops are predominantly basalt.
   - PIED-JUMO basalt scarp

2. Rock outcrops are tuffaceous or other than basalt.
   - PIED-JUMO tuff scarp

---

3. Shrub species with ≥7 percent cover are present.
   - Go to 4

3. Shrub species are absent *or* with <7 percent cover.
   - Go to 8

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4. Oaks are present with ≥7 percent cover.
   - Go to 5

4. Oaks are absent or with <7 percent cover.
   - Go to 6

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5. *Quercus undulata* is the dominant oak species.
   - PIED-JUMO/QUUN

5. *Quercus gambelii* is the dominant oak species.
   - PIED-JUMO/QUGA

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6. Arroyos with *Chrysothamnus nauseosus* or *Fallugia paradoxa* are present with ≥7 combined cover.
   - PIED-JUMO/CHNA-FAPA

6. *Chrysothamnus nauseosus* or *Fallugia paradoxa* are absent or with <7 percent combined cover.
   - Go to 7

7. *Cercocarpus montana* is present with ≥7 percent cover. *Artemisia tridentata* may or may not be present.

- PIED-JUMO/CEMO

7. *Cercocarpus montana* is absent or with <7 percent cover. *Artemisia tridentata* is ≥7 percent cover.

- PIED-JUMO/ARTR

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8. *Bouteloua gracilis* is ≥7 percent cover.

- PIED-JUMO/BOGR

8. *Bouteloua gracilis* is <7 percent cover.

- Go to 9

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9. *Muhlenbergia montana* is present with ≥7 percent cover.

- PIED-JUMO/MUMO

9. *Muhlenbergia montana* is absent or present with <7 percent cover.

- Go to 10

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10. *Schizachyrium scoparium* is present with ≥7 percent cover.

- PIED-JUMO/SCSC

10. *Schizachyrium scoparium* is absent or present with <7 percent cover. Large amounts of bare soil are present.

- PIED-JUMO/bare

Key F: *Pinus ponderosa* Forests. The landscape is a seminatural forest. *Pinus ponderosa* is the dominant tree species, being present with cover ≥7 percent. *Juniperus monosperma* and *Pinus edulis* may also be present, but other tree species are absent, occur as accidentals, or are <7 percent in cover.

1. Shrub species, primarily oaks, with ≥7 percent cover are present.
   - Go to 2

1. Shrub species are absent *or* with <7 percent cover.
   - Go to 3

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2. *Quercus undulata* is the dominant oak species.
   - PIPO/QUUN

2. *Quercus gambelii* is the dominant oak species.
   - PIPO/QUGA

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3. *Blepharoneuron tricholepis* is present with ≥7 percent cover.
   - PIPO/BLTR

3. Vegetation composition is various, but *Blepharoneuron tricholepis* is absent or present with <7 percent cover.
   - Go to 4

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4. *Bouteloua gracilis* is present with ≥7 percent cover.
   - PIPO/BOGR

4. *Bouteloua gracilis* is absent or present with <7 percent cover.
   - Go to 5

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5. *Muhlenbergia montana* is present with ≥7 percent cover.
   - PIPO/MUMO

5. *Muhlenbergia montana* may or may not be present. Combined cover of all understory plant species is <7 percent.
   - PIPO forest

Key G: Mixed Conifer Forests. The landscape is a seminatural forest. Trees ≥5 m (16 ft) tall with coverage >12 percent are present. Tree species other than *Pinus ponderosa*, *Pinus edulis*, or *Juniperus monosperma* are present with ≥7 percent cover. *Populus tremuloides* may be present or absent.

1. *Pseudotsuga menziesii* is present with ≥7 percent cover and reproducing successfully. *Abies concolor* or *Picea engelmannii* are absent or present as accidentals.

• Go to 2

1. *Pseudotsuga menziesii* is absent or present with <7 percent cover. *Abies concolor* or *Picea engelmannii* are present with ≥7 percent cover or are reproducing successfully.

• Go to 4

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2. *Populus tremuloides* is present with ≥12 percent cover. *Quercus* spp. are absent or present with <7 percent cover.

• PSME-POTR

2. *Populus tremuloides* is absent or present with <12 percent cover. *Quercus* spp. are present with ≥7 percent cover.

• Go to 3

---

3. *Quercus gambelii* is present with ≥7 percent cover. *Muhlenbergia montana* may or may not be present.

• PSME/QUGA

3. *Quercus gambelii* is absent or present with <7 percent cover. *Muhlenbergia montana* is present with ≥7 percent cover.

• PSME /MUMO

---

4. *Picea engelmannii* is present with ≥7 percent cover and reproducing successfully. *Abies concolor* is absent or present with <7 percent cover.

• Go to 5

4. *Abies concolor* is present with ≥7 percent cover or reproducing successfully. *Picea engelmannii* is absent or accidental.

• Go to 6

---

5. *Populus tremuloides* is present with ≥12 percent cover.

• PIEN-POTR

5. *Populus tremuloides* is absent or present with <12 percent cover. Composition of the understory is variable.

• PIEN forest

---

6. *Populus tremuloides* is present with ≥12 percent cover.

• ABCO-POTR

6. *Populus tremuloides* is absent or present with <12 percent cover.

• Go to 7

7. *Robinia neomexicana* is present with ≥7 percent cover.

- ABCO/RONE

7. *Robinia neomexicana* is absent or present with <7 percent cover.

- Go to 8

8. *Quercus gambelii* is present with ≥7 percent cover.

- ABCO/QUGA

8. *Quercus gambelii* is absent or present with <7 percent cover. Composition of the understory is variable.

- ABCO forest

Key H: Aspen Forests. The landscape is a seminatural forest. Trees are ≥5 m (16 ft) tall with coverage ≥12 percent are present. *Populus tremuloides* is present with ≥20 percent coverage. *Pseudotsuga menziesii*, *Abies concolor*, or *Picea engelmannii* are absent or present with <7 percent coverage.

1. *Athyrium filix-femina* is present with ≥7 percent cover.

- POTR/ATFI

1. *Athyrium filix-femina* is absent or present with <7 percent cover.

- Go to 2

---

2. *Bromus marginatus* is present with ≥7 percent cover. *Bromus ciliatus* is absent or present with <7 percent cover.

- POTR/BRMA

2. *Bromus ciliatus* is present with ≥7 percent cover. *Bromus marginatus* is absent or present with <7 percent cover.

- POTR/BRCI

Key I: Shrublands. Shrub species with ≥12 percent cover are present. Tree species are absent or not present to ≥5 m (16 ft) tall with coverage ≥12 percent. The land is not developed for industrial, urban, agricultural, residential, or other cultural purposes.

1. *Quercus gambelii* is present with ≥7 percent cover.
   - QUGA/BLTR

1. *Quercus gambelii* is absent or present with <7 percent cover.
   - Go to 2

---

2. *Atriplex canescens* is present with ≥7 percent cover.
   - ATCA

2. *Atriplex canescens* is absent or present with <7 percent cover.
   - Go to 3

---

3. *Chrysothamnus nauseosus* is present with ≥7 percent cover.
   - CHNA

3. *Chrysothamnus nauseosus* is absent or present with <7 percent cover.
   - Go to 4

---

4. *Artemisia tridentata* is present with ≥7 percent cover. *Robinia neomexicana* is absent or present with <7 cover.
   - ARTR

4. *Artemisia tridentata* may or may not be present. *Robinia neomexicana* is absent or present with ≥7 cover.
   - RONE

Key J: Grasslands. Shrub species are not present with ≥12 percent cover. Tree species are absent or not present to ≥5 m (16 ft) tall with coverage ≥12 percent. The land is not developed for industrial, urban, agricultural, residential, or other cultural purposes.

1. *Muhlenbergia montana* is present with ≥7 percent cover.

- MUMO

1. *Muhlenbergia montana* is absent or present with <7 percent cover.

- Go to 2

---

2. *Bouteloua gracilis* is present with ≥7 percent cover.

- BOGR

2. *Bouteloua gracilis* is absent or present with <7 percent cover.

- Go to 3

---

3. Grass species, such as *Danthonia intermedia*, are present with ≥7 percent cover. Elevations are above 2400 m (8000 feet).

- Montane Grassland

3. Grass species, such as *Danthonia intermedia*, are absent or present with <7 percent cover. Elevations are below 2400 m (8000 feet).

- Go to 4

---

4. *Festuca ovina* is present with ≥7 percent cover

- FEOV

4. *Festuca ovina* is absent or present with <7 percent cover.

- Go to 5

---

5. *Schizachyrium scoparium* is present with ≥7 percent cover.

- SCSC

5. *Schizachyrium scoparium* is absent or present with <7 percent cover.

- Go to 6

---

6. *Agropyron smithii* is present with ≥7 percent cover.

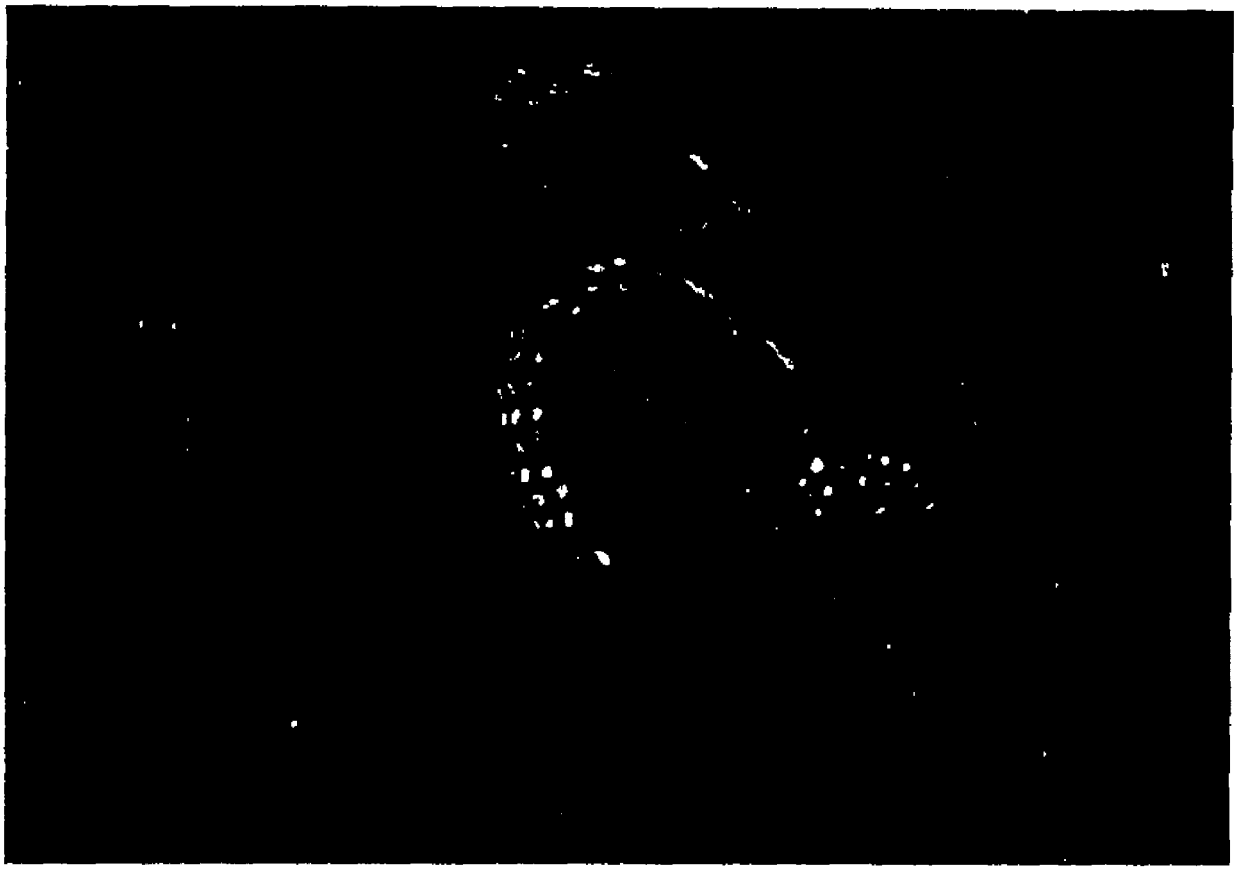
- AGSM

6. *Agropyron smithii* is absent or present with < 7 percent cover. Species compositions are various.

- Disturbed grassland

Annotated Checklist and Database for Vascular Plants of the Jemez Mountains

Teralene S. Foxx, Leland Pierce,
Gail D. Tierney, and Leslie A. Hansen



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Annotated Checklist and Database of Vascular Plants of the Jemez Mountains

Teralene S. Foxx, Leland Pierce*, Gail D. Tierney**, and Leslie A. Hansen**

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Abstract

Studies done in the last 40 years have provided information to construct a checklist of plants of the Jemez Mountains. The present data base and checklist builds on the basic list compiled by Teralene Foxx and Gail Tierney in the early 1980s. The checklist is annotated with taxonomic information, geographic and biological information, economic uses, wildlife cover, revegetation potential, and ethnographic uses. There are nearly 1000 species that have been noted for the Jemez Mountains. This list is cross-referenced with the USDA Natural Resource Conservation Service PLANTS data base species names and acronyms.

1.0 About the Checklist

In 1984, a list of species for the Jemez Mountains was constructed using survey data from information gathered by Foxx and/or Tierney (Foxx 1982; Tierney 1977; Tierney 1979; Foxx and Tierney 1980, 1982, 1984; Tierney and Foxx 1982; Foxx and Potter 1978; Potter and Foxx 1979, 1981, Potter, Foxx, and Barnes 1983) supplemented by information about collections from master's theses by Housley (1974), Koehler (1974), Osborne (1966), Robertson (1968), and Yarnell (1958) (section 5.3 of the reference list). The original survey included a literature survey of collections by private industry (Pilz et al. 1979, Whitford and Ludwig 1979; section 5.2 of references), the National Park Services (NPS) studies (Potter 1981), and habitat typing studies (Barnes 1982, Moir and Ludwig 1979). Additionally, unpublished information concerning collections made by Los Alamos National Laboratory (LANL) staff (Miera 1976) and research at Bandelier National Monument was included.

This report provides a single listing of all collections from the Jemez Mountains, including the Pajarito Plateau, Sierra del Los Valles, Valles Caldera, and portions of the Jemez west of the caldera. The floristic studies were conducted within an area bound on the south by Cochiti Canyon, on the north by Garcia Canyon, on the east by the Rio Grande, and by the Jemez River on the west (Figure 1).

Studies prior to 1985 provided the baseline information incorporated into the original checklist. Since 1985, a number of studies have been conducted at LANL, Bandelier National Monument, and within the National Forests. Each study has added to our knowledge of the presence and distribution of the species. Studies are noted in sections 5.2, 5.3, and 5.4 of the reference list. Of note are studies by Allen (1984, 1989), Jacobs (1989), and Foxx and Hoard (1984, 1995).

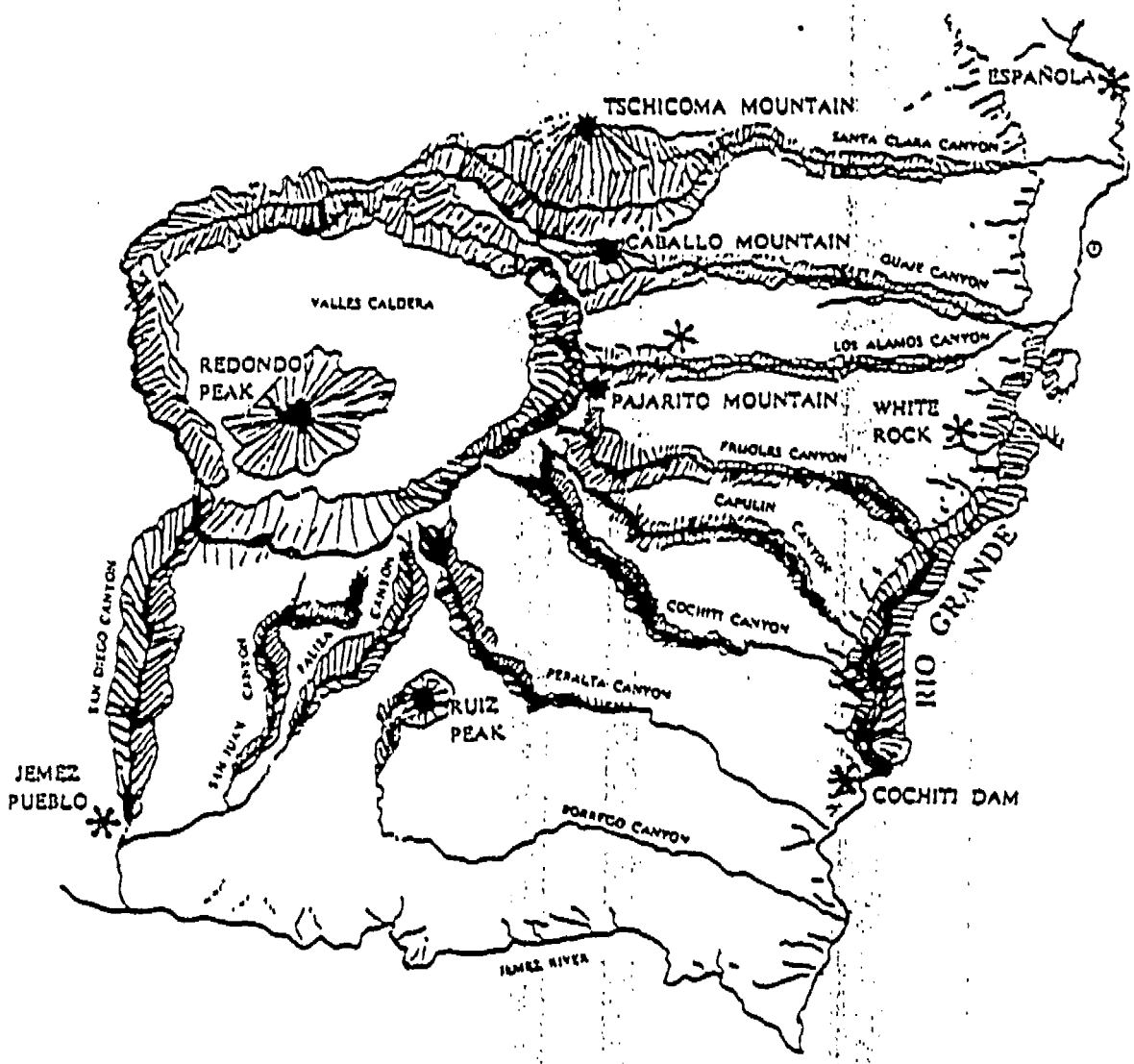


Figure 1. The Checklist Area.

In 1994, we began to update and annotate the checklist with further information. Most additional information came from *Plant Information Network: Data base* publication by Dittberner and Olson (1983). Although this publication references Colorado, Montana, Wyoming, Utah, and Arizona, we believe most of the information is pertinent to New Mexico. This publication provides specific information as to the biological, ecological, and human environment as related to plant species. In addition to this publication we have researched information from the references that can be found in the sections 5.6 and 5.7 of the reference list. To determine potential use of plants by various cultures in the area, we searched ethnobotanies and ethnographic literature for plant usage. The references used are under Ethnographic Literature in section 5.7 of the reference list. Wetland information was based on the *National List of Plant Species That Occur in Wetlands: New Mexico* (Reed 1988). Wetland references are found in section 5.5 of the reference list.

Each species was then searched in one of several floras including the following: Martin and Hutchins 1981, McDougall 1973, Benson 1977, Hitchcock 1971, Kearney and Peebles 1969, Correll and Johnston 1970, Harrington 1970, Gould 1977, Dittmer et al. 1954, and Allred 1982. Other botanical publications that provided information for the checklist are in section 5.2 of the reference list. Synonyms, habitat, habit, and blooming times were noted. In cases of conflicting information, *A Flora of New Mexico* by Martin and Hutchins (1980), the most recent and comprehensive text for the area, was used for the final authority on habitat, habit, and blooming times. Scientific names (nomenclature) found in the current Natural Resource Conservation Service (NRCS) PLANTS data base was used for a national standard or provides accurate translators to names as a cross-walk. PLANTS is a component of the evolving Interagency Taxonomic Information System (ITIS). The most current copy was obtained from the internet (http://www.plants.usda.gov/plants).

We have attached in Appendix A the references used in Dittberner and Olson (1983). These references provided the basis for the information they included in their data base and on which we have built the annotation of this checklist.

2.0 Description of the Area

2.1 Geographic and Geologic Setting

The Jemez Mountains are located in north-central New Mexico (Figure 2) and rise as a large volcanic landmass at the southern end of the Rocky Mountains. The mountains are a remnant of a massive volcano that erupted 1.4 to 1.1 million years ago. They lie astride the western fault margin of the Rio Grande rift, an 800-km-long (480 mi) intracontinental rift zone that extends southward from southern Colorado through New Mexico. Ash from the eruptions laid down 300 m (985 ft) of welded and nonwelded tuff on the eastern flanks called the Pajarito Plateau and on the western flanks, the Jemez Plateau. Los Alamos National Laboratory (LANL) is located on the Pajarito Plateau, which is dissected into a series of east- to southeast-trending narrow mesas, separated by deeply incised canyons (Burton 1982, Allen 1989).

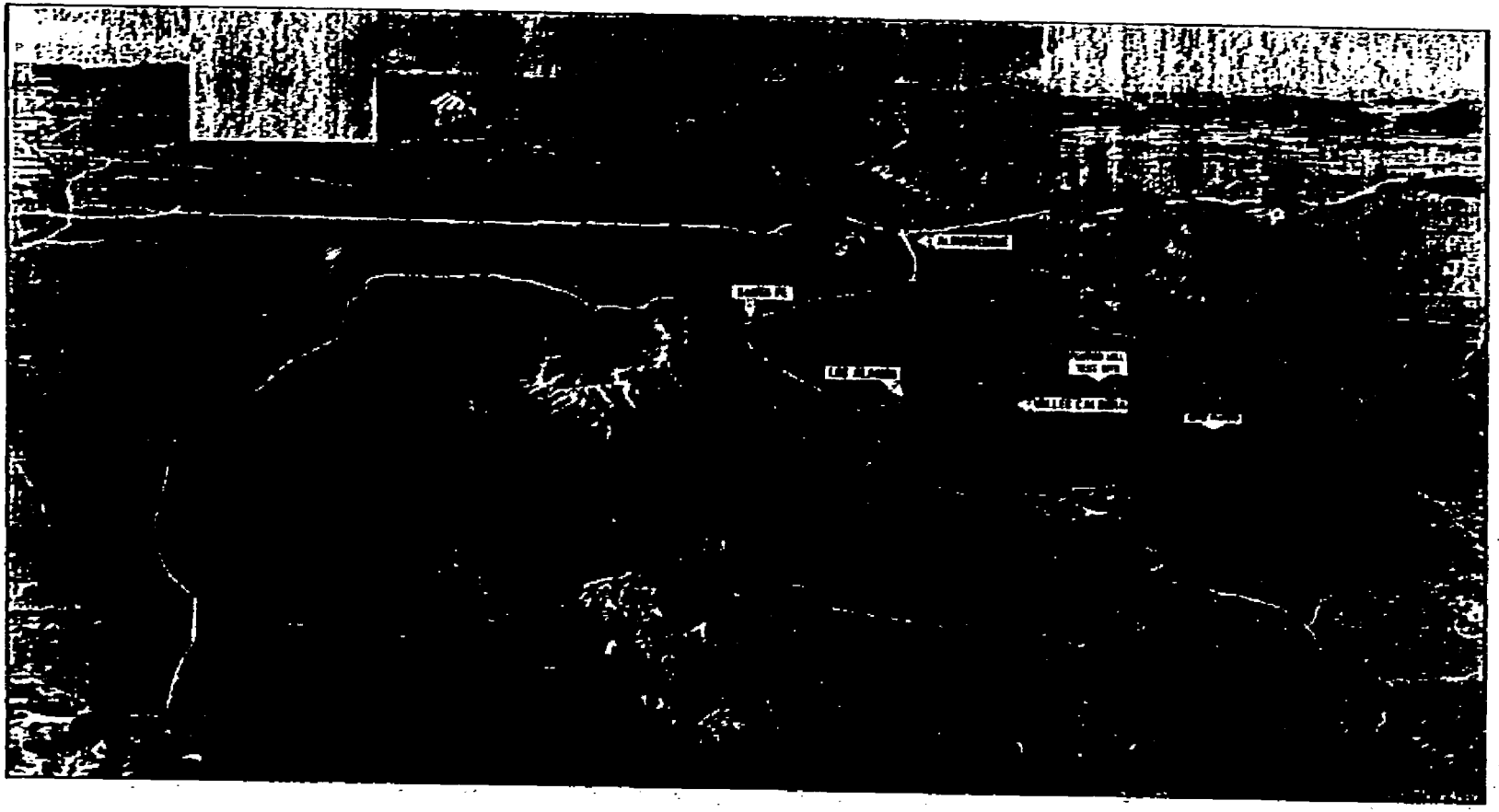


Figure 2. Location of the Jemez Mountains in north-central New Mexico. *(Photo courtesy of Coors)*

The prominent landforms of the Jemez Mountains include two central calderas (Valle Grande and Valle Toledo), domes within the calderas, and the mountainous remnants of the collapsed volcano (the Sierra del Los Valles), eastern and western plateau skirting the mountain (Pajarito and Jemez Plateaus), and White Rock Canyon through which the Rio Grande flows. The rim of the volcano has nine peaks including Cerro Grande, Pajarito Mountain, Tschicoma Peak, and Caballo Mountain. The tops of the mountains range from 2895 m (9500 ft) to over 3353 m (11,000 ft) in elevation. The highest peak being Tschicoma at 3,526 m (11,636 ft) (Burton 1982, Allen 1989) (Figure 3).

Los Alamos County lies on the eastern flanks of the mountain. Land ownership within the county includes LANL, which comprises 43 square miles (11,218 ha), the communities of Los Alamos and White Rock, and Santa Fe National Forest. The remainder of the Jemez area is within Sandoval County. Land ownership includes lands of the Santa Fe National Forest and private holdings such as the Baca Location.

The Pajarito Plateau is dissected into canyons and mesas. Only the upper reaches of the canyons have permanent water sources. Streams such as Frijoles Creek within Bandelier National Monument are perennial. However, most streams are ephemeral, flowing during spring snowmelt and during heavy rainstorms in the summer months. Springs and seeps can be found in the canyons and White Rock Canyon. Within the caldera and flowing through the mountains is the Jemez River. These water-rich areas in an otherwise semiarid environment often have a different and specific flora. Species such as helleborine orchid (*Epipactis gigantea*) are species of concern or others such as the cardinal lobelia (*Lobelia cardinalis*) are of local concern.

2.2 Climate

The area has a temperate mountain climate with four distinct seasons. Springs are dry and windy; summers, warm and often dry in June followed by a rainy season in July and August. July is the warmest month with an average daily high of 27.2 °C (81 °F) and an average daily low of 12.8 °C (55 °F). January is the coldest month with temperature ranges of a daily high of 4.4 °C (40 °F) to a low of -8.3 °C (17 °F). There is solar heating during the day and rapid radiant cooling at night. The average annual preciptation is 17.6 cm (18.7 in.). Lower elevations near the Rio Grande receive 13 cm (5.1 in.) less and the higher elevations may receive 13 cm (5.1 in.) more. The peak rainfall months are July and August. Most of the winter precipitation falls as snow with an average of 150 cm (59 in.). (Bowen 1990, 1992, Environmental Surveillance Report 1994).

2.3 Vegetation Cover and Community Types

Mapping and classification of the Jemez Mountains has been done by the US Forest Service for the Santa Fe National Forest (Moir 1979), by Allen (1989) for Bandelier National Monument, and by Koch et al. (1996) and Foxx et al. (1996) for Los Alamos County. The major cover classes include Mixed Conifer, Ponderosa Pine, Aspen, Pinon-Juniper woodlands, Juniper woodlands, Grasslands, and Shrublands. Within canyons and along streams there are riparian zones and wetlands, both forested and emergent, with small and unique habitats such as felsenmeers and springs.

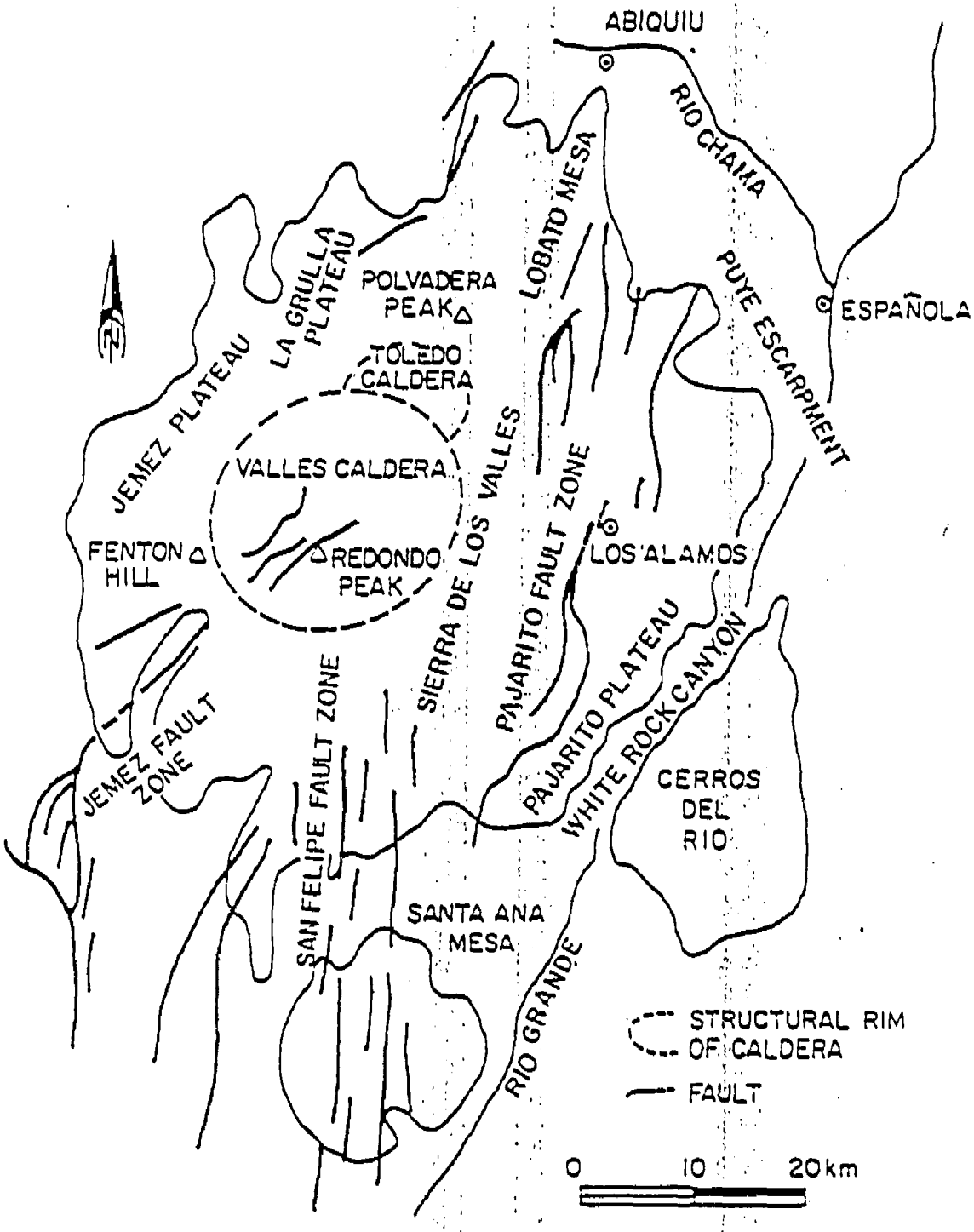


Figure 3. Generalized map of the Jemez Mountains.

3.0 Checklist arrangement

As a data base this checklist can be sorted by various attributes. For the purpose of this publication, the checklist is arranged alphabetically by taxonomic genus and species. To provide a visual example, we have printed out the complete file for nomenclature and just the first page of each of the other categories that make up this lengthy data base. Each category is an Excel 5 spread sheet with specific fields and information. We have supplied a complete listing of species of the Jemez Mountains by genus and species for the purpose of this report (Appendix A). For each other category we have pulled out a representative sheet. These representative sheets are found in Appendix B. In the heading of each sheet we have given a reference citation that refers to the reference list at the end of this paper.

In this section we describe the categories and the attributes of each category.

3.1 Nomenclature

1. Species Name: Species names are denoted by a generic name and a species designation. In some cases varieties or subspecies may be included. Species names are consistent with Martin and Hutchins (1980).

2. Species Name NRCS PLANTS: The NRCS PLANTS name or synonymy is included in a separate field. The NRCS name is part of the Interagency Taxonomic Information System (ITIS) and is the taxonomy used in this national standard. It may or may not correspond to the information in *Flora of New Mexico* and older texts. To reduce confusion about synonymy, we have included the NRCS name in a separate field. This allows the name to be cross-walked to the information in the present text delineating New Mexico flora.

3. Acronyms: We have included the acronyms for the plants found in the Jemez Mountains. The standard protocol is to use the first 2 letters of the species name and the first 2 letters of the species designation. To standardize these acronyms we have used the NRCS designations.

3.2 Common Names

1. Common name: The common name of the plant represents one or more names commonly found in botanical texts for the area. Common names may differ from source to source and region to region. Therefore, we have included as many common names as was reasonable. Many references in section 5.1 of the reference list have been searched for common names.

2. Synonyms: These are a series of discarded scientific names for various plants. Depending on the text, they may or may not still be in common usage. Synonyms given by Harrington (1954), Martin and Hutchins (1980), and Allred (1982) are included. No attempt has been made to determine validity of the synonyms.

3.3 Occurrence

Information in this category includes occurrence, blooming times, and habit.

1. Occurrence. The occurrence of a plant species is based on general observations, not precise quantitative data included in Foxx and Tierney (1985). If the collector was other than the authors, the reference is cited. Herbarium

specimens collected by Ora M. Clark are designated as being in the herbarium at Bandelier National Monument.

The following scheme was used to designate place occurrence.

- **ubiquitous**—Taxa occurring in a variety of habitats and communities.
- **common**—Taxa found extensively in one or two habitats or communities.
- **locally common**—Taxa found in clumps or patches within various habitats or communities but not distributed throughout the area.
- **not common**—Taxa not found extensively in various habitats or communities.
- **rare**—Only a few specimens occurring in isolated pockets in specific habitats. In many cases if the habitat was destroyed, the plant would disappear from the area.

2. *Blooms.* Contains information on the season(s) in which the plant blooms.

3. *Habit.* This category contains information about the growth form and outward appearance of the plant. This is known as the Habit. Information was taken from Martin and Hutchins (1980) and other references in section 5.2 of the reference list.

- **tree**—A woody plant that usually produces one main trunk or bole and a more or less distinct and elevated head.
- **shrub-tree**—A plant whose growth form may be either that of a shrub or a tree.
- **shrub**—A woody plant that remains low and produces several shoots or trunks from the base.
- **liana**—A woody plant with elongate, flexible, non-self-supporting stems.
- **vine**—A nonwoody plant with elongate, flexible, non-self-supporting stems.
- **perennial forb**—A nonwoody plant with self-supporting stem whose aboveground parts die each year and is not grasslike. Includes half-shrubs, or plants woody only at the base.
- **perennial grass**—Nonwoody plants belonging to the grass, sedge, or rush families.

3.4 Roots, Economic, and Old Field

The attributes of a plant that pertain to its own life processes are identified as biological (Dittberner and Olson 1983). Specific informaton was primarily taken from Dittberner and Olson (1983).

In this roots section there are three biological elements:

1) the mycorrhizal nature of the plant,
2) the ability of the plant to form nodules, and
3) the ability of the plant to fix nitrogen.

1. Mycorrhizal Relationships. The nature of the relationship of a plant to a mycorrhizal association. All plants listed as being mycorrhizal have been cited in the literature as such. It should be recognized that most plants are considered to be mycorrhizal, but published reports are available for only a few at the present time.

- **endomycorrhizal**—Mycorrhizal association having a loose network of fungal hyphae enclosing the root and intracellular hyphae penetrating the cortical cells of the root.

- **ectomycorrhizal**—Mycorrhizal association having a dense fungal sheath enclosing the root and intercellular hyphae penetrating the root cortex.

- **ectendomycorrhizal**—Mycorrhizal association having a dense fungal sheath enclosing the root and both inter- and intracellular hyphae penetrating the root cortex.

- **endo/ecto**—Refers to plants reported as being both endomycorrhizal and ectomycorrhizal.

- **ecto/ectendo**—Refers to plants reported as being both ectomycorrhizal and ectendomycorrhizal.

- **nonmycorrhizal**—Refers either to plants that have been examined for mycorrhizae with none found or plants that occur in families considered to be classically nonmycorrhizal (Aizoaceae, Amaranthaceae, Brassicaceae, Cruciferae, Caryophyllaceae, Chenopodiaceae, Commelinaceae, Cyperaceae, Fumariaceae, Juncaceae, Nyctaginaceae, Polygonaceae, and Urticaceae). Thus, the plants are probably nonmycorrhizal, although exceptions may be found in the future.

2. *Nodule Forming*. Occurrence of root nodules on a plant's roots.

- **reported**—Reported as nodule forming by observations or in the literature.

- **possible**—May form root nodules but no literature citation has been found.

- **no**—Reported as not nodule forming in the literature.

3. *Nitrogen Fixing*. A plant that can assimilate and fix the free nitrogen of the atmosphere with aid of microorganisms.

- **yes**—Plant fixes nitrogen, as reported in the literature.

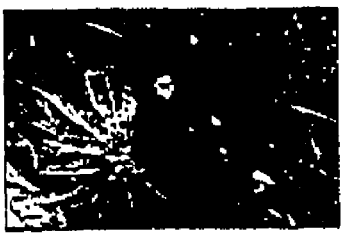
- **maybe**—The plant may fix nitrogen, but has not been reported as such in the literature.

- **no**—Plant is known not to fix nitrogen.

This category also contains information about the biology or life processes of plants and economic information including whether or not the plant can produce hayfever, is edible, or is considered a weed.

There are three economic fields:

1) Does the plant produce hayfever?
2) Is the plant edible?
3) Is the plant considered a weed?



4. Hayfever Causing. The plant induces a hayfever response in humans.

- **yes**—The plant is reported in the literature as causing hayfever.
- **maybe**—The plant is reported to possibly cause a hayfever response; it is thought to cause hayfever but is not yet proven.
- **no**—The plant is know to be definitely not hayfever causing in any circumstances and is reported so in the literature.

5. Edible. A plant that can be eaten as food by humans.

- **yes**—One or more parts of the plant are edible.
- **yes-qualified**—The plant is edible only after a specific preparation or in certain seasons. User should consult expert.
- **no**—The plant is not edible but not poisonous.
- **poisonous**—The plant contains a toxic substance or a potential toxic substance that would prove harmful if ingested.

6. Weediness. A plant considered undesirable or troublesome, especially one that has growth where it is not wanted. Each plant is scored only once in the order of precedence below. Most of the information was taken from Dittberner and Olson 1983.

- **noxious**—A plant that is listed on official noxious weed seed lists of Colorado, Montana, North Dakota, Utah, or Wyoming.
- **economic**—A plant whose growth and reproduction cause economic loss and has priority over colonizing.
- **colonizing**—A plant that has attributes enabling it to become easily established in areas of environmental disturbance or where it is not wanted.
- **non-weedy**—A plant that is not a weed.

7. Old Fields, Old Field References, and Old Field Comments. These categories contain information about plants and old field disturbance. Various references were used and are noted under Indicator Plants (5.6 in the reference list).

3.5 Wetlands and Disturbance

1 and 2. National Wetland List and National Wetland List (Reed 1988).

The information about plant species that occur in this category was compared with the *National List of Plant Species that Occur in Wetlands: New Mexico* (Reed 1988) (Column 2). This list was developed to provide an appendix to the *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin et al. 1979). Column 1 represents information from *National List of Plant Species that Occur in Wetlands* (Reed 1988). Information on the *National List* is sometimes slightly different than the listing for New Mexico. The plant species that occur in wetlands as used in the *National List* are defined as species that have environment where all or portions of the soil within the root zone become, periodically or continuously, saturated or inundated during the growing season (Reed 1988).

The following Indicator Categories are used in these first two columns.

- **obligate wetland** (OBL)—Occur almost always (estimated probablility > 99%) under natural conditions in wetlands.

- **facultative wetland** (FACW)—Usually occur in wetlands (estimated probability 67%–99%), but occasionally found in nonwetlands.

- **facultative** (FAC)—Equally likely to occur in wetlands or nonwetlands (estimated probability 34%–66%).

- **facultative upland** (FACU)—Usually occur in nonwetlands (estimated probability 67%–99%), but occasionally found in wetlands (estimated probability 1%–33%).

- **obligate upland** (UPL)—Occur in wetlands in other regions, but occur almost always (estimated probability >99%) under natural conditions in nonwetlands in any region, it is not on the National List.

3. Disturbed Sites. This is information about the presence of a plant in a disturbed site such as along roadsides, in burned areas, and on waste sites.

4. Disturbance References. This category represent a reference that indicates the type of disturbance. Various references were used for this section and are noted in section 5.7 of the reference list.

5. Comments on Disturbed Sites Growth. This category indicates the ability of a plant to grow on a disturbed site.

3.6 Fire and Flood

This category represents information about plants that are characteristically found after fire or flood disturbances.

- Associated with Fire
- Fire Reference
- Fire Comments
- Flooded Areas
- Flood References
- Flood Comments

3.7 Habitat

1. Habitat. This term is used to identify topographic position, soils, and communities where the plant was found. If the collector was other than those at LANL, Martin and Hutchins (1980) was consulted for habitat placement. The fields are taken from Foxx and Tierney (1984) and are not yet consistent with the cover types and community types included in Koch (1996) and Foxx and Balice (1996). However, most of the habitats can be cross-walked to these types.

2. and 3. Elevation. The elevational range given is an indication where the plant had been collected by Foxx and/or Tierney and during surveys done since 1980. If the collector was other than from LANL, Martin and Hutchins (1980) was consulted for the elevational range. This allows for sorting by elevation (e.g., 5400 ft or 6000 ft).

3.8 Revegetation

This category gives information on the potential for species to be used in revegetation. Much of the information in this category was taken from Dittberner and Olson (1983).

1. Potential Biomass Production. The relative genetic ability of a plant to produce plant material by weight on an annual basis compared to other members of the same life form.

- **high**—A plant possesses ability to produce a greater yield of dry plant material than most other species of the same life form. Examples of high producing species of different life forms are big bluestem (*Andropogon gerardii*), smooth brome (*Bromus inermis*), alfalfa (*Medicago sativa*), yellow sweetclover (*Melilotus officinalis*), big sagebrush (*Artemisia tridentata*), and Engelmann spruce (*Picea engelmannii*).

- **medium**—A plant produces an average yield of dry plant material as compared to other species of the same life form. Examples of medium producing species of different life forms are timothy (*Phleum pratense*), Kentucky bluegrass (*Poa pratensis*), common sunflower (*Helianthus annus*) limber pine (*Pinus flexilis*), and boxelder (*Acer negundo*).

- **low**—A plant produces a low yield of dry plant material as compared to other species of the same life form. Examples of low producing species of different life forms are cheatgrass (*Bromus tectorum*), northern bedstraw (*Galium boreale*), broom snakeweed (*Gutierrezia sarothrae*), and bearberry (*Arctostaphylos uva-ursi*).

- **very low**—A plant produces a very low yield of dry plant material as compared to other species of the same life form. Examples of very low producing species of different life forms are ring muhly (*Muhlenbergia torreyi*), harebell (*Campanula rotundifolia*), and cushion coryphantha (*Corypantha vivipara*).

2, 3, and 4. Gentle, Moderate, and Steep Slopes. These categories represent the ability of a plant to grow on different degrees of slope from gentle to steep. The major reference is from Dittberner and Olson (1983), most specifically for Colorado.

5. Erosion Control Potential. A plant that commonly exhibits growth habit, plant structure, biomass and/or root system that has the potential to reduce soil erosion in the area. The major reference is Dittberner and Olson, (1983), Colorado.

- **high**—A plant that has aggressive growth habits, persistent plant structure, high potential biomass, and/or a good soil-binding root-rhizome-runner system in established stands.

- **medium**—A plant that has moderately aggressive growth, moderately persistent plant structure, moderately potential biomass, and/or a moderate soil-binding root-rhizome-runner system in established stands.

- low—A plant that has poor growth, persistence, biomass, and/or a soil-binding root system that makes it generally inadequate for erosion control.

6. Establishment Requirements. The relative extent of cultural practices that must be employed to ensure a successful planting of the species on sites to which it is adapted in the area.

- high—Species requires elaborate or intensive cultural practices (e.g., irrigation, special seed treatments, containerized seedlings).

- medium—Species requires standard tillage practices or special cultural practices of short duration (e.g., plowing and/or discing and drilling).

- low—Species requires only minimal cultural practices (e.g., pioneer or invader species).

7. Short-term Revegetation Potential. The ability of a plant to become quickly established and exhibit rapid growth within 1 to 3 years (includes annuals).

- high—A plant demonstrates rapid growth, good cover, and good reproduction.

- medium—A plant demonstrates moderately rapid growth, fair cover, and fair reproduction.

- low—A plant demonstrates slow growth, poor cover, and poor reproduction.

8. Long-term Revegetation Potential. The ability of a plant to become established and persist over a period of more than 3 years in Colorado, Montana, North Dakota, Utah, or Wyoming.

- high—A plant demonstrates good growth, cover, reproduction, and stand maintenance characteristics.

- medium—A plant demonstrates fair growth, cover, reproduction, and stand maintenance characteristics.

- low—A plant demonstrates poor growth, cover, reproduction, and stand maintenance.

3.9 Origins and Biological Information

The biological and origins information was taken from Foxx and Tierney (1985), Martin and Hutchins (1980), and Dittberner and Olson (1983).

1. Origin. A determination if a plant has been introduced.

- native—A plant is in a natural part of the flora.

- introduced—A plant has been introduced into the environment by man or animals.

2. Reproduction Type. The sexual or asexual process by which a plant generates others of the same kind.

- sexual—The plant reproduces by pollination and fertilization.

- **vegetative**—All cases where structures such as bulbil, tuber stolons, and rhizomes, which are normally accessory means of reproduction, take over the whole reproductive processes of a plant.

- **apomictic**—The plant has a type of reproduction that results in the formation of seeds and embryos by a nonsexual process.

- **vegetative-sexual**—The plant reproduces vegetatively and sexually.

- **sexual-apomictic**—The plant reproduces sexually and apomicticly.

- **vegetative-sexual-apomictic**—The plant reproduces vegetatively, sexually, and apomicticly.

- **vegetative-apomictic**—The plant reproduces vegetatively and apomicticly.

3. Carbon Dioxide Fixation. The biochemical and physiological mechanism associated with the incorporation of CO2 and its ultimate conversion into carbohydrates.

- **C3**—The plant uses a pathway where the first step in CO2 fixation involves the formation of three-carbon compounds, the stomata are opened, and CO2 fixation is in the daylight.

- **C4**—The plant uses a pathway where the first step in CO2 fixation involves the formation of four-carbon compounds, the stomata are open, and CO2 is fixed in the daylight.

- **CAM (crassulaceous acid metabolism)**—The plant uses a pathway where the first step in CO2 fixation involves the formation of four-carbon compounds, the stomata are open, and CO2 is fixed in the dark.

- **other**—The plant uses other types of pathway (e.g., is intermediate between C3 and C4 plants).

- **none**—The plant does not fix carbon dioxide (i.e., nongreen parasitic or saprophytic plants).

4. Trophic Status. A plant's method of nutrient procurement.

- **autotrophic**—The plant is capable of self-nutrition; can use carbon, nitrogen, and sulfur in organic combinations and obtain energy from the sunlight.

- **parasitic**—The plant lives on and/or in other living organisms and obtains some or all of its nutrients from the host.

- **saprophytic**—The plant lives on and/or in dead organic material and obtains nutrients from it.

- **symbiotic**—The plant lives in close association with another plant and the symbiots derive nutritional requirements from each other.

5, 6, and 7. Anthesis. This is the time of flowering for angiosperms, or pollination for gynosperms. Most of this information was obtained from herbarium specimens and major floras for the areas. This information was taken from Dittberner and Olson (1983) primarily for Colorado.

3.10 Soils

Growth on Soils. The relative ability of a plant to show the full development of all phases of its growth potential on a particular soil texture or soil type where the plant normally occurs in Colorado, Montana, North Dakota, Utah, or Wyoming. This information was obtained from Dittberner and Olson (1983).

- good—The plant is highly adapted to growth on a particular soil texture or soil type.
- fair—The plant is moderately adapted to growth on a particular soil texture or soil type.
- poor—The plant shows little or no adaptability to growth on a particular soil texture or soil type.

3.11 Wildlife

This file contains information about the cover and food value of some of the species. This information was obtained from Dittberner and Olson (1983), primarily for Colorado.

Cover Value. The degree to which a plant provides environmental protection (i.e., thermal, nesting, brooding, or feeding cover) during one or more seasons for wildlife species.

- good—A plant is readily utilized for cover when available.
- fair—A plant is moderately utilized for cover when available.
- poor—A plant is rarely or never utilized for cover when available.

3.12 Ethnographic Information

The ethnographic information has been taken from a variety of ethnologies produced in the early 1900s. Each ethnography was searched and the information was included in five separate files. The various references used are noted under 5.7 of the reference list.

- Native American Tribal Uses
- Medicines and Dyes
- Construction and Weapons
- Household Use and Poisons
- Ceremonial Uses and Food

4.0 Acknowledgments

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Such a checklist and data base is continually evolving. We hope that this iteration adds to the knowledge of the area and provides a base on which to continue to build.

Terelane S. Foxx

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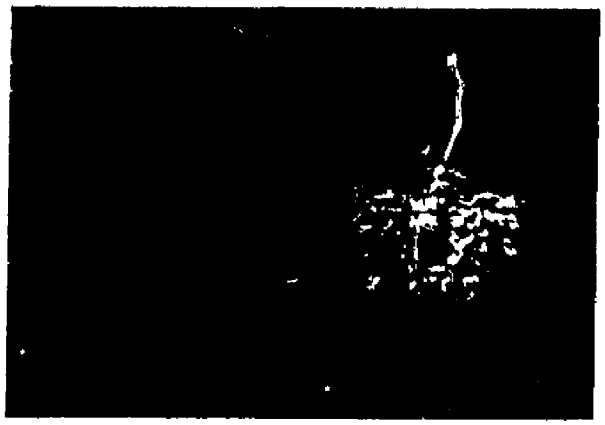

APPENDIX A

Nomenclature

Martin & Hutchins (1980) Species Identification	USDA NRCS PLANTS Database (1995)	Acronym
Abies concolor (Gord. & Glend.) Hoopes	Abies concolor (Gord. & Glend.) Lindl. ex Hildebr.	abco
Abies lasiocarpa (Hook.) Nutt. var. lasiocarpa	Abies lasiocarpa var. lasiocarpa (Hook.) Nutt.	abla
Acer glabrum var. neomexicanum (Greene) K. & P.	Acer glabrum var. neomexicanum (Greene) Kearney & Peebles	acgl2
Acer negundo L. var. interius (Britt.) Sarg.	Acer negundo var. interius (Britt.) Sarg.	acne2
Achillea lanulosa Nutt. subsp. lanulosa	Achillea millefolium var. occidentalis DC.	acmo
Aconitum columbianum Nutt.	Aconitum columbianum Nutt.	acco4
Actaea arguta Nutt. var. viridiflora (Greene) Isely	Actaea arguta Nutt. var. viridiflora (Greene) Robinson	acav
Aegopodium podagraria L.	Aegopodium podagraria L.	acep
Agastache pallidiflora (Heller) Rydb.	Agastache pallidiflora (Heller) Rydb.	agpa
Agoseris aurantiaca Greene	Agoseris aurantiaca Greene	agau5
Agoseris aurantiaca (Hook.) Greene	Agoseris aurantiaca (Hook.) Greene	agau2
Agoseris glauca (Pursh) Dietr. var. glauca	Agoseris glauca var. glauca (Pursh) Raf.	agglg
Agoseris glauca var. parviflora (Nutt.) Rydb.	Agoseris glauca var. parviflora (Nutt.) Rydb.	agglp
Agrimonia gryposepala Wallr.	Agrimonia gryposepala Wallr.	agrg2
Agrimonia striata Michx.	Agrimonia striata Michx.	agst
Agropyron dasystachyum (Hook.) Scribn.	Agropyron dasystachyum (Hook.) Scribn. & J. G. Smith	agda
Agropyron desertorum (Fisch.) Schult.	Agropyron desertorum (Fisch. ex Link) J. A. Schultes	agde2
Agropyron latiglume (Scribn. & Smith) Rydb.	Agropyron latiglume (Scribn. & J. G. Smith) Rydb.	agla3
Agropyron pseudobrevipilum Scribn. & Smith	Agropyron pseudobrevipilum Scribn. & J. A. Smith	agps
Agropyron repens (L.) Beauv.	Agropyron repens (L.) Beauv.	agre2
Agropyron smithii Rydb.	Agropyron Smithii Rydb.	agsm
Agropyron subsecundum (Link) Hitchc.	Agropyron subsecundum (Link) A. S. Hitchc.	agsu
Agropyron trachycaulum (Link) Malte	Agropyron trachycaulum (Link) Malte ex H. F. Lewis	agtr
Agrostis alba L.	Agrostis alba auct. non L.	agal3
Agrostis exarata Trin.	Agrostis exarata Trin.	agex
Agrostis idahoensis Nash	Agrostis idahoensis Nash	agid
Agrostis perennans (Walt.) Tuckerm.	Agrostis perennans (Walt.) Tuckerman	agpe
Agrostis scabra Willd.	Agrostis scabra Willd.	agsc5
Agrostis semiverta (Lam.) C. Ore.	Agrostis semiverta (Lam.) C. Clayton	agse2
Agrostis stolonifera L.	Agrostis stolonifera L.	agst2
Alnus alnobetula (Hill.) Schneid.	Alnus alnobetula (P. Mill.) Schneid.	al	
Alnus incana Moench var. occidentalis Cockll.	Alnus incana var. occidentalis Cockerell ex J. F. Macbr.	alco	
Alnus geyeri Wats.	Alnus geyeri S. Wats.	alge	
Alnus macrophylla Rydb.	Alnus macrophylla Rydb.	almaf	
Alnus tenuifolia Nutt. & Macbr.	Alnus tenuifolia A. Nels. & J. F. Macbr.	alte	
Alnus oblongifolia Torr.	Alnus oblongifolia Torr.	alob2	
Alnus tenuifolia Nutt.	Alnus tenuifolia Nutt.	alte2	
Alopecurus aequalis Sobol.	Alopecurus aequalis Sobol.	alae	
Althaea rosea Cav.	Alcea rosea (L.) Cav.	alro4	

Nomenclature

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Amaranthus albus L.	Amaranthus albus L.	amal
Amaranthus graecizans L.	Amaranthus graecizans auct. non L.	amgr
Amaranthus hybridus L.	Amaranthus hybridus L.	amhy
Amaranthus leucocarpus Wats	Amaranthus leucocarpus S. Wats	amle2
Amaranthus palmeri Wats	Amaranthus palmeri S. Wats	ampa
Amaranthus powellii Wats	Amaranthus powellii S. Wats	ampo2
Amaranthus retroflexus L.	Amaranthus retroflexus L.	amre
Amaranthus torreyi (Gray) Benth	Amaranthus torreyi auct. non (Gray) Benth. ex S. Wats	amto
Ambrosia artemisiifolia L.	Ambrosia artemisiifolia L.	amar2
Ambrosia psilostachya DC	Ambrosia psilostachya DC.	amps
Amelanchier bakeri Greene	Amelanchier bakeri Greene	amba5
Amelanchier oreophila A. Nels	Amelanchier oreophila A. Nels	amor2
Amelanchier polycarpa Greene	Amelanchier polycarpa Greene	ampo5
Amelanchier utahensis Koehne	Amelanchier utahensis Koehne	amut
Amorpha canescens Pursh	Amorpha canescens Pursh	amca6
Amorpha fruticosa L. var. angustifolia Pursh	Amorpha fruticosa var. angustifolia Pursh	amfra
Amorpha nana Nutt.	Amorpha nana Nutt.	amna
Anagallis arvensis L.	Anagallis arvensis L.	anar
Anaphalis margaritacea (L.) Gray	Anaphalis margaritacea (L.) Benth. & Hook. f.	anma
Andropogon barbinodis Lag	Andropogon barbinodis Lag	arba6
Andropogon gerardii Vitman	Andropogon gerardii Vitman	ange
Andropogon hallii Hack.	Andropogon hallii Hack.	anha
Andropogon saccharoides Sw.	Andropogon saccharoides Sw.	ansa5
Andropogon scoparius Michx.	Andropogon scoparius Michx.	ansc10
Andropogon springfeldii Gould	Andropogon springfeldii Gould	ansp5
Andropogon wrightii Hack.	Andropogon wrightii Hack.	anwr5
Androsace septentrionalis L. var. subulifera Gray	Androsace septentrionalis var. subulifera Gray	ansep
Anemone cylindrica Gray	Anemone cylindrica Gray	ancy
Angelica pinnata Wats.	Angelica pinnata S. Wats.	anpi2
Anoda cristata var. digitata (Gray) Hochr.	Anoda cristata var. digitata (Gray) Hochr.	ancrd
Antennaria marginata Greene	Antennaria marginata Greene	anma5
Antennaria parvifolia Nutt.	Antennaria parvifolia Nutt.	anpa4
Antennaria rosea (D. C. Eaton) Greene	Antennaria rosea (DC. Eaton) Greene	anro2
Antennaria rosulata Rydb.	Antennaria rosulata Rydb.	anro3
Aphanostephus arizonicus Gray	Aphanostephus arizonicus Gray	apar
Apocynum androsaemifolium L. var androsaemifolium	Apocynum androsaemifolium var androsaemifolium L.	apan
Apocynum cannabinum var. glaberrimum A. DC.	Apocynum cannabinum var. glaberrimum A. DC.	apca4
Apocynum medium Greene var. floribundum (Greene) Woodson	Apocynum medium var. floribundum (Greene) Woods	apme4
Aquilegia coerulea James	Aquilegia coerulea James	aqco

Nomenclature

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Aquilegia chrysantha Gray	Aquilegia chrysantha Gray	aqch
Aquilegia elegantula Greene	Aquilegia elegantula Greene	aqel
Aquilegia triternata Payson	Aquilegia triternata Payson	aqtr
Arabis divaricarpa A. Nels	Arabis X divaricarpa A. Nels. (pro sp.)	ardi2
Arabis drummondii Gray	Arabis drummondii Gray	ardr
Arabis fendleri (Wats.) Greene var. fendleri	Arabis fendleri var. fendleri (S. Wats.) Greene	arfel
Arabis glabra (L.) Bernh.	Arabis glabra (L.) Bernh.	argl
Arabis hirsuta (L.) Scop. var. pycnocarpa (Hopkins) Rollins	Arabis hirsuta var. pycnocarpa (M. Hopkins) Rollins	arhp
Arabis holboellii Hornem. var. retrofracta (Graham) Rydb.	Arabis holboellii var. retrofracta (Graham) Rydb.	arhor
Arabis perennans Wats.	Arabis perennans S. Wats.	arpe2
Aralia racemosa L.	Aralia racemosa L.	ara
Arceuthobium divaricatum Engelm.	Arceuthobium divaricatum Engelm.	ard3
Arceuthobium douglasii Engelm.	Arceuthobium douglasii Engelm.	ardo
Arceuthobium vaginatum (Willd.) Presl. subsp. cryptopodum (Engelm.) H.S.W.	Arceuthobium vaginatum ssp. cryptopodum (Engelm.) Hawksworth & Wiens	avac
Arctostaphylos pungens H. B. K.	Arctostaphylos pungens Kunth	arpu5
Arctostaphylos uva-ursi (L.) Spreng.	Arctostaphylos uva-ursi (L.) Spreng.	aruv
Arenaria confusa Rydb.	Arenaria confusa Rydb.	arco14
Arenaria fendleri Gray var. fendleri	Arenaria fendleri var. fendleri Gray	arfel3
Arenaria fendleri var. brevifolia (Maguire) Maguire	Arenaria fendleri var. brevifolia (Maguire) Maguire	arfeb
Arenaria macrophylla Hook.	Arenaria macrophylla Hook.	arma18
Aristida adscensionis L.	Aristida adscensionis L.	arad
Aristida arizonica Vasey	Aristida arizonica Vasey	are6
Aristida barbata Fourn.	Aristida barbata Fourn.	arba
Aristida divaricata Humb. & Bonpl.	Aristida divaricata Humb. & Bonpl. ex Willd.	ard5
Aristida fendleriana Steud.	Aristida fendleriana Steud.	arfe4
Aristida longiseta Steud.	Aristida longiseta Steud.	arlo3
Aristida purpurea Nutt.	Aristida purpurea Nutt.	arpu9
Artemisia bigelovii Gray	Artemisia bigelovii Gray	arbi3
Artemisia campestris subsp. pacifica (Nutt.) H. & C.	Artemisia campestris ssp. pacifica (Nutt.) Hall & Clements	arcap2
Artemisia cana Pursh	Artemisia cana Pursh	arca13
Artemisia carruthii Wood	Artemisia carruthii Wood ex Carruth.	arcaw2
Artemisia dracunculus L.	Artemisia dracunculus L.	ardr4
Artemisia filifolia Torr.	Artemisia filifolia Torr.	arfi2
Artemisia franserioides Greene	Artemisia franserioides Greene	arfr3
Artemisia frigida Willd.	Artemisia frigida Willd.	arfr4
Artemisia ludoviciana Nutt. subsp. albula (Woot.) Fern.	Artemisia ludoviciana ssp. albula (Woot.) Fern.	arlua
Artemisia ludoviciana Nutt. subsp. ludoviciana	Artemisia ludoviciana ssp. ludoviciana Nutt.	arlu2
Artemisia ludoviciana Nutt. subsp. mexicana (Willd.) Fern.	Artemisia ludoviciana ssp. mexicana (Willd. ex Spreng.) Fern.	arlum2
Artemisia ludoviciana Nutt. subsp. sulcata (Rydb.) Fern.	Artemisia ludoviciana ssp. sulcata (Rydb.) Fern.	arlus

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Artemisia ludoviciana subsp. redulena (Gray) Beck	Artemisia ludoviciana ssp. redulena (Gray) Beck	arlur
Artemisia tridentata Nutt.	Artemisia tridentata Nutt.	artr2
Asclepias asperula (Dene) Woodson subsp. asperula	Asclepias asperula ssp. asperula (Dene) Woods	assas
Asclepias engelmanniana Woodson	Asclepias engelmanniana Woods	asen
Asclepias involucrata Engelm.	Asclepias involucrata Engelm. ex Torr.	asin16
Asclepias macrotis Torr.	Asclepias macrotis Torr.	asma
Asclepias speciosa Torr.	Asclepias speciosa Torr.	assp
Asclepias subverticillata (Gray) Vail	Asclepias subverticillata (Gray) Vail	assu2
Asclepias tuberosa L. subsp. terminalis Woodson	Asclepias tuberosa ssp. terminalis Woods	astut
Asclepias viridiflora Raf.	Asclepias viridiflora Raf.	asvi
Asparagus officinalis L.	Asparagus officinalis L.	asof
Asplenium trichomanes L.	Asplenium trichomanes L.	astr2
Aster ericoides L.	Aster ericoides L.	aser3
Aster fendleri Gray	Aster fendleri Gray	asfe
Aster foliaceus Lindl.	Aster foliaceus Lindl. ex DC.	asfo
Aster glaucodes Blake var. glaucodes	Aster glaucodes var. glaucodes Blake	asgl3
Aster hesperius Gray	Aster hesperius Gray	ashe
Aster laevis L.	Aster laevis L.	asla5
Aster novae angliae L.	Aster novae angliae L.	asno
Aster occidentalis (Nutt.) Torr. & Gray	Aster occidentalis (Nutt.) Torr. & Gray	asoc
Aster pauciflorus Nutt.	Aster pauciflorus Nutt.	aspa8
Aster praealtus Poir.	Aster praealtus Poir.	aspr2
Astragalus agrestis Dougl.	Astragalus agrestis Dougl. ex G. Don	asag2
Astragalus amphiocrys (Gray) Rydb.	Astragalus amphiocrys Gray	asam5
Astragalus bisulcatus (Hook.) Gray	Astragalus bisulcatus (Hook.) Gray	asbi2
Astragalus crassicarpus Nutt.	Astragalus crassicarpus Nutt.	ascr2
Astragalus emoryanus (Rydb.) Cory	Astragalus emoryanus (Rydb.) Cory	asem2
Astragalus flexuosus Dougl.	Astragalus flexuosus (Hook.) Dougl. ex G. Don	asfl2
Astragalus gracilis Nutt.	Astragalus gracilis Nutt.	asgr3
Astragalus humistratus Gray	Astragalus humistratus Gray	ashu2
Astragalus lentiginosus var. neomexicanus (Barneby) Barneby	Astragalus lentiginosus var. neomexicanus (Barneby) Barneby	asle6
Astragalus lentiginosus Dougl. ex Hook.	Astragalus lentiginosus Dougl. ex Hook.	asle8
Astragalus lonchocarpus Torr.	Astragalus lonchocarpus Torr.	aslo3
Astragalus missouriensis Nutt. var. missouriensis	Astragalus missouriensis var. missouriensis Nutt.	asmis5
Astragalus mollissimus Torr.	Astragalus mollissimus Torr.	asmo7
Astragalus praelongus Sheld.	Astragalus praelongus Sheldon	aspr5
Astragalus shortianus Nutt.	Astragalus shortianus Nutt.	assh3
Athyrium filix-femina (L.) Roth ex. Martens var. californicum Butters	Athyrium filix-femina var. californicum Butters	atfic3
Atriplex canescens (Pursh) Nutt.	Atriplex canescens (Pursh) Nutt.	atca2

Nomenclature

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Atriplex patula L.	Atriplex patula L.	atpa4
Bahia biternata Gray	Bahia biternata Gray	baba3
Bahia dissecta (Gray) Britt	Bahia dissecta (Gray) Britt	badi
Bahia neomexicana Gray	Bahia neomexicana (Gray) Gray	bane
Bahia oblongifolia Gray	Bahia oblongifolia (Gray) Gray	baob2
Baileya multiradiata Harv. & Gray	Baileya multiradiata Harvey & Gray ex Gray	bamu
Bassia hyssopifolia (Pall.) Kuntze	Bassia hyssopifolia (Pallas) Kuntze	bahy
Beckmannia syzigachne (Steud.) Fern.	Beckmannia syzigachne (Steud.) Fern.	besy
Berberis fendleri Gray	Berberis fendleri Gray	befe
Berberis repens Lindl.	Berberis repens Lindl.	bere
Berlandiera lyrata Benth.	Berlandiera lyrata Benth.	bely
Betula erecta (Hods.) Coville	Betula erecta (Hods.) Coville	beer
Besseya plantaginea (James) Rydb.	Besseya plantaginea (James) Rydb.	bepl
Betula occidentalis Hook.	Betula occidentalis Hook.	beoc2
Bidens bigelovii Gray	Bidens bigelovii Gray	bibi
Bidens bipinnata L. var. bipinnata	Bidens bipinnata L.	bibi7
Bidens cernua L.	Bidens cernua L.	bice
Bidens cosmosa (Gray) Wieg.	Bidens cosmosa (Gray) Wieg.	bico3
Bidens frondosa L.	Bidens frondosa L.	bifr
Blepharoneuron tricholepis (Torr.) Nash	Blepharoneuron tricholepis (Torr.) Nash	bitr
Boerhavia coulteri (Hook.) I.J.S. Watts	Boerhavia coulteri (Hook.) I.J.S. Watts	boco2
Botrychium multifidum (S. G. Gmel.) Rupr. subsp. coulteri (Underw.) Clausen	Botrychium multifidum ssp. coulteri (Underwood) Brown	bomuc3
Bouteloua aristidoides (H. B. K.) Griseb.	Bouteloua aristidoides (Kunth) Griseb.	boar	
Bouteloua barbata Lag.	Bouteloua barbata Lag.	bobar2
Bouteloua curtipendula (Mich.) Torr.	Bouteloua curtipendula (Mich.) Torr.	bocu
Bouteloua eriopoda (Torr.) Torr.	Bouteloua eriopoda (Torr.) Torr.	boer4
Bouteloua gracilis (H. B. K.) Lag.	Bouteloua gracilis (Willd. ex Kunth) Lag. ex Griffiths	bogr2
Bouteloua hirsuta Lag.	Bouteloua hirsuta Lag.	bohi2
Bouteloua simplex Lag.	Bouteloua simplex Lag.	bosi2
Brassica juncea (L.) Czern.	Brassica juncea (L.) Czern.	bija
Brassica nigra (L.) Koch	Brassica nigra (L.) W. D. J. Koch	bini
Brickellia betonicifolia Gray	Brickellia betonicifolia Gray	bibe
Brickellia brachyphylla Gray	Brickellia brachyphylla (Gray) Gray	bibr2
Brickellia californica (Torr. & Gray) Gray	Brickellia californica (Torr. & Gray) Gray	bica3
Brickellia fendleri Gray	Brickellia fendleri Gray	bife
Brickellia grandiflora (Hook.) Nutt.	Brickellia grandiflora (Hook.) Nutt.	bigr
Bromus anomalus Rupr.	Bromus anomalus Rupr. ex Fourn.	bran
Bromus catharticus Vahl	Bromus catharticus Vahl	bica6
Bromus ciliatus L.	Bromus ciliatus L.	bici2

Nomenclature

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Bromus tectorum (Shear) Wood. & Stand	Bromus tectorum (Shear) Wood. & Stand	brte2
Bromus inermus Leyess	Bromus inermus Leyess	brin2
Bromus japonicus Thunb	Bromus japonicus Thunb. ex Murr.	brja
Bromus tectorum (Shear) Rydb.	Bromus tectorum (Shear) Rydb	brte6
Bromus marginatus Nees	Bromus marginatus Nees ex Steud	brma4
Bromus purgans L.	Bromus purgans L.	brpu4
Bromus tectorum L.	Bromus tectorum L.	brte
Buchloe dactyloides (Nutt.) Engelm.	Buchloe dactyloides (Nutt.) Engelm.	buda
Calochortus gunnisoni Wats	Calochortus gunnisoni S. Wats	cagu
Calochortus nuttallii Torr. & Gray	Calochortus nuttallii Torr. & Gray	canu3
Calyophus hartwegii (Benth.) Raven	Calyophus hartwegii (Bunch.) Raven	caha14
Calypso bulbosa (L.) Oakes	Calypso bulbosa (L.) Oakes	cabu
Camelina microcarpa Andrz.	Camelina microcarpa DC.	cami2
Campanula parryi Gray	Campanula parryi Gray	capa10
Campanula rotundifolia L.	Campanula rotundifolia L.	caro2
Capsella bursa pastoris (L.) Medic	Capsella bursa pastoris (L.) Medik	cabu2
Cardamine cordifolia Gray	Cardamine cordifolia Gray	cacc6
Cardaria draba (L.) Desv.	Cardaria draba (L.) Desv.	cadr
Carduus nutans L.	Carduus nutans L.	canu4
Carex aquatilis Wahlenb.	Carex aquatilis Wahlenb.	caaq
Carex bella Bailey	Carex bella Bailey	cabe3
Carex bolanderi Olney	Carex bolanderi Olney	cabo2
Carex brevior (Dewey) Mack.	Carex brevior (Dewey) Mackenzie	cabr10
Carex canescens L.	Carex canescens L.	caca11
Carex douglasii Boott	Carex douglasii Boott.	cado2
Carex eleocharis Bailey	Carex eleocharis Bailey	cael2
Carex festivella Mack.	Carex festivella Mackenzie	cafe2
Carex foenea Willd.	Carex foenea Willd.	cafo3
Carex geophila Mack.	Carex geophila Mackenzie	cage
Carex hystericina Mühl	Carex hystericina Mühl. ex Willd	cahy4
Carex interior Bailey	Carex interior Bailey	cain11
Carex lanuginosa Michx.	Carex lanuginosa Michx.	cala30
Carex nebrascensis Dewey	Carex nebrascensis Dewey	cane2
Carex occidentalis Bailey	Carex occidentalis Bailey	caoc2
Carex praegracilis W. Boott	Carex praegracilis W. Boott	capr5
Carex scoparia Schkuhr	Carex scoparia Schkuhr ex Willd	casc11
Carex stipata Muhl	Carex stipata Muhl.	cast5
Carex serotina Bailey	Carex serotina Bailey	case
Castilleja cordata Greene	Castilleja cordata Greene	cacc49

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Castilleja [illegible] ga Gray	Castilleja integra Gray	cain14
Castilleja linariaefolia Benth.	Castilleja linariifolia Benth.	cali4
Castilleja lineata Greene	Castilleja lineata Greene	cali5
Castilleja miniata Dougl.	Castilleja miniata Dougl. ex Hook.	cami12
Castilleja minor Gray	Castilleja minor (Gray) Gray	cami13
Castilleja rhexifolia Rydb.	Castilleja rhexifolia Rydb.	carh4
Ceanothus fendleri Gray	Ceanothus fendleri Gray	cefe
Celtis reticulata Torr.	Celtis reticulata Torr.	cere2
Cenchrus echinatus L.	Cenchrus echinatus L.	cece
Cenchrus pauciflorus Benth.	Cenchrus pauciflorus Benth.	cepa12
Centaurium calycosum (Buckl.) Fern.	Centaurium calycosum (Buckl.) Fern.	ceca3
Cerastium arvense L.	Cerastium arvense L.	cear4
Cerastium brachypodum (Engelm.) Robbins	Cerastium brachypodum (Engelm. ex Gray) B. L. Robins.	cebr3
Cerastium vulgatum L.	Cerastium vulgatum L. 1762, non 1755	cevu
Cerocarpus montanus Raf. var. montanus	Cerocarpus montanus var. montanus Raf.	cemon4
Cerocarpus montanus var. paucidentatus (Wats.) F. L. Martin	Cerocarpus montanus var. paucidentatus (S. Wats.) F. L. Martin	cemop
Chamaesaracha coniodes (Moric.) Britt.	Chamaesaracha coniodes (Moric. ex Dunal) Britt.	chco
Chamaesaracha coronopus (Dunal) Gray	Chamaesaracha coronopus (Dunal) Gray	chco2
Chelanthes feei Moore	Chelanthes feei T. Moore	chfe
Chelanthes fendleri Hook.	Chelanthes fendleri Hook.	chfe2
Chelanthes tomentosa Link	Chelanthes tomentosa Link	chto2
Chelanthus eatonii Hook.	Chelanthes eatonii Baker	chea
Chenopodium altescens Small	Chenopodium altescens Small	chal6
Chenopodium album L.	Chenopodium album L.	chal7
Chenopodium berlanderi Moq.	Chenopodium berlandieri Moq.	chbe4
Chenopodium capitatum (L.) Asch.	Chenopodium capitatum (L.) Ambrosi	chca4
Chenopodium cycloides A. Nels.	Chenopodium cycloides A. Nels.	chcy
Chenopodium desiccatum A. Nel. var. desiccatum	*Chenopodium desiccatum A. Nel.*	chde
Chenopodium desiccatum var. leptophylloides (Moq.)	Chenopodium desiccatum var. leptophylloides (J. Mor.) H. A. Wadd.	chdel2
Chenopodium fremontii Wats.	Chenopodium fremontii S. Wats.	chfr3
Chenopodium gigantospermum Aellen	Chenopodium gigantospermum Aellen	chgi2
Chenopodium glaucum L.	Chenopodium glaucum L.	chgl3
Chenopodium graveolens Wild. var. neomexicanum	Chenopodium graveolens var. neomexicanum (Aellen) Aellen	chgra
Chenopodium incanum (Wats.) Heller	Chenopodium incanum (S. Wats.) Heller	chin2
Chenopodium leptophyllum Nutt.	Chenopodium leptophyllum (Moq.) Nutt. ex S. Wats.	chle4
Chenopodium rubrum L.	Chenopodium rubrum L.	chru
Chenopodium watsonii A. Nels.	Chenopodium watsonii A. Nels.	chwa
Chimaphila umbellata (L.) Nutt.	Chimaphila umbellata (L.) W. Bart.	chum
Chloris virgata Sw.	Chloris virgata Sw.	chvi4

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Chrysopsis villosa (Pursh) Nutt	Chrysopsis villosa (Pursh) Nutt. ex DC.	chvi10
Chrysothamnus nauseosus subsp. bigelovii (Gray) H. & C.	Chrysothamnus nauseosus ssp. bigelovii (Gray) Hall & Clements	chnab2
Chrysothamnus nauseosus subsp. latisquameus (Gray) H. & C.	Chrysothamnus nauseosus ssp. latisquameus (Gray) Hall & Clements	chnal2
Chrysothamnus parryi (Gray) Greene subsp. attenuatus (M. E. Jones) H. & C.	Chrysothamnus parryi ssp. attenuatus (M. E. Jones) Hall & Clements	chpaa4
Chrysothamnus parryi (Gray) Greene subsp. howardii (Parry) H. & C.	Chrysothamnus parryi ssp. howardii (Parry ex Gray) Hall & Clements	chpah
Chrysothamnus viscidiflorus (Hook.) Nutt. subsp. viscidiflorus	Chrysothamnus viscidiflorus var. viscidiflorus (Hook.) Nutt.	chvv4
Cicuta douglasii (DC.) Coult. & Rose	Cicuta douglasii (DC.) Coult. & Rose	cida
Circaea alpina L.	Circaea alpina L.	cial
Cirsium neomexicanum Gray	Cirsium neomexicanum Gray	cine
Cirsium ochrocentrum Gray	Cirsium ochrocentrum Gray	cioc2
Cirsium pallidum Wood. & Standl.	Cirsium pallidum Wood. & Standl.	cipa5
Cirsium parryi (Gray) Petrak	Cirsium parryi (Gray) Petrak	cipa
Cirsium pulchellum (Greene) Wood. & Standl.	Cirsium pulchellum (Greene) Wood. & Standl.	cipu2
Cirsium undulatum (Nutt.) Spreng.	Cirsium undulatum (Nutt.) Spreng.	ciun
Cirsium vulgare (Savi) Ten.	Cirsium vulgare (Savi) Ten.	civu
Clematis drummondii Torr. & Gray	Clematis drummondii Torr. & Gray	cldr
Clematis ligusticifolia Nutt.	Clematis ligusticifolia Nutt.	cli2
Clematis pseudoalpina (Kuntze) Nels.	Clematis pseudoalpina (Kuntze) A. Nels.	clps2
Cleome serrulata Pursh	Cleome serrulata Pursh	cle
Chenopodium vulgare L.	Chenopodium vulgare L.	chvu
Collomia linearis Nutt.	Collomia linearis Nutt.	col2
Comandra pallida A. DC.	Comandra pallida A. DC.	copa26
Commelina dianthifolia Delile	Commelina dianthifolia Delile	co54
Conopholis mexicana Gray	Conopholis mexicana Gray ex S. Wats.	coma7
Convolvulus arvensis L.	Convolvulus arvensis L.	coar4
Convolvulus sepium L.	Convolvulus sepium L.	cose14
Conyza canadensis (L.) Cronq.	Conyza canadensis (L.) Cronq.	coca5
Corallorhiza maculata Raf.	Corallorhiza maculata (Raf.) Raf.	coma4
Corallorhiza striata Lindl.	Corallorhiza striata Lindl.	cost
Cordylanthus wrightii Gray	Cordylanthus wrightii Gray	cowr2
Coreopsis cardaminefolia (DC.) Torr. & Gray	Coreopsis cardaminefolia (DC.) Torr. & Gray	cocal2
Coreopsis tinctoria Nutt.	Coreopsis tinctoria Nutt.	co63
Coriandrum sativum L.	Coriandrum sativum L.	cosa
Cornus stolonifera Michx.	Cornus stolonifera Michx.	cost4
Corydalis aurea Willd.	Corydalis aurea Willd.	coau2
Corypha vivipara (Nutt.) Brit. and Rose	Corypha vivipara (Nutt.) Brit. and Rose	Cavi6a2
Cosmos parviflorus (Jacq.) H.B.K.	Cosmos parviflorus (Jacq.) Pers.	copa12
Crataegus erythropoda Ashe	Crataegus erythropoda Ashe	cer
Croton texensis (Klotzsch) Muell. Arg.	Croton texensis (Klotzsch) Muell. Arg.	cote4

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Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Cryptantha fendleri (Gray) Greene	Cryptantha fendleri (Gray) Greene	cufe3
Cryptantha jamesii (Torr.) Payson	Cryptantha jamesii (Torr.) Payson	cuja2
Cryptantha minima Rydb.	Cryptantha minima Rydb.	cumi5
Cryptogramma crispa (L.) R. Br. var. acrostichoides (R. Br.) C. B. Clark	Cryptogramma crispa ssp. acrostichoides (R. Br.) Hulten	crcra2
Cucurbita foetidissima H. B. K.	Cucurbita foetidissima Kunth	cufo
Cuscuta campestris Yuncker	Cuscuta campestris Yuncker	cuca2
Cuscuta umbellata H.B.K.	Cuscuta umbellata Kunth	cuum
Cymopterus bulbosus A. Nels.	Cymopterus bulbosus A. Nels.	cybu
Cynodon dactylon (L.) Pers.	Cynodon dactylon (L.) Pers.	cyda
Cynosurus echinatus L.	Cynosurus echinatus L.	cyec
Cyperus aristatus Rottb.	Cyperus aristatus Rottb.	cyar3
Cyperus esculentus L.	Cyperus esculentus L.	cyes
Cyperus fendlerianus Boeckl.	Cyperus fendlerianus Boeckl.	cyfe2
Cyperus rivularis Kunth.	Cyperus rivularis Kunth.	cyri
Cypripedium calceolus L. var. pubescens (Willd.) Correll	Cypripedium calceolus var. pubescens (Willd.) Correll	cycap2
Cystopteris fragilis (L.) Bernh.	Cystopteris fragilis (L.) Bernh.	cyfr2
Dactylis glomerata L.	Dactylis glomerata L.	dagl
Dalea brachystachys (Gray) Heller	Dalea brachystachys Gray	dabr
Dalea formosa Torr.	Dalea formosa Torr.	dafo
Dalea leporina (Ait.) K. & P.	Dalea leporina (Ait.) Bullock	dale3
Dalea nana (Torr.) Heller	Dalea nana Torr. ex Gray	dana
Dalea polygonoides Gray	Dalea polygonoides Gray	dapo3
Dalea terminalis M. E. Jones	Dalea terminalis M. E. Jones	dater8
Danthonia intermedia Vasey	Danthonia intermedia Vasey	dain
Danthonia parryi Scribn.	Danthonia parryi Scribn.	dapa2
Danthonia spicata (L.) Beauv.	Danthonia spicata (L.) Beauv. ex Roemer & J. A. Schultes	dasp2
Datura meteloides D.C.	Datura meteloides DC. ex Dunal	dame2
Delphinium occidentale (Watts.) Watts	Delphinium X occidentale (S. Watts) S. Wats.	deoc
Delphinium virescens Nutt. subsp. wootonii (Rydb.) Ewan	Delphinium virescens ssp. wootonii (Rydb.) Ewan	devir
Deschampsia caespitosa (L.) Beauv.	Deschampsia caespitosa (L.) P. Beauv.	deca18
Descurainia obtusa (Greene) O. E. Schulz subsp. obtusa	Descurainia obtusa ssp. obtusa (Greene) O. E. Schulz	deobo
Descurainia pinnata (Walt.) Britt.	Descurainia pinnata (Walt.) Britt.	depi
Descurainia richardsonii (Sweet) O. E. Schulz	Descurainia richardsonii O. E. Schultanz	deri2
Descurainia richardsonii (Sweet) O. E. Schulz subsp. incisa (Engelm.) Detling	Descurainia richardsonii ssp. incisa (Engelm.) Detling	deri
Descurainia richardsonii (Sweet) O. E. Schulz subsp. procera (Greene) Detling	Descurainia richardsonii ssp. procera (Greene) Detling	derip
Descurainia sophia (L.) Webb.	Descurainia sophia (L.) Webb ex Prantl	desa2
Descurainia richardsonii (Sweet) O. E. Schulz subsp. viscosa (Rydb.) Detling	Descurainia richardsonii ssp. viscosa (Rydb.) Detling	deriv
Distichlis spicata L.	Distichlis spicata (L.) Greene	disp
Distichlis stricta (Torr.) Rydb.	Distichlis stricta (Torr.) Rydb.	dist3

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Dithyrea wislizenii Engelm.	Dithyrea wislizenii Engelm.	diw6
Dodecatheon alpinum (Gray) Greene	Dodecatheon alpinum (Gray) Greene	dcal
Dodecatheon pulchellum (Pursh) Merr.	Dodecatheon pulchellum (Pursh) Merr	dcpu
Draba aurea Vahl var. aurea	Draba aurea Vahl ex Hornem	draa
Draba fladniziana Greene var fladniziana	Draba fladniziana var fladniziana Greene	drafl
Draba rectifructa C. L. Hitchc.	Draba rectifructa C. L. Hitchc.	drre
Draba reptans (Lam.) Fern.	Draba reptans (Lam.) Fern.	drre2
Draba spectabilis Greene	Draba spectabilis Greene	drsp
Dryopteris filix-mas (L.) Schott	Dryopteris filix-mas (L.) Schott	dfil2
Dyssodia papposa (Vent.) Hitchc.	Dyssodia papposa (Vent.) A. S. Hitchc.	dypa
Dyssodia tenuiloba (Gray)	Dyssodia tenuiloba (Gray) B. L. & L. Robins.	dytl2
Echinocereus fendleri Engelm.	Echinocereus fendleri (Engelm.) F. Seitz	ecfe
Echinocereus triglochidiatus Engelm. var triglochidiatus	Echinocereus triglochidiatus var triglochidiatus Engelm.	ectri
Echinocereus triglochidiatus var. melanacanthus (Engelm.) L. Benson	Echinocereus coccineus var. coccineus Engelm	eccoc
Echinocereus viridiflorus Engelm. var viridiflorus	Echinocereus viridiflorus var viridiflorus Engelm	ecvir
Echinocactus cinegalli (L.) Beaux.	Echinocactus cinegalli (L.) Beaux.	ecci
Elaeagnus angustifolia L.	Elaeagnus angustifolia L.	elan
Eleocharis macrostachya Britt.	Eleocharis macrostachya Britt.	elma5
Elymus canadensis L.	Elymus canadensis L.	elca4
Elymus glaucus Buckl.	Elymus glaucus Buckl	elgl
Elymus virginicus L.	Elymus virginicus L.	elvi3
Ephedra torreyana Wats.	Ephedra torreyana S. Wats.	eptor
Ephedra viridis Cov. var viridis	Ephedra viridis var viridis Coville	epviv
Epilobium angustifolium L.	Epilobium angustifolium L.	epan2
Epilobium ciliatum Raf.	Epilobium ciliatum Raf.	epci
Epilobium oregonense Hausskn.	Epilobium oregonense Hausskn.	epor2
Epilobium paniculatum Nutt.	Epilobium paniculatum Nutt. ex Torr. & Gray	eppa2
Epipactis gigantea Dougl.	Epipactis gigantea Dougl. ex Hook.	epgi
Equisetum arvense L.	Equisetum arvense L.	eqar
Equisetum hyemale L.	Equisetum hyemale L.	eqhy
Equisetum laevigatum A. Br.	Equisetum laevigatum A. Braun	eqla
Eragrostis avida Hitchc.	Eragrostis avida A. S. Hitchc.	erav
Eragrostis barrelieri Daveau	Eragrostis barrelieri Daveau	erba2
Eragrostis cilianensis (All.) Link	Eragrostis cilianensis (All.) Lut ex Janchen	erci
Eragrostis curvula (Schrad.) Nees	Eragrostis curvula (Schrad.) Nees	ercu2
Eragrostis hypnoides (Lam.) B. S. P.	Eragrostis hypnoides (Lam.) B. S. P.	erhy
Eragrostis pectinacea (Michx.) Nees	Eragrostis pectinacea (Michx.) Nees ex Steud.	erpe
Eragrostis trichodes (Nutt.) Wood	Eragrostis trichodes (Nutt.) Wood	ertr3
Erigeron canus A. Gray	Erigeron canus Gray*	ercan

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Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Erigeron divergens Torr. & Gray	Erigeron divergens Torr. & Gray	erdi4
Erigeron elatior (Gray) Greene	Erigeron elatior (Gray) Greene	erel9
Erigeron flagellaris Gray	Erigeron flagellaris Gray	er9
Erigeron formissimus Greene var formissimus	Erigeron formissimus var formissimus Greene	erfo12
Erigeron formossissimus Greene viscidus (Rydb.) Cronq	Erigeron formossissimus var. viscidus (Rydb.) Cronq	erfov
Erigeron nudiflorus Buckl.	Erigeron nudiflorus Buckl.	ernu7
Erigeron peregrinus (Pursh) Greene subsp. callianthemus (Greene) Cronq	Erigeron peregrinus ssp. callianthemus (Greene) Cronq	erpec
Erigeron philadelphicus L.	Erigeron philadelphicus L.	erph
Erigeron platyphyllus Greene	Erigeron platyphyllus Greene	erpl7
Erigeron pumilus Nutt. subsp. concinnoides Cronq	Erigeron pumilus ssp. concinnoides Cronq	erpuc
Erigeron rhizomatus Cronq	Erigeron rhizomatus Cronq	errh2
Erigeron simplex Greene	Erigeron simplex Greene	ersi3
Erigeron speciosus var. macranthus (Nutt.) Cronq	Erigeron speciosus var. macranthus (Nutt.) Cronq	erspm
Erigeron subtrinervis Rydb.	Erigeron subtrinervis Rydb. ex Porter & Britt	ersu2
Erigeron superbus Greene ex Rydb.	Erigeron superbus Greene ex Rydb.	ersu3
Erigeron utahensis Gray	Erigeron utahensis Gray	erut
Erigeron vetensis Rydb.	Erigeron vetensis Rydb.	erve2
Eriochloa gracilis (Fourn.) Hitch.	Eriochloa gracilis (Fourn.) A. S. Hitchc.	erg4
Eriogonum abertianum Torr.	Eriogonum abertianum Torr.	erab2
Eriogonum alatum Torr.	Eriogonum alatum Torr.	er.44
Eriogonum annuum Nutt.	Eriogonum annuum Nutt.	eran4
Eriogonum cernuum Nutt.	Eriogonum cernuum Nutt.	erce2
Eriogonum effusum Nutt.	Eriogonum effusum Nutt.	eref
Eriogonum jamesii Benth.	Eriogonum jamesii Benth.	erja
Eriogonum leptocladon Torr. & Gray	Eriogonum leptocladon Torr. & Gray	erle9
Eriogonum polycladon Benth.	Eriogonum polycladon Benth.	erpo4
Eriogonum racemosum Nutt.	Eriogonum racemosum Nutt.	erra3
Erodium cicutarium (L.) L'Her.	Erodium cicutarium (L.) L'Her. ex Ait.	erci6
Erysimum asperum (Nutt.) DC.	Erysimum asperum (Nutt.) DC.	eras2
Erysimum capitatum (Dougl.) Greene	Erysimum capitatum (Dougl. ex Hook.) Greene	erca14
Erysimum inconspicuum (Wats.) MacM.	Erysimum inconspicuum (S. Wats.) MacM.	erin7
Eupatorium herbaceum (Gray) Greene	Eupatorium herbaceum (Gray) Greene	erhe7
Euphorbia albomarginata Torr. & Gray	Euphorbia albomarginata Torr. & Gray	eual4
Euphorbia dentata Michx.	Euphorbia dentata Michx.	eude4
Euphorbia dentata var. euphosperma Engelm.	Euphorbia dentata var. euphosperma (Engelm.) Fern.	eudeu
Euphorbia exstipulata Engelm.	Euphorbia exstipulata Engelm.	euex4
Euphorbia fendleri Torr. & Gray var. fendleri	Chamaesyce fendleri (Torr. & Gray) Small	ufle3
Euphorbia geyeri Engelm.	Euphorbia geyeri Engelm.	euge
Euphorbia lurida Engelm.	Euphorbia lurida Engelm.	eulu

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Euphorbia missurica Pall. var. intermedia (Engelm.) L. C. Wheeler	Euphorbia missurica var. intermedia (Engelm.) L. C. Wheeler	euma
Euphorbia neomexicana Greene	Euphorbia neomexicana Greene	eune5
Euphorbia revoluta Engelm.	Euphorbia revoluta Engelm.	eure4
Euphorbia robusta (Engelm.) Small	Euphorbia robusta (Engelm.) Small	euro5
Euphorbia serpyllifolia Pers.	Euphorbia serpyllifolia Pers.	euse5
Eurotia lanata (Pursh) Moq.	Eurotia lanata (Pursh) Moq.	eula5
Evolvulus pilosus Nutt.	Evolvulus pilosus Nutt.	evpi
Fallugia paradoxa (D. Don) Endl.	Fallugia paradoxa (D. Don) Endl. ex Torr.	fapa
Fendlera rupicola Gray var. rupicola	Fendlera rupicola var. rupicola Gray	ferur
Festuca arizonica Vasey	Festuca arizonica Vasey	fear2
Festuca elatior L.	Festuca elatior L. p. p.	fel
Festuca octoflora Walt.	Festuca octoflora Walt.	feoc3
Festuca ovina L.	Festuca ovina L.	feov
Festuca sororia Piper	Festuca sororia Piper	feso
Festuca thurberi Vasey	Festuca thurberi Vasey	feth
Forestiera neomexicana Gray	Forestiera neomexicana Gray	fone
Fragaria americana (Porter) Britt.	Fragaria americana (Porter) Britt.	fram4
Fragaria ovalis (Lehm.) Rydb.	Fragaria ovalis (Lehm.) Rydb.	frov
Franseria acanthicarpa (Hook.) Cov.	Franseria acanthicarpa (Hook.) Coville.	frac2
Franseria confertiflora (DC.) Rydb.	Franseria confertiflora (DC.) Rydb.	froc3
Gaillardia pinnatifida Torr.	Gaillardia pinnatifida Torr.	gapi
Galium aparine L.	Galium aparine L.	gaap2
Galium asperrimum Gray	Galium asperrimum Gray	gaas3
Galium boreale L.	Galium boreale L.	gabo2
Galium fendleri Gray	Galium fendleri Gray	gafe
Galium microphyllum Gray	Galium microphyllum Gray	gami
Galium tinctorum L. var. subflorum (Weig.) Fern.	Galium tinctorum var. subflorum (Weig.) Fern.	gats
Gaura coccinea Nutt.	Gaura coccinea Nutt. ex Pursh	gaco5
Gaura parviflora Dougl.	Gaura parviflora Dougl. ex Lehm.	gapa6
Gentiana affinis Griseb.	Gentiana affinis Griseb.	geaf
Gentiana bigelovii Gray	Gentiana bigelovii Gray	gebi4
Gentiana plebeja Chara.	Gentiana plebeja Ledeb. ex Spreng.	gepl4
Gentiana strictiflora (Rydb.) A. Nels.	Gentiana strictiflora (Rydb.) A. Nels.	gest5
Geranium caespitosum James	Geranium caespitosum James	geca3
Geranium fremontii Torr.	Geranium fremontii Torr. ex gray	gefr2
Geranium fremontii var. parryi Engelm.	Geranium fremontii var. parryi Engelm.	gefrp
Geranium richardsonii Fisch. & Trout.	Geranium richardsonii Fisch. & Trautv.	geri
Geum macrophyllum Willd. var. perincisum (Rydb.) Raup	Geum macrophyllum var. perincisum (Rydb.) Raup	gemap
Geum rivale L.	Geum rivale L.	geri2

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Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Geum strictum Ait. var. strictum	Geum strictum Ait.	gest2
Geum triflorum Pursh var. ciliatum (Pursh) Fawcett	Geum triflorum var. ciliatum (Pursh) Fawcett	getri2
Gilia flavocincta A. Nels. subsp. australis (A. & V. Grant) Day & V. Grant	Gilia flavocincta spp. australis (A. & V. Grant) Day & V. Grant	gifla
Gilia leptomeria Gray	Gilia leptomeria Gray	gile3
Gilia pinnatifida Nutt.	Gilia pinnatifida Nutt. ex Gray	gipi
Glyceria borealis (Nash) Batchelder	Glyceria borealis (Nash) Batchelder	glbo
Glyceria grandis Wats.	Glyceria grandis S. Wats.	glgr
Glyceria striata (Lam.) Hitchc.	Glyceria striata (Lam.) A. S. Hitchc.	glst
Glycyrrhiza lepidota (Nutt.) Pursh	Glycyrrhiza lepidota Pursh	glle3
Gnaphalium chilense Spreng.	Gnaphalium chilense Spreng.	gnch
Gnaphalium chilense Spreng.	Gnaphalium chilense Spreng.	gnch
Gnaphalium grayi Nels. & Macbr.	Gnaphalium grayi Nels. & J. F. Macbr.	gngr
Gnaphalium macounii Greene	Gnaphalium macounii Greene	gnma
Gnaphalium palustre Nutt.	Gnaphalium palustre Nutt.	gnpa
Gnaphalium wrightii Gray	Gnaphalium wrightii Gray	gnwr
Goodyera oblongifolia Raf.	Goodyera oblongifolia Raf.	goob2
Goodyera repens (L.) R. Br.	Goodyera repens (L.) R. Br. ex Ait. f.	gore2
Grindelia aphanactis Rydb.	Grindelia aphanactis Rydb.	grap
Grindelia fastigiata Greene	Grindelia fastigiata Greene	grfa
Grindelia squarrosa (Pursh) Dunal	Grindelia squarrosa (Pursh) Dunal	grsq
Gutierrezia microcephala (DC.) Gray	Gutierrezia microcephala (DC.) Gray	gumi
Gutierrezia sarothrae (Pursh) Britt. & Rusby	Gutierrezia sarothrae (Pursh) Britt. & Rusby	gusa2
Habenaria hyperborea (L.) R. Br.	Habenaria hyperborea (L.) R. Br. ex Ait. f.	habhy3
Habenaria sparsiflora Wats.	Habenaria sparsiflora S. Wats.	hasp5
Hackelia floribunda (Lehm.) I. M. Johnston	Hackelia floribunda (Lehm.) I. M. Johnston	hafl2
Hackelia micrantha (Woot. & Standl.) I. M. Johnston	Hackelia micrantha (Woot. & Standl.) I. M. Johnston	hamic2
Hackelia pinetorum (Greene) I. M. Johnst.	Hackelia pinetorum (Greene ex Gray) I. M. Johnston	hapi2
Haplopappus crocetus Gray	Haplopappus crocetus Gray	hacr2
Haplopappus gracilis (Nutt.) Gray	Haplopappus gracilis (Nutt.) Gray	hagr11
Haplopappus nuttallii Torr. & Gray	Haplopappus nuttallii Torr. & Gray	hanu2
Haplopappus parryi Gray	Haplopappus parryi Gray	hapa3
Haplopappus spinulosus (Pursh) DC. subsp. spinulosus	Machaeranthera pinnatifida ssp. pinnatifida var. pinnatifida (Hook.) Shinners	mapip4
Hedeoma drummondii Benth.	Hedeoma drummondii Benth.	hedr
Hedeoma nana (Torr.) Briq.	Hedeoma nana (Torr.) Briq.	hena
Hedeoma oblongifolia (Gray) Heller	Hedeoma oblongifolia (Gray) Heller	heob
Hedeoma pulchellum Woot. & Standl.	Hedeoma pulchellum Woot. & Standl.	hepu12
Helenium autumnale L. var. montanum (Nutt.) Fern.	Helenium autumnale var. montanum (Nutt.) Fern.	heaum
Helenium hoopesii Gray	Helenium hoopesii Gray	hehoo5
Helianthella quinquenervis (Hook.) Gray	Helianthella quinquenervis (Hook.) Gray	hequi2

Martin & Hutchins (1930)	USDA NRCS PLANTS Database (1995)	Acronym
Helianthus annuus L.	Helianthus annuus L.	hean3
Helianthus arizonensis J	Helianthus arizonensis R. C. Jackson	hear6
Helianthus petiolaris Nutt	Helianthus petiolaris Nutt.	hepe
Helianthus rigidus (Cass.) Desf. subsp. subhirsutus (Raf.) Heiser	Helianthus rigidus ssp. subhirsutus (Raf.) Heiser	heris2
Heracleum lanatum Michx	Heracleum lanatum Michx.	hela4
Heuchera parvifolia Nutt	Heuchera parvifolia Nutt. ex Torr. & Gray	hepa11
Heracium carneum Greene	Hieracium carneum Greene	hica4
Heracium fendleri Sch. Bip	Hieracium fendleri Schlotern Bip	hife
Heterotheca odorata (L.) Beaur.	Heterotheca odorata (L.) Beaur.	heod
Hieracium jamesii (Torr.) Beath.	Hieracium jamesii (Torr.) Beath.	hija
Holosteum dumosum (Nutt.) Heller	Holosteum dumosum (Nutt. ex Hook.) Heller	hodu
Hordeum brachyantherum Nevski	Hordeum brachyantherum Nevski	hobr2
Hordeum jubatum L.	Hordeum jubatum L.	hoju
Humulus americanus Nutt.	Humulus lupulus ssp. americanus (Nutt.) A. & G. Love	hulua
Hydrophyllum fendleri (Gray) Heller	Hydrophyllum fendleri (Gray) Heller	hyfe
Hymenopappus filifolius Hook.	Hymenopappus filifolius Hook.	hyfi
Hymenopappus flavescens Gray var. canotomentosus Gray	Hymenopappus flavescens var. canotomentosus Gray	hyfla
Hymenopappus newberryi (Gray) J. M. Johnst	Hymenopappus newberryi (Gray) J. M. Johnston	hyne
Hymenopappus tenuifolius Pursh	Hymenopappus tenuifolius Pursh	hyte2
Hymenoxys acaulis (Pursh) Parker var. acaulis	Tetraneuris acaulis var. acaulis (Pursh) Greene	teca2
Hymenoxys acaulis var. arizonica (Greene) Parker	Hymenoxys acaulis var. arizonica (Greene) Parker	hycac2
Hymenoxys argentea (Gray) E. F. Parker	Hymenoxys argentea (Gray) Parker	hyar5
Hymenoxys brandegei (Porter) E. F. Parker	Hymenoxys brandegei Porter ex Gray	hybr
Hymenoxys hoopesii (Greene) Parker	Hymenoxys hoopesii (Greene) Parker	hyho
Hymenoxys richardsoni (Hook.) Cockerell var. floribunda (Gray) Parker	Hymenoxys richardsoni var. floribunda (Gray) Parker	hyrid
Hyoscyamus niger L.	Hyoscyamus niger L.	hyni
Hypericum formosum H. B. K.	Hypericum formosum H. B. K.	hyfo4
Ipomoea coccinea L. var. coccinea	Ipomoea coccinea L.	ipco3
Ipomoea federacea (L.) Jacq.	Ipomoea federacea Jacq.	ipfe
Ipomopsis aggregata (Pursh) V. Grant subsp. aggregata	Ipomopsis aggregata ssp. aggregata (Pursh) V. Grant	ipag2
Ipomopsis aggregata subsp. tenuis (Greene) Mardo & Hutch.	Ipomopsis aggregata ssp. tenuis (Greene) W. C. Mardo & C. R. Hutchins	ipagt3
Ipomopsis laxiflora (Coult.) V. Grant	Ipomopsis laxiflora (Coult.) V. Grant	ipla2
Ipomopsis longiflora (Torr.) V. Grant	Ipomopsis longiflora (Torr.) V. Grant	iplo2
Ipomopsis multiflora (Nutt.) V. Grant	Ipomopsis multiflora (Nutt.) V. Grant	ipmu3
Ipomopsis pumila (Nutt.) V. Grant	Ipomopsis pumila (Nutt.) V. Grant	ippu4
Iris missouriensis Nutt.	Iris missouriensis Nutt.	irmi
Iva axillaris Pursh	Iva axillaris Pursh	iwax
Iva xanthifolia Nutt.	Iva xanthifolia Nutt.	iwxa
Jamesia americana Torr. & Gray	Jamesia americana Torr. & Gray	jaam

Nomenclature

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Juncus balticus Willd. var. montanus Engelm.	Juncus balticus var. montanus Engelm.	jubam
Juncus bufonius L.	Juncus bufonius L.	jubu
Juncus confusus Cov.	Juncus confusus Coville	juco2
Juncus drummondii E. Mey.	Juncus drummondii E. Mey.	judr
Juncus interior Wieg.	Juncus interior Wieg.	juin2
Juncus longistylis Torr. var. longistylis	Juncus longistylis var. longistylis Torr.	julo4
Juncus marginatus Rostk.	Juncus marginatus Rostk.	juma4
Juncus mexicanus Willd.	Juncus mexicanus Willd. ex J. A. & J. H. Schultes	jume4
Juncus tenuis Willd.	Juncus tenuis Willd.	jute
Juncus torreyi Cov.	Juncus torreyi Coville	juto
Juncus xiphioides E. Mey.	Juncus xiphioides E. Mey.	juxi
Juniperus communis L.	Juniperus communis L.	juco6
Juniperus deppeana Steud.	Juniperus deppeana Steud.	jude2
Juniperus monosperma (Engelm.) Sarg.	Juniperus monosperma (Engelm.) Sarg.	jumo
Juniperus scopulorum Sarg.	Juniperus scopulorum Sarg.	jusc2
Kallstroemia hirsutissima Vail	Kallstroemia hirsutissima Vail ex Small	kahi
Kochia scoparia (L.) Roth	Kochia scoparia (L.) Schrad.	kosc
Koeleria cristata (L.) Pers.	Koeleria cristata auct. p. p. non Pers.	kocr
Krigia biflora (Walt.) Blake	Krigia biflora (Walt.) Blake	kibi
Kuhnia chlorolepis Wootton & Standley	Kuhnia chlorolepis Wootton & Standl.	kuch2
Lactuca canadensis L.	Lactuca canadensis L.	laca
Lactuca graminifolia Michx.	Lactuca graminifolia Michx.	lagr
Lactuca ludoviciana (Nutt.) DC.	Lactuca ludoviciana (Nutt.) Riddell	lalu
Lactuca pulchella (Pursh) DC.	Lactuca pulchella (Pursh) DC.	lapu
Lactuca serriola L.	Lactuca serriola L.	lase
Lactuca spicata (Lam.) Hitchc.	Lactuca spicata auct. non (Lam.) A. S. Hitchc.	lasp4
Lappula echinata Gilib.	Lappula squarrosa (Retz.) Dumort.	lasq
Lappula redowskii (Hornem.) Greene	Lappula redowskii auct. non (Hornem.) Greene	lare
Lappula texana (Scheele) Britt.	Lappula texana (Scheele) Britt.	late3
Lathyrus arizonicus Britt.	Lathyrus arizonicus Britt.	lazi6
Lathyrus leucanthus Rydb.	Lathyrus leucanthus Rydb.	lale2
Leersia oryzoides (L.) Swartz	Leersia oryzoides (L.) Sw.	leor
Lemna minor L.	Lemna minor L.	lemi3
Lepidium medium Greene var. medium	Lepidium medium Greene	leme3
Lepidium medium var. pubescens (Greene) Rollins	Lepidium medium var. pubescens (Greene) R. L. Rollins	lemep
Lesquerella fendleri (Gray) Wats.	Lesquerella fendleri (Gray) S. Wats.	lefe
Lesquerella intermedia (Wats.) Heller	Lesquerella intermedia (S. Wats.) Heller	leim3
Lesquerella rectipes Wootton & Standley	Lesquerella rectipes Wootton & Standl.	lere3
Leucelene ericoides (Torr.) Greene	Leucelene ericoides (Torr.) Greene	leer

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Listris punctata Hook.	Liatris punctata Hook.	lipu
Ligusticum porteri Coult. & Rose	Ligusticum porteri Coult. & Rose	lipo
Lilium umbellatum Pursh	Lilium umbellatum Pursh	lium2
Limosella aquatica L.	Limosella aquatica L.	liaq
Linaria vulgaris Mill	Linaria vulgaris P. Mill	livu2
Linum aristatum var. patula (Heller) E. & P.	Linum aristatum var. patula (Heller) Feaney & Fertles	lara2
Linum lewisii Pursh	Linum lewisii Pursh	lile3
Linum neomexicana Greene	Linum neomexicana Greene	line
Linum puberulum (Engelm.) Heller	Linum puberulum (Engelm.) Heller	lipu4
Linum rigidum Pursh "complex"	Linum rigidum Pursh "complex"	lri
Lithospermum colorense Greene	Lithospermum colorense Greene	lico7
Lithospermum incisum Lehm.	Lithospermum incisum Lehm.	lin2
Lithospermum multiflorum Torr.	Lithospermum multiflorum Torr. ex Gray	limu3
Lobelia cardinalis L. subsp. graminea (Lam.) McVaugh	Lobelia cardinalis ssp. graminea (Lam.) McVaugh	locag2
Lolium perenne L.	Lolium perenne L.	lope
Lonicera involucrata (Richards.) Banks	Lonicera involucrata Banks ex Spreng	loin5
Lotus wrightii (Gray) Greene	Lotus wrightii (Gray) Greene	lowr
Lupinus alpestris A. Nels.	Lupinus X alpestris A. Nels. (gro sp.)	lual5
Lupinus ammophilus Greene	Lupinus ammophilus Greene	luam
Lupinus argenteus Pursh	Lupinus argenteus Pursh	luar3
Lupinus brevicaulis Wats.	Lupinus brevicaulis S. Wats.	lubr2
Lupinus caudatus Kell. subsp. argophyllus (Gray) Phillips	Lupinus caudatus ssp. argophyllus (Gray) L. Phillips	lucaa
Lupinus kingii Wats.	Lupinus kingii S. Wats.	luki
Lupinus pusillus Pursh	Lupinus pusillus Pursh	lupu
Lupinus rubricaulis Greene	Lupinus rubricaulis Greene	luru5
Luzula parviflora (Ehrh.) Desv.	Luzula parviflora (Ehrh.) Desv.	lupa4
Lycium pallidum Miers	Lycium pallidum Miers	lypa
Lycopus americanus Muhl.	Lycopus americanus Muhl. ex W. Bart.	lyam
Lycurus phleoides H. B. K.	Lycurus phleoides Kunth	lyph
Machaeranthera amplifolia Wooton & Standl.	Machaeranthera amplifolia Wooton & Standl.	maam4
Machaeranthera bigelovii (Gray) Greene	Machaeranthera bigelovii (Gray) Greene	mabi
Machaeranthera canescens (Pursh) Gray	Machaeranthera canescens (Pursh) Gray	maca2
Machaeranthera linearis Greene	Machaeranthera linearis Greene	mali4
Machaeranthera tanacetifolia (H. B. K.) Nees	Machaeranthera tanacetifolia (Kunth) Nees	mata2
Machaeranthera tephrodes (Gray) Greene	Machaeranthera tephrodes (Gray) Greene	mate
Malacothrix fendleri Gray	Malacothrix fendleri Gray	mafe
Malaxis soulei L. O. Wms.	Malaxis soulei L. O. Williams	masc8
Malva neglecta L.	Malva neglecta Wallr.	mane
Malva parviflora L.	Malva parviflora L.	mapa5

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Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Mammillaria wrightii Engelm	Mammillaria wrightii Engelm	mawr2
Marrubium vulgare L.	Marrubium vulgare L.	marv
Maurandya antirrhiniflora Humb. & Bonpl	Maurandya antirrhiniflora Humb. & Bonpl. ex Willd	maar6
Medicago lupulina L.	Medicago lupulina L.	melu
Medicago sativa L.	Medicago sativa L.	mesa
Melampodium leucanthum Torr. & Gray	Melampodium leucanthum Torr. & Gray	mele2
Melica porteri Scribn.	Melica porteri Scribn.	mepo
Melilotus albus Desr	Melilotus albus Medik.	meal2
Melilotus indicus (L.) All	Melilotus indicus (L.) All.	mein2
Melilotus officinalis (L.) Lam	Melilotus officinalis (L.) Lam.	meof
Menodora scabra Gray	Menodora scabra Gray	mesc
Mentha arvensis L.	Mentha arvensis L.	mear4
Mentzelia albicaulis Dougl	Mentzelia albicaulis (Dougl. ex Hook.) Dougl. ex Torr. and Gray	mea6
Mentzelia laciniata (Rydb.) J. Darl	Mentzelia laciniata (Rydb.) J. Darl	mela
Mentzelia nuda var. stricta (Osterhout) Harrington	Mentzelia nuda var. stricta (Osterhout) Harrington	menus
Mentzelia pumila (Nutt.) Torr. & Gray var. pumila	Mentzelia pumila var. pumila Nutt. ex Torr. & Gray	mepup
Mentzelia pumila var. integra M. E. Jones	Mentzelia pumila var. integra (M. E. Jones) Feaney & Prestlus	mepui
Mentzelia pumila var. multiflora (Nutt.) Urb. & Gilg	Mentzelia pumila var. multiflora (Nutt.) Urban & Gilg	mepum
Mentzelia rusbyi Wood.	Mentzelia rusbyi Wood.	meru
Mentzelia brevistyla Wats	Mentzelia brevistyla S. Wats	mebr
Mentzelia franciscana Heller	Mentzelia franciscana Heller	mefr2
Mentzelia lanceolata var. lenderii Gray	Mentzelia lanceolata var. lenderii (Gray) Gray	melal
Mentzelia lanceolata (Pursh) DC. var lanceolata	Mentzelia lanceolata var. lanceolata (Pursh) DC.	melal2
Microseris linearifolia (DC.) Sch. Bip	Microseris linearifolia (Nutt.) Schultenz Bip	mli
Microseris mamus		not listed
Microsteris gracilis (Hook.) Greene	Microsteris gracilis (Hook.) Greene	migr
Mimulus floribundus Dougl	Mimulus floribundus Lindl	mifl2
Mimulus glabratus var. flemontii (Benth.) Grant	Mimulus glabratus var. flemontii (Benth.) A. L. Grant	migl
Mimulus guttatus D.C.	Mimulus guttatus DC.	migu
Mirabilis coccinea Benth. & Hook.	Mirabilis coccinea (Torr.) Benth. & Hook. f.	mico7
Mirabilis multiflora (Torr.) & Gray	Mirabilis multiflora (Torr.) Gray*	mimu
Mirabilis oxybaphoides Gray	Mirabilis oxybaphoides (Gray) Gray	mioxy
Moldavica parviflora (Nutt.) Britt	Moldavica parviflora (Nutt.) Britt	mopa4
Monarda menthaefolia Graham	Monarda menthaefolia Graham	momen3
Monarda pectinata Nutt	Monarda pectinata Nutt	mope
Monotropa lathyrana (Rydb.) Huken	Monotropa lathyrana (Rydb.) Huken	molat4
Muhlenbergia arsenei Hitchc	Muhlenbergia arsenei A. S. Hitchc.	muar4
Muhlenbergia asperifolia (Nees & Mey.) Parodi	Muhlenbergia asperifolia (Nees & Mey. ex Trin.) Parodi	muas
Muhlenbergia curtifolia Scribn	Muhlenbergia curtifolia Scribn	mucu

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Muhlenbergia mexicana (L.) Trin.	Muhlenbergia mexicana (L.) Trin.	mume2
Muhlenbergia montana (Nutt.) Hitchc.	Muhlenbergia montana (Nutt.) A. S. Hitchc.	mumo
Muhlenbergia pauciflora Buckl.	Muhlenbergia pauciflora Buckl.	mupa2
Muhlenbergia porteri Scribn.	Muhlenbergia porteri Scribn. ex Beal	mupo2
Muhlenbergia pulcherrima Scribn.	Muhlenbergia pulcherrima Scribn. ex Beal	mupu
Muhlenbergia racemosa (Michx.) B. S. P.	Muhlenbergia racemosa (Michx.) B. S. P.	mura
Muhlenbergia rigens (Benth.) Hitchc.	Muhlenbergia rigens (Benth.) A. S. Hitchc.	muri2
Muhlenbergia torreyi (Kunth) Hitch.	Muhlenbergia torreyi (Kunth) A. S. Hitchc. ex Bush	muto2
Muhlenbergia wolfii (Vasey) Rydb.	Muhlenbergia wolfii (Vasey) Rydb.	muwo
Muhlenbergia wrightii Vasey	Muhlenbergia wrightii Vasey ex Coult.	muwr
Muraea squamosa (Nutt.) Torr.	Muraea squamosa (Nutt.) Torr.	musq
Myosurus minimus L.		not listed
Nama dichotomum (R. & P.) Choisy	Nama dichotomum (Ruiz & Pavon) Choisy	nada
Nama hispidum Gray var. hispidum	Nama hispidum Gray	nahi
Nepeta cataria L.	Nepeta cataria L.	neca2
Nicotiana attenuata Torr.	Nicotiana attenuata Torr. ex S. Wats.	nia1
Nuttalina microcarpa Wats.	Nuttalina microcarpa S. Wats.	nomi
Nothofaena spp.	Nothofaena spp. R. Br.	nofa
Nothofaena standleyi Maxon	Nothofaena standleyi Maxon	nost
Oenothera alticaulis Pursh	Oenothera alticaulis Pursh	oeal
Oenothera caespitosa Nutt.	Oenothera caespitosa Nutt.	oeca2
Oenothera caespitosa subsp. eximia (Gray) Munz	Oenothera caespitosa ssp. eximia (Gray) Munz	oecae
Oenothera caespitosa subsp. montana (Nutt.) Munz	Oenothera caespitosa ssp. montana (Nutt.) Munz	oecem
Oenothera coronopifolia Torr. & Gray	Oenothera coronopifolia Torr. & Gray	oeco2
Oenothera flava (A. Nels.) Garrett	Oenothera flava (A. Nels.) Garrett	oefl
Oenothera hookeri Torr. & Gray	Oenothera hookeri Torr. & Gray	oeho
Oenothera laciniata Hill var. laciniata	Oenothera laciniata Hill	oela
Oenothera pallida Lindl. subsp. pallida	Oenothera pallida ssp. pallida Lindl.	oepap
Oenothera primiveris Gray	Oenothera primiveris Gray	oepr
Opuntia clavata Engelm.	Opuntia clavata Engelm.	opcl
Opuntia erinacea Engelm. & Bigel. var. erinacea	Opuntia erinacea var. erinacea Engelm. & Bigelow ex Engelm.	opera
Opuntia erinacea var. utahensis (Engelm.) L. Benson	Opuntia erinacea var. utahensis (Engelm.) L. Benson	operu2
Opuntia imbricata (Haw.) DC.	Opuntia imbricata (Haw.) DC.	opim
Opuntia macrorhiza Engelm. var. macrorhiza	Opuntia macrorhiza var. macrorhiza Engelm.	opma2
Opuntia phaeacantha Engelm. var. phaeacantha	Opuntia phaeacantha var. phaeacantha Engelm.	opph
Opuntia phaeacantha var. discata Engelm.	Opuntia phaeacantha var. discata (Griffiths) L. Benson & Walkington	opdi
Opuntia polyacantha var. polyacantha	Opuntia polyacantha var. polyacantha Haw.	oppop
Orobanche fasciculata var. Mesa (Parry) Achey	Orobanche fasciculata var. Mesa (Parry) Achey	orfa
Orobanche ludoviciana Nutt.	Orobanche ludoviciana Nutt.	orlu

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Orobanche multiflora Nutt.	Orobanche multiflora Nutt.	ormu
Orthocarpus luteus Nutt.	Orthocarpus luteus Nutt.	orlu2
Orthocarpus purpureo albus Gray	Orthocarpus purpureoalbus Gray ex S. Wats.	orpu2
Oryzopsis asperifolia Michx.	Oryzopsis asperifolia Michx.	oras
Oryzopsis hymenoides (R. & S.) Ricker	Oryzopsis hymenoides (Roemer & J. A. Schultes) Ricker ex Piper	orhy
Oryzopsis micrantha (Trin. & Rupr.) Thurb.	Oryzopsis micrantha (Trin. & Rupr.) Thurb.	ormi2
Osmorhiza obtusa (Coult. & Rose) Fern.	Osmorhiza obtusa (Coult. & Rose) Fern.	osob2
Oxalis metcalfei (Small) Knuth	Oxalis metcalfei (Small) R. Knuth	oxme3
Oxalis violacea L.	Oxalis violacea L.	oxvi
Oxybaphus fasciatus (Pursh) Sweet	Oxybaphus fasciatus (Pursh) Sweet	oxfa2
Oxybaphus linearis (Pursh) Robbins var. linearis	Oxybaphus linearis (Pursh) B. L. Robbins	oxli
Oxypolis fendleri (Gray) Heller	Oxypolis fendleri (Gray) Heller	oxfe
Oxytropis lambertii Pursh	Oxytropis lambertii Pursh	oxla3
Pachystima myrsinites (Pursh) Raf.	Pachistima myrsinites (Pursh) Raf.	pamy
Panicum bulbosum H. B. K.	Panicum bulbosum Kunth	pabu
Panicum capillare L. var. capillare	Panicum capillare L.	paca6
Panicum hallii Vasey	Panicum hallii Vasey	paha
Panicum helleri Nash	Panicum helleri Nash	pahe8
Panicum miliaceum L.	Panicum miliaceum L.	pami2
Panicum obtusum H. B. K.	Panicum obtusum Kunth	paob
Panicum scribnerianum Nash	Panicum scribnerianum Nash	pasc5
Panicum tennesseense Ashe	Panicum tennesseense Ashe	pate15
Panicum virgatum L.	Panicum virgatum L.	pavi2
Parthenium incanum H. B. K.	Parthenium incanum Kunth	pain2
Parthenocissus inserta (Kerner) K. Fritsch	Parthenocissus inserta (Kerner) Fritsch	pain10
Pectis angustifolia Torr.	Pectis angustifolia Torr. x B242	pean
Pectis papposa Harv. & Gray	Pectis papposa Harvey & Gray	pepa2
Pedicularis grayi A. Nels.	Pedicularis grayi A. Nels.	pegr
Pediocactus papyracanthus (Engelm.) L. Benson	Pediocactus papyracanthus (Engelm.) L. Benson	pepa20
Pellaea atropurpurea (L.) Link	Pellaea atropurpurea (L.) Link	peat2
Pellaea fendleri (Kunze) Prantl	Pellaea fendleri (Kunze) Prantl	pefe4
Pellaea limitanea (Maxon) Morton	Pellaea limitanea (Maxon) Morton	peli12
Pellaea longimucronata Hook.	Pellaea longimucronata Hook.	pelo8
Penstemon barbatus (Cav.) Roth subsp. torreyi (Benth.) Keck	Penstemon barbatus ssp. torreyi (Benth.) Keck	pebar
Penstemon eatonii Gray	Penstemon eatonii Gray	peea
Penstemon fendleri Torr. & Gray	Penstemon fendleri Torr. & Gray	pefe
Penstemon jamesii Benth.	Penstemon jamesii Benth.	peja
Penstemon leiotus Pennell	Penstemon leiotus Pennell	pele2
Penstemon linarioides subsp. coloradensis (A. Nels.) Keck	Penstemon linarioides ssp. coloradensis (A. Nels.) Keck	pelic

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Penstemon oligarrhenus Woot. & Standl	Penstemon oligarrhenus Woot. & Standl	peol
Penstemon rydbergii A. Nels	Penstemon rydbergii A. Nels.	pery
Penstemon secundiflorus Benth.	Penstemon secundiflorus Benth.	pese11
Penstemon virgatus Gray	Penstemon virgatus Gray	pevi4
Penstemon whipplianus Gray	Penstemon whipplianus Gray	pewh
Pericome caudata Gray	Pericome caudata Gray	peca10
Petalostemum candidum (Willd.) Michx.	Petalostemon candidus Michx	peca21
Petalostemum compactum (Spreng.) Swezey	Petalostemon compactus (Spreng.) Swezey var. E608	peco28
Petalostemum exile Gray	Petalostemon exilis Gray	peex3
Petalostemum purpureum (Vent.) Rydb.	Petalostemon purpureus (Vent.) Rydb. B591	pepu15
Petalostemum villosum Nutt.	Petalostemon villosum Nutt. B611	pevi12
Phacelia coerulea Greene	Phacelia coerulea Greene	phco
Phacelia corrugata A. Nels.	Phacelia corrugata A. Nels.	phco21
Phacelia heterophylla Pursh	Phacelia heterophylla Pursh	phhe2
Phacelia integrifolia Torr.	Phacelia integrifolia Torr.	phin
Phacelia magellanica (Lam.) Cov.	Phacelia magellanica (Lam.) Coville p.p.	phma13
Phacelia neomexicana Thurb. var. neomexicana	Phacelia neomexicana Thurb. ex Torr. B591	phne3
Phaseolus angustissimus Gray	Phaseolus angustissimus Gray	phan3
Phaseolus leptostachyus Torr. & Gray	Phaseolus leptostachyus Torr. & Gray	phle15
Philadelphus microphyllus var. microphyllus A. Gray	Philadelphus microphyllus var. microphyllus Gray	phmim
Phleum alpinum L.	Phleum alpinum L.	phal2
Phleum pratense L.	Phleum pratense L.	phpr3
Phlox longifolia Nutt.	Phlox longifolia Nutt.	phlo2
Phoradendron juniperinum Engelm.	Phoradendron juniperinum Engelm.	phju
Phragmites communis Trin.	Phragmites communis Trin.	phco15
Physalis foetens var. neomexicana (Rydb.) Waterfall	Physalis foetens var. neomexicana (Rydb.) Waterfall	phfon
Physalis hederaefolia var. cordifolia (Gray) Waterfall	Physalis hederaefolia var. cordifolia (Gray) Waterfall	phhec2
Physalis pubescens L.	Physalis pubescens L.	phpu7
Physocarpus monogynus (Torr.) Coult.	Physocarpus monogynus (Torr.) Coult.	phmo4
Picea engelmannii Parry	Picea engelmannii Parry ex Engelm.	pien
Picea pungens Engelm.	Picea pungens Engelm.	pipu
Pinus edulis Engelm.	Pinus edulis Engelm.	pied
Pinus flexilis James	Pinus flexilis James	pifl2
Pinus ponderosa Laws. var. scopulorum Engelm.	Pinus ponderosa Laws. var. scopulorum Engelm.	pipos
Plantago argyrata Morris	Plantago argyraea Morris	plar2
Plantago major L.	Plantago major L.	plma2
Plantago purshii R. & S.	Plantago purshii Roemer & J. A. Schultes	plpu80
Poa annua L.	Poa annua L.	poan
Poa bigelovii Vasey & Scribn.	Poa bigelovii Vasey & Scribn.	pobi

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Poa compressa L.	Poa compressa L.	poco
Poa fendleriana (Steud.) Vasey	Poa fendleriana (Steud.) Vasey	pofe
Poa interior Rydb.	Poa interior Rydb.	poin
Poa longiligula Scribn. & Williams	Poa longiligula Scribn. & Williams	polo
Poa nevadensis Vasey	Poa nevadensis Vasey ex Scribn.	pone3
Poa palustris L.	Poa palustris L.	popa2
Poa pattersonii Vasey	Poa pattersonii Vasey	popa3
Poa pratensis L.	Poa pratensis L.	pope
Potentilla trachysperma Torr. & Gray	Potentilla trachysperma Torr. & Gray	potr13
Polemonium foliosissimum Gray var. foliosissimum	Polemonium foliosissimum var. foliosissimum Gray	pofo13
Polygonum amphibium L. var. stipulaceum (Coleman) Fern.	Polygonum amphibium var. stipulaceum Coleman	pomas
Polygonum aviculare L.	Polygonum aviculare L.	poav
Polygonum bistortoides Pursh	Polygonum bistortoides Pursh	pobi6
Polygonum convolvulus L.	Polygonum convolvulus L.	poco10
Polygonum douglasii Greene	Polygonum douglasii Greene	podo4
Polygonum montanum (Small) Greene	Polygonum montanum Small	pomo16
Polygonum persicaria L.	Polygonum persicaria L.	pope3
Polygonum ramosissimum Michx.	Polygonum ramosissimum Michx.	pora3
Polygonum sawatchense Small	Polygonum sawatchense Small	posa17
Polypogon monspeliensis (L.) Desf.	Polypogon monspeliensis (L.) Desf.	pomo5
Populus angustifolia James	Populus angustifolia James	poan3
Populus fremontii var. wislizeni Wats.	Populus fremontii var. wislizeni S. Wats.	potrw2
Populus tremuloides Michx. var. aurea (Tides.) Daniels	Populus tremuloides var. aurea (Tidestrom) Daniels	potra
Portulaca oleracea L.	Portulaca oleracea L.	pool
Potentilla anserina L.	Potentilla anserina L.	poan5
Potentilla argyta Pursh subsp. convallaria Rydb.	Potentilla argyta ssp. convallaria (Rydb.) Keck	poarc
Potentilla concinna Richards	Potentilla concinna Richards	poco13
Potentilla crinita Gray	Potentilla crinita Gray	pocr4
Potentilla fruticosa L.	Potentilla fruticosa auct. non L.	pofr4
Potentilla hippiana Lehm.	Potentilla hippiana Lehm.	pohi6
Potentilla norvegica L.	Potentilla norvegica L.	pono3
Potentilla pensylvanica L.	Potentilla pensylvanica L.	pope8
Potentilla pulcherrima Lehm.	Potentilla pulcherrima Lehm.	popu9
Potentilla thurberi Gray var. thurberi	Potentilla thurberi var. thurberi Gray	poth1
Primula nutbyl Greene	Primula nutbyl Greene	prnu	
Prunella vulgaris L.	Prunella vulgaris L.	prvu	
Prunus americana Marsh.	Prunus americana Marsh.	praam	
Prunus emarginata (Dougl.) D. Dietr. var. emarginata	Prunus emarginata var. emarginata (Dougl. ex Hook.) Walp.	preme	
Prunus virginiana L. var. melanocarpa (A. Nels.) Sarg.	Prunus virginiana var. melanocarpa (A. Nels.) Sarg.	prvim	

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Pseudocymopterus montanus (Gray) Coult. & Rose	Pseudocymopterus montanus (Gray) Coult. & Rose	psmo
Pseudotsuga menziesii (Mirb.) Franco var. glauca (Beissner) Franco	Pseudotsuga menziesii var. glauca (Beissn.) Franco	psmeg
Psilostrophe tagetina (Nutt.) Greene	Psilostrophe tagetina (Nutt.) Greene	psta
Psoralea hypogaea Nutt.	Psoralea hypogaea Nutt. ex Torr. & Gray	psh y
Psoralea lanceolata Pursh	Psoralea lanceolata Pursh	psla
Psoralea tenuiflora Pursh	Psoralea tenuiflora Pursh	pste3
Ptelea trifoliata ssp. angustifolia (Benth.) V. L. Bailey	Ptelea trifoliata ssp. angustifolia (Benth.) V. Bailey	ptta
Pteridium aquilinum (L.) Kuhn var. pubescens	Pteridium aquilinum var. pubescens Underwood	ptarp2
Pterospora andromedea Nutt.	Pterospora andromedea Nutt.	ptan2
Pulsatilla ludoviciana (Nutt.) Heller	Pulsatilla ludoviciana Heller	pulu
Purshia tridentata (Pursh) D.C.	Purshia tridentata (Pursh) DC	putr2
Pyrola asarifolia Michx.	Pyrola asarifolia Michx.	pyas
Pyrola chlorantha Sw.	Pyrola chlorantha Sw.	pych
Pyrola elliptica Nutt.	Pyrola elliptica Nutt.	pyel
Pyrola minor L.	Pyrola minor L.	pymi
Pyrola picta J. E. Smith	Pyrola picta J. E. Sm.	pypi2
Pyrrocoma multicaulis DC.	Pyrrocoma multicaulis DC.	pymu2
Quercus gambelii Nutt.	Quercus gambelii Nutt.	quga
Quercus grisea Liebm.	Quercus grisea Liebm.	qugr3
Quercus pungens Liebm.	Quercus pungens Liebm.	qupu
Quercus turbinella Greene	Quercus turbinella Greene	qutu2
Quercus undulata Torr.	Quercus undulata Torr.	quun
Ranischia secunda (R. J. Garcia)	Ranischia secunda (R. J. Garcia)	rase2
Ranunculus abortivus L.	Ranunculus abortivus L.	rasb
Ranunculus aquatilis L. var. capillaceus (Thuill.) DC.	Ranunculus aquatilis var. capillaceus (Thuill.) DC.	raaqc
Ranunculus cardiophyllus Hook.	Ranunculus cardiophyllus Hook.	racar6
Ranunculus cymbalaria Pursh var. saximontanus Fern.	Ranunculus cymbalaria var. saximontanus (Fern.) Thorne	racys2
Ranunculus inamoenus Greene	Ranunculus inamoenus Greene	rain
Ranunculus macounii Britt.	Ranunculus macounii Britt.	rama2
Ranunculus macranthus Scheele	Ranunculus macranthus Scheele	rama3
Ranunculus sceleratus L. var. multifidus Nutt.	Ranunculus sceleratus var. multifidus Nutt.	rasem
Ratibida columnifera (Nutt.) Woot. & Standl.	Ratibida columnifera (Nutt.) Woot. & Standl.	raco3
Ratibida tagetes (James) Barnh.	Ratibida tagetes (James) Barnh.	rata
Rhus glabra L.	Rhus glabra L.	rhgl
Rhus radicans L.	Rhus radicans L.	rhra6
Rhus trilobata Nutt.	Rhus trilobata Nutt.	rhtr
Ribes cereum Dougl.	Ribes cereum Dougl.	rice
Ribes inebrians Lindl.	Ribes inebrians Lindl.	rein3
Ribes inerme Rydb.	Ribes inerme Ryd.	rein2

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Ribes leptanthum Gray	Ribes leptanthum Gray	rile
Ribes montigenum McClatchie	Ribes montigenum McClatchie	rimo2
Ribes pinetorum Greene	Ribes pinetorum Greene	ripi
Ribes wolfii Roth	Ribes wolfii Rothrock	riwo
Robinia neomexicana Gray	Robinia neomexicana Gray	rone
Rorippa islandica (Oeder) Borbas	Rorippa islandica (Oeder) Borbas	rois2
Rorippa nasturtium aquaticum (L.) Schinz & Thell	Rorippa nasturtium aquaticum (L.) Hayek	rona2
Rorippa obtusa (Nutt.) Britt.	Rorippa obtusa (Nutt.) Britt.	roob3
Rorippa palustris subsp. glabra (O. E. Schulz) Stuckey	Rorippa palustris var. glabra (O. E. Schulz) R. Stuckey	ropaj3
Rorippa palustris subsp. hispida (Desv.) Jonsell	Rorippa palustris ssp. hispida (Desv.) Jonsell	ropah
Rorippa sinuata (Nutt.) Hitchc.	Rorippa sinuata (Nutt.) A. S. Hitchc.	rosi2
Rorippa sylvestris (L.) Bess.	Rorippa sylvestris (L.) Bess.	rosy
Rorippa truncata (Jeps.) Stuckey	Rorippa truncata (Jeps.) R. Stuckey	rotr3
Rosa nutkana Presl.	Rosa nutkana K. Presl.	rono
Rosa woodsii var. fendleri (Crepin) Rydb.	Rosa woodsii var. fendleri (Crepin) Rydb.	rowof
Rosa woodsii var. arizonica (Rydb.) Martin & Hutchins	Rosa woodsii var. arizonica (Rydb.) W. C. Martin & C. R. Hutchins	rowoa2
Rubus parviflorus Nutt.	Rubus parviflorus Nutt.	rupa
Rubus strigosus var. arizonicus (Greene) E. S. P.	Rubus strigosus var. arizonicus (Greene) Fernald & Fernald	rustr3
Rudbeckia hirta L.	Rudbeckia hirta L.	ruhi2
Rudbeckia laciniata L.	Rudbeckia laciniata L.	rula3
Rumex acetosella L.	Rumex acetosella L.	ruac3
Rumex crispus L.	Rumex crispus L.	rucr
Rumex mexicanus Meisn.	Rumex mexicanus Meisn.	rume2
Rumex occidentalis Wats.	Rumex occidentalis S. Wats.	ruoc3
Rumex patientia L.	Rumex patientia L.	rupa5
Rumex triangulivalvis (Danser) Rech. f.	Rumex triangulivalvis (Danser) Rech. f.	rutr3
Salix bebbiana Sarg.	Salix bebbiana Sarg.	sabe2
Salix caudata (Nutt.) Heller	Salix caudata (Nutt.) Heller	saca39
Salix exigua Nutt.	Salix exigua Nutt.	saex
Salix irrorata Anderss.	Salix irrorata Anderss.	sair
Salix scouleriana Barratt	Salix scouleriana Barratt ex Hook.	sasc
Salvia pratensis L.	Salvia pratensis L.	sape2
Salvia reflexa Hornem.	Salvia reflexa Hornem.	sare3
Salvia subincisa Benth.	Salvia subincisa Benth.	sasu7
Sambucus melanocarpa Gray	Sambucus melanocarpa Gray*	same4
Sambucus microbotrys Rydb.	Sambucus microbotrys Rydb.	sami5
Sanicula alpicola Gray	Sanicula alpicola Gray	saal6
Saponaria officinalis L.	Saponaria officinalis L.	saof4
Sarcobatus vermiculatus (Hook.) Torr.	Sarcobatus vermiculatus (Hook.) Torr.	save4

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Saxifraga bronchialis L. subsp. austromontana (Wieg.) Piper	Saxifraga bronchialis ssp. austromontana (Wieg.) Piper	saba2
Saxifraga rhomboidea Greene	Saxifraga rhomboidea Greene	sarh2
Schedonnardus paniculatus (Nutt.) Trel.	Schedonnardus paniculatus (Nutt.) Trel.	scpa
Schizachne purpurascens (Torr.) Swallen	Schizachne purpurascens (Torr.) Swallen	scpu
Scleropogon brevifolius Phil.	Scleropogon brevifolius Phil.	scbr2
Scirpus californicus (C. A. Mey.) Steud.	Scirpus californicus (C. A. Mey.) Steud.	scca
Sedum cockerellii Britt.	Sedum cockerellii Britt.	seco
Senecio arizonicus Greene	Senecio arizonicus Greene	sear3
Senecio atratus Greene	Senecio atratus Greene	seat
Senecio bigelovii Gray var. bigelovii	Senecio bigelovii var. bigelovii Gray	setab
Senecio crassulus Gray	Senecio crassulus Gray	secr
Senecio cymbalaroides Nutt.	Senecio cymbalaroides Buek.	secy
Senecio douglasii var. longilobus (Benth.) L. Benson	Senecio douglasii var. longilobus (Benth.) L. Benson	sedul
Senecio eremophilus Richards. var. macdougalii (Heller) Cronq.	Senecio eremophilus var. macdougalii (Heller) Cronq.	seerm
Senecio eurypterus Greene	Senecio eurypterus Greene	seeu2
Senecio fendleri Gray	Senecio fendleri Gray	sefe
Senecio multicapitatus Greene	Senecio multicapitatus Greene ex Rydb.	semu2
Senecio multilobatus Torr. & Gray	Senecio multilobatus Torr. & Gray ex Gray	semu3
Senecio neomexicanus Gray	Senecio neomexicanus Gray	sene4
Senecio pauperculus Mackz.	Senecio pauperculus Mackz.	sepa5
Senecio pseudaureus Rydb.	Senecio pseudaureus Rydb.	sepa2
Senecio spartioides Torr. & Gray	Senecio spartioides Torr. & Gray	sesp3
Senecio triangularis Hook.	Senecio triangularis Hook.	setr
Senecio werneriifolius Gray	Senecio werneriifolius (Gray) Gray ex B265	sewe2
Senecio wootoni Green	Senecio wootoni Green	sewo
Setaria geniculata (Lam.) Beauv.	Setaria geniculata Beauv.	sege
Setaria lutescens (Weigel) Hubbard	Setaria lutescens (Weigel) F. T. Hubbard	selu4
Setaria macrostachya H. B. K.	Setaria macrostachya Kunth	semac5
Setaria viridis (L.) Beauv.	Setaria viridis (L.) Beauv.	seve4
Silene candida Gray	Silene candida Gray	sica3
Silene gallica L.	Silene gallica L.	sigal2
Silene noctiflora L.	Silene noctiflora L.	sino
Silene scouleri Hook.	Silene scouleri Hook.	sisc7
Sisymbrium altissimum L.	Sisymbrium altissimum L.	sial2
Sisyrinchium iridifolium L.	Sisyrinchium iridifolium L.	sir
Sisyrinchium bellidifolium Hook.	Sisyrinchium bellidifolium (Kunth) Hook. ex Torr. & Gray	sibe5
Sisyrinchium demissum Greene	Sisyrinchium demissum Greene	side4
Sisyrinchium montanum Greene	Sisyrinchium montanum Greene	simo2
Stanleyia pinnata (Pursh) J. G. Smith	Stanleyia pinnata (Pursh) J. G. Smith	stpi

Nomenclature

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Smilacina racemosa (L.) Desf.	Smilacina racemosa (L.) Desf.	smra
Smilacina stellata (L.) Desf.	Smilacina stellata (L.) Desf.	smst
Solanum americanum Mill.	Solanum americanum P. Mill.	soam
Solanum douglasii Dunal	Solanum douglasii Dunal	sodo
Solanum elaeagnifolium Cav.	Solanum elaeagnifolium Cav.	soel
Solanum jamesii Torr.	Solanum jamesii Torr.	soja
Solanum nigrum L.	Solanum nigrum auct. non L.	sona4
Solanum rostratum Dunal	Solanum rostratum Dunal	sora
Solanum sarachoides Sendtner	Solanum sarachoides Sendtner	sosa
Solanum triflorum Nutt.	Solanum triflorum Nutt.	sotr
Solidago altissima L.	Solidago altissima L.	soal6
Solidago canadensis L. var. canadensis	Solidago canadensis var. canadensis L.	socac3
Solidago canadensis var. glaucescens Rydb.	Solidago canadensis var. glaucescens Rydb.	socag
Solidago mollis Bartl.	Solidago mollis Bartl.	somo
Solidago multiradiata Ait.	Solidago multiradiata Ait.	somu
Solidago occidentalis (Nutt.) Torr. & Gray	Solidago occidentalis (Nutt.) Torr. & Gray	soocc4
Solidago pallida (Porter) Rydb.	Solidago pallida (Porter) Rydb.	sopa3
Solidago petradoria Blake	Solidago petradoria Blake	sope7
Solidago sparsiflora Gray	Solidago sparsiflora Gray	sosp5
Solidago spathulata var. neomexicana (Gray) Cronq.	Solidago spathulata var. neomexicana (Gray) Cronq.	sospn2
Solidago wrightii Gray var. wrightii	Solidago wrightii var. wrightii Gray	sowrw
Sonchus asper (L.) Hill	Sonchus asper (L.) Hill	soas
Sonchus oleraceus L.	Sonchus oleraceus L.	sool
Sophora nuttaliana Turner	Sophora nuttaliana B. L. Turner	sonu
Sorghastrum nutans (L.) Nash	Sorghastrum nutans (L.) Nash	sonu2
Spergularia marina (L.) Griseb.	Spergularia marina (L.) Griseb.	spma2
Sphaeralcea angustifolia (Cav.) G. Don var. cuspidata Britt. & Gray	Sphaeralcea angustifolia var. cuspidata Gray	spanc2
Sphaeralcea coccinea var. elata (Parker) Kearney	Sphaeralcea coccinea var. elata (E. G. Baker) Kearney	spcce2
Sphaeralcea fendleri Gray var. fendleri	Sphaeralcea fendleri ssp. fendleri Gray	spfef
Sphaeralcea incana Torr.	Sphaeralcea incana Torr. ex Gray	spin2
Sphenopholis intermedia (Rydb.) Rydb.	Sphenopholis intermedia (Rydb.) Rydb.	spin3
Sporobolus airoides (Torr.) Torr.	Sporobolus airoides (Torr.) Torr.	spai
Sporobolus asper (Michx.) Kunth	Sporobolus asper (Beauv.) Kunth	spas
Sporobolus contractus Hitchc.	Sporobolus contractus A. S. Hitchc.	spco4
Sporobolus cryptandrus (Torr.) Gray	Sporobolus cryptandrus (Torr.) Gray	spcr
Sporobolus neallyi Vasey	Sporobolus neallyi Vasey	spne
Sporobolus texanus Vasey	Sporobolus texanus Vasey	spte5
Stachys palustris L.	Stachys palustris L.	stpa
Stanleya pinnata (Pursh) Britt.	Stanleya pinnata (Pursh) Britt.	stpi

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1935)	Acronym
Stellaria jamesiana Torr.	Stellaria jamesiana Torr.	stja3
Stellaria longifolia Muhl.	Stellaria longifolia Muhl. ex Willd.	stlo
Stellaria longipes Goldie	Stellaria longipes Goldie	stlo2
Stephanomeria paucifolia (Torr.) A. Nels.	Stephanomeria paucifolia (Torr.) A. Nels.	stpa4
Stephanomeria tenuifolia (Torr.) Hall	Stephanomeria tenuifolia (Pall.) Hall	stte2
Stipa columbiana Macoun	Stipa columbiana auct. non Macoun	stco3
Stipa comata Trin. & Rupr.	Stipa comata Trin. & Rupr.	stco4
Stipa eminens Cav.	Stipa eminens Cav.	stem2
Stipa lettermani Vasey	Stipa lettermani Vasey	stle4
Stipa neomexicana	Stipa neomexicana (Thurb. ex Coult.) Scribn.	stne2
Stipa robusta (Vasey) Scribn.	Stipa robusta (Vasey) Scribn.	stro3
Streptanthus cordatus Nutt.	Streptanthus cordatus Nutt.	stco6
Streptopus amplexifolius (L.) D. C.	Streptopus amplexifolius (L.) DC.	stam2
Swertia radiata (Hell.) Kuntze	Swertia radiata (Hellogg) Kuntze	swra
Symphoricarpos occidentalis Hook.	Symphoricarpos occidentalis Hook.	syoc
Symphoricarpos oreophilus Gray	Symphoricarpos oreophilus Gray	syor2
Symphoricarpos rotundifolius	Symphoricarpos rotundifolius	syor
Talinum parviflorum Nutt.	Talinum parviflorum Nutt.	tapa3
Tamarix gallica L.	Tamarix gallica L.	taga
Tamarix pentandra Pall.	Tamarix pentandra Pallas	tape
Taraxacum laevigatum (Willd.) DC.	Taraxacum laevigatum (Willd.) DC.	tala2
Taraxacum officinale Weber	Taraxacum officinale G. H. Weber ex Wiggers	taof
Tetradymia canescens DC.	Tetradymia canescens DC.	teca2
Tetradymia canescens DC. var. inermis (Nutt.) Gray	Tetradymia canescens var. inermis (Nutt.) Payson	teca
Thalictrum fendleri Engelm. var. fendleri	Thalictrum fendleri var. fendleri Engelm. ex Gray	tlfe
Thelesperma filifolium Gray var. intermedium (Rydb.) Shinners	Thelesperma filifolium var. intermedium (Rydb.) Shinners	thfi
Thelesperma megapotamicum (Spreng.) Kuntze	Thelesperma megapotamicum (Spreng.) Kuntze	thme
Thelesperma trifidum (Poir.) Brit.	Thelesperma trifidum (Poir.) Brit.	thtr2
Thelypodium integrifolium (Nutt.) Endl. var. integrifolium	Thelypodium integrifolium var. integrifolium (Nutt.) Endl. ex Walp.	thin
Thelypodium wrightii Gray	Thelypodium wrightii Gray	thwr
Thermopsis montanum Nutt.	Thermopsis montanum Nutt.	thmo6
Thermopsis pinetorum Greene	Thermopsis pinetorum Greene	thpi5
Thlaspi alpestre L.	Thlaspi alpestre auct. non L.	thal5
Torreyochloa pauciflora (Presl.) Church	Torreyochloa pauciflora (J. Presl.) Church	topa3
Townsendia annua Beaman	Townsendia annua Beaman	toan
Townsendia eximia Gray	Townsendia eximia Gray	toex
Townsendia formosa Greene	Townsendia formosa Greene	tofo
Townsendia incana Nutt.	Townsendia incana Nutt.	toin
Townsendia escapa (Richards.) Porter	Townsendia escapa (Richards.) Porter	toes2

Martin & Hutchins (1980)	USDA NRCS PLANTS Database (1995)	Acronym
Tragia repetefolia Cav.	Tragia repetefolia Cav	tra
Tragopogon dubius Scop	Tragopogon dubius Scop	tdu
Tragopogon pratensis L.	Tragopogon pratensis L.	tpr
Trautvetteria grandis Nutt	Trautvetteria grandis Nutt	tgr10
Tribulus terrestris L.	Tribulus terrestris L.	tte
Tridens pilchellus (H. B. K.) Hitchc	Tridens pulchellus (Kunth) A. S. Hitchc.	tpu10
Trifolium dasyphyllum Torr. & Gray	Trifolium dasyphyllum Torr. & Gray	tda2
Trifolium hybridum L.	Trifolium hybridum L.	thy
Trifolium lacerum Greene	Trifolium lacerum Greene	tla20
Trifolium pratense L.	Trifolium pratense L.	tpr2
Trifolium procumbens L.	Trifolium procumbens L. 1755, non 1753	tpr7
Trifolium repens L.	Trifolium repens L.	tre3
Triodanis perfoliata (L.) Nieuwl	Triodanis perfoliata (L.) Nieuwl	tpe4
Trisetum montanum Vasey	Trisetum montanum Vasey	tmo5
Trisetum spicatum (L.) Richter	Trisetum spicatum (L.) Richter	tsp2
Typha latifolia L.	Typha latifolia L.	tyla
Urtica dioica procera (Muhl.) Weddl	Urtica dioica var. procera (Muhl. ex Willd.) Weddell	udp2
Urtica gracilenta Greene	Urtica gracilenta Greene	ugr
Urtica gracilis Ait	Urtica gracilis Ait	ugr3
Vaccinium myrtillus L.	Vaccinium myrtillus L.	vmy2
Valeriana arizonica Gray	Valeriana arizonica Gray	var3
Valeriana capitata Pall. ex Lrdl. subsp. acutiloba (Rydb.) F. G. Mey	Valeriana capitata ssp. acutiloba (Rydb.) F. G. Mey	vca2
Veratrum californicum Durand	Veratrum californicum Dur.	vca2
Verbascum thapsus L.	Verbascum thapsus L.	vth
Verbena bipinnatifida Nutt	Verbena bipinnatifida Nutt	vbi
Verbena bracteata Lag. & Rodr	Verbena bracteata Lag. & Rodr	vbr
Verbena hastata Wood. & Standl	Verbena hastata Wood. & Standl	vha
Verbena macdougalii Heller	Verbena macdougalii Heller	vma
Verbena wrightii Gray	Verbena wrightii Gray	vwr
Verbesina encelioides (Cav.) Benth. & Hook. subsp. encelioides	Verbesina encelioides ssp. encelioides (Cav.) Benth. & Hook. f. ex Gray	vene3
Veronica americana (Raf.)	Veronica americana Schwein. ex Benth.	vam2
Veronica arvensis L.	Veronica arvensis L.	var
Veronica peregrina L. var. xalapensis (H. B. K.) Pennell	Veronica peregrina var. xalapensis (Kunth) Pennell	vpe4
Veronica serpyllifolia L.	Veronica serpyllifolia L.	vse
Veronica wormskjoldii R. & S.	Veronica wormskjoldii Roemer & J. A. Schultes	vwo2
Viburnum lentago L.	Viburnum lentago L.	vle
Vicia americana Muhl. var. americana	Vicia americana ssp. americana Muhl. ex Willd.	vam3
Vicia americana Muhl. var. linearis	Vicia americana var. linearis (Nutt.) S. Wats.	vam8
Vicia americana var. minor Hook.	Vicia americana var. minor Hook.	vam

Martin & Hutchins (1930)	USDA NRCS PLANTS Database (1995)	Acronym
Vicia exigua Nutt.	*Vicia exigua* Nutt.	vice
Vicia leucophaea Greene	*Vicia leucophaea* Greene	vile3
Vigniera consitilla Gray	*Vigniera consitilla* Gray	vico
Vigniera multiflora (Nutt.) Blake	*Vigniera multiflora* (Nutt.) Blake	vimu
Viola adunca Smith	*Viola adunca* Sm.	vias3
Viola canadensis L.	*Viola canadensis* L.	vica4
Viola rafinesquii Greene	*Viola rafinesquii* Greene	vira
Viola pedatifida G. Don	*Viola pedatifida* G. Don	vipe2
Vicia arizonica Engelm. var. *arizonica*	*Vicia arizonica* Engelm.	viar2
Vicia vulgaris L.	*Vicia vulgaris* L.	vivu
Woodsia mexicana Fee		not listed
Woodsia oregana D. C. Eaton	*Woodsia oregana* DC. Eat.	woor
Xanthium strumarium L. var *canadense* (Mill.) Torr.	*Xanthium strumarium* L. var *canadense* (P. Mill.) Torr. & Gray	xaste
Yucca angustissima Engelm.	*Yucca angustissima* Engelm. ex Trel.	yuan2
Yucca baccata Torr.	*Yucca baccata* Torr.	yuba
Yucca glauca Nutt.	*Yucca glauca* Nutt.	yugl
Zauschneria grandiflora Nutt.	*Zauschneria grandiflora* Nutt.	zigr
Zygadenus elegans Pursh	*Zygadenus elegans* Pursh	zoel2

APPENDIX B

Common Names

Species Identification	Common Names (5 1)	Synonyms (5 1)
Abies concolor	White fir	None found
Abies lasiocarpa var. lasiocarpa	Corkbark fir; subalpine fir	None found
Acer glabrum var. neomexicanum	New Mexico maple; Rocky Mountain Maple	Acer neomexicanum
Acer negundo var. interius	Western boxelder, boxelder maple	Acer interior Brit ,Rulac interior (Brit) Nieuwl Negundo interius (Brit) Rydb
Achillea lanulosa subsp. lanulosa	Western yarrow	Achillea millefolium var. lanulosa (Nutt) Piper, A lanulosa subsp typica Heck
Aconitum columbianum	Monkshood	Aconitum lutescens A Nels ; A anthoracum Greene; A magillonicum Greene
Actaea arguta var. rubiflora	Western baneberry	Actaea rubiflora Greene
Aegilops cylindrica	Jointed Goatgrass	
Agastache pallidiflora	Giant hyssop	None found
Agoseris aurantiaca	Mountain dandelion	None found
Agoseris aurantiaca	Orange mountain dandelion	Agoseris purpurea (Gray) Greene, A greenei (Gray) Rydb ; Troximon aurantiacum
Agoseris glauca var glauca	Smooth mountain dandelion	Troximon glaucum Pursh; Agoseris pumila (Nutt) Rydb ; A lacinatata (Hitch) Greene
Agoseris glauca var parviflora	Pale mountain dandelion	Troximon parviflorum Nutt ; Agoseris parviflora (Nutt) Greene
Agrimonia gryposepala	Tall agrimony	None found
Agrimonia striata	Agrimony	Agrimonia bicornata Bicknell ; A bicornata var occidentalis Bicknell
Agropyron dasystachyum	Downy Wheatgrass	
Agropyron desertorum	Russian wheatgrass	Agropyron cristatum (L) Gaertn var pectinatum
Agropyron longiaristum	Wheatgrass	None found
Agropyron pseudorepens	False quackgrass	Elytrigia pseudorepens Scribn & Smith
Agropyron repens	Quackgrass	
Agropyron smithii	Western wheatgrass	Elytrigia smithii (Rydb) D B Dewey, Agropyron occidentale Scribn
Agropyron subsecundum	Bearded wheatgrass	Agropyron richardsonii (Trin) Schwer
Agropyron trachycaulum	Slender wheatgrass	Elymus trachycaulus (Link) Shinners; Agropyron pauciflorum (Schweinitz) Hitchc
Agrostis alba	Redtop	Agrostis stolonifera L.
Agrostis exarata	Spike Bent	
Agrostis idahoensis	Idaho redtop	None found
Agrostis perennans	Autumn Bent	
Agrostis scabra	Rough bent	None found
Agrostis semiverticillata	Water Bent	
Agrostis stolonifera	Red Top	
Ailanthus altissima	Tree of heaven	Ailanthus glandulosa Desf
Allium cernuum var. obtusum	Rocky Mountain nodding onion	Allium recurvatum Rydb
Allium geyeri	Geyer Onion	Allium funiculatum A Nels
Allium macropetalum	Mesa Onion	
Allium textile	Wild onion	Allium reticulatum Fraser
Alnus oblongifolia	New Mexico Alder	None found
Alnus tenuifolia	Thinleaf alder, mountain alder	None found
Alopecurus aequalis	Short awn Foxtail	
Althaea rosea	Hollyhock Mallow	

Species identification	Occurrence (5.0.2, 5.1.14)	Blooms (5.0.2, 5.1.14)	Habit (5.0.1, 5.1.14)
Abies concolor	Spring	Common	Tree
Abies lasiocarpa var. lasiocarpa	Not common	Spring	Tree
Acer glabrum var. neomexicanum	Locally common	Spring	Small tree
Acer negundo var. interius	Locally common	Spring	Tree
Achillea lanulosa subsp. lanulosa	Ubiquitous	Midsummer to fall	Perennial forb
Aconitum columbianum	Not common	Mid- to late summer	Perennial forb
Actaea arguta var. rubiflora	Locally common	Spring to early summer	Perennial forb
Agalinis cylindrica	Occasional		
Agastache pallidiflora	See Robertson (1966); Appendix I	Late summer to fall	Perennial forb
Agoseris aurantiaca	See Pitz et al. (1979)	Early to late summer	Perennial forb
Agoseris aurantiaca	Not common	Late summer	Perennial forb
Agoseris glauca var. glauca	Not common	Late summer	Perennial forb
Agoseris glauca var. parviflora			
Agrimonia gryposepala	See Robertson (1966)	Mid- to late summer	Perennial forb
Agrimonia striata	Locally common	Late summer	Perennial forb
Agropyron dasystachyum	Occasional		
Agropyron desertorum	Common	Late summer	Perennial grass
Agropyron fatigatum	See Appendix I	Late summer	Perennial grass
Agropyron pseudurepens	Osborne (1966); Robertson (1966); Pitz et al. (1979)	Early to late summer	Perennial grass
Agropyron repens	Occasional		
Agropyron smithii	Common	Early summer	Perennial grass
Agropyron subsecundum	See Pitz et al. (1979)	Early to late summer	Perennial grass
Agropyron trachycaulum	Abundant in seeded areas	Early summer	Perennial grass
Agrostis alba	Common	Early summer	Perennial forb
Agrostis exarata	Occasional		
Agrostis idahoensis	See Pitz et al. (1979)	Early to late summer	Perennial forb
Agrostis perennans	Occasional		
Agrostis scabra	Not common	Early to late summer	Perennial forb
Agrostis semiverticillata	Locally Abundant		
Agrostis stolonifera	Locally abundant		
Alnus alnobetula	Locally common	Early to midsummer	Tree
Alnus incana var. tenuifolia	Ubiquitous	Mid- to late summer	Perennial forb
Alnus geyeri	See Pitz et al. (1979)	Early summer to fall	Perennial forb
Alnus macrostachya	Locally Abundant		
Alnus rubra	Not common	Early spring	Perennial forb
Alnus oblongifolia	See Osborne (1966)	Spring	Tree
Alnus tenuifolia	Locally common	Spring	Tree
Alopecurus aequalis	Occasional		
Althaea rosea	Occasional		

Species identification	Habitat (5.0.2, 5.1.14)	Mn_Elev (5.0.2, 5.1.14)	Max_Elev (5.0.2, 5.1.14)
Abies concolor	Canyon sides, mountain slopes; often with spruce, mixed conifer forests	7500	9300
Abies lasiocarpa var. lasiocarpa	Mountain slopes; mixed conifer forests	8500	10000
Acer glabrum var. neomexicanum	Meadows, canyons, mixed conifer forests & moist wet	6500	8000
Acer negundo var. interius	Along streams and other moist areas	5400	7000
Achillea lanulosa subsp. lanulosa	Canyons, mountain slopes, meadows; pinyon juniper, ponderosa pine, mixed conif	7000	10000
Aconitum columbianum	Moist canyons, stream banks	8000	8500
Acrisea aquila var. viridiflora	Canyon bottoms, mountain slopes, mixed conifer forests	7500	10000
Aegilops cylindrica	Disturbed canyon bottoms	6000	6000
Agastache pallidiflora	Slopes and mesas; ponderosa pine and mixed conifer forests	7000	9500
Agoseris aurantiaca	Meadows	7000	10000
Agoseris aurantiaca	Meadows; subalpine meadows, spruce fir forest & Dry moist	9000	10000
Agoseris glauca var. glauca	Meadows; mixed conifer forests & Dry moist	7500	8000
Agoseris glauca var. parviflora			
Agrostemma gypsophila	Canyons	6500	8000
Agrostis stolonifera	Along streams, moist canyon bottoms	7500	8000
Agropyron dasystachyum	Mesas	6300	7150
Agropyron desertorum	Disturbed soil, juniper grassland, pinyon juniper woodland	5400	8000
Agropyron lutiglume	Meadows and open slopes	9000	9500
Agropyron pseudorepens	Mountains	6000	7500
Agropyron repens	Canyon bottoms	5700	5700
Agropyron smithii	Disturbed soil, pinyon juniper woodland, ponderosa pine forest	6500	7500
Agropyron subsecundum	Mountains and meadows	8000	10000
Agropyron trachycaulum	Transplant to Mesa fire roadsides pinyon juniper woodland mixed conif. forests	7000	9000
Agrostis alba	Canyon bottoms, meadows, mountain slopes; pinyon juniper woodland, ponderosa	6500	8500
Agrostis exarata	Canyon bottoms	5700	5700
Agrostis idahoensis	Meadows	7000	10000
Agrostis perennans	Canyon bottom meadows	8700	8700
Agrostis scabra	Canyon bottoms; mixed conifer forests	8000	8500
Agrostis semiverticillata	Moist canyon bottoms	6000	6300
Agrostis stolonifera	Moist canyon bottoms and mountain slopes	5300	9000
Alandhus altissima	Disturbed soil, around abandoned buildings	5400	7000
Allium cernuum var. obtusum	Canyons, mesas, meadows, mountain slopes pinyon juniper wood. pine mix con. subalpine	7000	10000
Allium geyeri	Meadows and slopes	6500	12000
Allium macropetalum	Dry mesas	6250	6250
Allium textile	Mesa tops, juniper grassland	6000	6500
Alnus oblongifolia	Along streams; pinyon juniper woodland, ponderosa pine forest	6000	7500
Alnus tenuifolia	Along streams in canyons; pinyon juniper woodland, ponderosa pine forest	6000	7500
Alopecurus aequalis	Boggy mountain meadows, pondedge	8950	9000

Species Identification	Elk_Cov (5 0.1)	Mule_Deer (5 0.1)	Whitetail (5 0.1)	Antelope (5 0.1)	Upl_Game (5 0.1)	Waterfowl (5 0.1)	Sm_NonG (5 0.1)	Sm_Mam (5 0.1)
Abies concolor	Good	Good						
Abies lasiocarpa var. lasiocarpa	Good	Good			Good		Good	Good
Acer glabrum var. neomexicanum							Good	Good
Acer negundo var. interius			Good				Good	Good
Achillea lanulosa subsp. lanulosa								
Aconitum columbianum								
Actaea arguta var. viridiflora								
Aegilops cylindrica								
Agastache pallidiflora								
Agoseris aurantiaca								
Agoseris aurantiaca								
Agoseris glauca var. glauca								
Agoseris glauca var. parviflora								
Agrimonia gypsicola								
Agrimonia striata								
Agropyron dasystachyum			Poor					
Agropyron desertorum								
Agropyron fragile								
Agropyron pseudorepens								
Agropyron repens								
Agropyron smithii			Poor					
Agropyron subsecundum								
Agropyron trachycaulum								
Agrostis alba								
Agrostis exarata			Poor					
Agrostis idahoensis								
Agrostis perennans								
Agrostis scabra								
Agrostis semiverticillata								
Agrostis stolonifera								
Alnaldus abissina								
Allium cernuum var. obtusum			Poor					
Allium geyeri								
Allium macropetalum								
Allium textile			Poor					
Alnus oblongifolia								
Alnus tenuifolia	Fair	Good	Poor		Fair		Good	Good
Alopecurus aequalis								

Soils

Species identification	Gr_Gravel (5 0.1)	Gr_Sand (5 0.1)	Gr_SandLoam (5 0.1)	Gr_Loam (5 0.1)	Gr_ClayLo (5 0 1)	Gr_Clay (5 0.1)	Gr_DenCla (5 0.1)
Abies concolor	POOR Fair	FAIR	GOOD	GOOD	FAIR Good	POOR Fair	POOR
Abies lasiocarpa var lasiocarpa	POOR Fair	POOR Fair	GOOD	Fair GOOD	FAIR Good	POOR Fair	POOR
Acer glabrum var neomexicanum	Fair POOR	FAIR	GOOD	GOOD	GOOD	Fair POOR	POOR
Acer negundo var interius	Fair POOR	FAIR	GOOD	GOOD	GOOD	Fair POOR	POOR
Achillea lanulosa subsp lanulosa							
Aconitum columbianum	POOR Fair	POOR Fair	GOOD	GOOD	Fair GOOD	POOR Fair	POOR
Actaea arguta var. viridiflora							
Aegilops cylindrica							
Agastache pallidiflora							
Agoseris arizonica							
Agoseris aurantiaca							
Agoseris glauca var glauca	POOR Fair	Poor FAIR	Fair GOOD	GOOD	GOOD	POOR Fair	POOR Fair
Agoseris glauca var parviflora							
Agrimonia gryposepala							
Agrimonia striata							
Agropyron dasystachyum	POOR Fair	Fair GOOD	Fair GOOD	GOOD	FAIR Good	POOR Fair Good	POOR
Agropyron desertorum	Poor Fair	Fair	Good	Good	Fair Good	Poor Fair	Poor
Agropyron lanigerum							
Agropyron pseudorepens							
Agropyron repens	POOR Fair	POOR Fair	GOOD	GOOD	GOOD	FAIR Good	POOR Fair
Agropyron smithii	POOR	POOR Fair	FAIR Good	GOOD	GOOD	Fair GOOD	FAIR
Agropyron subsecundum							
Agropyron trachycaulum	Poor	Poor Fair	Good	Good	Good	Fair	Poor
Agrostis alba							
Agrostis exarata	POOR Fair	FAIR Good	GOOD	GOOD	Fair GOOD	POOR Good	POOR Fair
Agrostis idahoensis	Fair	Good	Good	Good	Good	Fair	Poor
Agrostis perennans							
Agrostis scabra	Poor	Poor Fair	Good	Good	Good	Fair	Poor
Agrostis semiverticillata							
Agrostis stolonifera	POOR Fair	FAIR Good	GOOD	GOOD	GOOD	FAIR	POOR
Ailanthus altissima							
Allium cernuum var obtusum	Poor Fair	Fair	Good	Good	Good	Poor	Poor
Allium geyeri							
Allium macropetalum							
Allium textile	Poor	Fair	Good	Good	Good	Fair Good	Poor Fair
Alnus oblongifolia							
Alnus tenuifolia	POOR Fair	FAIR	GOOD	GOOD	GOOD	POOR Fair	POOR
Alopecurus aequalis							

Species identification	Origin (5 0 2)	Rep_Type (5 0.1)	CO2_Fix (5 0.1)	Troph_St (5 0.1)	Beg_Ant (5 0.1)	Anthesis (5 0.1)	End_Ant (5 0.1)
Abies concolor	Native	Sexual		Autotrophic			
Abies lasiocarpa var. lasiocarpa	Native	Sexual		Autotrophic			
Acer glabrum var. neomexicanum	Native	Sexual		Autotrophic			
Acer negundo var. interius	Native	Sexual	C3	Autotrophic	April	May	May
Achillea lanulosa subsp. lanulosa							
Aconitum columbianum	Native	Sexual		Autotrophic			
Actaea arguta var. viridiflora							
Aegilops cylindrica	Introduced	Sexual	C3	Autotrophic			
Agastache pallidiflora	Native	Sexual		Autotrophic			
Agoseris aurantiaca							
Agoseris aurantiaca	Native	Sexual		Autotrophic			
Agoseris glauca var. glauca	Native	Sexual	C3	Autotrophic	May	August	September
Agoseris glauca var. parviflora							
Agrimonia gryposepala	Native	Vegetative Sexual		Autotrophic			
Agrimonia striata	Native	Vegetative Sexual		Autotrophic			
Agropyron dasystachyum	Native	Vegetative Sexual		Autotrophic	June		August
Agropyron desertorum	Introduced	Sexual	C3	Autotrophic	June	July	August
Agropyron fragile							
Agropyron pseudorepens							
Agropyron repens	Introduced	Sexual	C3	Autotrophic	June		August
Agropyron smithii						June	August
Agropyron subsecundum	Native	Vegetative Sexual	C3	Autotrophic			
Agropyron trachycaulum	Native	Vegetative Sexual	C3	Autotrophic			
Agrostis alba							
Agrostis exarata	Native	Vegetative Sexual		Autotrophic	July		August
Agrostis idahoensis	Native	Sexual		Autotrophic	July	August	
Agrostis perennans	Introduced	Sexual	C3	Autotrophic			
Agrostis scabra	Native	Sexual	C3	Autotrophic	July	August	
Agrostis semiverticillata	Introduced	Vegetative Sexual		Autotrophic			
Agrostis stolonifera	Introduced		C3	Autotrophic	June		September
Alisma plantago	Introduced	Vegetative Sexual	C3	Autotrophic			
Allium cernuum var. obtusum	Native	Vegetative Sexual	C3	Autotrophic	May	July	September
Allium geyeri	Native	Vegetative Sexual		Autotrophic			
Allium macropetalum	Native	Vegetative Sexual		Autotrophic			
Allium textile	Native	Vegetative Sexual	C3	Autotrophic	May	June	August
Alnus oblongifolia							
Alnus tenuifolia	Native	Sexual		Autotrophic	May	June	August
Alopecurus aequalis	Native	Sexual	C3	Autotrophic			

Species identification	National Wetland List (5.5.1)	N.M. Wetland List (5.5.1)	Disturbed Sites	Disturbance References	Comments on Disturbed Sites Growth
Abies concolor			Y	Vale (1981)	Early invader
Abies lasiocarpa var. lasiocarpa	Upland, FAC	FACU (+)			
Acer glabrum var. neomexicanum	FACU, FAC	FAC	Y	Fleischner et al. (1983)	Inhabits primary succession habitats
Acer negundo var. interius	FAC, FACW	FACW (+)			
Achillea lanulosa subsp. lanulosa			Y	Fleischner et al. (1989)	Characteristic of disturbed sites
Aconitum columbianum	FACW	FACW			
Actaea arguta var. viridiflora					
Aegilops cylindrica					
Agastache pallidiflora					
Agoseris aurantiaca					
Agoseris aurantiaca	FACU, FAC	FAC			
Agoseris glauca var. glauca	FACU, FAC	FAC	Y	Russell (1985)	Frequent occurence on revegetated coal mines
Agoseris glauca var. parviflora			Y	Russell (1985)	Frequent occurence on revegetated coal mines
Agrimonia gryposepala	FACU, FACW (+)	FACW (+)			
Agrimonia striata	FACU (+), FAC	FAC (+)			
Agropyron dasystachyum	Upland, FAC	FAC	Y	Jastrow et al. (1984a), Sindelar (1984), Eddleman (1984)	Old well in mixed community on revegetated mined soil
Agropyron desertorum					
Agropyron latiglume			Y	Russell (1985)	Abundant occurence on revegetated coal mines
Agropyron pseudorepens					
Agropyron repens	Upland, FAC	FACU (+)	Y	Russell (1985)	Frequent occurence on revegetated coal mines
Agropyron smithii	Upland, FAC (+)	FAC (+)	Y	Paschal et al. (1985), Brand & Goetz (1986), Jastrow et al. (1984a), Sindelar (1984)	Dominant species in mined area. Does better on grazed land. Old well in mixed community on mined soils. Good invader on mined soils
Agropyron subsecundum			Y	Russell (1985)	Frequent occurence on revegetated coal mines
Agropyron trachycaulum	FACU, FAC	FAC	Y	Russell (1985)	Abundant occurence on revegetated coal mines
Agrostis alba	FACW, OBLW	FACW (+)			
Agrostis exarata	FACW	FACW			
Agrostis idahoensis		FAC, FACW			
Agrostis perennans	FACU, FACW	FAC			
Agrostis scabra	FAC, FAC (+)	FAC			
Agrostis semiverticillata	FACW, OBLW	FACW (+)			
Agrostis stolonifera	FAC (+), FACW	Not Indicated			
Alchemilla alpina	FACU	FACU			
Allium cernuum var. obtusum					
Allium geyeri	FACU	FACU			
Allium macropetalum					
Allium textile					

Species Identification	Potential Biomass (5 0.1)	Gentle Slopes (5 0.1)	Moderate Slopes (5 0.1)	Steep Slopes (5 0.1)	Erosion Control (5 0.1)	Establishment Requirements (5 0.1)	Short term Revegetation (5 0.1)	Long term Revegetation (5 0.1)
Abies concolor	Medium	Good	Good	Good	High	Medium	Low	High
Abies lasiocarpa var. lasiocarpa	Medium	Good	Good	Good	High	Medium	Low	High
Acer glabrum var. neomexicanum	Medium	Good	Good	Fair	Medium			
Acer negundo var. interius	Medium	Good	Fair	Poor	Medium			
Achillea lanulosa subsp. lanulosa								
Aconitum columbianum	Medium	Good	Good	Fair	Medium			
Actaea arguta var. viridiflora								
Aegilops cylindrica								
Agastache pallidiflora								
Agoseris aurantiaca								
Agoseris aurantiaca								
Agoseris glauca var. glauca	Low	Good	Good	Poor	Low			
Agoseris glauca var. parviflora								
Agrimonia gryposepala								
Agrimonia striata								
Agropyron dasystachyum	Medium	Good	Good	Fair	High	Medium	Medium	High
Agropyron desertorum		Good	Good	Fair		Medium	Medium	High
Agropyron latiglume								
Agropyron pseudorepens								
Agropyron repens								
Agropyron smithii	High	Good	Good	Fair	High	Medium	Medium	High
Agropyron subsecundum								
Agropyron trachycaulum		Good	Good	Fair				
Agrostis alba								
Agrostis exarata	Low	Good	Fair	Poor	Medium			
Agrostis idahoensis		Good	Good	Fair				
Agrostis perennans								
Agrostis scabra		Good	Good	Poor				
Agrostis semiverticillata								
Agrostis stolonifera	Medium	Good	Fair	Poor	High	Medium	Medium	High
Alardus abissinica								
Alium cernuum var. obtusum		Good	Good	Fair				
Alium geyeri								
Alium macropetalum								
Alium textile		Good	Good	Fair				
Alnus oblongifolia								
Alnus tenuifolia	Medium	Good	Good	Poor	Medium			

Fire and Flood

Species identification	Associated with fire	Fire Reference	Fire Comments	Flooded Areas	Flood References	Flood Comments
Abies concolor	Y	Thomas & Agee (1986)	Does well in post fire succession			
Abies lasiocarpa var. lasiocarpa						
Acer glabrum var. neomexicanum						
Acer negundo var. interior						
Achillea lanulosa subsp. lanulosa						
Aconitum columbianum						
Actaea arguta var. viridiflora						
Aegilops cylindrica						
Agastache pallidiflora						
Agoseris aurantiaca						
Agoseris aurantiaca						
Agoseris glauca var. glauca						
Agoseris glauca var. parviflora						
Ageratina gypsophila						
Ageratina stolata						
Agropyron dasystachyum						
Agropyron desertorum						
Agropyron lanceolatum						
Agropyron pseudurense						
Agropyron repens						
Agropyron smithii						
Agropyron subsecundum						
Agropyron trachycaulum				Y	Garstkopp (1988)	Does poorly under flooded conditions
Agrostis alba						
Agrostis exarata						
Agrostis idahoensis						
Agrostis perennans						
Agrostis scabra						
Agrostis semiverticillata						
Agrostis stolonifera						
Alnus incana ssp. tenuifolia						
Alnus cernua var. obtusum						
Alnus geyeri						
Alnus macrocephala						
Alnus tenuifolia						
Alnus oblongifolia						
Alnus tenuifolia						

Species identification	Mycorrhiza (5 0.1)	Nod_Form (5 0.1)	Nit_Fix (5 0.1)	Hayfever (5 0.1)	Edible (5 0.1)	Weediness (5 0.1)	Oldfields	Oldfield References	Oldfield Comments
Abies concolor	Ectomycorrhizal			No		Non weedy			
Abies lasiocarpa var lasiocarpa	Ectomycorrhizal	No	No	No		Non weedy			
Acer glabrum var neomexicanum				Yes		Non weedy			
Acer negundo var interior	Endomycorrhizal	Possible	Maybe	Yes					
Achillea lanulosa ssp lanulosa	Endomycorrhizal	No	No			Economic			
Aconitum columbianum					Poison	Non weedy			
Actaea arguta var rubiflora									
Aegilops cylindrica						Noxious CO			
Agastache pallidiflora						Non weedy			
Agoseris aurantiaca									
Agoseris aurantiaca					Yes Qualified	Non weedy			
Agoseris glauca var glauca	Endomycorrhizal			No		Non weedy			
Agoseris glauca var parviflora									
Agrostemma githago						Non weedy			
Agrostemma stellata						Non weedy			
Agropyron dasystachyum	Endomycorrhizal	No		Yes		Non weedy			
Agropyron desertorum						Colonizing			
Agropyron fragilis									
Agropyron pseudorepens									
Agropyron repens		No	No	Yes	Yes	Noxious All States			
Agropyron smithii	Endomycorrhizal	No	No	Yes		Non weedy			
Agropyron subsecundum									
Agropyron trachycaulum				Yes		Non weedy	Y	Jastrow et al (1984)	Dominant on old fields with sandy soils
Agrostis alba									
Agrostis exarata						Non weedy			
Agrostis idahoensis						Non weedy			
Agrostis perennans				Maybe		Non weedy			
Agrostis scabra		No	No			Colonizing			
Agrostis stolonifera						Colonizing			
Agrostis stolonifera	Endomycorrhizal		No	Yes		Non weedy			
Alkanna tinctoria	Endomycorrhizal			Yes	Poison	Colonizing			
Allium cernuum var obliquum					Yes	Economic			
Allium geyeri					Yes	Economic			
Allium macropetalum						Economic			
Allium textile					Yes	Economic			
Allium oliganthum									

Native American Tribal Use

Species identification	Zuni	Navajo	Tewa	Hopi	Cochiti	Isleta	Mes. Apache	Acoma	Jemez	Other
Abies concolor								Y		
Abies lasiocarpa var. lasiocarpa										
Acer glabrum var. neomexicanum						Y				
Acer negundo var. interius								Y		
Achillea lanulosa subsp. lanulosa	Y	Y			Y					
Aconitum columbianum										
Actaea arguta var. rubiflora										
Aegilops cylindrica										
Agastache pallidiflora										
Agoseris aurantiaca										
Agoseris aurantiaca										
Agoseris glauca var. glauca										
Agoseris glauca var. parviflora										
Agrostis gypsicola										
Agrostis stolonifera										
Agrostis stolonifera										
Agropyron dasystachyum										
Agropyron desertorum										
Agropyron latiglume										
Agropyron pseudorepens										
Agropyron repens										
Agropyron smithii								Y		
Agropyron subsecundum							Y			
Agropyron trachycaulum										
Agrostis alba										
Agrostis exarata										
Agrostis idahoensis										
Agrostis perennans										
Agrostis scabra										
Agrostis semiverticillata										
Agrostis stolonifera										
Alnus alnobetula										
Alnus cernuum var. obtusum								Y	Y	
Alnus geyeri										
Alnus maritima										
Alnus tenuifolia										
Alnus oblongifolia										
Alnus tenuifolia	Y	Y						Y		
Alopecurus aequalis										
Althaea rosea								Y		

Medicines and Dyes

Species identification	Medicine	Tribe Using	Medicine Comment	Medicine Reference	Dye	Tribe Using	Dye Comment	Dye Reference
Abies concolor								
Abies lasiocarpa var. lasiocarpa								
Acer glabrum var. neomexicanum								
Acer negundo var. interius								
Achillea lanulosa subsp. lanulosa	Y	Navajo; Cochiti	Used as an universal tonic; Used as a cure for chills	Elmore (1943). Goldfrank (1927)				
Aconitum columbianum								
Actaea arguta var. viridiflora								
Aegilops cylindrica								
Agastache pallidiflora								
Agoseris aurantiaca								
Agoseris aurantiaca								
Agoseris glauca var. glauca								
Agoseris glauca var. parviflora								
Agrimonia gryposepala								
Agrimonia striata								
Agropyron dasystachyum								
Agropyron desertorum								
Agropyron latiglume								
Agropyron pseudorepens								
Agropyron repens								
Agropyron smithii								
Agropyron subsecundum								
Agropyron trachycaulum								
Agrostis alba								
Agrostis exarata								
Agrostis idahoensis								
Agrostis geremana								
Agrostis scabra								
Agrostis semiverticillata								
Agrostis stolonifera								
Alkathus altissima								
Allium cernuum var. obtusum	Y	Jemez;	Mild stimulant; Used for sore throat	Cook;				
Allium geyeri								
Allium macropetalum								
Allium textile								
Alnus oblongifolia								

Construction and Weapons

Species identification	Construction	Tribe Using	Construction Comments	Construction References	Weapons	Tribe Using	Weapons Comments	Weapons References
Alnus concolor								
Alnus lusiocarpa var. lusiocarpa								
Acer glabrum var. neomexicanum					Y	Nuta	Used to make bows	Jones (1931)
Acer negundo var. interius								
Achillea lanulosa subsp. lanulosa								
Aconitum columbianum								
Actaea arguta var. versiflora								
Aegilops cylindrica								
Agastache pallidiflora								
Agoseris aurantiaca								
Agoseris aurantiaca								
Agoseris glauca var. glauca								
Agoseris glauca var. parviflora								
Agrostis gigantea								
Agrostis stolonifera								
Agropyron dasystachyum								
Agropyron desertorum								
Agropyron trachycaulum								
Agropyron pseudorepens								
Agropyron repens								
Agropyron smithii								
Agropyron subsecundum								
Agropyron trachycaulum								
Agrostis alba								
Agrostis exarata								
Agrostis idahoensis								
Agrostis perennans								
Agrostis scabra								
Agrostis semiverticillata								
Agrostis stolonifera								
Alopecurus aequalis								
Alopecurus pratensis								
Alopecurus saccatus								
Alopecurus geyeri								
Alopecurus macrostachyus								
Alopecurus textilis								
Alopecurus oligostachyus								
Alopecurus tenuiflorus								
Alopecurus aequalis								

Household Use and Poisons

Species Identification	Household	Tribe Using	Household Comments	Household References	Poison	Tribe Using	Poison Comments	Poison References
Abies concolor	✓	Acoma	Used as decoration in homes	Swank (1932)				
Acer lasiocarpa var. lasiocarpa								
Acer glabrum var. neomexicanum								
Acer negundo var. interior								
Achillea lanulosa subsp. lanulosa								
Aconitum columbianum								
Actaea arguta var. rubiflora					✓		Poison from fruits and rootstalks acts on heart	
Agoseris glauca								
Agoseris parviflora								
Agoseris aurantiaca								
Agoseris aurantiaca								
Agoseris glauca var. glauca								
Agoseris glauca var. parviflora								
Agoseris gracilens								
Agoseris stolata								
Agropyron dasystachyum								
Agropyron desertorum								
Agropyron latiglume								
Agropyron pseudorepens								
Agropyron repens								
Agropyron smithii	✓	Acoma	Used to protect worm damage to medicine plants, and to make the medicine smoother	Swank (1932)				
Agropyron subsecundum	✓	Mescalero Apache	Used as nutrition source for horses	Castetter & Opler				
Agropyron trachycaulum								
Agrostis alba	✓							
Agrostis exarata								
Agrostis idahoensis								
Agrostis gigantea								
Agrostis scabra								
Agrostis semiverticillata								
Agrostis stolonifera								
Alnus alnobetula								
Alnus rhombifolia var. oblongifolia								
Alnus tenuifolia								
Alnus macrocarpa								
Alnus tenuifolia								

Cermonial Uses and Food

Species Identification	Ceremonial	Tribe Using	Ceremonial Comment	Ceremonial Reference	Edible	Tribe Using	Edible Comment	Edible Reference
Abies concolor	Y	Acoma	Used as decoration for dances	Swank (1932)				
Abies lasiocarpa var. lasiocarpa								
Acer glabrum var. neomexicanum								
Acer negundo var. interius	Y	Acoma	Used for prayer sticks	Swank (1932)				
Achillea lanulosa subsp. lanulosa	Y	Zuni	Used in fire ceremonies	Stevenson				
Aconitum columbianum								
Actaea arguta var. rubiflora								
Aegilops cylindrica								
Agastache pallidiflora								
Agoseris aurantiaca								
Agoseris aurantiaca								
Agoseris glauca var. glauca								
Agoseris glauca var. parviflora								
Ajuncus gypsicepala								
Ajuncus stricta								
Agropyron dasystachyum								
Agropyron desertorum								
Agropyron longiflorum								
Agropyron pseudobrevipes								
Agropyron repens								
Agropyron smithii								
Agropyron subsecundum					Y	Mescalero Apache	Tubers eaten raw and with meat	Castetter & Opler
Agropyron trachycaulum								
Agrostis alba								
Agrostis exarata								
Agrostis idahoensis								
Agrostis perennans								
Agrostis scabra								
Agrostis semiverticillata								
Agrostis stolonifera								
Ailanthus altissima								
Allium cernuum var. obtusum					Y	Jemez, Acoma	Added to meat. Bulbs eaten	Cook; Swank (1932)
Allium geyeri								
Allium macropetalum								
Allium textile								
Alnus oblongifolia								

A Survey of Los Alamos County and Bandelier National Monument for Macroscopic Fungi

Nelson Jarmie and Fran J. Rogers

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A Survey of Los Alamos County and Bandelier National Monument for Macroscopic Fungi

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Abstract

Surveys have been conducted for macroscopic fungi within Los Alamos County and Bandelier National Monument (BNM) from 1991 to 1995. From the information gathered, we have developed a data base that provides information on species found, and the ecology and biology of each specimen collected. To date we have catalogued 1,048 specimens and identified 241 species. Fifty-one species are new to the State of New Mexico, 21 specimens are considered rare. This paper provides a preliminary listing of species found within Los Alamos County and BNM. Seventy-six percent of the specimens have been preserved and stored in a herbarium.

I. Introduction

The importance of fungi to the ecosystem is well expressed by Arnold (1992). He says, "Wild mushrooms are fascinating organisms, not only because of their tremendous variations in color and shape, but also in view of their unpredictable time of appearance, the rareness of so many species and their enormous ecological differentiation. Fungi are not only decorative, but are also essential components of our environment; without them there would be no long-term survival of the forests."

As indicated by Arnold's statement, the ecological importance of fungi is being recognized. Macroscopic fungi (large, visible fungi) have been found to be good indicators of environmental change. (Deka and Mishra 1981; Kinnes 1982; Wright and Tarrant 1957; Klopatek et al. 1987, Jansen 1990, Arnold 1992). In Europe, researchers have become alarmed at the disappearance of edible species such as the chanterelle. Researchers, such as Cherfas (1991), believe the disappearance is not due to over collecting but to subtle environmental impacts such as nitrogen fertilizer in farming.

To understand environmental change in the environment, we must know what species occur in an area, in which habitats they live, and the conditions of those habitats (Kosztarb1983). Some types of fungi can be indicative of certain environmental factors and may be indicators of unique or sensitive habitats. In our surveys, we encountered the rare Jemez Mountains salamander (*Plethodon neomexicanus*) in areas where we located a rare fungal species. It is important to understand the species diversity and species dependence on habitats, particularly those which support threatened, endangered, or species of concern. Understanding the fungal component of the ecosystem will help in making management decisions related to other trophic levels.

Within Los Alamos National Laboratory (LANL), the Los Alamos County, or the State of New Mexico there have been few intensive studies of the fungal flora. Indeed, diversity studies of fungi are rare in North America (Nishida 1992, Ammirati 1994). The area within Los Alamos County and Bandelier National Monument (BNM) offers a unique

opportunity to study the fungal species and their diversity. LANL represents a 112-km^2 (43-mi^2) area that is remote but does have the potential for contaminants to enter the environment because of Laboratory operations. BNM experienced a large fire in 1977 and provided an area to study fire disturbance and succession. Therefore, in 1991, we began a systematic survey of LANL, Los Alamos County, and BNM for fungi. Figure 1 shows the location of Los Alamos County and BNM.

The ultimate goals for a study related to fungi are the following:

1) To understand distribution patterns within the County and Bandelier.
2) To understand the diversity of species within these environments.
3) To record any rare and unusual species of the area.
4) To begin to understand the distribution patterns and potential change of these species.
5) To begin to understand the ecology of the species within these environments.

Once this baseline information is available, the potential exists to understand the fungal species as indicators, periodicity of species, and occurrence of rare and decreasing species. This paper documents the surveys done from 1991 to 1995 and discusses a data base developed from these surveys. With this baseline information and modeling of this baseline data, we can begin to understand more about the fungal flora of the areas.

2.0 Ecological and Taxonomic Information

2.1 Ecology

Macromycetes in the vegetative state (hypha) are thin segmented microscopic filaments hidden in the soil or host. Based on their functions these fungi are divided into three main functional-ecological groups: saprotrophic, parasitic, and mycorrihizal. Approximately 50% of the macromycetes are saprotrophic and 50% are mycorrhizal. There are very few parasitic species.

Saprophytic fungi are involved in the decomposition of dead organic matter, including leaf litter, wood, dung, and dead sporocarps of other fungi. The fungi are one of the few groups of organisms with effective enzyme systems for the breakdown of lignin, one of the main components of plant material.

Parasitic fungi species feed on living tissues of plants and animals including other fungi. They attack weakened hosts, mainly trees and other vascular plants, often killing them.

The mycorrhiza fungi participate in a beneficial symbiotic relationship with trees. This mutualist relationship is an intimate union between the fungal hyphae and the feeding rootlets of the tree. Many trees and bushes are obligatory ectomycorrhizal, (Arnolds 1992), including in our area willow (*Salix* spp.), juniper (*Juniperus* spp.), cottonwood (*Populus* spp.), pines (*Pinus* spp.), spruce (*Picea* spp.), Douglas fir (*Pseudotsuga* spp.), white fir (*Abies* spp.), Oak (*Quercus* spp.), and Birch (*Betula* spp.). It has been estimated that there are roughly 1,000 kg (2,200 lb) of hyphae per acre in an average forest.

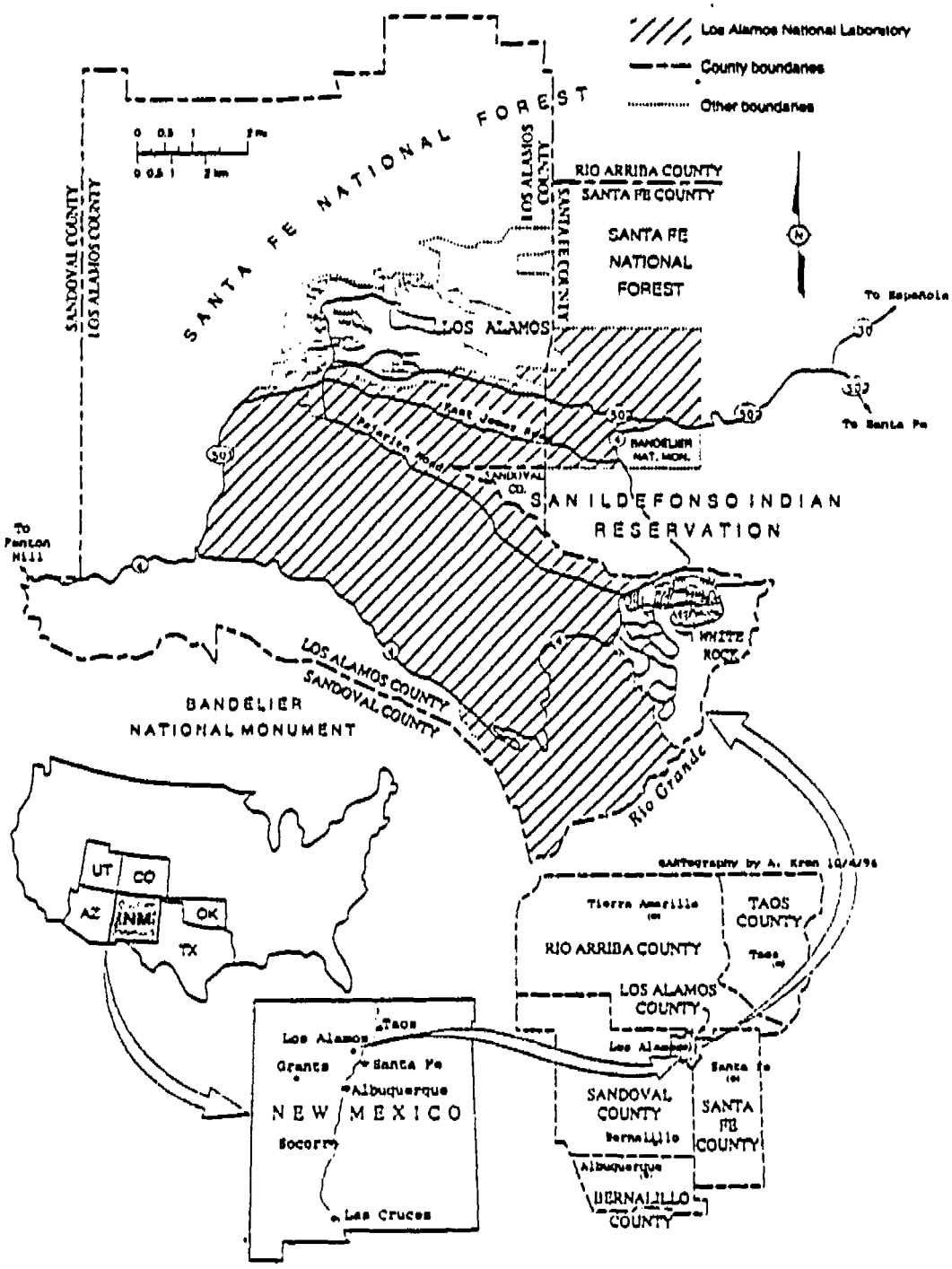

Figure 1. Locations of Los Alamos County and Bandelier National Monument.

2.2. Taxonomic Information

The taxonomy of fungi is complicated and we are not providing a full description in this paper but have outlined the various taxonomic levels in Figure 2. Some common representatives of this taxonomic hierarchy are in Table 1.

3.0 Methods

3.1 Collection Techniques

Specimens were taken from Los Alamos County in north-central New Mexico and the adjacent BNM. On LANL, emphasis was placed on areas where other botanical surveys were being conducted and in forest areas burned by fires, particularly the 1977 La Mesa fire. Because fungal fruiting depends heavily on soil moisture and atmospheric humidity, which, in Los Alamos, is dependent on altitude, we searched in areas at different elevations and within different vegetative zones from 1700 m to 2900 m (5500 ft to 9500 ft).

The fungal fruiting season runs normally from May through October, with most of the fruiting occurring in the rainy season from July through September. Most of our collections were made from July through September.

We established collection locations in BNM, LANL, and the Santa Fe National Forest, all within the Los Alamos County. Collections were made within several Laboratory Technical Areas (TA) including TA-0, 3, 18, 67, and in burn sites in BNM near the Juniper Campground, park headquarters, and parts of the 1977 La Mesa fire at Burnt Mesa, Apache Springs Road area, and the Dome Road intersection.

A collection site was defined as roughly a 100-m (330-ft) circle (unless a definite habitat change exists within). We attempted to informally scan each site several times during the season. The use of the term "collection" or "item" in this report refers to either a single fungal fruit or to a group of identical fruits from a gregarious stand of fungi. Universal Transverse Mercator (UTM) coordinates were determined for each site.

3.2 Identification

A first taxonomic identification was made from personal knowledge, reference to various field guides (see Appendix A), and suggestions from experts at forays. A number of species are only identifiable by microscopic study.

3.3 Voucher Preservation and Herbarium

A serious attempt was made to preserve and store voucher specimens for all species found. A herbarium system was designed. Each new specimen was spore printed, given preliminary identifications, dried as soon as possible, and put into storage. Seventy-six percent of all specimens were stored.

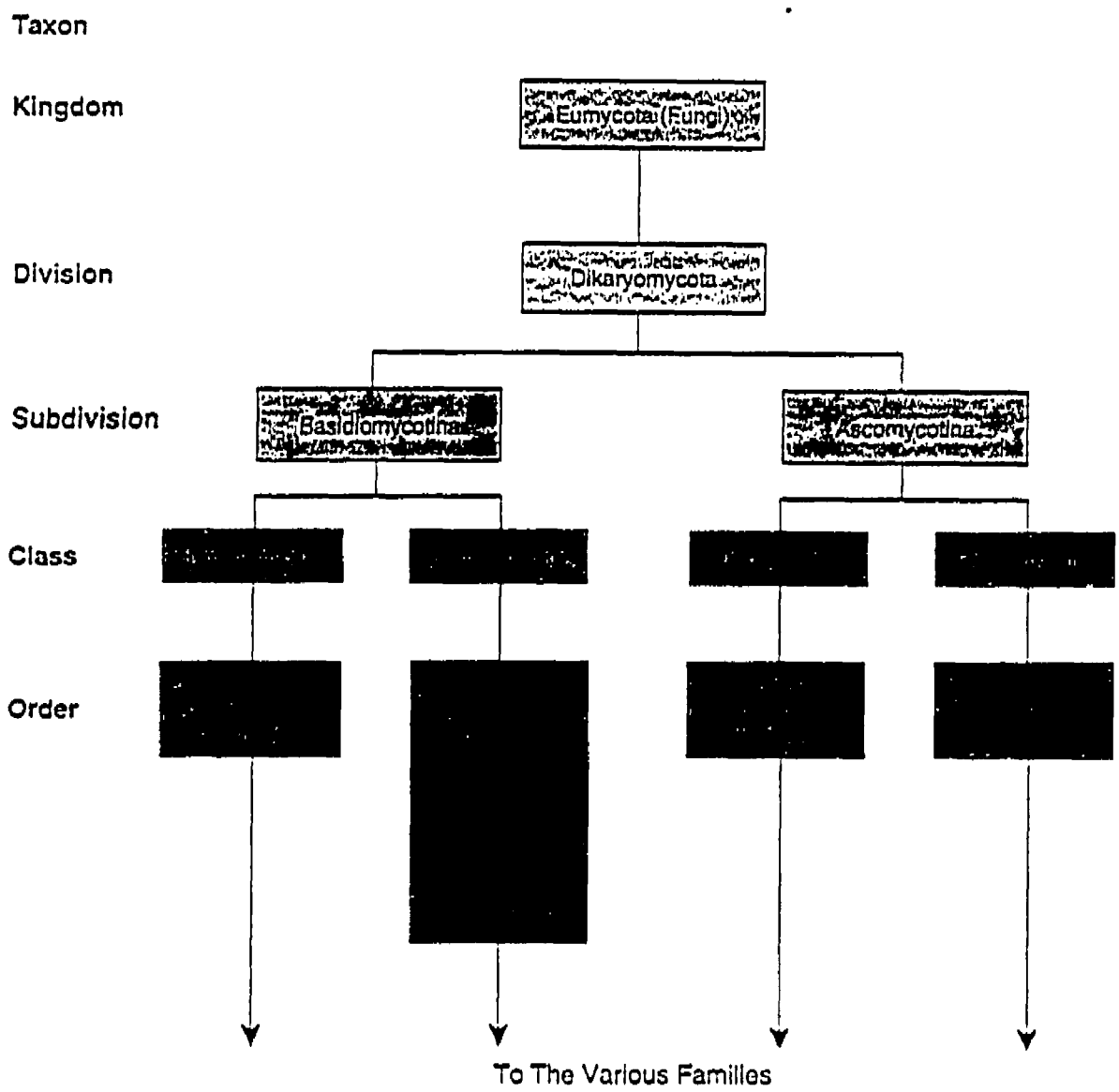

Figure 2. An outline of the various taxonomic levels of fungi.

Table 1. Common representatives of the taxonomic hierarchy for the macroscopic fungi.

Agaricales	Aphyllophorales	Gasteromycetes	Pezizales
Boletes	Polypores	Puffballs	Morels
Gilled fungi	Corals	Bird's nest	False morels
	Chantrelles	Stinkhorns	Cups
	Spinny fungi	False puffballs	Truffles
		Stalked puffballs	
		False truffles	

3.4 Computer Data Base

The computer data base, FoxBASE+/MAC was chosen for versatility and compatibility with other data bases. There is a data base record for each specimen studied. Computer data base field codes are explained in Appendix A.

The master data base is labeled 27FnABC: where 27 is the current version number, Fn = fungi, ABC for complete alphabetized list. The lists are

1. Long form of 27FnABC: holds most of the fields (31 fields).
2. Short form of 27 FnABC: concise complete list (11 fields).
3. Short form 27FnNum: sorted by accession number (ncode) (11 fields).
4. Species list 27FnSpList: one type entry for each species identified plus 6 entries with a known genus, but unknown species: thus the list also acts as a genus list (10 fields).
5. Species sort by order 27FnSpOrder (9 fields). Note dominance of the Hymenomycetes.

This data base has been completed and alphabetically sorted by genus, species, date, and accession number. The "short form" stands alone as a concise list of the most useful fields. The "long form" adds 20 additional fields to form a "complete list."

4.0 Results

The main data base was sorted both by the long form (31 fields) and the short form (11 fields). We have included the printout of the short form in Appendix B, C, and D. Information in the long form can be accessed through the data base, which will be established as a linkage to the Geographic Information System software ARC/INFO.

4.1 Summary Information from the Complete Data Base

We sorted the data base alphabetically by specimen and by accession number (27FnABC and 27FnNum). Table 2 shows the results of the information in the data base.

Table 2: Results of the surveys and collections completed in the main data base.

Number of Specimens	Item
1,048	Total number of records.
188	Total number of specimens whose species taxon could not be identified.
28	Total number of unknown families.
796	Total number of voucher specimens.
11	Microscopic studies.
79	Total number of specimens new to the New Mexico Mycological Society list.
82%	Total percent of specimens identified to species.
96%	Total percent of specimens identified to genus.
21	Number of specimens judged rare.
169	Number of specimens judged uncommon.
649	Number of specimens judged common.
39	Number of specimens judged abundant.

4.2 Summary Information When Data Base is Sorted by Species

We sorted the data base by each species being represented. This meant that specimens of the same species were lumped together, as a "type." Table 3 shows the information related to species.

The resulting data base field codes and species lists are found in the appendices. Table 4 represents the various printouts that are found in the appendices.

Table 3: Data base information sorted by species.

Number of Species	Comment
241	Identified species.
227	Of the total identifications, 227 were considered "reliable" (see discussion in Appendix A).
6	Species were judged rare.
51	Species are new to the New Mexico Mycological Society.
211	Species are of the Subdivision Basidiomycotina.
25	Species were of the Subdivision Ascomycotina.
9	Species were slime molds.

Table 4: Information found in appendices.

Appendix A
- Field Abbreviations for Los Alamos Fungi Data base
- Location and Elevation Code for Los Alamos Fungi Data base
- Identification Reliability Code for Los Alamos Fungi Data base
- Mycorrhizal Host and Immediate Habitat Code for the Los Alamos Data base
- Zone Code for the Los Alamos Fungi Data base
- Reference Codes for the Los Alamos Fungi Data base
- Collector/Identifier Codes for Los Alamos Fungi Data base
- Habitat Codes for Los Alamos Fungi Data base
- Occurrence Code for the Los Alamos Fungi Data base
- Growth Habit Code for Los Alamos Fungi Data base
- Edibility Code for Los Alamos Fungi Data base

Appendix B
- Los Alamos/Bandelier Fungi Survey—Species List

Appendix C
- Los Alamos/Bandelier Fungi Survey—Species List sorted by Order

Appendix D
- Los Alamos/Bandelier Fungi Survey—New to the New Mexico Mycology Lists

5.0 Conclusion

The efforts to collect, identify, and develop a data base for the macroscopic fungi of Los Alamos County has provided a listing of over 241 species, 51 that are considered new to New Mexico and 6 species that are considered rare. Additional work must be done on identification of unknown specimens. Completion of the data base invites study of the patterns of diversity, ecological systems with other living systems, and time and spatial fluctuations.

6.0 Acknowledgments

These surveys were sponsored by the Ecology Group (ESH-20) at LANL and the natural resurces group at BNM. We would like to express our thanks to Craig Allen at BNM and Teralene Foxx at LANL for their support.

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APPENDIX A

Field Abbreviations for Los Alamos Fungi Database.

July 15, 1996

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Version 27FnABC

ncode	Number code=mcode=our accession and herbarium number.
lcode	Letter code: first two letters of genus and species.
genus	Taxonomic Genus of specimen.
species	Species.
family	Family.
order	Order
commonname	Only if really universal. omitted in some versions.
grd	"Grade" Identification Reliability, see code list.
ref	Reference: Book and page number. see Reference code list.
loct	Location. see location code list.
date	Date of acquisition.
habi	Habitat, compatible with ESH-20 code. see habitat code list.
bndlr	.T.=Located in Bandelier Nat. Monument.
nmlst	.T.= specimen is on New Mexico list of 10/13/94 +1995 update.
ta	LANL Technical area. "00" means not on LANL land.
typ	Type S/M/P/X/U = Saprobe/Myycorrhiza/Parasite/Mixed/Unknown.
vchr	.T.=Voucher sample made. dried and stored in local herbarium.
pho	Photograph, P/S/N = Print/Slide/None
eat	Edibility (by various sources). A guide only, beware! See code list.
col/id	Collector/identifier. see code list. single set of initials is both.
alt	Altitude in kilofeet. see location code list.
zone	"Life zone" see code list.
host	Mycorrhizal and/or immediate habitat. see code list.
grthb	Growth habit. e.g. "scattered", see code list.
ocr	Occurrence code. e.g. "common" see code list
utmn	Universal Transverse Mercator coordinates, north. see location code.
utme	Universal Transverse Mercator coordinates, east. see location code.
day	Day of acquisition.
mon	Month.
year	Year.
mcro	.T.=Microscopic work has been done.
cmnts	Comments memo written in database. see comments printout.
mcode	=ncode=Jarmie's accession and herbarium number.
version	Version date or number identifies latest date of editing. Not on some versions.

loct: Location and Elevation Code for Los Alamos Fungi Database

Location site, about ±100 m July 14, 1996

Code	Elev. (Feet)	utmn 39xxxx0	utme* 3xxxx0 (m)	Location Description BNM# is Bandelier area number code.
AP1	8444	6526	7424	Apache springs itself, in little cañon. BNM #UF-23
AP2	8500	6556	7480	Apache Springs, Ponderosa grove to the NE. UF-23
AP3	8500	6584	7481	Apache Springs, MC between Springs and Hwy 4. UF-23
AS1	8200	6650	7550	American Springs Rd. N. of SR4
BC1	8700	6418	6300	Bills Canyon Picnic area, past meadow.
BN1	8949	6773	9158	Bandelier, S of intersection of Dome Rd and Hwy 4. UF-10
BN2	5800	5838	8617	Bandelier, near upper falls
BN3	6066	5998	8419	Bandelier, Headquarters. ±400 m. BNM #HQ-47.
BN4	6200	6140	8343	Bandelier, Ceremonial cave area.
BN5	7023	6414	7706	Bandelier, Upper Crossing.
BN6	7600	6606	7742	Bandelier, Back Gate/Ponderosa C.G. BNM #UH-27.
BN7	6689	6187	8439	Bandelier, Juniper C.G.
BU1	7200	6452	8015	Bandelier "Burnt Mesa" Plots BM1, BM2, BM3. #UF-35.
BU3	8960	6800	7160	Bandelier NE of Dome rd/Hywy 4. BNM #UF-3.
BU4	8960	6800	7100	Bandelier W of Dome rd/Hywy 4. BNM #UF-4.
BU6	9000	6760	7300	Bandelier S of Frijoles Cr. headwater. BNM #UF-6.
BU8	9000	6670	7350	Bandelier E of BU6, BNM #UF-8
BU26	8100	6600	7600	Bandelier Gully SE of Hywy 4 and Armstead Sp. rd. UF 26.
BU44	6300	6180	8260	Ban. Frijoles Cr. 2 mi. up from Cerem. Cave. BNM HQ-44.
BU46	6000	5950	8550	Bandelier SE of Rainbow House ruin. BNM area #HQ-46.
BU48	6580	5940	8270	S. of HQ betwn Lummis and Alamo Cany. BNM # BW-48
GP1	7000	7400	8250	Guaje Pines, in trees.
LA1	7400	7278	8056	Los Alamos, Urban Park, and other mid Los Alamos.
LA2	7200	7122	8048	Los Alamos, Canyon bottom near Ice Rink.
LB2	7400	7037	8000	LANL TA-3 area
LB3	7300	6806	8282	TA 67 mid mesa
LB4	7100	6823	8276	TA 67 Pajarito canyon.
LC1	7700	7210	7730	Los Alamos Canyon 1 mile W. of reservoir.
LC2	7400	7124	7905	Los Alamos Canyon. just W. of "West Road".
LC3	6500	7007	8810	Los Alamos Canyon. about 2 mi. W. of SR 4.
PC1	7900	7020	7750	Pajarito Canyon N. of SR501
PL1	9200	7330	7465	Pipeline Road shunt CC trails near Ski Hill.
PL3	9540	7625	7440	Pipeline Road, junction with shunt.
PR1	6540	6500	8900	Pajarito Canyon, N. of Pajarito Rd. (.1mi to St.Road 4)
PR3	6700	6591	8700	Pajarito Canyon, near structure 36-135. (Sump) (1.8 mi)
PR4	6700	6646	8611	Pajarito Canyon, near entrance to TA-18 (2.4mi to SR4)

Code	Elev. (Feet)	utmn 39xxxx0	utme* 3xxxx0 (m)	Location Description BNM# is Bandelier area number code.
RC1	6500	7447	8544	Rendija Canyon
SH1	7500	7072	7880	Ski Hill Road, Ponderosa grove near base.
SH2	8000	7117	7828	Ski Hill Road, So. Ponderosa grove. 1st flat stretch.
SH3	8600	7241	7641	Ski Hill Road, "Install Chains" turnout.
SH5	9200	7263	7538	Ski Hill Road, 1/2 mile below Spruce lift.
SH7	9260	7305	7427	Ski Hill Road, Spring area near Mother lift.
SH8	10000	7250	7400	Ski Hill, Spruce Forest SW of end of road, ridge.
WC1	7700	6673	7693	Water Canyon, near Hwy 4, 100 m north
WR1	6500	6466	9025	La Vista subdivision. White Rock area
WR3	6440	6400	9040	mid La Senda (PJ)

*Universal Transverse Mercator Coordinates, Zone 13, in meters.

grd: Identification Reliability Code for Los Alamos Fungi Database.

July 15, 1996

The grade is subjectively determined by the identifier.

grd

1 Well known, no doubt, species sure, no close brothers.

2 Well identified, but slight possibility of being a near species in a close group. Good for a foray or registry list.

3 Genus sure, species likely but don't bet on it. Often designated as a "Group" in a field guide.

4 Genus only

5 Family only

6 Order only

7 Unknown

host: Mycorrhizal Host and Immediate Habitat Code
for Los Alamos Fungi Database.

July 14, 1996 N. Jarmie

The host is estimated by the collector on the spot, within the "dripline" or within about 5m from a large tree. This is a guess at best.

JU	Juniper, One-seed, *Juniperus monosperma.*
RJ	Rocky Mt. Juniper, *Juniperus scopulorum.*
PI	Piñon Pine, *Pinus Edulis.*
PP	Ponderosa Pine, *Pinus ponderosa.*
LP	Limber Pine, *Pinus flexilis.*
DF	Douglass Fir, *Pseudotsuga menziesii.*
WF	White Fir, *Abies concolor.*
ES	Englemann Spruce, *Picea engelmanii.*
AS	Aspen, *Populus tremuloides.*
CO	Cottenwood, *Populus fremontii* var. *wislizenii.*
OK	Gambel (Scrub) Oak, *Quercus gambelii.*
OD	Other Deciduous, see "memo".
OC	Other Conifer, see "memo".
MC	Mixed Conifer. usually mix of firs, and some pine and spruce.
MT	Mixed Trees, Many varieties close.
RW	Rotten unidentified wood.
BW	Burned wood.
DW	Dead deciduous log.
DC	Dead conifer log.
MG	Meadow/grasses, No trees or obvious host.
DU	Dung
DI	Dirt.
SA	Saprophyte.
HU	Humus
FU	Fungus
NA	None of the above, see "memo".
UN	Unknown.

zone: Zone Code for Los Alamos Fungi Database.

July 15, 1996

Life Zones of the Southwest: Altitudes in meters are roughly median values.

ALP	ARCTIC/ALPINE	Above treeline 3000+ m 11500-up ft,
HUD	HUDSONIAN	Spruce (Engleman), Subalpine Fir, Aspen. 2900m 9500-11000 ft. ("Spruce-Fir") ("Subalpine")
CAN	CANADIAN	Douglass Fir, White Fir. Aspen, 2300m 8000-9500 ft. ("Fir-Aspen") ("Montane")("Mixed Conifer")
TRN	TRANSITION	Ponderosa Pine, Gambel Oak. 2100 m 6500-8000 ft. ("Pine-Oak") ("Foothills")
SNU	SONORAN, UPPER	Juniper, Piñon Pine, Sagebrush, Saltbush, Scrub Oak. 4500-6500 ft. upper: 1900 m("Piñon-Juniper") ("Pygmy-Conifer)" lower: 1700 m ("Plains"), ("Juniper Grassland")
SNL	SONORAN, LOWER	Mesquite, Creosote Bush, Yucca, Saguaro. 4500-down ft. ("Desert")

ref: Reference Codes for Los Alamos Fungi Database.

July 14, 1996

AMD Arora, D. 1986. *Mushrooms Demystified*. 2nd Ed. Ten Speed Press, Berkeley.

BSM Bessett, A., and W. J. Sundberg. 1967. *Mushrooms, A Quick Reference Guide to Mushrooms of North America*. Macmillan Field Guides. Macmillan Pub. Co., New York.

GLT P. G. Glick, *The Mushroom Trailguide*. Henry Holt, New York.

HMD D.M. Huffman, L.H. Tiffany, and G. Knaphus. 1989. *Mushrooms & Other Fungi of the Midcontinental United States*. Iowa State U. Press, Ames.

LAS Lincoff, G.H. 1981. *The Audubon Society Field Guide to North American Mushrooms*. A.A. Knopf, Inc., New York.

MNA Miller, O.K. 1977. *Mushrooms of North America*. E.P. Dutton & Co., Dubuque, Iowa.

MSM McKenney, M.., and D.N. Stuntz. 1987. *The New Savory Wild Mushroom*. Revised and Enlarged by Joseph Ammirati. U. of Washington Press, Seattle.

PNA Phillips, R. 1991. *Mushrooms of North America* Little, Brown and Co. Boston, Mass.

SWM Smith, A.H. 1975. *A Field Guide to the Western Mushrooms*. U. of Michigan Press, AnnArbor.

SGM Smith, A.H. H.V. Smith, and N. S. Weber. 1979. *How to Know the Gilled Mushrooms*. The Pictured Key Nature Series. Wm. C. Brown. Co. Pub., Dubuque.

SNG Smith, A.H. H.V. Smith, and N. S. Weber. 1973. How to Know the Non-Gilled Mushrooms. Wm. C. Brown. Co. Pub., Dubuque.

SSW States, J.S. 1990. *Mushrooms and Truffles of the Southwest*. U. of Arizona Press, Tucson.

col_id: Collector/Identifier Codes for Los Alamos Fungi Database.

July 14, 1996

NJ	Nelson Jarmie
FR	Fran J. Rogers
TF	Terelene Foxx
BI	Bill Isaacs
RP	Roger Petereon
JS	Jack States
JM	James Worrall
RG	Robert Gilbertson
TV	Tom Volk

habi: Habitat Codes for Los Alamos Fungi Database.

June 14, 1996

JG	Juniper Grassland
PJ	Piñon/Juniper
PJPP	Piñon/Juniper/PonderosaPine
PP	Ponderosa Pine
PJMC	Piñon/Juniper/Mixed Conifer.
MC	Mixed Conifer.
ES	Engleman Spruce.
SAM	Subalpine Meadow.
CB	Cañon Bottom.
CBPJ	Cañon Bottom/Piñon/Juniper.
CBPP	Cañon Bottom/Ponderosa Pine.
CBMC	Cañon Bottom/Mixed Conifer.
BQ	Bosque.
W	Wetland.
MG	Meadow or Grass.

ocr: Occurrence Code for Los Alamos Fungi Database.

July 15, 1996

ABN	Abundant, (Ubiquitous).
COM	Common.
UNC	Uncommon, (Infrequent).
RAR	Rare.
UNK	Unknown.

grhb: Growth Habit Code for Los Alamos Fungi Database.

July 15, 1996

ISO	Isolated
SCT	Scattered
GRG	Gregarious
CES	Cespitose (Bunched)
UNK	Unknown.

eat: Edibility Code for Los Alamos Fungi Database.

July 15, 1996

VGD	Very good.
EDB	Edible.
IND	Inedible
POI	Poisonous.
UNK	Unknown.

Beware! Many species are poisonous, some deadly. Text and appearance in field guides can be deceiving.

APPENDIX B

1991-1995 LOS ALAMOS/BANDELIER FUNGI SURVEY Species List Nelson Jarmie/Fran J. Rogers

genus	species	family	order	grd	ref	typ	commonname	ocr	ncode
Agaricus	augustus	Agaricaceae	Agaricales	2	LAS502	S	The Prince	URK	938
Agaricus	barrowsii	Agaricaceae	Agaricales	2	AHD69	H		URC	689
Agaricus	bitorquis	Agaricaceae	Agaricales	2	GLT130	S		COH	159
Agaricus	campestris	Agaricaceae	Agaricales	1	LAS505	S	Meadow mushroom	ARN	947
Agaricus	haemorrhoidarius	Agaricaceae	Agaricales	2	LAS505	S		URK	160
Agaricus	silvicola	Agaricaceae	Agaricales	2	AHD334	S		COH	187
Agaricus	xanthodermus	Agaricaceae	Agaricales	2	AHD329	S		URC	139
Agrocybe	pediades cf.	Bolbitiaceae	Agaricales	3	AHD468	S		COH	1142
Agrocybe	praecox cf.	Bolbitiaceae	Agaricales	3	AHD469	U		COH	166
Amanita	bisporigera cf.	Amanitaceae	Agaricales	3	AHD271	H	Destroying Angel	URC	168
Amanita	caesarea	Amanitaceae	Agaricales	2	AHD284	H	Caesar's Mush.	COH	1140
Amanita	constricta	Amanitaceae	Agaricales	2	AHD289	H		COH	1048
Amanita	fulva	Amanitaceae	Agaricales	2	LAS536	H		COH	662
Amanita	magniverrucata cf.	Amanitaceae	Agaricales	3	AHD274	H		URC	930
Amanita	muscaria v. mus.	Amanitaceae	Agaricales	1	AHD282	H	Fly Agaric	COH	1037
Amanita	pantherina	Amanitaceae	Agaricales	1	AHD280	H		COH	1092
Amanita	vaginata	Amanitaceae	Agaricales	2	LAS549	H	Grisette	COH	893
Arcyria	denudata	Trichiaceae	Trichiales	1	FSM63	U	Slime Mold	URK	933
Armillaria	albolanaripes	Tricholomataceae	Agaricales	2	AHD194	P		URK	642
Armillaria	mellea cf.	Tricholomataceae	Agaricales	3	LAS736	P	Honey Mushroom	ARN	1086
Armillaria	straminia cf.	Tricholomataceae	Agaricales	5	LAS734	P		URC	478
Armillaria	tabescens cf.	Tricholomataceae	Agaricales	3	AHD197	P		URK	919
Astraeus	hygrometricus	Astraeaceae	Sclerodermatales	1	AHD705	S		URC	418
Auricularia	auricula	Auriculariaceae	Auriculariales	2	AHD675	S	Tree Ear	COH	658
Auriscalpium	vulgare	Hydnaceae	Aphyllophorales	1	AHD629	S		URK	202
Battarrea	phalloides	Tulostomataceae	Tulostomatales	1	SSW156	S		URC	140
Bisporella	citrina	Leotiaceae	Helotiales	2	LAS362	S		URC	1075
Bjerkandera	adusta	Polyporaceae	Aphyllophorales	2	HHA270	S		COH	1079
Boletus	barrowsii	Boletaceae	Agaricales	1	AHD529	H		COH	1116
Boletus	calopus	Boletaceae	Agaricales	2	AHD523	H		COH	518
Boletus	chalciporus cf.	Boletaceae	Agaricales	5	URK000	U		RAR	1141
Boletus	chrysenteron cf.	Boletaceae	Agaricales	3	AHD519	H		URC	991
Boletus	edulis	Boletaceae	Agaricales	1	AHD530	H	King, Cep, etc	COH	925
Boletus	haematinus	Boletaceae	Agaricales	2	AHD528	H		URC	651
Boletus	rubripes	Boletaceae	Agaricales	2	AHD524	H		COH	771
Caloporus	dichrous	Polyporaceae	Aphyllophorales	2	LAS449	U		URK	386
Calvatia	gigantea	Lycoperdaceae	Lycoperdales	2	AHD681	S	Giant puffball	COH	422
Cantharellus	cibarius	Cantharellaceae	Aphyllophorales	1	LAS387	U	Chanterelle	URC	1090
Catathelasma	ventricosa	Tricholomataceae	Agaricales	2	AHD195	H		URC	900
Ceratiomyxa	fruticulosa	Ceratiomyxaceae	Ceratiomyxales	2	FSM30	U	Slime Mold	URK	206
Cheimonophyllum	candidissimus	Tricholomataceae	Agaricales	2	LAS743	S		URC	954
Chlorociboria	aeruginascens	Dermatiaceae	Helotiales	1	AHD878	S	Blue Stain	URC	1147
Chlorophyllum	molybdites	Lepiotaceae	Agaricales	1	AHD295	S		COH	1133
Chroogomphus	torrentosus	Gomphidiaceae	Agaricales	2	LAS650	H		URK	582
Chroogomphus	vinicolor	Gomphidiaceae	Agaricales	2	LAS651	H		COH	866
Clavariadelphus	lovejoyae	Clavariaceae	Aphyllophorales	2	AHD634	H		URC	864
Clavariadelphus	pistillaris	Clavariaceae	Aphyllophorales	2	LAS403	H		URK	580

genus	species	family	order	grd	ref	typ	commonname	ocr	ncode
Clavariadelphus	truncatus	Clavariaceae	Aphyllophorales	2	AHD634	S		COH	1064
Clavicorona	pyxidata	Clavariaceae	Aphyllophorales	2	LAS401	S	Coral Mushroom	COH	1014
Clavulina	cristata cf.	Clavariaceae	Aphyllophorales	3	AHD641	U	Coral Mushroom	COH	226
Clavulina	rugosa cf.	Clavariaceae	Aphyllophorales	3	AHD642	U	Coral Mushroom	COH	152
Clavulinopsis	corniculata	Clavariaceae	Aphyllophorales	2	AHD639	U		UTC	314
Clitocybe	dealbata	Tricholomataceae	Agaricales	2	AHD163	S		UTC	306
Clitocybe	dilatata	Tricholomataceae	Agaricales	2	LAS746	U		COH	1065
Clitocybe	gibba	Tricholomataceae	Agaricales	2	AHD157	S		COH	680
Clitocybe	gigantea cf.	Tricholomataceae	Agaricales	3	AHD158	S		UTK	920
Collybia	dryophila	Tricholomataceae	Agaricales	5	BHD131	S		UTK	230
Collybia	lentinoides cf.	Tricholomataceae	Agaricales	3	PHA61	S		UTK	616
Collybia	spongiosa cf.	Tricholomataceae	Agaricales	3	LAS756	S		UTC	957
Coltricia	perennis	Polyporaceae	Aphyllophorales	2	PHA259	S		UTK	1007
Coniophora	puteana	Coniophoraceae	Aphyllophorales	7	LAS415	U	Wet rot	UTK	373
Conocybe	lactea cf.	Bolbitiaceae	Agaricales	3	AHD472	S		COH	428
Conocybe	tenera cf.	Bolbitiaceae	Agaricales	4	LAS561	S		ABH	946
Coprinus	atramentarius	Coprinaceae	Agaricales	2	LAS596	S	Inky cap	COH	803
Coprinus	comatus	Coprinaceae	Agaricales	1	AHD345	S	Shaggy mane	COH	677
Coprinus	lagopus cf.	Coprinaceae	Agaricales	3	AHD350	S		UTK	697
Coprinus	micaceus	Coprinaceae	Agaricales	2	LAS600	S		COH	760
Coriolellus	carbonarius	Polyporaceae	Aphyllophorales	2	AHD503	U		UTC	266
Coriolopsis	gallica	Polyporaceae	Aphyllophorales	1	GPH216	S		UTC	822
Cortinarius	alboviolaceus cf.	Cortinariaceae	Agaricales	3	AHD447	H		UTC	654
Cortinarius	anomalus	Cortinariaceae	Agaricales	2	AHD447	H		UTK	737
Cortinarius	calochrous	Cortinariaceae	Agaricales	2	PHA145	H		COH	730
Cortinarius	glaucopus cf.	Cortinariaceae	Agaricales	3	AHD437	H		UTC	112
Crepidotus	applanatus cf.	Crepidotaceae	Agaricales	3	LAS636	S		UTC	443
Crepidotus	herbarum cf.	Crepidotaceae	Agaricales	3	AHD405	S		UTK	256
Crepidotus	mollis	Crepidotaceae	Agaricales	1	AHD406	S		COH	993
Crucibulum	laeve	Nidulariaceae	Nidulariales	2	LAS828	S	Bird's nest	COH	593
Cudonia	circinans	Leotiaceae	Helotiales	2	AHD873	S		COH	393
Cyathus	striatus	Nidulariaceae	Nidulariales	1	AHD828	S		COH	361
Cyptotrama	chrysopeplum	Tricholomataceae	Agaricales	1	PHA63	S		COH	994
Cystoderma	amianthinum cf.	Tricholomataceae	Agaricales	3	AHD200	U		UTK	855
Cystoderma	granulosum cf.	Tricholomataceae	Agaricales	3	AHD200	H		COH	828
Dacrymyces	palmatus	Dacrymycetaceae	Dacrymycetales	2	PHA300	S		COH	1137
Daedaleopsis	confragosa	Polyporaceae	Aphyllophorales	1	GPH226	U		UTC	932
Daldinia	concentrica cf.	Xylariaceae	Sphaeriales	5	LAS374	S		UTK	945
Flammulina	velutipes	Tricholomataceae	Agaricales	1	AHD220	S	Velvet Foot	COH	1009
Fomitopsis	canjanderi	Polyporaceae	Aphyllophorales	2	AHD580	S		UTC	1136
Fomitopsis	pinicola	Polyporaceae	Aphyllophorales	2	AHD578	S		COH	1029
Fuligo	septica	Physaraceae	Physarales	1	LAS845	S	Slime mold	COH	1132
Galerina	autumnalis cf.	Cortinariaceae	Agaricales	3	LAS620	S		COH	303
Ganoderma	applanatum	Polyporaceae	Aphyllophorales	1	LAS460	P	Artist's Conk	COH	1024
Gautieria	mexicana	Gautieriaceae	Gautieriales	1	AHD747	H		UTK	934
Geastrum	coronatum	Geastraceae	Lycoperdales	2	LAS818	S	Earth star	COH	686
Geastrum	saccatum	Geastraceae	Lycoperdales	2	LAS818	S	Earth star	COH	492
Geastrum	triplex	Geastraceae	Lycoperdales	1	AHD703	S	Earth star	COH	227
Globifomes	graveolens cf.	Polyporaceae	Aphyllophorales	3	LAS462	U	Sweet knot	UTC	11

genus	species	family	order	grd	ref	typ	commonname	ocr	ncode
Gloeophyllum	sepiarium	Polyporaceae	Aphyllophorales	1	LAS463	S		CCH	1018
Gomphidius	glutinosus	Gomphidiaceae	Agaricales	2	AHD482	H		CCH	1083
Gomphidius	oregonensis	Gomphidiaceae	Agaricales	2	AHD482	H	Insidious G.	CCH	203
Gomphus	bonari	Cantharellaceae	Aphyllophorales	2	LAS396	U		CCH	1066
Gomphus	floccosus	Cantharellaceae	Aphyllophorales	2	LAS396			CCH	953
Guepiniopsis	alpinus	Dacrymycetaceae	Dacrymycetales	2	SSW145	U		UBC	172
Gymnopolis	sapineus	Cortinariaceae	Agaricales	2	AHD408	U		UBC	817
Gymnosporangium	speciosus cf.	Pucciniaceae	Uredinales	3	TextBk	P	Juniper Rust	CCH	181
Gyromitra	esculenta	Helvellaceae	Pezizales	2	FRA303	U		UBC	1099
Gyromitra	infula	Helvellaceae	Pezizales	2	FRA303	S		UBC	1125
Hebeloma	crustuliniforme	Cortinariaceae	Agaricales	2	LAS624	H	Poison pie	CCH	886
Hebeloma	sinapizans cf.	Cortinariaceae	Agaricales	3	AHD465	H		UBC	1030
Helvella	acetabulum	Helvellaceae	Pezizales	2	AHD807	U	Cup Fungus	CCH	146
Helvella	crispa	Helvellaceae	Pezizales	2	AHD816	U	Saddle Mushroom	CCH	913
Helvella	elastica cf.	Helvellaceae	Pezizales	3	AHD813	U	Saddle Mushroom	UBC	247
Helvella	lacunosa	Helvellaceae	Pezizales	2	AHD815	U	Saddle Mushroom	CCH	149
Hemitrichia	clavata cf.	Trichiaceae	Trichiales	5	FSH66	S	Slime Mold	UBC	603
Hericium	abeitis	Hydnaceae	Aphyllophorales	2	AHD614	P		RAR	769
Hohenbuchelia	petaloides cf.	Tricholomataceae	Agaricales	3	AHD136	S		UBC	1138
Humaria	hemisphaerica	Pyronemataceae	Pezizales	2	LAS351	S		UBC	408
Hygrophoropsis	aurantiaca	Paxcillaceae	Agaricales	2	AHD479	S	False Chanterell	CCH	1119
Hygrophorus	acutoconica cf.	Hygrophoraceae	Agaricales	3	AHD115	U		UBC	831
Hygrophorus	chrysodon	Hygrophoraceae	Agaricales	2	LAS657	U		CCH	874
Hygrophorus	conicus	Hygrophoraceae	Agaricales	1	LAS658	U	Witch's Hat	CCH	1068
Hygrophorus	marginatus cf.	Hygrophoraceae	Agaricales	3	AHD112	U		UBC	713
Hygrophorus	pudorinus	Hygrophoraceae	Agaricales	2	AHD116	U		CCH	1069
Hygrophorus	speciosus	Hygrophoraceae	Agaricales	2	LAS667	U		CCH	1089
Hypomyces	chrysospermum	Hypocreaceae	Sphaeriales	1	LAS371	P		UBC	1038
Hypomyces	hyalinus cf.	Hypocreaceae	Sphaeriales	3	FRA313	P		UBC	704
Hypomyces	lactifluorum	Hypocreaceae	Sphaeriales	1	LAS373	P	Lobster Mushroom	CCH	1035
Hypomyces	luteovirens	Hypocreaceae	Sphaeriales	1	LAS373	P		UBC	1056
Inocybe	albodisca cf.	Cortinariaceae	Agaricales	3	AHD459	H		UBC	449
Inocybe	fastigiata	Cortinariaceae	Agaricales	2	LAS628	H		UBC	429
Inocybe	lanuginosa	Cortinariaceae	Agaricales	2	LAS630	H		UBC	305
Inocybe	maculata cf.	Cortinariaceae	Agaricales	3	AHD458	H		UBC	448
Inocybe	sororia	Cortinariaceae	Agaricales	2	LAS632	U		UBC	1103
Inonotus	tomentosus	Polyporaceae	Aphyllophorales	2	AHD569	P		UBC	1085
Irpex	lacteus	Polyporaceae	Aphyllophorales	2	LAS167	S		UBC	1043
Laccaria	amethystina cf.	Tricholomataceae	Agaricales	3	AHD172	S		UBC	773
Laccaria	bicolor	Tricholomataceae	Agaricales	2	AHD173	H		CCH	1027
Laccaria	laccata	Tricholomataceae	Agaricales	2	AHD172	S		CCH	901
Lactarius	barrowsii	Russulaceae	Agaricales	2	AHD69	U		UBC	1053
Lactarius	controversus cf.	Russulaceae	Agaricales	3	AHD70	H		UBC	1060
Lactarius	deliciosus	Russulaceae	Agaricales	2	LAS683	H		CCH	1113
Lactarius	olivaceoumbrinus	Russulaceae	Agaricales	2	AHD70	H		UBC	669
Lactarius	rubrilacteus	Russulaceae	Agaricales	1	AHD68	H		CCH	1094
Lactarius	torminosus	Russulaceae	Agaricales	2	LAS694	H		CCH	671
Lactarius	uvidus cf.	Russulaceae	Agaricales	3	AHD75	H		UBC	1098
Leccinum	aurantiacum	Boletaceae	Agaricales	1	LAS577	H		CCH	1010

genus	species	family	order	grd	ref	typ	commonname	ocr	ncode
Leccinum	insigne	Boletaceae	Agaricales	2	AHD540	H		COLI	673
Lentinellus	omphalodes cf.	Tricholomataceae	Agaricales	4	PHA208	U		UMK	982
Lentinellus	ursinus cf.	Tricholomataceae	Agaricales	4	AHD144	U		UMK	630
Lentinus	ponderosus	Tricholomataceae	Agaricales	2	AHD143	U		COLI	944
Lenzites	betulina	Polyporaceae	Aphyllophorales	2	AHD589	U		COLI	400
Lepiota	clypeolaria	Lepiotaceae	Agaricales	2	PHA31	S		UMC	523
Lepiota	cristata	Lepiotaceae	Agaricales	2	AHD106	S		COLI	896
Lepiota	rhacodes	Lepiotaceae	Agaricales	2	AHD297	S		COLI	615
Leucopaxillus	amarus	Tricholomataceae	Agaricales	2	LAS768	H		COLI	922
Leucophleps	spinispora	Leucogastraceae	Leucogastrales	1	AHD760	H		UMK	937
Lycogala	epidendrum	Reticulariaceae	Liceales	1	SSH206	S	Wolf's Fhart	ABH	1016
Lycogala	flavofuscum	Reticulariaceae	Liceales	2	FSH55	S	Slime Mold	UMC	192
Lycoperdon	americanum	Lycoperdaceae	Lycoperdales	2	AHD694	S	Puffball	UMC	358
Lycoperdon	echinatum	Lycoperdaceae	Lycoperdales	2	LAS824	S	Puffball	COLI	837
Lycoperdon	perlatum	Lycoperdaceae	Lycoperdales	2	LAS825	S	Puffball	COLI	624
Lycoperdon	pyriforme	Lycoperdaceae	Lycoperdales	2	AHD691	S	Puffball	COLI	1013
Marasmius	oreades	Tricholomataceae	Agaricales	1	LAS772	S	Fairy Ring Mush.	ABH	948
Melanoleuca	sp.	Tricholomataceae	Agaricales	5	AHD169	U		UMK	997
Morchella	augusticeps	Morchellaceae	Pezizales	2	AHD790	S	Morel	UMC	176
Morchella	elata	Morchellaceae	Pezizales	2	LAS713	S	Morel	UMC	177
Morchella	esculenta	Morchellaceae	Pezizales	2	LAS327	S	Morel	UMC	171
Mycena	haemotopus	Tricholomataceae	Agaricales	2	LAS781	S		UMK	602
Nidula	candida	Nidulariaceae	Nidulariales	2	AHD780	S	Birds Nest Mush.	COLI	222
Nolanea	sp.	Entolomataceae	Agaricales	4	AHD245	S		UMC	1108
Panaeolus	foenisecii	Coprinaceae	Agaricales	2	AHD360	S	Hay-Makers Mush.	COLI	431
Panaeolus	retirugis cf.	Coprinaceae	Agaricales	3	AHD357	S		UMK	218
Paxillus	atrotomentosis	Paxillaceae	Agaricales	2	LAS670	S		UMC	1046
Peniophora	gigantea	Corticiaceae	Aphyllophorales	2	LAS422	U		COLI	706
Peniophora	rufa	Corticiaceae	Aphyllophorales	1	LAS423	S		UMC	1011
Peziza	repanda	Pezizaceae	Pezizales	2	LAS347	S		COLI	1146
Peziza	succosa	Pezizaceae	Pezizales	2	PHG104	S		UMC	317
Phaeolus	schweinitzii	Polyporaceae	Aphyllophorales	2	LAS473	P	Dye Polypore	COLI	963
Phallus	impudicus	Phallaceae	Phallales	1	AHD768	S	Stinkhorn	COLI	818
Phlebia	sp.	Corticiaceae	Aphyllophorales	5	AHD610	S		UMK	985
Pholiota	aurivella cf.	Strophariaceae	Agaricales	3	LAS712	P		COLI	764
Pholiota	destruens	Strophariaceae	Agaricales	2	LAS714	S		COLI	980
Pholiota	limonella cf.	Strophariaceae	Agaricales	2	PHA174	U		UMC	459
Pholiota	lubrica cf.	Strophariaceae	Agaricales	3	AHD392	U		UMK	559
Pholiota	squarrosa	Strophariaceae	Agaricales	2	LAS716	P		COLI	752
Phylloporus	rhodoxanthus	Paxillaceae	Agaricales	1	AHD480	H	Gilled Bolete	UMK	890
Phyllotopsis	nidulans	Tricholomataceae	Agaricales	1	AHD140	S		COLI	1102
Pleurotus	ostreatus	Tricholomataceae	Agaricales	1	AHD134	S		COLI	1006
Pleurotus	sapidus	Tricholomataceae	Agaricales	2	AHD134	S	Oyster Mushroom	COLI	234
Pluteus	cervinus	Pluteaceae	Agaricales	1	AHD255	S	Fawn Mushroom	COLI	1019
Pluteus	cervinus v. alba	Pluteaceae	Agaricales	4	LAS675	S		UMC	291
Pluteus	lutescens	Pluteaceae	Agaricales	2	AHD257	S		UMC	1022
Polyporus	arcularius	Polyporaceae	Aphyllophorales	1	AHD563	S		COLI	971
Polyporus	badius cf.	Polyporaceae	Aphyllophorales	3	AHD562	S		UMC	407
Polyporus	elegans	Polyporaceae	Aphyllophorales	2	AHD562	U		UMC	60

genus	species	family	order	grd	ref	typ	commonname	ocr	ncode
Polyporus	squamosus	Polyporaceae	Aphyllophorales	2	PHA257	P		UTC	1105
Polyporus	varius	Polyporaceae	Aphyllophorales	2	AHD563	H		UTC	949
Poria	corticola cf.	Polyporaceae	Aphyllophorales	3	AHD602	S		UTK	986
Poria	spissa	Polyporaceae	Aphyllophorales	2	LAS484	S		COH	878
Psathyrella	carbonicola	Coprinaceae	Agaricales	1	AHD366	S		RAR	1134
Psathyrella	velutina	Coprinaceae	Agaricales	2	PHA178	S		UTC	546
Pseudohydnum	gelatinosum	Tremellaceae	Tremellales	2	AHD671	S		UTC	1047
Psilocybe	sp.	Strophariaceae	Agaricales	4	AHD368	S		RAR	1144
Pycnoporellus	alboluteus	Polyporaceae	Aphyllophorales	2	AHD571	S		UTC	1128
Pycnoporus	cinnabarinus	Polyporaceae	Aphyllophorales	2	LAS747	S		COH	981
Ramaria	vinosimaculaus cf.	Clavariaceae	Aphyllophorales	3	AHD653	U	Coral Mushroom	UTK	652
Rhizopogon	subsalmonius	Rhizopogonaceae	Hymenogastrales	1	SMG290	H		UTK	936
Russula	aeruginea cf.	Russulaceae	Agaricales	3	AHD95	H		UTK	653
Russula	brevipes	Russulaceae	Agaricales	2	LAS698	H		COH	1112
Russula	emetica cf.	Russulaceae	Agaricales	3	AHD97	H		COH	1005
Russula	maculata cf.	Russulaceae	Agaricales	3	AHD100	H		COH	869
Russula	rosacea cf.	Russulaceae	Agaricales	3	LAS705	H		COH	1081
Sarcoscypha	coccinea	Sarcoscyphaceae	Pezizales	4	AHD836	S		UTC	401
Scutellinia	erinaceus cf.	Pyronemataceae	Pezizales	3	AHD839	S	Yellow eye-lash	UTC	685
Scutellinia	scutellata	Pyronemataceae	Pezizales	1	LAS353	S	Eyelash cup	UTK	205
Sparassis	crispa	Clavariaceae	Aphyllophorales	2	AHD657	P		UTC	568
Sparassis	radicata	Clavariaceae	Aphyllophorales	2	AHD657	P	Cauliflower M.	UTC	462
Spathularia	flavida	Geoglossaceae	Helotiales	2	LAS360	S		COH	301
Spongipellis	pachyodon	Polyporaceae	Aphyllophorales	2	LAS488	S		UTK	426
Steccherinum	ochraceum	Hydnaceae	Aphyllophorales	5	LAS437	S		UTC	135
Stemonitis	splendens	Stemonitaceae	Stemonitales	1	LAS853	S	Slime mold	UTC	968
Stereum	complicatum	Stereaceae	Aphyllophorales	2	LAS497	S		COH	857
Stereum	hirsutum cf.	Stereaceae	Aphyllophorales	2	AHD605	S	Parchment Fungus	COH	384
Stereum	striatum	Stereaceae	Aphyllophorales	2	AHD605	S		COH	863
Stropharia	coronilla cf.	Strophariaceae	Agaricales	3	AHD377	S		UTK	216
Stropharia	kauffmanii	Strophariaceae	Agaricales	2	AHD360	S		UTC	1104
Suillus	granulatus	Boletaceae	Agaricales	2	LAS584	H		COH	1034
Suillus	lakei	Boletaceae	Agaricales	2	LAS585	H		COH	1004
Suillus	sibiricus	Boletaceae	Agaricales	2	AHD498	H		UTK	972
Tarzetta	cupularis	Pyronemataceae	Pezizales	2	PHA304	S		UTC	1076
Thelephora	terrestris	Thelephoraceae	Aphyllophorales	2	LAS413	S		COH	1026
Tremella	mesenterica cf.	Tremellaceae	Tremellales	6	AHD669	S	Jelly Fungus	UTC	1059
Trichaptum	abietinus	Polyporaceae	Aphyllophorales	2	AHD593	S		COH	995
Trichaptum	subchartaceum	Polyporaceae	Aphyllophorales	1	UTK000	S		UTC	964
Trichia	scabra cf.	Trichiaceae	Trichiales	3	FSH68	S	Slime Mold	UTC	1023
Tricholoma	sp.	Tricholomataceae	Agaricales	4	AHD176	U		UTK	389
Tricholomopsis	platyphylla	Tricholomataceae	Agaricales	2	AHD146	S		UTC	275
Tricholomopsis	rutilans	Tricholomataceae	Agaricales	2	AHD145	S		UTC	1135
Truncocolumella	citrina	Rhizopogonaceae	Hymenogastrales	2	LAS813	H		UTC	143
Tubifera	sp.	Reticulariaceae	Liceales	6	FSH54	S	Slime Mold	UTK	466
Tulostoma	brumale cf.	Tulostomataceae	Tulostomatales	3	AHD719	S		COH	687
Tulostoma	simulans	Tulostomataceae	Tulostomatales	2	LAS842	S		COH	829
Tyromyces	guttulatus cf.	Polyporaceae	Aphyllophorales	3	AHD599	S		UTC	190
Vascellum	lloydianum cf.	Lycoperdaceae	Lycoperdales	5	SMG247	S		RAR	1129

genus	species	family	order	grd	ref	typ	commonname	ocr	ncode
Volvariella	bombycina	Pluteaceae	Agaricales	2	IAS677	S		RAR	841
Xerosphalina	campanella	Tricholomataceae	Agaricales	1	IAS809	S		COH	974
Xerula	americana	Tricholomataceae	Agaricales	2	UNK000	U		RAR	258

APPENDIX C

1991-1995 LOS ALAMOS/BANDELIER FUNGI SURVEY Sort by Order Nelson Jarmie/Fran J Rogers

order	family	genus	species	ncode	grd	ref	typ	commonname
Agaricales	Agaricaceae	Agaricus	augustus	938	2	LAS502	S	The Prince
Agaricales	Agaricaceae	Agaricus	barrowsii	689	2	AHD69	H	
Agaricales	Agaricaceae	Agaricus	bitorquis	159	2	GLT130	S	
Agaricales	Agaricaceae	Agaricus	campestris	947	1	LAS505	S	Meadow mushroom
Agaricales	Agaricaceae	Agaricus	haemorrhoidarius	160	2	LAS505	S	
Agaricales	Agaricaceae	Agaricus	silvicola	187	2	AHD334	S	
Agaricales	Agaricaceae	Agaricus	xanthodermus	139	2	AHD329	S	
Agaricales	Amanitaceae	Amanita	bisporigera cf.	168	3	AHD271	H	Destroying Angel
Agaricales	Amanitaceae	Amanita	caesarea	1140	2	AHD284	H	Caesar's Mush.
Agaricales	Amanitaceae	Amanita	constricta	1048	2	AHD289	H	
Agaricales	Amanitaceae	Amanita	fulva	662	2	LAS536	H	
Agaricales	Amanitaceae	Amanita	magniverrucata cf.	930	3	AHD274	H	
Agaricales	Amanitaceae	Amanita	muscaria v. mus.	1037	1	AHD282	H	Fly Agaric
Agaricales	Amanitaceae	Amanita	pantherina	1092	1	AHD280	H	
Agaricales	Amanitaceae	Amanita	vaginata	893	2	LAS549	H	Grisette
Agaricales	Bolbitiaceae	Agrocybe	pediades cf.	1142	3	AHD468	S	
Agaricales	Bolbitiaceae	Agrocybe	praecox cf.	166	3	AHD469	U	
Agaricales	Bolbitiaceae	Conocybe	lactea cf.	428	3	AHD472	S	
Agaricales	Bolbitiaceae	Conocybe	tenera cf.	946	4	LAS561	S	
Agaricales	Boletaceae	Boletus	barrowsii	1116	1	AHD529	H	
Agaricales	Boletaceae	Boletus	calopus	518	2	AHD523	H	
Agaricales	Boletaceae	Boletus	chrysenteron cf.	991	3	AHD519	H	
Agaricales	Boletaceae	Boletus	edulis	925	1	AHD530	H	King, Cep, etc
Agaricales	Boletaceae	Boletus	haematinus	651	2	AHD528	H	
Agaricales	Boletaceae	Boletus	rubripes	771	2	AHD524	H	
Agaricales	Boletaceae	Chalciporus	sp.	1141	5	UNK000	U	
Agaricales	Boletaceae	Leccinum	aurantiacum	1010	1	LAS577	H	
Agaricales	Boletaceae	Leccinum	insigne	673	2	AHD540	H	
Agaricales	Boletaceae	Suillus	granulatus	1034	2	LAS584	H	
Agaricales	Boletaceae	Suillus	lakei	1004	2	LAS585	H	
Agaricales	Boletaceae	Suillus	sibiricus	972	2	AHD198	H	
Agaricales	Coprinaceae	Coprinus	atramentarius	803	2	LAS596	S	Inky cap
Agaricales	Coprinaceae	Coprinus	comatus	677	1	AHD345	S	Shaggy mane
Agaricales	Coprinaceae	Coprinus	lagopus cf.	697	3	AHD350	S	
Agaricales	Coprinaceae	Coprinus	micaceus	760	2	LAS600	S	
Agaricales	Coprinaceae	Panaeolus	foenisecii	431	2	AHD360	S	Hay-Makers Mush.
Agaricales	Coprinaceae	Panaeolus	retirugis cf.	218	3	AHD357	S	
Agaricales	Coprinaceae	Psathyrella	carbonicola	1134	1	AHD366	S	
Agaricales	Coprinaceae	Psathyrella	velutina	546	2	HRA178	S	
Agaricales	Cortinariaceae	Cortinarius	alboviolaceus cf.	654	3	AHD447	H	
Agaricales	Cortinariaceae	Cortinarius	anomalus	737	2	AHD447	H	
Agaricales	Cortinariaceae	Cortinarius	calochrous	730	2	HRA145	H	
Agaricales	Cortinariaceae	Cortinarius	glaucopus cf.	112	3	AHD437	H	
Agaricales	Cortinariaceae	Galerina	autumnalis cf.	303	3	LAS620	S	
Agaricales	Cortinariaceae	Gymnopolis	sapineus	817	2	AHD408	U	
Agaricales	Cortinariaceae	Hebeloma	crustuliniforme	886	2	LAS624	H	Poison pie
Agaricales	Cortinariaceae	Hebeloma	sinapizans cf.	1030	3	AHD465	H	

order	family	genus	species	ncode	grd	ref	typ	commonname
Agaricales	Cortinariaceae	Inocybe	albodisca cf.	449	3	AHD459	H	
Agaricales	Cortinariaceae	Inocybe	fastigiata	429	2	LAS628	H	
Agaricales	Cortinariaceae	Inocybe	lanuginosa	305	2	LAS630	H	
Agaricales	Cortinariaceae	Inocybe	maculata cf.	448	3	AHD458	H	
Agaricales	Cortinariaceae	Inocybe	sororia	1103	2	LAS632	U	
Agaricales	Crepidotaceae	Crepidotus	applanatus cf.	443	3	LAS636	S	
Agaricales	Crepidotaceae	Crepidotus	herbarum cf.	256	3	AHD405	S	
Agaricales	Crepidotaceae	Crepidotus	mollis	993	1	AHD406	S	
Agaricales	Entolomataceae	Nolanea	sp.	1108	4	AHD245	S	
Agaricales	Gomphidiaceae	Chroogomphus	tomentosus	582	2	LAS650	H	
Agaricales	Gomphidiaceae	Chroogomphus	vinicolor	866	2	LAS651	H	
Agaricales	Gomphidiaceae	Gomphidius	glutinosus	1083	2	AHD482	H	
Agaricales	Gomphidiaceae	Gomphidius	oregonensis	203	2	AHD482	H	Insidious G.
Agaricales	Hygrophoraceae	Hygrophorus	acutoconica cf.	831	3	AHD115	U	
Agaricales	Hygrophoraceae	Hygrophorus	chrysodon	874	2	LAS657	U	
Agaricales	Hygrophoraceae	Hygrophorus	conicus	1068	1	LAS658	U	Witch's Hat
Agaricales	Hygrophoraceae	Hygrophorus	marginatus cf.	713	3	AHD112	U	
Agaricales	Hygrophoraceae	Hygrophorus	pudorinus	1069	2	AHD116	U	
Agaricales	Hygrophoraceae	Hygrophorus	speciosus	1089	2	LAS667	U	
Agaricales	Lepiotaceae	Chlorophyllum	molybdites	1133	1	AHD295	S	
Agaricales	Lepiotaceae	Lepiota	clypeolaria	523	2	HUA31	S	
Agaricales	Lepiotaceae	Lepiota	cristata	896	2	AHD306	S	
Agaricales	Lepiotaceae	Lepiota	rhacodes	615	2	AHD297	S	
Agaricales	Paxcillaceae	Hygrophoropsis	aurantiaca	1119	2	AHD479	S	False Chanterell
Agaricales	Paxillaceae	Paxillus	atrotomentosis	1046	2	LAS670	S	
Agaricales	Paxillaceae	Phylloporus	rhodoxanthus	890	1	AHD180	H	Gilled Bolete
Agaricales	Pluteaceae	Pluteus	cervinus	1019	1	AHD255	S	Fawn Mushroo
Agaricales	Pluteaceae	Pluteus	cervinus v. alba	291	4	LAS675	S	
Agaricales	Pluteaceae	Pluteus	lutescens	1022	2	AHD257	S	
Agaricales	Pluteaceae	Volvariella	bombycina	841	2	LAS677	S	
Agaricales	Russulaceae	Lactarius	barrowsii	1053	2	AHD69	U	
Agaricales	Russulaceae	Lactarius	controversus cf.	1060	3	AHD70	H	
Agaricales	Russulaceae	Lactarius	deliciosus	1113	2	LAS683	H	
Agaricales	Russulaceae	Lactarius	olivaceoumbrinus	669	2	AHD70	H	
Agaricales	Russulaceae	Lactarius	rubrilacteus	1094	1	AHD68	H	
Agaricales	Russulaceae	Lactarius	torminosus	671	2	LAS694	H	
Agaricales	Russulaceae	Lactarius	uvidus cf.	1098	3	AHD75	H	
Agaricales	Russulaceae	Russula	aeruginea cf.	653	3	AHD95	H	
Agaricales	Russulaceae	Russula	brevipes	1112	2	LAS698	H	
Agaricales	Russulaceae	Russula	emetica cf.	1005	3	AHD97	H	
Agaricales	Russulaceae	Russula	maculata cf.	869	3	AHD100	H	
Agaricales	Russulaceae	Russula	rosacea cf.	1081	3	LAS705	H	
Agaricales	Strophariaceae	Pholiota	aurivella cf.	764	3	LAS712	P	
Agaricales	Strophariaceae	Pholiota	destruens	980	2	LAS714	S	
Agaricales	Strophariaceae	Pholiota	limonella cf.	459	2	HUA174	U	
Agaricales	Strophariaceae	Pholiota	lubrica cf.	559	3	AHD392	U	
Agaricales	Strophariaceae	Pholiota	squarrosa	752	2	LAS716	P	
Agaricales	Strophariaceae	Psilocybe	sp.	1144	4	AHD368	S	
Agaricales	Strophariaceae	Stropharia	[illegible]illa cf.	216	3	AHD377	S	

order	family	genus	species	ncode	grd	ref	typ	commonname
Agaricales	Strophariaceae	Stropharia	kauffmanii	1104	2	AHD180	S	
Agaricales	Tricholomataceae	Armillaria	albolanaripes	642	2	AHD194	P	
Agaricales	Tricholomataceae	Armillaria	mellea cf.	1086	3	LAS736	P	Honey Mushroom
Agaricales	Tricholomataceae	Armillaria	straminia cf.	478	5	LAS734	P	
Agaricales	Tricholomataceae	Armillaria	tabescens cf.	919	3	AHD197	P	
Agaricales	Tricholomataceae	Catathelasma	ventricosa	900	2	AHD195	M	
Agaricales	Tricholomataceae	Cheimonophyllum	candidissimus	954	2	LAS743	S	
Agaricales	Tricholomataceae	Clitocybe	dealbata	306	2	AHD163	S	
Agaricales	Tricholomataceae	Clitocybe	dilatata	1065	2	LAS746	U	
Agaricales	Tricholomataceae	Clitocybe	gibba	680	2	AHD157	S	
Agaricales	Tricholomataceae	Clitocybe	gigantea cf.	920	3	AHD158	S	
Agaricales	Tricholomataceae	Collybia	dryophila	230	5	HHD131	S	
Agaricales	Tricholomataceae	Collybia	lentinoides cf.	616	3	HHA61	S	
Agaricales	Tricholomataceae	Collybia	spongiosa cf.	957	3	LAS756	S	
Agaricales	Tricholomataceae	Cyptotrama	chrysopeplum	994	1	HHA63	S	
Agaricales	Tricholomataceae	Cystoderma	amianthinum cf.	855	3	AHD200	U	
Agaricales	Tricholomataceae	Cystoderma	granulosum cf.	828	3	AHD200	M	
Agaricales	Tricholomataceae	Flammulina	velutipes	1009	1	AHD220	S	Velvet Foot
Agaricales	Tricholomataceae	Hohenbuehelia	petaloides cf.	1138	3	AHD136	S	
Agaricales	Tricholomataceae	Laccaria	amethystina cf.	773	3	AHD172	S	
Agaricales	Tricholomataceae	Laccaria	bicolor	1027	2	AHD173	M	
Agaricales	Tricholomataceae	Laccaria	laccata	901	2	AHD172	S	
Agaricales	Tricholomataceae	Lentinellus	omphalodes cf.	982	4	HHA208	U	
Agaricales	Tricholomataceae	Lentinellus	ursinus cf.	630	4	AHD144	U	
Agaricales	Tricholomataceae	Lentinus	ponderosus	944	2	AHD143	U	
Agaricales	Tricholomataceae	Leucopaxillus	amarus	922	2	LAS768	M	
Agaricales	Tricholomataceae	Marasmius	oreades	948	1	LAS772	S	Fairy Ring Mush.
Agaricales	Tricholomataceae	Melanoleuca	sp.	997	5	AHD169	U	
Agaricales	Tricholomataceae	Mycena	haematopus	602	2	LAS781	S	
Agaricales	Tricholomataceae	Phyllotopsis	nidulans	1102	1	AHD140	S	
Agaricales	Tricholomataceae	Pleurotus	ostreatus	1006	1	AHD134	S	
Agaricales	Tricholomataceae	Pleurotus	sapidus	234	2	AHD134	S	Oyster Mushroom
Agaricales	Tricholomataceae	Tricholoma	sp.	389	4	AHD176	U	
Agaricales	Tricholomataceae	Tricholomopsis	platyphylla	275	2	AHD146	S	
Agaricales	Tricholomataceae	Tricholomopsis	rutilans	1135	2	AHD145	S	
Agaricales	Tricholomataceae	Xeromphalina	campanella	974	1	LAS809	S	
Agaricales	Tricholomataceae	Xerula	americana	258	2	UNK000	U	
Aphyllophorales	Cantharellaceae	Cantharellus	cibarius	1090	1	LAS387	U	Chanterelle
Aphyllophorales	Cantharellaceae	Gomphus	bonari	1056	2	LAS396	U	
Aphyllophorales	Cantharellaceae	Gomphus	floccosus	953	2	LAS396		
Aphyllophorales	Clavariaceae	Clavariadelphus	lovejoyae	864	2	AHD634	M	
Aphyllophorales	Clavariaceae	Clavariadelphus	pistillaris	580	2	LAS403	M	
Aphyllophorales	Clavariaceae	Clavariadelphus	truncatus	1064	2	AHD634	S	
Aphyllophorales	Clavariaceae	Clavicorona	pyxidata	1014	2	LAS401	S	Coral Mushroom
Aphyllophorales	Clavariaceae	Clavulina	cristata cf.	226	3	AHD641	U	Coral Mushroom
Aphyllophorales	Clavariaceae	Clavulina	rugosa cf.	152	3	AHD642	U	Coral Mushroom
Aphyllophorales	Clavariaceae	Clavulinopsis	corniculata	314	2	AHD639	U	
Aphyllophorales	Clavariaceae	Ramaria	vinosimaculaus cf.	652	3	AHD653	U	Coral Mushroom
Aphyllophorales	Clavariaceae	Sparassis	crispa	568	2	AHD657	P	

order	family	genus	species	ncode	grd	ref	typ	commonname
Aphyllophorales	Clavariaceae	Sparassis	radicata	462	2	NHD657	P	Cauliflower H.
Aphyllophorales	Coniophoraceae	Coniophora	puteana	373	7	LAS415	U	Wet rot
Aphyllophorales	Corticiaceae	Peniophora	gigantea	706	2	LAS422	U	
Aphyllophorales	Corticiaceae	Peniophora	rufa	1011	1	LAS423	S	
Aphyllophorales	Corticiaceae	Phlebia	sp.	985	5	NHD610	S	
Aphyllophorales	Hydnaceae	Auriscalpium	vulgare	202	1	NHD629	S	
Aphyllophorales	Hydnaceae	Hericium	abietis	769	2	NHD614	P	
Aphyllophorales	Hydnaceae	Steccherinum	ochraceum	135	5	LAS437	S	
Aphyllophorales	Polyporaceae	Bjerkandera	adusta	1079	2	PHA270	S	
Aphyllophorales	Polyporaceae	Caloporus	dichrous	386	2	LAS449	U	
Aphyllophorales	Polyporaceae	Coltricia	perennis	1007	2	PHA259	S	
Aphyllophorales	Polyporaceae	Coriolellus	carbonarius	266	2	NHD603	U	
Aphyllophorales	Polyporaceae	Coriolopsis	gallica	822	1	GPH216	S	
Aphyllophorales	Polyporaceae	Daedaleopsis	confragosa	932	1	GPH226	U	
Aphyllophorales	Polyporaceae	Fomitopsis	canjanderi	1136	2	NHD580	S	
Aphyllophorales	Polyporaceae	Fomitopsis	pinicola	1029	2	NHD578	S	
Aphyllophorales	Polyporaceae	Ganoderma	applanatum	1024	1	LAS460	P	Artist's Conk
Aphyllophorales	Polyporaceae	Globifomes	graveolens cf.	411	3	LAS462	U	Sweet knot
Aphyllophorales	Polyporaceae	Gloeophyllum	sepiarium	1018	1	LAS463	S	
Aphyllophorales	Polyporaceae	Inonotus	tomentosus	1085	2	NHD569	P	
Aphyllophorales	Polyporaceae	Irpex	lacteus	1043	2	LAS467	S	
Aphyllophorales	Polyporaceae	Lenzites	betulina	400	2	NHD589	U	
Aphyllophorales	Polyporaceae	Phaeolus	schweinitzii	963	2	LAS473	P	Dye Polypore
Aphyllophorales	Polyporaceae	Polyporus	arcularius	971	1	NHD563	S	
Aphyllophorales	Polyporaceae	Polyporus	badius cf.	407	3	NHD562	S	
Aphyllophorales	Polyporaceae	Polyporus	elegans	360	2	NHD562	U	
Aphyllophorales	Polyporaceae	Polyporus	squamosus	1105	2	PHA257	P	
Aphyllophorales	Polyporaceae	Polyporus	varius	949	2	NHD563	H	
Aphyllophorales	Polyporaceae	Poria	corticola cf.	986	3	NHD602	S	
Aphyllophorales	Polyporaceae	Poria	spissa	878	2	LAS484	S	
Aphyllophorales	Polyporaceae	Pycnoporellus	alboluteus	1128	2	NHD571	S	
Aphyllophorales	Polyporaceae	Pycnoporus	cinnabarinus	981	2	LAS747	S	
Aphyllophorales	Polyporaceae	Spongipellis	pachyodon	426	2	LAS488	S	
Aphyllophorales	Polyporaceae	Trichaptum	abietinus	995	2	NHD593	S	
Aphyllophorales	Polyporaceae	Trichaptum	subchartaceum	964	1	UHK000	S	
Aphyllophorales	Polyporaceae	Tyromyces	guttulatus cf.	190	3	NHD599	S	
Aphyllophorales	Stereaceae	Stereum	complicatum	857	2	LAS497	S	
Aphyllophorales	Stereaceae	Stereum	hirsutum cf.	384	2	NHD605	S	Parchment Fungus
Aphyllophorales	Stereaceae	Stereum	striatum	863	2	NHD605	S	
Aphyllophorales	Thelephoraceae	Thelephora	terrestris	1026	2	LAS413	S	
Auriculariales	Auriculariaceae	Auricularia	auricula	658	2	NHD675	S	Tree Ear
Ceratiomyxales	Ceratiomyxaceae	Ceratiomyxa	fruticulosa	206	2	FSH30	U	Slime Mold
Dacrymycetales	Dacrymycetaceae	Dacrymyces	palmatus	1137	2	PHA300	S	
Dacrymycetales	Dacrymycetaceae	Guepiniopsis	alpinus	172	2	SSH145	U	
Gautieriales	Gautieriaceae	Gautieria	mexicana	934	1	NHD747	H	
Helotiales	Dermatiaceae	Chlorociboria	aeruginascens	1147	1	NHD878	S	Blue Stain
Helotiales	Geoglossaceae	Spathularia	flavida	301	2	LAS360	S	
Helotiales	Leotiaceae	Bisporella	[illegible]ina	1075	2	LAS362	S	
Helotiales	Leotiaceae	Cudonia	[illegible]inans	393	2	NHD873	S	

order	family	genus	species	ncode	grd	ref	typ	commonname
Hymenogastrales	Rhizopogonaceae	Rhizopogon	subsalmonius	936	1	SMG290	H	
Hymenogastrales	Rhizopogonaceae	Truncocolumella	citrina	143	2	LAS813	H	
Leucogastrales	Leucogastraceae	Leucophleps	spinispora	937	1	AMD760	H	
Liceales	Reticulariaceae	Lycogala	epidendrum	1016	1	SSW206	S	Wolf's Phart
Liceales	Reticulariaceae	Lycogala	flavofuscum	192	2	FSM55	S	Slime Mold
Liceales	Reticulariaceae	Tubifera	sp.	466	6	FSM54	S	Slime Mold
Lycoperdales	Geastraceae	Geastrum	coronatum	686	2	LAS818	S	Earth star
Lycoperdales	Geastraceae	Geastrum	saccatum	492	2	LAS818	S	Earth star
Lycoperdales	Geastraceae	Geastrum	triplex	227	1	AMD703	S	Earth star
Lycoperdales	Lycoperdaceae	Calvatia	gigantea	422	2	AMD681	S	Giant puffball
Lycoperdales	Lycoperdaceae	Lycoperdon	americanum	358	2	AMD694	S	Puffball
Lycoperdales	Lycoperdaceae	Lycoperdon	echinatum	837	2	LAS824	S	Puffball
Lycoperdales	Lycoperdaceae	Lycoperdon	perlatum	624	2	LAS825	S	Puffball
Lycoperdales	Lycoperdaceae	Lycoperdon	pyriforme	1013	2	AMD691	S	Puffball
Lycoperdales	Lycoperdaceae	Vascellum	lloydianum cf.	1129	5	SMG247	S	
Nidulariales	Nidulariaceae	Crucibulum	laeve	593	2	LAS828	S	Bird's nest
Nidulariales	Nidulariaceae	Cyathus	striatus	361	1	AMD828	S	
Nidulariales	Nidulariaceae	Nidula	candida	222	2	AMD780	S	Birds Nest Mush.
Pezizales	Helvellaceae	Gyromitra	esculenta	1099	2	PHA303	U	
Pezizales	Helvellaceae	Gyromitra	infula	1125	2	PHA303	S	
Pezizales	Helvellaceae	Helvella	acetabulum	146	2	AMD807	U	Cup Fungus
Pezizales	Helvellaceae	Helvella	crispa	913	2	AMD816	U	Saddle Mushroom
Pezizales	Helvellaceae	Helvella	elastica cf.	247	3	AMD813	U	Saddle Mushroom
Pezizales	Helvellaceae	Helvella	lacunosa	149	2	AMD815	U	Saddle Mushroom
Pezizales	Morchellaceae	Morchella	augusticeps	176	2	AMD790	S	Morel
Pezizales	Morchellaceae	Morchella	elata	177	2	LAS713	S	Morel
Pezizales	Morchellaceae	Morchella	esculenta	171	2	LAS327	S	Morel
Pezizales	Pezizaceae	Peziza	repanda	1146	2	LAS347	S	
Pezizales	Pezizaceae	Peziza	succosa	317	2	MMG304	S	
Pezizales	Pyronemataceae	Humaria	hemisphaerica	408	2	LAS351	S	
Pezizales	Pyronemataceae	Scutellinia	erinaceus cf.	685	3	AMD839	S	Yellow eye-lash
Pezizales	Pyronemataceae	Scutellinia	scutellata	205	1	LAS353	S	Eyelash cup
Pezizales	Pyronemataceae	Tarzetta	cupularis	1076	2	PHA304	S	
Pezizales	Sarcoscyphaceae	Sarcoscypha	coccinea	401	4	AMD836	S	
Phallales	Phallaceae	Phallus	impudicus	818	1	AMD768	S	Stinkhorn
Physarales	Physacaceae	Fuligo	septica	1132	1	LAS845	S	Slime mold
Sclerodermatales	Astraeaceae	Astraeus	hygrometricus	418	1	AMD705	S	
Sphaeriales	Hypocreaceae	Hypomyces	chrysospermum	1038	1	LAS371	P	
Sphaeriales	Hypocreaceae	Hypomyces	hyalinus cf.	704	3	PHA313	P	
Sphaeriales	Hypocreaceae	Hypomyces	lactifluorum	1035	1	LAS373	P	Lobster Mushroom
Sphaeriales	Hypocreaceae	Hypomyces	luteovirens	1056	1	LAS373	P	
Sphaeriales	Xylariaceae	Daldinia	concentrica cf.	945	5	LAS374	S	
Stemonitales	Stemonitaceae	Stemonitis	splendens	968	1	LAS853	S	Slime mold
Tremellales	Tremellaceae	Pseudohydnum	gelatinosum	1047	2	AMD671	S	
Tremellales	Tremellaceae	Tremella	mesenterica cf.	1059	6	AMD669	S	Jelly Fungus
Trichiales	Trichiaceae	Arcyria	denudata	933	1	FSM63	U	Slime Mold
Trichiales	Trichiaceae	Hemitrichia	clavata cf.	603	5	FSM66	S	Slime Mold
Trichiales	Trichiaceae	Trichia	scabra cf.	1023	3	FSM68	S	Slime Mold
Tulostomatales	Tulostomataceae	Battarrea	phalloides	140	1	SSW156	S	

order	family	genus	species	ncode	grd	ref	typ	commonname
Tulostomatales	Tulostomataceae	Tulostoma	brumale cf.	687	3	AHD719	S	
Tulostomatales	Tulostomataceae	Tulostoma	simulans	829	2	IAS842	S	
Uredinales	Pucciniaceae	Gymnosporangium	speciosus cf.	181	3	TextBk	P	Juniper Rust

APPENDIX D

1991-1995 LOS ALAMOS/BANDELIER FUNGI SURVEY Not NM List Nelson Jarmie/Fran J. Rogers

July 15, 1996

Version 27FnSpList

genus	species	family	order	grd	typ	ocr	nmlst	ncode
							.F.	
Agaricus	barrowsii	Agaricaceae	Agaricales	2	H	UIC	.F.	689
Agaricus	haemorrhoidarius	Agaricaceae	Agaricales	2	S	UIK	.F.	160
Amanita	bisporigera cf.	Amanitaceae	Agaricales	3	H	UIC	.F.	168
Amanita	magniverrucata cf.	Amanitaceae	Agaricales	3	H	UIC	.F.	930
Amanita	muscaria v. mus.	Amanitaceae	Agaricales	1	H	COH	.F.	1037
Arcyria	denudata	Trichiaceae	Trichiales	1	U.	UIK	.F.	933
Boletus	calopus	Boletaceae	Agaricales	2	H	COH	.F.	518
Boletus	haematinus	Boletaceae	Agaricales	2	H	UIC	.F.	651
Chalciporus	sp.	Boletaceae	Agaricales	5	U	RAR	.F.	1141
Clavariadelphus	lovejoyae	Clavariaceae	Aphyllophorales	2	H	UIC	.F.	864
Collybia	lentinoides cf.	Tricholomataceae	Agaricales	3	S	UIK	.F.	616
Collybia	spongiosa cf.	Tricholomataceae	Agaricales	3	S	UIC	.F.	957
Coniophora	puteana	Coniophoraceae	Aphyllophorales	7	U	UIK	.F.	373
Coprinus	lagopus cf.	Coprinaceae	Agaricales	3	S	UIK	.F.	697
Coriolopsis	gallica	Polyporaceae	Aphyllophorales	1	S	UIC	.F.	822
Cortinarius	anomalus	Cortinariaceae	Agaricales	2	H	UIK	.F.	737
Gautieria	mexicana	Gautieriaceae	Gautieriales	1	H	UIK	.F.	934
Globifomes	graveolens cf.	Polyporaceae	Aphyllophorales	3	U	UIC	.F.	411
Gomphidius	oregonensis	Gomphidiaceae	Agaricales	2	H	COH	.F.	203
Gymnosporangium	speciosus cf.	Pucciniaceae	Uredinales	3	P	COH	.F.	181
Gyromitra	esculenta	Helvellaceae	Pezizales	2	U	UIC	.F.	1099
Hemitrichia	clavata cf.	Trichiaceae	Trichiales	5	S	UIK	.F.	603
Hericium	abeitis	Hydnaceae	Aphyllophorales	2	P	RAR	.F.	769
Hygrophorus	marginatus cf.	Hygrophoraceae	Agaricales	3	U	UIK	.F.	713
Hypomyces	hyalinus cf.	Hypocreaceae	Sphaeriales	3	P	UIC	.F.	704
Inocybe	albodisca cf.	Cortinariaceae	Agaricales	3	H	UIC	.F.	449
Laccaria	amethystina cf.	Tricholomataceae	Agaricales	3	S	UIK	.F.	773
Lactarius	olivaceoumbrinus	Russulaceae	Agaricales	2	H	UIK	.F.	669
Lepiota	rhacodes	Lepiotaceae	Agaricales	2	S	COH	.F.	615
Lycoperdon	echinatum	Lycoperdaceae	Lycoperdales	2	S	COH	.F.	837
Morchella	augusticeps	Morchellaceae	Pezizales	2	S	UIC	.F.	176
Phlebia	sp.	Corticiaceae	Aphyllophorales	5	S	UIK	.F.	985
Pholiota	lubrica cf.	Strophariaceae	Agaricales	3	U	UIK	.F.	559
Pleurotus	sapidus	Tricholomataceae	Agaricales	2	S	COH	.F.	234
Pluteus	cervinus v. alba	Pluteaceae	Agaricales	4	S	UIC	.F.	291
Polyporus	squamosus	Polyporaceae	Aphyllophorales	2	P	UIC	.F.	1105
Poria	corticola cf.	Polyporaceae	Aphyllophorales	3	S	UIK	.F.	986
Poria	spissa	Polyporaceae	Aphyllophorales	2	S	COH	.F.	878
Psathyrella	carbonicola	Coprinaceae	Agaricales	1	S	RAR	.F.	1134
Ramaria	vinosimaculaus cf.	Clavariaceae	Aphyllophorales	3	U	UIK	.F.	652
Russula	emetica cf.	Russulaceae	Agaricales	3	H	COH	.F.	1005
Spongipellis	pachyodon	Polyporaceae	Aphyllophorales	2	S	UIK	.F.	426
Steccherinum	ochraceum	Hydnaceae	Aphyllophorales	5	S	UIC	.F.	135
Stemonitis	splendens	Stemonitaceae	Stemonitales	1	S	UIC	.F.	968
Stereum	striatum	Stereaceae	Aphyllophorales	2	S	COH	.F.	863
Tarzetta	cupularis	Pyronemataceae	Pezizales	2	S	UIC	.F.	1076
Trichaptum	subchartaceum	Polyporaceae	Aphyllophorales	1	S	UIC	.F.	964

genus	species	family	order	grd	typ	ocr	nmlst	ncode
Trichia	scabra cf.	Trichiaceae	Trichiales	3	S	UIC	.F.	1023
Tulostoma	simulans	Tulostomataceae	Tulostomatales	2	S	COM	.F.	829
Vascellum	lloydianum cf.	Lycoperdaceae	Lycoperdales	5	S.	RAR	.F.	1129

Threatened and Endangered Species Plan GIS Phase

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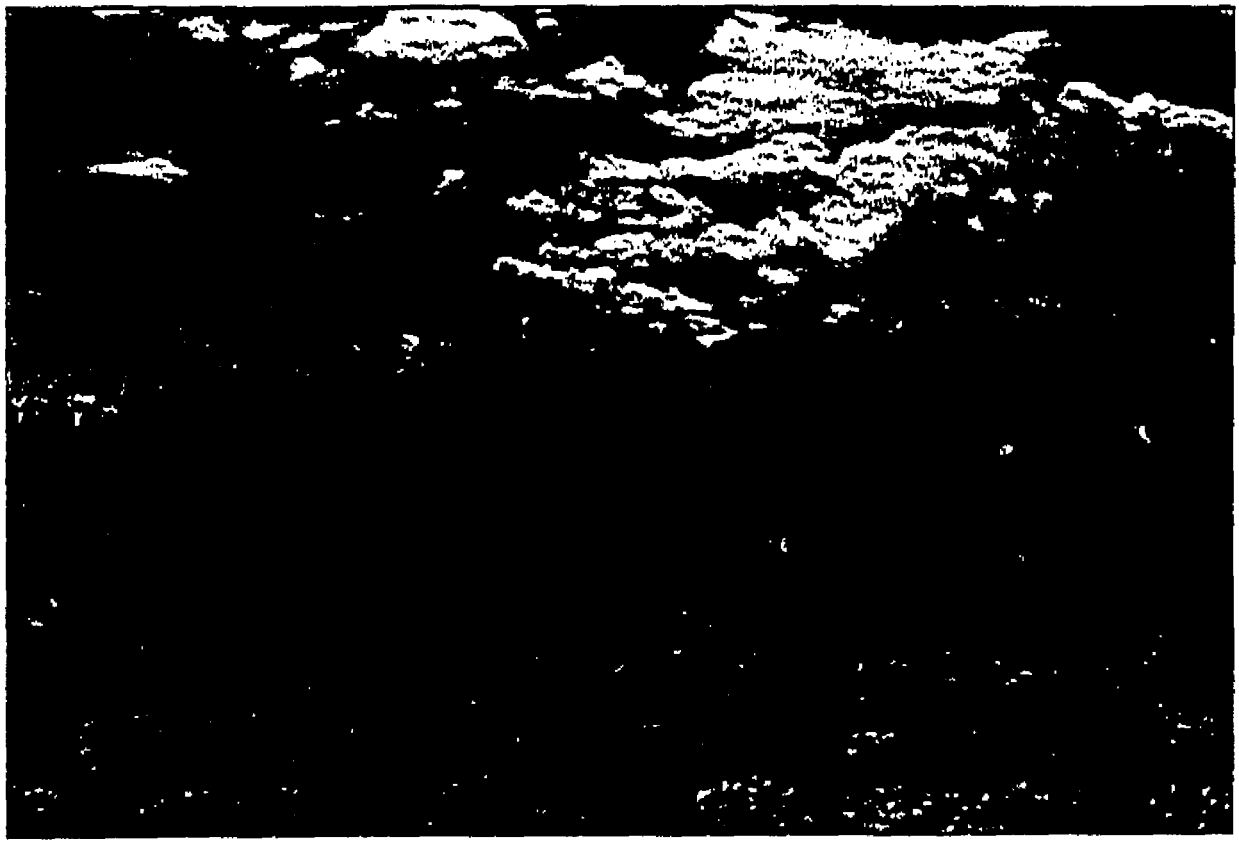

LA-UR-96-3527

Threatened and Endangered Species Plan GIS Phase

Kathryn D. Bennett, Tom E. Garrison**, Mary E. Salisbury*, and Steven W. Koch**

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**Facility for Information Management, Analysis, and Display

Abstract

During FY96, the Ecology Group (ESH-20) has begun to develop a Geographic Information System (GIS) data base for the Threatened and Endangered Species Habitat Management Plan. ESH-20 will use this data base to store ecological data, both spatial and tabular. Additionally, we will use the power of a GIS to query, analyze, model, and display data. We currently have a GIS data dictionary, a data base design, and have begun importing data into the design. Many data sets are completely imported into the data base. Currently, the data base contains 12,021 records. The data that have been imported into the data base can be queried, displayed, and analyzed spatially. We have an ArcView application that demonstrates these abilities. In addition, this application will serve as a screening tool for ESH-20 biologists performing assessments of new projects being proposed at the Laboratory.

1.0 Introduction

The development of data integration with a Geographic Information System (GIS) is Task 2 of the Threatened and Endangered Species Habitat Management Plan (TES HMP) (1996). The Threatened and Endangered Species (TES) GIS is an important component of the TES HMP. We intend the TES GIS to be the primary data base for TES data and other ancillary information. We will use the GIS to display, query, analyze, and model biological data. In addition, the GIS will be the repository for much of the tabular data that has previously been stored in paper form or in other electronic forms such as spreadsheets and text documents. In the past years, data owners have kept and managed their own data, leading to data losses and inconsistency in data base definitions and use. The centralized TES GIS data base will allow for consistent data base definitions and should reduce the loss of data.

We are using ARC/INFO as our GIS for the TES HMP. ARC/INFO was developed by Environmental Systems Research Institute, Inc. (ESRI) and it is used throughout federal agencies, including the Department of the Interior, U.S. Fish and Wildlife Service. Within ARC/INFO, ARC is used for all spatial analysis and INFO is the data base.

During FY96, the GIS development was broken down into 4 subtasks: development of a draft data dictionary, data inventory/data base design/naming conventions, data entry/conversion, and map production.

2.0 Subtasks

2.1 Subtask 1: Development of a Draft Data Dictionary

A data dictionary is utilized to store metadata (description of data set) about the coverages and to provide a robust tool to facilitate the management of the information. We based the GIS organization on a single

hierarchy of themes (e.g., ecology, geology, and hydrology). This hierarchy is implemented as a directory structure of superthemes with the coverage names following a naming convention that directly codes for the theme and content of the coverage data sets. Therefore, to manage the biological data, we used a data dictionary to document the various data sets. This metadata will conform with the Content Standards for Digital Spatial Metadata from the Federal Geographic Data Committee (FGDC). The data dictionary also supports other data types such as American Standard Code Information Interchange (ASCII) and includes vectors (GIS coverages as points, lines, and polygons), rasters (GIS grids and images), terrain models, and documents. This integration into a data dictionary enables many data base functions to be automated and provides a single source for information on all aspects of the TES HMP project. The data dictionary will be the key to creating the hypertext links via Hyper Text Markup Language (HTML) to tie together the disparate information pertinent to the TES HMP project.

The data dictionary is comprised of a collection of INFO tables related to each other by key items. All files and tables reside in a specific directory, /gis/sys/admin. There, the INFO tables are stored in the info directory and ARC Marco Language (AML) programs and menus are stored in the /gis/sys/admin/amls/olnd directory. The relationship between the various tables is summarized here. The relates (the common item in two tables that links them together) are depicted by connecting lines with the relate item shown with the line.

```
DICT------geoset------
    |- CHGLOG ------ reqnum -----
    |- GNOTES              | - RNOTES
    |- QNOTES
    |- DICT_TABLS
            |
            ------ table ------
                    | - TABL_ITMS
```

A brief explanation of each of these tables is given below:

geoset:	A geographic data set.
DICT:	The main data dictionary table.
CHGLOG:	The change log for the geoset, a unique record for each change or edit to the coverage or other data set.
RNOTES:	Individual request/edit notes for each record in CHGLOG. This allows more detailed information about the process steps that a geoset has undergone. RNOTES is related to the CHGLOG table via the reqnum item.
GNOTES:	Geoset notes. This stores the abstract of the geoset and other pertinent data about the geoset.
QNOTES:	Quality control information about the geoset. This is intended to store the FDGC-formatted metadata information about the geoset.
DICT_TABLS:	Stores information about tables related to the geoset, including the Arc Attribute Tables (pat, aat, etc.). This table provides for individually documenting related data.

TABL_ITMS: Stores information about individual items in the related tables and is related to the DICT_TABLS table via the table item.

The table definitions for these INFO tables are presented in Table 1 through Table 6.

The dictionary is envoked from ARC or from a Unix system prompt. From ARC the dictionary AML is run by 'Arc: &r dict'. From a Unix system prompt, the command 'dict' is typed in, followed by the enter key. Tables 7, 8, and 9 are examples of a biological coverage in the DICT, DICT_TBLS, and TABL_ITMS tables, respectively.

2.2 Subtask 2: Data Inventory/Data Base Design/Naming Conventions

2.2.1 Data Inventory

From January through April of 1996, a complete data inventory was made of ESH-20 biology data. During the inventory, the content, owner, and format of each data set was noted. After the data inventory was complete, the data needed to be organized into a functional GIS data base design.

2.2.2 Data Base Design

In May 1996, we began the data base design process. Resources from ESH-20 (the Biology Team), Facility for Information Management, Analysis, and Display (FIMAD), and ESRI were used. The TES GIS team interviewed each ESH-20 ecological data owner to determine owner and data users needs. From the interviews and reviewing each data set, a draft design was formulated. The principle organizing structure for the TES GIS was based on thematic content of the various data sets. The thematic structure was also intended to be hierarchical. The physical directory of the data as well as the naming convention for individual files reflect this thematic organization. All ecology data were stored under the supertheme of ECOL (Ecology). The following diagram illustrates the general structure of the ECOL supertheme into super-subthemes, thematic groups or layers, and themes or coverages.

Supertheme: ECOL
- Super-subthemes: ANIMAL, PLANT, TAE
  - Thematic group or Layer: (See Table 10)
    - Theme or Coverage: (See Table 10)

The design of the layers or thematic groups as well as individual themes and coverages are contained in Table 10. This table also indicates any related tables to the coverage and details their design.

2.2.3 Naming Conventions

As part of the review of data, meeting with data owners, and developing a design for each data set, it became apparent that naming conventions were needed. These conventions were needed for raw files from the field activities as well as within the GIS data base.

We established a naming convention for raw field data files. The file name could not be longer than 8 characters followed by a 3-character extension. The file name must contain a designation of the field study area, date, type of field data, and the plot or transect number. The example below illustrates the file name for the first vegetation transect conducted in upper Guaje Canyon on September 26, 1996.

GCU92696.V01

G = Guaje, C = Canyon, U = upper, 92696 = Date, V = Vegetation, and 01 = first transect for that date.

File naming conventions were also adopted within the GIS data base. All spatial data or coverages were automatically given a PAT or AAT extension by the ARC/INFO software, however, other related data sets needed a standardized convention. Table 11 contains the naming convention and definitions of files used in the GIS data base.

2.3 Subtask 3: Data Entry/Conversion

Upon completing the draft data base design, tables were defined in INFO and data existing in electronic form were converted to ASCII and imported into the INFO tables. However, some data files needed extensive editing prior to import. Table 12 shows an example of an electronic vegetation transect field data form and the fields and field order required for the GIS data base. In August of 1996, with the aid of our ESRI contractor, AML programs were written to ease the requirement for hand editing files. Several data automation programs were written that would reorganize data files for import to INFO. These AMLs are presented in Tables 13, 14, 15, and 16. Meanwhile, other non-electronic data were being manually entered into the data base.

From June 1, 1996, through September 15, 1996, a variety of ecological data sets have been developed within the GIS. Many of these data sets have both spatial and related attribute tables. A status of major data sets is given in Table 17.

2.4 Subtask 4: Map Production

For each major data set having spatial and attribute data, we produced maps. We used either ARCPLOT, a subsystem of ARC/INFO, or ArcView, a desktop GIS for map query and display. Eight maps were produced and are numbered Map 1 through Map 8. In addition to producing maps of spatial data sets, we generated tables with selected records of attribute data associated with the spatial data set. Map 1 contains locations of the vegetation transects conducted by ESH-20 throughout the Laboratory. Table 18 lists records of attribute data associated with the selected transect illustrated on Map 1.

Map 2 shows wetlands within the Laboratory and immediately adjacent areas. We developed the wetland coverage by using both the U.S. Fish and Wildlife's National Wetland Inventory (1990) for the area, as well as data collected with Global Positioning System (GPS) by ESH-20 during biological surveys of wetlands.

Locations of observation and field studies for invertebrates are shown in Map 3. The locational data are an approximate location. Table 19 lists selected records from the terrestrial insect data set. This table gives descriptive information as to the location, as well as what insect was found, by whom, and on what date.

The next map, Map 4, shows the locations of bird observations. These observations are from Laboratory employees, the general public, and personnel within ESH-20. This is a shared data set between ESH-20 and Bandelier National Monument. The locational data are given by the observer and may be considered approximate locations. The data

set does not contain locational data pertaining to ESH-20 formal bird censuses. This coverage is still being developed. Table 20 lists selected records of the attribute data associated with these bird observations.

Map 5 shows habitat for sensitive bird species. These habitat boundaries were developed by extensive field studies by a variety of bird experts of the area. At this point, attribute tables associated with these habitats are still under construction.

Many small mammal studies have been conducted at the Laboratory in the last five years. Map 6 displays the locations of these small mammal studies. In addition to the locational data, a vast amount of attribute data are associated with these locations. Table 21 lists selected records from individual small mammals that were captured at these locations. In addition to this table, Table 22 gives contaminant information associated with small mammals captured.

ESH-20 shares another data set with Bandelier National Monument, the mammal observation data set. This data set is similar to the bird observation data, except that not only does the data set give locations of large and medium-sized mammal sightings from the general public, but also contains locational data of ESH-20 formal studies on large and medium-sized mammals. These locations are displayed on Map 7 and attribute information associated with the informal (general public) observations is contained in Table 23. Information pertaining to ESH-20 formal studies is found in Table 24.

We initiated a study in ESH-20 to look at daily movements of elk by using GPS radio collars. These data are received by ESH-20 via an Argos satellite and the coordinate information transferred to our GIS data base. These locations are shown on Map 8. Table 25 lists selected records of attribute data associated with these locations.

2.5 An ArcView Program Application

During the first week of October 1996, we, with the aid of ESRI, will develop an ArcView program application that will demonstrate the abilities of the current data sets and will be a valuable tool to ESH-20 biologists and, eventually, Laboratory Project Leaders. We have designed the application to query the data bases to determine if the location of a proposed new project at the Laboratory will be in the potential or actual habitat of any TES as well as within wetlands. Figure 1 shows a simplistic diagram of the application. In addition, later versions of the application will show where other biological data exist relative to the project area. This application will help ESH-20 biologists determine where there are data gaps and if additional surveys are required.

3.0 Summary

During FY96, ESH-20 has begun to develop a GIS data base for the TES HMP. ESH-20 will use this data base to store ecological data, both spatial and tabular. In addition, we will use the power of a GIS to query, analyze, model, and display data. We currently have developed a GIS data dictionary, a data base design, and have begun importing data into the design. Many data sets are completely imported into the data base. Currently, the data base contains 12,021 records. The data that have been imported into the data base, can be queried, displayed, and analyzed spatially. We have an ArcView application that demonstrates these abilities. In addition, this application will serve to be a screening tool for ESH-20 biologists performing assessments of new projects being proposed at the Laboratory.

4.0 Acknowledgments

We would like to acknowledge FIMAD and ESRI (Bridgett Ady, Andy Huntington, and Larry Battan) for all of their help and assistance with all phases of the TES GIS data base development. Without their help, support, and patience we would not have completed FY96 requirements on time. In addition, we would like to acknowledge Teralene Foxx, TES HMP Project Leader, and John Huchton, ESH-20 Biology Team Leader, for their support, encouragement, and technical advice. Last but not least, we would like to thank all members of the Biology Team for their contribution to the data base design. The information they gave us was invaluable in designing the data base.

5.0 References

Foxx 1996: T.S. Foxx, "Threatened and Enadangered Species Habitat Management Plan for Los Alamos National Laboratory," Los Alamos National Laboratory internal report (March 1996).

USFWS 1990: Department of the Interior, U.S. Fish and Wildlife Service, "The National Wetland Inventory," U.S. Fish and Wildlife Service, Albuquerque, New Mexico (1990).

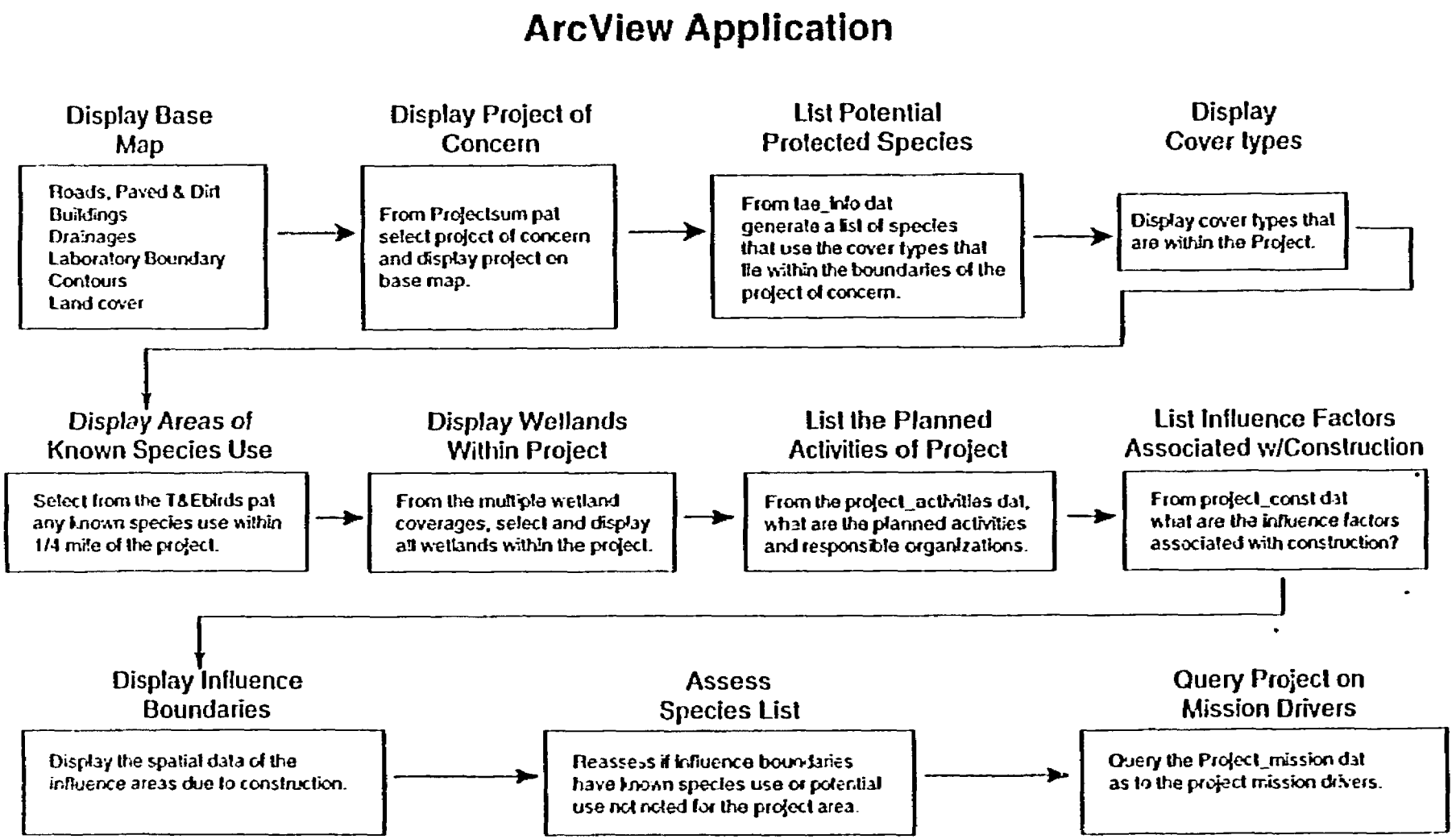

Figure 1. A simplistic diagram of the ArcView application for the query of data bases.

Table 1. Items in the main DICT table.

Item	Definition	Desc	Example
Source			
1. dict-id	4, 5, B	Unique record number	<integer>
2. geoset	15, 15, C	Name of Geo dataSet	t<catg>_<cou/ta>_<opt>
3. desc	80, 80, C	Short description of GeoSet	Technical Area boundaries
4. restrc	15, 15, C	Use restrictions	none|inhouse|wapproval| needto know
5. contact	80, 80, C	Contact for further info	Tom Garrison 665-2404

Item	Definition	Desc	Example
Administrative			
6. catgry	6, 6, C	Super-Theme	BND
7. ocatgry	30, 30, C	Old Super-Theme	BND
8. theme	6, 6, C	Theme name	bnd (boundaries)
9. locatn	60, 60, C	Location (full pathname)	/gis/boundaries
10.type	8, 8, C	Type of dataset	|cover|layer|table|image|grid
11.anno	15, 15, C	Annotation available	-,dxf
12.topol	8, 8, C	Topology of cover	poly<arc,point,net,link>
13.aextent	10, 10, C	Aerial extent	LANL, REG, STATE
14.appxmb	4, 6, F, 2	Approximate size (Mb)	1.2
15.map	5, 15, C	Biology or FIMAD map number if avail.	g100999
16.status	6, 6, C	Status of data set	CUR, DEL, REN
17.update	8, 8, I	Date of last QC check	3Nov1993
18.flag	4, 4, C	Misc. use flag	yes

Table 2. Items in GNOTES and QNOTES tables (related to dict table by geoset).

Item	Definition	Desc	Example
1. geoset	15, 15, C	Name of Geo dataSet	bnd_ta
2. note	70, 70, C	A note line	an example note

Table 3. Items in DICT_TABLS table (related to dict table by geoset).

Item	Definition	Desc	Example
1. geoset	15, 15, C	Name of Geo dataSet	bnd_ta
2. table	15, 15, C	Table name	bnd_ta.lut
3. desc	8, 8, C	Description of table	look up values for tas
4. status	40, 40, C	status of the table	complete

Table 4. Items in TABL_ITMS table (related to dict_tabls by table).

Item	Definition	Desc	Example
1. table	20.20.C	Table name	bnd_ta.lut
2. item	20.20.C	Table of the item	id
3. itmdef	8.8.C	Item definition	20.20.C
4. valreq	1.1.C	Value required?	yes/no
5. itmdesc	40.40.C	Item description	thematically unique identifier
6. datadomain	80.80.C	The domain of the values	character/positive real
7. comment	80.80.C	Comment	misc. comment or note

Table 5. Items in the CHGLOG table (related to the dict table by geoset).

Item	Definition	Desc	Example
1. geoset	15.15.C	Name of Geo dataset	t<catg>_<ou/ta>_<obt>
2. reqnum	6.6.I	Request number	10001
3. date	8.10.D	Request date	4/23/96
4 notes_file	15.15.C	location of notes	file
5 source	80.80.C	Source of data	USGS. DGL format
6 source_date	30.30.C	Date the data was developed	September 1987
7 source_proj	30.30.C	Map projection of source file	New Mexico State Plane. NAD87
8 source scale	10.10. I	Original scale of the source data	1:24000
9 media	20.20.C	What type of media are the data on	Electronic spreadsheet
10 m_qual	30.30.C	Quality of the media	Good
11 capture_proj	30.30.C	What projection data were captured in.	New Mexico State Plane. NAD87
12 capture_scale	30.30.C	What scale were the data captured in.	1:24000
13 capture_accu	30.30.C	How accurate was the capture	complete
14 pos_err	20.20.C	Position error	None
15 attr_err	20.20.C	Attribute errors	None
16 assigned	10.10.C	Who is assigned to data	Tom Garrison

Table 6. Items in Rnotes table (related to the chglog table by reqnum).

Item	Definition	Desc	Example
1. reqnum	6.6.I	Request Number	10001
2. note	80.80.C	A note line	imported DLGs

Table 7. A Selected Record from the DICT Table

Dict-id	Geoset	Desc	Restrc	Contac	Catgry	Ocatgry	Theme	Locatn	Type
1	birdobs	Location of informal bird observat-ions	none	David Keller: kellerd@lanl.gov	ECOL	N/A	birdob	/gis/ecol/anim/bird	COVER
Anno	**Topol**	**Aextent**	**Appxmb**	**Map**	**Status**	**Update**	**Flag**		
N/A	point	REGION		N/A	CUR	19960926			

Table 8. A Selected Record from the DICT_TBLS Table

Geoset	Table	Desc	Status
birdobs	birdobs.dat	Attributes associated with bird observations	complete to date

Table 9. A Selected Record from the TABL_ITMS Table

Table	Item	Itmdef	Valreq	Itmdesc	Datadomain	Comment
birdobs.dat	birdobs_id	4, 5, B	Y	thematically a unique identifier	real	

Table 10. TES data base design.

LAYER: VEGETATION

Coverage Name: LandCov Vegetation coverage Created from Landsat GRID Coverage

Feature Class	Table name	Entities	Value Req'd	Data Type	Associated Tables	Description/Values	Comments
Polygon	LandCov.PAT	Area	Y	8, 8, F			
		Perimeter	Y	8, 8, F			
		LandCov#	Y	4, 5, B			
		LandCov-ID	Y	4, 5, B			
		LandCov_ID	Y	6, 6, I		Unique ID for LandCover Polygons	
		LandCov_COD	Y	4, 4, C	Habitat.VVT Habitat.KEY	Alternate Name: Habitat_COD	
Region Subclass	LanCov PATMicro	Area	Y	8, 8, F		Microhabitats, e.g., Riparian	Digitize
		Perimeter	Y	8, 8, F			
		Micro#	Y	4, 5, B			
		Micro ID	Y	4, 5, B			
		Micro_COD	Y	4, 4, C	Micro VVT		
Region Subclass	LanCov PATWet	Area	Y	8, 8, F		Wetlands	Digitize; Create from NWI
		Perimeter	Y	8, 8, F			
		Wet#	Y	4, 5, B			
		Wet ID	Y	4, 5, B			
		Wet COD	Y	4, 4, C	Wet.VVT		
Region Subclass	LanCov PATZone	Area	Y	8, 8, F		Vegetation Zones	Create from underlying Landcover
		Perimeter	Y	8, 8, F			
		Zone#	Y	4, 5, B			
		Zone ID	Y	4, 5, B			
		Zone_COD	Y	4, 4, C	Zone.VVT		
Region Subclass	LandCov PATSoil	Area	Y	8, 8, F		Soils	Use FIMAD Soil Coverage?
		Perimeter	Y	8, 8, F			
		Soil#	Y	4, 5, B			
		Soil ID	Y	4, 5, B			
		Soil COD	Y	4, 4, C	Soil VVT		

Table 10. TES data base design.

LAYER: PLANTS

Coverage Name: VasPlants Vascular Plants

Feature Class	Table name	Entities	Value Req'd	Data Type	Associated Tables	Description/Values	Comments
Point	VasPlants PAT	Area	Y	8, 8, F			Many records in field
		Perimeter	Y	8, 8, F			notes by:
		VasPlants#	Y	4, 5, B			NM State Plane
		VasPlants ID	Y	4, 5, B			Canyon, Mesa Name
		Site_ID	N	10, 10, C	VasSite DAT VasPlants DAT	CODING SCHEME NEEDED FOR TRANSECTS, STATIONS, and SITE LOCATIONS.	TA, GPS, Plot etc.
		OBJ_ID	N	10, 10, C			Terri Fox can verify locations
Line	VasPlants AAT	FNODE#	Y	4, 5, B		Transect Data	
		TNODE#	Y	4, 5, B			
		LPOLY#	Y	4, 5, B			
		RPOLY#	Y	4, 5, B			
		Length	Y	8, 11, F, 3			
		VasPlants#	Y	4, 5, B			
		VasPlants ID	Y	4, 4, B			
		Trans_ID	Y	10, 10, C	VPTrans DAT	Unique Transect ID	
		OBJ_Trans_ID	N	10, 10, C			

Coverage Name: Survey Biological Survey Areas

Polygon	Survey PAT	Area	Y	8, 8, F			Field Notes.
		Perimeter	Y	8, 8, F			
		Survey#	Y	4, 5, B			Terri Fox can verify area locations
		Survey ID	Y	4, 5, B			
		Survey_ID	Y	10, 10, C			
		OBJ_ID	N	10, 10, C			
Region Subclass	Survey PATVasPl	Area	Y	8, 8, F		Vascular Plant Survey	Each type of biological and
		Perimeter	Y	8, 8, F			archaeological survey area
		VasPl#	Y	4, 5, B			could be a subclass
		VasPl ID	Y	4, 5, B			of survey.
		VasPl_ID	N	6, 6, C	VasSurvy DAT		
		OBJ_ID					

Table 10. TES data base design

Data Tables

Feature Class	Table name	Fatitles	Value Req'd	Data Type	Associated Tables	Description Values	Comments
	VasSite DAT	Site_ID	Y	6, 6, C	VasPlants DAT	Basic data from each collection site	Plant field notes and forms
		Date	Y	Date			
		Time	N	5, 5, C			
		Contam_ID	N	10, 10, C	Contam DAT	Contaminant Analysis Sample ID	
		Classifier	N	20, 20, C		Name	
		Elevation	N	5, 5, I			
		Aspect	N	3, 3, C			
		Slope	N	3, 3, I			
		Landform	N	30, 30, C		Basalt, Tuff, Rock Crevices, Cliffs	CODING SCHEME?
		Wood_Type	N	20, 20, C			CODING SCHEME?
		Veg_Summary	N	30, 30, C			
		Site Feature	N	20, 20, C		Mesa, Canyon, Slope of Canyon, Mountain	CODING SCHEME?
		Adj_Com_Plant	N	20, 20, C		burrows, tracks, scat	CODING SCHEME?
		Adj_Com_Animals	N	20, 20, C			CODING SCHEME?
		Animal_Ind	N	20, 20, C			CODING SCHEME?
		Disturbance	N	30, 30, C			CODING SCHEME?
		Threats	N	20, 20, C			CODING SCHEME?
		Future_Pol	N	20, 20, C			
		35MM_No_Roll	N	10, 10, C			
		Photo_Loc	N	10, 10, C		Photo archive location	
		Data_Source	Y	20, 20, C			
	VasPlants DAT	Site_ID	Y	7, 7, I			
		Type_COD	Y	1, 1, C			
		Species_COD	N	4, 4, C	Pspecies VVT Habitat DAT		
		DBH	N	4, 4, I			
		Cover%	N	4, 4, F			
		Height	N	3, 3, I			
		Data_Source	Y	20, 20, C			

Table 10. TES data base design.

Data Tables (cont)

Feature Class	Table name	Fields	Value Req'd	Data Type	Associated Tables	Description/Values	Comments
	VisSurvy.DAT	VisSurvy_ID	Y	6,6,C	VisSvyPl.DAT		Survey forms
		Date	Y	Date			
		TA	N	2,2,I			
		Can_Mess_Name	N	20,20,C			
		Drainage	N	20,20,C		Nearest Drainage	
		Survey_Type	N	10,10,C		Endangered Species, Herbarium etc.	CODING SCHEME?
		Survey_Level	N	10,10,C		Reconnaissance etc.	
		Habitat_COD	N	4,4,C	Habitat.VVT	Habitat (Community)	
		Topography					
		Site_Condition				Disturbed etc.	
		Disturbance					
		Collection #3			Herb.VVT		
		Comments					
		Photographs/Slides					
		Photo_Loc					
		Results					
		Data Source					
	VisSvyPl.DAT	VisSurvy_ID	Y				
		Species_COD	Y	4,4,C	Species.VVT Habitat.DAT		
		Cover	N	4,4,F			
		Canopy_class	N	1,2,I		1=5%, 2=6-25%, 3=26-51% 4=51-75%, 5=76-95%, 6=96-100%	
		Tree_number	N	4,4,I			
		Size_class	N	1,1,I		1=4", 2=4-6", 3=7-8", 4=9-10", 5=10-12", 6=13+"	
		Stage	N				
		Native	N	3,3,C		Yes/No	CODING SCHEME?
		Phenology	N	2,2,C			

Table 10. TES data base design.

Data Tables (cont)

Feature Class	Table name	Entities	Value Req'd	Data Type	Associated Tables	Description/Values	Comments
	VSLayer DAT	VasSurvy_ID	Y				
		LayerNo	Y	1, 1, I		1, 2, 3	
		Trees	N	3, 3, I			
		Shrubs	N	3, 3, I			
		Forbs	N	3, 3, I			
		Grasses	N	3, 3, I			
	VPTrans DAT	Trans_ID	Y	10, 10, C		Overstory Data (calc. from raw data)	
		Location_Name	Y	20, 20, C			
		Species_COD	Y	4, 4, C	Pspecies.VVT HabInd DAT		
		Type	Y	1, 1, C		U=Understory, O=Overstory	
		Nonplant_Cov	N	4, 4, F		Non Plant Cover %	
		Plant_Cov	N	4, 4, F		Plant Cover	
		Recorder	N	20, 20, C		Name	
		Av_DBH	N	4, 4, F		Average DBH	
		Number	N	4, 4, F		Number of Plants/Trees	
		Rel_Denisty	N	4, 4, F			
		Trees_Acre	N	4, 4, F		Trees per acre	
		Cover	N	4, 4, F		percent cover	
		Rel_Cover	N	4, 4, F		percent relative cover	
		Frequency	N	4, 4, F			
		Rel_frequency	N	4, 4, F			
		Import_index	N	4, 4, F		Importance Index	
		Raw_Data_Loc	N	20, 20, C		Location of Raw Data	
	HabInd DAT	Species_COD	Y	4, 4, C	Pspecies.VVT	Habitat Indicator Species	
		Weediness	N	10, 10, C			
		Wetlands_Nat	N	20, 20, C		Facultative, etc.	
		Wetlands_Reg7	N	20, 20, C			
		Other	N	20, 20, C		Disturbance,Flood, Fire, Old Fields, etc.	CODING SCHEME?
		Native_Am_Use	N	10, 10, C		Food, Medicine, etc.	

Table 10. IES data base design.

LAYER: BIRDS

Coverage Name: BirdObs — Bird Observations from 2 sources 1: LANL Bird Census and 2: Informal Observations

Feature Class	Table Name	Entities	Value Req'd	Data Type	Associated Tables	Discriptive/Values	Comments
Point	BirdObs PAT	Area	Y	8, 8, F			
		Perimeter	Y	8, 8, F			
		BirdObs#	Y	4, 5, B			
		BirdObs_ID	Y	4, 5, B			
		BirdObs_ID	Y	7, 7, I			
		Old_Obs_ID	N	10, 10, C		ID Number from historical records	
Line	BirdObs AAT	FNODE#	Y	4, 5, B			
		TNODE#	Y	4, 5, B			
		LPOLY#	Y	4, 5, B			
		RPOLY#	Y	4, 5, B			
		Length	Y	8, 10, F, 3			
		BirdTrans#	Y	4, 5, B			
		BirdTrans_ID	Y	4, 4, B			
		BirdTrans_ID	Y	10, 10, C		User-Defined Transect_ID to Describe Transect	
		Old_Trans_ID	N	10, 10, C		Old Transect ID	

Coverage Name: BirdAtlas — Bird Atlas Compiled from Observations in Grid Blocks

Polygon	BirdAtlas PAT	Area	Y	8, 8, F			
		Perimeter	Y	8, 8, F			
		BirdAtlas#	Y	4, 5, B			
		BirdAtlas_ID	Y	4, 5, B			
		BirdAtlas_ID	Y	3, 3, I			
		Block_No	Y	3, 3, I			

Table 10. TES data base design.

Data Tables

Feature Class	Table Name	Entities	Value Req'd	Data Type	Associated Tables	Discription/Values	Comments
	BirdObs.DAT	BirdObs_ID	Y	4, 5, C			
		Obs_Type	Y	4, 4, C		LANL or INEM	
		Species_COD	Y	4, 4, C	Species_VVT	Species Code	
		Habitat_COD	N	4, 4, C	Habitat_VVT	Habitat Code	
		Number_Obs	Y	2, 2, I		Number of Birds Sighted	
		Land_Own_COD	N	2, 2, C	Land_Own.VVT	Land Ownership	
		Collar_ID	N	15, 15, C		Collar_ID For Future Collaring Programs	
		EMScan_Av	N	3, 3, I		Lean body mass gms from EM Scan (av)	
		Date	Y	Date		Day, Month, Year	
		TA	N	2, 2, I		Technical Area	
		Location_Name	N	20, 20, C		Location Name	
		Sighted_By	N	20, 20, C		Name of person (PUBL or LANL who made observation)	
		Comments	N	128, 128, C		Comments	
		Data_Source	N	20, 20, C			
	BirdTrans.DAT	BirdsTrans_ID	Y	6, 6, I			
		Date	Y	Date			
		Species_COD	Y	4, 4, C	Species_VVT		
		Habitat_COD	Y				
		Number_Obs	Y	2, 2, I		Number of Birds sighted within Specific Radius	
		Rel_Abundance	Y	4, 4, F		Percentage	
		Method	N	20, 20, C		Method	
		Comments	N	128, 128, C			
	BirdAtlas.DAT	Block_No	Y	4, 4, I			
		Species_COD	Y	4, 4, C	ASpecies.VVT		
		Date	Y	Date			
		Breeding_Cat	Y	12, 12, C	Breeding Category		
		Reported_By	Y	20, 20, C	Reporter Name		

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Table 10. TES data base design.

LAYER: INVERTEBRATES

Coverage Name: Inverts Aquatic and Terrestrial Invertebrates

Feature Class	Table name	Entities	Value Req'd	Data Type	Associated Tables	Status	Automation Comments
Point	Inverts PAT	Area					
		Perimeter					
		Inverts#					
		Inverts ID					
		Sample ID					
		OLD_Sample_ID					

Data Tables

	AlSample DAT	Sample_ID	Y	7,7,I		Aquatic Invertebrates by Sample	
		Station_ID	N	10,10,C			
		Date	Y	Date		Day, Month, Year Collected	
		Collector	Y	20,20,C		Name of Collector	
		Dom_Taxa_COD	Y	4,4,I	InFamily_COD	Dominant Taxa (Family) Code	
		Biodiversity	N	4,4,I			
		Location Name	Y	20,20,C		General Location Name	
	AlSpecies DAT	Sample_ID	Y	7,7,I		Aquatic Invertebrates by Species in Sample	
		Family_COD	Y	4,4,C			
		Genus	N	20,20,C			
		Species	N	20,20,C			
		Qual_Rel_Abund	Y	10,10,C		Qualitative Abundance (rare, common, etc.)	Stud Crosswalk to provide codes
		Absolute Abundance	Y	8,18,F,3		Absolute Abundance	
		LifeStage_COD	N	3,3,I	LifeStage.VVT	Pupa, Juvenile, etc.	
		CTQ	N	3,3,I		Community Tolerance Quotient (calculated)	
	TerArtho DAT	Sample_ID	Y	7,7,I		Terrestrial Arthropods	
		Trap_ID	Y	10,10,C			
		Trap_Days_No	N	3,3,I		Number of Trapping Days	
		Date	Y	Date			

Table 10. TES data base design.

Data Tables (cont)

Feature Class	Table name	Fatitles	Value Req'd	Data Type	Associated Tables	Status	Automation Comments
		Habitat_COD	N	4, 4, C	Habitat VVT	Collection Habitat Under Trees and Shrubs	
		Family_COD	Y	4, 4, I	Family VVT		
		Genus	N	20, 20, C			
		Species	N	20, 20, C			
		Abs_Abund	Y	5, 5, I		Absolute Abundance	
		Collector	Y	20, 20, C			
	TerInsect DAT	Sample_ID	Y	7, 7, I			
		Trap_ID	Y	10, 10, C			
		Date	Y	Date			
		Family_COD	Y	4, 4, I	Family VVT		
		Genus	N	20, 20, C			
		Species	N	20, 20, C			
		Abs_Abund	Y	5, 5, I		Absolute Abundance	
		Collector	Y	20, 20, C			
	TerSnail DAT	Sample_ID	Y	7, 7, I		Terrestrial Snails	
		Station_ID	Y	10, 10, C			
		Date	Y	Date			
		Col_Hab_COD	N	4, 4, C	Habitat VVT	Collection Habitat Under Trees and Shrubs	
		Family_COD	Y	4, 4, C	Family VVT		
		Genus	N	20, 20, C			
		Species	N	20, 20, C			
		Collector	N	20, 20, C			
	WatQty DAT	Sample_ID	Y				
		Ph					
		Temp					
		Conductivity					
		DO				Dissolved Oxygen	

Table 10. TES data base design.

LAYER: REPTILES and AMPHIBIANS

Coverage Name: ReptAmph **Vegetation Coverage Created from Landsat GRID Coverage**

Feature Class	Table name	Entities	Value Req'd	Data Type	Associated Tables	Description/Values	Comments
Point	ReptAmph	Area	Y	8, 8, F			
		Perimeter	Y	8, 8, F			
		ReptAmph#	Y	4, 5, B			
		ReptAmph ID	Y	4, 5, B			
		ReptAmph_ID	Y	7, 7, I			
		OLD_ID	N	10, 10, C			

Data Tables

	ReptAmph DAT	ReptAmph_ID	Y	7, 7, I			
		Species_COD	Y	4, 4, C			
		Date	Y	Date			
		Trap_ID	Y	10, 10, C			
		SVL_mm	N	4, 4, I			
		TTL_mm	N	4, 4, I			
		RTL_mm	N	4, 4, I			
		Mass_gms	N	4, 4, I			
		Collector	Y	20, 20, C			
		Transponder_No	N	15, 15, C	Transpond EXP		Link to Transponder Table
		Comments	N	128, 128, C			

LAYER: MAMMALS

Coverage Name: Lmammal **Vegetation Coverage Created from Landsat GRID Coverage**

Feature Class	Table name	Entities	Value req'd	Data Type	Associated Tables	Description/Values	Comments
Point	LMammal PAT	Area	Y	8, 8, F		Large and Medium Mammals	
		Perimeter	Y	8, 8, F			
		LMammal#	Y	4, 5, B			
		LMammal ID	Y	4, 5, B			
		Capture_ID	Y	7, 7, I		Unique ID per Capture	

Table 10. TES data base design.

LAYER: MAMMALS (cont)

Coverage Name: Lmammal — Vegetation Coverage Created from Landsat GRID Coverage

Feature Class	Table name	Entities	Value req'd	Data Type	Associated Tables	Description/Values	Comments
		Mammal_ID	Y	7,7,I		Unique ID per mammal (reused when animal recaptured)	
		OLD_ID	N	10,10,C		OLD ID	
		Species_COD	Y	4,4,C	Species_VVT	Species Type Code	
		Trans_id					
		Status_COD	Y	2,2,I			
		Location_Name	N	40,40,C			

Coverage Name: Smammal — Small Mammals

Point	SMammals PAT	Area	Y	8,8,F		Small Mammals	
		Perimeter	Y	8,8,F			
		SMammal#	Y	4,5,B			
		SMammal ID	Y	4,5,B			
		Capture_ID	Y	7,7,I		Unique ID per Capture	
		Mammal_ID	Y	7,7,I		Unique ID per mammal (reused when animal recaptured)	
		OLD_ID	N	10,10,C		OLD ID	
		Species_COD	Y	4,4,C	Species_VVT	Species Type Code	
		Status_COD	Y	2,2,I			
		Location_Name	Y	20,20,C			

Coverage Name: Elk

Line	Elk AAT	FNODE#	Y	4,5,B			
		TNODE#	Y	4,5,B			
		LPOLY#	Y	4,5,B			
		RPOLY#	Y	4,5,B			
		Length	Y	8,18,F,3			
		ELI#	Y	4,5,B			
		Elk-ID	Y	4,4,B			
		Mammal_ID	Y	7,7,I			
		Capture_ID	Y	7,7,I			

Table 10. TES data base design.

Coverage Name: Elk (cont)

Feature Class	Table name	Fatkles	Value req'd	Data Type	Associated Tables	Description/Values	Comments
Point	Elk PAT	Area					
		Perimeter					
		Elk#					
		Elk-ID					
		Mammal_ID	Y	7,7,I			
		Capture_ID	Y	7,7,I			
Route	Elk RATELK						

Coverage Name: Accident — Accidents Caused by Large Mammals (usually Elk and Deer)

Point	Accident PAT	Area	Y	8,8,F			
		Perimeter	Y	8,8,F			
		Accident#	Y	4,5,B			
		Accident ID	Y	4,5,B			
		Mammal_ID	Y	7,7,I			
		Capture_ID	Y	7,7,I			
		Species_COD	Y	4,4,C	Species VVT		
		Accident_Time	Y	10,10,C			
		Date	Y	DATE			

Coverage Name: Station — Observations from Photo and Scent Stations

Point	Station PAT	Area	Y	8,8,F			
		Perimeter	Y	8,8,F			
		Station#	Y	4,5,B			
		Station ID	Y	4,5,B			
		Station_ID	Y	10,10,C	Station DAT		
		Station_TYPE	Y	2,2,C		PH=Photo, SC=Scent	
		Month	Y	3,3,C			
		Year	Y	4,4,C			
		Photo_Loc	N	30,30,C		Could be path to image	

Table 10. TES data base design.

Data Tables

Feature Class	Table name	Fatickes	Value req'd	Data Type	Associated Tables	Description/Values	Comments
	MamOBS DAT	Mammal_ID	Y			Wildlife Observation Data	
		Land_Own_COD	Y	2, 2, I	Land_Own_VVT	Land Ownership Code	
		Number_Obs	Y	3, 3, I		Number Observed	
		TA	Y	2, 2, I			
		Location_Name	N	20, 20, C			
		Observed_by	N	30, 30, C			
	I.Mammal DAT	Capture_ID	Y	7, 7, I			
		Collar_ID	N	10, 10, C		Can be reused - not unique to an individual	
		Sex	Y	1, 1, C			
		Wght	Y	4, 4, I			
		Hgt/Length	Y	4, 4, F			
		Foot_width	N	4, 4, F			
		Tail_lgth	N	4, 4, F			
		Ear_lgth	N	4, 4, F			
		Foot_lgth	N	4, 4, F			
		Age	Y	2, 2, I			
		Rep_Status	N	10, 10, C		Reproductive Status	
		Fetus_Number	N	2, 2, I		Number of Fetus	
		Fetus_Removed	N	2, 2, I		Fetus removed Yes/No	
		Collect_Stat_COD	Y	2, 2, I	Collect_Stat_VVT	Status of animal at sample collection time	
		Collect_Date	Y	Date		Date of Collection	
		Death_Date	N	Date		Date of Death	
		Trap_Method	N	10, 10, C		Trap Method	
		Capture_Status	Y	1, 1, I		New (1) or Recapture (2, 3, etc.)	
		Museum_ID	N	10, 10, C		Museum/Collection ID Number	
		Contaminant_ID	N	10, 10, C		Sample ID for Contaminant Analysis	
		Comments	N	128, 128, C			
	SMammal DAT	Capture_ID	Y	7, 7, I			
		Collar_ID	N	10, 10, C		Unique for each Individual	
		Sex	Y	1, 1, C			
		Wght	Y	4, 4, I			

Table 10. TFS data base design.

Data Tables (cont)

Feature Class	Table name	Fatieles	Value req'd	Data Type	Associated Tables	Description/Values	Comments
		Hgtl/Lngth	Y	4, 4, F			
		Foot_Wdth	N	4, 4, F			
		Tail_Lgth	N	4, 4, F			
		Ear_Lgth	N	4, 4, F			
		Foot_Lgth	N	4, 4, F			
		Age	Y	2, 2, I			
		FMScan_Av	N	3, 3, I		Lean body mass in grams from Average FM Scan	
		Rep_Status	Y	10, 10, C		Reproductive Status	
		Fetus_Number	N	2, 2, I		Number of Fetus	
		Fetus_Removed	N	2, 2, I		Fetus removed Yes/No	
		Collect_Stat_COD	Y	2, 2, I	Collect_Stat_VVT	Status of animal at sample collection time	
		Collect_Date	Y	Date		Date of Collection	
		Death_Date	N	Date		Date of Death	
		Trap_Method	N	10, 10, C			
		Capture_Status	Y	1, 1, I		New (1) or Recapture (2, 3, etc)	
		Museum_ID	N	10, 10, C		Museum/Collection Code Number	
		Contaminant_ID	N	10, 10, C		Sample ID for Contaminant Analysis	
		Comments	N	128, 128, C			
	MDisease DAT	Capture_ID	Y	7, 7, I			
		Disease_COD	Y		Disease_VVT	Diseases Tested	
		Result	Y	3, 3, C		Result (pos/neg)	
		Date	Y	Date		Date Tested	
		Sample_COD	Y		Sample_VVT	Sample Type Code	
	Parasite_DAT	Capture_ID	Y	7, 7, I			
		Parasite_COD	Y		Parasite_VVT	Parasite Codes	
	FoodHab DAT	Cature_ID	Y	7, 7, I			
		Sample_COD	Y		Sample_VVT	Food Matter Sample COD	
		Method	Y			Analysis Method	
		Food_General	Y			General Food Category	
		Food_Genus	N				

Table 10. TES data base design.

Data Tables (cont)

Feature Class	Table name	Entries	Value req'd	Data Type	Associated Tables	Description/Values	Comments
		Food_Spec	N				
		Slide_Numbr	N			Slide Number for Food Analysis	
		Comments	N				
	FoodRaw DAT	Slide_Numbr				Slide Number of Analysis Performed from Slide	
		Field_1				Relative Abundance by Field	
		Field_2				Relative Abundance by Field	
		Field_3				Relative Abundance by Field	
		Field_4				Relative Abundance by Field	
		Field_5				Relative Abundance by Field	
		Field_6				Relative Abundance by Field	
		Field_7				Relative Abundance by Field	
		Field_8				Relative Abundance by Field	
		Field_9				Relative Abundance by Field	
		Field_10				Relative Abundance by Field	
		Rel_Abund_Total				Relative Abundance from Entire Sample	
		Raw_Data_Loc				Raw Data Location (Path, Name, etc)	
	Deposition DAT	Capture_ID					
		Location				Location(s) of Storage	
		Storage Type					
		Comments					

Table 10. TES data base design.

Data Tables (cont)

Feature Class	Table name	Fatleies	Value req'd	Data Type	Associated Tables	Description/Values	Comments
	Eli_ColDAT	Capture_ID	Y	7, 7, I			
		Collar_ID	Y	7, 7, I			
		Collar_TYPE	Y	4, 4, C		VHF, GPS	
		Frequency	Y				
		Serial_Number	Y				
	Eli_Radio DAT	Capture_ID	Y	7, 7, I		Data from Radio on Collar	
		Day	Y	3, 3, I			
		Time_GMT	Y	4, 4, C			
		Year	Y	4, 4, I			
		Lat	Y				
		Lon	Y				
	Station DAT	Station_ID	Y	10, 10, C			
		Creature_Obs	Y	15, 15, C			
		Number_Obs	Y	3, 3, I			
		Size	N	2, 2, C		SM = sm. mammal, MM = med. mammal, LM = large mammal	

Data Tables

	T_E_Spec DAT	Species COD	Y	4, 4, C			
		Type	Y	10, 10, C			
		Group	N	10, 10, C			
		Family_COD	Y	4, 4, C			
		Class	Y	20, 20, C			
		FedState	N	20, 20, C			
		Distribution	Y	20, 20, C			
		Threats	N	30, 30, C			
		Requires	N	30, 30, C			
		Breed_Habitat	N	20, 20, C			
		Min_Elev	N	5, 5, I			
		Max_Elev	N	5, 5, I			
		LACounty	N	3, 3, C		yes/no	
		LAReference	N	50, 50, C			
		Reference	N	50, 50, C			
		KeyDesc	N	128, 128, C			
		Location_Name	N	20, 20, C			
		Comments	N	128, 128, C			

Table 10. TES data base design.

Data Tables (cont)

Feature Class	Table name	Entities	Value req'd	Data Type	Associated Tables	Description/Values	Comments
	Museum DAT	Museum_COD	Y				
		Location	Y				
		Date	Y				
		Habitat					
	Legal_Stat DAT	Species_COD	Y				
		Legal_Stat_COD	Y				
		Legal_Stat	Y				
		Date	Y			Date Legal Status Established	
		Comments					
	Contam DAT	Contaminant_ID	Y			Analysis ID Number	
		Sample_Type	Y			Fish, Overstory, Carcass, etc.	
		Species_COD	Y				
		Source_COD	Y			Source type Animal, Plant, Sediment etc.	
		CAS_NO	Y			Pb, Hg, etc. (Link to FIMAD Contaminant DB Table)	FIMAD
		Concentration	Y				
		Conc_Unit	Y			PPM, PPB, etc.	
		Analysis_Method	Y				

Key Tables

	HiHabitat KEY	HiStat_COD	Y	4, 4, C		Status of the Flora of the LA Nat Env Res Park	
		Species_COD	Y	4, 4, C		LA-6050 NERP, Vol II	
	AllHabitat KEY	Habitat_COD	Y	4, 4, C		Various Sources	
		Species_COD	Y	4, 4, C			

Table 10. TES data base design.

VVT, LUT Tables

Feature Class	Table name	Entieles	Value req'd	Data Type	Associated Tatles	Description/Values	Comments
	Habitat VVT	Habitat_COD	Y	4, 4, C			
		Habitat_Desc	Y	20, 20, C			
	ASpecies.VVT	Species_COD	Y	4, 4, C			
		Family_Name	Y	30, 30, C			
		Scient_Name	Y	30, 30, C			
		Common_Name	Y	30, 30, C			
		Alt_Common_Name	Y	30, 30, C			
	PSpecies VVT	Species_COD	Y	4, 4, C		Status of the Flora of the LA Nat Lnv Res Pa:A	
		Family_Name	Y	30, 30, C		LA8050 NERP, Vol II	
		Scient_Name	Y	30, 30, C			
		Synonym_1	N	30, 30, C			
		Synonym_2	N	30, 30, C			
		Synonym_3	N	30, 30, C			
		Elev_Min	Y	5, 5, I			
		Elev_Max	Y	5, 5, I			
		Occurrence	Y	20, 20, C			
		Blooms	Y	20, 20, C			
		Habit	Y	30, 30, C			
		Common_Name	Y	30, 30, C			
		Alt_Common_Name	N	30, 30, C			

Table 11. Naming conventioin of ecological data within the GIS data base.

Type of File	Description	File Name	File Extension	Example
Data Table	Contains attribute data only	Same name as the coverage the table relates to	.dat	BirdObs.dat
Look-up Table	Contains an attribute value and an associated symbol code	Same name as the coverage the table relates to	.lut	BirdObs.lut
Expansion Table	contains definitions of codes used in other tables	Same name as the coverage the table relates to	.exp	BirdObs.exp

Table 12. An example of an electronic field data form for vegetation transects.
Note: The GIS data table attribute requirements are listed at the bottom of this table

DATE:	06/16/92
Location:	THREEMILE CANYON
Reader/Recorder:	JAMES/KATHY/ALETHEA/MARY
NUMBER OF FEET PER TRANSECT:	450

			Qtr. 1	1			Qtr. 2	1			Qtr. 3	1			Qtr. 4	1
Plot #50	Species	No. Stems Shrubs	DBH Trees	% Cover	Species	No. Stems Shrubs	DBH Trees	% Cover	Species	No. Stems Shrubs	DBH Trees	% Cover	Species	No. Stems Shrubs	DBH Trees	% Cover
	PIPO	0	0	0.1	JUMO	1	3	10	PIPO	1	15.7	40	RONE	12	1.2	5
	ACNE	0	0	25	JUMO	1	2		PIPO	1	15.7		FONE	31	31.5	25
					JUMO	1	0.5		PIPO	1	15.7		QUGA	0	0	0.1
					ACNE	1	1.5	35	PIPO	1	6.7		JUSC	1	3	0.5
					ACNE	1	2.2		JUSC	1	0.5	5	JUSC	1	2.5	
					ACNE	1	2.5		FONE	25	2.5	15	JUSC	1	0.5	
					ACNE	1	3.1		RONE	9	0.9	5	RICE	12	1.2	0.5
					ACNE	1	1.5									
					ACNE	1	0.5									
					FONE	14	1.4	15								
					JUSC	1	1.5	5								
					SALX	4	0.4	5								
					BETE	5	0.5	0.1								
			Qtr. 1	1			Qtr. 2	1			Qtr. 3	1			Qtr. 4	1
Plot #50	Species	No. Stems Shrubs	DBH Trees	% Cover	Species	No. Stems Shrubs	DBH Trees	% Cover	Species	No. Stems Shrubs	DBH Trees	% Cover	Species	No. Stems Shrubs	DBH Trees	% Cover
	POPX	1	10.3	60	JUSC	1	8.3	30	RONE	9	0.9	15	FONE	11	1.1	5
	POPX	1	11.3		JUSC	1	1		RHTR	77	7.7	15	RHTR	20	2	5

Required Fields and Required Order of the GIS Data base

1.Trans_id	2.Location	3.Read_record	4.Trans_date	5.Ft_per_trans	6.Type
7.Scode	8.Nonplant_cov	9.Plant_cov	10.T_s_no	11.T_s_acre	12.Avg_dth
13.Rel_density	14.Rel_cov	15.Per_freq	16.Rel_freq	17.Impt_index	18.Comments

Table 13. The AML written for data automatioin of overstory vegetation transects. TAC.AML.

```
/*-----------------------------------------------
/*        Environmental Systems Research Institute
/*-----------------------------------------------
/*  Program: TAC.AML
/*  Purpose: Reads data from xxxC.TXT text file and loads into VEG_TRLN.DAT
/*-----------------------------------------------
/*    Usage: tac.aml <in_file>
/*
/* Arguments: in_file       - the name of the ascii text file to load
/*
/*
/*  Routines: ERRROR    - Handles any errors that may occur.
/*            WARN      - Handles any warnings that may occur.
/*
/*  Globals: none
/*-----------------------------------------------
/*    Calls: none
/*-----------------------------------------------
/*    Notes: The <in_file> needs to be in the following format:
/* line  1: skip - no data needed from this line
/* line  2: LOCATION (contained in single quotes)
/* line  3: TRANS_ID (contained in single quotes)
/* line  4: TRANS_DATE (contained in single quotes) ie: '06/23/96'
/* line  5: READ_RECORD (contained in single quotes)
/* line  6: FT_PER_TRANS (no quotes, must be numeric)
/* line  7: COMMENTS (contained in single quotes)
/* line  8: blank line
/* lines 9 to the next blank line: contain data in the following format:
/*   'SCODE', T_S_NO, T_S_ACRE, REL_DENSITY, AVG_DBH, PLANT_COV, REL_COV, (con't)
/*   PER_FREQ, REL_FREQ, IMPT_INDEX
/* line  x: at least one blank line
/* line  x+1 to the end of file: contain data in the following format:
/*   'SCODE', T_S_NO, T_S_ACRE, REL_DENSITY, PLANT_COV, REL_COV, (con't)
/*   PER_FREQ, REL_FREQ, IMPT_INDEX
/*
/*-----------------------------------------------
/*    Input: ascii data file with above format
/*   Output: records added to VEG_TRLN.DAT
/*-----------------------------------------------
/*  History: Andy Huntington (ESRI) - 7/31/96 - original coding
/*
/*-----------------------------------------------------------------------
/*

&severity &error &routine error
&severity &warning &routine warn

&args in_file

/* set the info_file to receive the data
```

```
&set info_file veg_trln.dat

/* Do some error checking

&if [null %in_file%] &then &do
  &type Usage: tac.aml <in_file>
  &return
&end

&if ^ [exists %in_file% -file] &then &do
  &type <in_file> %in_file% does not exist.  Exiting...
  &type Usage: tac.aml <in_file>
  &return
&end


/* Open file and check status

&set fileunit [open %in_file% openstat -r]
&if %openstat% ne 0 &then
  &return &error Error opening <in_file> for reading.  Exiting...


/* Initialize count variable to count number of records added
&set number_added 0


/* Read the universal data that applies to all records in file

/* Record 1.  Contains only header information.
&set record [read %fileunit% readstat]

/* Record 2 contains LOCATION item value
&set record [read %fileunit% readstat]
&set location [unquote %record%]

/* Record 3 contains TRANS_ID item value
&set record [read %fileunit% readstat]
&set trans_id [unquote %record%]

/* Record 4 contains TRANS_DATE item value
&set record [read %fileunit% readstat]
&set trans_date [unquote %record%]

/* Record 5 contains READ_RECORD item value
&set record [read %fileunit% readstat]
&set read_record [unquote %record%]

/* Record 6 contains FT_PER_TRANS item value
&set record [read %fileunit% readstat]
&set ft_per_trans [unquote %record%]

/* Record 7 contains COMMENTS item value
```

```
&set record [read %fileunit% readstat]
&set comments [unquote %record%]

/* Record 8 contains a blank line - do nothing with it
&set record [read %fileunit% readstat]


/* NONPLANT_COV and TYPE item values are not included in the file.

/* Universally set the value of NONPLANT_COV to be blank.
&set nonplant_cov 0


/* Record 9 until the blank section contains multiple data for each record.
/* Add the data to the INFO file using CURSORS.  Other option would be to write
/* out the data to an ascii file in the correct format, and then use ADD FROM
/* in INFO or TABLES.

/* First, declare and open a cursor on the INFO file
cursor tempcur declare %info_file% info rw
cursor tempcur open

/* postion cursor to last record in file if have more than 0 records
/* (want to add data to end of file instead of top)

&if %:tempcur.amlSnsel% gt 0 &then
 cursor tempcur %:tempcur.amlSnsel%

/* Read record 9 to the first blank line (end of first section), or to end of
/* file, whichever comes first, and parse data into variables.

/* move to record 9
&set record [read %fileunit% readstat]

&do &until %readstat% = 102 or %record% = ''

 /* set variables for each element in the line

 &set record [unquote %record%]

 &set scode [unquote [extract 1 %record%]]
 &set t_s_no [extract 2 %record%]
 &set t_s_acre [extract 3 %record%]
 &set rel_density [extract 4 %record%]
 &set avg_dbh [extract 5 %record%]
 &set plant_cov [extract 6 %record%]
 &set rel_cov [extract 7 %record%]
 &set per_freq [extract 8 %record%]
 &set rel_freq [extract 9 %record%]
 &set impt_index [extract 10 %record%]

 /* for top section, set TYPE to T
 &set type T
```

```
/* if any of the above variables for the numeric items contain blanks,
/* change them to "0" (zero)

 &do var &list t_s_no t_s_acre rel_density avg_dbh plant_cov rel_cov per_freq -
rel_freq impt_index
   &if [quote [unquote [value %var%]]] = '' &then
     &set %var% = 0
 &end

/* Now that the variables are set, add a record to the INFO file and
/* set the cursor variables.  Also, count up number of records added.

 cursor tempcur insert
 &set number_added = %number_added% + 1

 &do item &list trans_id location read_record trans_date ft_per_trans type -
comments scode nonplant_cov plant_cov t_s_no t_s_acre avg_dbh rel_density -
rel_cov per_freq rel_freq impt_index
   &set :tempcur.%item% [value %item%]
 &end

/* delete the above record specific variables
 &do var &list scode t_s_no t_s_acre rel_density avg_dbh plant_cov rel_cov -
per_freq rel_freq impt_index record
   &dv %var%
 &end

 &set record [read %fileunit% readstat]
 &type %readstat%

/* end the "do until " loop"
&end


/* Skip the section of blank records

&do &while %record% = '' and %readstat% ne 102
 &set record [read %fileunit% readstat]
&end


/* Now should be positioned at first record for the second section.  The same
/* proceedure as above will be used for this section, but the order of the values
/* is different, so it needs unique code.

/* AVG_DBH values are not included in the second section of the data file.
/* Insert a place holder for this value
&set avg_dbh = 0

/* read until the end of file or a blank line is reached.
&do &unul %readstat% = 102 or %record% = ''
```

```
/* set variables for each element in the line
&set record [unquote %record%]


&set scode [unquote [extract 1 %record%]]
&set t_s_no [extract 2 %record%]
&set t_s_acre [extract 3 %record%]
&set rel_density [extract 4 %record%]
&set plant_cov [extract 5 %record%]
&set rel_cov [extract 6 %record%]
&set per_freq [extract 7 %record%]
&set rel_freq [extract 8 %record%]
&set impt_index [extract 9 %record%]

/* for top section, set TYPE to S
&set type S

/* if any of the above variables for the numeric items contain blanks,
/* change them to "0" (zero)

&do var &list t_s_no t_s_acre rel_density plant_cov rel_cov per_freq -
rel_freq impt_index
  &if [quote [unquote [value %var%]]] = '' &then
    &set %var% = 0
&end

/* Now that the variables are set, add a record to the INFO file and
/* set the cursor variables.  Also, count up number of records added.

cursor tempcur insert
&set number_added = %number_added% + 1


&do item &list trans_id location read_record trans_date ft_per_trans type -
comments scode nonplant_cov plant_cov t_s_no t_s_acre avg_dbh rel_density -
rel_cov per_freq rel_freq impt_index
  &set :tempcur.%item% [value %item%]
&end

/* delete the above record specific variables
&do var &list scode t_s_no t_s_acre rel_density plant_cov rel_cov -
per_freq rel_freq impt_index record
  &dv %var%
&end

&set record [read %fileunit% readstat]

/* end the "do until " loop"
&end


/* clean up
```

```
/* close the in_file
&set closestat [close -all]

/* close and remove the cursor
cursor tempcur remove

/* report number of records added to INFO file
&type
&type Total number of records added to %info_file%:  %number_added%
&type

/* end of aml...
&return


/* error routine
&routine error
&severity &error &fail
&type An error has occurred in TAC.AML...
&type Please check the input file carefully for correct format.
&set closevar [close -all]
&if [quote [extract 2 [show cursor tempcur]]] = 'OPEN' &then
  cursor tempcur remove
&type
&type Total number of records added to %info_file%:  %number_added%
&type
&type *** Please check records in %info_file% carefully. ***
&type *** Invalid data might have been added. ***
&type
&return &error Terminating program TAC.AML.


/* warning routine
&routine warn
&severity &warning &ignore
&type A warning condition occurred.
&return
```

Table 14. The AML written for data automatioin of understory vegetation transects. TAC.AML.

```
/*-----------------------------------------------------------
/*          Environmental Systems Research Institute
/*-----------------------------------------------------------
/*  Program: TAU.AML
/*  Purpose: Reads data from xxxU.TXT text file and loads into VEG_TRLN.DAT
/*-----------------------------------------------------------
/*    Usage: tau.aml <in_file>
/*
/* Arguments: in_file   - the name of the ascii text file to load
/*
/*
/*  Routines: ERRROR    - Handles any errors that may occur.
/*            WARN      - Handles any warnings that may occur.
/*
/*  Globals: none
/*-----------------------------------------------------------
/*    Calls: none
/*-----------------------------------------------------------
/*    Notes: The <in_file> needs to be in the following format:
/* line  1: skip - no data needed from this line
/* line  2: LOCATION (contained in single quotes)
/* line  3: TRANS_ID (contained in single quotes)
/* line  4: TRANS_DATE (contained in single quotes) ie: '06/23/96'
/* line  5: READ_RECORD (contained in single quotes)
/* line  6: FT_PER_TRANS (no quotes, must be numeric)
/* line  7: COMMENTS (contained in single quotes)
/* line  8: blank line
/* lines 9 to the end of file: contain data in the following format:
/*   'SCODE', NONPLANT_COV, PLANT_COV, REL_COV, PER_FREQ, REL_FREQ, IMPT_INDEX
/*
/*-----------------------------------------------------------
/*    Input: ascii data file with above format
/*   Output: records added to VEG_TRLN.DAT
/*-----------------------------------------------------------
/*  History: Andy Huntington (ESRI) - 7/31/96 - original coding
/*
/*-----------------------------------------------------------
/*

&args in_file

&severity &error &routine error
&severity &warning &routine warn

/* set the info_file to receive the data
&set info_file veg_trln.dat

/* Do some error checking
```

```
&if [null %in_file%] &then &do
  &type Usage: tau.aml <in_file>
  &return
&end

&if ^ [exists %in_file% -file] &then &do
  &type <in_file> %in_file% does not exist.  Exiting...
  &type Usage: tau.aml <in_file>
  &return
&end


/* Open file and check status

&set fileunit [open %in_file% openstat -r]
&if %openstat% ne 0 &then
  &return &error Error opening <in_file> for reading.  Exiting...


/* Initialize count variable to count number of records added
&set number_added 0


/* Read the universal data that applies to all records in file

/* Record 1.  Contains only header information.
&set record [read %fileunit% readstat]

/* Record 2 contains LOCATION item value
&set record [read %fileunit% readstat]
&set location [unquote %record%]

/* Record 3 contains TRANS_ID item value
&set record [read %fileunit% readstat]
&set trans_id [unquote %record%]

/* Record 4 contains TRANS_DATE item value
&set record [read %fileunit% readstat]
&set trans_date [unquote %record%]

/* Record 5 contains READ_RECORD item value
&set record [read %fileunit% readstat]
&set read_record [unquote %record%]

/* Record 6 contains FT_PER_TRANS item value
&set record [read %fileunit% readstat]
&set ft_per_trans [unquote %record%]

/* Record 7 contains COMMENTS item value
&set record [read %fileunit% readstat]
&set comments [unquote %record%]
```

```
/* Record 8 contains a blank line - do nothing with it
&set record [read %fileunit% readstat]


/* TYPE, T_S_NO, T_S_ACRE, AVG_DBH, REL_DENSITY item values are not included
/* in the file.  Set them universally.

&set t_s_no 0
&set t_s_acre 0
&set avg_dbh 0
&set rel_density 0

/* For this file (TAxxxU.TXT), set TYPE to U
&set type U


/* Record 9 until the blank section contains multiple data for each record.
/* Add the data to the INFO file using CURSORS.  Other option would be to write
/* out the data to an ascii file in the correct format and then use ADD FROM
/* in INFO or TABLES.

/* First, declare and open a cursor on the INFO file:
cursor tempcur declare %info_file% info rw
cursor tempcur open

/* postion cursor to last record in file if have more than 0 records
/* (want to add data to end of file instead of top)

&if %:tempcur.am!$nsel% gt 0 &then
 cursor tempcur %:tempcur.am!$nsel%

/* Read record 9 to the first blank line or end of file,
/* and parse data into variables.

/* move to record 9
&set record [read %fileunit% readstat]

&do &until %record% = '' or %readstat% = 102

 &set record [unquote %record%]

 /* set variables for each element in the line

 &set scode [extract 1 %record%]
 &set nonplant_cov [extract 2 %record%]
 &set plant_cov [extract 3 %record%]
 &set rel_cov [extract 4 %record%]
 &set per_freq [extract 5 %record%]
 &set rel_freq [extract 6 %record%]
 &set impt_index [extract 7 %record%]

 /* if any of the above variables for the numeric items contain blanks,
 /* change them to "0" (zero)
```

```
&do var &list nonplant_cov plant_cov rel_cov  per_freq rel_freq impt_index
  &if [quote [unquote [value %var%]]] = '' &then
    &set %var% = 0
&end

/* Now that the variables are set, add a record to the INFO file and
/* set the cursor variables

cursor tempcur insert
&set number_added = %number_added% + 1

&do item &list trans_id location read_record trans_date ft_per_trans type ~
comments scode nonplant_cov plant_cov t_s_no t_s_acre avg_dbh rel_density ~
rel_cov per_freq rel_freq impt_index
  &set :tempcur.%item% [unquote [value %item%]]
&end

/* delete the above record specific variables
&do var &list scode nonplant_cov plant_cov rel_cov per_freq rel_freq ~
impt_index record
  &dv %var%
&end

&set record [read %fileunit% readstat]

/* end the "do until " loop"
&end


/* clean up

/* close the in_file
&set closestat [close -all]

/* close and remove the cursor
cursor tempcur remove

/* report number of records added to INFO file
&type
&type Total number of records added to %info_file%:  %number_added%
&type

/* end of aml...
&return
```

```
/* error routine
&routine error
&severity &error &fail
&type An error has occurred in TAU.AML...
&type Please check the input file carefully for correct format.
&set closevar [close -all]
&if [quote [extract 2 [show cursor tempcur]]] = 'OPEN' &then
  cursor tempcur remove
&type
&type Total number of records added to %info_file%:  %number_added%
&type
&type *** Please check records in %info_file% carefully. ***
&type *** Invalid data might have been added. ***
&type
&return &error Terminating program TAU.AML...


/* warning routine
&routine warn
&severity &warning &ignore
&type A warning condition occurred.
&return
```

Table 15. The AML written for data automation of one file type of bird census data. A.aml.

```
/*-----------------------------------------------------
/*          Environmental Systems Research Institute
/*-----------------------------------------------------
/*  Program: A.AML
/*  Purpose: Reads data from UP-LA-95.XLS.CSV text file and loads into
/*           BIRDCENC.DAT INFO file.
/*-----------------------------------------------------
/*    Usage: a.aml <in_file>
/*
/* Arguments: in_file       - the name of the ascii text file to load
/*
/*
/*  Routines: ERRROR    - Handles any errors that may occur.
/*            WARN      - Handles any warnings that may occur.
/*
/*  Globals: none
/*-----------------------------------------------------
/*    Calls: none
/*-----------------------------------------------------
/*    Notes: The <in_file> needs to be in the following format:
/* line  1: LOCATION:,<location>,TEMP...
/* line  2: OBSERVERS:,<observers>,WIND...
/* line  3: DATE:,<date>,TIME...
/* line  4: blank
/* line  5: blank
/* line  6: header information - no data needed
/* line  7: header information - no data needed
/* lines 8 to the end of file contain data in the following format:
/*   <point:time:day>,<habitat>,<species>,<0-25>,<25-50>,<50-75>, (con't)
/*   <75-100>,<age>,<sex>,<breeding>,...
/*
/*-----------------------------------------------------
/*    Input: ascii data file with above format
/*   Output: records added to BIRDCENC.DAT
/*-----------------------------------------------------
/*  History: Andy Huntington (ESRI) - 8/2/96 - original coding
/*
/*=====================================================
/*

&severity &error &routine error
&severity &warning &routine warn

&args in_file

/* set the info_file to receive the data
&set info_file BIRDCENS.DAT

/* Do some error checking
```

```
&if [null %in_file%] &then &do
  &type Usage: a.aml <in_file>
  &return
&end

&if ^ [exists %in_file% -file] &then &do
  &type <in_file> %in_file% does not exist.  Exiting...
  &type Usage: a.aml <in_file>
  &return
&end


/* Open file and check status

&set fileunit [open %in_file% openstat -r]
&if %openstat% ne 0 &then
  &return &error Error opening <in_file> for reading.  Exiting...


/* Initialize count variable to count number of records added
&set number_added 0


/* Read the universal data that applies to all records in file

/* OLD_TRANS_ID is set to <in_file>
&set old_trans_id %in_file%

/* This file does not contain information for r25-100.  Initialize
/* to be 0.
&set r25-100 0

/* Record 1.  Contains LOCATION item value
&set record [read %fileunit% readstat]
&set location [unquote [after [before %record% ,TEMP] LOCATION:,]]

/* Record 2 contains OBSERVER item value
&set record [read %fileunit% readstat]
&set recorder [after [before [quote %record%] ,WIND] OBSERVERS:,]

/* Record 3 contains DATE item value
&set record [read %fileunit% readstat]
&set date [extract 2 [unquote %record%]]

/* Skip next four records
&set record [read %fileunit% readstat]
&set record [read %fileunit% readstat]
&set record [read %fileunit% readstat]
&set record [read %fileunit% readstat]

/* Record 8 until the end of file contains data for each record.
/* Add the data to the INFO file using CURSORS.  Other option would be to write
```

```
/* out the data to an ascii file in the correct format, and then use ADD FROM
/* in INFO or TABLES.

/* First, declare and open a cursor on the INFO file
cursor tempcur declare %info_file% info rw
cursor tempcur open

/* postion cursor to last record in file if have more than 0 records
/* (want to add data to end of file instead of top)

&if %:tempcur.amlSnsel% gt 0 &then
  cursor tempcur %:tempcur.amlSnsel%

/* Read record 8 to the end of file, and parse data into variables.

/* move to record 8
&set record [read %fileunit% readstat]

&do &until %readstat% = 102 or %record% = ''

  &set record [unquote %record%]

  /* check for new point.  If new point, then set variables for point and habitat.
  /* For new points, the format is slightly different since extract on data without
  /* leading commas produces different results

  &if [quote [extract 1 %record%]] cn ':' or [quote [extract 1 %record%]] cn '-' -
or [quote [extract 1 %record%]] cn '/' &then &do
    &set point [extract 1 %record%]
    &set habitat [extract 2 %record%]
    &set spp_code [extract 3 %record%]
    &set r0-25 [extract 4 %record%]
    &set r25-50 [extract 5 %record%]
    &set r50-75 [extract 6 %record%]
    &set r75-100 [extract 7 %record%]
    &set age [extract 8 %record%]
    &set sex [extract 9 %record%]
    &set breeding [extract 10 %record%]
    /* set point_id to be combination of location and point variables
    &set point_id %location% %point%
  &end

  &else &do
    /* set other values for each element
    &set spp_code [extract 1 %record%]
    &set r0-25 [extract 2 %record%]
    &set r25-50 [extract 3 %record%]
    &set r50-75 [extract 4 %record%]
    &set r75-100 [extract 5 %record%]
    &set age [extract 6 %record%]
    &set sex [extract 7 %record%]
    &set breeding [extract 8 %record%]
  &end
```

```
/* if any of the above variables for the numeric items contain blanks,
/* change them to "0" (zero)

&do var &list r0-25 r25-50 r50-75 r75-100
  &if [quote [unquote [value %var%]]] = '' &then
    &set %var% = 0
&end

/* Now that the variables are set, add a record to the INFO file and
/* set the cursor variables.  Also, count up number of records added.

cursor tempcur insert
&set number_added = %number_added% + 1

&do item &list point_id date habitat spp_code r0-25 r25-50 r50-75 -
r75-100 r25-100 age sex breeding recorder old_trans_id
  &set :tempcur.%item% [value %item%]
&end

/* delete the above record specific variables
&do var &list spp_code r0-25 r25-50 r50-75 r75-100 age sex breeding
  &dv %var%
&end

&set record [read %fileunit% readstat]
&type %readstat%

/* end the "do until " loop"
&end


/* clean up

/* close the in_file
&set closestat [close -all]

/* close and remove the cursor
cursor tempcur remove

/* report number of records added to INFO file
&type
&type Total number of records added to %info_file%:  %number_added%
&type

/* end of aml...
&return
```

```
/* error routine
&routine error
&severity &error &fail
&type An error has occurred in A.AML...
&type Please check the input file carefully for correct format.
&set closevar [close -all]
&if [quote [extract 2 [show cursor tempcur]]] = 'OPEN' &then
  cursor tempcur remove
&type
&type Total number of records added to %info_file%:  %number_added%
&type
&type *** Please check records in %info_file% carefully. ***
&type *** Invalid data might have been added. ***
&type
&return &error Terminating program A.AML.



/* warning routine
&routine warn
&severity &warning &ignore
&type A warning condition occurred.
&return
```

Table 16. The AML written for data automation on a second file type of bird census data, B.aml.

```
/*-----------------------------------------------------------
/*          Environmental Systems Research Institute
/*-----------------------------------------------------------
/*  Program: A.AML
/*  Purpose: Reads data from UP-LA-95.XLS.CSV text file and loads into
/*           BIRDCENC.DAT INFO file.
/*-----------------------------------------------------------
/*    Usage: a.aml <in_file>
/*
/* Arguments: in_file       - the name of the ascii text file to load
/*
/*
/*  Routines: ERRROR        - Handles any errors that may occur.
/*            WARN          - Handles any warnings that may occur.
/*
/*  Globals: none
/*-----------------------------------------------------------
/*    Calls: none
/*-----------------------------------------------------------
/*    Notes: The <in_file> needs to be in the following format:
/* line  1: LOCATION:,<location>,TEMP...
/* line  2: OBSERVERS:,<observers>,WIND...
/* line  3: DATE:,<date>,TIME...
/* line  4: blank
/* line  5: blank
/* line  6: header information - no data needed
/* line  7: header information - no data needed
/* lines 8 to the end of file contain data in the following format:
/*   <point:time:day>,<habitat>,<species>,<0-25>,<25-50>,<50-75>, (con't)
/*   <75-100>,<age>,<sex>,<breeding>....
/*
/*-----------------------------------------------------------
/*    Input: ascii data file with above format
/*   Output: records added to BIRDCENC.DAT
/*-----------------------------------------------------------
/*  History: Andy Huntington (ESRI) - 8/2/96 - original coding
/*
/*-----------------------------------------------------------

&severity &error &routine error
&severity &warning &routine warn

&args in_file

/* set the info_file to receive the data
&set info_file BIRDCENS.DAT

/* Do some error checking
```

```
&if [null %in_file%] &then &do
  &type Usage: a.aml <in_file>
  &return
&end

&if ^ [exists %in_file% -file] &then &do
  &type <in_file> %in_file% does not exist.  Exiting...
  &type Usage: a.aml <in_file>
  &return
&end


/* Open file and check status

&set fileunit [open %in_file% openstat -r]
&if %openstat% ne 0 &then
  &return &error Error opening <in_file> for reading.  Exiting...


/* Initialize count variable to count number of records added
&set number_added 0


/* Read the universal data that applies to all records in file

/* OLD_TRANS_ID is set to <in_file>
&set old_trans_id %in_file%

/* This file does not contain information for r25-100.  Initialize
/* to be 0.
&set r25-100 0

/* Record 1.  Contains LOCATION item value
&set record [read %fileunit% readstat]
&set location [unquote [after [before %record% ,TEMP] LOCATION:,]]

/* Record 2 contains OBSERVER item value
&set record [read %fileunit% readstat]
&set recorder [after [before [quote %record%] ,WIND] OBSERVERS:,]

/* Record 3 contains DATE item value
&set record [read %fileunit% readstat]
&set date [extract 2 [unquote %record%]]

/* Skip next four records
&set record [read %fileunit% readstat]
&set record [read %fileunit% readstat]
&set record [read %fileunit% readstat]
&set record [read %fileunit% readstat]

/* Record 8 until the end of file contains data for each record.
/* Add the data to the INFO file using CURSORS.  Other option would be to write
```

```
/* out the data to an ascii file in the correct format, and then use ADD FROM
/* in INFO or TABLES.

/* First, declare and open a cursor on the INFO file
cursor tempcur declare %info_file% info rw
cursor tempcur open

/* postion cursor to last record in file if have more than 0 records
/* (want to add data to end of file instead of top)

&if %:tempcur.amlSnsel% gt 0 &then
 cursor tempcur %:tempcur.amlSnsel%

/* Read record 8 to the end of file, and parse data into variables.

/* move to record 8
&set record [read %fileunit% readstat]

&do &until %readstat% = 102 or %record% = ''

 &set record [unquote %record%]

 /* check for new point.  If new point, then set variables for point and habitat.
 /* For new points, the format is slightly different since extract on data without
 /* leading commas produces different results

 &if [quote [extract 1 %record%]] cn ':' or [quote [extract 1 %record%]] cn '-' -
or [quote [extract 1 %record%]] cn '/' &then &do
   &set point [extract 1 %record%]
   &set habitat [extract 2 %record%]
   &set spp_code [extract 3 %record%]
   &set r0-25 [extract 4 %record%]
   &set r25-50 [extract 5 %record%]
   &set r50-75 [extract 6 %record%]
   &set r75-100 [extract 7 %record%]
   &set age [extract 8 %record%]
   &set sex [extract 9 %record%]
   &set breeding [extract 10 %record%]
   /* set point_id to be combination of location and point variables
   &set point_id %location% %point%
 &end

 &else &do
  /* set other values for each element
  &set spp_code [extract 1 %record%]
  &set r0-25 [extract 2 %record%]
  &set r25-50 [extract 3 %record%]
  &set r50-75 [extract 4 %record%]
  &set r75-100 [extract 5 %record%]
  &set age [extract 6 %record%]
  &set sex [extract 7 %record%]
  &set breeding [extract 8 %record%]
 &end
```

```
/* if any of the above variables for the numeric items contain blanks,
/* change them to "0" (zero)

&do var &list r0-25 r25-50 r50-75 r75-100
  &if [quote [unquote [value %var%]]] = '' &then
    &set %var% = 0
&end

/* Now that the variables are set, add a record to the INFO file and
/* set the cursor variables.  Also, count up number of records added.

cursor tempcur insert
&set number_added = %number_added% + 1

 &do item &list point_id date habitat spp_code r0-25 r25-50 r50-75 ~
r75-100 r25-100 age sex breeding recorder old_trans_id
   &set :tempcur.%item% [value %item%]
 &end

 /* delete the above record specific variables
 &do var &list spp_code r0-25 r25-50 r50-75 r75-100 age sex breeding
   &dv %var%
 &end

 &set record [read %fileunit% readstat]
 &type %readstat%

/* end the "do until " loop"
&end


/* clean up

/* close the in_file
&set closestat [close -all]

/* close and remove the cursor
cursor tempcur remove

/* report number of records added to INFO file
&type
&type Total number of records added to %info_file%:  %number_added%
&type

/* end of aml...
&return
```

```
/* error routine
&routine error
&severity &error &fail
&type An error has occurred in A.AML...
&type Please check the input file carefully for correct format.
&set closevar [close -all]
&if [quote [extract 2 [show cursor tempcur]]] = 'OPEN' &then
  cursor tempcur remove
&type
&type Total number of records added to %info_file%:  %number_added%
&type
&type *** Please check records in %info_file% carefully. ***
&type *** Invalid data might have been added. ***
&type
&return &error Terminating program A.AML.



/* warning routine
&routine warn
&severity &warning &ignore
&type A warning condition occurred.
&return
```

Table 17. Status of major data sets.

Dataset Name	Contents	Status	Type of Data	Number of Records or Locations
PLANT				
Veg_trln.aat	Vegetation Transects	90% of known transect locations are in the TES data base.	Coverage	> 100
Veg_trln.dat	Attribute data associated with vegetation transects.	75 % of known transect attribute data are in an INFO table	Data Attributes	> 2,000
Herbarium.dat/pat	Locational data and attribute data related to the LANL Herbarium collection.	Manual data entry is 75% complete. Import to INFO needed. Spatial coverage needs to be developed after data entry is complete.	Coverage Data Attributes	600
NPDESwet.pat Frijpoly.pat Whitepoly.pat Guajepoly.pat Puyepoly.pat Frijnwi.aat Whitenwi.aat Guajenwi.aat Puyenwi.aat	Loactional data of wetlands.	Wetlands reside in 9 coverages. Will reduce to 1 coverage.	Coverage	600
Plant.exp	Expansion table with definition of plant codes.	In an INFO table.	Expansion Table	1072
ANIMAL				
Inverts.pat	Locational data related to invertebrate studies conducted at LANL.	All terrestrial insect study locations are in ARC/INFO. 25% of the aquatic invertebrate locations are in.	Coverage	25
TerInsect.dat	Attribute data asseiated with terrestrial insect studies. Coverage is inverts.pat	All terrestrial insect data have been import to an INFO table	Data Attributes	1558
Aispecies.dat	Attribute data associated with aquatic invertebrates. Location data stored in Inverts.pat	25% of the data attribute information are in an INFO table. Data for studies conducted in Guaje and Los Alamos Canyons are completely imported.	Data Attributes	~ 500
Birdobs.pat	Locational data associated with informal bird surveys.	100 % of locational data are in an ARC/INFO coverage	Coverage	52
Birdobs.dat	Attribute data associated with the bird observations.	100 % of data attributes have been imported to the INFO table	Data Attributes	2161

Table 17 (cont.)

Dataset Name	Contents	Status	Type of Data	No. of Records or Locations
smmamal.pat	Locational data asociated with small mammal surveys.	100 % of the locational data are in an ARC/INFO coverage.	Coverage	25
smmammal.dat	Data attribute information associated with small mammal studies.	All data from 1990 through 1995 have been imported in to the INFO table.	Data attributes	2067
contam.dat	Contaminant data attributes associated with ecological studies.	Small mammal and plant contaminant data from 1994 and 1995 have been imported into an INFO table.	Data attributes	717
mammalobs.pat	Locational data associated with informal surveys and formal surveys involving large and medium-sized mammals.	100 % of the locational data are in an ARC/INFO coverage.	Coverage	96
mammalobs.dat	Data attribute information associated with informal observations of large and medium-sized mammals.	100% of the collected data are in an INFO table.	Data attributes	263
lgmammal.dat	Data attributes associated with formal studies of large mammals.	100 % of the 1995 data attributes have been imported into an INFO file.	Data attributes	8
elk.pat	Locational data associated with LANL's GPS elk tracking study.	All data from April through August have been imported to an ARC/INFO coverage	Coverage	633
accident.pat	Locational data associated with traffic accidents involving animals	All data through 1994 have been imported into an ARC/INFO coverage.	Coverage	114
TAE				
TESbirds.pat	Locational data associated with sensitive bird habitat	Habitat locations for 4 bird species have been developed.	Coverage	18
MISC				
Projectsum.pat	Locational data associated with proposed projects.	Data entered weekly as projects are reviewed.	Coverage	150
Projectsum.dat	Attribute data for proposed projects. Coverage is Projectsum.pat	Dat entered weekly as projects are reviewed.	Data attributes	140

Tables 18 through 25

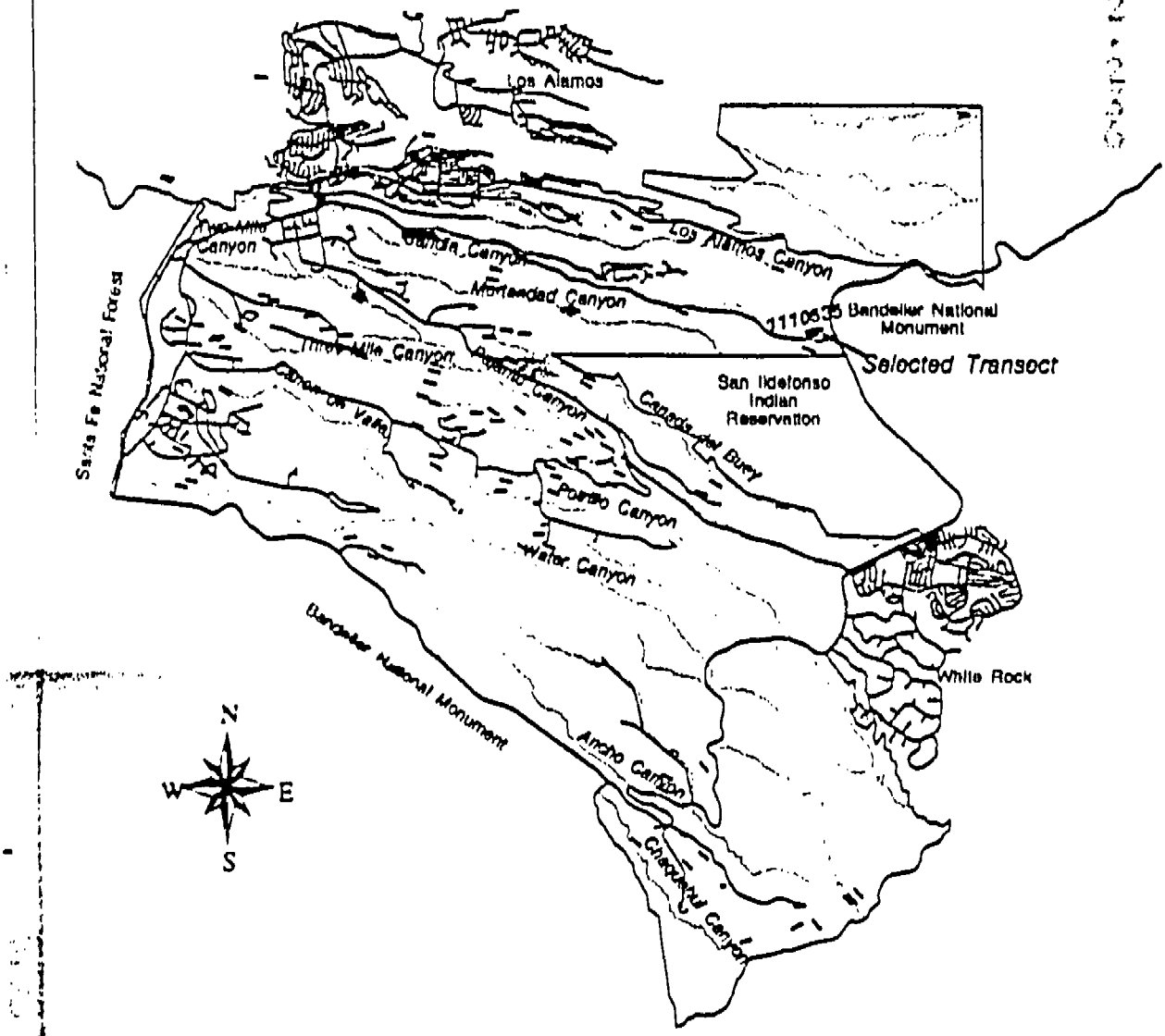
have been inserted behind

the Map they reference.

Map 1: Vegetation Transects

Selected Transect Shown with Id Number

(See next page for attribute information)



Legend

- Selected Transect
- Vegetation Transects
- LANL
- Paved Roads
- Drainages

1:72679

2 0 2 4 6 8 10 12 Kilometers

2 0 2 4 6 8 Miles

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BIOLOGY TEAM, ESH-20 ECOLOGY GROUP

PREPARED SEPTEMBER, 1995

Table 18. Attribute Data for vegetation Transect 1110535

Trans_id	Location	Read_record	Trans_date	Ft_per_trans	Type	Scode	Nonplant_cov	Plant_cov
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	SOIL	32.49	0
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	ROCK	0.14	0
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	LITTER	46.67	0
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	CRUST	1.29	0
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	BOGR	0	5.14
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	ARDR	0	3.29
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	SPCR	0	2.5
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	MEAL	0	1.49
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	AGAL	0	0.01
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	BRTE	0	3.04
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	ARCA	0	0.26
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	CHNA	0	0.86
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	STCO	0	0.07
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	CRJA	0	0.07
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	ARFR	0	0.36
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	BADI	0	0.16
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	VETH	0	0.01
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	GRTR	0	0.14
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	ARLU	0	0.07
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	ANPA	0	0.01
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	IPAG	0	0.04
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	LOWR	0	0.21
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	ERCA	0	0.29
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	OENX	0	0.23
1110535	LOWER SANDIA	TIM HAARMANN/DEBBIE RISBERG	19930602	700	U	POAX	0	0.43

Location of transect 1110535 is shown on Map 1.

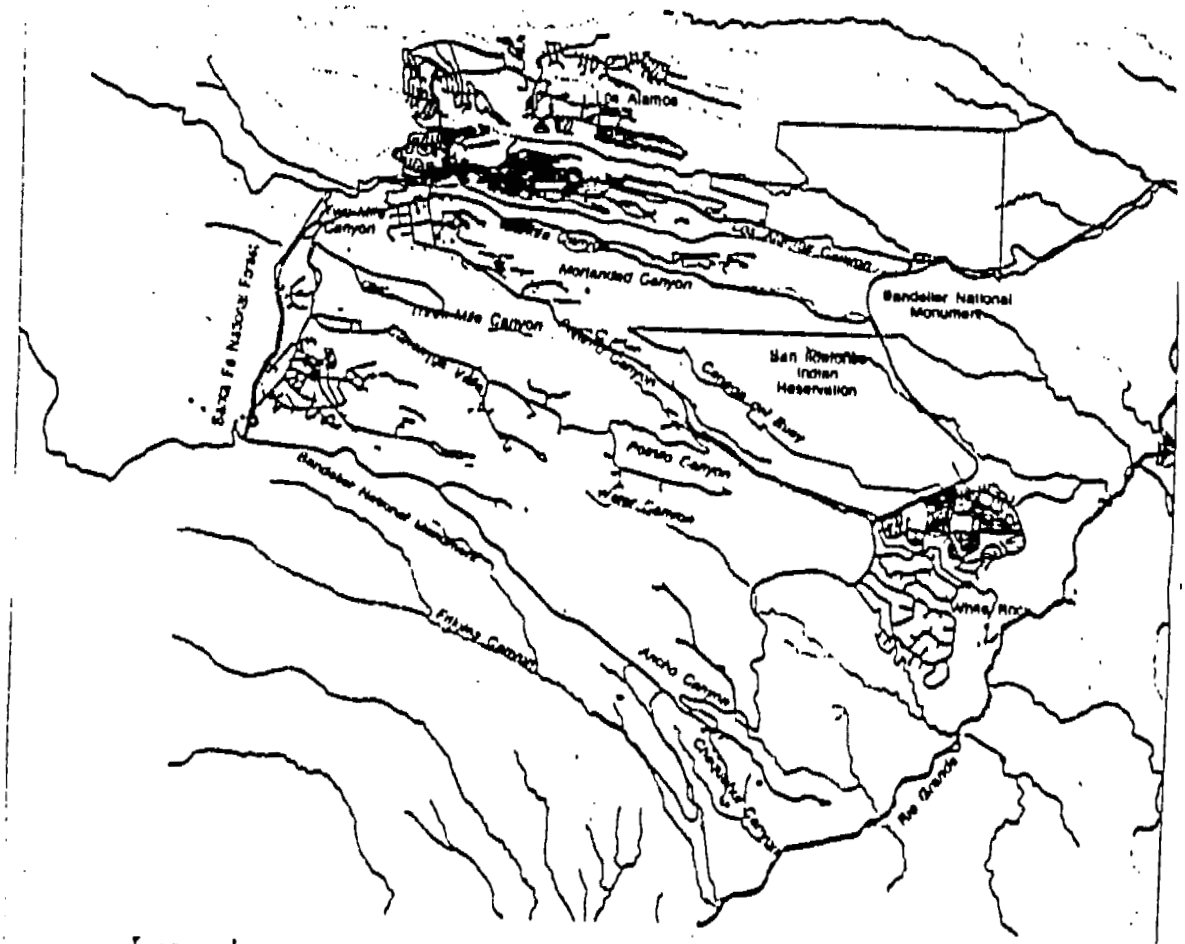
Table 18. Attribute Data for vegetation Transect 1110535

T_s_no	T_s_acre	Avg_dbh	Rel_density	Rel_cov	Per_freq	Rel_freq	Impt_index	Comments
0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	
0	0	0	0	6.25	0.03	1.79	4.02	
0	0	0	0	24.99	0.27	16.96	20.98	
0	0	0	0	15.97	0.16	9.82	12.89	
0	0	0	0	12.15	0.11	7.14	9.65	
0	0	0	0	7.22	0.21	13.39	10.31	
0	0	0	0	0.07	0.01	0.89	0.48	
0	0	0	0	14.79	0.2	12.5	13.64	
0	0	0	0	1.26	0.11	7.14	4.2	
0	0	0	0	4.17	0.03	1.79	2.98	
0	0	0	0	0.35	0.01	0.89	0.62	
0	0	0	0	0.35	0.01	0.89	0.62	
0	0	0	0	1.74	0.01	0.89	1.31	
0	0	0	0	0.77	0.06	3.57	2.17	
0	0	0	0	0.07	0.01	0.89	0.48	
0	0	0	0	0.69	0.03	1.79	1.24	
0	0	0	0	0.35	0.01	0.89	0.62	
0	0	0	0	0.07	0.01	0.89	0.48	
0	0	0	0	0.22	0.06	3.57	1.89	
0	0	0	0	1.04	0.03	1.79	1.41	
0	0	0	0	1.39	0.03	1.79	1.59	
0	0	0	0	1.11	0.04	2.68	1.89	
0	0	0	0	2.08	0.04	2.68	2.38	

Location of transect 1110535 is shown on Map 1.

Map 2: Wetlands

Map contains NWI wetlands and wetlands mapped during LANL biology surveys



Legend

- Wetlands
- LANL
- Paved Roads
- Drainages

1:86174

3.1 0 3.1 6.2 9.3 12.4 Kilometers

2.1 0 2.1 4.2 6.3 8.4 Miles

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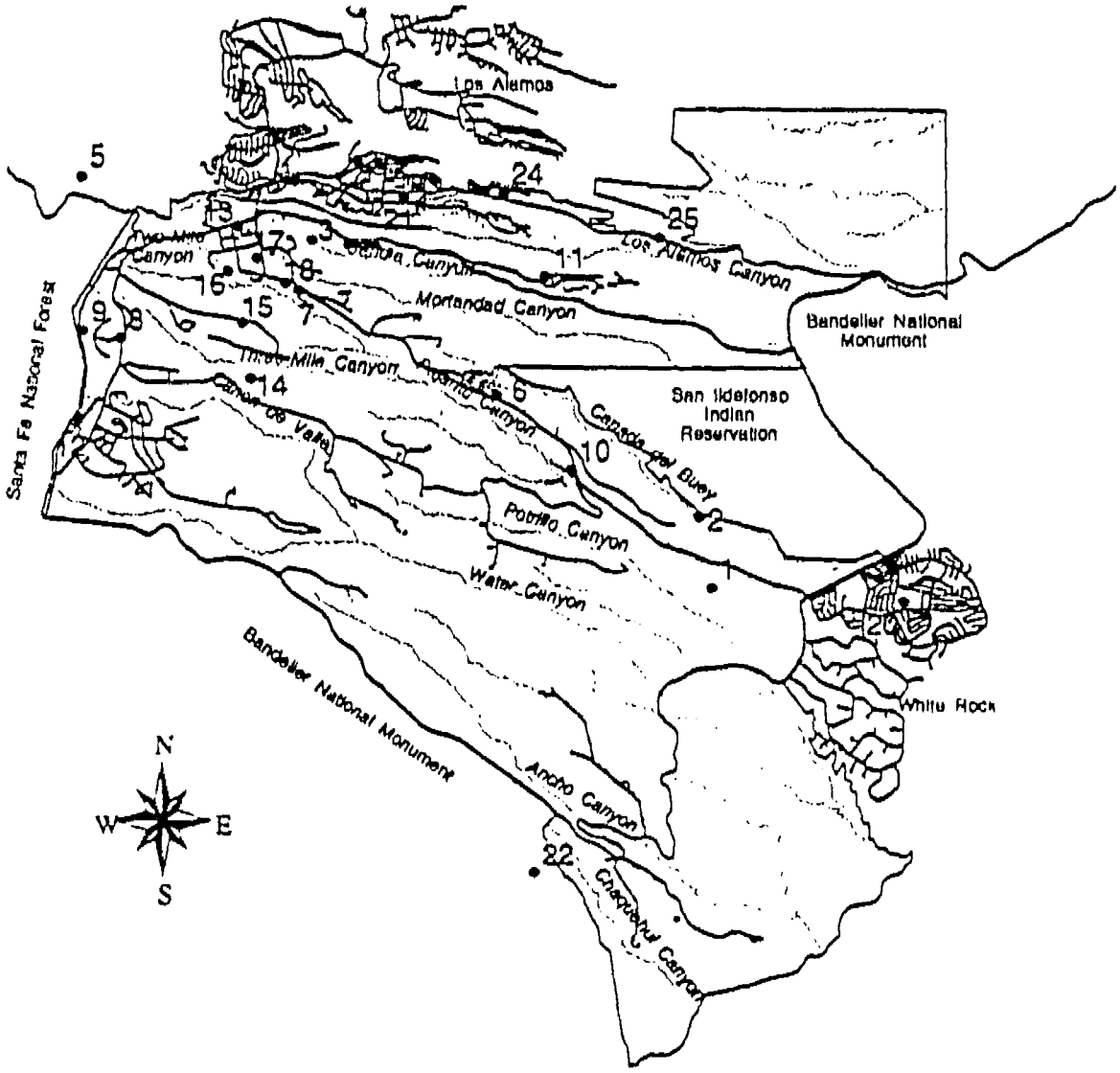
PREPARED SEPTEMBER, 1996

N
W E
S

Map 3: Insect Observations

Locations Shown with Loc_no Number

(See next page for observation attribute information)



Legend

- Insect Observations
- LANL
- Paved Roads
- Drainages

1:72679

2 0 2 4 6 8 10 12 Kilometers

2 0 2 4 6 8 Miles

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BIOLOGY TEAM, ESH-20 ECOLOGY GROUP
PREPARED: SEPTEMBER, 1996

Table 19. Insect Observations
(Selected records from inverts.dat table.)

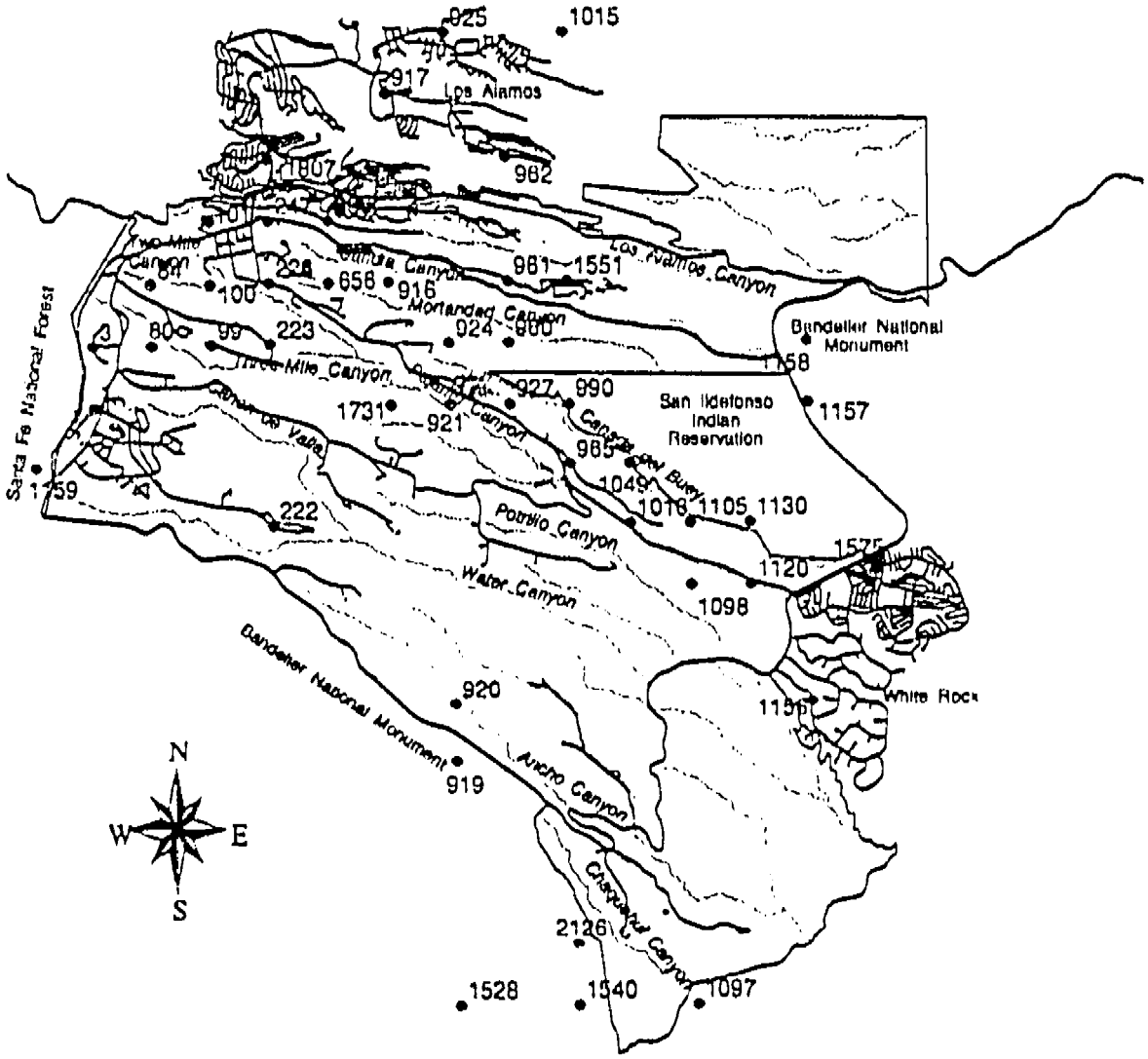
loc_no	Sample_id	Trap_id	Family	Genus	Abs_abund	Location	Date	Collector	Identifer
3		0	Aeshnidae	Aeschna multicolor	1	Sandia Canyon	19900818	T. Haarmann	Flint
1		0	Aeshnidae		1	Pajarito Wetlands	19920624	T. Haarmann	
13		0	Aeshnidae		1	TA-3 Otowi Bldg.	19930701	D. Yeamans	
1		0	Aeshnidae		1	Pajarito Wetlands	19920605	T. Haarmann	
12		0	Aeshnidae		1	TA-16 Pond	19920714	T. Haarmann	
1		0	Libellulidae		1	Pajarito Wetlands	19920624	T. Haarmann	
1		0	Libellulidae	Libellula quadrimacu	1	Pajarito Wetlands	19900609	T. Haarmann	Flint
1		0	Libellulidae		1	Pajarito Wetlands	19920605	T. Haarmann	
1		0	Libellulidae		1	Pajarito Wetlands	19920605	T. Haarmann	
9		0	Libellulidae		1	TA-8 Ice Pond	19940709	T. Haarmann	
1		0	Libellulidae		1	Pajarito Wetlands	19920706	T. Haarmann	
1		0	Libellulidae		1	Pajarito Wetlands	19930614	T. Haarmann	
3		0	Gomphidae	Ophiogomphus severus	1	Sandia Canyon	19900710	T. Haarmann	
13		0	Gomphidae		1	TA-3 Otowi Bldg.	19930701	D. Yeamans	
3		0	Coenagrionidae	Argia vivida	1	Sandia Canyon	19900801	T. Haarmann	Flint
8		0	Coenagrionidae	Argia vivida	1	TA-8	19900808	T. Haarmann	Flint
3		0	Coenagrionidae	Argia vivida	1	Sandia Canyon	19900801	T. Haarmann	Flint
3		0	Coenagrionidae	Argia vivida	1	Sandia Canyon	19900801	T. Haarmann	Flint
1		0	Coenagrionidae		1	Pajarito Wetlands	19920629	T. Haarmann	
1		0	Coenagrionidae		1	Pajarito Wetlands	19920629	T. Haarmann	
1		0	Coenagrionidae		1	Pajarito Wetlands	19920605	T. Haarmann	
1		0	Coenagrionidae		1	Pajarito Wetlands	19920605	T. Haarmann	
1		0	Coenagrionidae		1	Pajarito Wetlands	19920605	T. Haarmann	
1		0	Coenagrionidae		1	Pajarito Wetlands	19920605	T. Haarmann	
1		0	Coenagrionidae		1	Pajarito Wetlands	19930625	T. Haarmann	
2		0	Gryllacrididae	Stenopelmatus fuscus	1	Canada del Buey	19900712	T. Haarmann	
2		0	Gryllacrididae		1	Canada del Buey	19900712	T. Haarmann	
1		0	Gryllacrididae		1	Pajarito Wetlands	19900608	T. Haarmann	W. Mackay
2		0	Gryllacrididae		1	Canada del Buey	19920603	T. Haarmann	
1		0	Gryllacrididae		1	Pajarito Wetlands	19900801	T. Haarmann	
1		0	Gryllacrididae	Stenopelmatus fuscus	1	Pajarito Wetlands	19900608	T. Haarmann	
1		0	Gryllacrididae		1	Pajarito Wetlands	19920621	T. Haarmann	
1		0	Gryllacrididae		1	Pajarito Wetlands	19900807	T. Haarmann	
1		0	Gryllidae	Ceuthophilus pallidu	1	Pajarito Wetlands	19900808	T. Haarmann	T. Haarmann

Previous page shows observation location by loc_no number.

Map 4: Bird Observations

Locations Shown with Birdobs-id Number

(See next page for observation attribute information)



Legend

- Bird Observations
- LANL
- Paved Roads
- Drainages

1:75429

3 0 3 6 9 12 Kilometers

2 0 2 4 6 8 Miles

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BIOLOGY TEAM, ESH-20 ECOLOGY GROUP

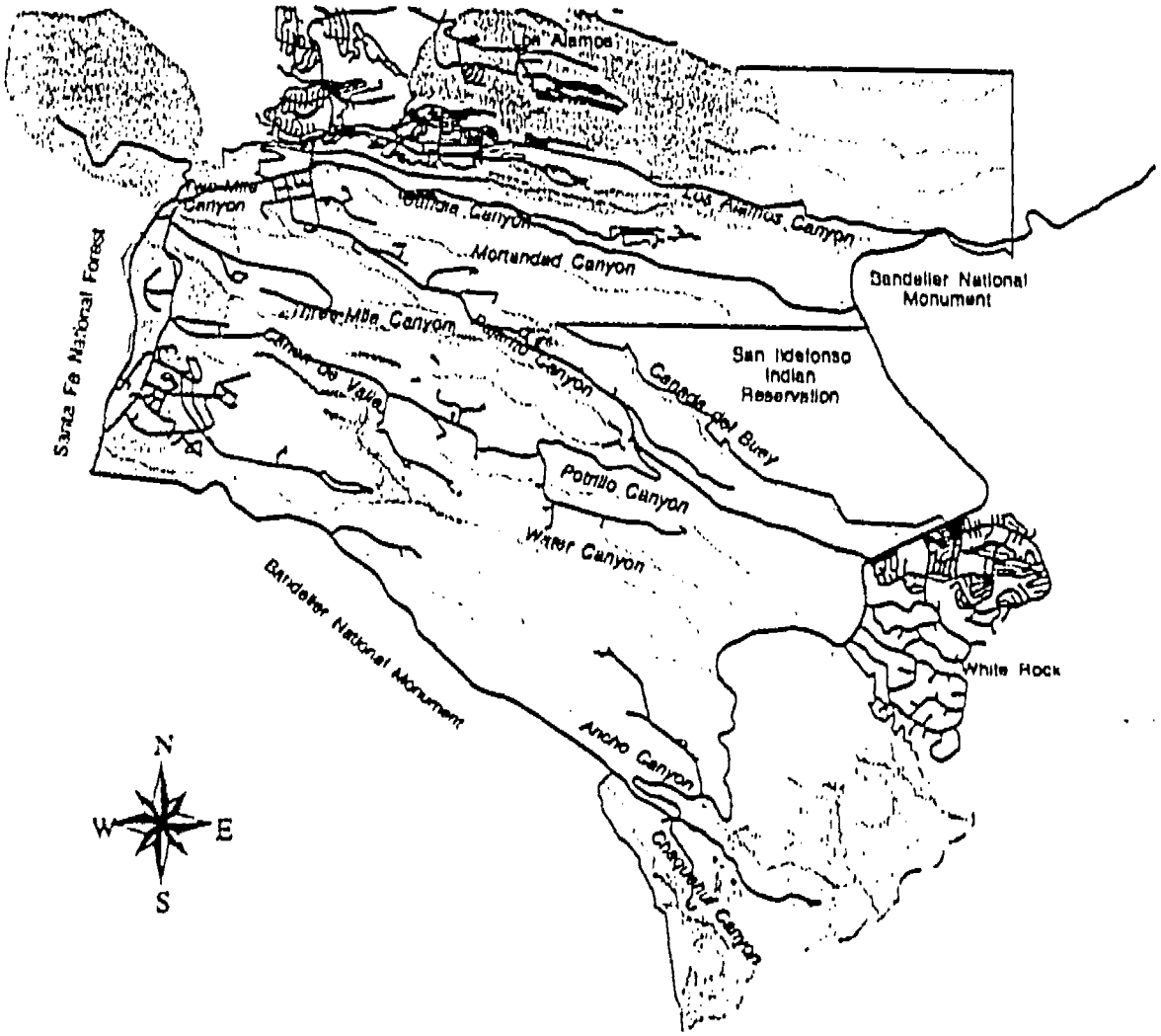
PREPARED: SEPTEMBER, 1996

Table 20. Bird Observations
(Selected records from birdobs.dat table.)

Birdobs-id	Code	Month	Day	Year	Land	Ta	Numobs	Status	Vegtype
1	COCO	10	2	1991	L	3	1	1	410
1	PIPI	10	17	1991	L	16	1	1	225
3	COAU	8	21	1991	L	8	1	1	410
3	SIPY	8	21	1991	L	8	1	1	410
3	CYSI	8	21	1991	L	8	1	1	410
3	MELE	10	22	1991	L	8	1	1	240
3	CAGU	10	22	1991	L	8	1	1	210
3	FASP	6	28	1991	L	8	1	1	999
3	COAU	6	28	1991	L	8	1	1	999
3	SASA	6	28	1991	L	8	1	1	140
3	BUJA	2	25	1991	L	8	1	1	240
3	BUJA	2	26	1991	L	8	1	1	240
3	BUJA	2	27	1991	L	8	1	1	240
3	CYST	2	28	1991	L	8	1	1	420
3	FASP	3	5	1991	L	8	1	1	240
3	FASP	3	6	1991	L	8	1	1	240
3	FASP	3	15	1991	L	8	1	1	240
3	FASP	3	21	1991	L	8	1	1	240
3	NUCO	4	2	1991	L	8	1	1	240
3	SICU	4	5	1991	L	8	1	1	240
3	SASA	4	8	1991	L	8	1	1	240
3	COAU	4	25	1991	L	8	1	1	240
3	BUJA	4	25	1991	L	8	1	1	240
3	FASP	4	25	1991	L	8	1	1	240
3	COAU	4	29	1991	L	8	1	1	420
3	PIVI	4	29	1991	L	8	1	1	420
3	TUMI	4	29	1991	L	8	1	1	420
3	JUHY	4	29	1991	L	8	1	1	420
3	PAGA	4	29	1991	L	8	1	1	420
3	SICU	4	30	1991	L	8	1	1	240
3	SIME	4	30	1991	L	8	1	1	240
3	LOCU	5	1	1991	L	8	1	1	420
3	PIER	5	1	1991	L	8	1	1	420
3	SICU	5	1	1991	L	8	1	1	240
3	CYST	5	1	1991	L	8	1	1	420
3	FASP	5	3	1991	L	8	1	1	140
3	FASP	5	7	1991	L	8	1	1	140
3	FASP	5	8	1991	L	8	1	1	140
3	PILU	5	9	1991	L	8	1	1	0
3	PILU	5	10	1991	L	8	1	1	260
3	SIPY	5	10	1991	L	8	1	1	410
3	TUMI	5	10	1991	L	8	1	1	410
3	DECO	5	10	1991	L	8	1	1	410
3	SPPA	5	10	1991	L	8	1	1	260
3	COAU	5	10	1991	L	8	1	1	410
3	TRAE	5	10	1991	L	8	1	1	410
3	BUJA	5	13	1991	L	8	1	1	140
3	COCO	5	13	1991	L	8	1	1	140

Previous page shows observation location by Birdobs-id number

Map 5: Identified Potential Habitat for Sensitive Bird Species



Legend

Potential Habitat	Paved Roads
LANL	Drainages

1:73589

3 0 3 6 9 12 Kilometers

2 0 2 4 6 8 Miles

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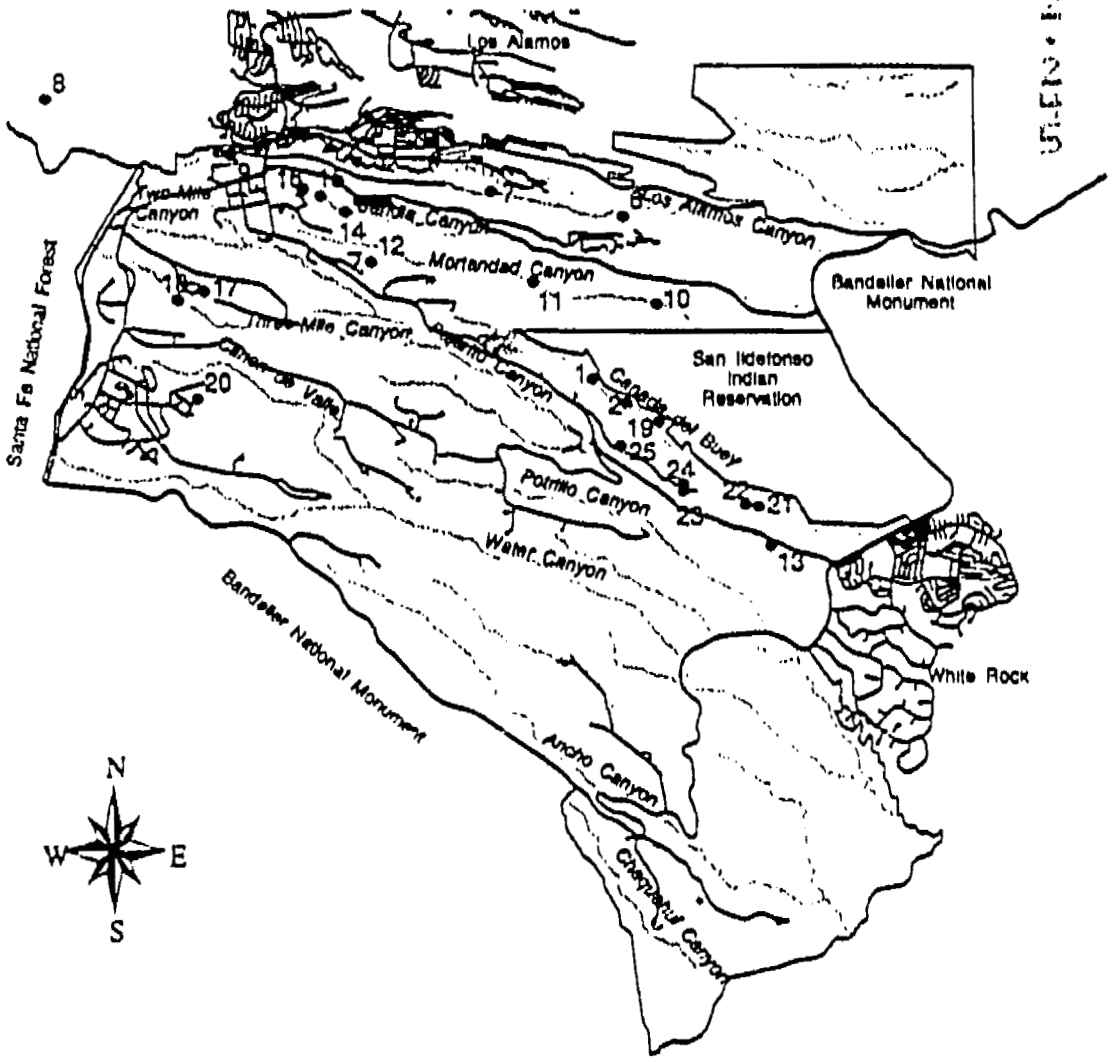
PREPARED: SEPTEMBER, 1996

Map 6: Locations of Small Mammal Studies

Locations Shown with Site_id Number

(See next page for small mammal attribute information)



Legend

• Study Locations	Paved Roads
LANL	Drainages

1:73589

3 0 3 6 9 12 Kilometers

2 0 2 4 6 8 Miles

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BIOLOGY TEAM, ESH-20 ECOLOGY GROUP

PREPARED: SEPTEMBER, 1996

Table 21. Small Mammal Data
(Selected records from smmam.dat table.)

Trap_date	Mortality_cod	Mortality_date	Site_id	Contam_id	Capture_id	Mammal_id	Museum_id	Location	Sublocation
34507	1	34507	22	24	1807	1807	0	TA54	N/A
34507	1	34507	22	24	1805	1805	0	TA54	N/A
34507	1	34507	22	24	1808	1808	0	TA54	N/A
34507	1	34507	22	24	1803	1803	0	TA54	N/A
34507	1	34507	22	24	1809	1809	0	TA54	N/A
34507	1	34507	22	24	1806	1806	0	TA54	N/A
34507	1	34507	22	24	1801	1801	0	TA54	N/A
34507	1	34507	22	24	1802	1802	0	TA54	N/A
34507	1	34507	22	23	1792	1792	0	TA54	N/A
34507	1	34507	22	23	1798	1798	0	TA54	N/A
34507	1	34507	22	23	1797	1797	0	TA54	N/A
34507	1	34507	22	23	1800	1800	0	TA54	N/A
34507	1	34507	22	23	1794	1794	0	TA54	N/A
34507	1	34507	22	23	1796	1796	0	TA54	N/A
34507	1	34507	22	23	1795	1795	0	TA54	N/A
34507	1	34507	22	23	1799	1799	0	TA54	N/A
34507	1	34507	22	22	1789	1789	0	TA54	N/A
34507	1	34507	22	22	1790	1790	0	TA54	N/A
34507	1	34507	22	22	1786	1786	0	TA54	N/A
34507	1	34507	22	22	392	1703	0	TA54	N/A
34507	1	34507	22	22	1788	1788	0	TA54	N/A
34507	1	34507	22	22	1784	1784	0	TA54	N/A
34507	1	34507	22	22	1785	1785	0	TA54	N/A
34507	1	34507	22	22	1787	1787	0	TA54	N/A
34507	1	34507	21	21	385	2222	0	TA54	N/A
34507	1	34507	21	21	386	2223	0	TA54	N/A
34507	1	34507	21	21	384	2221	0	TA54	N/A
34508	1	34508	21	21	390	2218	0	TA54	N/A
34508	1	34508	21	21	387	2224	0	TA54	N/A
34508	1	34508	21	21	389	2263	0	TA54	N/A
34508	1	34508	21	21	391	2216	0	TA54	N/A
34508	1	34508	21	21	388	2215	0	TA54	N/A
34506	1	34506	21	20	379	2220	0	TA54	N/A
34506	1	34506	21	20	380	2262	0	TA54	N/A

Previous page shows small mammal study locations by site_id number.

Cont. Table 21. Small Mammal Data

Mammal_id	Grid_number	Trap_number	Subtrap	Method	Sp_code	Capture_status	Sex	Rep_status	Fetus_number	Fetus_removed
1807	2	N/A	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1805	2	N/A	N/A	SNAP	PEMA	N	U	UNDETERMINED	0	N/A
1808	2	N/A	N/A	SNAP	PEMA	N	F	UNDETERMINED	0	N/A
1803	2	N/A	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1809	2	N/A	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1806	2	N/A	N/A	SNAP	PEMA	N	F	UNDETERMINED	0	N/A
1801	2	17	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1802	2	N/A	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1792	2	N/A	N/A	SNAP	PEMA	N	F	UNDETERMINED	0	N/A
1798	2	14	N/A	SNAP	PEMA	N	F	UNDETERMINED	0	N/A
1797	2	13	N/A	SNAP	PEMA	N	F	UNDETERMINED	0	N/A
1800	2	16	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1794	2	10	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1796	2	12	N/A	SNAP	PEMA	N	F	UNDETERMINED	0	N/A
1795	2	11	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1799	2	15	N/A	SNAP	PEMA	N	U	UNDETERMINED	0	N/A
1789	2	N/A	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1790	2	N/A	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1786	2	N/A	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1703	2	N/A	N/A	SNAP	PEMA	R	U	UNDETERMINED	0	N/A
1788	2	N/A	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1784	2	N/A	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1785	2	N/A	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
1787	2	N/A	N/A	SNAP	PEMA	N	F	UNDETERMINED	0	N/A
2222	1	N/A	N/A	SNAP	PEMA	N	F	UNDETERMINED	0	N/A
2223	1	N/A	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
2221	1	N/A	N/A	SNAP	PEMA	R	U	UNDETERMINED	0	N/A
2218	1	N/A	N/A	SNAP	PEMA	R	U	UNDETERMINED	0	N/A
2224	1	N/A	N/A	SNAP	PEMA	N	F	UNDETERMINED	0	N/A
2263	1	N/A	N/A	SNAP	PEMA	R	U	UNDETERMINED	0	N/A
2216	1	N/A	N/A	SNAP	PEMA	R	U	UNDETERMINED	0	N/A
2215	1	N/A	N/A	SNAP	PEMA	N	M	UNDETERMINED	0	N/A
2220	1	12	N/A	SNAP	PEMA	R	U	UNDETERMINED	0	N/A
2262	1	13	N/A	SNAP	PEMA	N	F	UNDETERMINED	0	N/A

Cont. Table 21. Small Mammal Data

Mammal_id	Total_weight	Bag_weight	Net_weight	Body_length	Tail_length	Ear_length	Foot_length	Tag_number	Comments	EI
1807	16.5	0	16.5	7.5	6.5	0	0	0	NO COMMENTS	0
1805	0	0	0	0	0	0	0	0	NO COMMENTS	0
1808	20	0	20	9	6.5	0	0	0	NO COMMENTS	0
1803	12	0	12	6.5	5.5	0	0	0	NO COMMENTS	0
1809	15.5	0	15.5	8	6	0	0	0	NO COMMENTS	0
1806	15	0	15	7	7	0	0	0	NO COMMENTS	0
1801	15.5	0	15.5	8	7	0	0	0	NO COMMENTS	0
1802	18.5	0	18.5	8	7	0	0	0	NO COMMENTS	0
1792	16	0	16	7.5	6.5	0	0	0	NO COMMENTS	0
1798	13	0	13	7	5.5	0	0	0	NO COMMENTS	0
1797	21.5	0	21.5	9.5	7	0	0	0	NO COMMENTS	0
1800	14.5	0	14.5	6.5	6	0	0	0	NO COMMENTS	0
1791	47	0	47	11.5	6.5	0	0	0	NO COMMENTS	0
1796	14	0	14	7	5.5	0	0	0	NO COMMENTS	0
1795	13	0	13	8	6.5	0	0	0	NO COMMENTS	0
1799	0	0	0	0	0	0	0	0	VERY GREY	0
1789	21	0	21	8	7	0	0	0	NO COMMENTS	0
1790	17.5	0	17.5	6.5	5.5	0	0	0	NO COMMENTS	0
1786	13	0	13	7	5.5	0	0	0	NO COMMENTS	0
1703	0	0	0	0	0	0	0	2216	NO COMMENTS	0
1788	14	0	14	7	5.5	0	0	0	NO COMMENTS	0
1784	9.5	0	9.5	6.5	5.5	0	0	0	NO COMMENTS	0
1785	14	0	14	7.5	6.5	0	0	0	NO COMMENTS	0
1787	14.5	0	14.5	6.5	6.5	0	0	0	NO COMMENTS	0
2222	13	0	13	7	5.6	1.7	1.8	2221	NO COMMENTS	0
2223	17.5	0	17.5	8.5	9.5	2	2	2222	NO COMMENTS	0
2221	0	0	0	0	0	0	0	2263	NO COMMENTS	0
2218	0	0	0	0	0	0	0	2263	NO COMMENTS	0
2224	47	0	47	11	10.2	1.4	2.9	2223	NO COMMENTS	0
2263	0	0	0	0	0	0	0	2215	NO COMMENTS	0
2216	0	0	0	0	0	0	0	2218	NO COMMENTS	0
2215	12.5	0	12.5	7.5	5.5	1.3	1.7	2224	NO COMMENTS	0
2220	0	0	0	0	0	0	0	2215	NO COMMENTS	0
2262	45	0	45	12	10	1.6	3	2220	NO COMMENTS	0

Cont. Table 21. Small Mammal Data

Mammal_id	E2	E3	E4	E5	Avg_emscan
1807	0	0	0	0	0
1805	0	0	0	0	0
1808	0	0	0	0	0
1803	0	0	0	0	0
1809	0	0	0	0	0
1806	0	0	0	0	0
1801	0	0	0	0	0
1802	0	0	0	0	0
1792	0	0	0	0	0
1798	0	0	0	0	0
1797	0	0	0	0	0
1800	0	0	0	0	0
1794	0	0	0	0	0
1796	0	0	0	0	0
1795	0	0	0	0	0
1799	0	0	0	0	0
1789	0	0	0	0	0
1790	0	0	0	0	0
1786	0	0	0	0	0
1703	0	0	0	0	0
1788	0	0	0	0	0
1784	0	0	0	0	0
1785	0	0	0	0	0
1787	0	0	0	0	0
2222	0	0	0	0	0
2223	0	0	0	0	0
2221	0	0	0	0	0
2218	0	0	0	0	0
2224	0	0	0	0	0
2263	0	0	0	0	0
2216	0	0	0	0	0
2215	0	0	0	0	0
2220	0	0	0	0	0
2262	0	0	0	0	0

Table 22. Select Records from the Chemical.dat Table
Table shows chemical concentratons of an analyte by media.

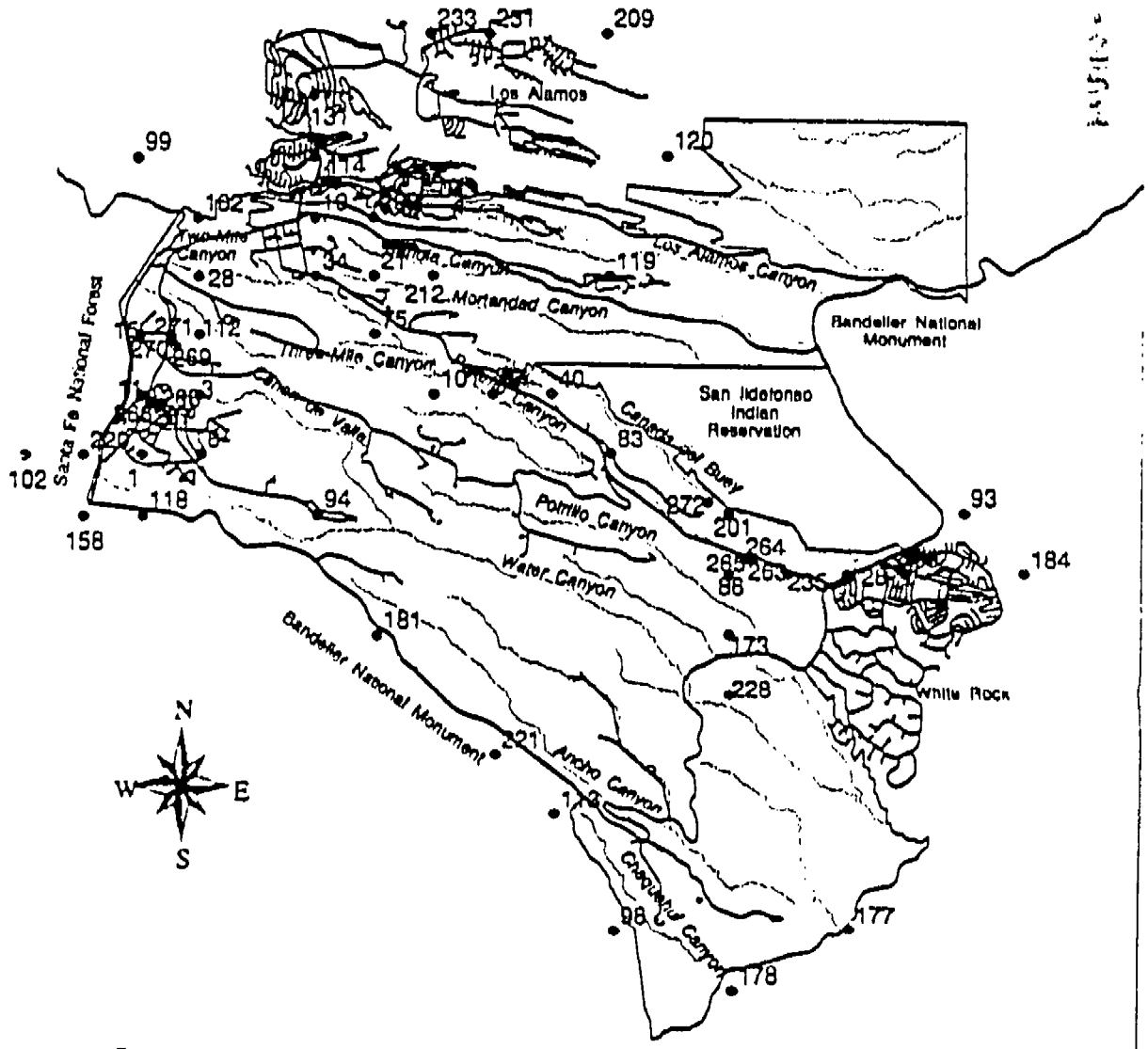
Month	Year	Contam_id	Sample_type	Location_num	Sample_name	Replicate	Chemical	Concentration
6	94	21	CARCASS	1	6211	3	CS137	0.04
6	94	21	CARCASS	1	6211	3	SR90	2.8
6	94	21	CARCASS	1	6211	3	CO60	1.12
6	94	21	CARCASS	1	6211	3	BI214	0.58
6	94	21	CARCASS	1	6211	3	AM241	0.012
6	94	21	CARCASS	1	6211	3	U	0.513
6	94	21	CARCASS	1	6211	3	PU239	0.02
6	94	21	CARCASS	1	6211	3	PU238	0.012
6	94	19	CARCASS	1	6211	1	PU238	0.137
6	94	19	CARCASS	1	6211	1	PU239	0.034
6	94	19	CARCASS	1	6211	1	U	0.384
6	94	19	CARCASS	1	6211	1	AM241	0.01
6	94	21	CARCASS	1	6211	3	K40	47.19
6	94	21	CARCASS	1	6211	3	EU152	2.66
6	94	19	CARCASS	1	6211	1	SR90	1.7
6	94	19	CARCASS	1	6211	3	TL208	0.26
6	94	20	CARCASS	1	6211	2	TL208	0.25
6	94	19	CARCASS	1	6211	1	TL208	0.22
6	94	19	CARCASS	1	6211	1	K40	50.15
6	94	20	CARCASS	1	6211	2	AM241	0.009
6	94	20	CARCASS	1	6211	2	U	0.565
6	94	19	CARCASS	1	6211	1	BI214	0.41
6	94	19	CARCASS	1	6211	1	CS137	0.04
6	94	19	CARCASS	1	6211	1	EU152	2.24
6	94	19	CARCASS	1	6211	1	CO60	0.94
6	94	20	CARCASS	1	6211	2	CO60	1.01
6	94	20	CARCASS	1	6211	2	BI214	0.72
6	94	20	CARCASS	1	6211	2	K40	49.47
6	94	20	CARCASS	1	6211	2	EU152	2.36
6	94	20	CARCASS	1	6211	2	PU239	0.023
6	94	20	CARCASS	1	6211	2	PU238	0.173
6	94	20	CARCASS	1	6211	2	CS137	0.04
6	94	20	CARCASS	1	6211	2	SR90	3.4
6	94	23	CARCASS	2	6222	2	U	0.397
6	94	22	CARCASS	2	6222	1	TL208	0.2
6	94	23	CARCASS	2	6222	2	PU238	0.001
6	94	23	CARCASS	2	6222	2	AM241	0.034
6	94	22	CARCASS	2	6222	1	CO60	0.94
6	94	22	CARCASS	2	6222	1	BI214	0.49
6	94	22	CARCASS	2	6222	1	K40	43.87
6	94	22	CARCASS	2	6222	1	EU152	2.89
6	94	24	CARCASS	2	6222	3	EU152	2.39
6	94	24	CARCASS	2	6222	3	CO60	0.96
6	94	24	CARCASS	2	6222	3	TL208	0.21
6	94	24	CARCASS	2	6222	3	K40	45.39
6	94	23	CARCASS	2	6222	2	SR90	0.6
6	94	23	CARCASS	2	6222	2	PU239	0.072
6	94	24	CARCASS	2	6222	3	BI214	0.5

(Contam_id is the key field to the smmam.dat table.)

Map 7: Mammal Observations

Locations Shown with Site_id Number

(See next page for observation attribute information)



Legend

- Mammal Observations
- LANL
- Paved Roads
- Drainages

1:73589

3 0 3 6 9 12 Kilometers

2 0 2 4 6 8 Miles

LOS ALAMOS NATIONAL LABORATORY
BIOLOGY TEAM, ESH-20 ECOLOGY GROUP
PREPARED: SEPTEMBER, 1996

Table 23. Mammal Observations
(Selected records from mammalobs.dat table.)

Site_id	Code	Month	Day	Year	Land	Ta	Numobs	Status	Vegtype
1	ODHE	8	5	1991	L	0	1	1	405
1	ODHE	8	5	1991	L	0	1	1	405
1	OHDE	10	7	1991	L	0	3	2	405
1	ODHE	10	10	1991	L	0	4	1	405
1	ODHE	10	10	1991	L	0	1	1	405
1	ODHE	11	4	1991	L	0	4	1	405
1	ODHE	11	4	1991	L	0	10	1	405
1	PRLO	11	4	1991	L	0	1	1	140
3	ODHE	8	7	1991	L	0	3	2	405
3	CEEL	10	8	1991	L	0	13	1	405
3	CEEL	10	9	1991	L	0	26	1	405
3	CALA	10	10	1991	L	0	4	1	405
3	CEEL	7	8	1991	L	0	2	2	405
3	CEEL	7	8	1991	L	0	20	2	405
3	ODHE	7	23	1991	L	0	3	1	405
3	ODHE	7	30	1991	L	0	2	1	405
3	CALA	8	5	1991	L	0	5	2	405
3	ODHE	4	13	1993	L	0	3	1	420
3	CEEL	4	13	1993	L	0	20	1	420
3	CEEL	4	14	1993	L	0	2	1	420
3	ODHE	4	14	1993	L	0	10	1	420
3	CEEL	4	19	1993	L	0	44	1	420
3	ODHE	4	20	1993	L	0	6	1	420
3	CEEL	4	7	1993	L	0	14	1	420
3	ODHE	4	12	1993	L	0	1	1	420
3	ODHE	4	13	1993	L	0	3	1	420
3	CEEL	1	30	1992	L	0	2	1	405
3	CEEL	3	17	1992	L	0	6	1	405
3	CEEL	3	17	1992	L	0	5	1	405
6	ODEH	10	9	1991	L	0	5	2	405
6	ODHE	7	25	1991	L	0	3	1	405
6	CEEL	7	30	1991	L	0	20	2	405
6	CEEL	9	13	1991	L	0	2	1	420
6	ODHE	4	14	1993	L	0	1	1	420
6	CEEL	4	21	1993	L	0	14	1	420
6	ODHE	3	31	1993	L	0	2	1	420
6	CEEL	4	6	1993	L	0	57	1	420
6	CEEL	4	7	1993	L	0	6	1	420
6	CEEL	4	12	1993	L	0	33	1	420
6	CEEL	2	4	1992	L	0	3	1	405
6	CEEL	3	24	1992	L	0	14	1	405
6	CEEL	3	26	1992	L	0	14	1	405
11	ODHE	10	15	1991	L	0	3	1	225
11	ZZSQ	9	26	1991	L	0	1	1	420
11	ODHE	9	27	1991	L	0	3	1	250
11	ODHE	10	15	1991	L	0	3	1	225
11	CEEL	10	15	1991	L	0	24	1	225
11	CEEL	10	23	1991	L	0	1	1	225

Previous page shows observation by Site_id number.

Table 24. Large Mammal Data
(Selected records from lgmam.dat)

Trap_date	Mortality_cod	Mortality_date	Site_id	Contam_id	Capture_id	Mammal_id	Museum_id	Location
35136	0		265	0	1	1	0	PAJARITO ROAD
35139	0		272	0	2	2	0	CANADA DEL BUEY
35143	0		263	0	3	3	0	PAJARITO ROAD
35150	0		264	0	4	4	0	PAJARITO ROAD
35158	0		266	0	5	5	0	TA-16
35178	2	9/14/96	268	0	6	6	0	TA-16
35178	0		267	0	7	5	0	TA-16

Map 7 shows large mammal trap locations by site_id number.

Cont. Table 24. Large Mammal Data

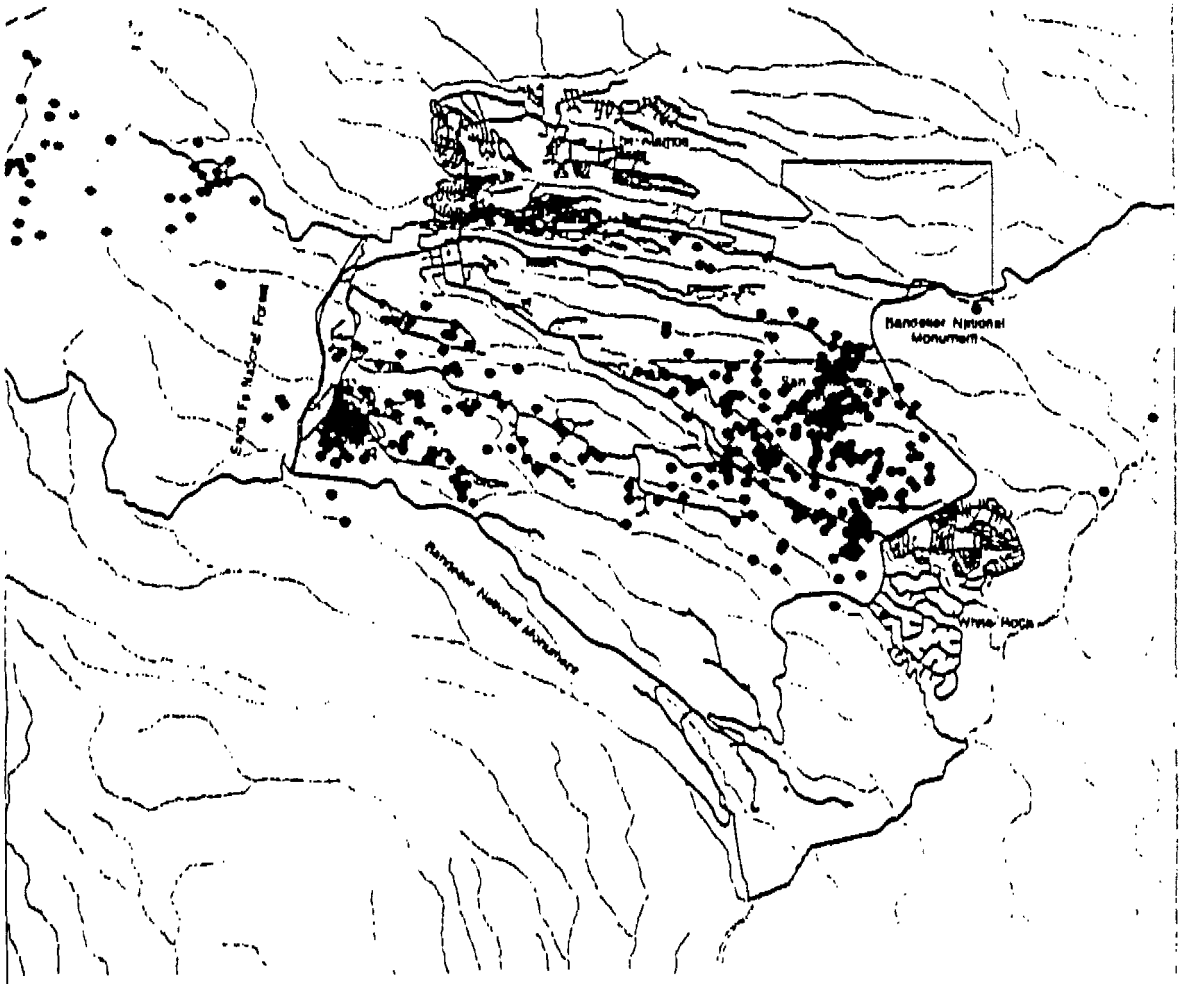
Sublocation	Trap_number	Subtrap	Method	Sp_code	Capture_status	Sex	Rep_status	Fetus_number	Fetus_removed
NEAR LIFT STATION	1		CLOVER	CEEL	N	F	PREGNANT	0	
ACROSS FROM SMALL MET TO	2		CLOVER	CEEL	N	F		0	
NEAR LIFT HOUSE BY CAMER	3		CLOVER	CEEL	N	F	PREGNANT	0	
NEAR LIFT HOUSE ON HILL	4		CLOVER	CEEL	N	F		0	
NEAR THE STEAM PLANT MAR	5		CLOVER	CEEL	N	F		0	
NEAR MARSH AT STEAM PLAN	6		CLOVER	CEEL	N	M		0	
NEAR MARSH AT STEAM PLAN	7		CLOVER	CEEL	R	F		0	

Cont. Table 24. Large Mammal Data

Body_weight	Body_length	Tail_length	Ear_length	Foot_length	Age	Tag_number	Comments
650	58	0	0	0	5	16037	SUNNY AND CLEAR DAY
545	48	0	0	0	2	16036	OVERCAST MORNING; HAD IVORIES
617	62	0	0	0	5	16034	SUNNY AND CLEAR (30 DEG) MORNING
525	56	0	0	0	0	16035	SUNNYAND CLEAR (40 DEG)
545	52	0	0	0	2	16033	SUNNY, BREEZY AND 40 DEGREES
659	0	0	0	0	2	16038	SUNNY AND COLD; YOUNG WITH SPIKE
0	0	0	0	0	0	16033	RECAPTURED ELK NO NEW MEASUREMENTS WERE TAKEN

Map 8: GPS Locations from 6 Radio-Collared Elk

(See next page for attribute information)



Legend

GPS Locations by Collar_Id Number

16033 - 16038

LANL

Paved Roads

Drainages

1:93196

3 0 3 6 9 12 15 Kilometers

2 0 2 4 6 8 10 Miles

N

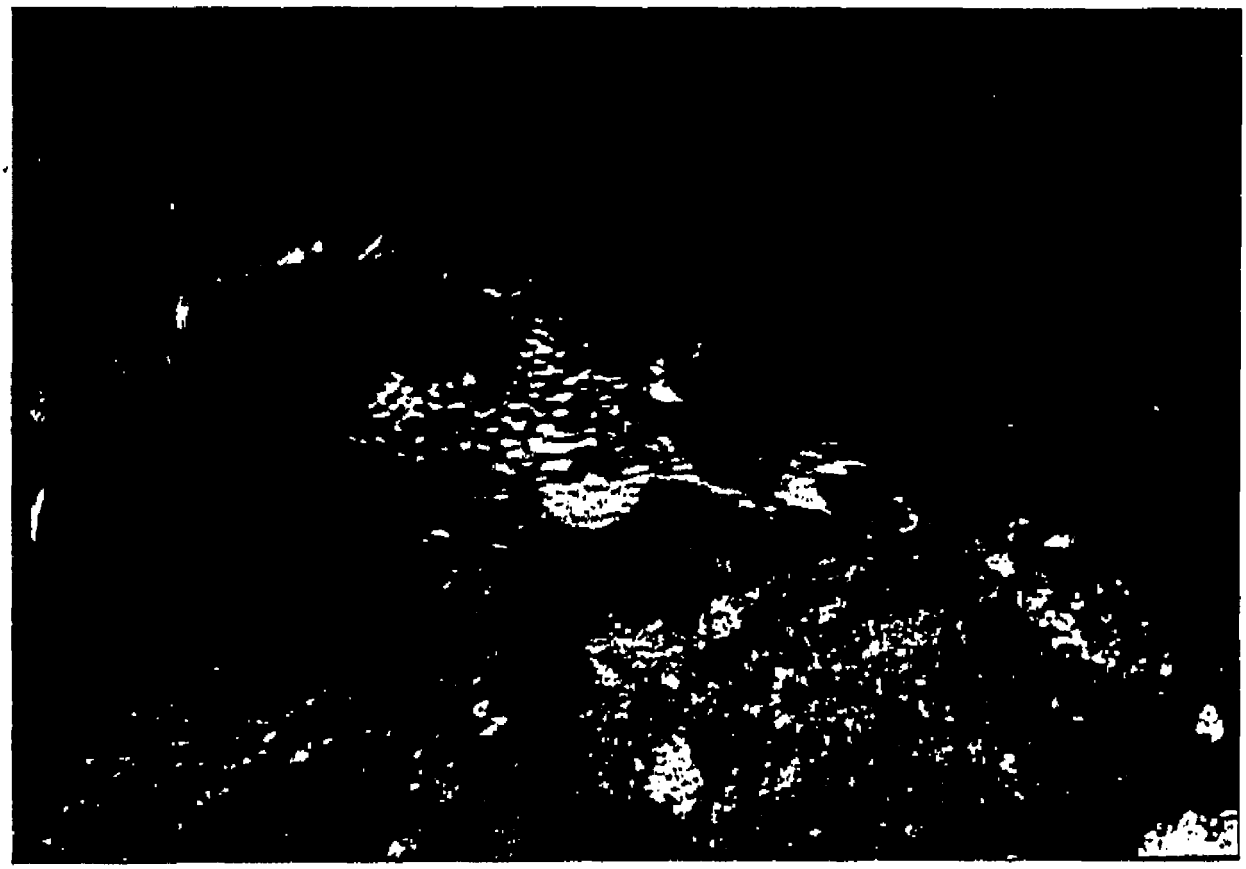
Table 25. Attribute Information for GPS Locations of Elk

Area	Perimeter	Elkgps#	Elkgps-id	Sequence	Capture_id	Collar_id	Julian_day	Gmt
0	0	1	1	5	1	16037	69	17:02
0	0	2	2	4	2	16037	68	18:00
0	0	3	3	3	3	16037	67	19.02
0	0	4	4	2	4	16037	66	20.00
0	0	5	5	1	5	16037	64	22.32
0	0	6	6	3	6	16036	68	18.00
0	0	7	7	2	7	16036	67	19.00
0	0	8	8	1	8	16036	66	20.00
0	0	9	9	5	9	16034	84	19.00
0	0	10	10	4	10	16034	83	20.00
0	0	11	11	3	11	16034	82	21.00
0	0	12	12	2	12	16034	81	22.03
0	0	13	13	8	13	16036	85	1.01
0	0	14	14	7	14	16036	84	2.00
0	0	15	15	6	15	16036	83	3.00
0	0	16	16	5	16	16036	82	4.02
0	0	17	17	4	17	16036	81	05:00
0	0	18	18	8	18	16037	85	1:00
0	0	19	19	7	19	16037	83	3:00
0	0	20	20	6	20	16037	79	7:01
0	0	21	21	1	21	16034	80	23:00
0	0	22	22	9	22	16036	86	00:00
0	0	26	26	9	26	16037	86	00:01
0	0	30	30	9	30	16034	92	11:02
0	0	31	31	8	31	16034	91	12:00
0	0	32	32	7	32	16034	90	13:00
0	0	33	33	6	33	16034	89	14:02
0	0	34	34	7	34	16035	92	20:00
0	0	35	35	6	35	16035	91	21:00
0	0	36	36	5	36	16035	90	22:00
0	0	37	37	4	37	16035	89	23:00
0	0	38	38	3	38	16035	89	00:00
0	0	39	39	2	39	16035	88	01:00
0	0	40	40	1	40	16035	87	02:02
0	0	49	49	2	49	16033	94	23:02
0	0	50	50	1	50	16033	94	00:33
0	0	56	56	9	56	16035	94	18:00
0	0	57	57	8	57	16035	93	19:01
0	0	68	68	2	68	16038	95	18:40
0	0	69	69	1	69	16038	94	19:15
0	0	70	70	6	70	16033	107	10:01
0	0	71	71	5	71	16033	105	12:02
0	0	72	72	4	72	16033	103	14:02
0	0	73	73	3	73	16033	102	15:02
0	0	97	97	9	97	16033	113	04:00
0	0	98	98	8	98	16033	111	6:01
0	0	99	99	7	99	16033	110	7:01
0	0	131	131	5	131	16038	115	22:01

Previous page shows GPS locations from 6 elk.

Preliminary Ecological Risk Assessment of the Mexican Spotted Owl at the Los Alamos National Laboratory

Anthony F. Gallegos, Gilbert J. Gonzales, Kathryn D. Bennett, and Larry E. Pratt



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Preliminary Ecological Risk Assessment of the Mexican Spotted Owl at the Los Alamos National Laboratory

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Abstract

The Record of Decision on the Dual Axis Radiographic Hydrodynamic Test Facility Environmental Impact Statement mandates that the Department of Energy take special precautions to protect the Mexican spotted owl (*Strix occidentalis lucida*) at the Los Alamos National Laboratory. In order to do so, risk to the owl presented by radiological and nonradiological contaminants must be estimated. A preliminary ecological risk assessment on the Mexican spotted owl in two Ecological Exposure Units was performed using a modified EPA Quotient method, the FORTRAN model "ECORSK3" and a geographic information system (GIS). Estimated doses to the owl were compared against reference doses generating hazard indices for three risk source types ("Unadjusted," "Background," and "Contaminated Nest Sites").

Hazard Quotient results, based on modeling assumptions and conditions, indicated no unacceptable risk to the owl, including a measure of cumulative effects from multiple contaminants that assumes a linear additive toxicity type. Information on risk by specific geographical location was generated which can be used to manage contaminated areas, owl habitat, facility siting and facility operations in order to maintain risk from contaminants to acceptably low levels.

1.0 Introduction

The Record of Decision on the Dual Axis Radiographic Hydrodynamic Test Facility (DARHT) Environmental Impact Statement (EIS) mandates that the Department of Energy take special precautions to protect the Mexican spotted owl (*Strix occidentalis lucida*) at the Los Alamos National Laboratory (LANL) (DOE 1996, DOE 1995). In order to do so, risks to the owl presented by radiological and nonradiological contaminants must be estimated.

This report presents the results of a preliminary ecological risk assessment on the Mexican spotted owl. The general approach for performing the assessment was to make a quantitative appraisal of the potential effects that soil contaminants might have on the owl when introduced through the soil ingestion pathways using the Quotient Method prescribed by the US Environmental Protection Agency (EPA) (1996, 1992). The methodology generally involved comparing calculated doses to the owl against reference doses (RfDs) either provided by or calculated from the scientific literature. Two potential Mexican spotted owl habitats were evaluated on LANL. Each consisted of a predetermined potential nesting/roosting zone and a calculated foraging area. Collectively the potential nesting/roosting zone and the feeding zone comprised a Mexican spotted owl "Ecological Exposure Unit" (EEU) (Figure 1).

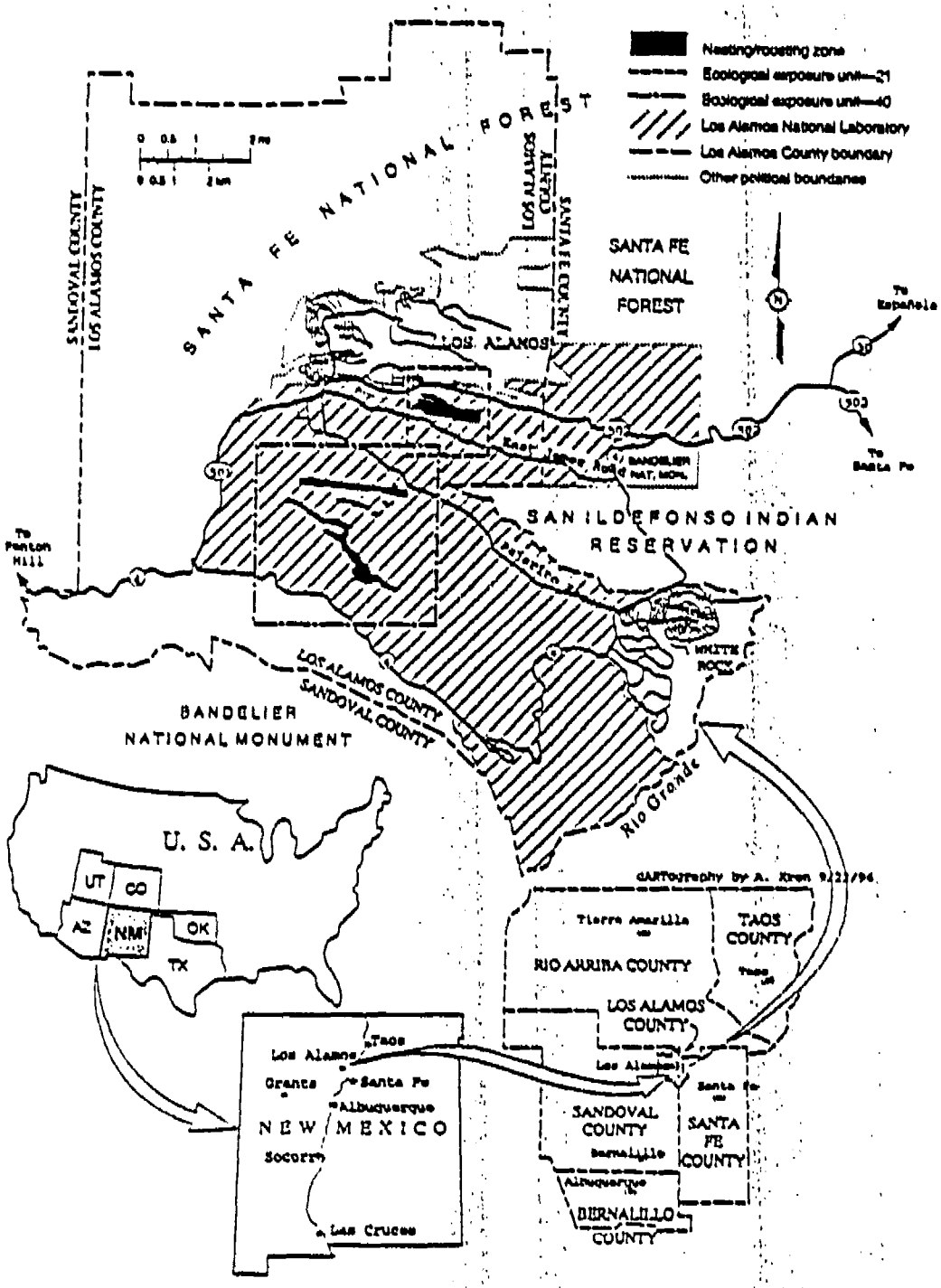


Figure 1. Locations of ecological exposure units for ecorisk assessment of Mexican spotted owl at LANL.

2.0 Methods

2.1 Development of Ecological Exposure Units

An EEU is a unit defined by the biology of a species or group, within which an ecological risk assessment is conducted (Ferenbaugh et al. 1996). As mentioned, each EEU for Mexican spotted owl consists of a predetermined potential nesting/roosting zone (Johnson 1993) and a calculated foraging area.

Potential nesting/roosting zones were based on work performed by Johnson (1993) in which he developed a topographic model to rate the physical potential of habitat for breeding spotted owls. Topographic data of United States Geological Survey 1-degree Digital Elevation Models provided the input for modeling the potential habitat. Historical owl locations were extracted from a New Mexico Department of Game and Fish database prepared by the New Mexico Natural Heritage Program. The model was developed by examining topographic characteristics of owl locations and random locations to find a scalar function of topography that quantitatively separated inhabitated areas from random locations. The database included 1,383 records of historical reports and United States Forest Service inventory and monitoring daytime follow-up field work through 1991. See Johnson (1993) for more detail on the methodology for identifying potential owl habitat. The foraging area around a specific potential nesting site or home range (HR) was estimated according to Peters (1993) as based on body weight. The maximum foraging area and the extreme boundaries of each EEU were then established by mapping an area that was 3,000 ft from the extreme-most north, south, west, and east boundary of the nesting/roosting zone. The resultant EEUs are shown in Figures 2 and 3. "EEU-21" includes foraging and nesting/roosting areas that center around Los Alamos Canyon and encompass all or portions of LANL Technical Areas (TAs) 02, 05, 21, 35, 53, 60, 61, and 73. "EEU-40" includes foraging and nesting/roosting areas that center around Pajarito Canyon and Cañon de Valle and encompass all or portions of LANL TAs 06, 09, 11, 14, 15, 16, 22, 35, 36, 37, 39, 40, 46, 48, 49, 50, 52, 55, 63, 64, 66, and 67.

Each EEU was mapped using a geographic information system (GIS) and the GIS software ARC/INFO. ARC/INFO is a GIS software developed by Environmental Systems Research Institute, Inc. (ERSI).

GIS was used to create spatial data sets, combine information from different spatial data sets, generate a spatial grid, and produce maps. We digitized the spatial extent of the nesting and roosting spotted owl habitat into ARC/INFO to create a coverage (theme or layer). We assigned this habitat an attribute coverage factor of 99. The modeling also required additional coverages to be developed, a grid stet and a forage habitat coverage.

More specifically, we first developed a grid that would encompass the spatial extent needed for the modeling activity. In ARC/INFO, we created the grid using the command GENERATE with the fishnet option. The size of each grid cell was 100 ft X 100 ft. The ecological risk model required that each row and column of the grid was designated by a label. In addition, the coordinates of the center of each grid cell were needed. We developed the *Basic* program listed below to generate these attributes. These attributes were then added to the grid spatial data set.

```
REM GRID Program
REM This program generates the label id for
the rows and columns of the grid
REM It also generates the x,y coordinate of
the center of each grid cell.
REM The input #1 file should contain the x
minimum and y minimum values.
REM The user must edit the program with the
input and output filename.
REM The user must input the number of rows
and columns needed for the grid.
REM This information is required at the DO
WHILE statements
counter = 0
OPEN "c:\<filename>" FOR INPUT AS #1
OPEN "c:\<filename>" FOR OUTPUT AS #2
  INPUT #1, x, y
  LET yo = y
  DO
    LET counter = counter + 1
    LET rowo = counter
    LET counter = 0
    LET xo = x
    DO WHILE (counter) <= 259
      LET counter = counter + 1
      LET colo = counter
      WRITE #2, rowo, colo, xo, yo
      LET xo = xo + 100
      LOOP
    LET yo = yo + 100
  LOOP WHILE counter <= 199
```

The next coverage developed in ARC/INFO was the forage coverage. We created the forage coverage by selecting 30 grid cells above the maximum x, y extent of the owl habitat and 30 grid cells below the minimum x, y extent. We gave the forage habitat an attribute factor of 1.

After these three coverages were made, additional information was needed that required combining coverages. First, we needed the column and row labels and coordinates of the each grid cell center for sample locations. The sample locations were in an existing coverage developed for the LANL's Environmental Restoration Program. We intersected the grid coverage and the sample location coverage to create a new coverage. This new coverage contained the sample locations as well as the grid attributes of row, column, and coordinates.

Next, we combined three coverages to obtain one coverage with the attribute factor from the grid, the owl habitat, and the forage habitat. We wanted the attribute factor for the owl nesting/roosting habitat to be 99, the foraging habitat that was not within the owl nesting/roosting habitat to be 1, and the grid that was not within either (i.e., surrounding the foraging habitat) to be 0. We accomplished this through a couple of coverage intersects and defining a single new attribute factor.

When all coverages had been developed, we generated maps in either ARC/PLOT of ARC/INFO or ArcView. ArcView is a desktop GIS for map display, production, and query. It was also developed by ESRI.

2.2 Data Compilation Procedure

Analytical results from sampling performed for environmental restoration activities at LANL are maintained in an Oracle database by the Facility for Information, Management, and Display (FIMAD). FIMAD data can be accessed through the command line Structured Query

Language or through the graphical interface Databrowser. The data for the Threatened and Endangered Species Project was accessed primarily with the latter.

Soil sampling data are stored in several tables, depending on the attribute of the data, when the data was collected, and the field unit from which the data was collected. If a sample was taken before April 1, 1995, the results are stored in one of the "analytical_info" tables, and if a sample was taken after April 1, 1995, the results are stored in the "stage" tables.

The data for the Threatened and Endangered Species project were compiled from the FIMAD database for each foraging area according to the following procedure:

- In order to determine which samples were relevant to the Threatened and Endangered Species study, all FIMAD-identified sampling locations within each foraging area were identified graphically from a map showing all the sampling locations stored in FIMAD (see Figures 2 and 3).

- Sampling locations were then linked to sample identification numbers and field units to determine where the analytical results would be stored.

- Five FIMAD tables were queried for the analytical results:
  - analytical_info_fu01,
  - analytical_info_fu02,
  - analytical_info_fu03,
  - analytical_info, and
  - sample_request_header_stage.

The "analytical" tables contain data for the field units 1–5 gathered prior to April 1,1995, and the "stage" table contains data for samples gathered after April 1, 1995.

- As part of the query language, analytical results were screened to contain only samples with a beginning depth = "0". The data was then exported to a personal computer and modified further using Excel software.

- All records were screened by "sample units," and those records not given in grams or kilograms were discarded. All remaining records were converted to mg/kg for organic elements and heavy metals or to pCi/g for radioactive elements, leaving only the surface soil sample data relevant to the Threatened and Endangered Species study. Although higher quantities of contaminants have been found at intermediate soil depths than at shallow depths elsewhere at LANL (Gonzales and Newell 1996), their bioavailability to aboveground biota is unknown.

- All sample values for records which were below the detection limits of the instrumentation used in the analysis were changed to zero.

- Every sample record was assigned the appropriate cell (100 ft x 100 ft) of the grid covering the feeding area. The grid cells are labeled with the row and column in which they are found (see Figures 2 and 3).

- Averages were calculated for each analyte within every grid cell containing at least one record of data. Since the "grid" was superimposed onto a map of sampling locations that were concentrated around pre-identified "potential release sites," sample locations are not scattered evenly throughout the cells of the grid. Consequently, some cell averages include the data from several samples, others include the data from only one sample, while still others have no analytical data. Furthermore, not all cells have analytical results for the same set of analytes, because the same analyses were not requested for the investigation of all the "potential release sites" in the area. Lastly, an entire 100- x 100-ft area was assumed to contain an analyte concentration that was measured in as little as one sample. This is considered a conservative assumption in most cases. An instance in which this assumption would not be conservative is where contamination is present in a drainage channel that is downstream from a liquid waste outfall. For example, Gonzales and Newell (1996) found elsewhere in LANL that the spatial change in radionuclide concentrations below an outfall were statistically insignificant for an 800-ft distance.

- The number of analytes with sample results was calculated for each cell.

- The grid cells were assigned the x- and y-coordinates calculated at the center of each cell.

- Mean "natural" (inorganics) or 95th percentile upper tolerance level (radionuclides) soil background concentration values of analytes were assigned to each analyte within each grid cell, and zeros were assigned in the absence of a background value.

- RfDs, RfD adjustment factors, and occupancy factors (all discussed in a later section) were then assigned to each analyte within each grid cell.

The final data contained the fields: grid cell id, analyte, analyte code, analyte average (by grid cell), RfD, RfD adjustment, occupancy factor, mean "natural" (inorganics) or 95th percentile upper tolerance level (radionuclides) background value, number of analytes per cell, x-coordinate, and y-coordinate. Finally, the fields were formatted as an "eeuinp.dat" database for input to the model "ECORSK3".

2.3 Preliminary List of Contaminants of Potential Ecological Concern

Contaminants of potential ecological concern (COPECs) are those

- known to have been used or to be present in the EEU,

- to which receptors within the EEU are known to be sensitive,

- identified as of concern during any human health risk assessment conducted in the same area, and

- which warrant concern because of other factors such as toxicity, persistence, exposure potential or food chain transfer (Ferenbaugh et al. 1996).

Using the procedure discussed in the previous section, a preliminary list of COPECs for each EEU was generated by querying LANL's FIMAD database for surface layer soil analytical results. Any analyte listed in the FIMAD database for which no

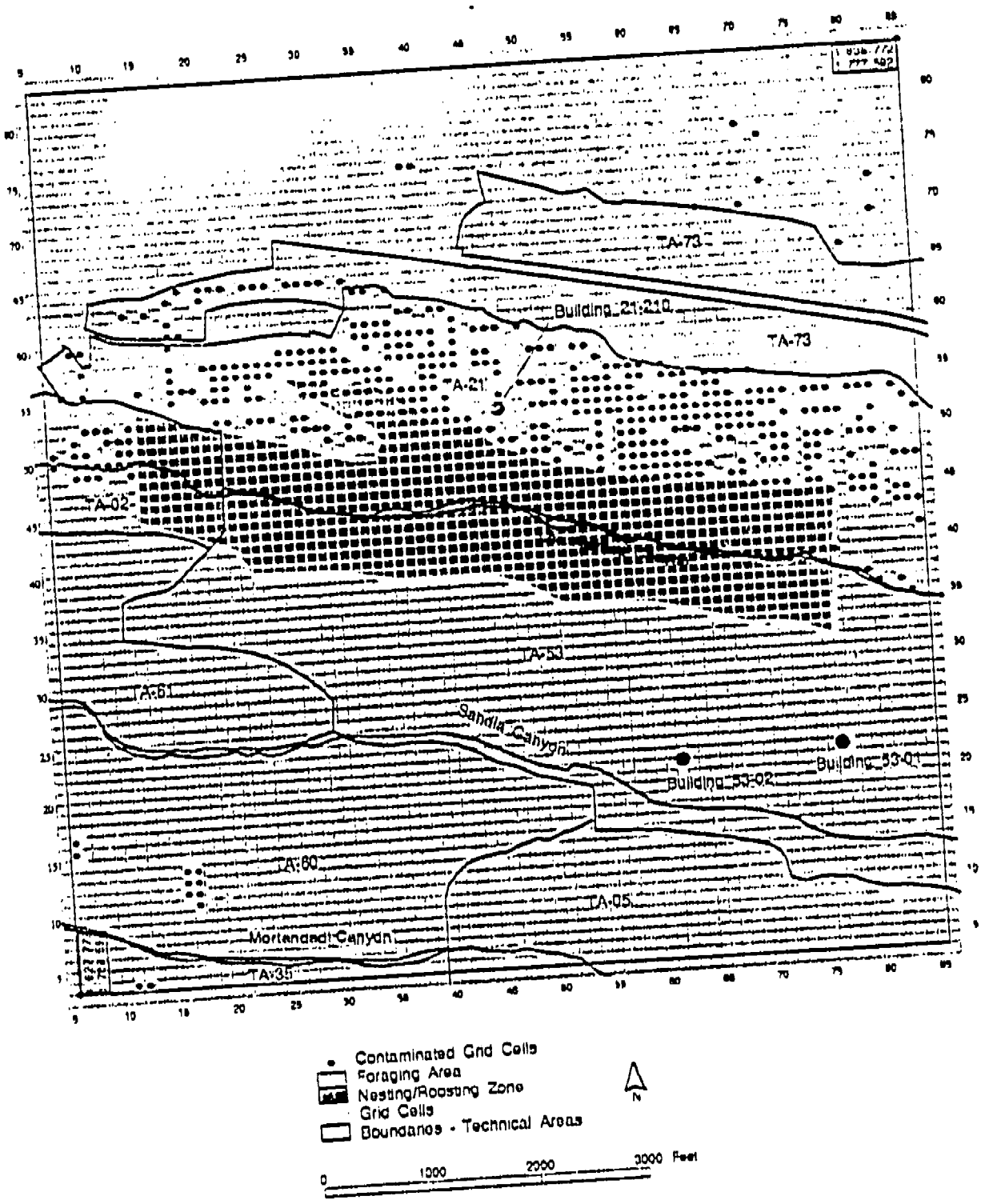


Figure 2. Ecological Exposure Unit -21

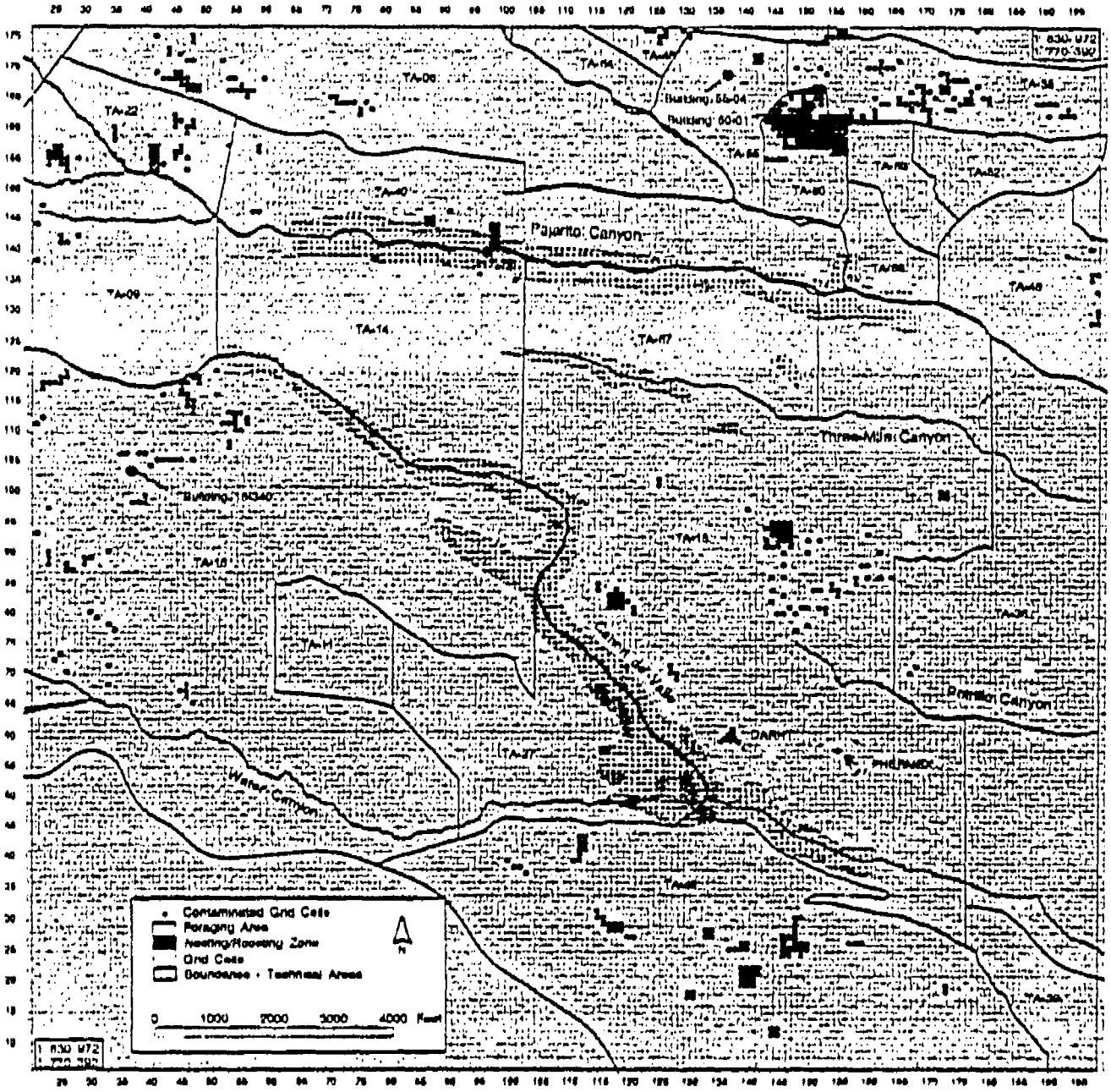


Figure 3. Ecological Exposure Unit - 40

analytical detections were made in the entire EEU were not included in the list. The preliminary COPEC list for the two EEUs is provided in Table A-1 in the appendix. Contribution to risk by any given COPEC could be calculated, as discussed later, only if a RfD is available for that COPEC. The preliminary COPEC list for the Mexican spotted owl should ultimately be revised on the basis of Mexican spotted owl sensitivity, and whether complete pathways exist from the sources to the Mexican spotted owl (Ferenbaugh et al. 1986).

2.4 Food Web Definition

The Mexican spotted owl is a first order carnivore and is known to consume woodrats, mice, voles, cottontail rabbits, pocket gophers, bats, other mammals, birds, reptiles, and insects (Ganey 1992). In Arizona, Ganey (1992) reported that woodrats (*Neotoma*), white-footed mice (*Peromyscus*), and voles (*Microtus*) constitute between 61 to 83% of prey on a frequency basis and between 59 to 88% on a biomass basis. Prey abundance was the main factor influencing selection of the rodent species. At LANL, *Peromyscus* spp. are possibly the most prevalent sources of food to the Mexican spotted owl, followed by *Microtus* and *Sorex* (Biggs 1995). Based on data reported by Biggs (1995) for Los Alamos Canyon and Cañon de Valle, which are two of the three major canyons or portions of canyons that comprise the potential Mexican spotted owl habitat in this study, our estimates of weighted mean Mexican spotted owl diet on a composition basis are:

- 46% for *Peromyscus maniculatus* (deer mouse),
- 23% for *Microtus longicaudus* (long-tailed vole),
- 14% for *Peromyscus boylii* (brush mouse),
- 6.2% for *Microtus montanus* (montane vole),
- 5.8% for *Neotoma mexicana* (Mexican woodrat),
- 2% for *Sorex vagrens* (vagrant shrew), and
- 4% other.

These are based solely on species abundance and can be considered the primary sources of food to the Mexican spotted owl at LANL until a more detailed food web involving the Mexican spotted owl is developed. Ingestion of soil-contaminated pelts is likely the major source of potential contamination to the owl (Beyer et al. 1994).

2.5 Pathways of Exposure

A general conceptual model, based on Ferenbaugh et al. (1996), on pathways of contaminant exposure for the Mexican spotted owl are as follows:

- Primary Source of Contamination:
  Burial and outfalls;
- Primary Release Mechanisms:
  Burial and disposal of liquids through drains;
- Migration Pathways:
  Infiltration/sorption, biodegradation, organic volatilization, chemical reactions, and radioactive decay;

- Contact Pathways:
  Soil, volatiles/airborne dust, sediment, surface water;

- Intermediate Pathways:
  Transport from soil and soil contaminated vegetation to herbivores; and

- Primary Direct Exposure Route:
  Ingestion of soil-contaminated pelts as a first order carnivore.

The preceding section on food webs established consumption of rodents as the main activity leading to potential contamination of the owl. This activity results in ingestion of soil-contaminated pelts as the dominant contaminant exposure pathway for the Mexican spotted owl. *Peromyscus* burrow into the near surface soil, which serves as the primary source of contamination. Based on abundance, they may serve as a more dominant exposure source than other food sources.

Although the abundance of the pocket gopher (*Thomomys bottae*) in Los Alamos County has been studied only on a very limited basis because of its subsurface dwelling, its occurrence at LANL has been documented (Bennett et al. 1996, Hakonson et al. 1982) and it is known to interact significantly with soil contaminant distribution (Gonzales et al. 1995). Therefore, it could also serve as a pathway to the Mexican spotted owl in isolated cases.

2.6 Risk Calculation

Defined simplistically, ecological risk is the actual or potential effects of contaminants on flora and fauna. The measure used in this study to quantitatively appraise ecological risk to the Mexican spotted owl is the Quotient Method (EPA 1996, 1992) whereby the Hazard Quotient (HQ) serves as the measure of potential risk. The general form of the HQ is defined as

$$HQ = \text{Exposure (mg/kg-d)}/\text{RfD (mg/kg-d)} \qquad (1)$$

which is the ratio of exposure to a toxicity reference dose (RfD). When HQs for all contaminants are summed, it becomes a cumulative HQ and is termed Hazard Index (HI). A more detailed version of the formula above for computing the HI from multiple contaminated areas is:

$$HI = [I \times F_s/BW] \sum_j O_i \sum_l C_{i,j}/RfD_j \,. \qquad (2)$$

where

- HI = cumulative HQ over all contaminated grid cells and contaminants (COPECs),

- I = food intake, kgfwt/d (3.94×10^{-2} kg(fwt)/d for owl)

- BW = body wt = 0.55 kg(fwt), kgfwt, (0.55 kg(fwt) for owl)

- F_s = fraction of food intake as soil = 0.05,

- O_i = occupancy factor on contaminated sites = proportional to the fraction of feeding area occupied by contaminated grid cells (i.e., equal weighting given to contaminated and noncontaminated grid cells),

- $C_{i,j}$ = contaminant concentration in soil, mg/kg, for the ith contaminated grid cell, and the jth contaminant,

- RfD_j = receptor (owl) reference toxicological dose in mg/kg-d for the jth contaminant (Note: RfDs are discussed in the next section).

Wildlife may ingest amounts of soil while feeding that are substantial enough to constitute the main source of exposure to environmental contaminants (Beyer et al. 1994). The fraction of food intake as soil , F_s, is currently an issue under consideration at LANL. EPA guidance is that, for screening purposes, this parameter should be 50%, given that soil ingestion can range from less than 2% in some small birds and small mammals to ≈ 100% in earthworms (Ferenbaugh et al. 1996). LANL guidance is that the screening approach to this parameter may be examined to determine if the use of less conservative assumptions is justified in order to better reflect specific site and/or receptor conditions (Ferenbaugh et al. 1996). Beyer et al. (1994) conducted laboratory and field studies to estimate F_S in 28 herbivore or carnivore avian, mammal, and reptile species. Although the range in mean F_S for the avian species was <2–30%, all of the avian species evaluated either consume soil organisms as a dominant source of food or deliberately consume sediment for proper functioning of the gizzard. This is in contrast to the feeding habits of the Mexican spotted owl. Since the owl is a first order carnivore, it would not have the exposure from soil ingestion that the avian species in the Beyer et al. study did. Also, for the two omnivores, the red fox and the racoon, studied by Beyer et al. that prey on rodents like the owl, the average F_s was 6.1%. Of these two, the only diet of the red fox was predominantly carnivore, therefore its F_s of 2.8 is more applicable to the owl. For these reasons, and F_s value at the lower end of the range established by Beyer et al. (1994) is justified. Therefore, an F_s value of 5.0% was assumed for the Mexican spotted owl in this study. A more detailed formula for computing the HQ is presented in a later section.

Upon selecting a nest site, the model ECORSK3 (described later in this report) developed a foraging area for the Mexican spotted owl (3.66 km^2) and calculated a HQ for each COPEC within each 100- x 100-ft grid cell of the foraging area. The model repeated this estimate based on the number of repetitive (replication) nest sites selected. By assuming that the owl forages in noncontaminated as well as contaminated grid cells, our risk estimate lessens a source of error that Tiebout and Brugger (1995) conclude leads to overestimation of risk; i.e., the error associated with the implicit assumption normally made in the Quotient Method that birds remain in a contaminated zone.

The data in Table A-2 is an example of model output for a case in which there were 100 randomly selected nest sites. Hazard quotients were then combined into three "Hazard Value Types" by various "Risk Sources" as shown in Table 1.

Table 1. Experimental Design of Study on Preliminary Ecological Risk Assessment of the Mexican Spotted Owl at the Los Alamos National Laboratory.

Ecological Exposure Unit-21

Risk Source:	Unadjusted			Background			Contaminated Nest Site			Selected		
Hazard Value Type:	HI	HQ_{sq} x Loc	HQ_{sq} x Loc x COFEC	HI	HQ_{sq} x Loc	HQ_{sq} x Loc x COFEC	HI	HQ_{sq} x Loc	HQ_{sq} x Loc x COFEC	HI	HQ_{sq} x Loc	HQ_{sq} x Loc x COFEC
Nest Site No												
1												
2												
3												
-												
-												
-												

Ecological Exposure Unit-40

Risk Source:	Unadjusted			Background			Contaminated Nest Site			Selected		
Hazard Value Type:	HI	HQ_{sq} x Loc	HQ_{sq} x Loc x COFEC	HI	HQ_{sq} x Loc	HQ_{sq} x Loc x COFEC	HI	HQ_{sq} x Loc	HQ_{sq} x Loc x COFEC	HI	HQ_{sq} x Loc	HQ_{sq} x Loc x COFEC
Nest Site No.												
1												
2												
3												
-												
-												
-												

Definitions of the Risk Sources and Hazard Value Types are as follows:

Risk Sources

- Unadjusted risk - Contains the risk associated with Laboratory activities. Sources of HQ values include (i) HQs associated with contaminated grid cells making no adjustment for background soil concentrations; and (ii) for grid cells where sampled COPEC soil concentrations result in Unadjusted HQs < Background HQs then Background HQs are entered.

- Background risk - Represents the risk associated with "natural" background concentrations of COPECs measured in this study. Computes HQs by entering the mean (inorganics) or UTL (radionuclides) "natural" background soil concentration into the HQ formula for grid cells in a foraging area for which COPECs existed in the Unadjusted data set.

- Contaminated Nest Site - Represents the unadjusted risk resulting from "situating" nest sites on contaminated grid cells within the "nesting/roosting" zone. The number of foraging areas is equal to the number of "contaminated" grid cells that exist within the nesting/roosting zone of each EEU. This value was estimated as 86 for EEU-21 and 16 for EEU-40.

Hazard Value Type

- HI (Hazard Index) - A sum of the HQs for all COPECs and all grid cells in a foraging area averaged across the number of replications.

- Mean Partial HQ x Location - A sum of the HQs for all COPECs separated by location and averaged across "replications."

- Mean Partial HQ x Location x COPEC. A sum of the HQs separated by location (grid cell) and COPEC and averaged across "replications."

The most useful Hazard Value Type for conveying total risk is the Hazard Index (HI): Using the Unadjusted HI as an example for discussion purposes, consider that for each of 100 randomly selected potential nest sites of the Mexican spotted owl and thus 100 replications, an HQ was calculated for a 3.66 km^2 HR, or foraging area, for each COPEC at each grid cell. The HI (or Mean Total HQ) sums the HQs for all COPECs and all grid cells in a foraging area and is an average of the 100 sets of data (replications). Because the HI is the sum of the HQs for all COPECs, it serves as an index of cumulative effects from multiple contaminants and is the most conservative of the three Hazard Value Types.

2.7 Reference Doses

Metals. The RfDs chosen to use as contribution to the HQs for organic and metal COPECs were the chronic no observed adverse effects levels (NOAELs) in units of mg COPEC per kg body wt of the owl per day. The NOAELs and related information used are listed in Table A-3 in the appendix. In order of descending use, the manner in which NOAELs were compiled was

1) obtained directly from the scientific literature,

2) computed from chronic intake doses, and

3) computed from LD_{50s}.

Table A-3 identifies the NOAELs used in this assessment; references from which the NOAELs were derived; test species on which they are based, in some cases, the chemical form which the NOAEL is based; the toxicological test endpoint; and comparison or alternative NOAELs or RfDs which could have been used. The NOAELs for the metal COPECs are based on avian test species. The NOAELs for the organic COPECs are based primarily on laboratory rats. No adjustments were made for extrapolating between phylogenetic lines of species. In human risk assessments, RfDs are typically adjusted (lowered) by a factor of 10 to account for (make conservative) the uncertainty of extrapolating RfDs within and between species. Because of a broader range of uncertainty in ecological risk, an uncertainty factor (UF) of 10 may be inadequate in ecological risk assessment (Calabrese and Baldwin 1993). Attempts to calculate extrapolations of RfDs have been made however the bases vary from one researcher to another. For example, Sample et al. (1995) assumed that "smaller animals have higher metabolic rates and are usually more resistant to toxic chemicals because of more rapid rates of detoxification and that metabolism is proportional to body weight." Conversely, in a study of risk to vertebrates from pesticides, Tiebout and Brugger (1995) predicted that small-bodied insectivores faced the highest ecological risk. Other possible sources of uncertainty that are not necessarily exclusive of each other include

- extrapolation of acute dose derived NOAELs to chronic responses,
- lowest observed adverse effect level (LOAEL) to NOAEL conversions,
- extrapolation of sensitive-test-species data to nonsensitive or "normal" life stages,
- extrapolation of less-than-lifespan toxicological data to lifespan,
- time to achievement of contaminant steady-state in laboratory tests on which NOAELs are based, and
- laboratory to field extrapolation (Calabrese and Baldwin 1993).

Some of the above-listed factors have the potential to increase or decrease (under- or overestimate) toxicological values. Also, several instances of interdependence of UFs exist, therefore the assumption that these factors are independent in their application as UFs would likely lead to over-conservatism (Calabrese and Baldwin 1993). For these reasons, the authors believe that the collective amount of uncertainty originating from different sources is great enough and/or variable enough such that adjustment for such uncertainty would make the results unusable because of large total margins of introduced error.

Radionuclides. Ecological risk assessment at LANL sometimes does not address risk from radiation because LANL has adopted the guidance of the International Atomic Energy Agency (Ferenbaugh et al. 1996) which says that if humans are adequately protected from the effects of radiation, then other organism populations are likely to be sufficiently protected (IAEA 1992). Under this assumption, if the results of human risk assessment(s) of the same contaminated areas as assessed for the Mexican spotted owl indicate that humans are adequately protected, the conclusion would be that individuals and populations of other organisms are adequately protected. It is the individual Mexican spotted owl that is of concern in this study.

Reproduction is the primary endpoint of concern for populations of organisms. Populations can remain healthy if only a small percentage of their population has their reproductive capability adversely impaired, but individuals cannot contribute to maintaining the health of a population if those individuals are irreparably damaged. Therefore, the Mexican spotted owl was also assessed for potential impact from radionuclides. Because RfDs for radionuclides in avian species were unavailable, human risk screening action levels (SALs), in mg of radionuclide per kg of soil were used in place of RfDs. A list of SALs used appears in Table A-3.

2.8 Model

The development of methods for estimating the effects of toxic substances on animal and plant populations at LANL, with particular interest in ecosystem dynamics, is an ongoing program at this laboratory. Recent efforts to standardize the estimation methods have been published for LANL by the Environmental Science Group, EES-15, and are used as a guide for this study (Ferenbaugh 1996).

The Threatened and Endangered Species Habitat Management Plan (HMP) being developed by the Ecology Group, ESH-20, (DOE 1996) includes an ecological risk component involving threatened and endangered species (TES), which are the subject of this study. The HMP risk component for a TES does not include an initial conservative screening of contaminated sites, because, for individual screenings, unlike the proposed methodology of EES-15, the sites are not grouped into potential release sites, but into sampling locations that have identifiable North-South (N-S) and East-West (E-W) coordinates obtained from GIS through LANL's FIMAD database that are assessed for ecological risk in a cumulative manner.

2.8.1 GIS/FIMAD Data Conversion

The coordinates of these sites were converted into grid cell information for processing. Also, adequate potential release site areal definition was not available for use in the estimation method to be described, and an area equal to that of a single grid cell (100 ft x 100 ft in this application) was assigned to each source of contamination. However, provision is made for modification of the animal occupancy estimates if deemed

necessary. Otherwise, this assignment was assumed to be a conservative measure in most cases. In addition, if any contaminant from two or more sampling sites was determined to be located in the same grid cell, then an arithmetical mean of the sample concentration was used to represent that contaminant in that grid. Finally, as available background concentrations were recorded for each grid where contamination was present, (organic materials excluded) in order to estimate LANL-contributed risk. This topic is described in more detail in another section of this report.

2.8.1.1 Grid Mapping of Mexican Spotted Owl Habitat

The grid mapping of animal habitat for the study (Mexican spotted owl) was accomplished by ESH-20 investigators using the GIS method accompanied by ground truth surveys. A coding scheme was selected whereby nonhabitat grid cells were coded differently from grids within the Mexican spotted owl habitat, and finally, the potential nesting sites of these animals within the habitat were coded separately. A plot of two Mexican spotted owl potential habitats—a site situated near TA-21, and the other centralized in the vicinity of TA-40—are presented in Figures 4A and 4B, respectively. In this study it was assumed that the Mexican spotted owl would not have nesting sites outside of the nesting areas, but could forage in both the nesting and adjoining EEU-designated areas as shown in the previous figures. The foraging area around a specific nesting site or home range (HR) was estimated according to Peters (1993) for various animal types as:

HR	$= 1.39 \times BODWT^{1.37}$	mammal, carnivore,	(3a)
	$= 0.632 \times BODWT$	mammal, herbivore,	(3b)
	$= (Eq.\ 3a + Eq.\ 3b) / 2$	mammal, omnivore,	(3c)*
HR	$= 8.3 \times BODWT^{1.37}$	bird, carnivore,	(3d)
	$= 0.026 \times BODWT^{1.71}$	bird, herbivore,	(3e)
	$= (Eq.\ 3d + Eq.\ 3e) / 2$	bird, omnivore, and	(3f)*
HR	$= 0.12 \times BODWT^{0.95}$	reptiles and amphibians,	(3g)

where

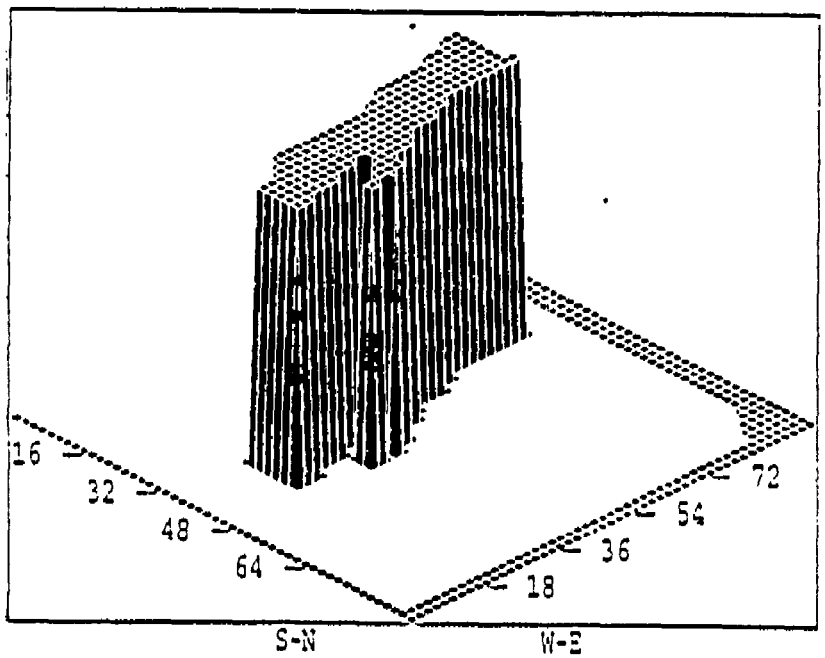
HR = animal home range, km^2 and
BODWT = animal body weight, kgfwt.

* Estimated from scatter plot data of Peters (1993) for all 3 types of foragers.

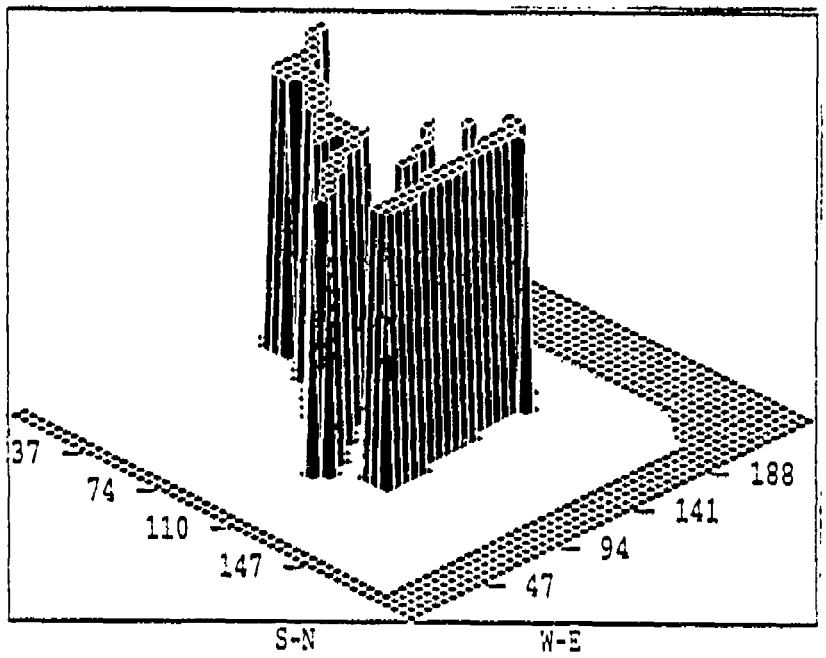
An illustration of the HR (4) for the Mexican spotted owl around a specific potential nesting site (10) on a given EEU(2) and unused nesting sites (6) is presented in Figures 5A and 5B for the TA-21 (EEU-21) and the TA-40 (EEU-40) sites, respectively. The user of the model also has the option of entering the HR directly into the code.

2.8.1.2. Computer Code Software Development For Ecorisk Determination

A set of computer codes, one of which is called ECORSK3, written in FORTRAN 77 (Salford Software Limited 1994) with graphics capability (Interactive Software Services 1992), were developed to transform GIS-FIMAD into three-dimensional graphics and to utilize the data to perform an ecological risk assessment of toxicological substances on the Mexican spotted owl in a given EEU as illustrated in Figure 6. These codes integrate EEU, nesting area, HR data, and toxicological substances locations and concentrations within a given EEU to estimate ecological risk to a specific animal and produce visual and



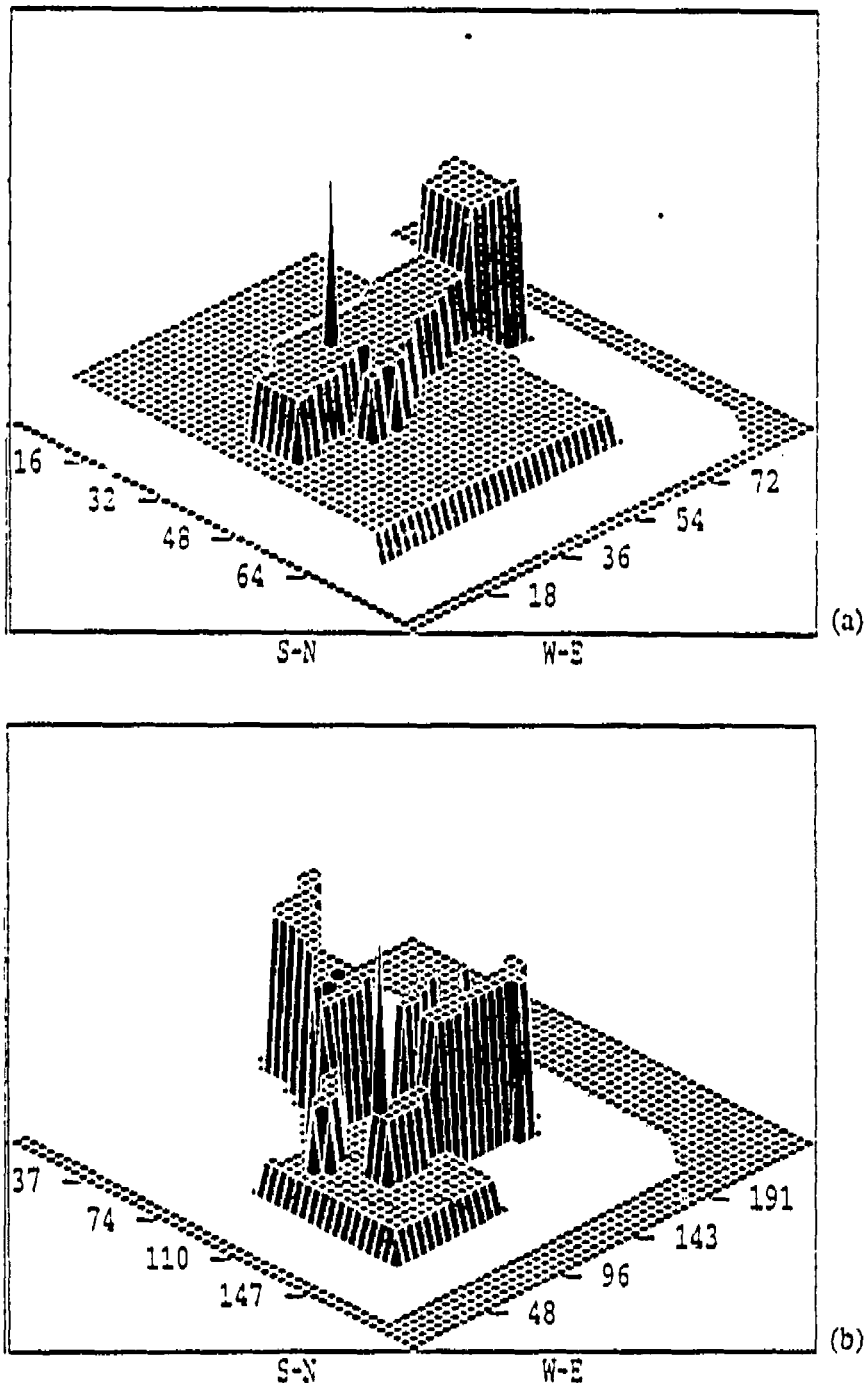
(a)



(b)

Red = Grid
Yellow = EEU
Magenta = Nest site area

Figure 4. EEU and nest sites at (a) TA-21 and (b) TA-40.



Red = Grid
Yellow = Unused EEU
Green = Home range (used EEU)
Blue = Used nest site area
Magenta = Unused nest site area
Spike = Nest site

Figure 5. Home range from nest site on (a) EEU-21and (b) EEU-40.

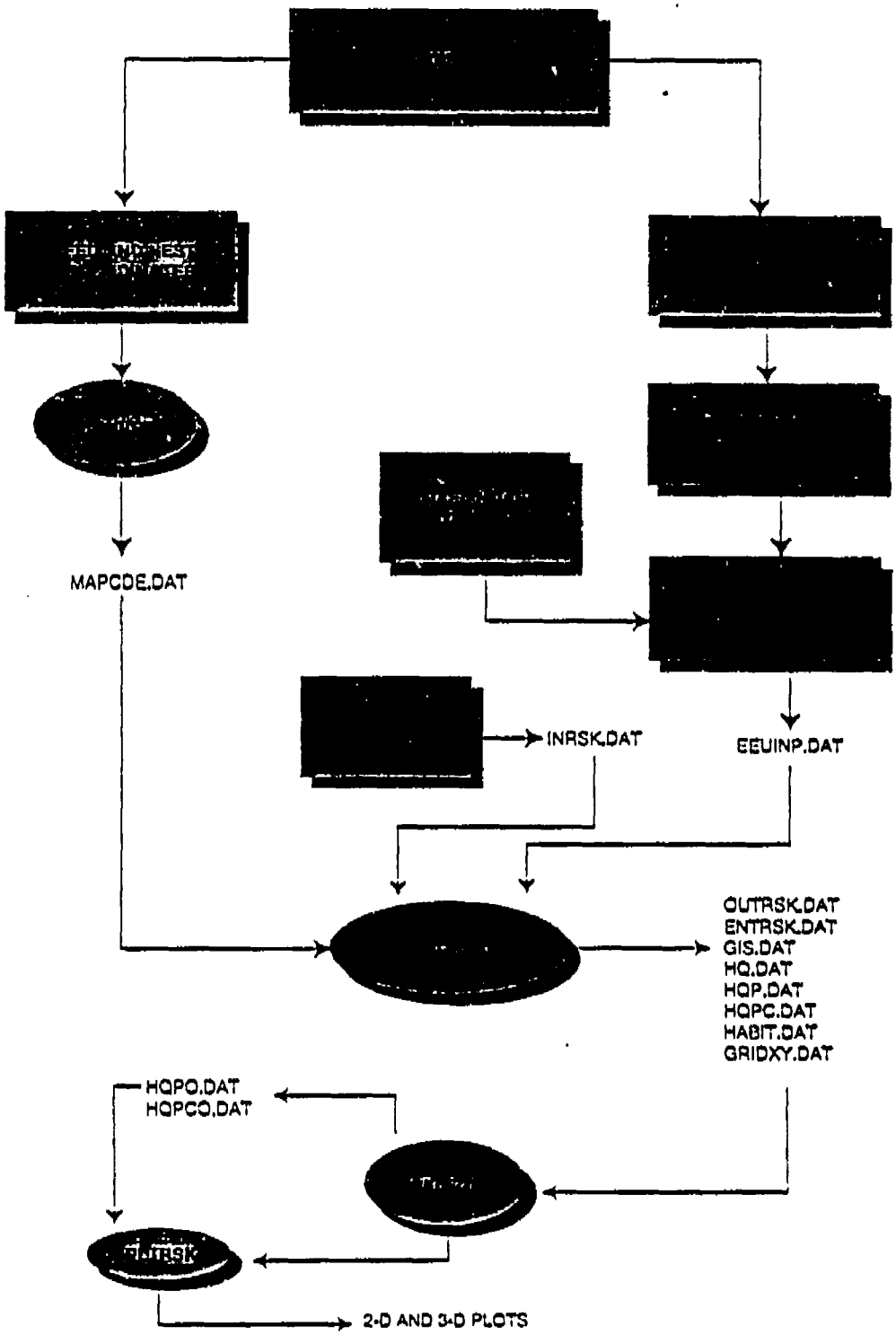


Figure 6. Fortran Code Integration Strategy with GIS and FIMAD Data

statistical representations of these estimates. The files obtained from ECORSK3 output can be further processed to produce more specific graphics via overlays on to the EEU mapping. For example, the 3-d plots in Figures 4A and 4B were produced from the gridxy.dat output file from the EEU-21 and EEU-40 runs of ECORSK3, whereas, the plots in Figures 5A and 5B for EEU-21 and EEU-40, respectively, were produced from specific nesting site information stored in output file habit.dat. Examples of 3-d plot overlays and other plots involving other output files listed in Figure 6 will be illustrated in later sections of this report when the specific type of information is under discussion. Finally, the executable versions of these codes are MS-DOS PC versions which are transportable to other PCs (for PC users without Salford/Interactive software) by appropriate Run DBOS software that is provided by Salford for this purpose. Satisfactory transport and use of these codes has been demonstrated at ESH-20 by a co-author of this report.

2.8.2. Methodological Development and Assumptions Used In Ecological Risk Assessments

The use of tools described above for the acquisition, transformation, and utilization of COPECs within the habitat of the Mexican spotted owl or other TES at LANL for estimating ecological risk are of necessity based on a number of simplifying assumptions to be described. The exceptions to the methodological development by EES-15 for ecological risk assessment for both TES and non-TES alike have been noted earlier in this report. However, there are some similarities which require discussion. In fact there are some similarities in the approach developed in this study with the efforts of the Environmental Restoration Program at LANL in assessing human risk from these same COPECs (LANL 1993). The use of human SALs in addressing the toxicological effects of radionuclides on animals is common to both the EES-15 methodological development and the one employed in this study. This is supported by an International Atomic Energy Agency report (IAEA 1992) that affirms adequate protection for animals by employing human risk criteria to this class of contaminants. The basis for this argument is that the human standard (10 mrem/yr) is 3650 times more protective (lower) than current animal protection criteria of about 10 mrad/day. This is an issue of current consideration, but remains the position of EES-15 because soil SALs for animals are not available.

2.8.2.1 Hazard Quotient Method for Ecological Risk Assessment

The underpinning of the methods for this study is the use of the HQ method in making ecological risk assessments. It is currently being used with respect to human health assessment at LANL (LANL 1993), and is to be used in a tiered approach for animals by EES-15 (Ferenbaugh 1996). The HQ is based on the ratio of an actual dose of a potentially toxic substance or COPEC that an animal consumes on a chronic basis to a toxicological chronic RfD which, if exceeded, may cause an observable adverse effect:

$$HQ = D_c / D_r \qquad (4a)$$

where

HQ = hazard quotient,
D_c = chronically consumed dose, mg-COPEC/kg-body weight-day, and

D_r = consumed dose above which observable adverse effects may occur, mg-COPEC/kg-body weight-day.

Several assumptions with respect to this relationship must be recognized: A predetermined estimate of ingested dose of COPEC is not readily available for wildlife, and must be estimated from a variety of food and non-food sources into the gut of an animal. This approach would require the use of more sophisticated ecological transport models such as ECOTRAN (Gallegos 1996) to make this assessment on food chain and non-food chain bases which would include air particulate transport and soil ingestion as well. The approach taken for this study is to assume that soil ingestion is the primary dose constituent to the animal, and that it suffices to use an estimate of contaminated soil ingestion to make this approximation. There are some limitations to this approach where biomagnification occurs between species in different trophic levels, and it may be necessary to address this issue in a separate study if significant concentrations of COPECs with this type of property are present in a given EEU.

The next major assumption concerns the choice of a proper toxicological reference point to apply to a given wildlife species. The employment of NOAEL or LOAEL (EPA 1992) is subject to uncertainty when extrapolating between animals of similar and different phylogenetic lines (Calabrese and Baldwin 1993). Some discussion of this is made in another section of this report. Efforts were made to match NOAEL/LOAEL data within phylogenetic lines when possible. In either case, extrapolations were not made between phylogenetic lines.

2.8.2.2 Hazard Quotient Method using SALs

The HQ method using human SALs for animals is similar to the HQ method involving ingested doses:

$$HQ = SC / SAL, \qquad (4b)$$

where

HQ = hazard quotient,
SC = soil concentration of COPEC, mg-COPEC/kg-soil, and
SAL= screening action level, mg-COPEC/kg-soil.

The SAL is estimated using the RESRAD code for radionuclide exposure to humans from elements of the food chain and non-food chain deposition processes (LANL 1993). This study uses the above relationship for estimating radionuclide HQs, although they are additive with HQs developed from dose information. Both Equations 4a and 4b are limited in field applications where COPEC ingestion must be integrated from HR and potential nest site considerations, and are presented in this report to illustrate the basic building block of the cumulative HQ estimation that is used by ECORSK3.

2.8.3 Cumulative HQ Estimation Method using ECORSK3

The model ECORSK3 integrates GIS information with basic toxicological information on a number of COPECs with basic physiological data to estimate Hazard Indices (cumulative HQs) from more than one COPEC in the EEU of a specific animal such as the Mexican spotted owl:

$$HI = Food \times Soilf / Bodwt \times \sum_{j=1}^{ncs} Occup_j \sum_{l=1}^{ncoc} Dc_{j,l} \, (Dr_l \times Dar_l), \quad \text{non-radionuclides} \qquad (5a)$$

or,

$$HI = \sum_{j=1}^{ncs} Occup_j \sum_{l=1}^{ncoc} SC_{j,l} \, / \, (SAL_l \times SALa_l), \quad \text{radionuclides} \qquad (5b)$$

where

HI	= cumulative HQ for all COPECs,
Food	= amount of food consumed by a given animal, kg/day,
Soilf	= fraction of food ingestion consumed as soil,
$Occup_j$	= occupancy factor on the jth contamination site,
$Dc_{j,l}$	= chronically consumed dose, mg-COPEC/kg-body weight-day for the jth contamination site (exposure dose) of the lth COPEC
Dr_l	= consumed dose above which observable adverse effects may occur, mg-COPEC/kg-body weight-day of the lth COPEC,
Dar_l	= adjustment factor for Dr_l above for the lth COPEC,
$SC_{j,l}$	= soil concentration of COPEC, mg-COPEC/kg-soil for the jth contamination site of the lth COPEC,
SAL_l	= screening action level, mg-COPEC/kg-soil of the lth COPEC,
$SALa_l$	= adjustment factor for SAL_l above for the lth COPEC,
ncs	= number of contamination sites, and
ncoc	= number of contaminants in the jth contamination site.

This approach assumes that sub-lethal doses of various contaminants are additive in their effect, rather than synergistic, antagonistic, or independent.

The following subsections will present a discussion of those elements in the above relationships which have not received adequate attention to clarify the use of the equations.

2.8.3.1. Daily Food Consumption (Food)

Daily food consumption of a given animal is estimated in ECORSK3 using the following relationships (EPA 1993):

$$Food = 0.0687 \times BODWT^{0.886} \text{ mammals,} \qquad (6a)$$

$$Food = 0.0582 \times BODWT^{0.651} \text{ birds,} \qquad (6b)$$

$$Food = 0.0135 \times (BODWT * 1000)^{0.773} \text{ reptiles and amphibians,} \qquad (6c)$$

where:

Food = food consumption rate, kg/day, of dry matter and

BODWT = body weight of animal, kgfwt.

It should be noted that these equations represent relationships that can be applied to the general types of animals specified above, however, more specific relationships for special subtypes are also available if more precision is required.

2.8.3.2. Soil Intake Fraction (Soilf) and Body Weight (BODWT)

The amount of soil consumed by wildlife animals during feeding varies considerably depending on feeding strategy and type of food consumed (Beyer et al. 1994). Our estimate for the Mexican spotted owl is that five percent of its dietary intake consists of soil, and this value was used as input to the ECORSK3 model. Also, a body weight of 0.55 kgfwt was assumed for both male and female Mexican spotted owl, although some variation occurs between and within sexes. More detailed information on the selection of these parameters is presented in another section of this report.

2.8.3.3. Occupancy Factor (Occup)

Occupancy factors are defined in this study as the fraction of the time in a given day that an animal spends feeding in a given area. Furthermore, it is assumed to be time averaged over a long period to obtain a probabilistic relationship. This factor can be determined on an areal basis if it is assumed that any given area within an animal's habitat is equally likely to serve as a feeding location for a given animal over the long term. However, many factors could restrict or enhance a given area to support feeding activities depending on the distribution of food in the EEU, and the relative accessibility of that area. The occupancy factor used for this study involving the Mexican spotted owl is that all grid areas are equally accessible if they are within the HR of that animal:

$$Occup_i = A_i / \sum_{j=1}^{ng} A_j \, Ef_j \qquad (7)$$

where:

$Occup_i$ = occupancy factor of the ith grid,
A_i = area, km^2, of the ith grid within the HR of a given animal,
A_j = area, km^2, of the jth grid within the HR of a given animal,
Ef_j = enhancement factor of the jth grid within the HR of a given animal, and
ng = number of grid cells sites within the HR of a given animal.

Since the enhancement factor is part of the ECORSK3 input, the user is able to modify this relationship to reflect increased or decreased feeding in a specific grid area. It was noted earlier in this section that the mean contamination of a given COPEC is assumed to apply to the entire grid cell as defined in the model. Hence, the enhancement factor can be used to modify this assumption if desired. It should be evident from this discussion that the location of the potential nesting site within an EEU is going to determine which contaminated and noncontaminated grid cells are going to be included in the summation portion of Eq. 7, and the selection process employed will be discussed in the following subsection.

2.8.4. ECORSK3 Model Operation Strategies

Model operation follows an ordered procedure that can be summarized as follows:

- Create output files and enter input parameters;

- From input parameters
  - create grid system,
  - define EEU on grid system,
  - define potential nesting area on grid system,
  - locate COPECs on EEU,
  - define the HR from animal allometric data, and
  - define food intake rate from animal allometric data.

- Establish potential nesting sites on nesting area on
  - contaminated grids within the nesting area,
  - random nest sites within the nesting area, or
  - selected or known nesting sites within the nesting area.

- Establish grid cells to be included within the HR from a given potential nest site.

- Determine contaminated grid cells within the HR from a given nest site.

- Estimate HI from all contaminated grid cells in HR from a given nest site for a given COPEC.

- Repeat for each COPEC.

- Repeat for another potential nest site.

- Output partial and total HQ estimates.

- Plot 3-D graphics of partial and total HQ estimates.

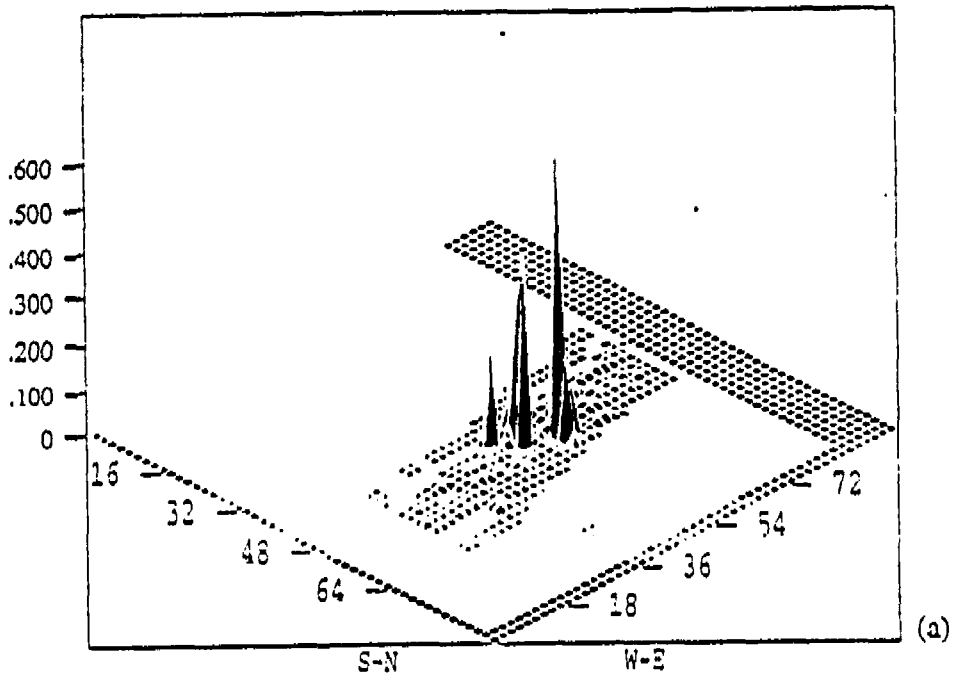
2.8.4.1 Nest Site Establishment

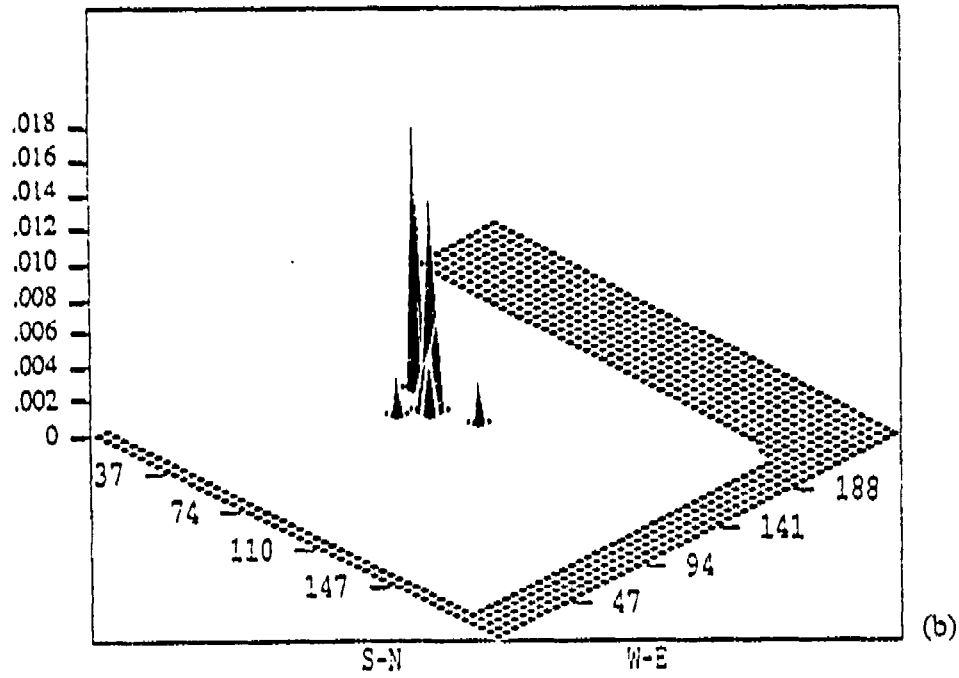
The selection of potential nest sites on contaminated grid cells within the nesting was used for HQ determinations to determine if any clustering of contaminated sites would result in significantly different HQs when compared with random nest site selections that are presented in Figures 7A and 7B for the Mexican spotted owl on EEU-21 and EEU-40 sites, respectively. These plots illustrate the variation of total (cumulative) HQs from different nesting sites. A comparison of these two nest selection strategies is discussed in another section of this report, and the importance of making these comparisons is presented in the results section of this report.

2.8.4.2 Establishment of Grid Cells to be Included for a Given Nest Site

After establishment of a given nest site to be used in the HQ determination, the model uses the HR estimate to determine specific grid cells within the EEU that are included around the specific nest site.

This is accomplished by systematically increasing the coordinates around a potential nest site in inscribed squares within increasing concentric circles formed around the nest site that results in a "square doughnut" appearance, and increasing square doughnut holes in the middle. This iterative process is repeated until the sum of the enclosed grid cells equals the HR of the animal in question. The selected grid cells must be within the EEU of the animal in question, or they are





Red = Grid
Yellow = EEU
Green and Blue = Partial HQs
Y-Axis = HQ

Figure 7. Partial HQs at (a) nest site 53-46 at EEQ-21 and (b) nest site 105-79 at EEQ-40.

rejected. Consequently, the final pattern of the selected grid cells may deviate from a perfect square around the potential nest site. Finally, this routine is repeated for each potential nest site selected in the model.

2.8.4.3 Identification of Contaminated Grid Cells in the HR for a Given Nest Site

The model searches each grid cell within a HR around a nest site for COPECs to be included in HQ calculations. In addition, it searches the perimeter of the HR and includes contaminated grid cells within one grid cell length in the HQ calculations for a given nest site. This strategy is followed because all contaminated grid cells are assigned the next highest cell numbers on both grid axes. For example, if the grid coordinates of a given contaminated grid are estimated as 15.5 and 120.2, for X- and Y-axes, respectively, they are coded as 16 and 121 for use in the model. The model also addresses contamination areas which may exceed the area of a grid cell. If the latter is made to occupy more than one grid area, then the overlap from the perimeter of the HR can exceed the length of a grid cell.

2.8.4.4 HQ Estimation Procedure

The model tests each contaminated grid cell within the HR of an animal at a given potential nest site for completeness of information required for executing Eqs. 5a and 5b above. This is necessary because the database obtained through FIMAD may not have information for all COPECs it identifies within the EEU of a given animal such as the Mexican spotted owl. Hence, all concentration values that are reported as being less than zero are set to zero. Furthermore, if the reported contaminant concentration is below mean background (organic contaminants excluded), then the sample concentrations are made equal to the reported background levels. Similarly, if the toxicological reference dose (Dr) described in Eq. 5a was not included or reported as zero, then the corresponding COPEC is excluded from the HQ calculations. The same criteria applies to SAL data reporting (Eq. 5b). Hence, the number of COPECs for which an HQ is estimated may vary. The database containing this information (eeuinp.dat) should be updated, and HQ estimates should be recalculated periodically.

2.8.5 Model Output

The reporting of results in this section from the output of ECORSK3 will be limited to the description of 3-d graphical output. The statistical and other analytical output is discussed in the results and discussion sections of this report.

The presentation given here is only a small portion of the potential output for this model, but should suffice in illustrating 3-d output capabilities. Three 3-d plots have already been presented, one of which required overlaying of total HQ data output (hq.dat) for a given random nest site on the EEU grid file (gridxy.dat). Other plotting options are described below.

2.8.5.1 Demonstrated 3-D Graphics of Partial HQs from Contaminated Grids for a Given Nest Site

The ECORSK3 model outputs partial HQs from all contaminated grid cells within the HR surrounding each potential nest site specified (hqp.dat). Using the SELECT code (hqpo.dat, see Figure 6), the user can select a specific nest site and view the partial HQs from each

contaminated grid within the HR of a given animal's nest site. The plots shown in Figures 8A and 8B show the partial HQs contributing to the total HQ on specific nest sites on EEU-21 and EEU-40, respectively. There is a significant difference in size between the sites, and it is reflected in the observed variance of the partial HQs. On the TA-21 site, practically all of the EEU is included in most HR determinations, and one would expect less variation than where the EEU is significantly larger than the HR of the Mexican spotted owl. All 3-d plots are generated from the code PLTRSK as illustrated in Figure 6.

2.8.5.2 Demonstrated 3-D Graphics of Total HQs from Specific COPECs from Contaminated Grids in an HR

The model also outputs total HQs by COPEC for 3-d graphics presentation (hqpc.dat) which can then be used as input to SELECT to produce an output (hqpco.dat) which is then used as input to PLTRSK to create the desired plots. The plots shown in Figures 9A and 9B for EEU-21, and Figures 10A and 10B for EEU-40 show the effects of several COPECs on the overall total HQ from all COPECs combined. The specific COPECs selected for plotting contributed significantly to the overall HQ in each case. Note the unequal contribution of HQ from these COPECs from different nest sites.

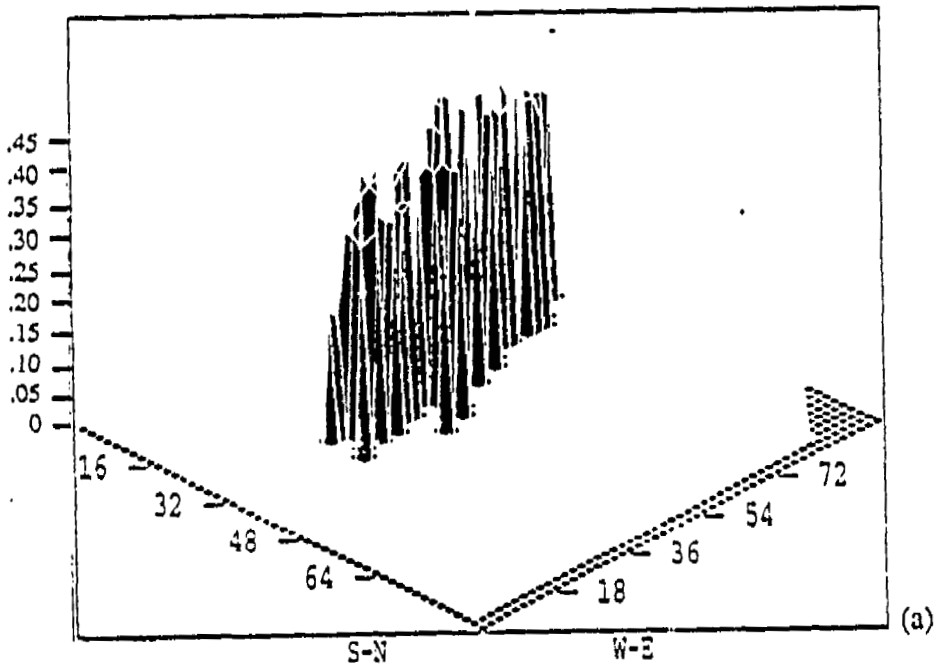
2.9 Statistical Analyses

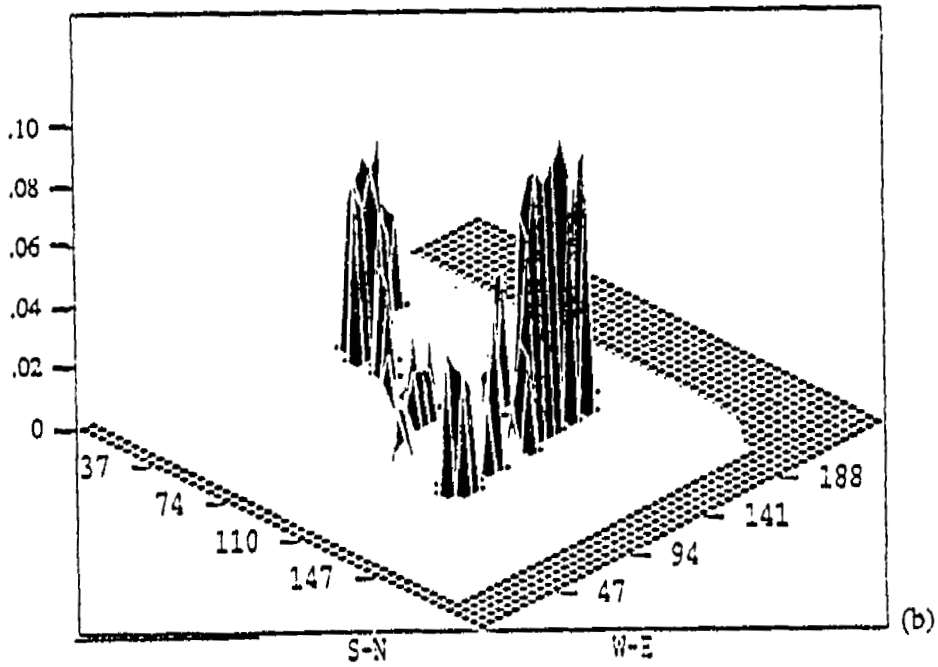
Model output data were imported to spreadsheet format and COPECs and contaminated grid cell locations were sorted by HQ in descending order. This enabled the identification of the most problematic COPECs and locations on a relative basis.

Treating Risk Sources as "treatments" and defining replications as the number of randomly-located or specified nest sites within any Risk Source, analyses of variance (ANOVA) for data with a single criterion of classification for any number of groups with unequal replication were performed as a method of detecting nonspecific differences between HI means for Unadjusted, Background, and Contaminated Nest Site Risk Sources (Steel and Torrie 1980). Duncan's New Multiple Range Test was applied to Risk Source HI means such that each HI mean was compared with every other HI mean within an EEU (Steel and Torrie 1980). This was performed in order to detect which, if any, specific means differed statistically.

3.0 Results

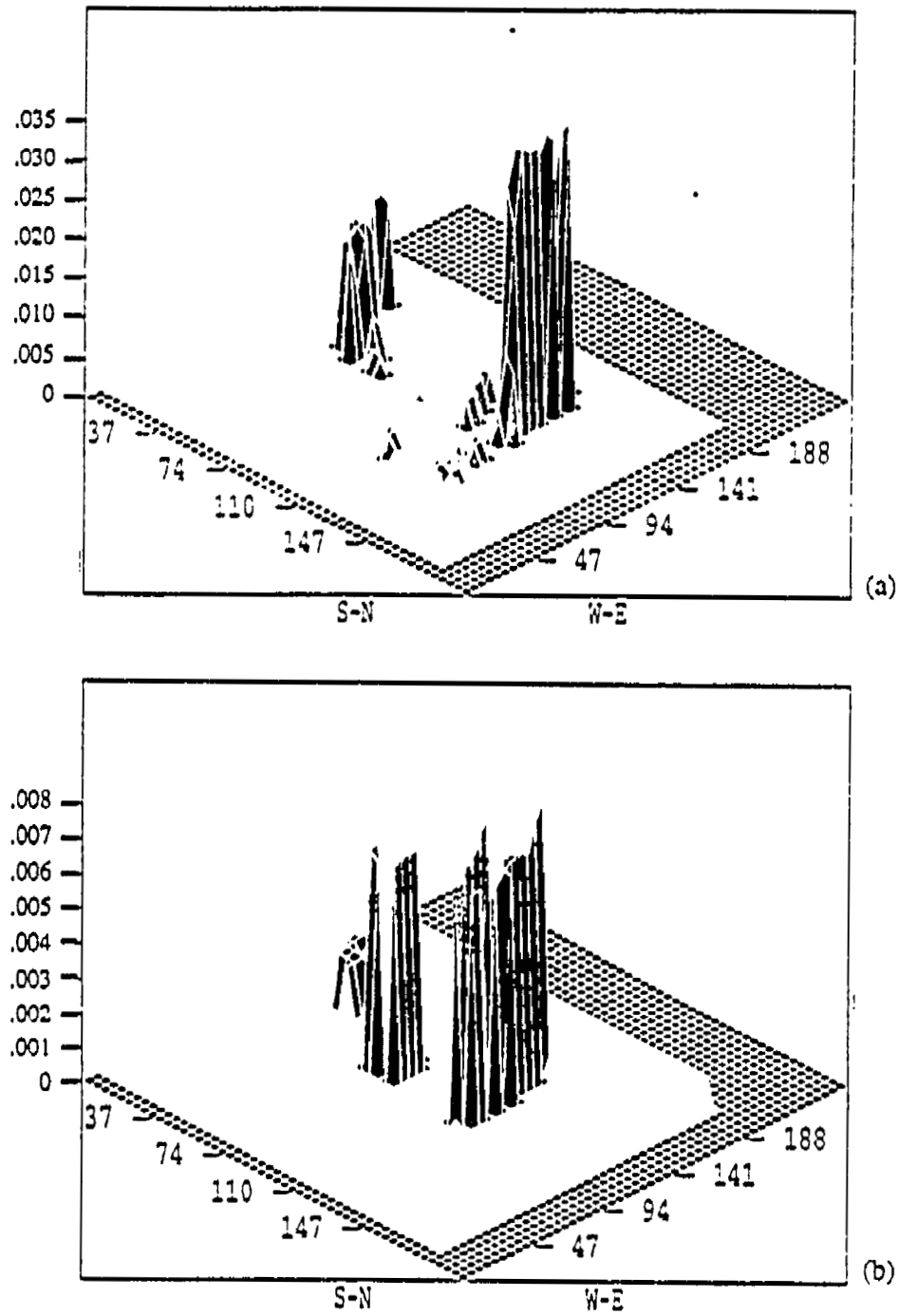
Table 2 reports the HI for "Unadjusted," "Background," and "Contaminated Nest Site" data for EEU-21 and EEU-40. The Unadjusted HI, calculated as the mean total HQ, is 0.44 and 0.05 for EEU-21 and EEU-40, respectively. The HI is a sum of the HQs for all COPECs, thus serving as an index of cumulative effects from multiple contaminants and multiple sites. Hazard indices less than 1.0 indicate that, under the assumptions and conditions applied, the sites pose no unacceptable risk to the Mexican spotted owl. The HI measures additive or linear effects, making no measure of threshold or synergistic effects, amelioristic effects, bioaccumulation, bioconcentration, nor biomagnification. Also, little, if any, information exists in published literature on the toxicological or ecotoxicological effects of environmental contaminants on owls, therefore RfDs from laboratory studies on other avian and mammal species were used.





Red = Grid
Yellow = EEU
Green, Blue, Violet = HQs
Y-Axis = HQs

Figure 8. Total HQs from all next sites at (a) EEU-21 and (b) EEU-40.



Red = Grid
Yellow = EEU
Green, Blue, Violet = HQs
Y-Axis = HQs

Figure 10. Total HQs from (a) K-40 and (b) antimony at random nest sites at EEU-40.

Table 2. Hazard index (HI) and mean partial hazard quotients (HQs) for the Mexican spotted owl preliminary ecological risk assessment at the Los Alamos National Laboratory. HI and HQ values are followed by the mean standard error and number of observations in parenthesis.

Ecological Exposure Unit	Hazard Index (Cumulative)	Mean Partial HQ (x Loc ID)	Mean Partial HQ (x Loc ID x COPEC)
EEU-21			
Unadjusted x Random Nest	0.44[a] (±3.40 E-02) (100)	1.12E-03 (±4.54E-03) (38829)	5.38E-05 (±6.33-04) (807560)
Background x Random Nest	0.14[b] (±1.37E-02) (100)	3.63E-04 (±2.13E-04) (38829)	2.02E-05 (±4.63E-05) (695223)
Nest Sites on Contaminated Sites Within Nesting Zone	0.44[a] (±3.13E-02) (86)	1.13E-03 (±4.56E-03) (33429)	5.41E-05 (±6.35E-04) (699700)
EEU-40			
Unadjusted x Random Nest	4.76E-02[a] (±2.54E-02) (100)	5.99E-04 (±8.34E-04) (7956)	3.07E-05 (±1.69E-04) (155370)
Background x Random Nest	3.70E-02[a] (±3.32E-02) (100)	4.54E-04 (±3.00E-04) (8158)	2.55E-05 (±6.55E-05) (145419)
Nest Sites on Contaminated Sites Within Nesting Zone	2.05E-02[a] (±9.06E-03) (16)	5.71E-04 (1.50E-03) (574)	2.95E-05 (±3.36E-04) (11115)

Within each EEU, any two HI values with the same letter are significantly different at $\alpha = 0.05$

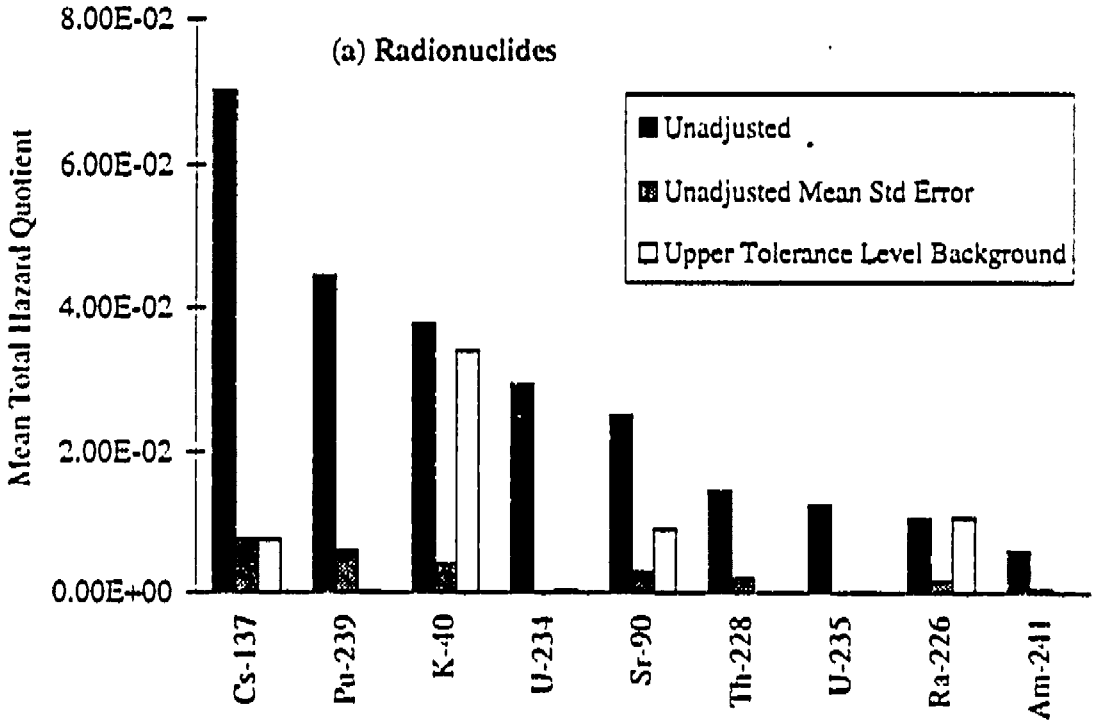
Tables A-4 and A-5 in the appendix identify the cumulative HQs for each of the 100 replications that, when averaged, result in the HI. Tables A-6 and A-7 in the appendix present HQs by COPEC totaled across contaminated sites (grid cells) for the Mexican spotted owl in EEU-21 and EEU-40, respectively. These results also indicate that the sites pose no unacceptable risk to the Mexican spotted owl.

The F value, a product of ANOVA and used for generally detecting differences between arithmetic means, was significant for both EEUs, indicating that differences may exist between Unadjusted, Background, and Contaminated Nest Site HI means (Tables A-8 and A-9 in the appendix). Duncan's new multiple range test revealed that for EEU-21, the Background HI was significantly (α = 0.05) lower than Unadjusted and Contaminated Nest Site HIs (Table A-8). For EEU-40, the multiple range test indicated no significant differences between means at the 95% confidence level (Table A-9).

Figures 11 and 12 show the HQ by COPEC totaled across grid cells for the COPECs with the highest HQs for the Unajusted Risk. Tables A-6, A-7, A-10, and A-11 in the appendix present this type of value for all COPECs for which an HQ could be calculated (i.e., for which an RfD was available). Cesium-137, K-40, Al, and V were common to the top 10 COPECs for the two EEUs. The COPEC with the highest HQ for either EEU, Cs-137 (Table A-6), is about an order of magnitude below the value necessary to present an unacceptable potential risk to the owl.

Figures 13 and 14 show the spatial distribution of HQ ranges for contaminated grid cells in EEU-21 and EEU-40, respectively. The plotted HQ ranges in Figures 13 and 14 represent the risk contributed by each contaminated grid cell to the total risk (HI) for potential nest #10 of EEU-21 and potential nest #'s 40, 43 and 98 of EEU-40. The highest contribution to risk in EEU-21 is from a small cluster of partial HQs located centrally on the northern edge of the nesting/roosting zone, extending northeasterly across TA-21 and into DP Canyon (Fig. 13). The highest partial HQs in EEU-40 are in TAs 15 and 50.

Figure 15 shows the distribution of Unadjusted HIs (cumulative HQs) for each of 100 random potential nest sites of EEU-40. The potential nest sites with the highest relative risk are clustered in the areas (1) of the eastern one-half of Pajarito Canyon; and (2) where Water Canyon meets Cañon de Valle adjacent to the DARHT.



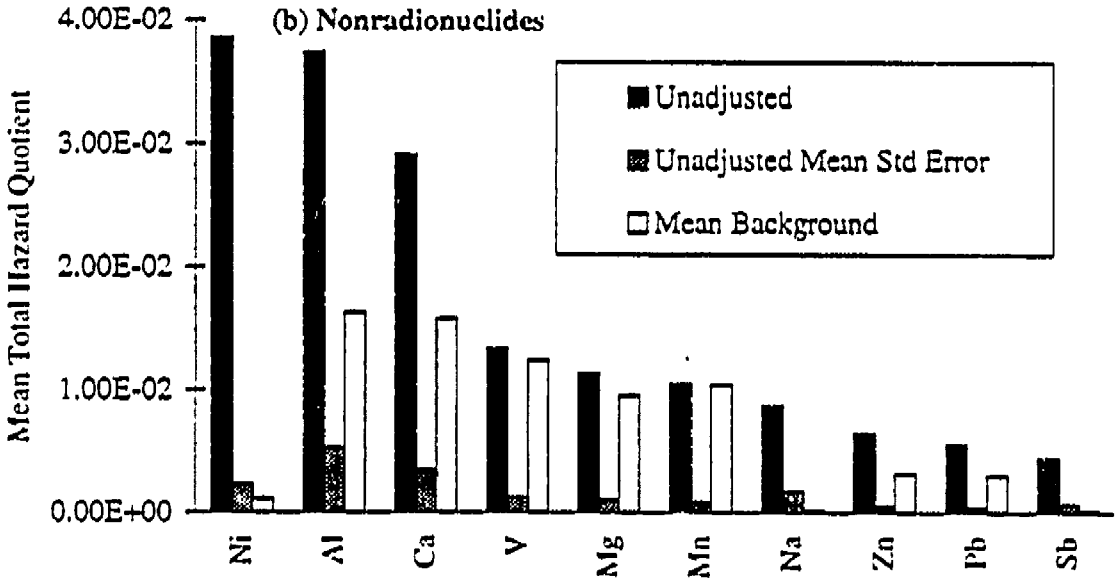
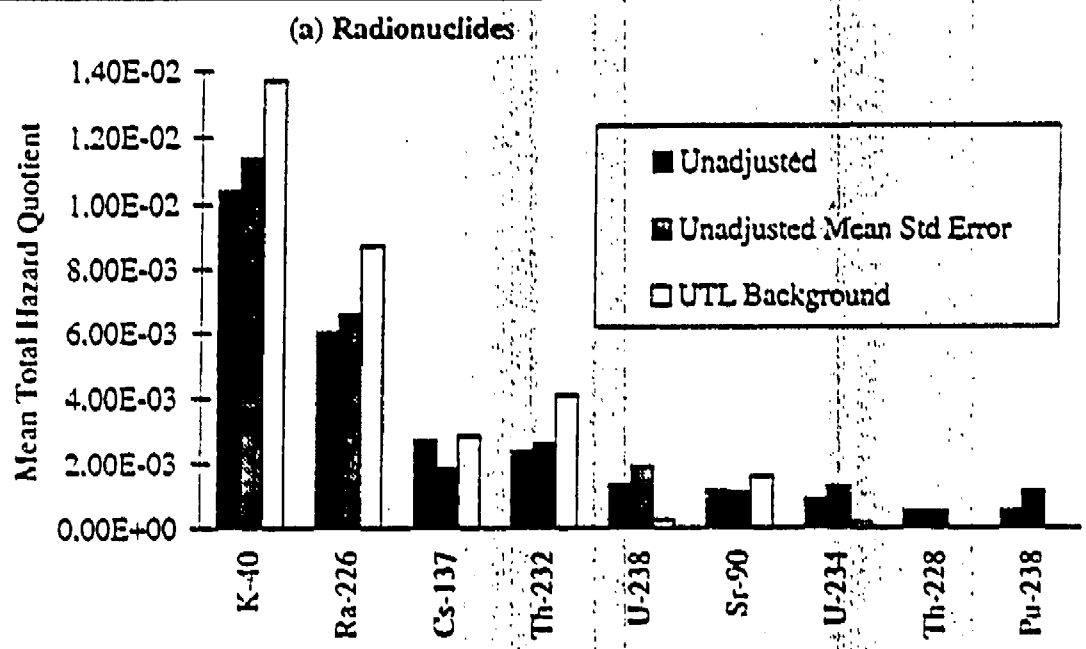


Figure 11. Risk Associated with Unadjusted and Background Soil Concentrations for (a) Radionuclides, and (b) Nonradionuclides in the Preliminary Ecological Risk Assessment of the Mexican Spotted Owl at LANL, Ecological Exposure Unit - 21.



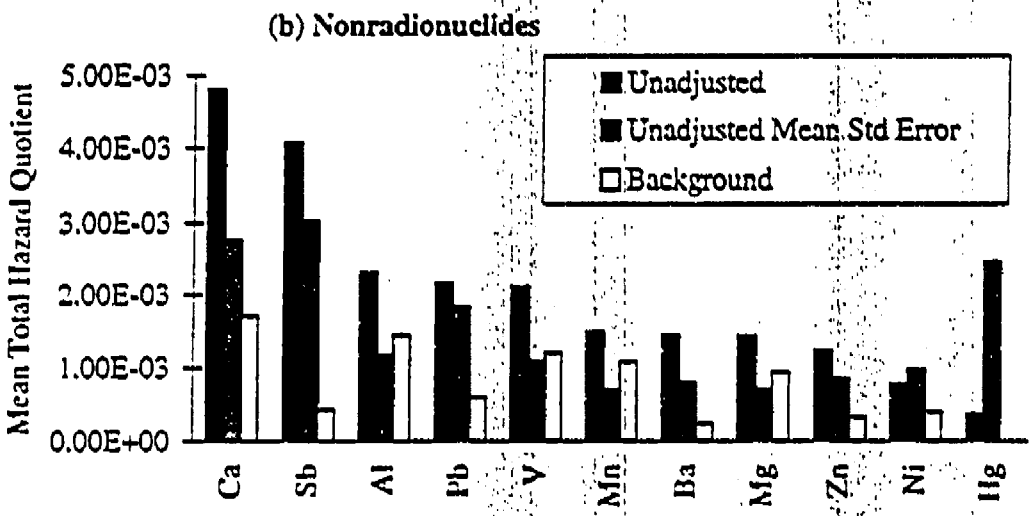


Figure 12. Risk Associated with Unadjusted and Background Soil Concentrations for (a) Radionuclides, (b) Nonradionuclides in the Preliminary Ecological Risk Assessment of the Mexican Spotted Owl at LANL, Ecological Exposure Unit - 40.

4.0 Discussion

Data such as that in Figures 13 and 14 can be used to identify the locations of contamination, which if managed, would most effectively maintain the risk to the owl from contamination at acceptably low levels. Data such as that in Figure 15 on the geographical distribution of risk by nest location can be used to identify how to manage the spatial aspects of owl habitat so that risk to the owl is maintained at acceptably low levels; this could include the management of owl habitat, DARHT operations and/or siting of new facilities.

Little, if any, toxicological information on owls is available in the published literature. Esselink et al. (1995) found no indications of toxic effects on the barn owl (*Tyto alba guttata*) from Cd, Cu, Pb, Mn, or Fe at respective median levels of 1.09, 14.5, 0.94, 6.7, and 785 mg contaminant/kg drywt organ tissue for the kidney. Respective levels of these same metals in the liver that were associated with no toxic effects were 0.55, 29.2, 0.64, 9.8, and 1466 mg/kg. Respective tibia levels of 0.03, 1.80, 1.54, 2.60, and 45 mg/kg also were not associated with adverse effects.

The potential for COPECs to bioaccumulate, bioconcentrate, or biomagnify in the Mexican spotted owl was not assessed in this study. Bioaccumulation is the gradual buildup of a contaminant in an owl over time as the owl is exposed repeatedly through time. Bioconcentration is the selective build-up of a contaminant by an organ or organs of the owl to levels that are aproportional in comparison to the blood concentration or to other organs and resulting from a single exposure. Bioconcentration is the buildup of contaminants as they are passed through food chains through time by virtue of the fact that an organism consumes many times its weight over its life span. A few cases in history have implied that the higher the trophic level of an organism on a food chain, the greater is its susceptibility for biomagnification (Leidy 1980). In this scenario, carnivores such as the Mexican spotted owl could be more subject to biomagnification than herbivores. However biomagnification is more apparent in aquatic systems than terrestrial and recent studies question the validity of biomagnification in terrestrial systems (Laskowski 1991).

While biomagnification of the chlorinated hydrocarbons (organochlorines) is fairly well proven (Walker 1990), the concentration of heavy metals in animals is not necessarily a property of food chains (Laskowski 1991). Heavy metal biomagnification has been implicated mostly in mammals (Shore and Douben 1994, Hegstrom and West 1989, Ma 1987). Conclusions to the contrary are that

- heavy metal biomagnification is not a rule in terrestrial food chains (Lazkowski 1991, Beyer et al. 1985, Grodzinska et al. 1987, Willamo and Nuorteva 1987, Nuorteva 1988),

- "biomagnification alone cannot lead to very high concentrations of most heavy metals in top carnivores" (Laskowski 1991), and

- "biomagnification cannot be responsible for toxic effects of heavy metals in terrestrial carnivores" (Laskowski 1991).

Of the top 10 COPECs in EEU-21 and EEU-40, nickel, aluminum, antimony, lead, vanadium, and manganese are metals.

Organic forms of mercury (Hg) are documented as being especially prone to biomagnification. Only inorganic Hg was considered in this study. Although canyon bottoms are likely to contain anaerobes that are capable of methylating Hg, its relative rank in cumulative HQ was 32nd for EEU-21 and 20th for EEU-40. The highest-HQ organics for EEU-21 were fluoranthene and pentachlorophenol with HQs of 1.59E-06 and 1.07E-06, respectively (Table A-6). For EEU-40 the highest-HQ organics were dieldrin and methoxychlor with HQs of 4.86E-06 and 1.82E-06, respectively (Table A-7).

Even if a worst case UF of 1000 (Calabrese and Baldwin 1993) for extrapolating RfDs across phylogenetic lines in aquatic systems were applied in this terrestrial system to the chlorinated hydrocarbon COPECs, the highest HQs would still only be in the 1E-03 range. Nevertheless, the issue of contaminant potential biomagnification in the Mexican spotted owl cannot yet be completely dispelled because

- biomagnification of heavy metals to toxic levels can occur from relatively low concentrations in soil (Ma 1987),

- even if a chemical or its metabolites have high NOAELs in long-term ecotoxicity or toxicity tests, incomplete metabolic elimination of contaminants, also known as bound residues, can result in unacceptable risk from bioaccumulation or biomagnification (Franke et al. 1994),

- bioconcentration factors (BCFs) have not yet been specifically established for the particular site conditions and receptor of this study.

The Quotient Method does not assess the likelihood of the effect(s) under consideration. Using a more sophisticated ecological transport model such as ECOTRAN (Gallegos 1996) greater insight into the magnitude of the effects expected at various levels of exposure can be obtained by evaluating the full stressor-response curve instead of a single point and by considering the frequency, timing, and duration of the exposure (EPA 1996, 1992).

This study assessed the potential effects on the Mexican spotted owl that existing soil contaminants within the Mexican spotted owl foraging area might have. The existing contamination studied has no particular relevance to the DARHT except for any, if any, additional contribution that the DARHT may make to the existing contaminant load. Potential effects to the Mexican spotted owl from activities related specifically to the DARHT have only been qualitatively postulated (DOE 1996; Keller and Risberg 1995). Potential contaminant releases from normal and off-normal operations and from postulated accidents involving the DARHT as identified in the DARHT EIS (DOE 1996) and in the DARHT Biological Assessment (Keller and Risberg 1995) must be quantitatively assessed for potential impact to the Mexican spotted owl in order to meet the DARHT-related commitments made by the DOE regarding protection of natural resources. In a pilot study at LANL (LANL 1995) a methodology was developed which can be modified for making this assessment.

Additional TES to be assessed in fiscal year 1997 include the peregrine falcon, bald eagle, southwestern willow flycatcher, Jemez Mountain salamander, and New Mexico meadow jumping mouse.

5.0 Conclusions

The assumptions, conditions, and factors in Table 3, categorized according to whether we consider them "conservative," "realistic," or "nonconservative," were used in calculating risk from contaminants to the Mexican spotted owl.

Table 3. The assumptions, conditions, and factors used in calculating risk from contaminants.

Conservative	Realistic	Nonconservative
		risk not estimated for contaminants for which RfDs not available
radioactive decay of radionuclides not calculated		
		environmental restoration not factored
		quotient method not probabilistic
antagonism not assessed		
FIMAD database is current and accurate	FIMAD database is current and accurate	FIMAD database is current and accurate
organics NOAELs, based on rats & humans, likely lower than would be for avian test species	RfDs/NOAELs for metals based on avian test species and are chronic	uncertainty factor not applied to across-animal-class NOAELs for organic COPECs
	% of dietary food intake as soil = 5	
	mean natural background COPEC values, not UTLs, used for inorganics	
	average, not maximum, COPEC soil concentrations used	
contamination level measured at sampling points assumed for 100 x 100 ft area		
assumed bioavailability of COPECs = 100%		

Under the assumptions and conditions applied in this study, the sites pose no unacceptable risk to the Mexican spotted owl. Additional assessment is needed in the areas of

- potential biomagnification,
- the establishment of NOAELs for the organic and radionuclide COPECs that are more directly applicable to avian species,
- exposure pathway definition,
- toxicological information on the Mexican spotted owl, and
- grouping of COPECs by biological effect types, including the consideration of synergism and/or antagonism.

Per the discussion section, impact to the Mexican spotted owl from potential contaminant releases identified in the DARHT EIS as related to normal, off-normal and accident conditions remain to be quantitatively assessed in order to meet commitments made by the Department of Energy.

Acknowledgments

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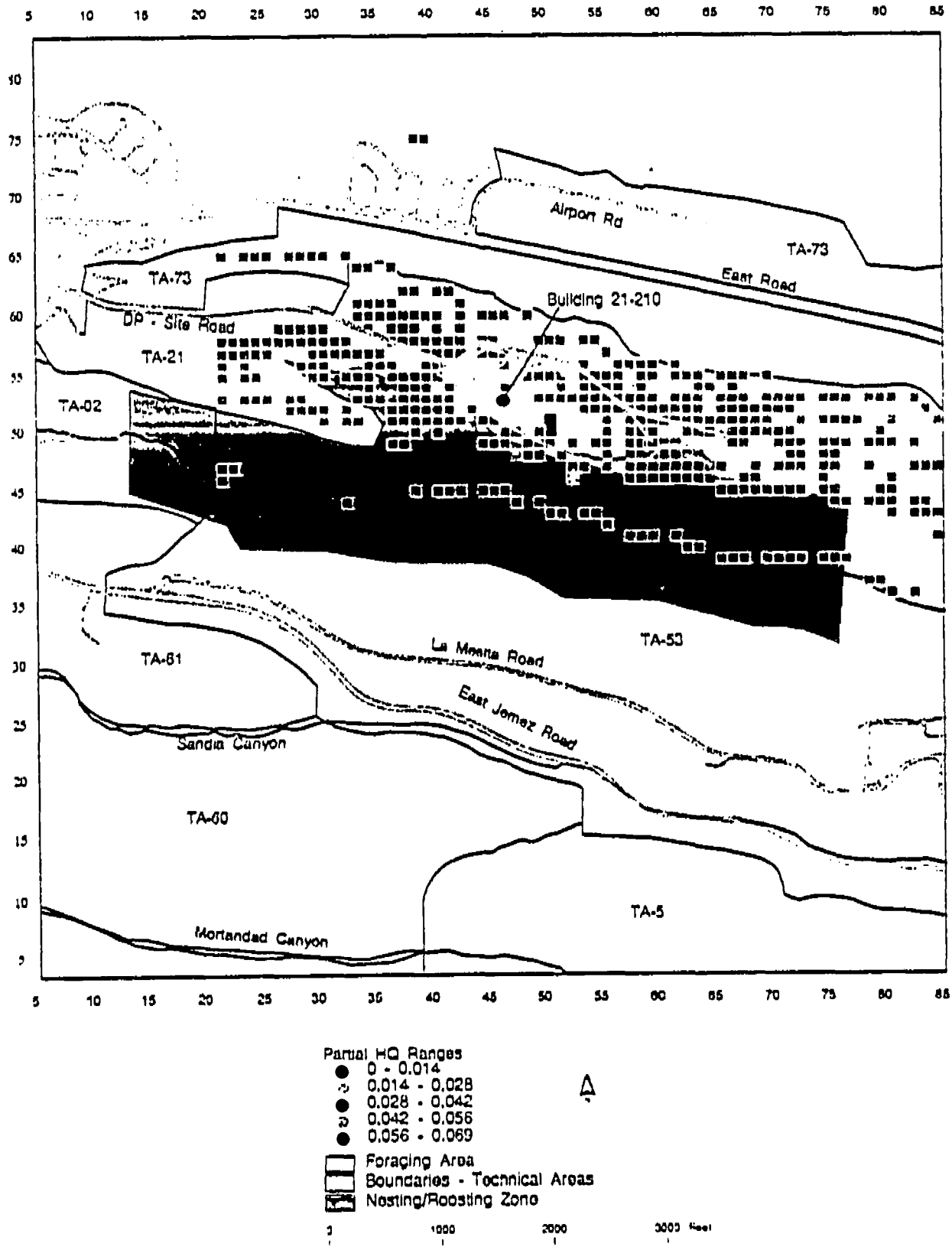


Figure 13.
Distribution of Unadjusted Partial HQs in EEU-21 for the 1st of 100 Random Potential Nest Locations (identifies the spatial source of partial risk contributing to the total risk at potential nest site #1).

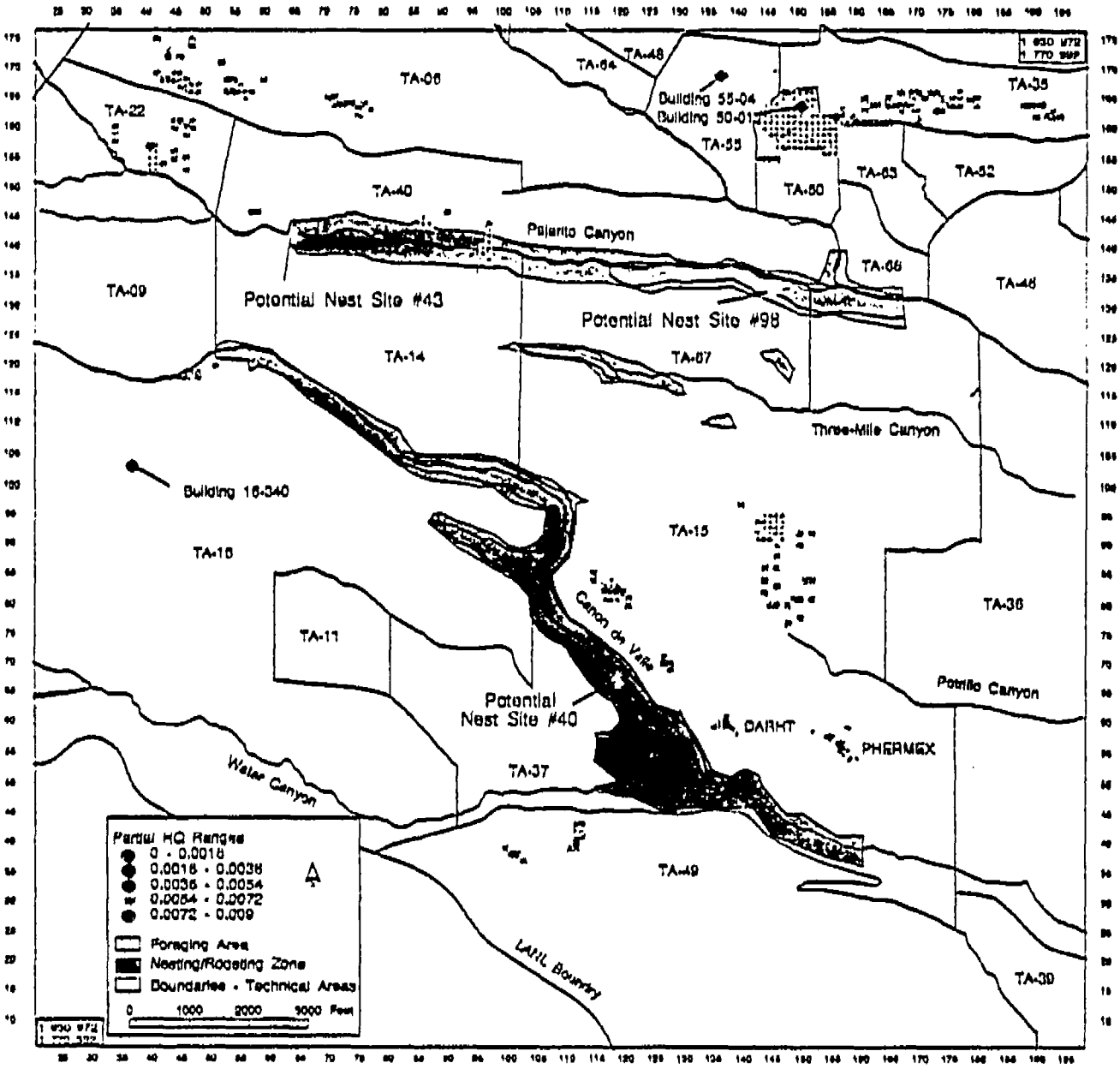
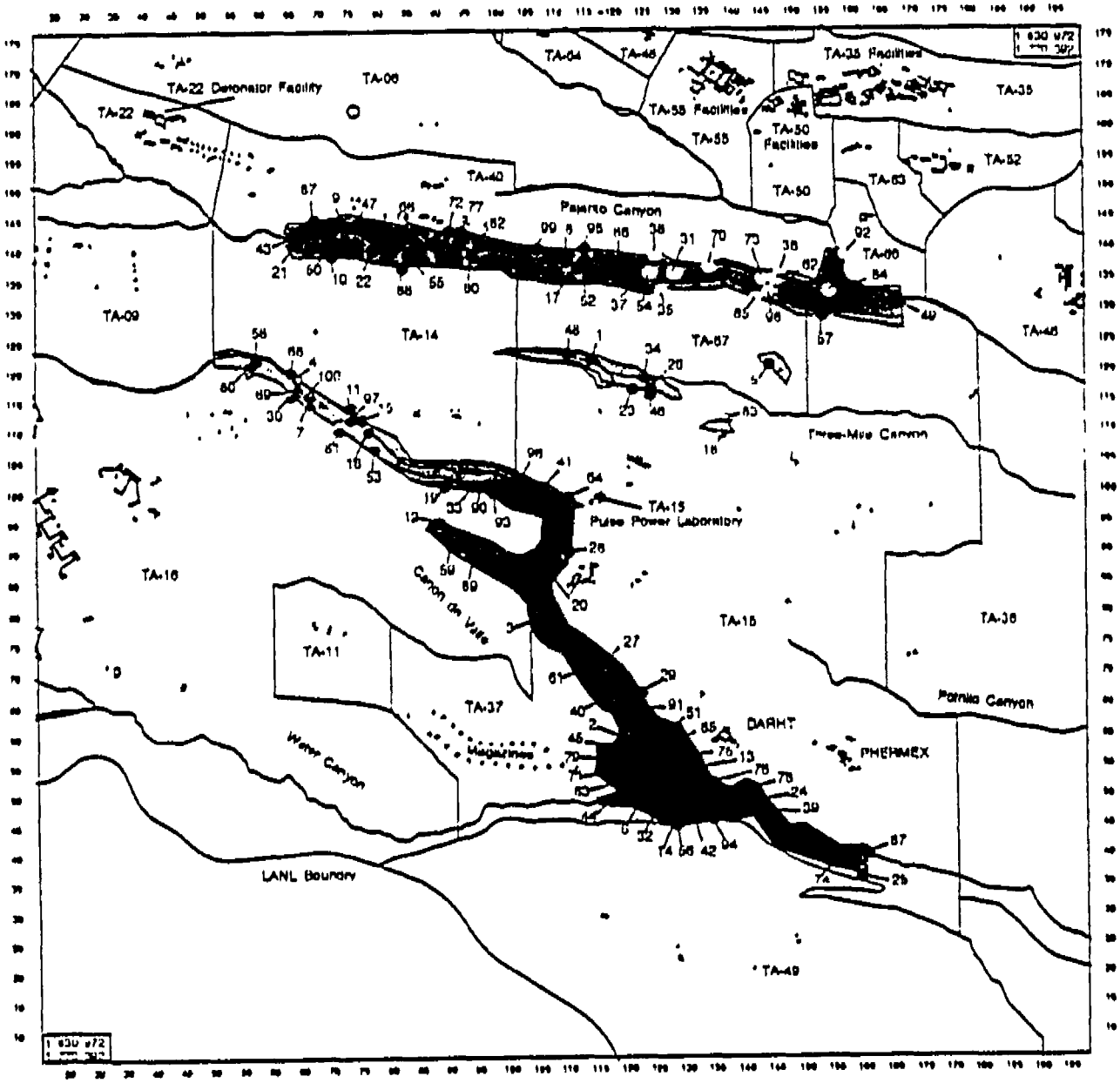


Figure 14. Distribution of Unadjusted Partial HQs in EEU-40 for Potential Nest Sites 40, 43, and 98
(Identifies the spatial source of partial risk contributing to the total risk at potential nest sites 40, 43, and 98).



Hazard Index Ranges
- 0.011 - 0.029
- 0.029 - 0.047
- 0.047 - 0.066
- 0.066 - 0.084
- 0.084 - 0.102

Foraging Area
Permanent Buildings
Boundaries - Technical Areas
Nesting/Roosting Zone

0 1000 2000 3000 4000 Feet

Figure 15. Hazard Indices by Potential Nest Site for EEU - 40.

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List of Acronyms

EEU	Ecological Exposure Unit
FIMAD	Facility for Information Management, Analysis and Display
TA	Technical Area
TES	Threatened and Endangered Species
COPEC	Contaminant of Potential Ecological Concern
RfD	Reference Dose (e.g. NOAEL)
NOAEL	No Observed Adverse Effects Level
LOAEL	Lowest Observed Adverse Effects Level
HQ	Hazard Quotient
HI	Hazard Index
F	Fraction of Food Intake as Soil
UF	Uncertainty Factor
SAL	Screening Action Level (soil)
GIS	Geographical Information System
HR	Home Range
BODWT	Body Weight
ESH-20	Environmental, Safety and Health Division, Ecology Group
EES-15	Earth and Environmental Sciences Division, Environmental Sciences Group
HMP	Habitat Management Plan
SC	Soil Concentration
ANOVA	Analysis of Variance
DARHT	Dual Axis Radiographic Hydrodynamic Test Facility
UTL	Upper Tolerance Level (e.g. 95th percentile)
EIS	Environmental Impact Statement

APPENDIX

Table A-1. Preliminary List of Contaminants of Potential Ecological Concern for Ecological Exposure Units 21 and 40.

EEU-21COPECs

Organics

1	Acenaphthene	16	Bismuth-212	31	Dichlorobenzene(1,4)[p-]	46	Nitrosodi n propylamine[N-]
2	Acetone	17	Bismuth-214	32	Dichlorodifluoromethane	47	Pentachlorophenol
3	Anthracene	18	Butanone[2-]	33	Dichloroethene[1,1-]	48	Phenanthrene
4	Aroclor[Mixed-]	19	Butylbenzylphthalate	34	Diethylphthalate	49	Phenol
5	Aroclor1254	20	Carbondisulfide	35	Dinitrotoluene[2,4-]	50	Pyrene
6	Aroclor1260	21	Chlorate	36	Fluoranthene	51	Styrene
7	Benzene	22	Chlorine	37	Fluorene	52	Tetrachloroethylene
8	Benzo[a]anthracene	23	Chloro-3-methylphenol[4-]	38	HumicAcid	53	Toluene
9	Benzo[a]pyrene	24	Chlorobenzene	39	Indeno[1,2,3-cd]pyrene	54	TotalOrganicCarbon
10	Benzo[b]fluoranthene	25	Chlorophenol[o-]	40	Isopropyltoluene[4-]	55	Trichlorobenzene[1,2,4-]
11	Benzo[g,h,i]perylene	26	Chrysene	41	Methylenechloride	56	Trichloroethene
12	Benzo[k]fluoranthene	27	Di-n butylphthalate	42	Methylnaphthalene[2-]	57	Trichlorofluoromethane
13	Benzoicacid	28	Di-n octylphthalate	43	Naphthalene	58	Trimethylbenzene[1,2,4-]
14	Bis(2-ethylhexyl)phthalate	29	Dibenzo[a,h]anthracene	44	NitrateNitrogen	59	Trimethylbenzene[1,3,5-]
15	Bismuth-211	30	Dibenzofuran	45	Nitrophenol[4-]		

Inorganics

1	Aluminium	9	Calcium	17	Lithium	25	Silicon
2	Antimony	10	Carbon	18	Magnesium	26	Silicon Dioxide
3	Arsenic	11	Chromium	19	Manganese	27	Silver
4	Barium	12	Cobalt	20	Mercury	28	Sodium
5	Beryllium	13	Copper	21	Molybdenum	29	Strontium
6	Boron	14	Cyanide	22	Nickel	30	Thallium
7	Bromine	15	Iron	23	Potassium	31	Uranium
8	Cadmium	16	Lead	24	Selenium	32	Zinc

Table A-1. Preliminary List of Contaminants of Potential Ecological Concern for Ecological Exposure Units 21 and 40. (cont)

Radionuclides

1	Actinium-227	39	Lead-210	51	Radium-223	62	Thorium-227
2	Actinium-228	40	Lead-211	52	Radium-224	63	Thorium-228
3	Americium-241	41	Lead-212	53	Radium-225	64	Thorium-229
4	Americium-243	42	Lead-214	54	Radium-226	65	Thorium-230
5	Barium-140	43	Manganese-54	55	Radium-228	66	Thorium-232
6	Cerium-144	44	Neptunium-237	56	Radon-219	67	Thorium-234
33	Cesium-134	45	Plutonium-238	57	Ruthenium-106	68	Tritium
34	Cesium-137	46	Plutonium-239	58	Sodium-22	69	Uranium-234
35	Cobalt-57	47	Potassium-40	59	Strontium-90	70	Uranium-235
36	Cobalt 60	48	Protactinium-231	60	Technitium-99	71	Uranium-238
37	Europium-152	49	Protactinium-234	61	Thallium-208		
38	Iodine-129	50	Protactinium-234				

EEU-40 COPECs

Organics

1	Acenaphthene	16	Benzo[a]pyrene	31	Bromodichloromethane	46	Chloroform
2	Acenaphthylene	17	Benzo[b]fluoranthene	32	Bromoform	47	Chloromethane
3	Acetone	18	Benzo[g,h,i]perylene	33	Bromomethane	48	Chloronaphthalene [2-]
4	Aldrin	19	Benzo[k]fluoranthene	34	Bromophenylphenyl ether [4-]	49	Chlorophenol [o-]
5	Amino-2,6-dinitrotoluene [4-	20	Benzoic acid	35	Butanone [2-]	50	Chlorophenylphenyl ether [4-]
6	Amino-4,6-dinitrotoluene [2-	21	Benzyl alcohol	36	Butyl benzyl phthalate	51	Chrysene
7	Amino-4,6-dinitrotoluene [2-	22	BHC [alpha-]	37	Carbazole	52	Di-n-butyl phthalate
8	Aniline	23	BHC [beta-]	38	Carbon disulfide	53	Di-n-octyl phthalate
9	Anthracene	24	Bis(2-chloroethoxy)methane	39	Carbon tetrachloride	54	Dibenzo[a,h]anthracene
10	Aroclor [Mixed-]	25	Bis(2-chloroethyl)ether	40	Chlordane	55	Dibenzofuran
11	Aroclor 1016	26	Bis(2-chloroisopropyl)ether	41	Chloro-3-methylphenol [4-]	56	Dichlorobenzene (1,2) [o-]
12	Aroclor 1254	27	Bis(2-chloroisopropyl)ether	42	Chloroaniline [4-]	57	Dichlorobenzene (1,3) [m-]
13	Azobenzene	28	Bis(2 ethylhexyl)phthalate	43	Chlorobenzene	58	Dichlorobenzene (1,4) [p-]
14	Benzene	29	Bromobenzene	44	Chlorodibromomethane	59	Dichlorodifluoromethane
15	Benzo[a]anthracene	30	Bromochloromethane	45	Chloroethane	60	Dichloroethane [1,1-]

Table A-1. Preliminary List of Contaminants of Potential Ecological Concern for Ecological Exposure Units 21 and 40. (cont)

EEU-40 COPECs (continued)

Organics (continued)

61	Dichloroethane [1,2-]	79	Ethylbenzene	97	Methylene chloride	115	Styrene
62	Dichloroethene [1,1-]	80	Fluoranthene	98	Methylnaphthalene [2-]	116	Tetrachloroethane [1,1,2,2-]
63	Dichloroethene [trans-1,2-]	81	Fluorene	99	Methylphenol [2-]	117	Tetrachloroethylene
64	Dichloroethylene [cis-1,2-]	82	Heptachlor	100	Methylphenol [4-]	118	Toluene
65	Dichlorophenol [2,4-]	83	Heptachlor epoxide	101	Naphthalene	119	Toxaphene
66	Dichloropropane [1,2-]	84	Hexachlorobenzene	102	Nitroaniline [2-]	120	Trichlorobenzene [1,2,4-]
67	Dichloropropene [cis-1,3-]	85	Hexachlorobutadiene	103	Nitroaniline [3-]	121	
68	Dichloropropene [trans-1,3-]	86	Hexachlorocyclopentadiene	104	Nitroaniline [4-]	122	Trichloroethane [1,1,1-]
69	Dieldrin	87	Hexachloroethane	105	Nitrobenzene	123	Trichloroethane [1,1,2-]
70	Diethyl phthalate	88	Hexanone [2-]	106	Nitrophenol [2-]	124	Trichloroethene
71	Dimethyl phthalate	89	HMX	107	Nitrophenol [4-]	125	Trichlorofluoromethane
72	Dimethylphenol [2,4-]	90	Indeno[1,2,3-cd]pyrene	108	Nitrosodi-n-propylamine [N-]	126	Trichlorophenol [2,4,5-]
73	Dinitrobenzene [1,3-]	91	Isophorone	109	Nitrosodiphenylamine [N-]	127	Trichlorophenol [2,4,6-]
74	Dinitrophenol [2,4-]	92	Isopropylbenzene	110	Pentachlorophenol	128	Trinitrobenzene [1,3,5-]
75	Dinitrotoluene [2,4-]	93	Methoxychlor	111	Phenanthrene	129	Trinitrotoluene [2,4,6-]
76	Dinitrotoluene [2,6-]	94	Methyl-2-pentanone [4-]	112	Phenol	130	Vinyl acetate
77	Endosulfan sulfate	95	Methyl-4,6-dinitrophenol [2-]	113	Pyrene	131	Vinyl chloride
78	Endrin	96	Methyl iodide	114	RDX		Xylenes (o + m + p) [Mixed-]

Inorganics

1	Aluminium	8	Chromium	15	Magnesium	22	Silver
2	Antimony	9	Cobalt	16	Manganese	23	Sodium
3	Arsenic	10	Copper	17	Mercury	24	Thallium
4	Barium	11	Cyanide	18	Molybdenum	25	Tritium
5	Beryllium	12	Iron	19	Nickel	26	Uranium
6	Cadmium	13	Lead	20	Potassium	27	Vanadium
7	Calcium	14	Lithium	21	Selenium	28	Zinc

Table A-1. Preliminary List of Contaminants of Potential Ecological Concern for Ecological Exposure Units 21 and 40. (cont)

Radionuclides							
1	Actinium-228	12	Europium-152	23	Protactinium-231	33	Thallium-208
2	Americium-241	13	Lead-210	24	Protactinium-234	34	Thorium-227
3	Barium-140	14	Lead-211	25	Radium-223	35	Thorium-228
4	Bismuth-211	15	Lead-212	26	Radium-224	36	Thorium-230
5	Bismuth-212	16	Lead-214	27	Radium-226	37	Thorium-232
6	Bismuth-214	17	Manganese-54	28	Radium-228	38	Thorium-234
7	Cerium-144	18	Neptunium-237	29	Radon-219	39	Uranium-234
8	Cesium-134	19	Plutonium-238	30	Ruthenium-106	40	Uranium-235
9	Cesium-137	20	Plutonium-239	31	Sodium-22	41	Uranium-238
10	Cobalt-57	21	Plutonium-239/240	32	Strontium-90		
11	Cobalt-60	22	Potassium-40				

Table A-2. Example of "Outrsk.dat", output data for the first of 100 randomly selected nest sites for the Mexican Spotted Owl in EEU-21. Hazard quotient is by location within an ~ 1469 acre feeding range and makes no correction for "natural" background concentrations of contaminants (sum of partial HQ column is also found as the first cumulative HQ value in Table A-4.

```
**********ECOLOGICAL RISK INPUT SUMMARY***************
*************using ECORSK, Version 1******************
program run on 08/23/96 by afg/gjg you have selected random seed number = 1000
*****************************************************
ANIMAL = spotted owl
*****************************************************
ANIMAL TYPE selected for spotted owl is specified as
2.00000   1=MAMMAL,2=BIRD,3=REPTILE, AND 4=AMPHIBIAN
FEEDING TYPE FOR spotted owl is selected as
10.0000   10=CARNIVORE,100=HERBIVORE, AND 1000=AMPHIBIAN
*****************************************************
BODY WEIGHT,KGFWT, for spotted owl = 0.550000
soil intake, fraction of food ingestion, for spotted owl = 5.000000E-02
*****************************************************
THE AREA, KM2, of the EEU for spotted owl is 5.95000
*****************************************************
THE MAX. AND MIN. N-S UTM COORDINATES for spotted owl
are 1.777992E+06 and 1.769292E+06
THE MAX. AND MIN. E-W UTM COORDINATES for spotted owl
are 1.637072E+06 and 1.627272E+06
*************END OF ECORSK INPUT SUMMARY*************
***********ECOLOGICAL RISK OUTPUT SUMMARY*************
*********using ECORSK, Version 1*********************
*****************************************************
THE AREA,KM2, of the HOME-RANGE for spotted owl is 3.65911
*****************************************************
FOOD CONSUMPTION,KGFWT/DAY, for spotted owl is 3.943657E-02
*****************************************************
for spotted owl maximum E-W distance of EEU in ft = 9800.00
for spotted owl maximum N-S distance of EEU in ft = 8700.00
*****************************************************
```

Table A-2. Example of "Outrsk.dat", output data for the first of 100 randomly selected nest sites for the Mexican Spotted Owl in EEU-21. Hazard quotient is by location within an ~ 1469 acre feeding range and makes no correction for "natural" background concentrations of contaminants (sum of partial HQ column is also found as the first cumulative HQ value in Table A-4. (cont)

Nest Site Location		Contaminant Location				Nest Site Location		Contaminant Location			
Column	Row	Column	Row	Partial HQ	Rank	Column	Row	Column	Row	Partial HQ	Rank
53	46	58	53	6.95E-02	1	53	46	37	55	1.30E-03	30
53	46	51	51	4.11E-02	2	53	46	33	57	1.30E-03	31
53	46	51	50	2.81E-02	3	53	46	38	52	1.29E-03	32
53	46	48	48	2.25E-02	4	53	46	42	51	1.29E-03	33
53	46	58	51	1.90E-02	5	53	46	37	60	1.23E-03	34
53	46	54	47	1.05E-02	6	53	46	62	46	1.22E-03	35
53	46	59	54	8.66E-03	7	53	46	71	49	1.22E-03	36
53	46	52	48	7.45E-03	8	53	46	34	57	1.22E-03	37
53	46	50	50	4.85E-03	9	53	46	64	48	1.18E-03	38
53	46	58	56	3.10E-03	10	53	46	67	51	1.18E-03	39
53	46	60	46	2.22E-03	11	53	46	77	51	1.18E-03	40
53	46	38	54	2.10E-03	12	53	46	80	45	1.17E-03	41
53	46	39	54	2.05E-03	13	53	46	36	60	1.16E-03	42
53	46	57	52	2.04E-03	14	53	46	60	46	1.15E-03	43
53	46	77	44	1.83E-03	15	53	46	81	49	1.13E-03	44
53	46	35	61	1.83E-03	16	53	46	43	51	1.13E-03	45
53	46	61	48	1.80E-03	17	53	46	39	60	1.12E-03	46
53	46	61	46	1.77E-03	18	53	46	47	56	1.10E-03	47
53	46	68	55	1.61E-03	19	53	46	76	44	1.09E-03	48
53	46	63	46	1.59E-03	20	53	46	62	56	1.07E-03	49
53	46	68	52	1.58E-03	21	53	46	38	55	1.06E-03	50
53	46	65	54	1.58E-03	22	53	46	35	57	1.06E-03	51
53	46	50	48	1.52E-03	23	53	46	37	56	1.05E-03	52
53	46	67	50	1.49E-03	24	53	46	22	57	1.05E-03	53
53	46	72	48	1.41E-03	25	53	46	60	48	1.04E-03	54
53	46	72	49	1.37E-03	26	53	46	79	44	1.02E-03	55
53	46	33	58	1.35E-03	27	53	46	67	49	1.02E-03	56
53	46	60	51	1.31E-03	28	53	46	57	56	1.02E-03	57
53	46	55	52	1.31E-03	29	53	46	68	45	1.01E-03	58

Table A-2. Example of "Outrsk.dat", output data for the first of 100 randomly selected nest sites for the Mexican Spotted Owl in EEU-21. Hazard quotient is by location within an ~ 1469 acre feeding range and makes no correction for "natural" background concentrations of contaminants (sum of partial HQ column is also found as the first cumulative HQ value in Table A-4. (cont)

Nest Site Location		Contaminant Location				Nest Site Location		Contaminant Location			
Column	Row	Column	Row	Partial HQ	Rank	Column	Row	Column	Row	Partial HQ	Rank
53	46	56	47	1.01E-03	59	53	46	30	59	9.15E-04	87
53	46	47	57	1.00E-03	60	53	46	62	48	9.11E-04	88
53	46	72	47	9.97E-04	61	53	46	66	51	9.09E-04	89
53	46	31	57	9.94E-04	62	53	46	68	51	9.09E-04	90
53	46	70	51	9.92E-04	63	53	46	33	52	9.06E-04	91
53	46	60	49	9.84E-04	64	53	46	69	52	9.05E-04	92
53	46	36	53	9.83E-04	65	53	46	31	58	9.03E-04	93
53	46	76	49	9.78E-04	66	53	46	64	46	8.97E-04	94
53	46	79	47	9.74E-04	67	53	46	59	48	8.97E-04	95
53	46	53	47	9.69E-04	68	53	46	47	49	8.90E-04	96
53	46	50	49	9.65E-04	69	53	46	28	58	8.80E-04	97
53	46	69	45	9.61E-04	70	53	46	70	45	8.69E-04	98
53	46	41	53	9.61E-04	71	53	46	37	61	8.66E-04	99
53	46	68	50	9.60E-04	72	53	46	41	55	8.65E-04	100
53	46	62	47	9.59E-04	73	53	46	70	50	8.62E-04	101
53	46	47	50	9.52E-04	74	53	46	72	45	8.58E-04	102
53	46	41	58	9.47E-04	75	53	46	64	55	8.55E-04	103
53	46	46	49	9.41E-04	76	53	46	60	47	8.53E-04	104
53	46	64	51	9.44E-04	77	53	46	66	45	8.50E-04	105
53	46	30	58	9.43E-04	78	53	46	38	51	8.49E-04	106
53	46	31	59	9.35E-04	79	53	46	71	50	8.42E-04	107
53	46	39	55	9.30E-04	80	53	46	73	45	8.39E-04	108
53	46	66	52	9.28E-04	81	53	46	75	45	8.39E-04	109
53	46	47	54	9.27E-04	82	53	46	43	57	8.35E-04	110
53	46	61	47	9.25E-04	83	53	46	35	60	8.26E-04	111
53	46	39	58	9.25E-04	84	53	46	67	52	8.22E-04	112
53	46	59	49	9.22E-04	85	53	46	60	52	8.20E-04	113
53	46	42	52	9.21E-04	86	53	46	42	57	8.17E-04	114

Table A-2. Example of "Outrsk.dat", output data for the first of 100 randomly selected nest sites for the Mexican Spotted Owl in EEU-21. Hazard quotient is by location within an ~ 1469 acre feeding range and makes no correction for "natural" background concentrations of contaminants (sum of partial HQ column is also found as the first cumulative HQ value in Table A-4. (cont)

Nest Site Location		Contaminant Location				Nest Site Location		Contaminant Location			
Column	Row	Column	Row	Partial HQ	Rank	Column	Row	Column	Row	Partial HQ	Rank
53	46	68	49	8.06E-04	115	53	46	81	51	7.14E-04	144
53	46	41	60	7.97E-04	116	53	46	81	43	7.13E-04	145
53	46	76	53	7.82E-04	117	53	46	43	58	7.11E-04	146
53	46	45	57	7.74E-04	118	53	46	76	45	7.05E-04	147
53	46	75	46	7.70E-04	119	53	46	41	59	7.01E-04	148
53	46	36	61	7.64E-04	120	53	46	40	54	7.00E-04	149
53	46	63	52	7.63E-04	121	53	46	29	58	7.00E-04	150
53	46	58	46	7.58E-04	122	53	46	38	59	6.96E-04	151
53	46	42	58	7.56E-04	123	53	46	39	50	6.91E-04	152
53	46	45	58	7.55E-04	124	53	46	35	54	6.87E-04	153
53	46	31	55	7.54E-04	125	53	46	31	52	6.86E-04	154
53	46	73	49	7.53E-04	126	53	46	71	52	6.85E-04	155
53	46	83	43	7.47E-04	127	53	46	73	48	6.84E-04	156
53	46	24	53	7.46E-04	128	53	46	42	53	6.82E-04	157
53	46	75	47	7.44E-04	129	53	46	23	57	6.80E-04	158
53	46	70	52	7.44E-04	130	53	46	72	52	6.79E-04	159
53	46	34	53	7.43E-04	131	53	46	31	51	6.74E-04	160
53	46	38	60	7.40E-04	132	53	46	81	44	6.73E-04	161
53	46	45	49	7.37E-04	133	53	46	71	47	6.73E-04	162
53	46	37	52	7.34E-04	134	53	46	67	54	6.73E-04	163
53	46	53	53	7.28E-04	135	53	46	34	55	6.72E-04	164
53	46	64	52	7.23E-04	136	53	46	46	57	6.72E-04	165
53	46	73	47	7.22E-04	137	53	46	34	51	6.71E-04	166
53	46	75	48	7.20E-04	138	53	46	76	48	6.70E-04	167
53	46	35	53	7.20E-04	139	53	46	72	50	6.69E-04	168
53	46	37	58	7.20E-04	140	53	46	30	57	6.69E-04	169
53	46	57	55	7.16E-04	141	53	46	37	51	6.66E-04	170
53	46	76	47	7.15E-04	142	53	46	78	51	6.66E-04	171
53	46	71	45	7.14E-04	143	53	46	75	49	6.64E-04	172

Table A-2. Example of "Outrsk.dat", output data for the first of 100 randomly selected nest sites for the Mexican Spotted Owl in EEU-21. Hazard quotient is by location within an ~ 1469 acre feeding range and makes no correction for "natural" background concentrations of contaminants (sum of partial HQ column is also found as the first cumulative HQ value in Table A-4. (cont)

Nest Site Location		Contaminant Location				Nest Site Location		Contaminant Location			
Column	Row	Column	Row	Partial HQ	Rank	Column	Row	Column	Row	Partial HQ	Rank
53	46	81	45	6.61E-04	173	53	46	80	49	6.19E-04	201
53	46	34	61	6.61E-04	174	53	46	37	59	6.15E-04	202
53	46	41	51	6.60E-04	175	53	46	34	60	6.15E-04	203
53	46	26	58	6.60E-04	176	53	46	75	51	6.12E-04	204
53	46	35	56	6.59E-04	177	53	46	35	55	6.12E-04	205
53	46	80	44	6.57E-04	178	53	46	42	51	6.11E-04	206
53	46	37	49	6.57E-04	179	53	46	36	56	6.11E-04	207
53	46	67	45	6.55E-04	180	53	46	25	57	6.04E-04	208
53	46	77	49	6.55E-04	181	53	46	27	58	6.04E-04	209
53	46	41	57	6.53E-04	182	53	46	59	52	6.03E-04	210
53	46	38	53	6.50E-04	183	53	46	22	58	5.99E-04	211
53	46	83	44	6.43E-04	184	53	46	46	58	5.98E-04	212
53	46	38	58	6.41E-04	185	53	46	51	49	5.97E-04	213
53	46	80	50	6.39E-04	186	53	46	26	57	5.83E-04	214
53	46	33	55	6.36E-04	187	53	46	24	56	5.77E-04	215
53	46	33	51	6.35E-04	188	53	46	62	52	5.76E-04	216
53	46	79	49	6.34E-04	189	53	46	65	51	5.73E-04	217
53	46	76	51	6.31E-04	190	53	46	40	60	5.72E-04	218
53	46	31	56	6.31E-04	191	53	46	59	46	5.70E-04	219
53	46	83	49	6.30E-04	192	53	46	30	52	5.70E-04	220
53	46	54	56	6.30E-04	193	53	46	39	51	5.69E-04	221
53	46	38	49	6.29E-04	194	53	46	41	56	5.68E-04	222
53	46	25	58	6.27E-04	195	53	46	23	58	5.68E-04	223
53	46	73	51	6.23E-04	196	53	46	43	60	5.66E-04	224
53	46	24	58	6.22E-04	197	53	46	65	46	5.62E-04	225
53	46	45	51	6.20E-04	198	53	46	32	58	5.62E-04	226
53	46	59	53	6.20E-04	199	53	46	65	47	5.61E-04	227
53	46	36	57	6.20E-04	200	53	46	32	57	5.58E-04	228

Table A-2. Example of "Outrsk.dat", output data for the first of 100 randomly selected nest sites for the Mexican Spotted Owl in EEU-21. Hazard quotient is by location within an ~ 1469 acre feeding range and makes no correction for "natural" background concentrations of contaminants (sum of partial HQ column is also found as the first cumulative HQ value in Table A-4. (cont)

Nest Site Location		Contaminant Location				Nest Site Location		Contaminant Location			
Column	Row	Column	Row	Partial HQ	Rank	Column	Row	Column	Row	Partial HQ	Rank
53	46	39	52	5.54E-04	229	53	46	81	41	4.59E-04	257
53	46	40	58	5.44E-04	230	53	46	35	59	4.30E-04	258
53	46	46	51	5.43E-04	231	53	46	62	55	4.28E-04	259
53	46	48	50	5.41E-04	232	53	46	52	53	4.19E-04	260
53	46	59	55	5.41E-04	233	53	46	81	46	4.06E-04	261
53	46	50	55	5.39E-04	234	53	46	31	61	4.05E-04	262
53	46	60	53	5.35E-04	235	53	46	52	55	4.03E-04	263
53	46	39	59	5.31E-04	236	53	46	56	55	4.01E-04	264
53	46	84	47	5.30E-04	237	53	46	60	47	3.93E-04	265
53	46	61	54	5.28E-04	238	53	46	23	47	3.89E-04	266
53	46	27	59	5.28E-04	239	53	46	61	53	3.87E-04	267
53	46	49	49	5.25E-04	240	53	46	33	41	3.80E-04	268
53	46	57	53	5.20E-04	241	53	46	29	65	3.77E-04	269
53	46	29	59	5.20E-04	242	53	46	60	51	3.72E-04	270
53	46	28	59	5.17E-04	243	53	46	58	47	3.70E-04	271
53	46	51	55	5.16E-04	244	53	46	40	53	3.68E-04	272
53	46	67	39	5.15E-04	245	53	46	35	61	3.68E-04	273
53	46	29	56	5.06E-04	246	53	46	22	47	3.61E-04	274
53	46	56	42	5.03E-04	247	53	46	69	50	3.61E-04	275
53	46	41	50	5.02E-04	248	53	46	29	53	3.64E-04	276
53	46	50	58	5.02E-04	249	53	46	25	55	3.62E-04	277
53	46	73	53	5.01E-04	250	53	46	50	53	3.60E-04	278
53	46	43	59	5.01E-04	251	53	46	54	54	3.58E-04	279
53	46	79	37	4.96E-04	252	53	46	68	46	3.57E-04	280
53	46	49	48	4.89E-04	253	53	46	81	53	3.57E-04	281
53	46	66	53	4.87E-04	254	53	46	57	54	3.56E-04	282
53	46	28	52	4.79E-04	255	53	46	55	55	3.51E-04	283
53	46	54	52	4.60E-04	256	53	46	22	65	3.50E-04	284

Table A-2. Example of "Outrsk.dat", output data for the first of 100 randomly selected nest sites for the Mexican Spotted Owl in EEU-21. Hazard quotient is by location within an ~ 1469 acre feeding range and makes no correction for "natural" background concentrations of contaminants (sum of partial HQ column is also found as the first cumulative HQ value in Table A-4. (cont)

Nest Site Location		Contaminant Location				Nest Site Location		Contaminant Location			
Column	Row	Column	Row	Partial HQ	Rank	Column	Row	Column	Row	Partial HQ	Rank
53	46	58	50	3.48E-04	285	53	46	83	47	2.99E-04	313
53	46	59	56	3.45E-04	286	53	46	40	55	2.99E-04	314
53	46	41	52	3.43E-04	287	53	46	22	46	2.98E-04	315
53	46	30	65	3.42E-04	288	53	46	37	64	2.98E-04	316
53	46	58	51	3.40E-04	289	53	46	61	52	2.96E-04	317
53	46	56	50	3.39E-04	290	53	46	52	54	2.96E-04	318
53	46	56	52	3.39E-04	291	53	46	67	53	2.92E-04	319
53	46	65	50	3.38E-04	292	53	46	24	55	2.92E-04	320
53	46	63	48	3.37E-04	293	53	46	31	65	2.92E-04	321
53	46	58	52	3.37E-04	294	53	46	38	62	2.91E-04	322
53	46	54	55	3.35E-04	295	53	46	51	53	2.89E-04	323
53	46	44	52	3.32E-04	296	53	46	55	54	2.88E-04	324
53	46	59	51	3.31E-04	297	53	46	67	55	2.87E-04	325
53	46	70	55	3.31E-04	298	53	46	40	56	2.86E-04	326
53	46	53	49	3.30E-04	299	53	46	58	49	2.85E-04	327
53	46	63	51	3.26E-04	300	53	46	54	43	2.84E-04	328
53	46	39	53	3.26E-04	301	53	46	56	57	2.84E-04	329
53	46	62	51	3.22E-04	302	53	46	61	51	2.83E-04	330
53	46	25	65	3.19E-04	303	53	46	56	49	2.81E-04	331
53	46	43	61	3.18E-04	304	53	46	40	51	2.81E-04	332
53	46	28	65	3.16E-04	305	53	46	56	48	2.78E-04	333
53	46	64	50	3.15E-04	306	53	46	68	53	2.78E-04	334
53	46	51	58	3.15E-04	307	53	46	61	47	2.75E-04	335
53	46	56	51	3.12E-04	308	53	46	63	55	2.75E-04	336
53	46	66	39	3.11E-04	309	53	46	66	55	2.75E-04	337
53	46	49	60	3.07E-04	310	53	46	61	49	2.73E-04	338
53	46	59	50	3.04E-04	311	53	46	30	56	2.72E-04	339
53	46	84	43	3.00E-04	312	53	46	55	49	2.71E-04	340

Table A-2. Example of "Outrsk.dat", output data for the first of 100 randomly selected nest sites for the Mexican Spotted Owl in EEU-21. Hazard quotient is by location within an ~ 1469 acre feeding range and makes no correction for "natural" background concentrations of contaminants (sum of partial HQ column is also found as the first cumulative HQ value in Table A-4. (cont)

Nest Site Location		Contaminant Location				Nest Site Location		Contaminant Location			
Column	Row	Column	Row	Partial HQ	Rank	Column	Row	Column	Row	Partial HQ	Rank
53	46	54	53	2.71E-04	341	53	46	25	53	2.45E-04	369
53	46	45	60	2.70E-04	342	53	46	39	75	2.45E-04	370
53	46	73	39	2.68E-04	343	53	46	70	39	2.44E-04	371
53	46	83	53	2.68E-04	344	53	46	22	53	2.44E-04	372
53	46	71	39	2.67E-04	345	53	46	80	53	2.43E-04	373
53	46	43	45	2.67E-04	346	53	46	49	55	2.42E-04	374
53	46	56	54	2.67E-04	347	53	46	24	65	2.42E-04	375
53	46	55	58	2.67E-04	348	53	46	45	45	2.38E-04	376
53	46	54	58	2.64E-04	349	53	46	42	62	2.38E-04	377
53	46	56	53	2.63E-04	350	53	46	75	39	2.36E-04	378
53	46	58	41	2.62E-04	351	53	46	66	47	2.36E-04	379
53	46	30	55	2.62E-04	352	53	46	40	52	2.36E-04	380
53	46	55	53	2.61E-04	353	53	46	77	39	2.35E-04	381
53	46	40	75	2.60E-04	354	53	46	42	45	2.34E-04	382
53	46	53	46	2.59E-04	355	53	46	47	45	2.34E-04	383
53	46	41	45	2.59E-04	356	53	46	60	50	2.34E-04	384
53	46	41	62	2.59E-04	357	53	46	71	53	2.34E-04	385
53	46	70	53	2.57E-04	358	53	46	26	65	2.34E-04	386
53	46	46	60	2.57E-04	359	53	46	39	45	2.31E-04	387
53	46	85	47	2.56E-04	360	53	46	22	55	2.31E-04	388
53	46	62	53	2.53E-04	361	53	46	76	39	2.29E-04	389
53	46	75	53	2.52E-04	362	53	46	62	41	2.29E-04	390
53	46	40	57	2.52E-04	363	53	46	52	43	2.28E-04	391
53	46	63	53	2.50E-04	364	53	46	52	58	2.28E-04	392
53	46	72	53	2.50E-04	365	53	46	39	62	2.28E-04	393
53	46	22	56	2.50E-04	366	53	46	61	40	2.27E-04	394
53	46	62	49	2.49E-04	367	53	46	55	43	2.27E-04	395
53	46	58	48	2.48E-04	368	53	46	46	45	2.27E-04	396

Table A-2. Example of "Outrsk.dat", output data for the first of 100 randomly selected nest sites for the Mexican Spotted Owl in EEU-21. Hazard quotient is by location within an ~ 1469 acre feeding range and makes no correction for "natural" background concentrations of contaminants (sum of partial HQ column is also found as the first cumulative HQ value in Table A-4. (cont)

Nest Site Location		Contaminant Location				Nest Site Location		Contaminant Location			
Column	Row	Column	Row	Partial HQ	Rank	Column	Row	Column	Row	Partial HQ	Rank
53	46	26	53	2.27E-04	397	53	46	72	39	2.23E-04	411
53	46	47	60	2.27E-04	398	53	46	60	41	2.23E-04	412
53	46	83	36	2.26E-04	399	53	46	63	47	2.23E-04	413
53	46	59	41	2.26E-04	400	53	46	79	53	2.23E-04	414
53	46	85	41	2.26E-04	401	53	46	85	43	2.16E-04	415
53	46	48	44	2.26E-04	402	53	46	28	53	2.16E-04	416
53	46	50	44	2.26E-04	403	53	46	63	40	2.14E-04	417
53	46	85	51	2.26E-04	404	53	46	33	65	2.13E-04	418
53	46	80	37	2.24E-04	405	53	46	63	50	2.03E-04	419
53	46	68	39	2.24E-04	406	53	46	84	52	1.87E-04	420
53	46	51	43	2.24E-04	407	53	46	59	47	1.77E-04	421
53	46	29	52	2.24E-04	408	53	46	24	57	1.13E-04	422
53	46	77	53	2.24E-04	409	53	46	60	55	7.50E-05	423
53	46	81	36	2.23E-04	410	53	46	60	56	7.21E-05	424

$HQ_{53,46} = 0.468816$

Table A-3. Reference doses (RfDs) used in the preliminary ecolgocial risk assessment of the Mexican Spotted Owl at the Los Alamos National Laboratory.

Analyte	NOAEL mg/kg/d	Reference	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
Inorganics							
Aluminum	109.700	Carriere et al. 1986	ringed dove	Al (SO4)	reproduction		
Antimony	0.035	LANL, 1994				0.035=rat LOAEL, whole body & blood	LANL, 1994 and EPA, 1996
Arsenic	1.160	Whitworth et al., 1991 In: Weston, 1995.	1-d mallard		Chronic NOAEL, behavioral effects	1) 0.001; 2) 0.009 mg/L = human oral NOAEL	1) LANL, 1994; 2) EPA, 1996
Barium	20.800	Johnson et al. 1960	1-day chicks	hydroxide	mortality	0.21= oral human NOAEL for BaCn, cardiovasc. target	LANL, 1994
Boron	28.800	Smith and Anders 1989	mallard ducks	boric acid	reproduction	28.8	
Beryllium	0.540	LANL, 1994			Oral rat NOAEL (EPA, 1996)	= oral rat NOAEL (EPA, 1996)	
Cadmium	1.450	White et al. 1978	mallard ducks	chloride	reproduction	1. 0.005; 2. 19.1 = oral NOAEL in rat	1. EES-15 Appeal, 2. EPA, 1996
Calcium	24.000	Shane and Young, 1968 In: Weston, 1995	White leghorn chick		Chronic death from renal failure	None	
Chromium III	3.810	Hill and Matrone, 1970 In: Weston, 1995	3-wk chick		Chronic weight loss and mortality	1. 1468; 2. 5% = oral NOEL, rat	1. LANL, 1994; 2. EPA, 1996
Chromium VI	3.800	Hill and Matrone, 1970 In: Weston, 1995	3-wk chick		Chronic NOAEL, body weight	2.4 = oral NOAEL, rat	LANL, 1994 /EPA, 1996

Table A-3. Reference doses (RfDs) used in the preliminary ecolgocial risk assessment of the Mexican Spotted Owl at the Los Alamos National Laboratory. (cont)

Analyte	NOAEL mg/kg/d	Reference	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
Cobalt		LANL, 1994	rat LD_{50}				
Copper	46.970	Mehring et al. 1960	1 day chicks	oxide	growth, mortality	5.3 mg = single dose NOAEL, human	
Cyanide	10.800	LANL, 1994				oral NOAEL, rat	
Fluorides	4.500	LANL, 1994				0.06 = oral NOAEL, human	
Hydrogen Fluoride							
Iron							
Lead	1.130	Edens et al. 1976	Japanese quail	acetate	reproduction	0.9	LANL, 1994
Lithium	480.000	Opresko et al., 1994	red-winged blackbird	$LiCl_2$	NOAEL = [15,000 ppm (feeding dose) x bw]/bw, no endpoint stated		
Magnesium	32.000	Opresko et al., 1994	Japanese quail		NOAEL = [1,000 ppm (feeding dose) x bw]/bw, endpoint=physiology	no EPA, 1996 value	
Manganese	9.140	Vohra&Kratzer, 1968 In: Weston, 1995	turkey poults		Acute NOAEL	1) 0.14=oral human NOAEL; 2) 0.005	1) EPA, 1996; 2) LANL, 1994
Mercury	0.064	Opresko et al., 1994	Japanese quail	HgCl	NOAEL = [2 ppm (feeding dose) x bw]/bw; endpoint=physiology	1) 0.32; 2) 0.0064	1) LANL, 1994; 2) ORNL, CH3Hg NOAEL for mallard
Molybdenum	0.280	Lepore and Miller, 1964 In: Weston, 1995	7-mo hen		50% embryo mortality [LD_{50}] x 0.01		

Table A-3. Reference doses (RfDs) used in the preliminary ecolgocial risk assessment of the Mexican Spotted Owl at the Los Alzmos National Laboratory. (cont)

Analyte	NOAEL mg/kg/d	Reference	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
Nickel	0.676	Weber&Reid, 1968 In: Weston, 1995	1-d chick		wt. gain	1) 5.0, 2)100 ppm = rat diet NOAEL	1) LANL, 1994; 2) EPA, 1996
Nitrate	1.600	LANL, 1994					
Nitrite	1.000	LANL, 1994				10 ppm = oral human NOEL, methemoglobinemia	
Potassium		LANL, 1994					
Selenium	0.400	Heinz et al. 1989	mallard duck		reproduction	1. 0.015; 2. 0.853 mg/d = human NOAEL, whole body	1. LANL, 1994; 2. EPA, 1996
Silver	0.344	___&Jensen, 1975 In: Weston, 1995	1-d chick		Chronic growth and mortality	0.0014	LANL, 1994
Sodium	124 000	Scott et al., 1960 In: Weston, 1995	1-d quail		Chronic NOAEL, "no effects"	20.4=oral NOAEL in rat, CNS	EPA, 1996
Thallium	1.200	Opresko et al., 1994	golden eagle	$TlSO_4$	LD_{50} x 0.01	1) 0.22=oral NOAEL, rat (Tl_2O_3); 2) 0.192=LC_{50} pheasant	1) Hudson et al., 1984 In: Weston, 1995.
Vanadium	0.320	Opresko et al., 1994	mallard duck	$VaSO_4$	NOAEL = [10 ppm (feeding dose) x bw]/bw; endpoint=blood chemistry	5 ppm=rat oral diet NOAEL	EPA, 1996

Table A-3. Reference doses (RfDs) used in the preliminary ecolgocial risk assessment of the Mexican Spotted Owl at the Los Alamos National Laboratory. (cont)

Analyte	NOAEL mg/kg/d	Reference	Test Species	Chemical Form	Endpoint, Comment and/or Test Species	Comparison NOAEL (mg/kg/d)	Reference to Comparison Value
Zinc	1.935	Stahl et al. 1990	white leghorn hens		reproduction	1) 10.1=chronic "no effects" NOAEL in 1-d chicks; 2) 0.2231="acute dose" x 0.01 in great horned owl; 3) 0.1	1) Oh et al, 1979 In: Weston, 1995; 2) Opresko et al., 1994 ; 3) LANL, 1994

Volatile Organic Compounds	NOAEL mg/kg/d	Reference	Volatile Organic Compounds	NOAEL mg/kg/d	Reference
1,1,1,2-Tetrachloroethane	89.300	LANL, 1994	4-hydroxy-4-methyl-2-pentanone(d)		LANL, 1994
1,1,1-Trichloroethane			4-isopropytoluene		
1,1,2,2-Tetrachloroethane			4-Methyl-2-pentanone (MIK)		
1,1,2-trichloro-1,2,2-trifluoroethane	273.000	LANL, 1994	Acetone	100.000	LANL, 1994
1,1,2-Trichloroethane	3.900	LANL, 1994	Benzene		
1,1-Dichloroethane			Benzoic acid	4.460	LANL, 1994
1,1-Dichloroethene	9.000	LANL, 1994	Bromobenzene(d)		
1,2,3-Trimethyl benzene(d)			Bromochloromethane(d)		
1,2,4-Trimethylbenzene			Bromodichloromethane	17.900	LANL, 1994
1,2-di bromo-3-Chloropropane			Bromoform	17.900	LANL, 1994
1,2-Dichloroethane			Bromomethane	1.400	LANL, 1994
1,2-Dichloropropane			Carbon disulfide	11.000	LANL, 1994
1,3,5-Trimethylbenzene			Carbon tetrachloride	0.710	LANL, 1994
1,3- Dichloropropene	3.000	LANL, 1994	Chlorobenzene	19.000	LANL, 1994
2-Butanone (Methyl ethyl ketone)	1771.000	LANL, 1994	Chloroethane		
2-Hexanone(g)			Chloroethane		
3-carene(d)			Chloroform	12.900	LANL, 1994

Table A-3. Reference doses (RfDs) used in the preliminary ecolgocial risk assessment of the Mexican Spotted Owl at the Los Alamos National Laboratory. (cont)

Volatile Organic Compounds	NOAEL mg/kg/d	Reference	Volatile Organic Compounds	NOAEL mg/kg/d	Reference
Chloromethane			Vinyl Chloride		
cis-1,2-Dichloroethene			Xylene (Total)	179.000	LANL, 1994
cis-1,3-Dichloropropene			Semi-Volatile Organic Compounds		
Dibromochloromethane	21.400	LANL, 1994	Trichloropropane (1,2,3)	5.710	LANL, 1994
Dibromoethane			(2,4-Dicheorophenoxy) propionic acid (dichloroprop)(d)		
dibromomethane(d)			1,2,4-Trichlorobenzene	14.800	LANL, 1994
Dichlorodifluoromethane (1,2)-(1,3) (2,2)	15.000	LANL, 1994	1,2-Dichlorobenzene	85.700	LANL, 1994
Dichloropropane (1,2)			1,3-Dichlorobenzene		
Ethyl benzene	97.100	LANL, 1994	1,4-Dichlorobenzene		
hexanone (methy butyl ketone)(d)			1,4-methan Azulene, decahydro-4,4,8(d)		
Isopropyl benzene			2,2-Oxybis(1-chloropropane) (bis[2-chloroisopropyl]ether)		
Limonene(d)			2,4,5-Trichlorophenoxyacetic acid	3.000	LANL, 1994
Methanol	500.000	LANL, 1994	2,4,5-Trichlorophenoxy Propionic Acid	0.750	LANL, 1994
Methyl Iodide(d)			2,4,5-Trichlorophenol	100.000	LANL, 1994
Methylene Chloride	5.850	LANL, 1994	2,4,6-Trichlorophenol		
n butylbenzene(d)			2,4-D	1.000	LANL, 1994
n-Hexane			2,4-DB	8.000	LANL, 1994
Nitrotoluenes			2,4-Dichlorophenol	0.300	LANL, 1994
o-Chlorotoluene	20.000	LANL, 1994	2,4-Dimethylphenol	50.000	LANL, 1994
p-Chlorotoluene(d)			2,4-Dinitrophenol	2.000	LANL, 1994
propyl benzene(d)			2-Nitrophenol(d)		
Styrene	200.000	LANL, 1994	2-Chloronaphthalene		
Tetrachloroethylene	14.000	LANL, 1994	2-Chlorophenol	5.000	LANL, 1994
Toluene	223.000	LANL, 1994	2-Methyl-4,6 dimitrophenol(d)		
trans-1,2-Dichloroethene	17.000	LANL, 1994	2-Methylnaphthalene(d)		
trans-1,3-Dichloropropene			2-Methylnaphthalene(g)		
Trichloroethene			2-Methylphenol (o cresol)	50.000	LANL, 1994
Trichlorofluoromethane	349.000	LANL, 1994	2-Nitroaniline, (o-Nitroaniline)		

Table A-3. Reference doses (RfDs) used in the preliminary ecolgocial risk assessment of the Mexican Spotted Owl at the Los Alamos National Laboratory. (cont)

Volatile Organic Compounds	NOAEL mg/kg/d	Reference	Volatile Organic Compounds	NOAEL mg/kg/d	Reference
2-Nitroaniline			Benzidine	2.700	LANL, 1994
2-Nitrophenol(g)			Benzo[a]anthracene		
2-Nitrophenol)(g)			Benzo[a]pyrene		
2H-1 benzo pyran-2-one(d)			Benzo[b]fluoranthene		
3,3'-Dichlorobenzidine			Benzo[ghi]perylene		
3 Nitroaniline(m-nitroaniline)(g)			Benzo[k]fluoranthene		
3-Nitroaniline			Benzyl acholol(d)		
4-Chloro-3 methylphenol (p chloro m-			Benzyl alcohol		
4,6 Dinitro-2-methylphenol(g) (4,6-			Beta-BHC		
4- Nitrophenol			Bis(2-ethylhexyl)phthalate		
4 Bromophenyl phenyl ether(d)			Bis(2chloroethoxy)methane(g)		
4 Bromophenyl phenylether(g)			Bis (2-chloroethyl)ether		
4 Chloro o-tolyoxyacetic acid(d)			Butyl benzyl phthalate	159.000	LANL, 1994
p Chloroaniline	12.500	LANL, 1994	Carbazole		
4 Chlorophenyl phenyl ether(d)			Cetyl alcohol(d)		
4 Chlorophenyl phenylether(g)			Chlordane	0.055	LANL, 1994
4-Methylphenol (p cresol)	5.000	LANL, 1994	Chlordane	0.055	LANL, 1994
4-Nitroaniline(p nitroaniline)(g)			Chlorophenoxy acetic acid (2-methy-4)		
4-Nitroaniline			Chrysene		
Acenaphthene	175.000	LANL, 1994	Dalapon	8.450	LANL, 1994
Acenaphthylene(d)			DDD	165.000	LANL, 1994
Acenaphthylene(g)			DDE	42.000	LANL, 1994
Adipic ester(d)			DDT	0.050	LANL, 1994
Aldrin	0.025	LANL, 1994	DDT	0.050	LANL, 1994
Alpha BHC			delta BHC(d)		
Aniline			Di-n butylphthalate		
Anthracene	1000.000	LANL, 1994	Di-n octyl phthalate	175.000	LANL, 1994
Arochlors (all)	0.007	LANL, 1994	Dibenzo[a,h]anthracene		
Arobenzene			Dibenzofuran(d)		

Table A-3. Reference doses (RfDs) used in the preliminary ecolgocial risk assessment of the Mexican Spotted Owl at the Los Alamos National Laboratory. (cont)

Volatile Organic Compounds	NOAEL mg/kg/d	Reference	Volatile Organic Compounds	NOAEL mg/kg/d	Reference
Benzene acetic acid(d)			Dibenzofuran(g)		
Dicamba	3.000	LANL, 1994	Methoxychlor	5.010	LANL, 1994
Dieldrin	0.005	LANL, 1994	N-Nitrosodi-N propylamine		
Diethylphthalate	750.000	LANL, 1994	N-Nitrosodimethylamine		
Dimethyl phthalate	1000.000	LANL, 1994	N-Nitrosodiphenylamine		
Dimethylformamide			Naphthalene		
Dinoseb	1.000	LANL, 1994	Nitrobenzene	4.600	LANL, 1994
Endosulfan I & II	0.150	LANL, 1994	Octacosane(d)		
Endosulfan sulfate(d)			Octadeconoic acid(d)		
Endosulfan			Octamethylcyclotetrasiloxane(d)		
Endrin	0.025	LANL, 1994	PCB (aroclors)	0.007	LANL, 1994
Ethyl acetate	900.000	LANL, 1994	Pentachlorophenol	3.000	LANL, 1994
Ethylene glycol	200.000	LANL, 1994	Phenanthrene carboxylic acid(d)		
Fluoranthene	125.000	LANL, 1994	Phenanthrene(d)		
Fluorene	125.000	LANL, 1994	Phenanthrene(g)		
Heptachlor Epoxide	0.013	LANL, 1994	Phenol	60.000	LANL, 1994
Heptachlor	0.150	LANL, 1994	Phthalate ester(d)		
Hexachlorobenzene	0.080	LANL, 1994	Pyrene	75.000	LANL, 1994
Hexachlorobutadiene			Tetradecanoic acid(d)		
Hexachlorocyclopentadiene	7.000	LANL, 1994	Toxaphene		
Hexachloroethane	1.000	LANL, 1994	Vinyl Acetate	100.000	LANL, 1994
Hexadeconoic acid(d)			High Explosives		
Indeno[1,2,3 cd]pyrene			1,3,5-TNB (trinitrobenzene)	0.510	LANL, 1994
Isophorone	150.000	LANL, 1994	1,3-DNB (dinitrobenzene)	0.400	LANL, 1994
Lindane (gamma BHC)	0.330	LANL, 1994	2,4,6-TNT (trinitrotoluene)	0.500	LANL, 1994
Mecoprop (MCPP)	3.000	LANL, 1994	2,4-DNT (dinitrotoluene)	0.260	LANL, 1994
Mecoprop(d)			2,6-DNT (dinitrotoluene)		

Table A-3. Reference doses (RfDs) used in the preliminary ecolgocial risk assessment of the Mexican Spotted Owl at the Los Alamos National Laboratory. (cont)

Volatile Organic Compounds	NOAEL mg/kg/d	Reference	Volatile Organic Compounds	NOAEL mg/kg/d	Reference
2-amino-2,6-DNT (aminodinitrotoluene)(g)			Nitrocellulose (non-toxic)(g/k)		
2-amino-4 6-Dimitrotoluene(d)			Nitromethane(g)		
4-amino-2,6 DNT (amino-dinitrotoluene)(g)			NP (bis[2,2-dinitropropyl]acetal/formal)(g)		
Ammonium nitrate(g)			PETN (pentaerythritolletra nitrate)		
Barium nitrate (soluble barium)			RDX (trimethylenetri-nitramine)	0.300	LANL, 1994
.CEF (tri[b chloroethyl]phosphate)(g)			TATB (triaminotrinitrobenzene)(g)		
DPA (diphenylyamine)	2.500	LANL, 1994	Tetryl (N-methyl-N,2,4,6-tetranitrobenzeneamine)		
HMX (cyclotetramethylenete-tranitramine)	50.000	LANL, 1994			

Radionuclides	SAL pCi/g	Reference	Radionuclides	SAL pCi/g	Reference
Americium-241	17.000	FIMAD	Ruthenium-106	14.000	FIMAD
Carbon-14	41.000	FIMAD	Sodium-22	1.300	FIMAD
Cerium-144	56	FIMAD	Strontium-90	5.900	FIMAD
Cesium-134	1.800	FIMAD	Technetium-99	38.000	FIMAD
Cesium-137	4.000	FIMAD	Thorium-228	1.7	FIMAD
Cobalt-57	40.000	FIMAD	Thorium-230	5.000	FIMAD
Cobalt-60	0.900	FIMAD	Thorium-232	5.000	FIMAD
Gross Alpha Activity			Tritium	820.000	FIMAD
Iodine-129	41.000	FIMAD	Uranium-233	86.000	FIMAD
Manganese-54	3.400	FIMAD	Uranium-234	86.000	FIMAD
Plutonium-238	20.000	FIMAD	Uranium-235	18.000	FIMAD
Plutonium-239	18.000	FIMAD	Uranium-238	59.000	FIMAD
Potassium-40	12.000	FIMAD	Depleted Uranium	59.000	FIMAD
Radium-226	5.000	FIMAD	Uranium	66.000	FIMAD
Radium-228	5.000	FIMAD			

Table A-4. Cumulative hazard quotient totalled for all COPECs at all contaminated locations within a feeding range for each of 100 randomly selected Mexican Spotted Owl nest sites in the TA-21 Ecological Exposure Unit ("EEU-21").

Nest Site No.	Nest Location (Cell Grid ID)		Cumulative Hazard Quotient	Nest Site No.	Nest Location (Cell Grid ID)		Cumulative Hazard Quotient	Nest Site No.	Nest Location (Cell Grid ID)		Cumulative Hazard Quotient	Nest Site No.	Nest Location (Cell Grid ID)		Cumulative Hazard Quotient
	Column	Row			Column	Row			Column	Row			Column	Row	
1	53	46	0.468816	26	20	49	0.391384	51	37	50	0.452522	76	53	37	0.462222
2	39	50	0.45305	27	58	42	0.457553	52	29	45	0.426078	77	19	46	0.40891
3	44	45	0.465594	28	24	43	0.403417	53	24	50	0.415968	78	36	44	0.456303
4	66	45	0.447131	29	31	48	0.422038	54	18	49	0.400186	79	27	43	0.426853
5	39	50	0.453995	30	42	46	0.461244	55	65	37	0.418208	80	51	42	0.468242
6	47	49	0.466013	31	37	54	0.451538	56	42	46	0.466814	81	14	46	0.300835
7	24	49	0.400584	32	21	51	0.404681	57	68	37	0.438879	82	29	43	0.435976
	19	49	0.389259	33	29	49	0.418374	58	34	47	0.447874	83	50	45	0.467768
9	67	41	0.443267	34	31	41	0.422555	59	51	47	0.471117	84	51	41	0.467367
10	32	44	0.42606	35	29	48	0.419469	60	51	47	0.471117	85	39	41	0.467408
11	57	40	0.459951	36	38	52	0.453849	61	31	40	0.436128	86	68	44	0.413102
12	49	39	0.467952	37	76	32	0.436163	62	28	42	0.428323	87	32	41	0.444364
13	37	48	0.444503	38	29	45	0.421953	63	63	40	0.418713	88	75	40	0.399834
14	69	42	0.439136	39	39	50	0.461416	64	68	43	0.431138	89	24	47	0.423962
15	25	50	0.406221	40	34	44	0.44,629	65	16	46	0.292889	90	18	47	0.412551
16	37	42	0.443707	41	24	42	0.410035	66	20	49	0.407097	91	68	44	0.412473
17	23	44	0.39627	42	30	56	0.412089	67	60	41	0.449858	92	60	40	0.444778
18	59	44	0.45636	43	50	38	0.471067	68	42	39	0.468849	93	36	48	0.458134
19	39	52	0.454963	44	15	46	0.283563	69	26	46	0.422542	94	47	49	0.470791
20	50	44	0.470371	45	63	44	0.450296	70	14	53	0.408273	95	23	46	0.423728
21	28	50	0.412556	46	31	49	0.427909	71	58	39	0.450194	96	74	35	0.411758
22	52	38	0.470462	47	67	42	0.439293	72	25	51	0.425677	97	68	37	0.419499
23	45	41	0.464183	48	39	53	0.462518	73	16	52	0.414708	98	40	44	0.470578
24	34	42	0.434759	49	54	45	0.464302	74	20	52	0.423014	99	30	42	0.439784
25	59	40	0.455629	50	45	42	0.470112	75	58	41	0.418014	100	76	38	0.405691

Table A-5. Cumulative hazard quotient totalled for all COPECs at all contaminated locations within a feeding range for each of 100 randomly selected Mexican Spotted Owl nest sites in EEU-40.

Nest Site No.	Nest Location (Cell Grid ID)		Cumulative Hazard Quotient	Nest Site No.	Nest Location (Cell Grid ID)		Cumulative Hazard Quotient	Nest Site No.	Nest Location (Cell Grid ID)		Cumulative Hazard Quotient
	Column	Row			Column	Row			Column	Row	
1	115	122	2.94E-02	32	126	49	6.07E-02	63	126	54	7.38E-02
2	124	58	5.24E-02	33	95	101	2.17E-02	64	111	99	3.48E-02
3	105	79	1.10E-02	34	124	119	3.07E-02	65	127	58	6.42E-02
4	65	119	2.79E-02	35	127	133	9.42E-02	66	88	141	3.40E-02
5	145	121	1.94E-02	36	147	136	9.05E-02	67	161	40	3.95E-02
6	125	53	7.26E-02	37	122	134	8.27E-02	68	64	120	2.02E-02
7	67	114	2.67E-02	38	126	139	9.71E-02	69	65	117	2.17E-02
8	111	138	2.40E-02	39	139	47	5.49E-02	70	135	137	9.85E-02
9	73	144	4.27E-02	40	119	67	4.86E-02	79	117	56	6.61E-02
10	71	139	5.45E-02	41	106	100	2.26E-02	80	57	121	1.83E-02
11	74	114	2.43E-02	42	131	50	6.31E-02	81	72	110	1.53E-02
12	89	95	1.58E-02	43	64	142	4.81E-02	82	96	141	3.36E-02
13	131	54	6.88E-02	44	118	49	5.82E-02	83	138	112	5.30E-02
14	129	46	5.39E-02	45	122	58	5.85E-02	84	155	133	9.02E-02
15	76	112	2.37E-02	46	125	116	3.75E-02	85	143	132	9.39E-02
16	77	110	2.01E-02	47	75	144	3.65E-02	86	120	138	7.51E-02
17	113	137	3.29E-02	48	111	123	2.75E-02	87	68	145	4.82E-02
18	137	109	4.88E-02	49	167	131	8.12E-02	88	83	137	3.33E-02
19	90	101	1.69E-02	50	70	140	4.96E-02	89	95	89	2.83E-02
20	108	86	1.29E-02	51	126	60	5.73E-02	90	96	101	2.64E-02
21	65	141	5.59E-02	52	114	138	4.33E-02	91	121	64	5.97E-02
22	78	140	3.41E-02	53	78	107	1.06E-02	92	158	139	9.60E-02
23	122	117	3.02E-02	54	125	136	9.67E-02	93	98	100	2.63E-02
24	137	48	5.61E-02	55	84	139	3.53E-02	94	135	46	6.17E-02
25	160	36	4.00E-02	56	129	45	5.90E-02	95	114	140	3.94E-02
26	125	117	3.10E-02	57	154	129	6.79E-02	96	103	102	2.42E-02
27	117	72	3.82E-02	58	58	122	1.76E-02	97	74	112	1.39E-02
28	111	90	3.24E-02	59	91	91	2.06E-02	98	145	133	0.102227
29	123	67	5.11E-02	60	95	139	3.46E-02	99	106	140	1.96E-02
30	64	116	2.15E-02	61	115	71	4.45E-02	100	67	116	1.45E-02
31	129	136	9.18E-02	62	146	135	0.100119				

Table A-6. Mean hazard quotient, unadjusted for background, by COPEC totalled across grid cells for the Mexican Spotted Owl in Ecological Exposure Unit-21 (EEU-21).

Std Error	Unadjusted Mean HQ	Std Error	Rank	No. Obs.	Background Mean HQ	Std. Error
Cesium-137	7.02E-02	7.80E-03	1	100	7.68E-03	1.01E-03
Plutonium-239	4.45E-02	6.15E-03	2	100	1.72E-04	1.51E-05
Nickel	3.85E-02	2.39E-03	3	100	1.13E-03	1.09E-04
Potassium-40	3.78E-02	4.19E-03	4	100	3.39E-02	4.04E-03
Aluminum	3.74E-02	5.37E-03	5	100	1.63E-02	1.40E-03
Uranium-234	2.94E-02	5.24E-05	6	100	3.34E-04	4.55E-05
Calcium	2.91E-02	3.55E-03	7	100	1.58E-02	1.35E-03
Strontium-90	2.51E-02	3.08E-03	8	100	9.20E-03	8.25E-04
Thorium-228	1.46E-02	2.16E-03	9	100	#N/A	#N/A
Vanadium	1.34E-02	1.25E-03	10	100	1.24E-02	1.07E-03
Uranium-235	1.28E-02	1.95E-05	11	100	9.60E-05	9.65E-06
Magnesium	1.14E-02	1.09E-03	12	100	9.54E-03	8.16E-04
Radium-226	1.09E-02	1.76E-03	13	100	1.09E-02	1.76E-03
Manganese	1.05E-02	9.07E-04	14	100	1.04E-02	8.91E-04
Sodium	8.80E-03	1.77E-03	15	100	1.84E-04	1.71E-05
Zinc	6.59E-03	5.67E-04	16	100	3.20E-03	2.74E-04
Americium-241	6.12E-03	5.70E-04	17	100	#N/A	#N/A
Lead	5.71E-03	4.67E-04	18	100	3.05E-03	2.60E-04
Thorium-232	4.73E-03	4.67E-04	19	100	3.51E-03	4.67E-04
Antimony	4.57E-03	7.53E-04	20	100	2.11E-04	1.76E-05
Thorium-230	2.65E-03	2.68E-04	21	100	#N/A	#N/A
Plutonium-238	2.55E-03	2.65E-04	22	100	4.07E-05	3.59E-06
Barium	1.76E-03	1.77E-04	23	100	1.26E-03	1.08E-04
Uranium-238	7.99E-04	7.05E-05	24	100	4.58E-04	6.23E-05
Chromium	7.05E-04	5.46E-05	25	100	4.27E-04	3.65E-05
Cesium-134	6.37E-04	7.31E-06	26	100	#N/A	#N/A
Cobalt-60	6.02E-04	4.24E-04	27	100	#N/A	#N/A
Silver	4.33E-04	3.26E-05	28	100	#N/A	#N/A
Arsenic	4.07E-04	3.71E-05	29	100	3.76E-04	3.18E-05
Beryllium	3.77E-04	4.39E-05	30	100	1.48E-04	1.12E-05
Ruthenium-106	3.16E-04	5.83E-05	31	100	#N/A	#N/A
Mercury	2.86E-04	5.16E-05	32	100	#N/A	#N/A
Selenium	2.83E-04	5.48E-05	33	100	6.53E-05	4.86E-06
Molybdenum	2.82E-04	3.44E-05	34	100	#N/A	#N/A

Table A-6. Mean hazard quotient, unadjusted for background, by COPEC totalled across grid cells for the Mexican Spotted Owl in Ecological Exposure Unit-21 (EEU-21).

Std Error	Unadjusted Mean HQ	Std Error	Rank	No. Obs.	Background Mean HQ	Std. Error
Manganese-54	2.49E-04	4.67E-06	35	100	#N/A	#N/A
Thallium	2.37E-04	9.73E-05	36	100	5.23E-06	6.00E-07
Sodium-22	1.19E-04	1.30E-05	37	100	#N/A	#N/A
Cadmium	8.81E-05	5.74E-06	38	100	5.19E-05	3.99E-06
Copper	5.77E-05	4.83E-06	39	100	2.44E-05	2.09E-06
Radium-228	4.26E-05	0.00E+00	40	64	#N/A	#N/A
Cobalt-57	2.86E-05	2.34E-07	41	100	#N/A	#N/A
Uranium	1.58E-05	1.38E-06	42	100	8.31E-06	7.60E-07
Cerium-144	5.00E-06	9.24E-07	43	100	#N/A	#N/A
Lithium	3.34E-06	4.73E-07	44	100	#N/A	#N/A
Pyrene	1.98E-06	5.99E-08	45	100	#N/A	#N/A
Iodine-129	1.92E-06	5.53E-07	46	100	#N/A	#N/A
Chromium VI	1.61E-06	0.00E+00	47	100	#N/A	#N/A
Fluoranthene	1.59E-06	3.35E-08	48	100	#N/A	#N/A
Pentachlorophen	1.07E-06	3.37E-07	49	100	#N/A	#N/A
Benzoic acid	8.17E-07	1.29E-09	50	100	#N/A	#N/A
Tritium	7.06E-07	2.47E-07	51	100	#N/A	#N/A
Boron	6.13E-07	3.73E-07	52	90	#N/A	#N/A
Cyanide	2.02E-07	2.95E-10	53	100	#N/A	#N/A
Chlorobenzene	7.37E-08	1.08E-10	54	100	#N/A	#N/A
Fluorene	5.36E-08	9.32E-10	55	100	#N/A	#N/A
Acenaphthene	4.85E-08	4.97E-09	56	100	#N/A	#N/A
Phenol	4.23E-08	6.37E-11	57	100	#N/A	#N/A
Anthracene	1.33E-08	4.94E-10	58	100	#N/A	#N/A
Methylene chlor	8.49E-09	2.46E-09	59	100	#N/A	#N/A
Acetone	5.50E-09	3.88E-10	60	100	#N/A	#N/A
Technetium-99	3.98E-09	0.00E+00	61	81	#N/A	#N/A
Butyl benzyl ph	3.03E-09	6.49E-10	62	100	#N/A	#N/A
Tetrachloroethy	2.44E-09	3.98E-11	63	100	#N/A	#N/A
Toluene	2.35E-09	1.41E-10	64	100	#N/A	#N/A
Di-n-octyl phtha	1.79E-09	0.00E+00	65	89	#N/A	#N/A
Carbon disulfide	1.04E-09	1.45E-10	66	68	#N/A	#N/A
Trichlorofluoro	8.50E-11	0.00E+00	67	100	#N/A	#N/A
Styrene	1.68E-11	2.56E-14	68	100	#N/A	#N/A
	4.35E+00					

Table A-7. Mean hazard quotient, unadjusted for background, by COPEC totalled across grid cells for the Mexican Spotted Owl in EEU-40.

Contaminant	Unadjusted Mean HQ	Std Error	Rank	No. Obs.	Background Mean HQ	Std. Error
Potassium-40	1.04E-02	1.14E-02	1	100	1.37E-02	1.51E-02
Radium-226	6.03E-03	6.58E-03	2	100	8.71E-03	9.50E-03
Calcium	4.81E-03	2.77E-03	3	100	1.70E-03	6.35E-04
Antimony	4.07E-03	3.03E-03	4	100	4.28E-04	2.67E-04
Cesium-137	2.73E-03	1.84E-03	5	100	2.84E-03	2.45E-03
Thorium-232	2.38E-03	2.62E-03	6	61	4.08E-03	3.33E-03
Aluminum	2.32E-03	1.18E-03	7	100	1.44E-03	4.77E-04
Lead	2.18E-03	1.83E-03	8	100	5.92E-04	3.60E-04
Vanadium	2.12E-03	1.09E-03	9	100	1.20E-03	3.99E-04
Manganese	1.49E-03	6.96E-04	10	100	1.08E-03	4.05E-04
Barium	1.45E-03	7.97E-04	11	100	2.43E-04	1.50E-04
Magnesium	1.43E-03	7.04E-04	12	100	9.36E-04	3.11E-04
Uranium-238	1.34E-03	1.89E-03	13	77	2.41E-04	2.69E-04
Zinc	1.24E-03	8.47E-04	14	100	3.30E-04	1.24E-04
Strontium-90	1.15E-03	1.08E-03	15	70	1.58E-03	1.22E-03
Uranium-234	8.91E-04	1.28E-03	16	77	1.76E-04	1.97E-04
Nickel	7.76E-04	9.85E-04	17	100	3.99E-04	2.47E-04
Thorium-228	5.43E-04	5.16E-04	18	41	#N/A	#N/A
Plutonium-238	5.41E-04	1.13E-03	19	76	5.96E-06	6.38E-06
Mercury	3.76E-04	2.47E-03	20	100	#N/A	#N/A
Uranium-235	2.53E-04	4.12E-04	21	99	3.35E-05	3.84E-05
Plutonium-239	2.41E-04	3.07E-04	22	53	3.16E-05	2.49E-05
Arsenic	2.03E-04	8.61E-05	23	100	1.09E-04	6.82E-05
Chromium	2.00E-04	1.66E-04	24	100	8.56E-05	5.30E-05
Selenium	1.63E-04	1.77E-04	25	100	7.09E-05	4.43E-05
Silver	1.12E-04	1.65E-04	26	98	#N/A	#N/A
Cobalt-60	9.30E-05	1.32E-04	27	99	#N/A	#N/A
Beryllium	8.37E-05	4.25E-05	28	100	4.60E-05	2.99E-05
Copper	8.02E-05	8.45E-05	29	100	2.86E-06	1.05E-06
Radium-228	6.10E-05	2.47E-09	30	11	#N/A	#N/A
Thorium-230	5.92E-05	5.45E-05	31	27	#N/A	#N/A
Sodium	5.57E-05	2.46E-05	32	100	2.66E-05	8.83E-06

Table A-7. Mean hazard quotient, unadjusted for background, by COPEC totalled across grid cells for the Mexican Spotted Owl in EEU-40. (cont)

Contaminant	Unadjusted Mean HQ	Std Error	Rank	No. Obs.	Background Mean HQ	Std. Error
Cadmium	5.10E-05	2.93E-05	33	100	3.92E-05	2.44E-05
Americium-241	4.61E-05	4.23E-05	34	93	#N/A	#N/A
Thallium	4.54E-05	6.10E-05	35	100	7.65E-06	5.11E-06
Cesium-134	2.46E-05	7.89E-06	36	24	#N/A	#N/A
Sodium-22	2.39E-05	2.20E-05	37	97	#N/A	#N/A
Uranium	1.98E-05	2.73E-05	38	100	8.28E-07	4.58E-07
Ruthenium-106	1.26E-05	9.75E-06	39	96	#N/A	#N/A
Dieldrin	4.86E-06	6.80E-06	40	29	#N/A	#N/A
Methoxychlor	1.82E-06	3.39E-06	41	26	#N/A	#N/A
Manganese-54	1.64E-06	9.78E-10	42	35	#N/A	#N/A
Cerium-144	1.33E-06	9.89E-07	43	99	#N/A	#N/A
Pentachlorophenol	3.55E-07	9.28E-11	44	16	#N/A	#N/A
Endrin	3.30E-07	1.61E-07	45	35	#N/A	#N/A
Aldrin	2.95E-07	7.16E-08	46	11	#N/A	#N/A
Heptachlor epoxide	2.41E-07	1.11E-07	47	12	#N/A	#N/A
Cyanide	2.26E-07	2.50E-07	48	88	#N/A	#N/A
Cobalt-57	1.79E-07	1.22E-10	49	19	#N/A	#N/A
Pyrene	1.19E-07	2.79E-07	50	85	#N/A	#N/A
Fluoranthene	6.27E-08	1.76E-07	51	85	#N/A	#N/A
Nitrobenzene	4.70E-08	2.28E-08	52	83	#N/A	#N/A
Heptachlor	2.65E-08	0.00E+00	53	6	#N/A	#N/A
Acenaphthene	2.09E-08	2.52E-08	54	27	#N/A	#N/A
Fluorene	1.45E-08	1.56E-08	55	14	#N/A	#N/A
Lithium	1.06E-08	1.08E-08	56	6	#N/A	#N/A
Tritium	8.61E-09	1.99E-08	57	43	#N/A	#N/A
Anthracene	2.34E-09	4.11E-09	58	42	#N/A	#N/A
Di-n-octyl phthalate	1.60E-09	1.37E-09	59	32	#N/A	#N/A
Butyl benzyl phthalate	1.25E-09	6.25E-10	60	11	#N/A	#N/A
Acetone	9.61E-10	8.05E-10	61	26	#N/A	#N/A
Methylene chloride	7.46E-10	3.74E-10	62	27	#N/A	#N/A
Carbon disulfide	9.92E-11	6.84E-11	63	2	#N/A	#N/A
Toluene	1.78E-11	9.11E-12	64	15	#N/A	#N/A

Table A-8. Analysis of variance for data with a single criterion of classification, any number of groups, and unequal replication: applied to EEU-21 HQ data.

Source	df	SS	MS	F
Among HQ	2.0	5.728982	2.864491	3744.20*
Within HQ	283	0.2165086	0.000765	
Total	285			

*Calculated F > $F_{2,283,.05}$=3.00; SIG

r	100	100	86	Correction Factor	= 31.872835
sum	43.48946	14.083367	37.902985	Total SS	= 5.9454906
mean	0.4348946	0.1408337	0.4407324	Trt SS	= 5.728982
sumsq	19.028083	2.0019542	16.788288	Error SS	= 0.2165086
X2/r	18.913331	1.9834123	16.705073		
sumx2 (delta)	0.1147521	0.018542	0.0832146		
Std Dev	0.0340457	0.0136855	0.0312889		

Duncan's New Multiple Range Test for unequal replication

	MEANS		
	Background HQ	Unadjust HQ	Nest on Contam HQ
	0.14083367	0.4348946	0.440732384

Value of p	2	3	sqrt(1/2(1/r1)+(1/r2))*adjusted ISR (ISR*col m)				
SSR (.05; n2=213)	2.77	2.92	0.259807621	0.026004706	NOC-bck=	0.299898714	>0.026005; SIG
ISR	0.095877753	0.10009216	0.122474487	0.011742579	NOC-unaj=	0.005837784	<0.0117; NS
			0.259807621	0.024909771	unadj-bck=	0.29406093	>0.02491; SIG

Table A-9. Analysis of variance for data with a single criterion of classification, any number of groups, and unequal replication, EEU-40.

Source	df	SS	MS	F
Among HQ	2	0.012702	0.006351	7.77*
Within HQ	213	0.174207	0.000818	
Total	215			

*Calculated $F > F_{2,213,0.01} = 4.61$; SIG

r	100	100	16	Correction Term	=	0.358078
sum	4.764374	3.702205	0.328018	Total SS	=	0.186909
mean	0.047644	0.037022	0.020501	Trt SS	=	0.012702
sumsq	0.290855	0.246177	0.007955	Error SS	=	0.174207
X2/r	0.226993	0.137063	0.006725			
sumx2 (delta)	0.063862	0.109114	0.00123			
Std Dev	0.025398	0.033199	0.009057			

Duncan's New Multiple Range Test for unequal replication

	MEANS						
	Contam Nest Q		Background HQ		Unadjust HQ		
	0.020501		0.037022		0.047644		
Value of p	2	3	sqrt(1/2(1/r1)+(1/r2)))r-adjusted ISR (ISR*col m)				
SSR (.05; n2=213)	2.77	2.92	0.259808	0.017108	unad-contm=	0.027143	<0.0659; NS
ISR	0.062467	0.06585	0.122474	0.007651	unaj-bck=	0.010622	<0.0625; NS
			0.259808	0.016229	bck-contam	0.016521	<0.0625; NS

Table A-10. Average HQ by COPEC with MXSO nests "situated" only on contaminated sites (grid cell) within the nesting/roosting zone of EEU-21.

3.757971E-02	6.102398E-03	86.0000	Aluminum	1
1.778595E-03	1.952050E-04	86.0000	Barium	2
2.989687E-02	3.724970E-03	86.0000	Calcium	3
7.110608E-04	5.556438E-05	86.0000	Chromium	4
5.912151E-05	5.234973E-06	86.0000	Copper	5
5.747525E-03	4.836115E-04	86.0000	Lead	6
1.146516E-02	1.213588E-03	86.0000	Magnesium	7
1.053334E-02	9.803392E-04	86.0000	Manganese	8
2.575392E-03	1.673924E-04	86.0000	Plutonium-238	9
4.521944E-02	3.909097E-03	86.0000	Plutonium-239	10
2.534686E-02	2.207445E-03	86.0000	Strontium-90	11
1.590268E-05	1.560000E-06	86.0000	Uranium	12
1.348974E-02	1.390728E-03	86.0000	Vanadium	13
6.676383E-03	5.914622E-04	86.0000	Zinc	14
6.189482E-03	3.639781E-04	86.0000	Americium-241	15
8.881605E-03	1.976862E-03	86.0000	Sodium	16
1.542303E-02	1.884271E-03	86.0000	Thorium-228	17
2.728760E-03	2.941901E-04	86.0000	Thorium-230	18
4.868359E-03	5.121079E-04	86.0000	Thorium-232	19
2.937798E-02	5.464653E-05	86.0000	Uranium-234	20
1.275377E-02	2.143111E-05	86.0000	Uranium-235	21
7.979870E-04	6.353366E-05	86.0000	Uranium-238	22
1.605638E-06	1.821040E-09	76.0000	Chromium VI	23
2.795625E-04	6.298463E-05	86.0000	Selenium	24
4.150288E-04	3.953634E-05	86.0000	Arsenic	25
3.789993E-04	4.890020E-05	86.0000	Beryllium	26
3.338510E-06	5.377950E-07	86.0000	Lithium	27
3.915035E-02	1.617318E-04	86.0000	Nickel	28
4.228176E-03	1.046241E-03	86.0000	Antimony	29
5.207132E-07	3.774916E-07	81.0000	Boron	30
7.063457E-02	5.336340E-03	86.0000	Cesium-137	31
5.121018E-04	4.060598E-04	86.0000	Cobalt-60	32
1.609431E-06	2.477406E-08	86.0000	Fluoranthene	33
3.054803E-04	5.252321E-05	86.0000	Mercury	34
9.137563E-09	2.068504E-09	86.0000	Methylene chloride	35
2.951263E-04	3.356871E-05	86.0000	Molybdenum	36
2.004111E-06	4.628700E-08	86.0000	Pyrene	37
3.977275E-09	0.000000E+00	81.0000	Technetium-99	38
8.322924E-07	2.607195E-07	86.0000	Tritium	39
2.534294E-04	1.074578E-04	86.0000	Thallium	40
8.956618E-05	5.863944E-06	86.0000	Cadmium	41
2.362836E-09	1.745028E-10	86.0000	Toluene	42
4.319164E-04	4.181703E-05	86.0000	Silver	43
5.541743E-09	4.548517E-10	86.0000	Acetone	44

Table A-10. Average HQ by COPEC with MXSO nests "situated" only on contaminated sites (grid cell) within the nesting/roosting zone of EEU-21. (cont)

5.177112E-06	1.138545E-06	86.0000	Cerium-144	45
2.866699E-05	2.714747E-07	86.0000	Cobalt-57	46
3.881229E-02	4.950854E-03	86.0000	Potassium-40	47
1.141805E-02	1.834817E-03	86.0000	Radium-226	48
3.186288E-04	8.416420E-05	86.0000	Ruthenium-106	49
1.195364E-04	1.631214E-05	86.0000	Sodium-22	50
6.359731E-04	7.946966E-06	86.0000	Cesium-134	51
2.503596E-04	5.412074E-06	86.0000	Manganese-54	52
4.995738E-08	4.527992E-09	86.0000	Acenaphthene	53
1.351134E-08	3.722683E-10	86.0000	Anthracene	54
5.408107E-08	7.156122E-10	86.0000	Fluorene	55
1.791245E-09	1.423274E-12	76.0000	Di-n-octyl phthalate	56
7.365316E-08	1.031365E-10	86.0000	Chlorobenzene	57
1.157280E-06	3.244065E-07	86.0000	Pentachlorophenol	58
2.016187E-07	2.823081E-10	86.0000	Cyanide	59
2.438970E-09	3.452502E-12	86.0000	Tetrachloroethylene	60
8.500713E-11	5.939208E-14	86.0000	Trichlorofluorometha	61
1.078818E-09	1.408072E-12	76.0000	Carbon disulfide	62
8.170544E-07	1.349100E-09	86.0000	Benzoic acid	63
4.230883E-08	5.506730E-11	86.0000	Phenol	64
4.259351E-05	0.000000E+00	76.0000	Radium-228	65
2.193235E-06	4.255922E-07	86.0000	Iodine-129	66
2.940870E-09	7.202943E-10	86.0000	Butyl benzyl phthala	67
1.679291E-11	2.382701E-14	86.0000	Styrene	68

Table A-11. Average HQ by COPEC with MXSO nests "situated" on a contaminated site only (grid cell) within the nesting/roosting zone of EEU-40.

6.118620E-06	4.387655E-07	16.0000	Americium-241	1
1.221520E-06	2.780783E-07	16.0000	Cerium-144	2
1.916759E-03	9.749970E-05	16.0000	Cesium-137	3
1.052823E-05	1.345101E-06	16.0000	Cobalt-60	4
1.384702E-05	0.000000E+00	16.0000	Sodium-22	5
1.006908E-03	4.622180E-05	16.0000	Strontium-90	6
7.447396E-06	1.680965E-09	16.0000	Ruthenium-106	7
1.262980E-03	1.257502E-04	16.0000	Aluminum	8
2.967670E-04	4.606857E-05	16.0000	Antimony	9
4.471169E-05	5.715408E-06	16.0000	Arsenic	10
2.565983E-04	2.185237E-05	16.0000	Barium	11
2.067741E-05	2.227969E-06	16.0000	Beryllium	12
2.090558E-05	1.737392E-06	16.0000	Cadmium	13
3.123759E-03	2.644536E-04	16.0000	Calcium	14
3.987763E-05	4.627530E-06	16.0000	Chromium	15
3.575382E-05	7.574687E-07	16.0000	Copper	16
3.833079E-04	7.176642E-05	16.0000	Lead	17
8.269986E-04	8.055100E-05	16.0000	Magnesium	19
2.106987E-04	1.955010E-05	16.0000	Nickel	20
2.718355E-05	3.148964E-06	16.0000	Selenium	21
1.829011E-05	7.101810E-07	16.0000	Silver	22
2.486686E-05	3.406341E-06	16.0000	Sodium	23
3.749210E-06	3.862830E-07	16.0000	Thallium	24
5.136296E-07	3.841966E-08	16.0000	Uranium	25
1.083896E-03	1.040602E-04	16.0000	Vanadium	26
7.645941E-04	9.749525E-05	16.0000	Zinc	27
2.959009E-03	0.000000E+00	16.0000	Potassium-40	28
1.786178E-03	0.000000E+00	16.0000	Radium-226	29
1.303910E-05	1.561132E-06	16.0000	Uranium-235	30
3.266789E-03	8.377125E-03	16.0000	Mercury	31
6.414898E-09	1.520390E-08	16.0000	Fluoranthene	32
5.242503E-08	1.393266E-07	16.0000	Pyrene	33
3.713977E-05	7.473882E-06	16.0000	Uranium-234	34
5.277391E-05	1.044159E-05	16.0000	Uranium-238	35
6.698035E-10	0.000000E+00	16.0000	Methylene chloride	36
3.134680E-10	0.000000E+00	4.00000	Acetone	37
4.103994E-05	6.041707E-07	4.00000	Plutonium-238	38
4.814839E-06	4.518031E-06	4.00000	Plutonium-239	39
3.801904E-04	2.693228E-04	4.00000	Thorium-228	40
1.000052E-04	6.824041E-05	4.00000	Thorium-230	41
1.748706E-04	1.211539E-04	4.00000	Thorium-232	42
9.121492E-09	1.666188E-12	2.00000	Acenaphthene	3
3.147741E-09	0.000000E+00	2.00000	Anthracene	44
9.941413E-09	0.000000E+00	2.00000	Fluorene	45
2.256550E-08	0.000000E+00	2.00000	Lithium	46
1.475742E-10	3.640494E-14	2.00000	Carbon disulfide	47
4.368868E-08	0.000000E+00	2.00000	Cyanide	48
1.698560E-09	0.000000E+00	2.00000	Nitrobenzene	49

Integrating Project Requirements with Threatened and Endangered Species Habitat Requirements, A Pilot Demonstration

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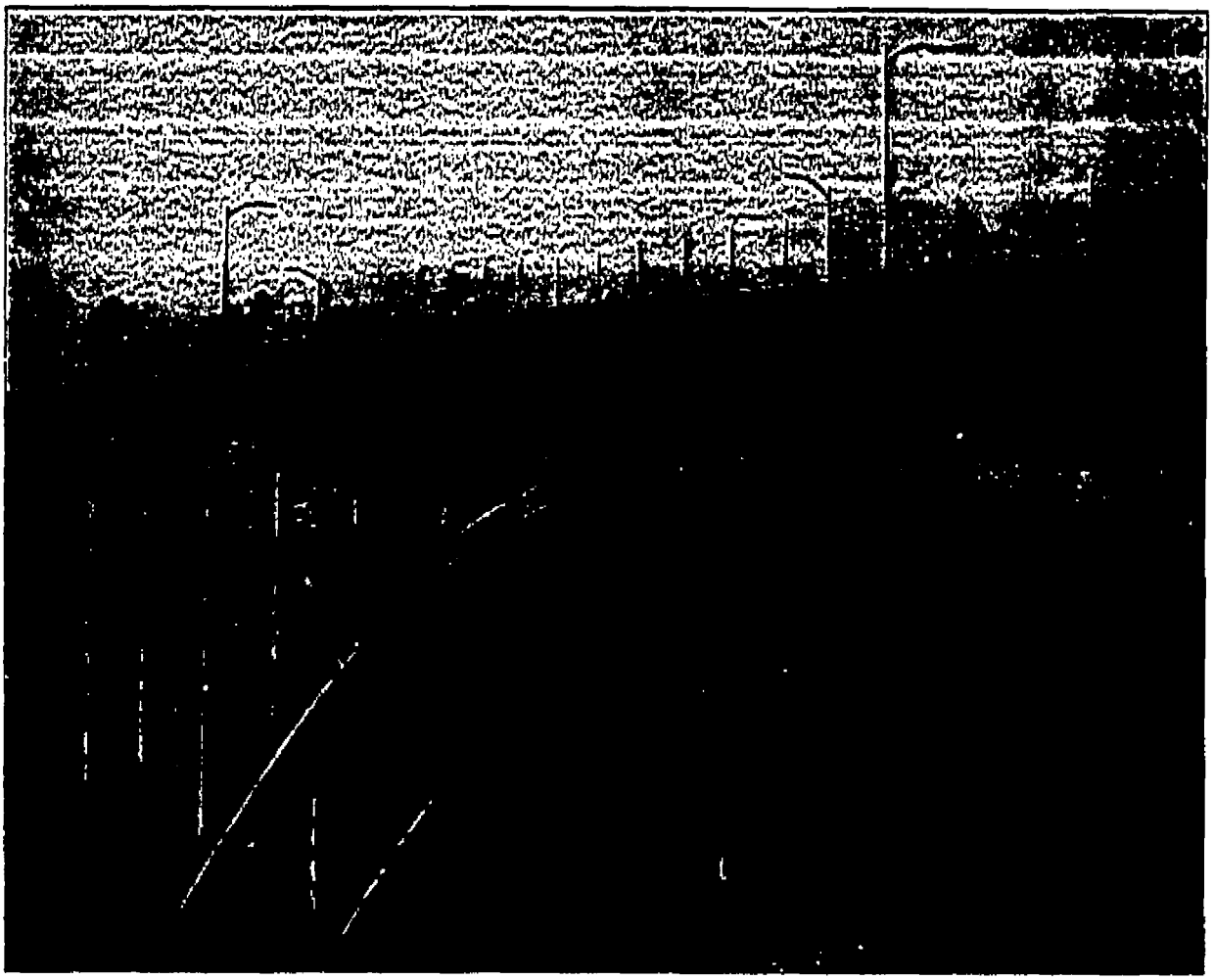

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Integrating Project Requirements with Threatened and Endangered Species Habitat Requirements, A Pilot Demonstration

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Abstract

The Mission Task of the Threatened and Endangered Species (TES) Habitat Management Plan (HMP) identifies and considers the current Department of Energy (DOE) and University of California mission and tactical goals for Los Alamos National Laboratory as translated into projects and activities. The objective of this task is to create an element within the TES HMP that considers the projects and activities and their relationship to TES and Species of Concern (SOC) and the habitats that these organisms use. In this first phase of this task, we have examined data related to projects, defined a process for evaluation of projects, and developed a pilot demonstration to evaluate a hypothetical project using a geographic information system ArcView application. This application evaluates the interactions between projects and activities and TES, SOC, and their habitats.

1.0 Introduction

In 1994, the Secretary of the Department of Energy (DOE) sent a memorandum to the various offices directing that DOE and its contractors conduct natural resource planning in accordance with "ecosystems management." Ecosystems management is an interdisciplinary approach that integrates all aspects of natural resource management (e.g., species that are threatened or endangered, wetlands, wildlife, forest management) with the rest of the mission of each facility. This document deals with one aspect of natural resource management, that of threatened and endangered species (TES).

The Endangered Species Act (Public Law 93-205) requires protection and conservation of federally listed TES of plants and animals. To accomplish ecosystems management of TES species at Los Alamos National Laboratory (LANL or Laboratory), it is essential to understand the activities related to the mission of the Laboratory and the effects of those activities on TES or the habitat that is critical to TES.

This report describes work completed in Fiscal Year 1996 (FY96) for the mission task (Task 5) of the TES Habitat Management Plan (HMP) for LANL (Foxx 1996). This report provides a description of a proposed process used to identify, document, and evaluate the interactions between mission-driven projects and the regulatory requirements of protection and conservation relative to TES and Species of Concern (SOC) within the boundaries of LANL.

During FY96 the goal of this task was to identify what information had been gathered on LANL projects and activities from other sources such as the Site-Wide Environmental Impact Statement (SWEIS), to define a process for evaluating alternatives for completing projects and activites and

quanitifying their impacts, and to develop a pilot demonstration using the Geographic Information System (GIS) ArcView. The initial review indicated that there are a large variety of projects and activities at LANL. Many projects will not impact TES or SOC because they are not located near or within TES or SOC habitats. However, some projects may have activities that will, if conducted in a TES or SOC habitat, cause the organism to not fully use that habitat. When an activity has an effect we call it an influence factor. Our challenge was to develop an evaluation procedure to identify the influence factors and develop a process to recommend alternative sites or mitigation actions. Ultimately, we want to quantify cumulative impacts of proposed Laboratory activities over multiyear planning scales.

As an initial test of the evaluation process using the GIS, we developed a hypothetical project. Using this project we demonstrate how the ArcView application can be used for evaluation of activities early in the planning stage of a project. This paper describes the steps to the development of the ArcView application and its use as an evaluation tool in integrating requirements for activities with TES concerns.

2.0 Background

2.1 Need for Planning Tools in TES Evaluations

The need for integration of TES concerns with the project and construction activities at LANL was emphasized by the discovery of TES during the writing of an Environmental Impact Statement (EIS). Because TES issues had previously only been done on a site-by-site basis, and the TES species was only recently listed, the presence of the species was not identified until the environmental documentation was partially completed. The discovery threatened to slow the approval of the EIS and planned activities.

The EIS and TES example clearly demonstrated the planning liability of conducting the traditional project-by-project biological reviews. In October 1995, the DOE and LANL initiated the site-wide TES HMP as a means of organizing existing information, gathering new information, and implementing a valuable management tool for current and future planning. In addition to other mitigation actions, the need for a TES HMP was further emphasized in the EIS Record of Decision (ROD). Therefore, with the issuance of the ROD in October 1995, a mandate to develop a site-wide HMP was included.

2.2 LANL Projects and Activities

For the purpose of this report we are using the following definitions:

1) Mission: The long-range direction of LANL.

2) Projects: Specific projects and programs, both short- and long-term, related to the tactical plan (e.g., construction projects).

3) Activities: Specific activities related to a project or program (e.g., noise, cutting trees).

4) Influence Factor: Specific activities in association with an action may influence the ability of a TES to use a habitat. For example, noise is an activity that, when the levels are too high in a TES habitat, may cause a TES bird to abandon the site as a nesting area. If the noise does not impact a TES habitat, it is merely defined as an activity in this report.

All projects and activities of LANL are related to the mission. Our evaluations are being done at the level of projects and activities. It is at the project level that the interaction of TES with LANL mission requirements can be determined. Therefore, although this task was called a mission task, we will be working at the project and activity level.

2.3 Development of Planning Tools

In 1996, we initiated the first year of a three-year program to develop a HMP. The activities in the 1996 Work Plan outlined eight tasks that can each stand alone but collectively are intended to be used to understand the relationship of TES to Laboratory projects.

To date we have developed a land cover map (Koch et al. 1996) that identifies cover types and a preliminary land cover classification that identifies community types throughout the Laboratory. Using this land cover map we can more easily define potential habitat for TES. Additionally, we have surveyed the literature to define the habitat requirements for TES and SOC. Using this information, combined with project and activity data, we can use the GIS as a tool to develop an evaluation process and to integrate habitat requirements with project activities.

The GIS task has taken information from data bases, previously developed map layers such as structures and roads in Engineering data bases, habitat requirements, and land cover types. Using this information, Bennett et al. (1996) have developed an ArcView application for evaluation of projects (Figure 1).

3.0 Methods

There are three steps that must be taken to integrate activites with TES requirements.

- Identify classes of projects and activities. These actions may be short term or continuous. Development of a data base to identify these short-term and long-term activities is essential.

- Identify the influence factors of these actions and activities. Influence factors can be determined by the habitat requirements and disturbance tolerance of specific species. This can be done through a literature review (Gonzales et al. 1996) and from previous USFWS project reviews.

- Determine how the activities and the influence factors can be evaluated early in the planning process to allow projects that are needed to meet the tactical goals of the mission of the Laboratory to move forward while maximizing protection and conservation of TES.

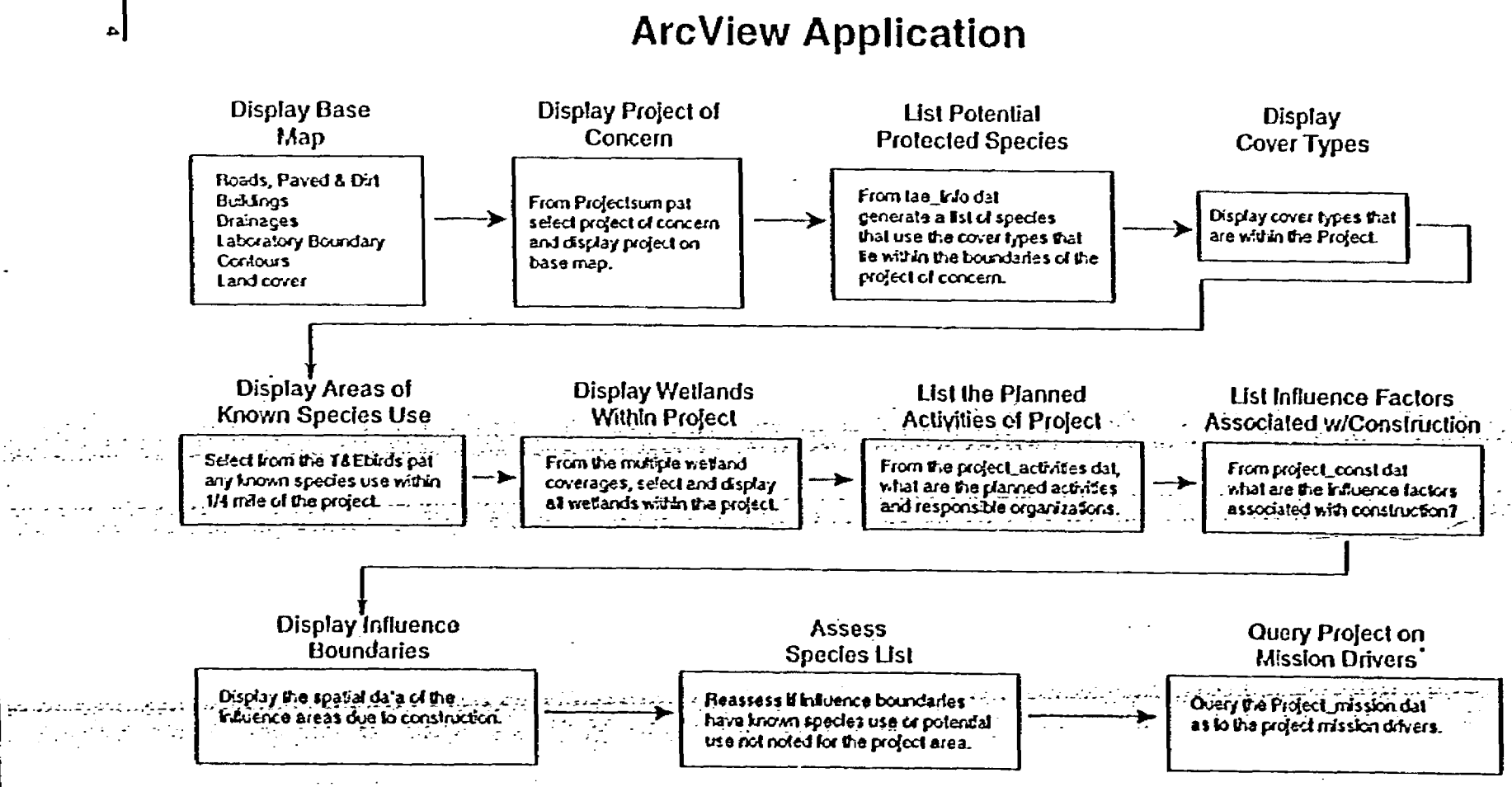

Figure 1. An ArcView application for evaluation of projects.

4.0 Results

4.1 Demonstration of the Evaluation of a Hypothetical Project

For our hypothetical project, we selected the building of an access road. The road project had two alternative routes, one on the northeast side of a canyon (road 1) and the other on the southwest side of the canyon (road 2), and the TES habitat existing in the canyon. In the early stages of the project, the planner wants to determine the most appropriate route when considering TES issues. Using these two possible alignments, an evaluation of each road is done using the ArcView Application.

4.1.1 Determination of Activities, Habitat Requirements, and Influence Factors

Four steps were taken in the evaluation process.

- Evaluate the project for activities,
- Identify the TES habitat in the project area,
- Identify the habitat requirements for the TES, and
- Run the ArcView application to identify the best alternative routing.

4.1.2 Project Evaluation

We defined activities related only to the construction phase of our hypothetical road. Those activities are

- noise from equipment,
- cutting trees,
- reduction of ground cover, and
- potential impact to a canyon bottom.

4.1.3 Identification of the TES Habitat and Habitat Requirements

Using maps developed for the HMP by Koch et al. (1996) and survey information (Keller 1996, Trippe and Haarmann 1996, Bogan et al. 1996, Johnson 1996) we have identified potential habitat for various TES (Figure 2). These maps and the information from the literature review (Gonzales et al. 1996) provided information about the habitat requirements for the TES species within the designated TES habitats.

The habitat requirements included

- breeding or nesting sites with varying types and density of vegetation,
- roosting sites,
- foraging areas,
- watering areas, and
- protective cover with varying types and density of vegetation.

4.1.4 Conducting the Evaluation

We ran the ArcView Application using the two alternative sites for a road for two influence factors—noise and cutting trees. In one alternative, the road went directly into a TES habitat (southwest of the canyon); in the other, the road was outside the TES habitat (northeast of the canyon) (Figure 2). In Figure 2, we provide an example of how tree cutting, an activity of the road building project, becomes an influence factor for the alternative on the southwest side of the canyon. However, if the road is sited to the northeast side of the canyon and does not enter into the TES habitat, the cutting of trees will not be a hinderance to the TES. In the first case where

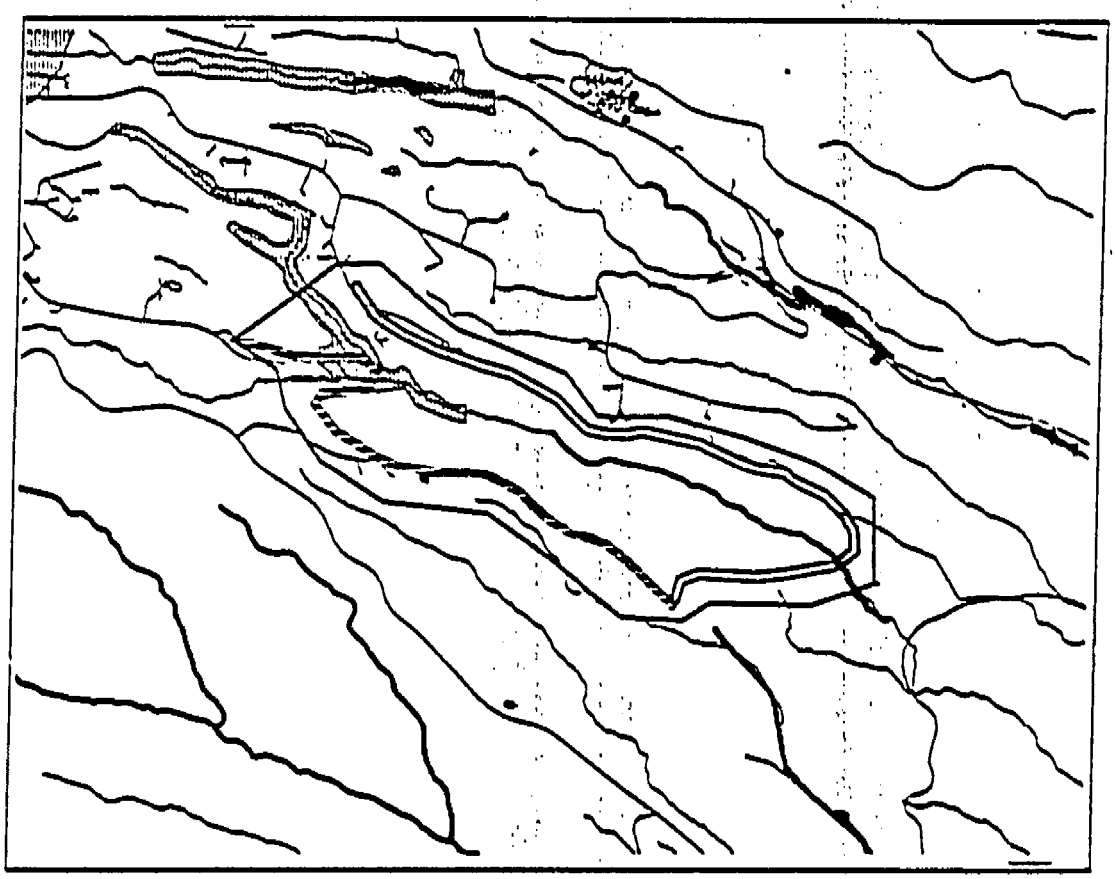

Figure 2. Map shows influence factor of tree loss associated with road site alternatives for a hypothetical project.

the road enters into the TES habitat, if the road siting cannot be moved, then mitigation measures and consultation with USFWS would be necessary. By directing the road away from the TES habitat, activities do not become influence factors and mitigation actions need not be taken in relation to cutting trees.

Using the ArcView Application, we can assess each influence factor or multiple factors for the activities of a project.

This application provides a base on which to build a better assessment tool. It will be further developed as we get more information about species, habitats, habitat requirements, and LANL activities in FY97.

5.0 Conclusion

Using and integrating the information from a hypothetical project with information developed in other tasks for the FY96 HMP effort, we have developed a preliminary evaluation tool. This tool used in early planning can incorporate the TES issues and avoid delays because of siting. This tool must be further refined, additional influence factors identified, and habitat requirements evaluated. In FY97, actual projects and activities will be evaluated for their relationship with TES, SOC, and the habitats they use within LANL.

6.0 References

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Literature Review
and
Species Habitat Use Documentation

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Literature Review and Species Habitat Use Documentation

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Abstract

During FY96, we did a systematic search of the literature to find information about species that are endangered, threatened, or species of concern that inhabit or use the 43 mi^2 of Los Alamos National Laboratory. To date, we have entered references related to these species into a bibliographic database called ProCite. From the literature, we have developed habitat use and feeding habits tables for 10 of the species.

1.0 Introduction

Essential to understanding the habitat requirements of endangered and threatened species and species of concern is information gathered by other researchers. Background information is needed for toxicological modeling and ecological risk studies, developing Habitat Evaluation Procedures, conducting threatened and endangered species (TES) surveys, developing monitoring plans, and understanding habitat requirements.

Using databases already established by the New Mexico Natural Heritage Program and searching the published literature, we have developed a listing of information about each species in the "Threatened, Endangered, and Sensitive Species Profile" (Hinojosa 1996).

2.0 Methods

Bibliographic databases were searched for the period January 1991 to January 1996 using TES names as the key terms. The database most used was BIOSIS. Publications of the U.S. Forest Service, U.S. Fish and Wildlife Service, and Bureau of Land Management were also searched for relevant titles. Citation lists from articles, periodicals, and books were examined for other sources of information.

Requests were made of many government agencies to supply listings of previous publications that might be relevant to the study. All appropriate U.S. Fish and Wildlife recovery plans and their listing of articles by TES were obtained. The complete listing of publications available through the U.S. Forestry Service's Intermountain Research Station at Ogden, Utah, and the Rocky Mountain Forest and Range Experiment Station in Fort Collins, Colorado, were reviewed. The New Mexico Natural Heritage Program provided a listing of articles concerning Los Alamos TES.

We have established a reference listing on ProCite bibliographic software from Personal Bibliographic Software. ProCite can efficiently manage large databases containing thousands of variable length records, and encompassing many different types of material.

Standard bibliographic fields and key words allow researchers to search the database for specific information.

3.0 Results and Conclusions

To date, we have accumulated and entered 403 references (Appendix A). From these references we have reviewed the literature for habitat use and feeding habits for the following species:

Mexican spotted owl
bald eagle
American peregrine falcon
southwestern willow flycatcher
Jemez Mountains salamander
northern goshawk
New Mexico meadow jumping mouse
whooping crane
black-footed ferret
spotted bat

Habitat use information for these species is summarized in Tables 1-10. The reference list is found in Appendix A. As new references are identified they are added to the database.

4.0 References

Hinojosa 1996: H.A. Hinojosa and L.K. Nguyen, "Threatened, Endangered, and Sensitive Species Profile," Los Alamos National Laboratory report LA-UR-96-1269.

Table 1. Habitat Use and Feeding Habits of the Mexican Spotted Owl.

Habitat Requirements				
General	Roosting/Nesting	Forage	Location	Reference
Old growth/ mature conifer forest				Marcot & Holthausen, 1987; Forsman et al., 1984; Laymon, 1988; Ganey & Balda, 1989 and Thomas et al., 1990 In: Ganey, 1992
Old Growth/ uneven-aged forest				Rinkevich, 1995
>40° slopes				Rinkevich, 1995
	Virgin MC (roosting) More big logs, higher canopy closure, and > densities/basal area of trees & snags than random sites; Roosting > canopy closure, more big logs, and > densities than foraging sites	≥ expected in virgin MC/PP; <expected in managed forest	N. Arizona	Ganey & Balda, 1991
	Species Association: Psme, 92%, > expected based on availability		Cascade Mts., Washingtn	Buchanan et al., 1993
	Psme, 87%		Oregon	Forsman et al., 1984
	Psme, 83%		California	Lallaye, 1988
	Most common nest type: those originally made by the N. Goshawk (55%)		Cascade Mts., Washington	Buchanan et al., 1993

Table 1. Habitat Use and Feeding Habits of the Mexican Spotted Owl. (cont)

Habitat Requirements				
General	Roosting/Nesting	Forage	Location	Reference
Home Range (Acres)				
7,268 (pair)			Washingtn	Allen & Brewer, 1986
6,020 (pair)			Oregon	Forsman & Meslow, 1985
1,469			LANL, Generic for carnivore birds based on body wt	Peters, 1993
2,000			LANL	Keller, 1996
3,000-5,000 (pair)			Pacific NW	Payne, 1987 In:Thomas et al., 1990
5,178 (individual)			WA/OR	Marcot & Holthausen, 1987
Minimum Viable Population – Owl Pairs: 20			Pacific NW	Payne, 1987
Minimum Number Owl Territories in a Cluster – 20			Pacific NW	Lamberson, 1991
Woodrats (*Neotoma*), White-footed Mice (*Peromyscus*), Voles(*Microtus*) 61-83% of prey (59-88% of biomass)			Arizona	Ganey, 1992

Table 2. Habitat Use and Foraging Habits of the Bald Eagle Potentially Pertinent to Wintering on LANL and Surrounding Areas.

Habitat Requirements					
General	Roosting	Nesting	Perching/Foraging	Location	Reference
Migrant, winter resident and potentially breed along the Rio Grande and on adjacent LANL, LA County, BNM and SFNF lands				Los Alamos, NM area.	Klingel, 1995.
Tends to center around nesting territory.					Snow, 1973
			Susceptible to DDE and potentially to other environmental pollutants.		Snow, 1973; Grubb et al., 1990; Vickery, 1995; Anthony et al., 1994.
	Canyons most extensively used as winter roost areas. Psme in northern exposures free from human inter-ference most commonly used. More tolerant when same roosts are used.			Utah	Edwards, 1969
Home Range (Acres): 1. 5436 (avg. resident pairs) (areas of highest use avg. <124 ac.; varies between breeding and nonbreeding periods; varies w/season and particular pairs)		Generally old growth forest near shoreline. Tree species use: Sitka spruce – 49% Psme – 40%	Habitat Association: Forage from perches in "mixed-mature conifers & river island hardwoods; not used according to availability; Habitat / Breeding / NB O G conif/bdlf 27% 21% Mat conif/bdlf 30% 38%	OR, WA – Columbia River Estuary	Garrett et al.; 1993

Table 2. Habitat Use and Foraging Habits of the Bald Eagle Potentially Pertinent to Wintering on LANL and Surrounding Areas. (cont)

Habitat Requirements					
General	Roosting	Nesting	Perching/Foraging	Location	Reference
2. >1265; considerable variation.			Catfish, carp & sucker ~ 66% Rabbit ~ 10-15%	C. Arizona, river dwelling.	Recovery Team, 1982
			Habitat Adult Juvenile Conifer 43% 15% Deciduous 57% 85% Conifer perches taller, in denser stands and of greater mean slope than deciduous.	N.central Mich, continuous mixed-forest	Bowerman et al., 1993
		Varies tremendously even w/in same state; dependent on tree species.			Snow, 1973
		All nests were in Psme, usually the tallest.		San Juan Island	Retfalvi, 1965.
		Usually in largest or stoutest Pien, lodgepole pine, whitebark pine, or Psme.		Yellowstone	Murphy, 1965
		Sitka spruce most frequently used		Tongass Nat'l forest, Alaska	Poulin (1968) and Corr (1969)
		In Sitka spruce 90% of time		Admiralty Island, Alaska	
			Most (99%) foraging attempts for rainbow trout, in creek habitat (87%) vs. River, and for live prey (87%).	N. Arizona	Robards et al. (1966)

Table 3. Habitat Use and Foraging Habits of the American Peregrine Falcon Potentially Pertinent to LANL and Surrounding Areas.

Habitat Requirements				
General	Nesting	Foraging	Location	Reference
Summer resident and migrant on LANL, LA County, BNM and SFNF lands.			Los Alamos, NM area.	Klingel, 1995.
	Historically on cliffs (200-300 ft high), usually in below 9,500 ft elev. in mountainous areas or near rivers or lakes; currently mainly on mountain cliffs in PP or PJ dependent on prey abundance and diversity, often near water.	Travel up to 17 mi. to forage in areas including wetlands/ riparian habitats, gorges and mtn valleys. Diet includes terrestrial birds. Susceptible to DDT or, potentially to other environmental pollutants.	Rocky Mtn region; SW.	RM/SW Recovery Team, 1984.
		Travel up to 7 mi.		World Wildlife Fund, 1990

Table 4. Extrapolated Habitat Use and Foraging Habits of the Southwestern Willow Flycatcher.

Habitat Use/Requirements		Qualification/Location	Reference
General	Nesting		
Occasional or rare in the Jemez Mountains. Possible breeding habitat on LANL and BNM lands.		Los Alamos, NM area.	
	≥ 20% cover	(not Southwestern variety) British Columbia	Stein, 1963
	Salix > Rosa > Cornus, Lonicera > Almus, Amelanchier (abundance-influenced)	British Columbia	Stein, 1963
Riparian: Cottonwood & willow, dryer habitat than the alder flycatcher but near water		LANL	Klingle 1995
Swamps, willow thickets			Browning, 1993
Salix spp. and freemont cottonwood (P. fremontii) Understory: mulefat (Baccharis Salicifolia) and Dense hoary nettle (Urtica Dioica)		River valley S. Sierra Nevada Mountains	Uychara and Narins, 1995
Dry Habitats: have thorn bush (Crataegus spp.) and crabapple (Malus spp.)		Ontario, Canada	Barlow and McGillivray, 1983
Wet Habitats: willow/poplar or willow/alder		Ontario, Canada	Barlow and McGillivray, 1983

Table 5. Extrapolated Habitat Use and Foraging Habits of the Jemez Mountains Salamander.

Habitat Use/Requirements	Qualification/Location	Reference
Confirmed on Los Alamos County, BNM and Sanfa Fe National Forest lands and is believed to be on LANL lands as well.	Los Alamos, NM area.	Klingel, 1995
Habitat Association/Relationship: + w/talus, organic surface layer, & N. aspect; – w/mineral soils, exposed substrates, S. aspect, & conifer/tan oak type; None w/forest age or canopy cover.	Del Norte Salamander; North Coastal California	Diller and Wallace, 1994
Dominant Habitat Associations/Relationships:	Psme dominated stands, Cascade Range, WA	Szaro et al., 1988

	ensatina	W. redback
Forest Age Rank (NS)		
young	39%	48%
old gr moderate	19%	8%
old-growth dry	17%	35%
old-growth wet	8%	3%
mature	17%	6%

(Note: old-gr wet habitat type contained very few salaman. of either spp)

Cover Type (highest associa)	snag bark	log bark
Degree of snag/log decomposition	intermed	intermed
Snag/log (course woody debris) size	10-30 cm	10-30 cm

No correlations between slope or aspect.

Table 6. Habitat Use and Foraging Habits of the Northern Goshawk

Habitat Use/Requirements					
General	Nesting	Forage	Dispersal	Location	Reference
Ponderosa Pine, Mixed Conifer, Spruce/Fir. Prefers deep conifer-dominated mixed woodlands, especially in mountains. Breeding confirmed on LA County, LANL, BNM and SFNF lands.		Preys on birds and mammals as large as cottontail rabbit.		Los Alamos, NM area	Klingel, 1995.
11 active nest sites, 5 in Jemez mtns., SFNF; 5 in Pinos Altos mtns., Gila NF; 1 in Peloncillo mtns. sw NM Elevation: 1800 to 2560 m. Narrow ridges, escarpments, mtn. slopes, terraces, alluvial land. Avg. annual precip. = 40–45 cm. Pinyon-juniper, mixed associations of chapparral, ponderosa pine, grasslands, and riparian. Suggests old growth is preferred if available (not in Jemez, due to logging)	Stands: 27% – Ponderosa pine/ Gambel's oak, 27% – Pond. pine/gray oak, 18% – mixed conifer (white & Douglas fir/ Pond. pine/Gambel's oak) 74% nests in Pond. pine. Mean tree height = 25.9 m; mean nest height – 16.9 m. No preference for nest exposure. Often < 1 km from permanent water. Density mean = 959.3 trees/ha. Avg dbh = 21.5 cm, avg basal area = 21.1 m^2/ha.	Hunt in areas 0.8 km to 8 km from nest.		NM	Kennedy, 1986.
Timber stands reach goshawk habitat suitability when site is 25 m at age 75. Prefer late successional forests. Noted a proximity of nests to water source. Noted limited info available on foraging habits. In AZ, 1.1 pair per 1000 ha.	Mature to old growth forest, dbh: 20-75 cm, ≥ 8 ha, density = 450 trees/ha, range: 270-1530 trees/ha, canopy cover 40%-89% (higher end preferred), often open understory, on flat benches or lower 1/3 of hillside, slopes 0%-45%. No preference for exposure in NM. Often near clearings, small logging roads, stream beds, or other natural paths of flight. Most within 0.4 km of an opening 0.04-0.4 ha. Shift sites every 1–5 years. Don't renest if disturbed.			Northern Rockies*	Lilieholm et al., 1993.

Table 6. Habitat Use and Foraging Habits of the Northern Goshawk. (cont)

Habitat Use/Requirements					
General	Nesting	Forage	Dispersal	Location	Reference
Used alarm, wailing, and begging calls to determine location of goshawk's nest sites. Most likely to find when within 200 m of nest.	23 of 27 nesting sites in Ponderosa pine and 4 of 27 were in mixed conifer dominated by Douglas-fir and white fir.			North-central NM & AZ	Kennedy & Stahlecker, 1993.
Study found that goshawks moved southward in September and returned to nesting site in March/April. Snow storms caused movement further south.	Found in Lodgepole Pine & aspen at lower elevations; subalpine fir & Engelmann spruce at higher elevations, w/ sagebrush/prairie around woodlands.			South-central Wyoming	Squires and Ruggiero, 1995.
	Breeds first week in April. Density of territorial pairs is 2.56 per 100 km^2, of laying pairs: 2.15 per 100 km^2. Cold/rainy weather decreased breeding success. Built stick nests.	Pigeons		Germany	Kostrzewa and Kostrzewa,* 1990.
Mass = 800–1200 g; survives cold better. Can go >10 consec. days w/ little/no food.				Germany	_____, 1991.
Ponderosa Pine, mixed (often Douglas fir and white fir), spruce-fir. Mosaic of young to old trees. Large trees > 18 in dbh, snags, downed logs > 12 in diam. and 8 ft. long, woody debris, small openings < 4 acres, some herbaceous and shrubby understories. Home range = 6000 acres. Food and available nest sites limit density of goshawks.	Area = 30 acres, on a northerly aspect (shady) in a drainage or canyon, often near stream, ≥ 1 stand of large old trees, dense canopy cover. Mar. – Sept. Post fledging family area (PFA) = 420 acres, patches of dense trees, herbaceous and/or shrubby understory, snags, downed logs, small openings.	= 5400 acres around PFA. Hunt from tree perches. Open understory. Squirrels, rabbits, woodpeckers, jays, grouse.		South-west, U.S.	Reynolds, et al., 1992.

Table 6. Habitat Use and Foraging Habits of the Northern Goshawk. (cont)

Habitat Use/Requirements					
General	Nesting	Forage	Dispersal	Location	Reference
12 breeding prs. in 150 km^2 studied.		Winter: pigeon, jay & pheasant. Reproductive season: pigeon, blackbird, starling, jay, rabbit.		Germany	Opdam, et al., 1977.
No nests were found on LANL, but 2 nests on SFNF, near LANL were found. Foraging on LANL.	Ponderosa pine, mixed species, and spruce-fir forests.	Prey habitats: snags, downed logs, woody.		LANL, NM	Sinton and Kennedy, 1994.
	Predation primary cause of nestling deaths.	More food, female – at nest		SFNF, NM	Ward & Kennedy, 1996
Mature forests preferred. < 20 ha patch size preferred. Avg. Range: 5700 ha.	Boreal forest.	Large patches of mature forests. Spruce Winter: squirrels, Breeding: pigeon, black grouse, hooded crow.		Sweden	Widen, 1989.
	Forests 50-1000 ha surrounded by fields.	> 90% birds, pigeons, domestic hens, jays, woodpeckers, thrushes, corvides, voles, hares, and squirrels.		Poland	Goszczynski & Pilatowski, 1986.

Table 7. Habitat Use and Foraging Habits of the New Mexico Meadow Jumping Mouse

Habitat Use/Requirements					
General	Nesting	Forage	Dispersal	Location	Reference
Found in riparian, mixed conifer, spruce/fir, areas. Prefers lush grassy/weedy ground cover. Hides under heavy vegetation. Hibernates in winter. Requires water nearby. Confirmed on LA County and SFNF lands, possibly on LANL lands.	In hollow logs or in short burrows.			Los Alamos, NM area.	Klingel, 1995.
Boreal from Canada to Alaska and the Eastern US Some near water sources, some not. Near roadside ditches w/ tall grasses, open woodlands, grasslands associated w/ trees/shrubs, or tall grass prairie, primarily big and little bluestem & Indian grass. With an avg. height of 60-90 cm. Prefer deep litter.			Roadsides with mesic tall grass. Riparian corridors with tall grass	Kansas	Choate et al., 1991.
High mountains, lush grasses & sedges among willows & alders along cool streams preference in NM. Home ranges of 0.08 to 0.35 ha. some along Rio Grande Valley.	Early fall burrow, hibernate until late April.	Reproductive parts of grasses & dicots. Insects.		NM	Findley, 1987.
Study trapped over 50 sites in NM, found in Jemez (Upper Guadalupe River drainage), Rio Grande Valley. Mesic habitats in lowland valleys & along montane streams. Narrow grass-forbes-willow streamside riparian zone, along permanent waterways. May persist along man-made waterways.				NM	Morrison, J. L., 1992.
Moist, lowland habitats: willow-alder thickets or grass/sedge meadows, near water. Dense ground-cover, few/no trees. Can swim across river..					
Dense grass and sedge cover near water. Proximity to water crucial. Density 82.9/ha, seemed high.		Grass seeds		MN	Tester, et al., 1993.

Table 8. Habitat Use and Feeding Habits of the Whooping Crane.

Habitat Use/Requirements					
General	Nesting/Roosting	Forage	Dispersal/ Migration	Location	Reference
Migrant along Rio Grande and Cochiti Reservoir. Doesn't stop on LANL, but flies over. Often same location, every year. Rivers/streams/marshes.	Roosts on sand bars				Klingel, 1995
Favor wetlands pH = 7.6-8.3. Time budget - daylight hours in staging area & summer – 40%–73% is foraging. Mean home range is 4.1 km^2. Predators: Black bear, wolverine, gray wolf, red fox, lynx, Bald Eagle, Northern Raven. Threats: hurricanes to wintering ground, contaminant spills, collisions with objects (especially power lines), degradation of habitat by humans, human disturbance, loss of gene diversity.	Roosting: Most wetlands used are <4 ha within 1 km of feeding site. >40% were <0.5 ha. Heavily vegetated wetlands generally not used. Do not perch in trees. Older chicks roost on small islands or clumps of vegetation. Older birds roost in water 13–20 cm deep. Nesting Territories range from 1.3 to 47.1 km^2. Once disturbed, they will usually not renest. Faithful to breeding territories. Nests ≥ 300 m apart. Often built on a shallow water island made of surrounding vegetation.	On a variety of croplands. In breeding grounds: mollusks, crustaceans, aquatic insects, minnows, frogs, snakes. Migration: frogs, fish, plant tubers, crayfish, insects, waste grains in harvested fields. Winter: crabs, clams. In upland: acorns, snails, mice, voles, crayfish, grasshopper, and snakes. Croplands account for 70% of feeding sites for nonfamilies; wetlands account of 67% of feeding sites for families.	Wild #1: Migrates north end of March to begin of April. Migrates south, arrives late Oct. to mid-Nov. Wild #2 – migrates north in early Feb, follows RioGrande north, stages in San Luis Valley (CO), arrives north in April, early May. Arrives in NM in Nov., 48–180 km south of Albuquerque.	3 wild flocks, 4 captive. Wild #1 Flock: nests in Wood Buffalo Nat'l Park & winters Gulf Coast., TX. Wild #2 Flock: summer ID, w. WY, sw MT & winter in middle Rio Grande Valley of NM. Wild #3 Flock – Florida.	Lewis, 1995.
Lakes/marshes dried up and cranes left area in the 1930's drought.	If disturbed, often abandon nest. Large marshes of grassland are excellent breeding habitat.	Shallow water, near nest.		Saskatchewan, Canada.	Hjertaas, 1994.

Table 8. Habitat Use and Feeding Habits of the Whooping Crane. (cont)

Habitat Use/Requirements					
General	Nesting/Roosting	Forage	Dispersal/ Migration	Location	Reference
Home ranges: 12.0-18.9 km^2 for isolated breeding pairs. Areas where "nonbreeders" are found. Breeding ranges go in a southern direction.	Return to same area. Novice pairs may nest some distance from running water, but as older, move nests closer to stable water. Core nest areas: 3.2 to 4.2 km^2			Wood Buffalo National Park, Canada.	Kuyt, 1993.
Low tolerance for human presence. Winter – salt flats, marshes, barrier islands. Salt grass, saltwort, popping cane, glasswort, sea ox-eye, cordgrass.	Poorly drained. Overstory black spruce, tamarack, willow.	Blue crabs, clams.	South – mid. Sept., arrive in mid. Nov. at wintering grounds.	Wood Buffalo National Park, Canada – Aransas Nat'l Wildlife Refuge, TX	Matthews, ed., 1990.
pH = 7.6 to 8.3.	Bullrush, cattails, sedges, spike rush, musk-grass, bentgrass, arrow grass.	Shallow holes for wading & feeding. Insects & crustaceans, some amphipods, snails, Fiddler crabs, eels, snakes, acorns (Allen, 1952 – freshwater minnows, marsh onions, prairie lily, roots of three-square, crops – potatoes & sprouting corn.) Allen & Uhler study – polychaete worm, pistol shrimp, *mud shrimp, *blue crabs, crayfish, short razor clams, green razor clams. Juveniles – berries, insects, aquatic invertebrates. Chance prey: fish, insects, reptiles.	Eat egg masses of frogs & toads, insects, and fish. North – April. South – leave end Sept. arrive mid – Nov. Wade in 5-10 in deep. Drink brackish water.	Wood Buffalo National Park, Canada – Aransas Nat'l Wildlife Refuge, TX (WBNP-ANWR)	Johnsgard,, 1983.

Table 8. Habitat Use and Feeding Habits of the Whooping Crane. (cont)

Habitat Use/Requirements					
General	Nesting/Roosting	Forage	Dispersal/ Migration	Location	Reference
		Mollusks, insects, *crab *shrimp, , some: grass-hoppers, reptiles, crops.	North - April	(WBNP-ANWR)	Walkinshaw, 1973.
Remote from human activities. Winter – Marshes – salt grass, saltwort, cordgrass, glasswort, sea ox-eye. Interior: oak brush, grassland, swales, ponds live oak, redbay, bluestem.	Overstory: white spruce, black spruce, tamarack, willows. Understory: dwarf birch, labrador tea, bearberry.	Cropland – 70% – nonfam-ilies, Wetlands – 67% – families. Probe. Brackish bays, marshes, salt flats: bluecrabs, clams, wolf-berry. Upland: acorns, snails, crayfish, insects.	Roost in marshy wetlands < 4 a & within 1 km of feeding site. South – mid. Sept., arrive – Nov. North – April.	(WBNP-ANWR)	U.S. Fish and Wildlife Service, 1994.
39% of fledged in Rocky Mtn. population die from collisions w/ power lines. Markers helped.				San Luis Valley, CO	Brown and Drewien, 1995.
	Roost: 0.04 to 78.1 ha wetland. Baltic rush, sedges, spicerushes. Greasewood. Water < 30 cm; away from shore lines. Sparse understory, extensive visibility w/in 90 m. Avoid humans.	Sites: plowed barley fields, harvested potato fields – size 1/8 to 1/4 section.	ID to NM, stages in San Luis Valley. Rio Grande flows through. Elevation 2100 m to 2400 m. Wetlands.	San Luis Valley, CO.	Shenk and Ringelman 1992.

Table 8. Habitat Use and Feeding Habits of the Whooping Crane. (cont)

Habitat Use/Requirements					
General	Nesting/Roosting	Forage	Dispersal/ Migration	Location	Reference
	Pile of grass or marsh hay (about 3 ft. diameter) w/ a small indention in middle for nest. Some built on muskrat houses. Often built in water on a small island. In shallow water w/ emergents to build nesting platform.			Saskatchewan Canada. (WBNP-ANWR)	Hjertaas, 1994. Walkinshaw, 1973.
	Roost in shallow water wetlands.			(WBNP-ANWR)	Group B
Wetlands, like: marshes, lake margins, sloughs, and potholes. Prefer shallow water. Dominant emergent: bulrush, cattail, and sedge.				(WBNP-ANWR)	Group A

Group A = Lewis, 1995; Walkinshaw, 1973; Hjertaas, 1994; Mathews, 1990, Johnsgard, 1983; and U.S. Fish and Wildlife Service 1994.
Group B = Lewis, 1995; Walkinshaw, 1994; Kuyt, 1993; Johnsgard, 1983; and U.S. Fish and Wildlife Service, 1994.

Table 9. Habitat Use and Foraging Habits of the Black-footed Ferret.

Habitat Use/Requirements					
General	Nesting	Forage	Dispersal	Location	Reference
Prairie. Not likely on LANL or LA County Lands.		Main prey – prairie dog.		LANL, LA County.	Klingel, 1995
Preyed upon by great-horned owls, golden eagles, coyotes. Prairies of the Great Plains. 40-60 ha of prairie dog colony to support one ferret. No known wild populations (1990). Captive breeding efforts. Problem – distemper, genetic diversity.	Prairie dog burrows. Breeds: March/April.	Mainly prairie dog, also mice, voles, ground squirrels, gophers, birds, and insects. Nocturnal.		North America. (Historic: Great Plains & inter-montane in Rockies.	Matthews, ed., 1990 and U.S. Fish and Wildlife Service, 1988.
50 ha of prairie dog town/ferret, (Forrest et al., 1985). 2500 ha for sustainable population. Problem – distemper.				North America.	Flesness in Seal et al. (ed.),1989.
Thought extinct – 1972. Found small population in Meeteetse, WY – 1981. Last wild – 1987. Captive breeding. Reintroducing – current. Suitable site: 10,000 acres.	In prairie dog burrows. Young born – May/June.	Prairie dogs. Drag kill to burrow.		North America. (Looking at MT, SD, WY, CO, UT, and AZ for reintrod.	U.S. Fish and Wildlife Service
Population > 100 increases survival chances. 1 adult female per 57 ha. (Forrest, et al.)	1 ferret litter/36 ha (Hillman and Linder)			CO	Thorne, 1989.
Prairie dog towns. Few records indicate former range in lowlands of central NM.	March/April – mating.	Nocturnal. Prairie dogs, ground squirrels.		NM	Findley, 1987.
Plains from ND and MT south to TX. In CO – plains east of mountains up to 9200 ft. Few west of divide.		Main: prairie dogs. Other: small animals.		CO	Warren, 1942.

Table 10. Habitat Use and Foraging Habits of the Spotted Bat.

Habitat Use/Requirements					
General	Nesting/Roosting	Forage	Dispersal/ Migration	Location	Reference
Distributed from MT to Mexico & southern CA to NM. Ponderosa pine & Pinion-juniper.	Roosts: cracks in cliffs. Single young in May/June.	Open meadows, after midnight.		CO	Armstrong, et al., 1994.
Western North America. Canyon bottoms. Low elevation. In diverse habitat types.		Open meadows, throughout night. 1 per 50 m range. Insects. Flew 10-30 m high.		Dinosaur Nat'l Mon. CO-UT.	Storz, 1995.
	Roost: cliffs. Exits within 30 min. after sunset. Return time varies. Faithful to day roost.	Marshes, open Ponderosa Pine. Return to same areas. Moths, while in flight. Flew 5-15 m high. Does not support exclusive foraging territories.		British Columbia.	Wai-Ping and Fenton, 1989.
Western North America Wide elevations & variety of habitats. Often in dry, rough, desert terrain.	Roost: rock crevices.	Moths, some June beetles (Ross, 1962, Easterla, 1965). After midnight.		North America.	Watkins, 1977.
Variety of habitats. No vegetation restriction. Used riparian areas in canyons.	Roost: canyon walls.	Soon after dark. Throughout night. Flew >10 m high. Not restricted to vegetation type.		Dinosaur Nat'l Mon. CO-UT.	Navo, et al., 1992.
Active from sunset to sunrise. Not in heavy rain.	Roost: high, steep cliff faces. Appeared faithful to roost. Left within 1 hr. after sunset. Singly.	Alone, territorial. Old fields. Prefer: open area surrounded by Ponderosa Pine. Flew 10 m high. Insects. Moths (Ross, 1967, Poche, 1981).		British Columbia.	Leonard and Fenton, 1982.
Variety of habitats. Arid/semiarid w/ sage & rabbit bush & short grasses, or open Ponderosa Pine	Cracks/crevices between loose rocks on high, steep cliff faces.	Near Ponderosa pine forest edge in clearings. Flies 10-30 m high. Moths		LANL, NM.	Tyrell & Brack, 1992.
No habitat preference.				Western North America.	Fenton, et al., 1987.

Appendix A
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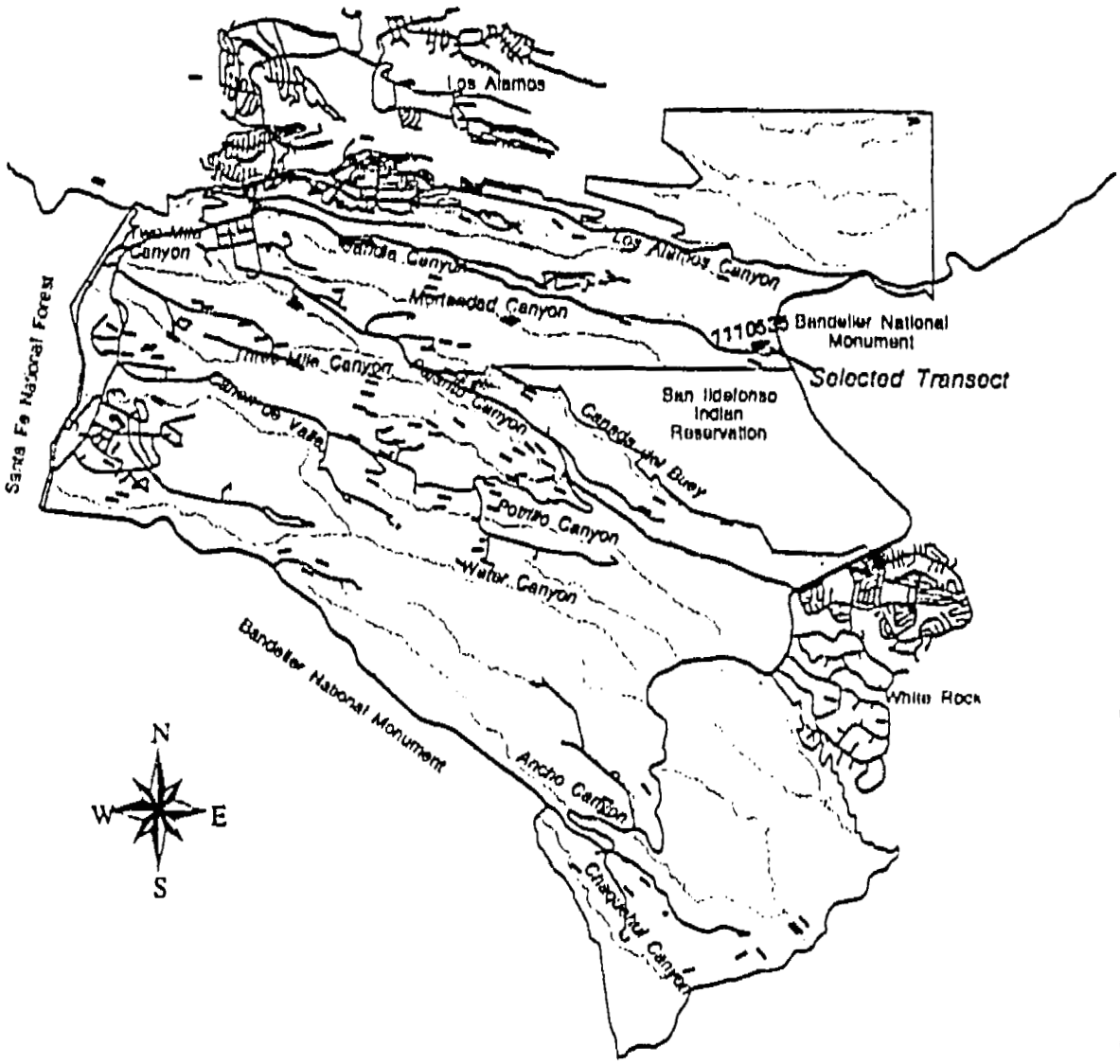
Map 1: Vegetation Transects

Selected Transect Shown with Id Number

(See next page for attribute information)



Legend

- Selected Transect
- Vegetation Transects
- LANL
- Paved Roads
- Drainages

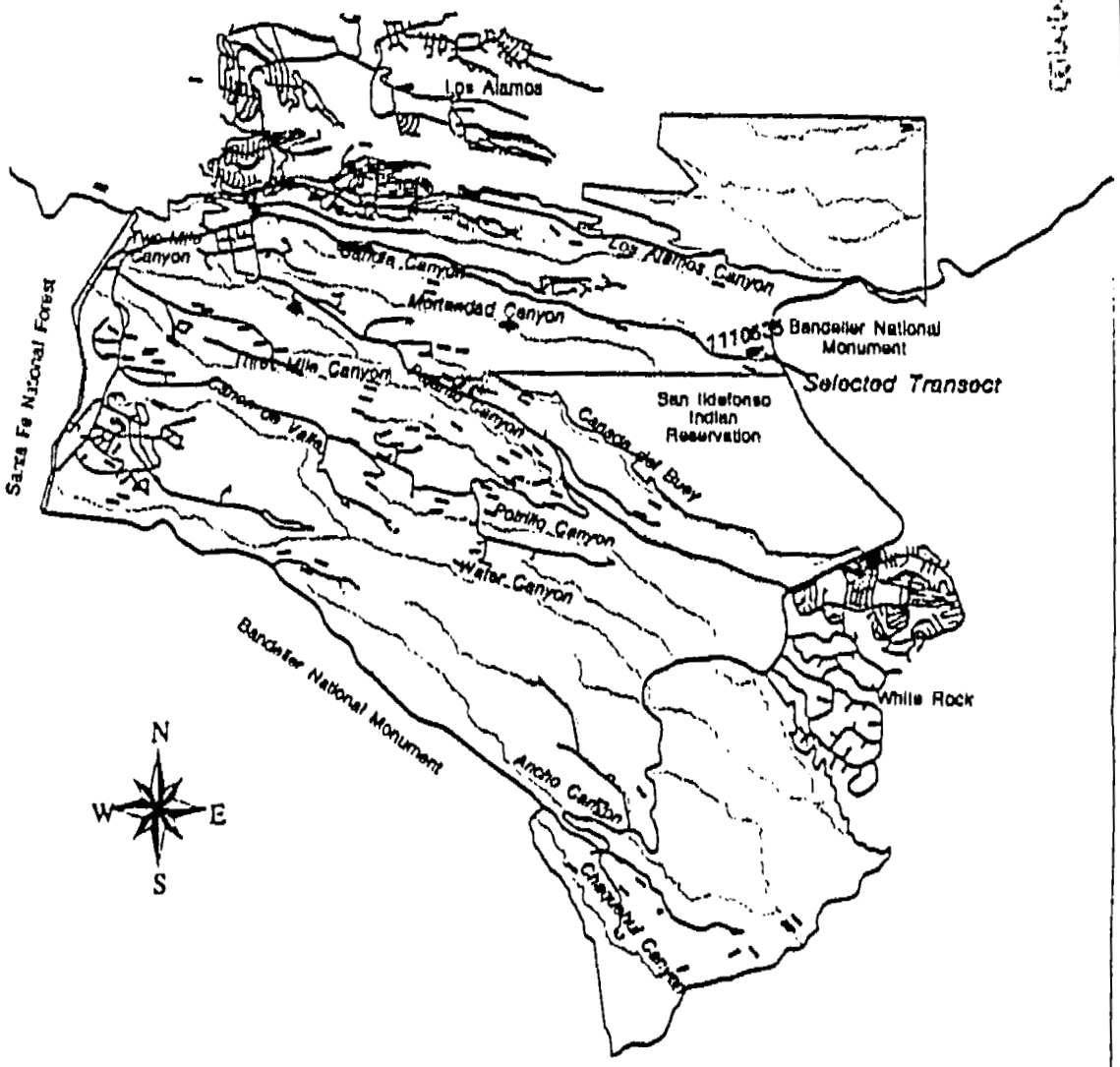
1:72679

2 0 2 4 6 8 10 12 Kilometers

2 0 2 4 6 8 Miles

LOS ALAMOS NATIONAL LABORATORY
BIOLOGY TEAM, ESH-20 ECOLOGY GROUP
PREPARED: SEPTEMBER, 1996

Map 1: Vegetation Transects



Legend

- Selected Transect
- Vegetation Transects
- LANL
- Paved Roads
- Drainages

1:72679

2 0 2 4 6 8 10 12 Kilometers

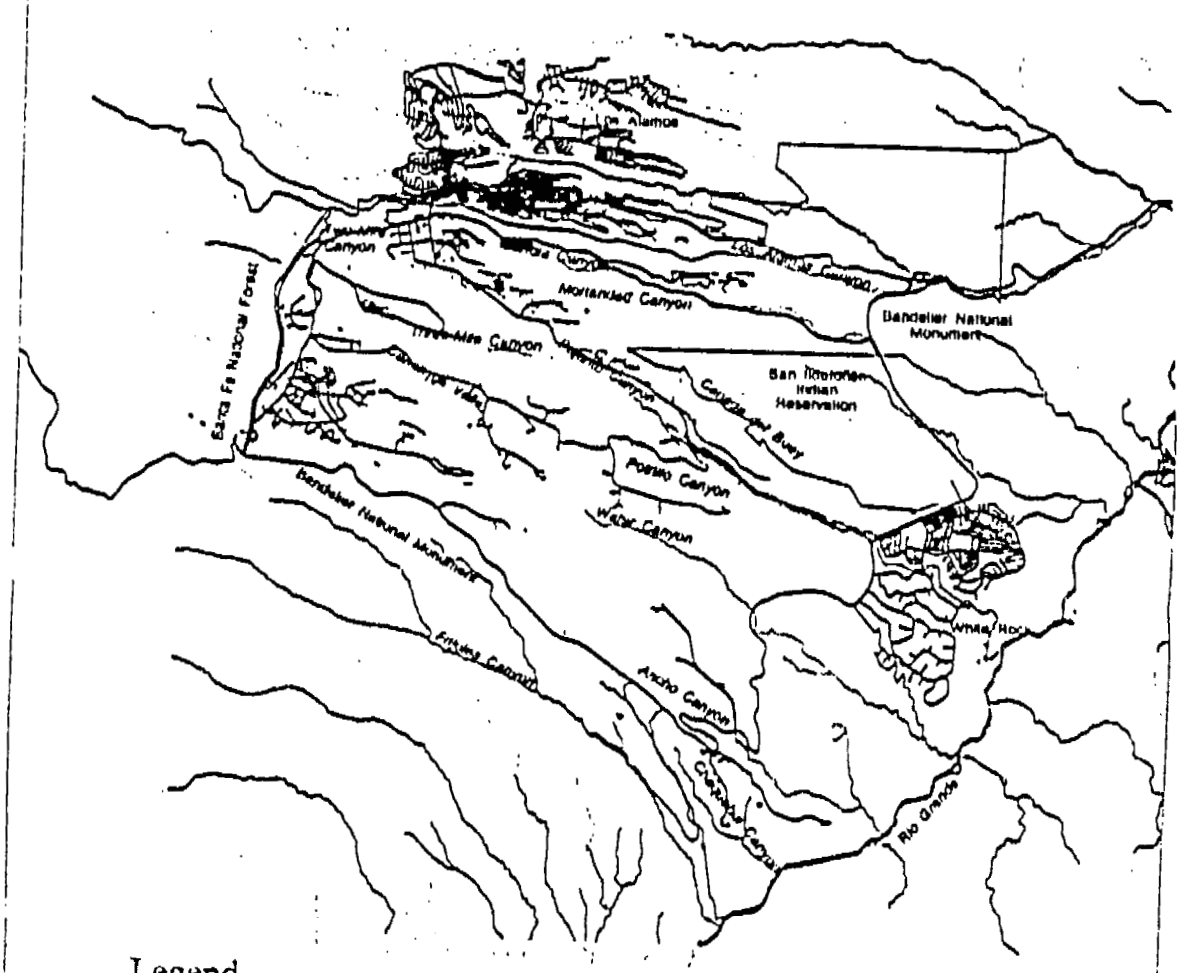
2 0 2 4 6 8 Miles

LOS ALAMOS NATIONAL LABORATORY
BIOLOGY TEAM, HSH-20 ECOLOGY GROUP
PREPARED: SEPTEMBER, 1996

Figure 3. The locations of transects for the quantitative land cover surveys.

Map 2: Wetlands

Map contains NWI wetlands and wetlands mapped during LANL biology surveys



Legend

- Wetlands
- LANL
- Paved Roads
- Drainages

1:86174

3.1 0 3.1 6.2 9.3 12.4 Kilometers

2.1 0 2.1 4.2 6.3 8.4 Miles

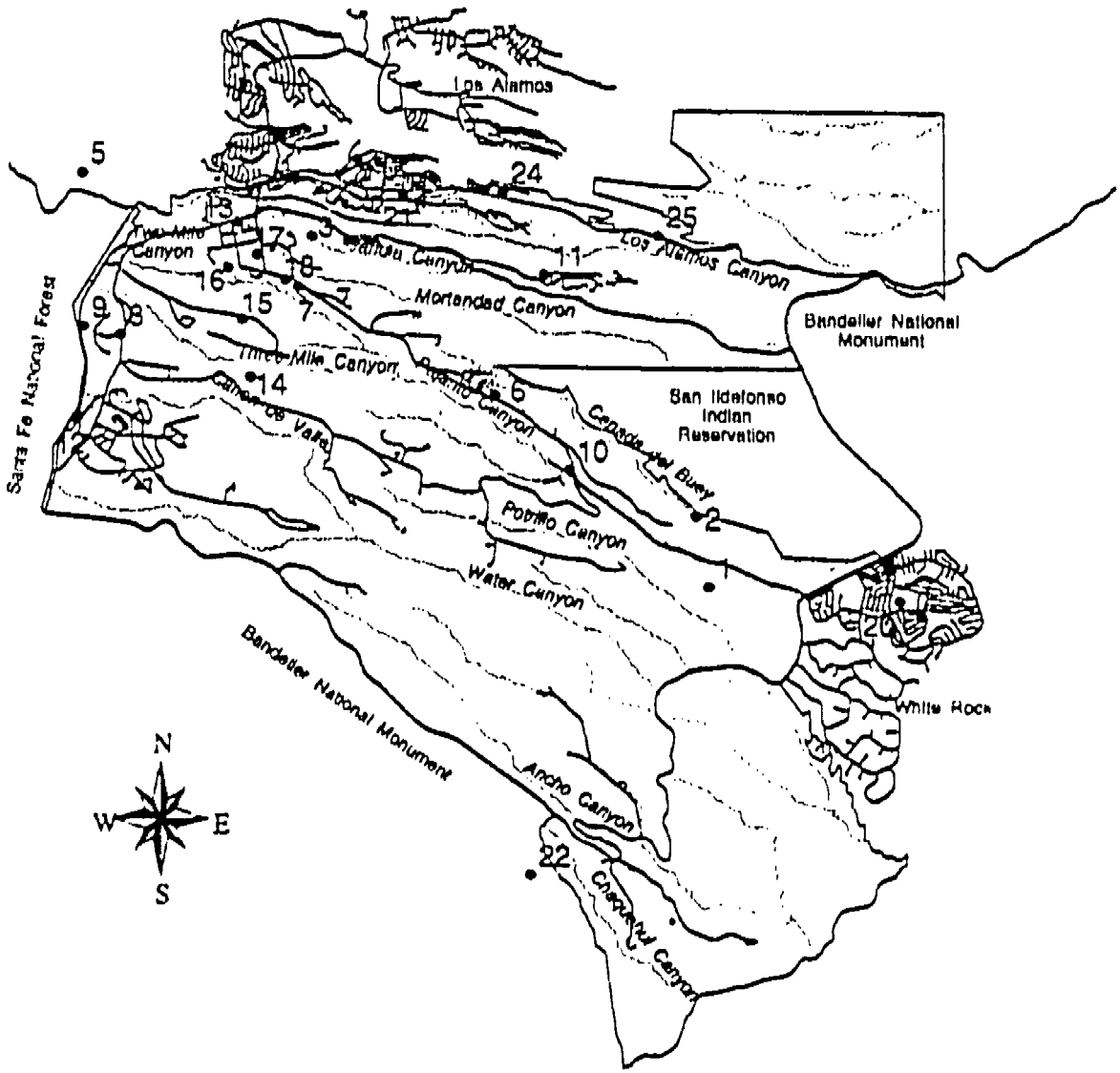
LOS ALAMOS NATIONAL LABORATORY
BIOLOGY TEAM, ESH-20 ECOLOGY GROUP
PREPARED: SEPTEMBER, 1996

N
W E
S

Map 3: Insect Observations

Locations Shown with Loc_no Number

(See next page for observation attribute information)



Legend

• Insect Observations	Paved Roads
LANL	Drainages

1:72679

2 0 2 4 6 8 10 12 Kilometers

2 0 2 4 6 8 Miles

LOS ALAMOS NATIONAL LABORATORY

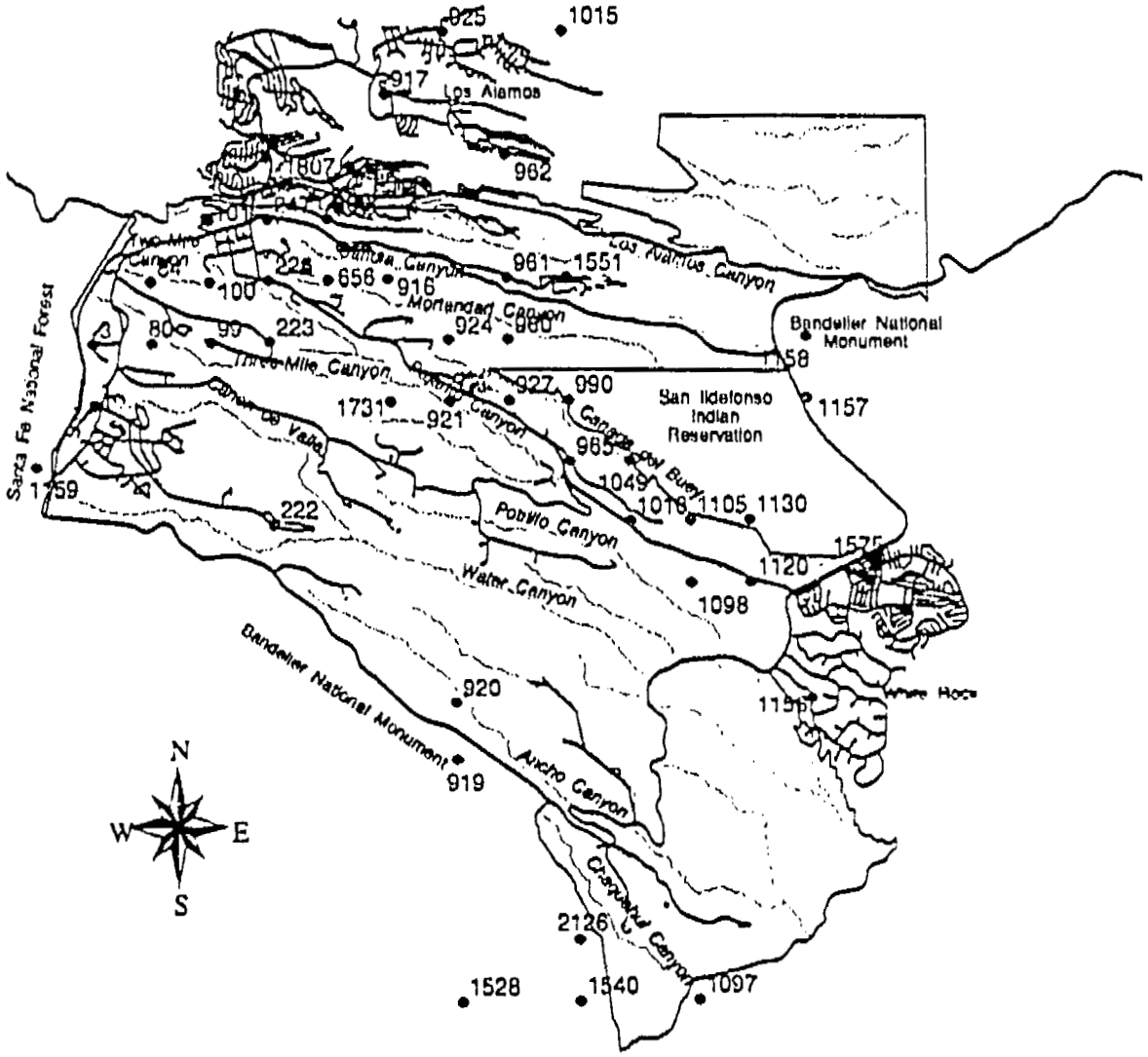
BIOLOGY TEAM, ESH-20 ECOLOGY GROUP

PREPARED: SEPTEMBER, 1996

Map 4: Bird Observations

Locations Shown with Birdobs-id Number

(See next page for observation attribute information)



Legend

• Bird Observations	Paved Roads
LANL	Drainages

1:75429

3 0 3 6 9 12 Kilometers

2 0 2 4 6 8 Miles

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PREPARED: SEPTEMBER, 1996

Map 5: Identified Potential Habitat for Sensitive Bird Species

Legend

Potential Habitat	Paved Roads
LANL	Drainages

1:73589

3 0 3 6 9 12 Kilometers

2 0 2 4 6 8 Miles

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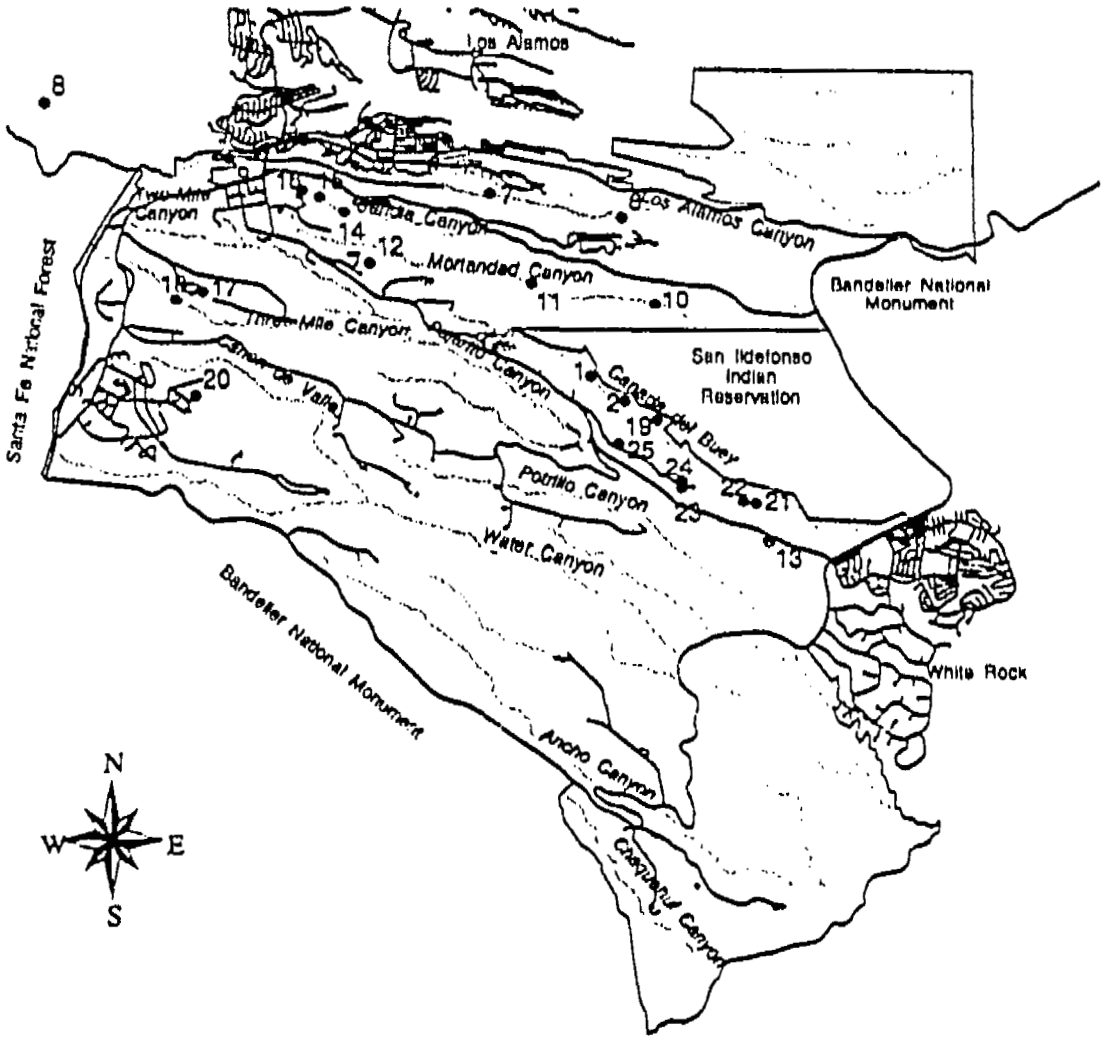
Map 6: Locations of Small Mammal Studie

Locations Shown with Site_id Number

(See next page for small mammal attribute information)



Legend

• Study Locations	Paved Roads
LANL	Drainages

1:73589

3 0 3 6 9 12 Kilometers

2 0 2 4 6 8 Miles

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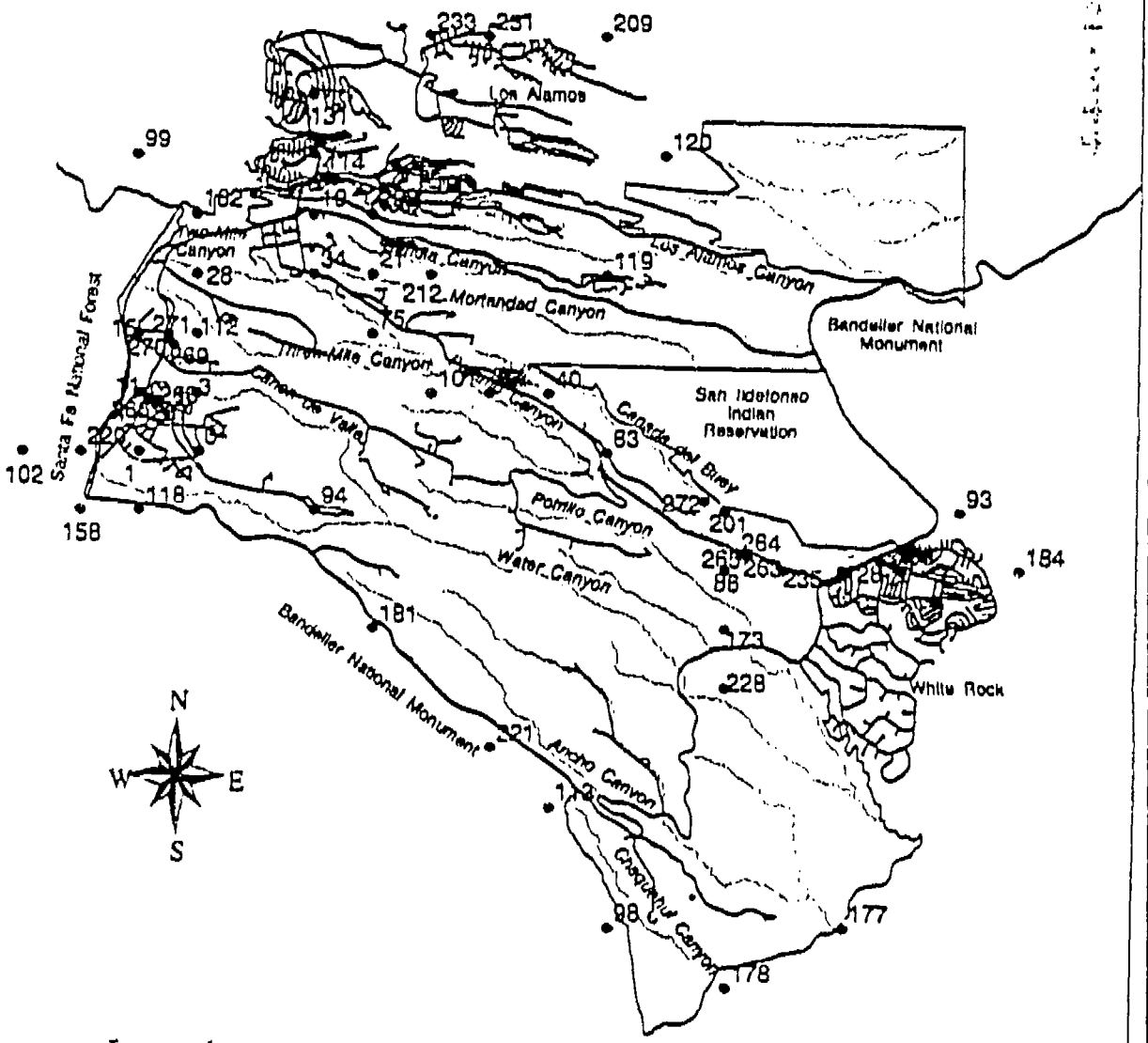
PREPARED: SEPTEMBER, 1996

Map 7: Mammal Observations

Locations Shown with Site_id Number

(See next page for observation attribute information)



Legend

- Mammal Observations
- LANL
- Paved Roads
- Drainages

1:73589

3 0 3 6 9 12 Kilometers

2 0 2 4 6 8 Miles

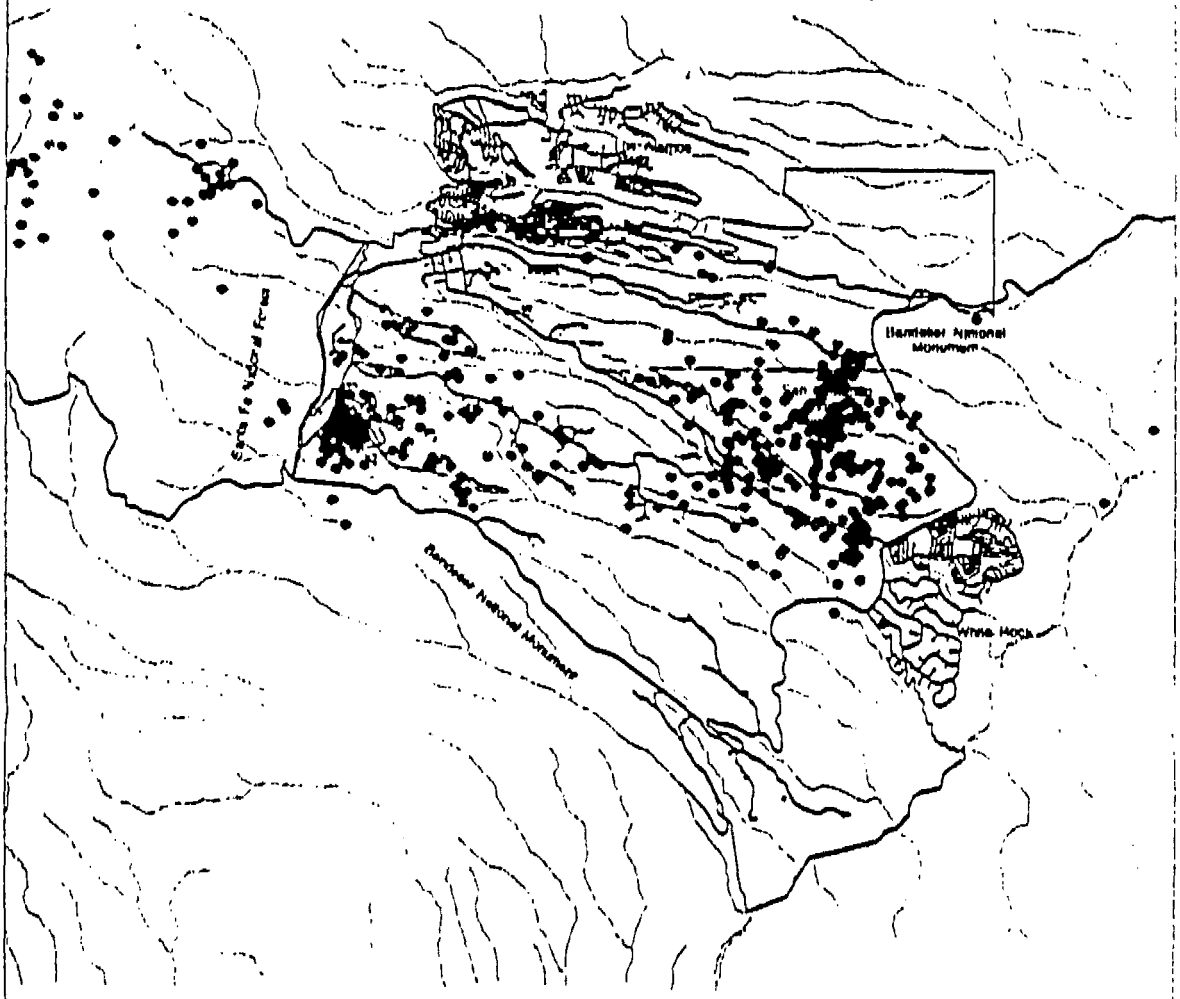
LOS ALAMOS NATIONAL LABORATORY

BIOLOGY TEAM, ESH-20 ECOLOGY GROUP

PREPARED: SEPTEMBER, 1996

Map 8: GPS Locations from 6 Radio-Collared Elk

(See next page for attribute information)



Legend

GPS Locations by Collar_Id Number

16033 - 16038

LANL

Paved Roads

Drainages

1:93196

3 0 3 6 9 12 15 Kilometers

2 0 2 4 6 8 10 Miles

N

Figure 1. The colored areas show the predicted Jemez Mountains salamander habitat

Figure A-1. Land Cover Map - TES Habitat Management Plan

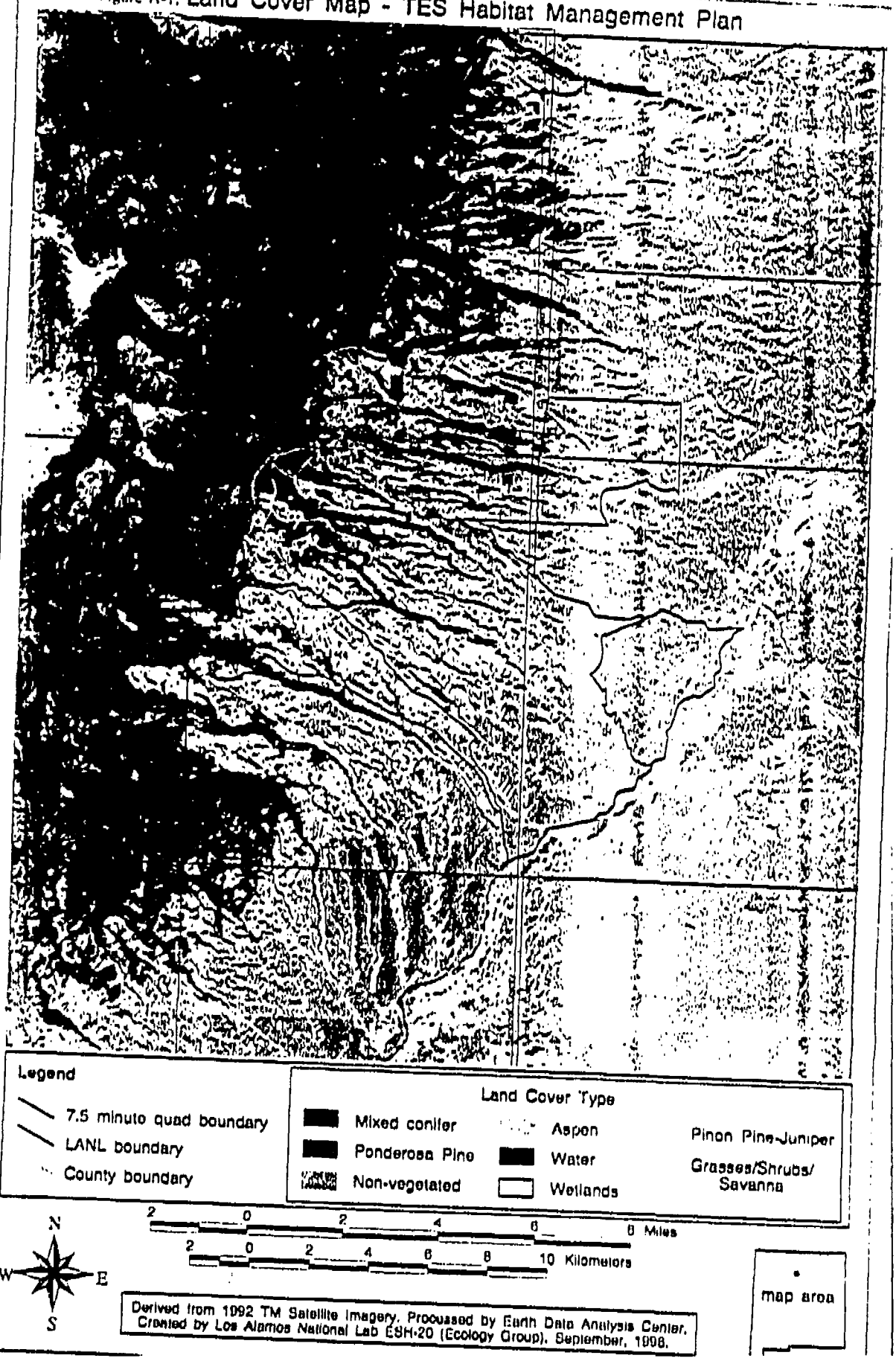


Figure A-2. Land Cover Map - Guaje Mountain quadrangle

Legend

- Paved roads
- LANL boundary
- Drainages

Land Cover Type

- Mixed conifer
- Ponderosa Pine
- Non-vegetated
- Aspen
- Water
- Wetlands
- Pinon Pine-Juniper
- Grasses/Shrubs/ Savanna

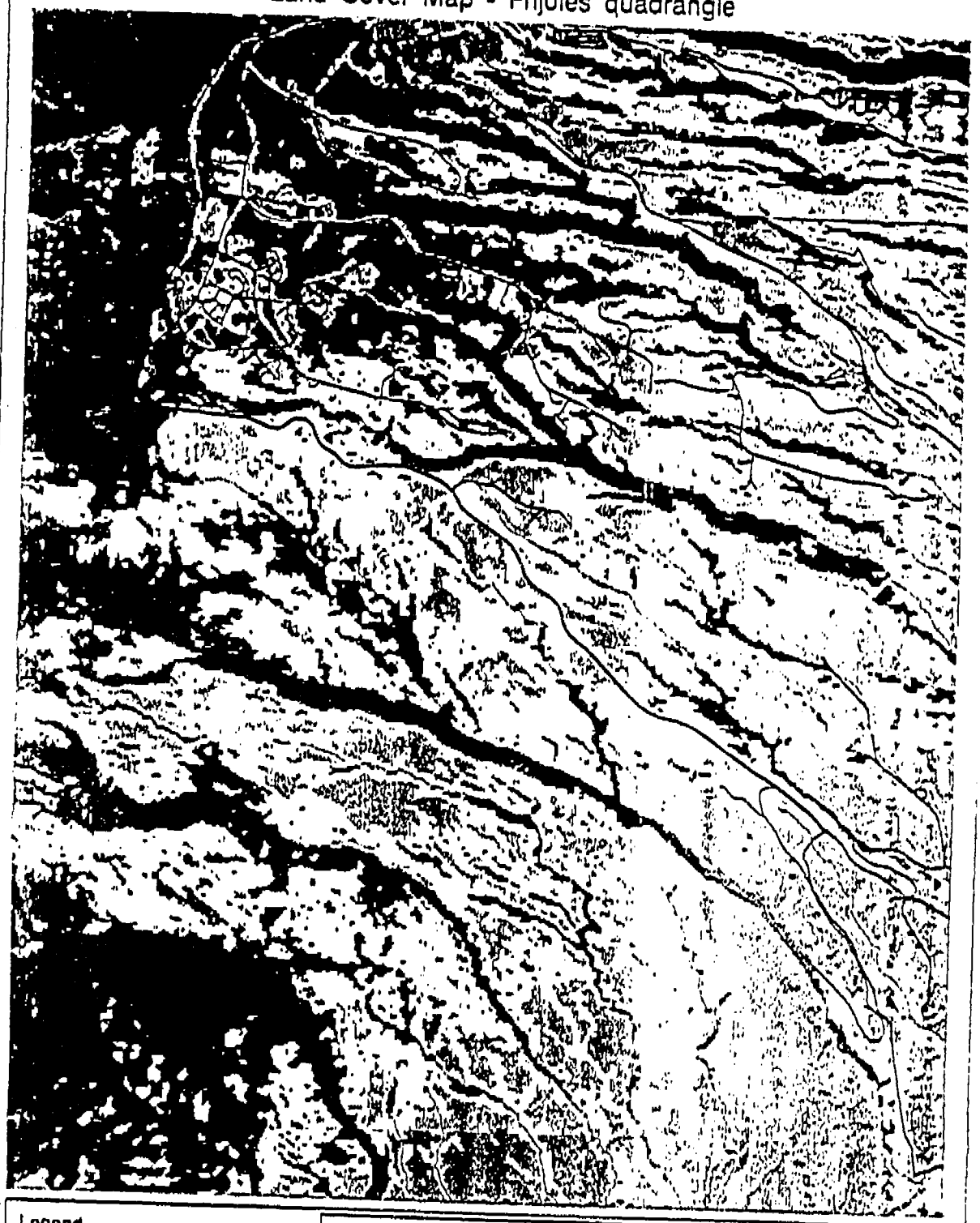
N W E S

2 0 2 4 6 Kilometers

1 0 1 2 3 4 Miles

Derived from 1992 TM Satellite Imagery. Processed by Earth Data Analysis Center. Created by Los Alamos National Lab ESH-20 (Ecology Group). September, 1996.

Figure A-3. Land Cover Map - Frijoles quadrangle



Legend

- Paved roads
- LANL boundary
- Drainages

Land Cover Type

- Mixed conifer
- Ponderosa Pine
- Non-vegetated
- Aspen
- Water
- Wetlands
- Pinon Pine-Juniper
- Grasses/Shrubs/ Savanna

N W E S

2 0 2 4 6 Kilometers

1 0 1 2 3 4 Miles

Derived from 1992 TM Satellite Imagery. Processed by Earth Data Analysis Center. Created by Los Alamos National Lab ESH-20 (Ecology Group), September, 1998.

Figure A-4. Land Cover Map - White Rock quadrangle

Legend

- Paved roads
- LANL boundary
- Drainages

Land Cover Type

- Mixed conifer
- Ponderosa Pine
- Non-vegetated
- Aspen
- Water
- Wetlands
- Pinon Pine-Juniper
- Grasses/Shrubs/Savanna

N W E S

2 0 2 4 6 Kilometers

1 0 1 2 3 4 Miles

Derived from 1992 TM Satellite Imagery. Processed by Earth Data Analysis Center.
Created by Los Alamos National Lab ESH-20 (Ecology Group). September, 1996