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Ecological Baseline Studies in Los Alamos and Guaje Canyons County of Los Alamos, New Mexico

A Two-Year Study

Los Alamos
NATIONAL LABORATORY

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ABSTRACT

During the summers of 1993 and 1994, the Biological Resource Evaluations Team (BRET) of the Environmental Protection Group (ESH-8) conducted baseline studies within two canyon systems, Los Alamos and Guaje Canyons. Biological data was collected within each canyon to provide background and baseline information for Ecological Risk models. Baseline studies included establishment of permanent vegetation plots within each canyon along the elevational gradient. Then, in association with the various vegetation types, surveys were conducted for ground dwelling insects, birds, and small mammals. The stream channels associated with the permanent vegetation plots were characterized and aquatic macroinvertebrates collected within the stream monthly throughout a six-month period. The Geographic Position System (GPS) in combination with ARC INFO was used to map the study areas. Considerable data was collected during these surveys and are summarized in individual chapters.

PREFACE

Teralene S. Foxx

1 INTRODUCTION

1.1 Baseline Studies and Ecological Risk

Development of procedures for Ecological Risk Assessment for the Laboratory's Environmental Restoration (ER) Program has provided an opportunity to develop a team effort between researchers in ESH-8, EES-15, and Colorado State University. ESH-8 was given the task to collect baseline data that would be used and needed for Ecological Risk Models being developed by EES-15 in conjuction with Colorado State University. This interim report summarizes the data collected from a two-year study within two canyon ecosystems.

As part of the corrective actions for the Environmental Restoration Program, the risk of conducting a specific action to humans and the natural environment must be determined. In some cases, the actions that are proposed to protect humans may in fact pose a risk to biota and the ecological environment. Therefore, to assure that actions do not immeasurably impact the biotic environment, both a Human Risk Assessment and an Ecological Risk Assessment must be conducted and the risk of that action on the environment determined. Beyond determination of risk, stakeholders may review the proposed actions through the Natural Resource Damage Assessment process. Both the Ecological Risk Assessment and the Natural Resource Damage Assessment require baseline data to make informed decisions.

Ecological risk and natural resource damage assessments are required for the ER program and are discussed in Appendix L of the Environmental Restoration Installation Work Plan (IWP). The implementation of the assessments are to be integrated with collection of data needed to comply with the Endangered Species Act, National Environmental Policy Act, New Mexico Wildlife Conservation Act, Protection of Native New Mexico Plants, and floodplain wetland protection, site characterization activities and

Corrective Measures Study. Three stages of the process of developing a risk assessment have been defined. They are

1) Ecological Risk Screening (ERS),
2) Ecological Risk Assessment (ERA), and
3) Natural Resource Damage Assessment.

The first stage in the process in development of risk assessment is ERS. The purpose of this stage is to conduct preliminary, conservative evaluations of potential ecological impacts. To accomplish stage one, preliminary ERS models are being developed by Colorado State University. The task required for the development of the ERS model includes a Preliminary Ecological Risk Screening, Operable Unit Assessment, Ecological Baseline Study and finally a Screening model implementation. For these ERS models, baseline data related to the biota and the natural environment is required.

The Biological Resource Evaluations Team, ESH-8, has collected baseline data for threatened, endangered, and sensitive species and senstive habitats such as wetland within each Operable Unit (OU) during the past three years. The results of these surveys and the associated concurrence with US Fish and Wildlife Service are found in each Operable Unit draft Biological and Floodplain Wetland Assessments. The biological assessments provide baseline data on a variety of organisms on a one time basis but do not provide multi-year data sets. Multi-year studies provide information on variability in the biological community as related to varying weather conditions and population densities related to varying environmental conditions.

Although, the characterization of the biotic environment within each OU was done during surveys for compliance with the Endangered Species Act and floodplain/wetland protection provided a large quanity of habitat information, specific long-term information of related organisms in the various trophic levels have not been collected. Therefore, it was deemed important to establish some long-term study areas to get multi-year data to support ecological risk assessments and natural resource damage assessment as well as long-term data information for National Environmental Protection Act. For FY93, the focus of data collection was two canyon systems, one within the confines of the Laboratory, Los Alamos Canyon, and one within the adjacent Santa Fe National Forest, Guaje Canyon to the north side of Los Alamos Canyon. These canyons were selected for these initial studies because they both had streams that were perennial at the higher reaches and ephemeral at the lower. Each canyon has an impoundment at approximately 8000 ft, and both canyons have access by road.

Within each canyon system, permanent vegetation plots were established to provide information on plant species diversity and plant communities (Chapter 1 & 2). In addition to phytosociological data, biomass was collected for both the understory and overstory species (Chapters 1, 2, & 3). In the vicinity of the vegetation plots, sampling stations were established for collection of aquatic invertebrates (Chapter 4) and ground-dwelling insects (Chapter 7 & 8). Additionally, the stream channel characteristics were defined (Chapter 6). Within the major plant communities, small mammal population studies were conducted (Chapter 10) and bird observation data compiled (Chapter 9). Additionally, an extension of the 1992 bat survey was continued in these canyons systems (Chapter 10). Attempts were made to identify medium and large mammal predators by use of scent stations. However, we did not gather enough essential data to include in this report.

2 ENVIRONMENTAL SETTING

2.1 General Setting

Los Alamos County is located in north-central New Mexico on the Pajarito Plateau approximately 120 km (80 mi) north of Albuquerque and 40 km (25 mi) northwest of Santa Fe. The plateau forms an apron of volcanic sedimentary rocks along the eastern central edge of the Jemez Mountains and stretches approximately north to south for 33 to 40 km (20 to 25 mi) and 8 to 16 km (5 to 10 mi) from east to west. The average elevation of the plateau is about 2286 meters (7,500 ft). It slopes gently eastward from the mountains toward the Rio Grande River where it ends in steep slopes formed by the down-cutting of the river.

The plateau extends into a number of narrow mesas separated by deep canyons caused by southeast-trending intermittent streams. Geological substrate, Bandelier tuff, was deposited from volcanic eruptions in the Jemez Mountains about 1.1 to 1.4 million years ago. The tuffs overlap other volcanics that are underlain by the conglomerate of the Puye Formation. This conglomerate intermixed with Chino Mesa basalts along the Rio Grande River.

The area is characterized by a semiarid, temperate mountain climate. Summer temperatures typically range from 10° C (50° F) to 27° C (80° F) during a 24-hr period. Winter temperatures generally range from about 0° C (15° F) to about 10° C (50° F) during a 24-hr period. The annual precipitation in the vicinity of Los Alamos ranges from 33 to 46 cm (13 to 18 in) with much of it occurring during summer rain showers in July and August.

2.2 Description of the Study Sites

Lower and middle Los Alamos Canyon are within the boundaries of Los Alamos National Laboratory (LANL). Upper Los Alamos Canyon lies within US Forest Service (USFS) land. Guaje Canyon is to the north of USFS land within Los Alamos County. For comparative purposes each of the two canyon locations used for this project were divided into three sections: upper, middle, and lower canyon.

The upper portions (or western end) of both canyons are characterized by increased elevations, permanent water flow, and denser plant growth. The terrain in the upper sections is steep with relatively narrow canyon bottoms. Although a stream channel runs through all sites of both canyons, water is perennial only in the upper sections of both canyons and in mid Guaje Canyon. The areas immediately adjacent to the stream channels have riparian vegetation. Vegetation in upper Guaje Canyon is characterized by mixed conifer with aspen, mixed conifer, and ponderosa pine. The National Wetlands Inventory (NWI) classifies this area as riverine, upper perennial, unconsolidated bottom, permanently flooded. Upper Los Alamos Canyon is characterized by mixed conifer with aspen. This area is classified by the NWI as riverine, upper perennial, unconsolidated bottom, and permanently flooded.

The terrain in the mid portion of Guaje Canyon is much like that in the upper portion. Although the canyon sides are not as steep as those in upper Guaje, the canyon bottom is narrow and is characterized by dense vegetation (mixed conifer with aspen). Water flow in the stream channel is ephemeral and usually present. This area is classified by the NWI the same as upper Guaje Canyon. Terrain in the mid portion of Los Alamos Canyon is narrow with steep cliff sides and dense vegetation. The vegetation is characterized by mixed conifer with some aspen and ponderosa pine. Water flow in this portion of the canyon is intermittent and depends on water released from the reservoir upstream. The NWI classifies this area as alustrine, scrub-shrub, broad-leaved diciduous, temporarily flooded.

The lower sections of both canyons are broader than the upper and middle sections, but lower Guaje Canyon is more narrow than lower Los Alamos Canyon. Steep cliffs make up the canyon walls of lower Los Alamos Canyon. In both canyons, the vegetation is more open than the higher sections. Where surveys were conducted in lower Guaje, the stream flows for part of the year. The NWI classifies this area as riverine, intermittent, stream bed, and seasonally flooded. Vegetation in lower Guaje Canyon is characterized by mixed conifer, ponderosa pine, and pinyon-juniper. The water flow in lower Los Alamos Canyon is intermittent and usually flows only during the rainy season and only for short periods of time. The NWI classifies this area as riverine, intermittent, stream bed, and temporarily flooded. Vegetation in lower Los Alamos Canyon is characterized by open stands of ponderosa pine and pinyon-juniper.

3 METHODS

Prior to conducting studies within Los Alamos and Guaje Canyons, a temporary special use permit was obtained from the USFS for upper Los Alamos Canyon and for Guaje Canyon. All small mammal capture-release studies were approved by the LANL Small Animal Use Committee. All personnel were trained in CPR First Aid, Survival Training, HASWOPER, and Radiation Workers Training.

The methodology for each survey is described within each related chapter. All vegetation surveys were conducted during the months of July and August. Because access to Guaje Canyon was impeded by the road condition and distance from Los Alamos, all studies with the exception of aquatic invertebrate and bird surveys, were primarily done during the last week in July. Aquatic invertebrate studies were done on a monthly basis from May through October and bird surveys, seasonally. Guaje Canyon was closed by the US Forest Service in October. Both upper Los Alamos Canyon and Guaje Canyon are not accessible during the winter months.

Small mammal studies were hindered by the outbreak of hantavirus in New Mexico. This required additional training from the Communicable Disease Center (CDC) in the safe handling of potentially infected rodents. The recommended protocol required personal protective equipment including respirators and class D protection. This protocol placed additional field stress on personnel and increased the survey time needed to collect the small mammal data.

4 SUMMARY OF RESULTS

4.1 Canyon Bottom and Riparian Vegetation (Chapter 1)

- Vegetation surveys along the stream channel and within the canyon bottom showed similar number of species within each canyon: Guaje 126 species, Los Alamos Canyon 125 species.

- Species richness was similar in each canyon but species composition differed.

- Dominant tree species in each canyon indicated a mixed conifer-riparian habitat.

Canyon	Area of Canyon	Dominant Trees	Dominant Shrubs
Guaje	upper	Alder	Cliff bush
		New Mexico Maple	Serviceberry
		Engelmann spruce	
		Ponderosa pine	
	mid	Alder	Serviceberry
		Water birch	Rose
		Aspen	
		Douglas fir	
	lower	New Mexico Maple	Gooseberry
		Alder	Fendler Barberry
		Narrowleaf Cottonwood	
		Ponderosa pine	
Los Alamos Canyon	upper	Engelmann spruce	Serviceberry
		Aspen	Chokecherry
		New Mexico Maple	
		White fir	
	mid	White fir	Serviceberry
		New Mexico Maple	Chokecherry
		Douglas fir	
		Engelmann spruce	
	lower	Birch	Willow
		Ponderosa pine	Fendler Barberry
		Quercus gambellii (tree form)	

- Understory species with the highest importance values were as follows:

Guaje Canyon: Cutleaf coneflower, Goosegrass, Richardson's geranium, and Meadow horsetail.

Los Alamos Canyon: Wild strawberry, James geranium, Redtop, Western Wheatgrass.

4.2 North and South Slope Vegetation (Chapter 2)

4.3 Biomass Estimations (Chapter 3)

Los Alamos Canyon.

- The mixed conifer forests of Los Alamos Canyon were dominated by Engelmann spruce, ponderosa pine, limber pine, white fir, and Douglas fir.

- The density of trees within Los Alamos Canyon varied from a high of 494 trees/ha in lower Los Alamos Canyon to a low of 201 trees/ha in mid Los Alamos Canyon.

- The average diameter breast high (DBH) of the dominant trees within Los Alamos Canyon varied from a low of 6.9 cm in upper Los Alamos Canyon to a high of 20.1 cm in lower Los Alamos Canyon.

- Aboveground tree biomass varied from 160 metric tons/ha in lower Los Alamos Canyon to a low of 71 ton/ha in mid Los Alamos Canyon.

- Herbaceous layer aboveground biomass varied from 3.71 kg/ha (units inconsistent).

Guaje Canyon.

- The mixed conifer forests in Guaje Canyon were dominated by ponderosa pine, Douglas fir, Engelmann spruce, limber pine and white fir.

- The density of trees within Guaje Canyon varied from a high of 595 trees/ha in upper Guaje Canyon to a low of 291 trees/ha in lower Guaje Canyon.

- The average DBH of the dominant trees within Guaje Canyon varied from a high of 16.8 cm to a low of 13. 5 cm.

- The aboveground tree biomass varied from 239 metric tons/ha to a low of 135 metric tons/ha.

4.4 Aquatic Macroinvertebrates and Water Quality (Chapter 4)

- Over 35,000 individual aquatic invertebrates within 63 taxa in Los Alamos Canyon and 81 in Guaje Canyon were collected, identified, and analyzed.
- All monthly pH, conductivity, temperature, and dissolved oxygen taken in both streams were within acceptable limits.
- Stream drying due to weather conditions eliminated resident macroinvertebrates in lower Los Alamos Canyon in the lower sampling stations in both years.
- Data show that aquatic communities are more diverse and richer in Guaje Canyon than Los Alamos Canyon.
- Averages of biological condition scores for each station throughout the sampling seasons show a clear pattern of increasing downstream impairment in Los Alamos Canyon in both years.

4.5 Mollusks (Chapter 5)

- Thirteen species of snails were found in Los Alamos and Guaje Canyons. Two taxa not previously reported in the state were identified.
- Nine hundred and ninety-seven (997) individual snails representing eight families and 13 species were identified.
- Species diversity was high.

4.6 Stream Channel Analysis (Chapter 6)

- Analysis was made on stream flow and stream bank characteristics in each canyon.

4.7 Arthropods (Chapter 7 and 8)

- A total of more than 22,500 individual arthropods were trapped and identified.
- There was no statistical difference in the numbers and types of arthropods found in Los Alamos and Guaje Canyons.
- Although, not statistically significant, the biggest difference was types and numbers of arthropods found in the various plant communities along the elevational gradient.

4.8 Birds (Chapter 9)

- Three locations were censused: Los Alamos Canyon, Guaje Canyon, and Puye Mesa.
- There were statistically significant differences between these locations. The canyons had higher bird censuses than did the mesatop location.
- In Los Alamos Canyon the 1993 census revealed 44 species and 569 birds; in 1994 the census revealed 42 species and 568 birds.

- In Guaje Canyon the 1993 census revealed 48 species and 669 birds; 1994 the census revealed 42 species and 568 birds.
- On Puye Mesa there were 30 species and 167 birds.

4.9 Small Mammals (Chapter 10)

- Capture rates were not significantly different between 1993 and 1994.
- Eleven small mammal species were captured.
- Overall species diversity was similar for both canyons.
- Procedures to bleed animals for seroprevalence of hantavirus did not appear to affect captured and recapture rates.
- Eight percent (8%) of deer mice and four percent (4%) of the voles capture in Guaje and Los Alamos Canyons were positive for hantavirus. Three other species were questionably positive.

4.10 Geographic Position System and Geographic Information System Activities (Chapter 11)

- Mapping has been completed.
- During 1996 the attribute data collected during the ecorisk study will be linked to spacial data.

4.11 Sensitive/Threatened and Endangered Species (Chapter 12)

Spotted Bat Survey.

- Twelve species were found in Los Alamos and Guaje Canyons.
- Recordings of bat echolocations taken in Los Alamos Canyon show a 90% chance of being emitted from spotted bat. Recordings have been sent to experts for confirmation.

- Additional bat surveys will be conducted by the National Biological Survey during 1996.

Spotted Owl.

- Terrell Johnson monitored spotted owl habitats in Guaje Canyon for the Forest Service.
- Habitat modeling indicates that Los Alamos Canyon below Omega Site is good perching habitat for Mexican Spotted Owl.

5 RESEARCH NEEDS RELATED TO BASLINE DATA

5.1 General

- Continue studies within Los Alamos and Guaje Canyons for a minimum of 2 years or more if possible to get multi-year data.
- Develop similar study sites and information for dry canyons and mesa tops.
- Decide if sampling of organisms for contaminants is desirable and determine which organisms to sample.
- Develop a study to define the range of free-ranging mammals such as elk, deer, and bear that may be of economic or ethnozoological importance to stakeholders.
- Continue the use of the GPS and ARC INFO in mapping ranges of organisms and sensitive habitats.
- Continue the development of databases that summarize the information gathered for the Pajarito Plateau.

5.2 Vegetation

- Vegetation studies should continue and a resurvey of the permanet plots should be done on a set annual, biannual, or triannial cycle.

5.3 Aquatic Macroinvertebrates

- Further study is required to understand impacts affecting streams in Los Alamos Canyon.
- Study design must be altered to elucidate the overwhelming impact to resident macroinvertebrate communities.
- An additional station will be established in lower Los Alamos Canyon above the outfall at TA-2. This will allow detection of disturbances due to authorized discharges and accidental spills into the stream.
- Identify reference streams and possible study areas while continuing to add to the taxa stream. Perhaps add Frijoles or Santa Clara Canyons as reference sites.

5.4 Arthropods

- Continue the arthropod pitfall traps within the canyon systems.
- Establish beehives in both canyon systems and analyze for contaminants.
- Collect isopods and analyze for contaminants.
- Do arthopod decomposition studies to further define contaminant movement.

5.5 Birds

- Continue bird surveys within Los Alamos and Guaje Canyon
- Net for birds yearly to provide a basis for the survivorship of individual birds and provide population estimates.

5.6 Small Mammals

- Increase number of trapping grids from two to three for each habitat type.
- Ascertain information on mortality, reproductive, and survivability rates by obtaining larger samples.
- Develop additional techniques to define animal health by use of parameters such as body fat and parasite loads.

5.7 Scent Stations

- Further define the appropriate use of scent stations.

5.8 Large Mammals

- Using remote sensing and telemetry techniques define migration routes and fawning/calving areas.

5.9 Sensitive/Threatened/Endangered Species

- New listings are continually being made. Species listed will require a minimum of 2 years of survey.
- Monitor any sensitive/threatened/endangered species within any of the permanent study areas.
- Additional studies must be done to determine the presence of the spotted bat within Los Alamos and Guaje Canyon

6 ACKNOWLEDGMENTS

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CHAPTER 1

RESULTS OF CANYON BOTTOM AND STREAM CHANNEL VEGETATION SURVEYS IN GUAJE AND LOS ALAMOS CANYONS (1993)

by

ALETHEA K. BANAR

ABSTRACT

In 1993, the Biological Resource Evaluations Team conducted field surveys in Guaje and Los Alamos Canyons, Los Alamos County. Biological data for ecological risk assessment at Los Alamos National Laboratory was collected and included vegetation surveys. The purpose of the current study is to determine the plant species diversity and communities of these canyons. Many plants are indicator species and changes in species diversity or plant communities could signal an environmental change. The study of these two canyons should provide a measure of the effect man has on naturally occurring plant populations. This chapter describes the methods established for long-term monitoring of vegetation at Los Alamos National Laboratory and summarizes findings from the first year of data. Future reports will present new data as it becomes available.

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1 INTRODUCTION

In 1993, surveys were conducted by the Biological Resource Evaluations Team (BRET) to identify biotic components of two canyon systems within Los Alamos County. As part of these surveys, information was collected on vegetation to characterize the plant communities. The data collected in these surveys is to be used as part of an ecological risk assessment (eco-risk) being conducted by Los Alamos National Laboratory (LANL). These canyon surveys will help determine impacts the Laboratory may have on ecosystems within and adjacent to Laboratory property. Differences in vegetation characteristics between the canyons could indicate Laboratory activities are causing adverse impacts to the biotic environment. One of the two canyon systems, Guaje Canyon, was selected as a control to compare to a second canyon system , Los Alamos

Canyon. Los Alamos Canyon lies partially within Laboratory boundaries and was selected for the possible impacts of Laboratory activities in this canyon.

2 METHODS

Vegetation transects were set up in Guaje Canyon and Los Alamos Canyon during July and August of 1993 to measure plant overstory and understory characteristics. Three transects were placed in the upper, mid, and lower portions of each canyon. A circular plot technique was used to measure the overstory components of the forest, woodland, and riparian communities. This technique is used primarily in riparian zones and multi-stemmed pinyon-juniper woodlands but was chosen because all transects in this study are located along stream channels. The understory was measured using Daubenmeier plots placed along a transect line (Daubenmeier 1959). Plant species were recorded as four letter codes made up of the first two letters of the genus name and species name. If the species could not be determined, the first three letters of the genus and an X were used. A list of the codes and their corresponding scientific and common names can be found in Appendix 1-A.

2.1 Overstory

A circular plot technique was used to measure overstory components within riparian zones and woodlands. A 304.80-m (1000-ft) transect line was placed along the habitat that was to be evaluated. For the eco-risk project, the transect was placed along the canyon bottom in the stream channel. When water was present in the stream channel, the transect line was placed on the north bank as close as possible to the water. Three circular plots were established along the transect with their centers at the 42.67-m (140-ft) point, the 152.40-m (500-ft) point, and the 262.13-m (860-ft) point (Figure 1). Each center point was staked with a piece of angle iron or rebar and flagged. The compass points (north, south, east, and west) on the perimeter of each circular plot were staked with large nails and flagged.

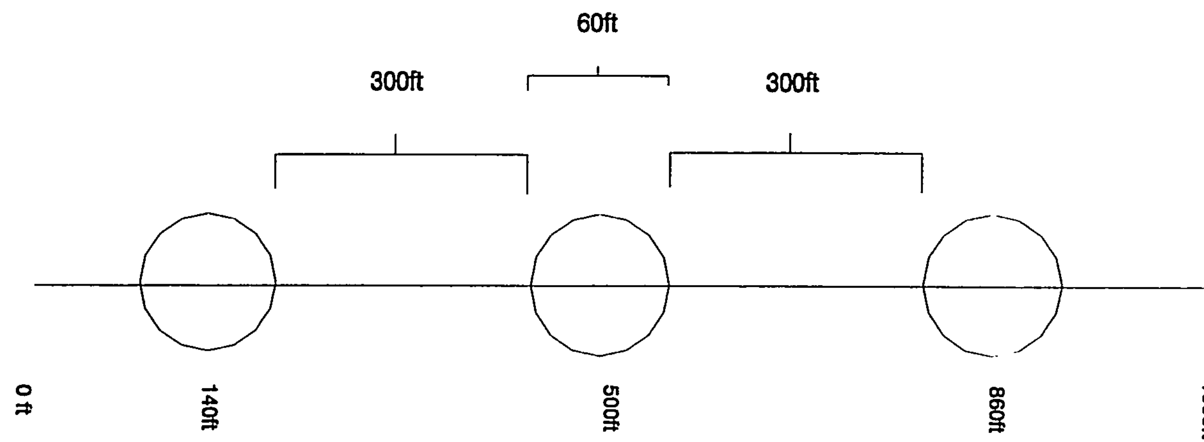


Fig. 1 Vegetation Transect

Data was recorded for all trees within a 9.14-m (30-ft) radius of the center point. The data included species, height, crown diameter, condition, number of stems, diameter, and percent cover. All multistemmed species, such as pinyon pine and juniper, were measured for basal diameter. All single-stemmed trees such as ponderosa pine were measured for diameter at breast height (DBH). Any tree with a DBH of 5 in. or greater was labeled with an aluminum tag that was nailed to its north side. All shrub species 3 ft in height or more were recorded as overstory. These were measured for DBH and the number of stems was counted. A shrub species was recorded as a tree if a stem had a DBH of three inches or more. Percentage of cover for each species was determined by dividing the circle into four equal subplots (quarters) and estimating the cover within each of the subplots. In addition, general location of trees and shrubs in each circular plot was mapped.

2.2 Understory

A quadrat method was used to measure the cryptogamic and herbaceous layer, the percent bare soil, litter, and woody species less than 0.91 m (3 ft) tall. In this survey, a Daubenmire plot of 20 x 50 cm (7.87 x 19.69 in.) was placed every 3.05 m (10 ft) along the transect line established for overstory evaluation (Daubenmire 1959). Visual estimates were used to determine species composition and percent cover. Beginning at the center point of the first circular plot, quadrats were placed along the line and read until a maximum of 213.36 m (700 ft) was reached for a single transect. It should be noted that grasses in a plot were often recorded as a combined total cover for grass species and not separated out into individual species.

Plants that were not identified in the field were collected and taken to BRET's laboratory for identification. All plants were identified using Martin and Hutchins (1980), Foxx and Hoard (1984), and Foxx and Tierney (1985). When necessary, voucher specimens were collected and archived in the EM-8 Herbarium.

3 RESULTS

Vegetation species were analyzed to obtain values of percent cover, relative cover, frequency, and relative frequency. An importance index was calculated for each species based on the average of the relative cover and relative frequency values. The overstory analysis includes trees or shrubs per acre, and a relative density value (Appendix 1-B). The following summary of the data only deals with relative cover, relative frequency, and importance index values.

3.1 Guaje Canyon

In upper Guaje Canyon, a total of 38 plant species was recorded; 13 overstory and 25 understory. For tree species, ponderosa pine (*Pinus ponderosa*) and thinleaf alder (*Alnus tenuifolia*) have the highest relative cover values (25.50% and 24.28% respectively) (Fig. 2). Relative cover of Engelmann spruce (*Picea engelmannii*) was slightly lower in value (15.61%). The highest relative frequency value, 14.29%, was shared by Engelmann spruce, Douglas fir (*Pseudotsuga menziesii*), white fir (*Abies concolor*), thinleaf alder, and Rocky Mountain maple (*Acer glabrum*). Thinleaf alder had the highest importance index value (33.33%). The shrub layer was dominated by cliffbush (*Jamesia americana*) and serviceberry (*Amelanchier utahensis*) with relative covers of 54.17% and 41.67% respectively. Cliffbush had the highest relative frequency value (40%) and importance index value (59.03%). It should be noted that though the relative values for shrubs appear large, there were very few shrub species in this transect.

Of the understory species recorded, moss and cutleaf coneflower (*Rudbeckia laciniata*) had the highest relative cover values (29.72% and 19.92% respectively) (Fig. 3). Various grass species, moss, and cutleaf coneflower had the highest relative frequency values (14.29%, 13.66% and 10.56% respectively). These three species also had the highest importance index values (11.53%, 21.69%, and 15.24%). All other species recorded for upper Guaje Canyon are listed in Tables 1 and 2.

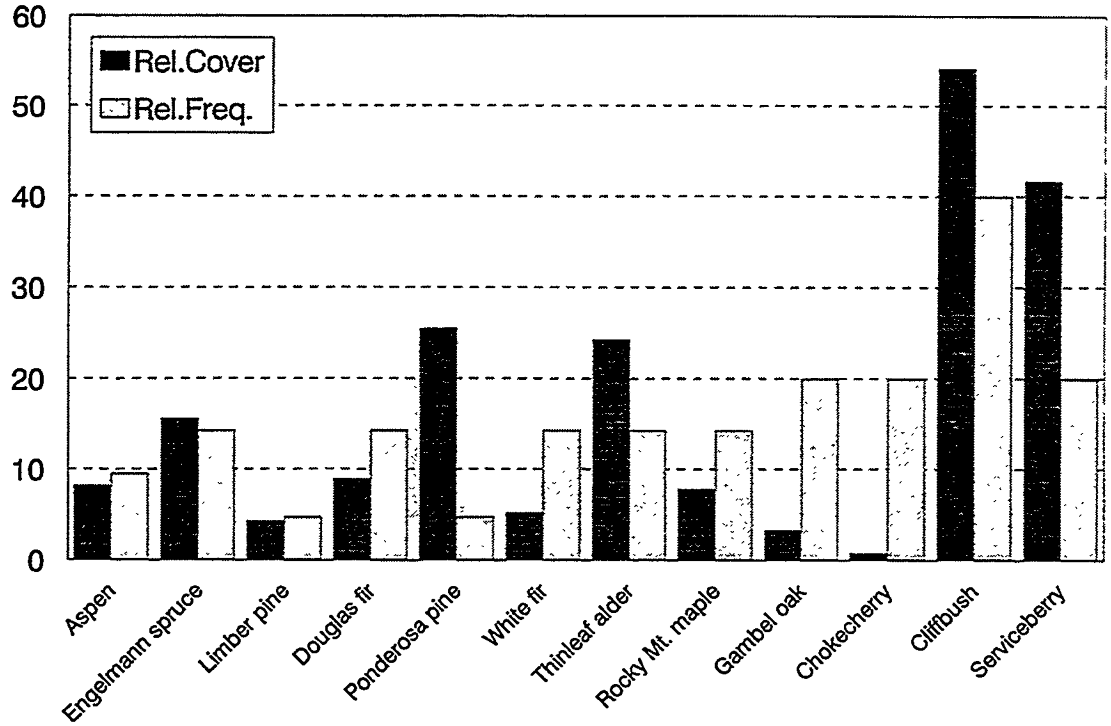
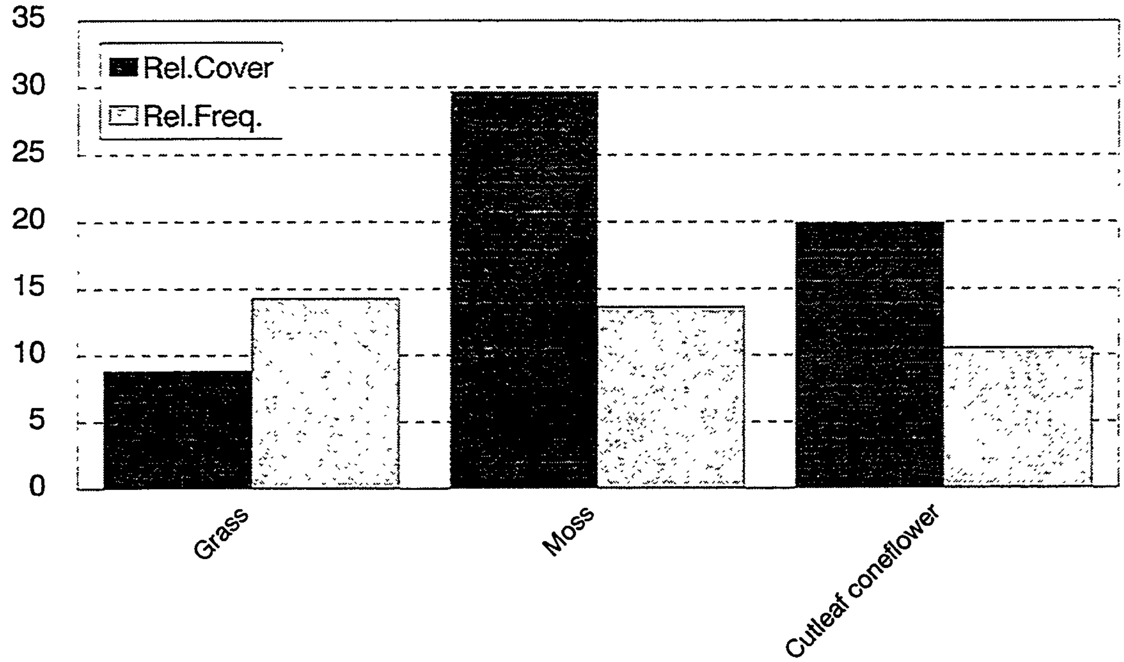


Fig. 2 Upper Guaje Canyon Overstory



Species less than 10% not listed

Fig. 3 Upper Guaje Canyon Understory

Table 1. Overstory Species By Site

Trees

Species	Los Alamos Canyon lower	Los Alamos Canyon mid	Los Alamos Canyon upper	Guaje Canyon lower	Guaje Canyon mid	Guaje Canyon upper
White fir		X	X	X	X	X
Rocky Mountain maple		X	X	X	X	X
Thinleaf alder				X	X	X
Water birch	X				X	
One-seed juniper	X					
Rocky Mountain juniper	X					
Dwarf juniper	X					
Gambel oak	X					
Ponderosa pine	X	X		X		X
Douglas fir	X	X	X	X	X	X
Engelmann fir		X	X		X	X
Limber pine			X		X	X
Aspen		X	X		X	X
Narrow leaf cottonwood	X			X		
Snags		X	X	X	X	X

Shrubs

Species	Los Alamos Canyon lower	Los Alamos Canyon mid	Los Alamos Canyon upper	Guaje Canyon lower	Guaje Canyon mid	Guaje Canyon upper
Boxelder maple				X		
Serviceberry		X	X			X
Fendler barberry	X			X		
New Mexico olive	X					
Cliffbush	X	X	X		X	X
Chokecherry		X	X			X
Gambel oak	X	X	X	X	X	X
Wavyleaf oak	X					
New Mexico locust	X	X	X		X	
Wax current	X			X		
Gooseberry		X		X	X	

Table 1 (cont.)

Species	lower	mid	upper	lower	mid	upper
Wild rose	X			X	X	
Raspberry				X	X	
Willow	X		X			
Narrowleaf yucca	X					

Table 2 Understory Species By Site

Species	Los Alamos Canyon lower	Los Alamos Canyon mid	Los Alamos Canyon upper	Guaje Canyon lower	Guaje Canyon mid	Guaje Canyon upper
White fir		X				
Rocky Mountain maple						X
Yarrow		X	X	X	X	X
Boxelder maple		X				
Redtop	X	X	X	X		
Western wheatgrass	X	X	X			
Wheatgrass sp.	X		X			
Agrimony				X		
Thinleaf alder					X	
Serviceberry		X	X			
Little bluestem	X					
Fendler barberry	X			X		
Water birch		X				
Borage				X		
Smooth brome	X					
Bromegrass	X	X	X	X		
Carrot				X	X	X
Sedge		X	X		X	
Lamb's quarters		X	X			
Soil crust	X					
Western water hemlock		X				
Thistle		X				X
Clematis		X	X			
Coralroot		X				
Dogwood					X	
Timber oatgrass		X				
Willowweed				X		
Meadow horsetail				X	X	
Horsetail sp.		X	X			
Fleabane			X			X
Wild strawberry		X	X	X	X	X
Goosegrass						X
Bedstraw sp.			X	X	X	
James geranium		X	X			
Richardson's geranium				X	X	X
Geranium sp.					X	
Grass spp.				X	X	X
Waterleaf sp.					X	
Squaw lettuce						X

Table 2 (cont.)

Species	Los Alamos Canyon lower	mid	upper	Guaje Canyon lower	mid	upper
Cliffbush		X	X			
Inland rush	X			X		
Chicory lettuce				X		
Lichens	X				X	X
Bearberry honeysuckle			X			X
Wolftail or Texas timothy	X					
Horsemint				X		
Moss	X			X	X	X
Bluntseed sweet cicely			X		X	X
Woodsorrel				X		
Virginia creeper	X					
Mountain lover			X			
Beardtongue		X	X			
Bluegrass sp.		X				
Muttongrass	X					
Beauty potentilla				X		
Aspen		X	X			X
Ponderosa pine	X					
Chokecherry		X		X		
Selfheal or Healall						X
Pseudocymopterus						X
Fragile fern			X		X	X
Gambel oak		X				
White water crowfoot				X		
Macoun's buttercup						X
Buttercup sp.					X	
Gooseberry				X	X	
New Mexico locust	X	X				
Wild rose		X			X	
Cutleaf coneflower		X	X	X	X	X
Thimbleberry					X	X
Raspberry		X		X	X	X
Willow		X				
Burroweed						X
Common dandelion		X				
Yellow sweet clover	X			X	X	
Red clover				X		
Fendler meadowrue		X	X		X	X

Table 2 (cont.)

Species	Los Alamos Canyon lower	Los Alamos Canyon mid	Los Alamos Canyon upper	Guaje Canyon lower	Guaje Canyon mid	Guaje Canyon upper
Stinging nettle		X		X		
VACU				X		
Valerian						X
American speedwell			X			
Mullein			X	X		
Vetch			X	X	X	X

In mid Guaje Canyon, a total of 41 plant species was recorded; 15 overstory and 26 understory. The tree species with the highest relative cover value was Douglas fir (27.54%) followed by white fir (17.45%) (Fig. 4). Engelmann spruce, limber pine (*Pinus flexilis*), and aspen (*Populus tremulodies*) shared the highest relative frequency value (16.67%). Thinleaf alder had the highest importance index value of 19.24%. New Mexico locust (*Robinia neomexicana*) and cliffbush had the highest relative cover for shrubs (34.79% and 30.31% respectively). Cliffbush had the highest relative frequency value (30.00%) followed by wild rose (*Rosa woodsii*) and raspberry (*Rubus strigosus*) with values of 20.00%. Cliffbush had the highest importance index value of 33.33%.

Of the understory species recorded for this portion of the canyon, the majority of the relative cover was divided between moss, cutleaf coneflower, various grass species, Richardson's geranium (*Geranium richardsonii*), and gooseberry (*Ribes inerme*) (18.57%, 14.06%, 12.94%, 11.15%, and 10.18% respectively) (Fig. 5). Richardson's geranium and various grass species had the highest values for relative frequency (16.67% and 12.67% respectively). Richardson's geranium had the highest importance index value of 13.91%. All other species recorded for mid Guaje Canyon are listed in Tables 1 and 2.

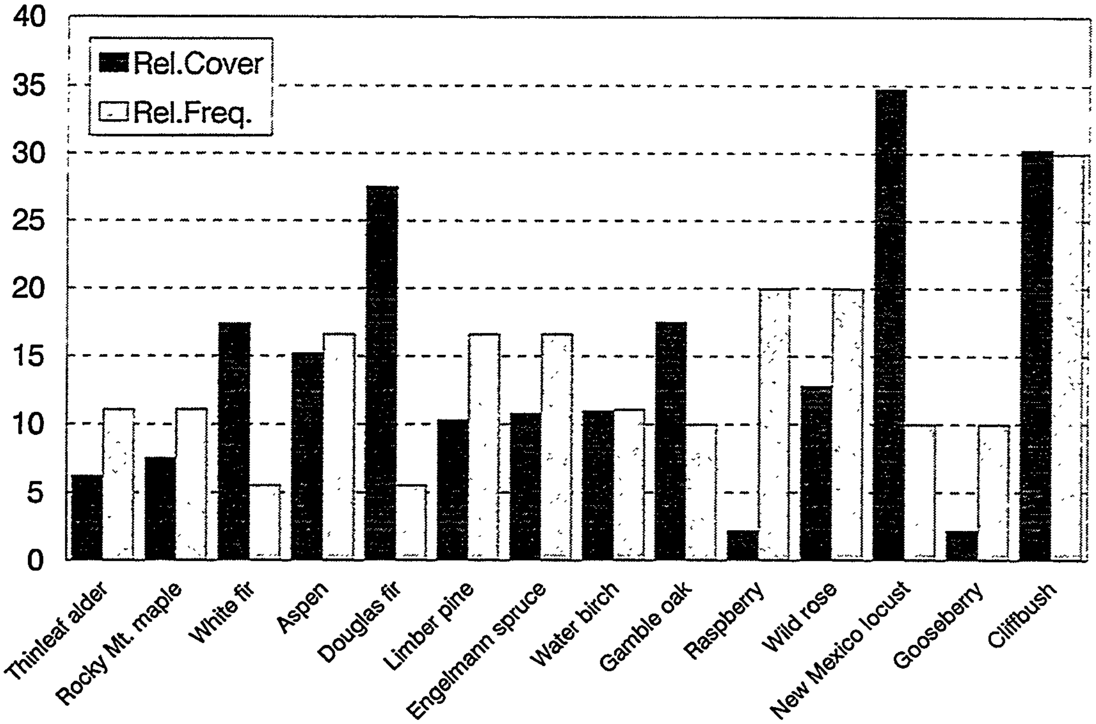
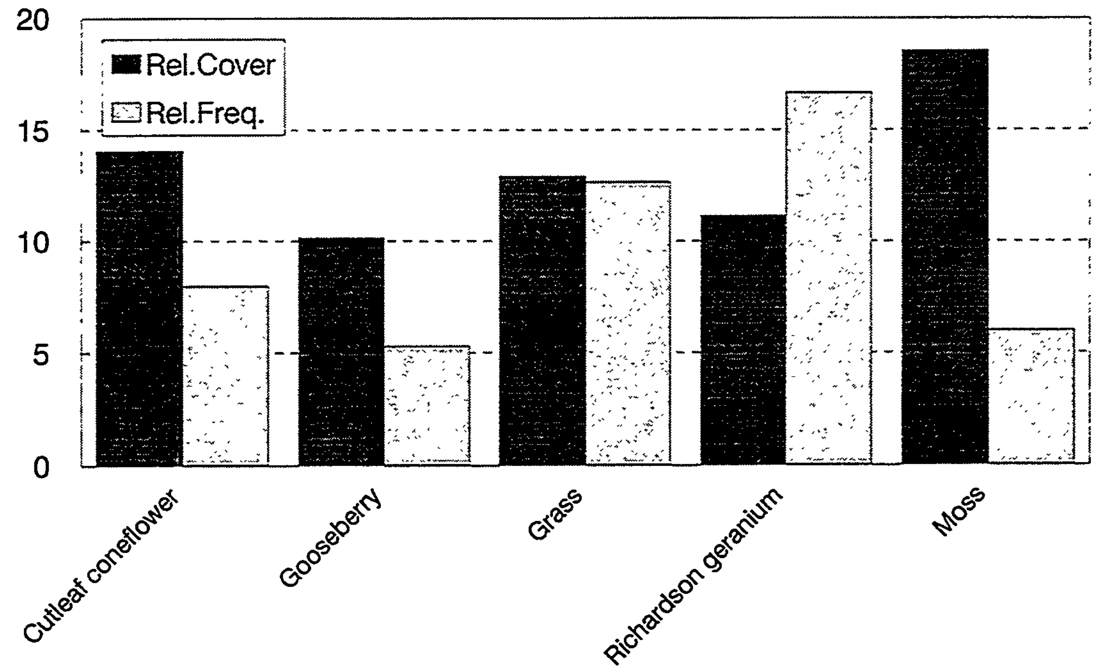


Fig. 4 Mid Guaje Canyon Overstory



Species less than 10% not shown

Fig. 5 Mid Guaje Canyon Understory

In the lower section of Guaje Canyon, a total of 47 species was recorded; 14 overstory and 33 understory. The dominant tree species was Douglas fir with relative cover value of 30.02% (Fig. 6). Ponderosa pine, Douglas fir, white fir, and thinleaf alder had relative frequency values of 17.65%. Narrowleaf cottonwood (*Populus angustifolia*) followed with 11.76% value. Rocky Mountain maple had the highest importance index value of 20.85%. Gooseberry had the highest relative cover value for shrubs (32.17%). Gooseberry and Fendler barberry (*Berberis fendleri*) had the highest relative frequency values (25.00%). Gooseberry had the highest importance index value of 32.94%.

Of the understory species recorded, various grass species had the highest relative cover and frequency values (46.83% and 23.91% respectively) (Fig. 7). Cutleaf coneflower had a relative cover value of 11.15%. Meadow horsetail (*Equisetum arvense*) had a relative frequency value of 10.87%. Various grass species had the highest importance index value of 35.37%. All other species recorded for lower Guaje Canyon are listed in Tables 1 and 2.

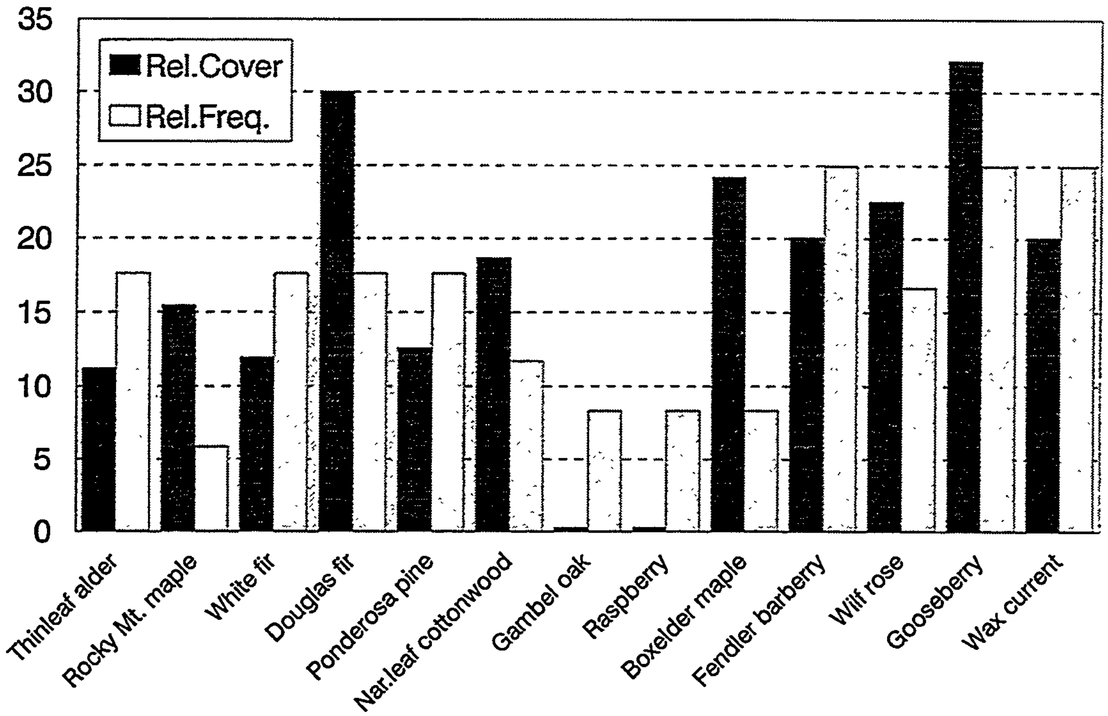


Fig. 6 Lower Guaje Canyon Overstory

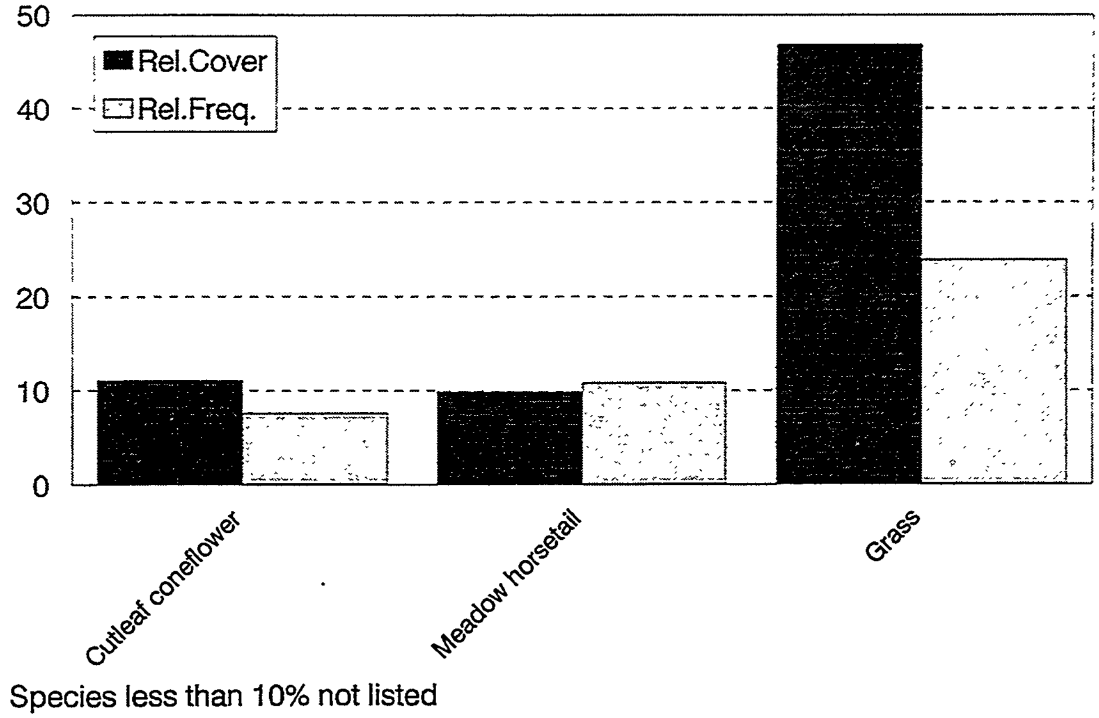


Fig. 7 Lower Guaje Canyon Understory

3.2 Los Alamos Canyon

In upper Los Alamos Canyon, a total of 40 species was recorded: 12 overstory and 28 understory. For overstory trees, aspen had the highest relative cover value followed by Douglas fir (30.59% and 19.12% respectively) (Fig. 8). Aspen and white fir had the highest relative frequency value (20.00%). Engelmann spruce had the highest importance index value of 24.15%. The shrub layer was dominated by cliffbush for relative cover, relative frequency, and importance index values (56.36%, 33.33%, and 65.12% respectively). Cutleaf coneflower, wild strawberry (*Fragaria americana*), and James geranium (*Geranium caespitosum*) had the largest relative cover values (10.20%, 9.46%, and 8.32% respectively) for understory (Fig. 9). Wild strawberry and James geranium had the highest values for relative frequency (18.57% and 12.14% respectively). Wild strawberry had the highest importance index value of 14.10%. All other species recorded for upper Los Alamos Canyon are listed in Tables 1 and 2.

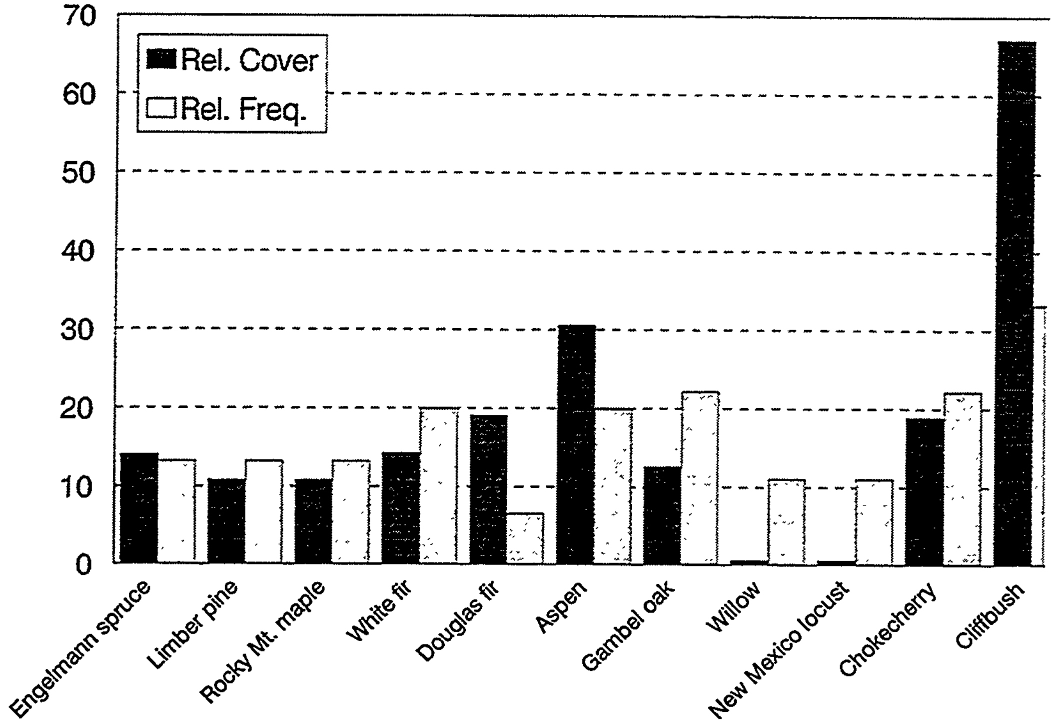
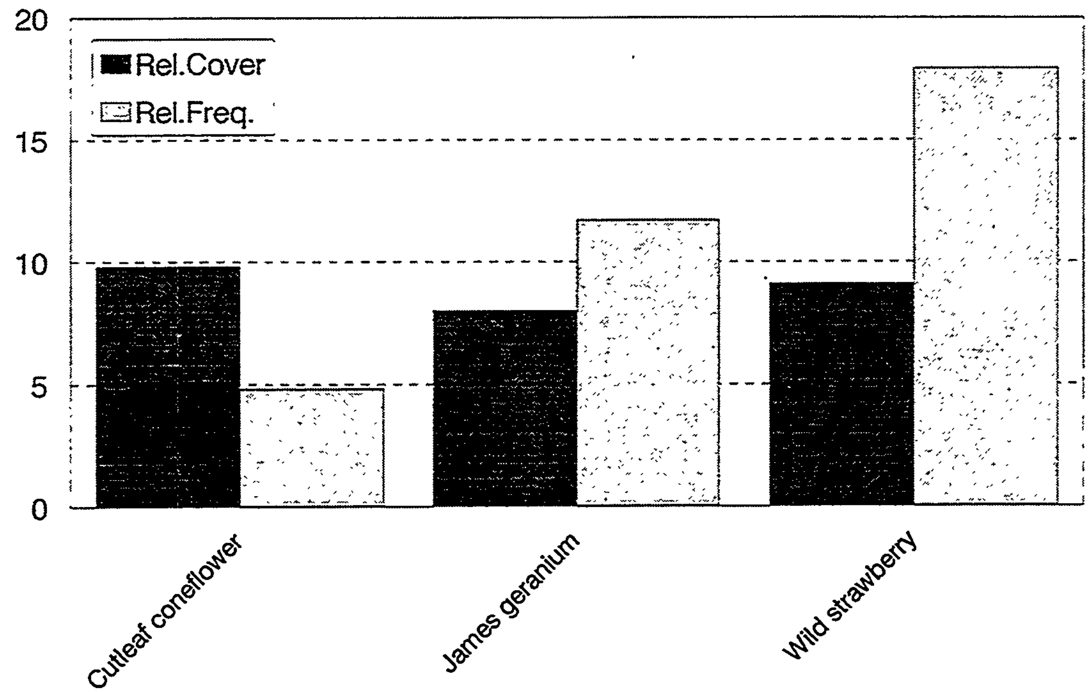


Fig. 8 Upper Los Alamos Overstory



Species less than 10% not shown

Fig. 9 Upper Los Alamos Canyon Understory

In the mid portion of the canyon, a total of 47 species was recorded: 13 overstory and 34 understory. Among tree species, Engelmann spruce and Douglas fir had the highest relative cover values (24.12% and 22.19%) (Fig. 10). The highest relative frequency was shared by Douglas fir, white fir, and thinleaf alder (23.08% each). White fir had the highest importance index value of 28.79%. Chokecherry (Prunus virginiana) had the highest relative cover value among shrubs (40.37%). Cliffbush (33.33%) and Gambel oak (*Quercus gambelii*) had the highest values for relative frequency (22.22%). Cliffbush had the highest importance index value of 41.95%.

Among the understory species, redtop (*Agrostis alba*) had the highest value for relative cover (23.71%) followed by raspberry (18.72%) (Fig. 11). These species also had the highest relative frequency values (19.74% and 15.02% respectively). Redtop had the highest importance index value of 21.73%. All other species recorded for mid Los Alamos Canyon are listed in Tables 1 and 2.

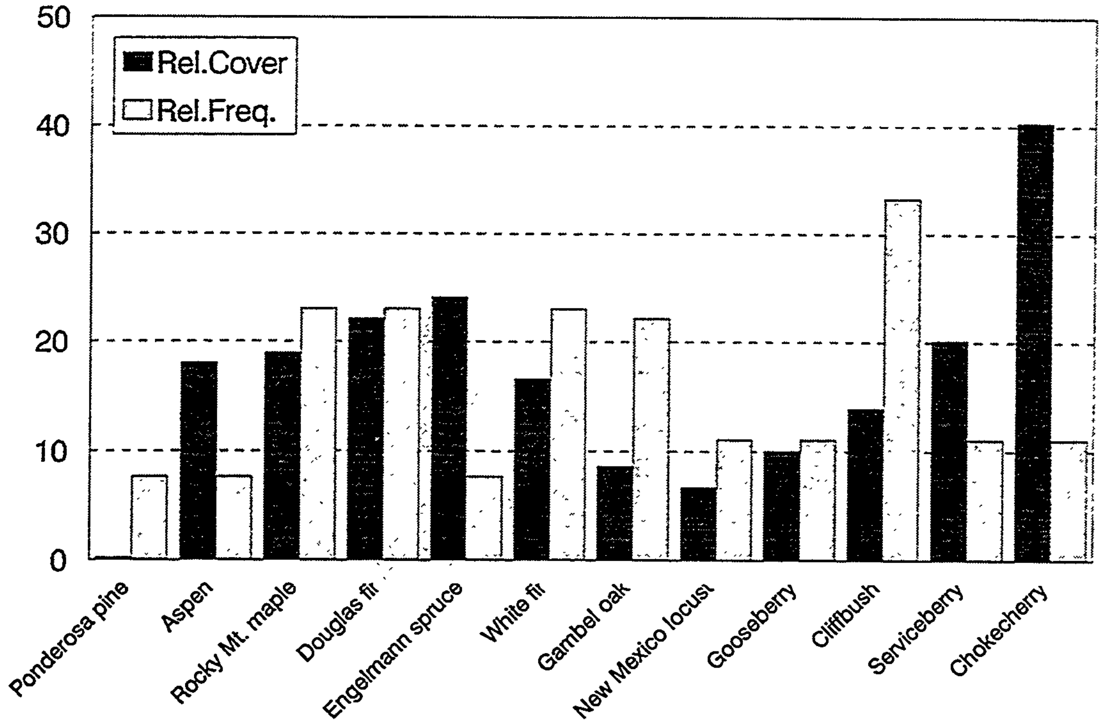
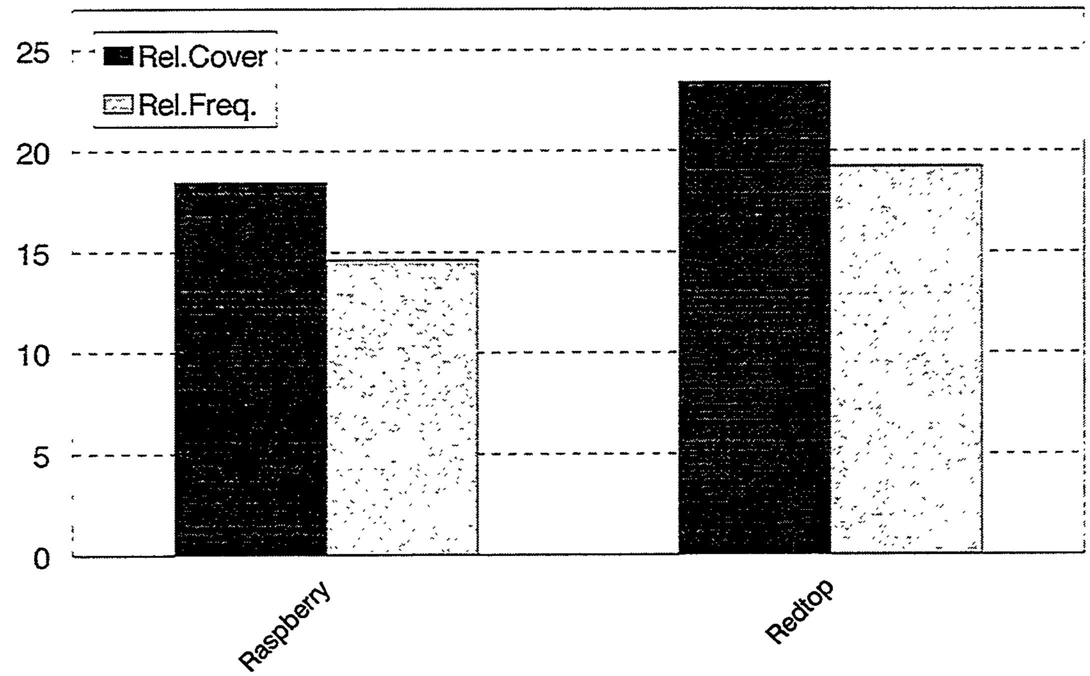


Fig. 10 Mid Los Alamos Canyon Overstory

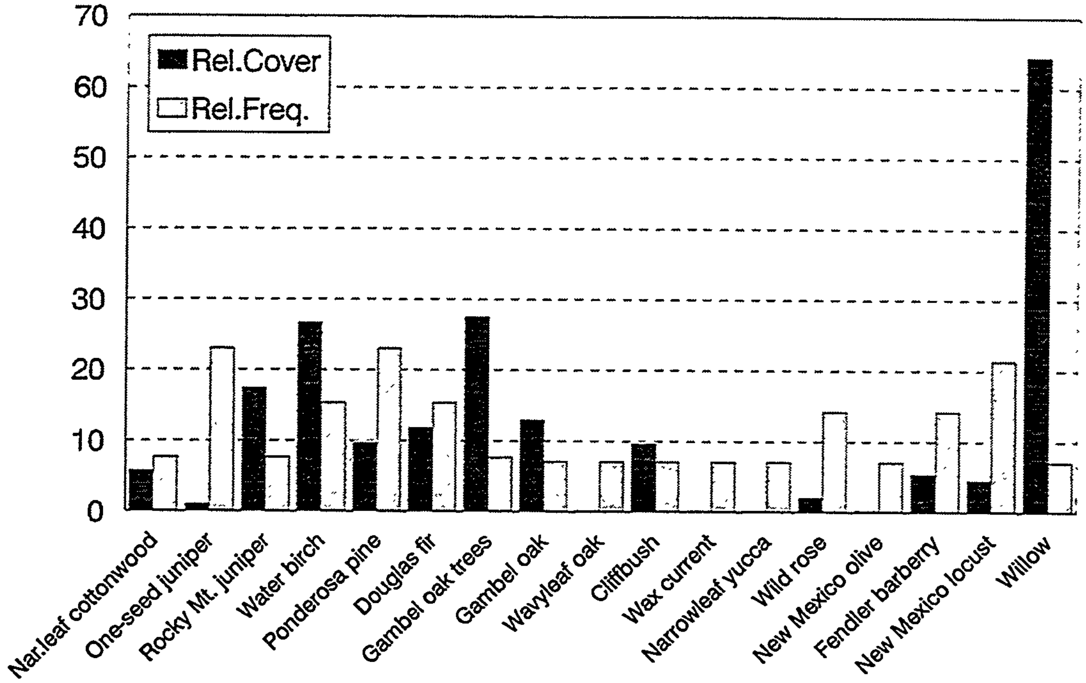


Species less than 10% not shown

Fig. 11 Mid Los Alamos Canyon Understory

In the lower portion of Los Alamos Canyon, a total of 33 species was recorded: 17 overstory and 16 understory. The species with the highest relative cover values were Gambel oak (27.54%) and water birch (*Betula occidentialis*) (26.70%) (Fig. 12). One-seed juniper (*Juniperus monosperma*) and ponderosa pine shared the highest relative frequency values (23.08%). Water birch had the highest importance index value of 32.51%. In the shrub layer, willow (*Salix sp.*) had the highest relative cover value (64.51%). The species with the highest relative frequency value was New Mexico locust (21.43%). Willow had the highest importance index value of 34.73%.

In the understory layer, redtop had the highest value for relative cover and frequency values (44.66% and 32.71% respectively) (Fig. 13). This species was followed by smooth brome (*Bromus inermis*) in both measurements (25.35% and 26.17% respectively). Redtop had the highest importance index value of 38.84%. All other species recorded for lower Los Alamos Canyon are listed in Tables 1 and 2.



Species with less than 1% show as zero

Fig. 12 Lower Los Alamos Canyon Overstory

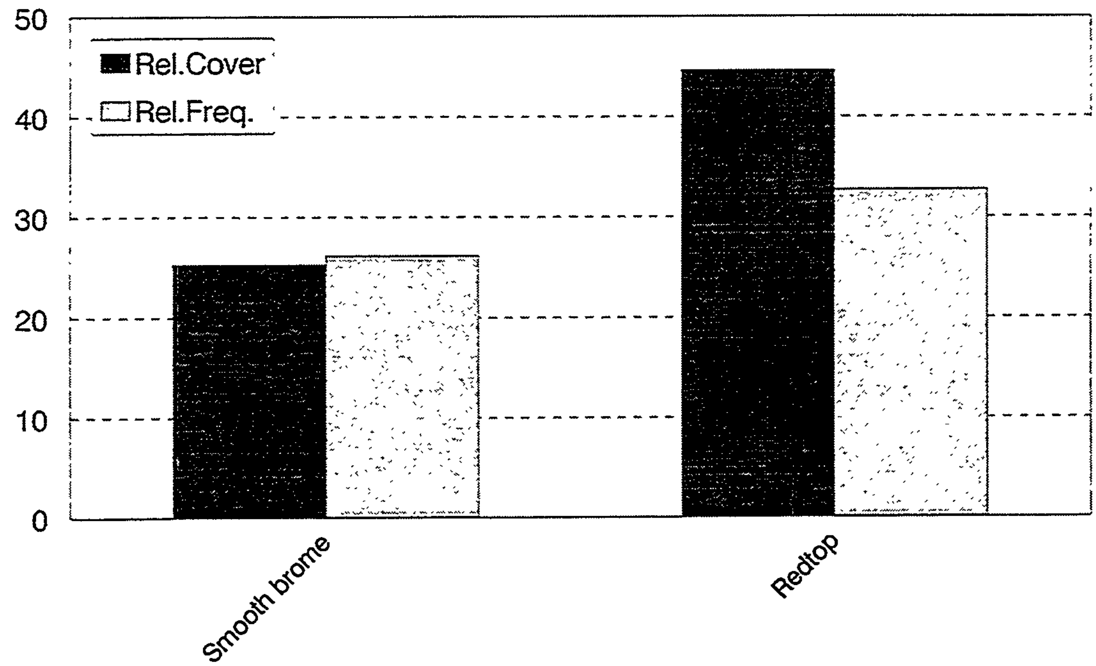


Fig. 13 Lower Los Alamos Canyon Understory

4 DISCUSSION

The total numbers of species recorded for each canyon were similar. Guaje had a total of 126 species among the upper, mid, and lower transects: 42 in the overstory and 84 in the understory. Los Alamos had a total of 120 species among all transects: 42 in the overstory and 78 in the understory. Although the diversity is similar between canyons, the compositions differ. The difference in composition is most apparent when comparing the lower canyon overstory transects. No juniper species were recorded in lower Guaje Canyon but lower Los Alamos Canyon had both one-seed and Rocky Mountain junipers. This may be because the lower portion of Guaje Canyon tends to be narrower and has a more reliable water flow than lower Los Alamos Canyon. Based on these differences, it is possible that the transects in the lower portions of each canyon need to be relocated to obtain a better species match. The lower transect in Guaje Canyon could be moved farther down the canyon to attempt to match lower Los Alamos Canyon vegetation.

Tree and shrub composition between Guaje and Los Alamos Canyons shared some similarities. In most locations the tree and shrub species were similar between the comparable sections of the canyons (Table 1). In contrast, very few of the understory species in each section of Guaje Canyon were recorded in the corresponding sections of Los Alamos Canyon (Table 2). Few similarities were seen between canyon sections for understory plants. Of the species that had ten percent or more relative cover and/or relative frequency values, cutleaf coneflower was seen in both upper transects (Figs. 3 and 9). These differences may be due to sampling size since only one transect was set up along the stream channel in each section of the canyon systems. Another factor may be the differences in water flow in the stream channels. Guaje Canyon has water almost year round in the sections that were surveyed. This is reflected in the moisture-loving species recorded in this canyon. The water flow in mid Los Alamos Canyon is dependent on water released from the reservoir upstream, and the lower portion experiences flow only during rain events. Grass species were dominant in the mid and lower portions of Los Alamos Canyon. The mid and lower portions of Guaje Canyon did have grasses in the top section, however, these were recorded as total cover for grass and not separated out into individual species. Recording grasses as individual species may lower numerical values for grass in Guaje Canyon. These factors may increase the differences seen in species composition identified among sections of the canyons.

4.1 Research Needs

Studies conducted in Los Alamos and Guaje Canyons need to be continued to determine the effects LANL may be having on its surrounding environment. Surveying each canyon on a yearly basis will provide baseline data for the canyons. This may be used to determine any changes that are taking place in the environment as a result of Laboratory activities. Additional vegetation surveys in these canyons, such as north- and south-facing slopes or the canyon bottom away from the stream channel, will provide a more complete representation of plant species in the canyon systems.

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APPENDIX 1-A

Vegetation Species List

Species Code	Scientific Name	Common Name
Trees		
ABCO	Abies concolor	White fir
ACGL	Acer glabrum	Rocky Mountain maple
ALTE	Alnus tenuifolia	Thinleaf alder
BEOC	Betula occidentialis	Water-birch
JUMO	Juniperus monosperma	One-seed juniper
JUSC	Juniperus scopulorum	Rocky Mountain juniper
PIPO	Pinus ponderosa	Ponderosa pine
PSME	Pseudotsuga menziesii	Douglas fir
PIEN	Pinus engelmannii	Engelmann spruce
PIFL	Pinus flexilis	Limber pine
POTR	Populus tremulodies	Aspen
POAN	Populus angustifolia	Narrow leaf cottonwood
Shrubs		
ACNE	Acer negundo	Boxelder maple
AMUT	Amelanchier utahensis	Serviceberry
BEFE	Berberis fendleri	Fendler barberry
FONE	Forestiera neomexicana	New Mexico olive
JAAM	Jamesia americana	Cliffbush
JUCO	Juniperus communis	Dwarf juniper
PRVI	Prunus virginiana	Chokecherry
QUGA	Quercus gambelii	Gambel oak
QUUN	Quercus undulata	Wavyleaf oak
RONE	Robinia neomexicana	New Mexico locust
RICE	Ribes cereum	Wax current
RIIN	Ribes inerme	Gooseberry
ROWO	Rosa woodsii	Wild rose
RUST	Rubus strigosus	Raspberry
SALX	Salix sp.	Willow
YUAN	Yucca angustissima	Narrowleaf yucca
Understory		
ACLA	Achillea lamulosa	Yarrow
AGAL	Agrostis alba	Redtop
AGSM	Agropyron smithii	Western wheatgrass
AGRX	Agropyron sp.	Wheatgrass
Agrimonia	Agrimonia sp.	Agrimony
ANSC	Andropogon scoparius	Little bluestem
BORAG	Boraginaceae sp.	Borage family sp.
BRIN	Bromus inermis	Smooth brome
BROX	Bromus sp.	Bromegrass
CARROT	Umbelliferae sp.	Carrot family sp.
CARX	Carex sp.	Sedge
CHENOPOD	Chenopodium sp.	Lamb's quarters
CHRIPTO	Chriptograms	Soil crusts

Species Code Understory	Scientific Name	Common Name
CIDO	Cicuta douglasii	Western water hemlock
CIRX	Circium sp.	Thistle
CLEX	Clematis sp.	Clematis
COST (L.A.Can.)	Corallorhiza striata	Coralroot
COST (G.Can.)	Cornus stolonifera	Dogwood
DAIN	Danthonia intermedia	Timber oatgrass
EPCI	Epilobium eiliatum	Willowweed
EQAR	Equisetum arvense	Meadow horsetail
EQUX	Equisetum sp.	Horsetail
ERIX	Erigeron sp.	Fleabane
FRAM	Fragaria americana	Wild strawberry
GAAP	Galium aparine	Goosegrass
GALX	Galium sp.	Bedstraw
GECA	Geranium caespitosum	James geranium
GERI	Geranium richardsonii	Richardson's geranium
GERX	Geranium sp.	Geranium sp.
GRASS SPP.	Graminae sp.	Grass sp.
HYDX	Hydrophyllum sp.	Waterleaf sp.
HYFE	Hydrophullum fendleri	Squaw lettuce
JUIN	Juncus interior	Inland rush
LAPU	Lactuca pulchella	Chicory lettuce
Lichens	-----	Lichens
LOIN	Lonicera involucrata	Bearberry honeysuckle
LYPH	Lycurus phleoides	Wolftail/Texas timothy
MEAL	Melilotus albus	White sweet clover
MEOF	Melilotus officinalis	Yellow sweet clover
MELA	Mertensia lanceolata	Chimingbells
MELU	Medicago lupulina	Black medic
MERX	Mertensia sp.	Bluebells
MOME	Monarda menthaefolia	Horsemint
MOSS	------	Moss
OSOB	Osmorhiza obtusa	Bluntseed sweet cicely
OXME	Oxalis metcalfei	Woodsorrel
PAIN	Parthenocissus inserta	Virginia creeper
PAMY	Pachystima myrsinites	Mountain lover
PENX	Penstemon sp.	Beardtongue
POAX	Poa sp.	Bluegrass sp.
POFE	Poa fendleriana	Muttongrass
POPU	Potentilla pulcherrima	Beauty potentilla
PRVU	Prunella vulgaris	Selfheal/Healall
PSMO	Pseudocymopterus montanus	Pseudocymopterus
PTFR	Pteridium fragilis	Fragile fern
PRVI	Prunus virginiana	Chokecherry
RAAQ	Ranunculus aquatilis	White water-crowfoot
RAMA	Ranunculus macounii	Macoun's buttercup
RANX	Ranunculus sp.	Buttercup sp.
RUBX	Rudbeckia sp.	Coneflower sp.
RULA	Rudbeckia laciniata	Cutleaf coneflower
RUPA	Rubus parviflorus	Thimbleberry

Species Code Understory	Scientific Name	Common Name
SAOR	Salicornia occidentalis/ allenrolfea occidentalis	Burroweed
TAOF	Taraxacum officinale	Common dandelion
TROF	Trifolium melilotus var. officinalis	Yellow sweet clover
TRPA	Trifoliuim parryi	Red clover
THFE	Thalictrum fendleri	Fendler meadowrue
URGR	Urtica gracilis	Stinging nettle
VACU	(Code could not be identified with any species)	
VEAC	Valeriana acutiloba	Valerian
VEAM	Veronica americana	American speedwell
VETH	Verbascum thapsus	Mullein
VICA	Vicia sp.	Vetch

APPENDIX 1-B

Upper Guaje Canyon Overstory
Date: 7/26/93
Reader/Recorder: Keller/Banar
Three Circular Plots (250 Feet)
File Name: GUA3C

	#Trees	#Trees Per Acre	Rel. Density	Avg. DBH	%Cover	Rel. Cover	%Freq.	Rel. Freq.	Importance Index
Trees									
PIEN	21.00	107.69	5.51	6.13	10.71	15.61	0.43	14.29	11.80
PIPO	2.00	10.26	0.52	21.40	17.50	25.50	0.14	4.76	10.26
PIFL	2.00	10.26	0.52	1.60	3.00	4.37	0.14	4.76	3.22
PSME	12.00	61.54	3.15	7.02	6.15	8.97	0.43	14.29	8.80
SNAG	5.00	25.64	1.31	0.04	0.00	0.00	0.29	9.52	3.61
POTR	12.00	61.54	3.15	4.38	5.64	8.21	0.29	9.52	6.96
ACGL	83.00	425.64	21.78	0.13	5.36	7.82	0.43	14.29	14.63
ABCO	10.00	51.28	2.62	3.34	3.60	5.24	0.43	14.29	7.39
ALTE	234.00	1200.00	61.42	1.56	16.67	24.28	0.43	14.29	33.33
Total =	381	1953.846	100	45.6091	68.6370	100	3	100	100

	#Shrubs	#Shrubs Per Acre	Rel. Density	%Cover	Rel. Cover	%Freq.	Rel. Freq.	Importance Index
Shrubs								
QUGA	5.00	25.64	12.20	0.40	3.33	0.14	20.00	11.84
PRVI	1.00	5.13	2.44	0.10	0.83	0.14	20.00	7.76
JAAM	34.00	174.36	82.93	6.50	54.17	0.29	40.00	59.03
AMUT	1.00	5.13	2.44	5.00	41.67	0.14	20.00	21.37
Total =	41.00	210.26	100.00	12.00	100.00	0.71	100.00	100.00

Mid Guaje Canyon Overstory
Date: 7/26/93
Reader/Recorder: Keller/Banar
Three Circular Plots (250 Feet)
File: GUA2C

	#Trees	#Trees Per Acre	Rel. Density	Avg. DBH	%Cover	Rel. Cover	%Freq.	Rel. Freq.	Importance Index
Trees									
PIEN	6.00	30.77	5.26	2.35	4.33	10.83	0.43	16.67	10.92
PIFL	5.00	25.64	4.39	3.22	4.14	10.35	0.43	16.67	10.47
PSME	5.00	25.64	4.39	5.16	11.02	27.54	0.14	5.56	12.49
SNAG	14.00	71.79	12.28	0.41	0.00	0.00	0.43	16.67	9.65
BEOC	39.00	200.00	34.21	0.73	4.40	11.00	0.29	11.11	18.77
POTR	17.00	87.18	14.91	6.03	6.11	15.26	0.43	16.67	15.61
ACGL	17.00	87.18	14.91	0.61	3.03	7.57	0.29	11.11	11.20
ABCO	11.00	56.41	9.65	7.93	6.98	17.45	0.14	5.56	10.88
ALTE	46.00	235.90	40.35	5.02	2.50	6.25	0.29	11.11	19.24
Total =	114	584.6153	100	26.43410	40.0110	100	2.5714	100	100

	#Shrubs	#Shrubs Per Acre	Rel. Density	%Cover	Rel. Cover	%Freq.	Rel. Freq.	Importance Index
Shrubs								
QUGA	6.00	30.77	4.96	2.55	17.57	0.14	10.00	10.84
RIIN	14.00	71.79	11.57	0.33	2.24	0.14	10.00	7.94
ROWO	32.00	164.10	26.45	1.87	12.86	0.29	20.00	19.77
RONE	8.00	41.03	6.61	5.05	34.79	0.14	10.00	17.13
JAAM	48.00	246.15	39.67	4.40	30.31	0.43	30.00	33.33
RUST	13.00	66.67	10.74	0.33	2.24	0.29	20.00	10.99
Total =	121.00	620.51	100.00	14.52	100.00	1.43	100.00	100.00

Lower Guaje Canyon Overstory
Date: 7/28/93
Reader/Recorder: Keller/Banar
Three Circular Plots (250 Feet)
File Name: GUA1C3

	#Trees	#Trees Per Acre	Rel. Density	Avg. DBH	%Cover	Rel. Cover	%Freq.	Rel. Freq.	Importance Index
Trees									
POAN	4	20.51	3.00	0.00	8.33	18.71	0.28	11.76	11.16
PIPO	10	51.28	7.49	6.71	5.61	12.59	0.42	17.65	12.58
PSME	10	51.28	7.49	7.45	13.37	30.02	0.42	17.65	18.39
SNAG	11	56.41	8.24	1.24	0.00	0.00	0.28	11.76	6.67
ACGL	55	282.05	41.20	1.52	6.89	15.48	0.14	5.88	20.85
ABCO	3	15.38	2.25	5.17	5.33	11.97	0.42	17.65	10.62
ALTE	40.5	207.69	30.34	0.13	5.00	11.22	0.42	17.65	19.74
Total =	133.5	684.6153	100	22.2216	44.5464	100	2.39497	100	100

	#Shrubs	#Shrubs Per Acre	Rel. Density	%Cover	Rel. Cover	%Freq.	Rel. Freq.	Importance Index
Shrubs								
QUGA	1	15.13	0.23	0.10	0.32	0.14	8.33	2.96
RIIN	182	933.33	41.65	10.03	32.17	0.42	25.00	32.94
RICE	4	20351	0.92	0.10	0.32	0.14	8.33	3.19
ROWO	69	353.85	15.79	7.03	22.56	0.28	16.67	18.34
ACNE	1	0.00	0.00	7.55	24.22	0.14	8.33	10.85
BEFE	177	907.69	40.50	6.26	20.09	0.42	25.00	28.53
RUST	4	20.51	0.92	0.10	0.32	0.14	8.33	3.19
Total =	438.00	2241.03	100.00	31.17	100.00	1.69	100.00	100.00

Upper Guaje Canyon Understory
Date: 7/26/93
Reader/Recorder: Foxx/Cross
500 Feet Transect File Name: GUA3U

Species	Plant Cover	Rel. Plant Cover	Freq.	Rel. Freq.	Importance Index
Bare Soil					
Rock					
Litter					
FRAM	1.48	2.61	0.18	5.59	4.10
GERI	2.12	3.74	0.24	7.45	5.60
VICA	0.48	0.85	0.16	4.97	2.91
POTR	0.02	0.04	0.02	0.62	0.33
GRASS	4.98	8.78	0.46	14.29	11.53
MOSS	16.86	29.72	0.44	13.66	21.69
LICHEN	1.02	1.80	0.10	3.11	2.45
PSMO	0.02	0.04	0.02	0.62	0.33
ERIX	1.50	2.64	0.04	1.24	1.94
RUPA	0.70	1.23	0.04	1.24	1.24
GAAP	2.20	3.88	0.28	8.70	6.29
HYFE	2.56	4.51	0.20	6.21	5.36
OSOB	0.92	1.62	0.12	3.73	2.67
CIRX	0.80	1.41	0.02	0.62	1.02
ACGL	0.10	0.18	0.02	0.62	0.40
CARROT	1.70	3.00	0.10	3.11	3.05
RULA	11.30	19.92	0.34	10.56	15.24
PTFR	0.22	0.39	0.06	1.86	1.13
RUST	2.70	4.76	0.10	3.11	3.93
RAMA	0.22	0.39	0.04	1.24	0.82
MELA	4.00	7.05	0.16	4.97	6.01
SAOR	0.50	0.88	0.02	0.62	0.75
VEAC	0.02	0.04	0.02	0.62	0.33
ACLA	0.10	0.18	0.02	0.62	0.40
THFE	0.20	0.35	0.02	0.62	0.49
Total =	56.72	100	3.22	100	100

Mid Guaje Canyon Understory
Date: 7/26/93
Reader/Recorder: Foxx/Cross
500 Feet Transect File Name: GUA2U

Species	Plant Cover	Rel. Plant Cover	Freq.	Rel. Freq.	Importance Index
Litter					
MOSS	7.66	18.57	0.18	6.00	12.28
LICHEN	1.08	2.62	0.04	1.33	1.98
GERI	4.60	11.15	0.50	16.67	13.91
MELA	1.60	3.88	0.10	3.33	3.61
GALX	1.02	2.47	0.24	8.00	5.24
GRASS	5.34	12.94	0.38	12.67	12.80
PTFR	0.94	2.28	0.16	5.33	3.81
OSOB	0.44	1.07	0.10	3.33	2.20
ROWO	0.10	0.24	0.02	0.67	0.45
RUPA	2.60	6.30	0.12	4.00	5.15
VICA	0.20	0.48	0.12	4.00	2.24
CARROT	1.20	2.91	0.12	4.00	3.45
TROF	0.04	0.10	0.04	1.33	0.72
FRAM	0.54	1.31	0.14	4.67	2.99
EQAR	0.10	0.24	0.02	0.67	0.45
RUST	1.30	3.15	0.10	3.33	3.24
HYDX	0.70	1.70	0.04	1.33	1.51
THFE	0.50	1.21	0.02	0.67	0.94
RULA	5.80	14.06	0.24	8.00	11.03
RIIN	4.20	10.18	0.16	5.33	7.76
ACLA	0.06	0.15	0.06	2.00	1.07
RANX	0.02	0.05	0.02	0.67	0.36
COST	0.02	0.05	0.02	0.67	0.36
GERX	0.20	0.48	0.02	0.67	0.58
CARX	0.50	1.21	0.02	0.67	0.94
ALTE	0.50	1.21	0.02	0.67	0.94
Total =	41.26	100	3	100	100

Lower Guaje Canyon Understory
Date: 7/26/93
Reader/Recorder: Foxx/Banar
700 Feet Transect   File Name: GUAU1

Species	Plant Cover	Rel. Plant Cover	Freq.	Rel. Freq.	Importance Index
Bare Soil					
Rock					
Litter					
BROMUS	0.79	1.78	0.09	3.26	2.52
VICA	0.57	1.29	0.07	2.72	2.01
FRAM	1.07	2.42	0.06	2.17	2.30
OXME	0.01	0.03	0.01	0.54	0.29
TROF	0.30	0.68	0.06	2.17	1.43
GERI	2.37	5.37	0.19	7.07	6.22
EQAR	4.36	9.86	0.29	10.87	10.36
GRASS	20.70	46.83	0.63	23.91	35.37
LAPU	0.14	0.32	0.01	0.54	0.43
RUST	2.86	6.46	0.10	3.80	5.13
CARROT	0.57	1.29	0.07	2.72	2.01
ACLA	0.43	0.97	0.14	5.43	3.20
AGAL	0.51	1.16	0.04	1.63	1.40
BORAG1	0.64	1.45	0.09	3.26	2.36
GALX	0.69	1.55	0.14	5.43	3.49
AGRIMONIA	0.30	0.68	0.04	1.63	1.15
RULA	4.93	11.15	0.20	7.61	9.38
VACU	0.14	0.32	0.01	0.54	0.43
RAAQ	0.79	1.78	0.03	1.09	1.43
URGR	0.07	0.16	0.01	0.54	0.35
MELA	0.14	0.32	0.03	1.09	0.71
MELU	0.33	0.74	0.09	3.26	2.00
RIIN	0.14	0.32	0.03	1.09	0.71
BEFE	0.29	0.65	0.04	1.63	1.14
TRPA	0.14	0.32	0.01	0.54	0.43
MOSS	0.01	0.03	0.01	0.54	0.29
MOME	0.24	0.55	0.06	2.17	1.36
PRVI	0.00	0.00	0.00	0.00	0.00
JUIN	0.36	0.81	0.01	0.54	0.68
MEAL	0.01	0.03	0.01	0.54	0.29
POPU	0.14	0.32	0.01	0.54	0.43
VETH	0.07	0.16	0.01	0.54	0.35
EPCI	0.07	0.16	0.01	0.54	0.35
Total =	44.2	100	2.628	100	100

Upper Los Alamos Canyon Overstory
DATE: 7/28/93
Reader/Recorder: Keller/Haarmann/Dunham/Banar
Three Circular Plots (250 Feet)
File Name: LA3C3

	#Trees	#Trees Per Acre	Rel. Density	Avg. DBH	%Cover	Rel. Cover	%Freq.	Rel. Freq.	Importance Index
Trees									
PIEN	63.00	323.08	45.00	1.91	6.46	14.11	0.29	13.33	24.15
PIFL	4.00	20351	2.86	3.27	5.00	10.92	0.29	13.33	9.04
PSME	4.00	20.51	2.86	13.10	8.75	19.12	0.14	6.67	9.55
SNAG	12.00	61.54	8.57	0.51	0.00	0.00	0.29	13.33	7.30
POTR	5.00	25.64	3.57	12.98	14.00	30.59	0.43	20.00	18.05
ACGL	36.00	84.62	25.71	0.14	5.00	10.92	0.29	13.33	16.66
ABCO	16.00	82.05	11.43	3.19	6.56	14.34	0.43	20.00	15.26
Total =	140	717.9487	100	35.1009	45.7708	100	2.1428	100	100

	#Shrubs	#Shrubs Per Acre	Rel. Density	%Cover	Rel. Cover	%Freq.	Rel. Freq.	Importance Index
Shrubs								
QUGA	5.00	25.64	1.80	2.00	12.67	0.29	22.22	12.23
SALX	1.00	5.13	0.36	0.10	0.63	0.14	11.11	4.03
RONE	1.00	5.13	0.36	0.10	0.63	0.14	11.11	4.03
PRVI	7.00	35.90	2.52	3.00	19.00	0.29	22.22	14.58
JAAM	264.00	1353.85	94.96	10.59	67.06	0.43	33.33	65.12
Total =	278.00	1425.64	100.00	15.79	100.00	1.29	100.00	100.00

Mid Los Alamos Canyon Overstory
Date: 7/28/93
Reader/Recorder: Haarmann/Banar/Salisbury/Risberg
Three Circular Plots (250 Feet)
File Name: LA2C2

	#Trees	#Trees Per Acre	Rel. Density	Avg. DBH	%Cover	Rel. Cover	%Freq.	Rel. Freq.	Importance Index
Trees									
PIEN	5.000	25.641	10.20	3.50	10.00	24.12	0.143	7.69	14.01
PIPO	1.000	5.128	2.04	0.10	0.10	0.24	0.143	7.69	3.32
PSME	5.000	25.641	10.20	8.66	9.20	22.19	0.429	23.08	18.49
SNAG	1.000	5.128	2.04	0.07	0.00	0.00	0.143	7.69	3.24
POTR	2.000	10.256	4.08	2.70	7.50	18.09	0.143	7.69	9.96
ACGL	12.000	61.538	24.49	0.05	7.87	18.99	0.429	23.08	22.19
ABCO	23.000	117.949	46.94	6.46	6.78	16.36	0.429	23.08	28.79
Total =	49	251.282	100	21.5359	41.4540	100	1.8571	100	100

	#Shrubs	#Shrubs Per Acre	Rel. Density	%Cover	Rel. Cover	%Freq.	Rel. Freq.	Importance Index
Shrubs								
QUGA	7.000	35.897	3.66	4.29	8.65	0.286	22.22	11.51
RIIN	3.000	15.385	1.57	5.00	10.09	0.143	11.11	7.59
RONE	3.000	15.385	1.57	3.33	6.73	0.143	11.11	6.47
PRVI	12.000	61.538	6.28	20.00	40.37	0.143	11.11	19.25
JAAM	150.000	769.231	78.53	6.92	13.97	0.429	33.33	41.95
AMUT	16.000	82.051	8.38	10.00	20.18	0.143	11.11	13.22
Total =	191.00	979.49	100.00	49.54	100.00	1.29	100.00	100.00

Lower Los Alamos Canyon Overstory
Date: 7/14/93
Reader/Recorder: Dunham/Banar
Three Circular Plots (250 Feet)
File Name: LAOM1C

	#Trees	#Trees Per Acre	Rel. Density	Avg. DBH	%Cover	Rel. Cover	%Freq.	Rel. Freq.	Importance Index
Trees									
JUMO	9.00	46.15	8.91	0.92	0.90	1.04	0.43	23.08	11.01
JUSC	1.00	5.13	0.99	10.00	15.00	17.40	0.14	7.69	8.69
POAN	2.00	10.26	1.98	14.10	5.00	5.80	0.14	7.69	5.16
PIPO	24.00	123.08	23.76	11.06	8.37	9.71	0.43	23.08	18.85
PSME	5.00	25.64	4.95	5.06	10.18	11.81	0.29	15.38	10.71
BEOC	56.00	287.18	55.45	0.05	23.02	26.70	0.29	15.38	32.51
QUGAt	4.00	20.51	3.96	0.00	23.75	27.54	0.14	7.69	13.07
Total =	101	517.948	100	41.1929	86.2274	100	1.8571	100	100

	#Shrubs	#Shrubs Per Acre	Rel. Density	%Cover	Rel. Cover	%Freq.	Rel. Freq.	Importance Index
Shrubs								
QUUN	1.00	5.13	0.59	0.10	0.19	0.14	7.14	2.64
QUGA	23.00	117.95	13.61	6.73	13.03	0.14	7.14	11.26
RICE	2.00	10.26	1.18	0.10	0.19	0.14	7.14	2.84
YUAN	1.00	5.13	0.59	0.10	0.19	0.14	7.14	2.64
SALX	55.00	282.05	32.54	33.33	64.51	0.14	7.14	34.73
ROWO	20.00	102.56	11.83	1.07	2.06	0.29	14.29	9.39
RONE	14.00	71.79	8.28	2.37	4.58	0.43	21.43	11.43
BEFE	44.00	225.64	26.04	2.77	5.37	0.29	14.29	15.23
JAAM	9.00	46.15	5.33	5.00	9.68	0.14	7.14	7.38
Total =	169.00	866.67	100.00	51.68	100.00	2.00	100.00	100.00

Upper Los Alamos Canyon Understory
Date: 7/28/93
Reader/Recorder: Biggs/Bennett
700 Feet Transect File Name: LA3U2

Species	Plant Cover	Rel. Plant Cover	Freq.	Rel. Freq.	Importance Index
Bare Soil					
Rock					
Litter					
AGAL	1.00	3.76	0.04	2.14	2.95
AGSM	0.22	0.81	0.06	2.86	1.83
BROX	1.23	4.62	0.16	7.86	6.24
GEJA	2.21	8.32	0.24	12.14	10.23
JAAM	1.36	5.10	0.06	2.86	3.98
EQUX	2.00	7.52	0.11	5.71	6.62
YARROW	0.07	0.27	0.01	0.71	0.49
FRAM	2.52	9.46	0.37	18.57	14.01
OSOB	0.29	1.08	0.04	2.14	1.61
AMUT	0.14	0.54	0.01	0.71	0.63
VERONICA	0.14	0.54	0.03	1.43	0.98
CARX	0.86	3.22	0.04	2.14	2.68
H2O	2.07	7.78	0.06	2.86	5.32
RULA	1.79	6.71	0.10	5.00	5.86
PENX	1.14	4.30	0.03	1.43	2.86
ERIX	0.86	3.23	0.04	2.14	2.69
POTR	0.14	0.54	0.03	1.43	0.98
MERTENSIA	1.14	4.30	0.03	1.43	2.86
LOIN	0.29	1.07	0.01	0.71	0.89
CLEX	0.71	2.68	0.06	2.86	2.77
VETH	0.57	2.15	0.07	3.57	2.86
GALX	0.50	1.88	0.07	3.57	2.73
RULA	2.71	10.20	0.10	5.00	7.60
PTFR	0.14	0.54	0.03	1.43	0.98
VICA	1.36	5.10	0.09	4.29	4.69
PAMY	0.29	1.07	0.03	1.43	1.25
CHENOPOD	0.36	1.34	0.03	1.43	1.39
THFE	0.29	1.07	0.01	0.71	0.89
AGSP	0.21	0.81	0.03	1.43	1.12
Total =	26.604	100	2	100	100

Mid Los Alamos Canyon Understory
Date: 7/28/93
Reader/Recorder: Biggs/Bennett
700 Feet Transect   File Name: LA2U.WK1

Species	Plant Cover	Rel. Plant Cover	Freq.	Rel. Freq.	Importance Index
Bare Soil					
Rock					
Litter					
CLEX	2.50	4.85	0.17	5.15	5.00
POAX	0.71	1.39	0.10	3.00	2.20
BROX	0.22	0.42	0.04	1.29	0.85
GEJA	2.50	4.86	0.30	9.01	6.93
FRAM	0.93	1.80	0.13	3.86	2.83
THFE	1.07	2.08	0.09	2.58	2.33
RULA	2.36	4.58	0.13	3.86	4.22
AGAL	12.22	23.71	0.66	19.74	21.73
AGSM	0.36	0.69	0.07	2.15	1.42
RUST	9.64	18.72	0.50	15.02	16.87
URGR	0.22	0.42	0.03	0.86	0.64
RONE	1.93	3.74	0.07	2.15	2.94
CIRX	0.72	1.39	0.07	2.15	1.77
ACLA	1.22	2.36	0.17	5.15	3.76
TAOF	0.71	1.39	0.11	3.43	2.41
ACNE	0.07	0.14	0.01	0.43	0.28
PENX	0.57	1.11	0.04	1.29	1.20
EQUX	2.79	5.41	0.13	3.86	4.64
CHENOPOD	0.36	0.69	0.04	1.29	0.99
QUGA	1.86	3.61	0.06	1.72	2.66
DAIN	0.00	0.00	0.01	0.43	0.22
POTR	0.29	0.55	0.03	0.86	0.71
AMUT	3.43	6.66	0.10	3.00	4.83
COST	1.36	2.63	0.03	0.86	1.75
JAAM	0.07	0.14	0.01	0.43	0.28
ABCO	0.07	0.14	0.03	0.86	0.50
CARX	0.14	0.28	0.03	0.86	0.57
BEOC	0.36	0.69	0.01	0.43	0.56
CIDO	0.50	0.97	0.01	0.43	0.70
MELA	0.07	0.14	0.01	0.43	0.28
PRVI	0.43	0.83	0.01	0.43	0.63
ROWO	1.21	2.36	0.06	1.72	2.04
PENX	0.29	0.55	0.03	0.86	0.71
SALX	0.36	0.69	0.01	0.43	0.56
Total =	51.51	100.00	3.33	100.00	100.00

Lower Los Alamos Canyon Understory
Date: 7/14/93
Reader/Recorder: Dunham/Keller/Benson/Banar
700 Feet Transect File Name: OMEGA1U

Species	Plant Cover	Rel. Plant Cover	Freq.	Rel. Freq.	Importance Index
Bare Soil					
Rock					
Litter					
Moss	0.71	2.93	0.01	0.94	1.94
PAIN	0.09	0.35	0.04	2.83	1.59
AGSM	0.36	1.47	0.04	2.83	2.15
BROX	1.03	4.23	0.13	8.49	6.36
LYPH	0.21	0.88	0.03	1.89	1.38
BRIN	6.17	25.35	0.40	26.42	25.88
POFE	1.64	6.75	0.11	7.55	7.15
MEOF	0.30	1.23	0.04	2.83	2.03
AGAL	10.87	44.66	0.50	33.02	38.84
JUIN	1.36	5.58	0.06	3.77	4.67
CHRIPTOGRAM	0.07	0.29	0.01	0.94	0.62
AGRX	0.01	0.06	0.01	0.94	0.50
PIPO	0.01	0.06	0.01	0.94	0.50
BEFE	0.50	2.05	0.04	2.83	2.44
RONE	0.79	3.23	0.03	1.89	2.56
ANSC	0.21	0.88	0.03	1.89	1.38
Total =	24.34	100.00	1.51	100.00	100.00

CHAPTER 2

RESULTS OF NORTH- AND SOUTH-FACING SLOPE VEGETATION SURVEYS IN GUAJE AND LOS ALAMOS CANYONS (1994)

by

Daniel A. Dunham

ABSTRACT

In 1994, the Ecological Studies Team conducted field studies in Guaje and Los Alamos Canyons, Los Alamos County. The purpose of the current study is to continue the vegetation studies in the canyon bottoms completed in 1993. The completion of the two years work in these two canyons should provide a measure of the effect man has on naturally occurring plant populations. This paper addresses studies conducted on the north– and south–facing canyon slopes.

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1 INTRODUCTION

In 1994, the Ecological Studies Team conducted field studies in Guaje and Los Alamos Canyons, Los Alamos County. We collected species composition information from the plant communities on the north- and south-facing slopes in each canyon adjacent to the three permanent plots in the canyon bottom. The canyon bottom plant communities were described in 1993. Los Alamos Canyon dissects a portion of Los Alamos National Laboratory (LANL). However, Guaje runs parallel to Los Alamos Canyon, but entirely outside LANL boundaries.

2 METHODS

We used standard ecological techniques in the habitat evaluation to measure cover, density and frequency of the vegetative component. Transect lines were located on the north- and south-facing slopes adjacent to the 1993 permanent plots in the canyon bottoms. Circular plots, belt transects, and Daubenmire plots were utilized along the same transect line to measure components of the tree, shrub, and herbaceous layers.

This paper summarizes the evaluations of the overstory and understory components. We can map this species information into geographic information systems such as ARC INFO.

2.1 Overstory Evaluation

The Team used the circular plot technique and the line intercept technique to measure the overstory components of the forest, woodland, and riparian communities. We used circular plots in multistemmed pinyon-juniper woodlands and along some riparian zones. We used the line intercept method particularly in taller, single-stemmed overstory habitats, such as ponderosa pine and mixed-conifer series species, and in riparian zones.

We based the total length of each transect on a species area curve, or a maximum of 1000 ft. The purpose of the species area curve is to provide an adequate sample of the cumulative sum of the number of different species found along a transect. We count individual plant species within each plot. The total length of the transect is adequate when the curve becomes relatively level or we no longer find new plant species in subsequent plots.

Circular Plots. The team used a circular plot technique to measure the overstory components within riparian zones or woodlands (Woodin and Lindsay 1954). Field technicians placed a transect line within the habitat we evaluated (maximum 1000 ft or until the species area curve had leveled). We established circular plots every 100 ft along the transect. We measured all multistemmed trees (e.g., pinyons and junipers) within a 30-ft radius of the center point located on the transect line for basal diameter. We measured all single-stemmed trees (e.g., ponderosa pine. and mixed-conifer) for diameter at breast height (DBH). A field technician estimated the shrub cover by dividing the circle into four equal subplots and estimating the amount of area each individual species covered within the circle.

Line Intercept. Field teams measured the overstory component within conifer forests using a line intercept technique (Lindsay 1955). Field technicians collected data within a 20-ft wide strip centered on a transect line. We measured all tree DBH and counted all shrub stems within the strip.

Each 50-ft strip segment measured from the start of the transect, constituted a plot for frequency estimation. To estimate foliar cover of trees and shrubs within each segment, we measured and recorded the areas in which foliage intercepted the actual transect line.

2.2 Understory Evaluation

We used the quadrat method, a Daubenmire plot of 20 x 50 cm (Daubenmire 1959), to measure the cryptogamic and herbaceous layers, percent bare soil, rock or litter, and woody species less than 3-ft tall. We determined foliar cover and species composition. We recorded cover estimates until we met one of two conditions: the cumulative species total (graphed as the species area curve) stopped increasing, or the number of quadrats totaled 100 for each transect. We identified all plants using Martin and Hutchins (1980), Foxx and Hoard (1984) and Foxx and Tierney (1985). We took any questionable identifications to the University of New Mexico herbarium for confirmation.

2.3 Results

We used an importance index, that is an average of relative cover, relative frequency, and relative density, to identify the dominants in the canopy layers. We used the above three values for trees and shrubs to calculate an importance index. We used relative cover and relative frequency to calculate an importance index for the herbaceous layer. Higher importance index values indicate greater degrees of dominance. We placed a check list of plant species in Table 1 and 2.

Upper Guaje Canyon. We recorded a total of 14 overstory and 23 understory species in upper Guaje Canyon (see Tables 1 and 2).

The absolute tree cover on north-facing slopes in upper Guaje Canyon was 82.40%. The dominant tree species were *Acer glabrum, Populus tremuloides,* and *Abies concolor*. The highest relative percent cover values were 30.76, 25.85, and 25.79 for *Populus tremuloides, Pseudotsuga menzesii,* and *Abies concolor* respectively. The highest relative frequency was 18.20 for *Populus tremuloides, Pseudotsuga menzesii,* and *Acer glabrum*. The highest relative densities were 50.50, 17.82, and 13.86 for *Acer glabrum, Populus tremuloides,* and *Abies concolor* respectively.

Table 1 Overstory Species Presence/Absence List: Guaje Canyon

Shrubs				Trees			
SPECIES	**LOWER**	**MID**	**UPPER**	**SPECIES**	**LOWER**	**MID**	**UPPER**
Amelanchier utahensis			X	*Abies concolor*	X	X	X
Berberis fendleri	X			*Acer glabrum*	X	X	X
Cercocarpus montanus	X			*Juniper communis*			
Jamesia americana		X	X	*Juniperus monosperma*			
Physocarpus monogynus	X			*Juniperus scopulorum*			
Prunus virginiana			X	*Pinus edulis*	X		
Quercus gambelii	X	X	X	*Picea engelmannii*		X	X
Quercus undulata	X			*Pinus flexilis*	X	X	X
Ribes cereum	X		X	*Pinus ponderosa*	X		X
Ribes inerme	X	X	X	*Populus timuloides*		X	X
Robinia neomexicana		X	X	*Pseudotsuga menziesii*	X	X	X
Rosa woodsii	X	X		*SNAG*	X	X	X
Rubus strigosus	X	X					
Yucca angustifolia	X						

The absolute shrub cover on north-facing slopes in upper Guaje Canyon was 11.50%. The dominant shrub species were *Jamesia americana, Ribes cereum,* and *Quercus gambellii.* The highest relative percent cover values were 75.22, 16.59, and 6.96 for *Jamesia americana, Ribes cereum,* and *Quercus gambellii* respectively. The highest relative frequency was 30.77 for *Jamesia americana,* and *Ribes cereum,* and 15.38 for *Quercus gambellii.* The highest relative densities were 72.68, 19.59, and 3.09 for *Jamesia americana, Ribes cereum,* and *Quercus gambellii* respectively.

The absolute herbaceous plant cover on north-facing slopes in upper Guaje Canyon was 57.15%. The dominant understory species were *Pachystima myrsenites, Fragaria americana,* and *Geranium richardsonii.* The highest relative percent cover values were 13.39, 5.15, and 5.26 for *Pachystima myrsenites, Quercus gambellii,* and *Geranium richardsonii* respectively. The highest relative frequencies were 14.61, 10.11, and 7.87 for *Pachystima myrsenites, Fragaria americana,* and *Geranium richardsonii* respectively.

The absolute tree cover on south-facing slopes in upper Guaje Canyon was 84.00%. The dominant tree species were *Pinus ponderosa, Pseudotsuga menzesii,* and *Abies concolor.* The highest relative percent cover values were 51.90, 44.88, and 3.21 for *Pinus ponderosa, Pseudotsuga menzesii,* and *Abies concolor* respectively. The highest relative frequency was 25.00 for *Pinus ponderosa, Pseudotsuga menzesii,* and *Abies concolor* collectively. The highest relative densities were 36.99, 36.99, and 17.81 for *Pinus ponderosa, Pseudotsuga menzesii,* and *Abies concolor* respectively.

The absolute shrub cover on south-facing slopes in upper Guaje Canyon was 8.00%. The dominant tree species were *Quercus gambellii, Robinia neomexicana,* and *Prunus virginiana.* The highest relative percent cover values were 88.75, 6.88, and 4.38 for *Quercus gambellii, Rosa woodsii,* and *Robinia neomexicana* respectively. The highest relative frequency was 44.44, 22.22, and 22.22 for *Quercus gambellii, Robinia neomexicana,* and *Prunus virginiana* respectively. The highest relative densities were 85.71, 8.79, and 4.40 for *Quercus gambellii, Robinia neomexicana,* and *Prunus virginiana* respectively.

The absolute herbaceous plant cover on south-facing slopes in upper Guaje Canyon was 30.15%. The dominant understory species were *Fragaria americana, Andropogon scoparius,* and *Carex spp.* The highest relative percent cover values were 20.07, 19.24, and 14.93 for *Fragaria americana, Andropogon scoparius,* and *Juniperus scopulorum* respectively. The highest relative frequencies were 18.87, 16.98, and 10.30 for *Fragaria americana, Andropogon scoparius,* and *Carex spp* respectively.

Mid Guaje Canyon. We recorded a total of 12 overstory and 13 understory species in mid Guaje Canyon (see Tables 1 and 2).

The absolute tree cover on north-facing slopes in mid Guaje Canyon was 76.85%. The dominant tree species were *Acer glabrum, Populus tremuloides,* and *Pseudotsuga menzesii.* The highest relative percent cover values were 61.39, 12.87, and 10.89 for *Acer glabrum, Pseudotsuga menzesii,* and *Abies concolor* respectively. The relative frequency was 19.04 for *Acer glabrum, Populus tremuloides, Pseudotsuga menzesii,* and *Abies concolor.* The highest relative densities were 61.39, 12.87, and 7.92 for, *Acer glabrum, Pseudotsuga menzesii,* and *Populus tremuloides* respectively.

The absolute shrub cover on north-facing slopes in mid Guaje Canyon was 12.7%. The dominant tree species were *Jamesia americana, Physocarpus monogynus,* and *Quercus gambellii.* The highest relative percent cover value was 100.00 for *Jamesia americana..* The highest relative frequency was 30.77 for *Jamesia americana* and 23.08 for *Physocarpus monogynus,* and *Quercus gambellii* respectively. The highest relative densities were 74.84, 11.95, and 8.80 for *Jamesia americana, Physocarpus monogynus,* and *Quercus gambellii* respectively.

The absolute herbaceous plant cover on north-facing slopes in mid Guaje Canyon was 3.13%. The dominant understory species *Muhlenbergia montana, Quercus gambellii,* and *Rhus trilobata.* The highest relative percent cover values were 72.77, 10.64, and 10.64 for *Muhlenbergia montana, Quercus gambellii,* and *Rhus trilobata* respectively. The highest relative frequencies were 72.41 and 6.90 for *Muhlenbergia* *montana* and *Antennaria parvifolia* respectively. The rest of the species present had the same relative frequency value.

Table 2 Understory Species Presence/Absence List: Guaje Canyon

SPECIES	LOWER	MID	UPPER	SPECIES	LOWER	MID	UPPER
Agropyron smithii		X		*Geranium caestiposum*	X	X	X
Antennaria parvifolia	X	X	X	*Hymenoxis richardsonii*	X		
Andropogon scoparius	X			*Lithospermum multiflorum*	X	X	
Aauilegia caerula			X	*Medicago lupulina*	X		
Arabis fendleri			X	*Muhlenbergia montana*	X		X
Artemisia ludoviciana		X	X	*Oxalis violacea*		X	X
Berberis fendleri	X			*Pachystima mysenites*	X		X
Bromus anomalus			X	*Penstemon spp.*			X
Brickellia spp.		X		*Pseudocymopteris montanus*	X		X
Bromus spp.	X			*Sitanion hysterix*		X	X
Campanula rotundifolia		X	X	*Solidago spp.*	X		X
Carex spp.	X		X	*Thalictrum fendleri*		X	X
Cysopteris fragilis			X	*Thelosperma trifidum*	X		
Festuca oviza			X	*Townsendia incana*			X
Fragaria americana	X	X	X	*Taraxicum officinale*		X	
Galium aparine		X	X	*Valeriana capitata*	X		X
Galium borealis	X			*Vicia americana*	X		X

The absolute tree cover on south-facing slopes in mid Guaje Canyon was 71.70%. The dominant tree species were *Pseudotsuga menzesii, Acer glabrum,* and *Abies concolor*. The highest relative percent cover values were 65.55, 18.83, and 11.44 for *Pseudotsuga menzesii, Acer glabrum,* and *Abies concolor* respectively. The highest relative frequency was 33.33, 25.00, and 8.33 for *Pseudotsuga menzesii, Acer glabrum,* and *Abies concolor* respectively. The highest relative densities were 38.24, 32.40, and 26.47 for *Pseudotsuga menzesii, Acer glabrum,* and *Quercus gambellii* respectively.

The absolute shrub cover on souh-facing slopes in mid Guaje Canyon was 17.00%. The only shrub species present were *Quercus gambellii and Ribes inerme*. The relative percent cover values were 16.00 and 1.00 for *Quercus gambellii* and *Ribes inerme* respectively. The highest relative frequency was 60.44 and 39.56 for *Quercus gambellii* and *Ribes inerme* respectively. The relative densities were 62.79 and 37.21 for *Ribes inerme* and *Quercus gambellii* respectively.

The absolute herbaceous plant cover on south-facing slopes in mid Guaje Canyon was 25.76%. The dominant understory species were *Fragaria americana, Quercus gambellii,* and *Ptelia trifoliata*. The highest relative percent cover values were 13.01, 10.68, and 9.71 for *Fragaria americana, Quercus gambellii* and *Agropyron smithii* respectively. The highest relative frequencies were 11.86, 11.86, 8.47, and 8.47 for *Fragaria americana, Ptelia trifoliata, Brickellia spp.* and *Bromus spp.* respectively.

Lower Guaje Canyon. We recorded a total of 16 overstory and 18 understory species in lower Guaje Canyon (see Tables 1 and 2).

The absolute tree cover on north-facing slopes in lower Guaje Canyon was 74.91%. The dominant tree species were *Pseudotsuga menzesii, Pinus ponderosa,* and *Pinus flexilis*. The highest relative percent cover values were 55.89, 30.78, and 8.81 for *Pseudotsuga menzesii, Pinus ponderosa,* and *Pinus flexilis* respectively. The highest relative frequencies were 30.00, 28.00, and 14.00 for *Pseudotsuga menzesii, Pinus ponderosa,* and *Pinus flexilis* respectively. The highest relative densities were 48.04, 33.52, and 6.14 for *Pseudotsuga menzesii, Pinus ponderosa,* and *Pinus flexilis* respectively.

We did not record a measurable amount of shrub cover on north-facing slopes in lower Guaje Canyon. The only shrub species present in our transect was *Quercus gambelli.* The stem density was 2.90 stems per acre.

The absolute herbaceous plant cover on north-facing slopes in lower Guaje Canyon was 11.25%. The dominant understory species were *Carex spp., Muhlenbergia montana,* and *Fragaria americana.* The highest relative percent cover values were 12.44, 4.74, and 2.96 for *Carex spp., Muhlenbergia montana,* and *Fragaria americana* respectively. The highest relative frequencies were 11.11, 11.11, and 7.94 for *Carex spp., Muhlenbergia montana,* and *Fragaria americana* respectively

The absolute tree cover on south-facing slopes in lower Guaje Canyon was 60.08%. The dominant tree species were *Pseudotsuga menzesii, Pinus ponderosa,* and *Pinus flexilis.* The highest relative percent cover values were 33.2, 55.49, and 10.66 for *Quercus spp., Pinus ponderosa,* and *Pinus edulis* respectively. The highest relative frequencies were 30.00, 28.00, and 14.00 for *Pseudotsuga menzesii, Pinus ponderosa,* and *Pinus flexilis* respectively. The highest relative densities were 48.04, 33.52, and 6.14 for *Pseudotsuga menzesii, Pinus ponderosa,* and *Pinus flexilis* respectively.

The absolute shrub cover on south-facing slopes in lower Guaje Canyon was 3.57%. The dominant shrub species were *Quercus gambellii, Q. undulata,* and *Cercocarpus montanus.* The highest relative percent cover values were 53.73 and 46.27 for *Q. undulata* and *Quercus gambelli.* No measurable cover was recorded for *Cercocarpus montanus.* The highest relative frequencies were 45.00, 25.00, and 25.00 for *Quercus gambellii, Q. undulata,* and *Cercocarpus montanus* respectively. The highest relative densities were 41.57, 39.89, and 15.17 for *Q. undulata, Quercus gambellii,* and *Cercocarpus montanus.*

The absolute herbaceous plant cover on south-facing slopes in lower Guaje Canyon was 9.16%. The dominant understory species were *Muhlenbergia montana,* *Andropogon scoparius,* and *Sitanion hystrix.* The highest relative percent cover values were 20.38, 17.47, and 12.08 for *Andropogon scoparius, Muhlenbergia montana,* and *Sitanion hystrix* respectively. The highest relative frequencies were 20.00, 14.00, and 12.00 for *Muhlenbergia montana, Andropogon scoparius,* and *Sitanion hystrix* respectively.

Upper Los Alamos Canyon. We recorded a total of 11 overstory and 20 understory species in upper Los Alamos Canyon (see Tables 3 and 4).

The absolute tree cover on north-facing slopes in upper Los Alamos Canyon was 73.43%. The dominant tree species were *Pseudotsuga menzesii, Abies concolor,* and *Acer glabrum.* The highest relative percent cover values were 29.50, 29.80, and 6.33 for *Pseudotsuga menzesii, Abies concolor,* and *Acer glabrum* respectively. The highest relative frequency was 25.00 for *Pseudotsuga menzesii, Abies concolor,* and *Acer glabrum* collectively. The highest relative densities were 50.00, 29.41, and 8.82 for *Pseudotsuga menzesii, Abies concolor,* and *Pinus flexilis* respectively.

The absolute shrub cover on north-facing slopes in upper Los Alamos Canyon was 17.08%. The dominant shrub species were *Jamesia americana, Quercus gambellii,* and *Prunus virginiana.* The highest relative percent cover values were 50.24, 31.22, and 18.00 respectively. The highest relative frequency was 26.67 for *Jamesia americana* and *Prunus virginiana,* and 23.33 for *Quercus gambellii.* The highest relative densities were 47.60, 29.15, and 18.63 for *Jamesia americana, Quercus gambellii,* and *Prunus virginiana* respectively.

Table 3 Overstory Species Presence/Absence List: Los Alamos Canyon

Shrubs				Trees			
SPECIES	**LOWER**	**MID**	**UPPER**	**SPECIES**	**LOWER**	**MID**	**UPPER**
Amelanchier utahensis		X	X	*Abies concolor*		X	X
Berberis fendleri	X	X		*Acer glabrum*		X	X

Table 3 (cont.)

SPECIES	LOWER	MID	UPPER	SPECIES	LOWER	MID	UPPER
Jamesia americana	X	X	X	*Juniperus monosperma*	X		
Physocarpus monogynus				*Juniperus scopulorum*	X		
Prunus virginiana			X	*Pinus edulis*	X		
Quercus gambelii	X	X	X	*Picea engelmannii*		X	X
Quercus undulata	X			*Pinus flexilis*			X
Ribes cereum	X			*Pinus ponderosa*	X	X	
Ribes inerme		X		*Populus timuloides*		X	X
Robinia neomexicana	X	X	X	*Pseudotsuga menziesii*	X	X	X
Rosa woodsii	X			*Quercus gambelii*	X		
Yucca angustifolia	X			SNAG		X	X

The absolute herbaceous plant cover on north-facing slopes in upper Los Alamos Canyon was 21.70%. The dominant understory species in upper Los Alamos Canyon were *Pachystima myrsenites, Physocarpus monogynus,* and *Quercus gambelli*. The highest cover values were 23.96, 18.13, and 9.29 for *Pachystima myrsenites, Physocarpus monogynus,* and *Quercus gambelli* respectively. The highest relative frequencies were 25.75, 10.18, and 7.78 for *Pachystima myrsenites, Fragaria americana,* and *Physocarpus monogynus* respectively.

The absolute tree cover on south-facing slopes in upper Los Alamos Canyon was 35.36%. The absolute tree cover on south-facing slopes in upper Guaje Canyon was 84.00%. The dominant tree species were *Abies concolor, Pseudotsuga menzesii,* and *Pinus ponderosa*. The highest relative percent cover values were 83.51, 11.31, and 1.65 for *Abies concolor, Pinus ponderosa,* and *Pseudotsuga menzesii* respectively. The highest relative frequency was 48.15 and 22.22 for *Pseudotsuga menzesii* and *Abies concolor*, and 11.11 for *Pinus ponderosa* and *P. flexilis*. The highest relative densities were 83.51 and 13.95 for *Abies concolor* and *Pseudotsuga menzesii* respectively, and 2.32 for *Pinus ponderosa* and *P. flexilis* collectively.

The absolute shrub cover on south-facing slopes in upper Los Alamos Canyon was 29.67%. The dominant shrub species were *Quercus gambellii, Jamesia americana,* and *Prunus virginiana.* The highest relative percent cover values were 57.02, 29.50, and 13.48 for *Quercus gambellii, Jamesia americana,* and *Prunus virginiana* respectively. The highest relative frequency was 23.63, 21.81, and 10.91 *Quercus gambellii, Prunus virginiana,* and *Jamesia americana* respectively. The highest relative densities were 36.33, 33.63, and 20.34 for *Quercus gambellii, Jamesia americana,* and *Prunus virginiana* respectively.

The absolute herbaceous plant cover on south-facing slopes in upper Los Alamos Canyon was 33.38%. The dominant understory species in upper Los Alamos Canyon were *Quercus gambellii, Fragaria americana,* and *Muhlenbergia montana.* The highest cover values were 17.27, 9.14, and 7.09 for *Quercus gambellii, Fragaria americana,* and *Muhlenbergia montana* respectively. The highest relative frequencies were 10.83, 14.65, and 7.64 for *Quercus gambellii, Fragaria americana,* and *Muhlenbergia montana* respectively.

Mid Los Alamos Canyon. We recorded a total of 12 overstory and 19 understory species in mid Los Alamos Canyon (see Tables 3 and 4).

The absolute tree cover on north-facing slopes in mid Los Alamos Canyon was 67.83%. The dominant tree species were *Pseudotsuga menzesii, Quercus gambellii,* and *Pinus ponderosa.* The highest relative percent cover values were 50.33, 13.00 and 4.50 for *Pseudotsuga menzesii, Quercus gambellii,* and *Pinus ponderosa* respectively. The highest relative frequencies were 63.16, 32.06, and 4.31 for *Pseudotsuga menzesii, Quercus gambellii,* and *Pinus ponderosa* respectively.

The absolute shrub cover on north-facing slopes in mid Los Alamos Canyon was <1.00%. The dominant shrub species were *Quercus gambellii, Jamesia americana,* and *Prunus virginiana.* The highest relative percent cover values were 57.02, 29.50, and

13.48 for *Quercus gambellii, Jamesia americana,* and *Prunus virginiana* respectively. The highest relative frequency was 23.63, 21.81, and 10.91 *Quercus gambellii, Prunus virginiana,* and *Jamesia americana* respectively. The highest relative densities were 36.33, 33.63, and 20.34 for *Quercus gambellii, Jamesia americana,* and *Prunus virginiana* respectively.

The absolute herbaceous plant cover on north-facing slopes in mid Los Alamos Canyon was 8.05%. The dominant understory species were *Poa fendleriana, Quercus gambellii* and *Berberis fendleri.* The highest relative percent cover values were 29.19, 21.74, and 13.66 for *Bouteloua gracilis, Poa fendleriana,* and *Andropogon scoparius* respectively. The highest relative frequencies were 31.03, 20.69, and 6.90 for *Poa fendleriana, Berberis fendleri,* and *Quercus gambellii* respectively.

The absolute tree cover on south-facing slopes in mid Los Alamos Canyon was 40.67%. The dominant tree species were *Quercus spp., Pinus ponderosa,* and *Pinus edulis.* The highest relative percent cover values were 33.2, 55.49, and 10.66 for *Quercus spp., Pinus ponderosa,* and *Pinus edulis* respectively. The highest relative frequencies were 41.94, 35.48, and 12.90 for *Pinus edulis, Juniperus monosperma,* and *Pinus ponderosa* respectively. The highest relative densities were 70.71, 17.86, and 6.42 for *Quercus spp, Pinus ponderosa,* and *Juniperus monosperma* respectively.

The absolute herbaceous plant cover on south-facing slopes in mid Los Alamos Canyon was 16.35%. The dominant understory species were *Andropogon scoparius, Bouteloua gracilis,* and *Bromus spp.* The highest relative percent cover values were 32.90, 32.57, and 14.98 for *Andropogon scoparius, Bromus spp,* and *Bouteloua gracilis* respectively. The highest relative frequencies were 29.63, 29.63, and 11.11 for *Bouteloua gracilis, Andropogon scoparius* and *Bromus spp* respectively.

Table 4 Understory Species Presence/Absence List: Los Alamos Canyon

SPECIES	LOWER	MID	UPPER	SPECIES	LOWER	MID	UPPER
Achillea lanulosa	X		X	*Geranium caespitosum*		X	X
Agropyron smithii		X	X	*Gutierrezia sarothae*		X	
AGTR	X			*Hymenoxis richardsonii*		X	
Andropogon gerardi		X		*Ipomopsis aggregata*	X		
Antennaria parviflora		X	X	*Linum neomexicana*	X		
Andropogon schoparium	X	X		*Lupinus caudatus*	X		
Artemisia carruthii		X		*Lycurus phleoides*	X		
Artemisia dracunculus	X			*Medicago lupulina*	X		
Aristida longiseta		X		*Muhlenbergia montana*	X	X	X
Artemisia ludoviciana	X	X		*Opuntia spp.*	X		
Berberis fendleri	X			*Oryzopsis hymenoides*	X		
Bouteloa gracilis		X		*Oxalis violacea*			X
Bromus anomalus		X	X	*Pachystima myrsinites*			X
Bromus inermes	X			*Penstemon spp.*			X
Bromus spp.		X	X	*Phleum pratensis*	X		
Campanula rotundiflora			X	*Poa spp.*		X	
Cheno podium graveolens	X			*Poa fendleriana*	X		
Chrysopsis villosa	X			*Rhus radicans*			X
Cryptantha jamesii	X	X		*Senecio fendleri*		X	X
Danthonia intermedia			X	*Sitanion hystrix*	X		
Elysmus canadensis	X			*Smilaciana racemosa*			X

Table 4 (cont.)

SPECIES	LOWER	MID	UPPER	SPECIES	LOWER	MID	UPPER
Erigeron flagelleris	X			*Sporobolus cryptntha*	X		
Eriogonum jamesii		X		*Thalictrum fendleri*	X		
Eupatorium herbceum			X	*Taraxacum officinale*	X	X	
Fragaria americana			X	*Valeriana capitata*			X
Galium aparine	X		X	*Viola canadensis*			X

Lower Los Alamos Canyon. We recorded a total of 6 overstory and 27 understory species in lower Los Alamos Canyon (see Tables 3 and 4).

The absolute tree cover on north-facing slopes in lower Los Alamos Canyon was 40.67%. The dominant tree species were *Quercus spp., Pinus ponderosa,* and *Pinus edulis*. The highest relative percent cover values were 33.2, 55.49, and 10.66 for *Quercus spp., Pinus ponderosa,* and *Pinus edulis* respectively. The highest relative frequencies were 41.94, 35.48, and 12.90 for *Pinus edulis, Juniperus monosperma,* and *Pinus ponderosa* respectively. The highest relative densities were 70.71, 17.86, and 6.42 for *Quercus spp, Pinus ponderosa,* and *Juniperus monosperma* respectively.

The absolute herbaceous plant cover on north-facing slopes in lower Los Alamos Canyon was 10.43 %. The dominant understory species were *Bouteloua gracilis, Chrysopsis villosa,* and *Muhlenbergia montana*. The highest relative percent cover values were 40.77, 26.98, and 8.39 for *Bouteloua gracilis,* moss species, and *Chrysopsis villosa* respectively. The highest relative frequencies were 23.40, 17.02, and 14.89 for *Bouteloua gracilis, Chrysopsis villosa,* and *Muhlenbergia montana* respectively.

The absolute tree cover on south-facing slopes in lower Los Alamos Canyon was 22.02%. The dominant tree species were *Juniperus monosperma, Pinus ponderosa,* and *Pinus edulis*. The highest relative percent cover values were 65.38, 24.23, and 10.39 for *Pinus ponderosa, Pinus edulis,* and *Juniperus monosperma* respectively. The highest relative frequencies were 41.18, 38.24, and 20.59 for *Pinus edulis, Juniperus* *monosperma,* and *Pinus ponderosa* respectively. The highest relative densities were 61.82, 27.27, and 10.91 for *Juniperus monosperma, Pinus edulis,* and *Pinus ponderosa* respectively.

The absolute herbaceous plant cover on south-facing slopes in lower Los Alamos Canyon was 9.19%. The dominant understory species were *Bouteloua gracilis* and *Andropogon scoparius*. The highest relative percent cover values were 69.36 and 18.04 for *Bouteloua gracilis* and *Andropogon scoparius* respectively. The highest relative frequencies were 63.27 and 16.33 for *Bouteloua gracili,* and *Andropogon scoparius* respectively.

3 DISCUSSION

The vegetational composition of each canyon's respective transects differ because of relative elevation variation between the lower transects. However, disagreement between transect data that elevational differences alone do not explain, are in understory species composition of comparable transects.

4 REFERENCES

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CHAPTER 3

BIOMASS ESTIMATION IN TWO CANYON ECOSYSTEMS

by

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ABSTRACT

The Ecological Studies Team (EST) placed vegetation transects in two locations, Guaje Canyon and Los Alamos Canyon, in Los Alamos County. EST used tree measurements and herbaceous clip plots to estimate total aboveground biomass. Tree biomass values aid in quantifying mineral cycles and contaminant pathways in forest ecosystems. A comparison of the two canyons will provide a controlled means to study these cycles and pathways.

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1 INTRODUCTION

The Ecological Studies Team (EST) collected plant material and data in two canyons, Los Alamos and Guaje Canyons. Human activity is more prevalant in Los Alamos Canyon than in Guaje Canyon. Guaje Canyon will be our control area for comparison.

Los Alamos Canyon runs mostly through property owned by Los Alamos National Laboratory. The upper canyon in the Santa Fe National Forest contains a domestic water and recreational impoundment, Los Alamos Reservoir.

Guaje Canyon runs through the Santa Fe National Forest north of the Los Alamos townsite. The Forest Service restricts vehicular traffic most of the year. A flume transports some water from a small reservoir in the upper canyon. However the stream is perennial throughout the year. The disturbances appear to influence the plant community less than in Los Alamos Canyon.

2 ENVIRONMENTAL SETTING

EST performed vegetation studies and collected plant material for total aboveground biomass determination. We divided this project into the upper, middle, and lower canyon for comparisons. Upper canyon portions are narrower and at a higher elevation. These deeper canyons contribute to more favorable plant-water relations that promote denser growth. The soils at all sites are on shallow to moderately deep well-drained soils developed from weathered welded tuff. The A_1 horizon is light to dark brown loam to sandy loam (Nyhan et al. 1978). This first mineral soil layer contains abundant fine to medium-sized roots.

The perennial reaches of the streams in each canyon directly influence vegetative composition and density. The stream is perennial in the entire study area in Guaje Canyon. The stream is perennial in Los Alamos Canyon only above the reservoir. Los Alamos County controls spring snowmelt and summer thunderstorm runoff at the dam. The resultant flow below Los Alamos Reservoir is thus intermittent.

3 METHODS

We measured overstory and understory vegetation characteristics in either 9-m radius circular plots or 0.1-m^2 quadrats. Circular plots, 9 m in diameter, enclosed the sampling units for bole diameter estimation (trees), shrub stem counts, and canopy cover estimation. Both ends and the transect center located three circular plots. We estimated canopy cover of grasses, forbs, rock, litter, bare soil, and lichen and moss with visual estimates in 0.1-m^2 quadrats (Daubenmire 1959). Three-meter intervals set the distance between these Daubenmire plots. The layout included 30 Daubenmire plots between each end plot and the central plot.

Additionally, biomass estimation used 3-m circular plots and 0.1-m^2 quadrats. We recorded grass and forb percentages by species, and clipped standing live plants to ground level in ten 0.1-m^2 plots. All clipped material was bagged, ovendried, and weighed. The intervals between each end of the transect and the central circular plot contained five biomass plots. We placed a 3-m circular plot concentric to each smaller plot.

Shrub biomass estimations employ 3-m circular plots. We clipped five stems in each plot. We also recorded length and basal diameter for each clipped stem. Five randomly selected stems constituted the clipped sample for shrub clumps exceeding 20 stems. However, we counted the total number of stems and estimated the diameter and the average length of all stems in such clumps. All clipped material was bagged, ovendried, and weighed.

Dry weight of whole trees, or parts of trees, correlates well with their diameter at breast height (DBH). This characteristic permits regression analysis of tree biomass (Baskerville 1972). The regression equations for deciduous trees used in this study are from Golz et al. (1979). These equations predict average biomass from diverse sites in the western United States. The regression equations for the conifer species and aspens in this study were developed by A. F. Gallegos, S. M. McEllin, and B. J. Garcia (unpublished report). The later equations were developed from studies in northern New Mexico including Los Alamos County.

Appendix 3-A lists the data used in the regression equations for tree biomass, and Appendix 3-B includes data on herbaceous dry weights.

4 RESULTS

4.1 Lower Los Alamos Canyon

This site is a conifer forest dominated by ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menzeii*). The dominant trees are 15 to 17 m tall. The younger trees are 3 to 11 m tall. The forest has a density of 494 trees/ha. The average DBH of the trees in this conifer forest is 20.1 cm. The sapling layer (DBH<10 cm) consisting of Gambel oak (*Quercus gambelii*) and New Mexico locust (*Robinia neomexicana*) has a density of 190 stems/ha.

A deciduous tree community occupies the stream bank, and is dominated by western water birch (*Betula occidentalis*), New Mexico olive (*Foresteria neomexicana*), Gambel oak, and narrowleaf cottonwood (*Populus angustifolia*). The birch and oak have a density of 291 stems/ha. The density of cottonwood is 10 trees/ha and their average DBH is 28.1 cm.

The total aboveground tree biomass is 160 metric tons/ha. Ponderosa pine constitutes 87.7% of this biomass. Douglas fir accounts for 3.4%. The trees in the riparian community comprise 8.6%.

The total herbaceous layer aboveground biomass is 3.71 kg/ha. The herbaceous layer consisted of a total forb aboveground biomass of 434 gm/ha and a total graminoid aboveground biomass of 3.27 kg/ha.

4.2 Mid Los Alamos Canyon

This site is a conifer forest consisting of Englemann spruce (*Picea englemannii*) and ponderosa pine dominated by White fir (*Abies concolor*) and Douglas fir. The dominant trees are 12 to 28 m tall. The younger trees are 2 to 9 m tall. The forest has a density of 201 trees/ha. The average DBH of the trees in this conifer forest is 13.6 cm. The sapling layer consisting of Gambel oak has a density of 38 stems/ha. Aspens (*Populus tremuloides*) in this forest have a density of 11 trees/ha and an average DBH of 6.9 cm.

A deciduous tree community of Rocky Mountain maple trees and various shrubs line the stream bank. The Rocky Mountain maple has a density of 65 stems/ha and the trees have an average DBH of less than 3 cm.

The total aboveground tree biomass is 71 metric tons/ha. White fir constitutes 65.7% of this biomass. Douglas fir and Englemann spruce account for 28.7% and 2.0% respectively. The trees in the riparian community comprise 3.1%.

The total herbaceous layer aboveground biomass is 0.621 gm/ha. The herbaceous layer consisted of a total forb aboveground biomass of 0.117 gm/ha and a total graminoid aboveground biomass of 0.504 gm/ha.

4.3 Upper Los Alamos Canyon

This site is a conifer forest consisting of White fir and limber pine (*Pinus flexilis*) dominated by Englemann spruce (*Picea englemannii*) and Douglas fir. The dominant trees are 11 to 25 m tall. The younger trees are 2 to 7 m tall. The forest has a density of 472 trees/ha. The average DBH of the trees in this conifer forest is 6.9 cm. Aspen (*Populus tremuloides*) in this forest have a density of 27 trees/ha and an average DBH of 3.6 cm. The sapling layer consisting of Gambel oak and New Mexico locust has a density of 13 stems/ha.

A deciduous tree community consisting of Rocky Mountain maple trees and various shrubs lines the stream bank. The Rocky Mountain maple has density of 165 stems/ha and the trees have an average DBH of less than 3 cm.

The total aboveground tree biomass is 82 metric tons/ha. Englemann spruce constitutes 50.1% of this biomass. Douglas fir, White fir, and limber pine account for 44.8% collectively. The trees in the riparian community comprise less than 3%.

The total herbaceous layer aboveground biomass is 2.28 kg/ha. The herbaceous layer consisted of a total forb aboveground biomass of 1.08 kg/ha and a total graminoid aboveground biomass of 1.20 kg/ha.

4.4 Lower Guaje Canyon

This site is a conifer forest dominated by ponderosa pine (*Pinus ponderosa*) and Douglas fir (*Pseudotsuga menzeii*). The dominant trees are 10 to 22 m tall. The younger trees are 3 to 8 m tall. The forest has a density of 291 trees/ha. The average DBH of the trees in this conifer forest is 16.9 cm.

A deciduous tree community occupies the stream bank and is dominated by Rocky Mountain maple, alder (*Alnus tenuifolia*), and narrowleaf cottonwood. The alder and Rocky Mountain maple have a density of 1534 stems /ha. The density of cottonwood is 51 trees/ha and their average DBH is 53.7 cm.

The total aboveground tree biomass is 231 metric tons/ha. Narrowleaf cottonwood constitute 62.1% of the total aboveground tree biomass. The three conifer species account for 24.2% collectively.

The total herbaceous layer aboveground biomass is 1.70 kg/ha. The herbaceous layer consisted of a total forb aboveground biomass of 0.992 gm/ha, and a total graminoid aboveground biomass of 0.704 gm/ha.

4.5 Mid Guaje Canyon

This site is a conifer forest consisting of Englemann spruce and limber pine dominated by White fir (*Abies concolor*) and Douglas fir. The dominant trees are 11 to 29 m tall. The younger trees are 2 to 8 m tall. The forest has a density of 342 trees/ha. The average DBH of the trees in this conifer forest is 13.5 cm. The sapling layer consisting of Gambel oak and New Mexico locust has a density of 177 stems/ha. Aspens (*Populus tremuloides*) in this forest have a density of 103 trees/ha and an average DBH of 15.3 cm.

A deciduous tree community of Rocky Mountain maple, birch, and alder trees and various shrubs lines the stream bank. The deciduous trees have a density of 710 stems/ha.

The total aboveground tree biomass is 135 metric tons/ha. White fir constitutes 64.5% of this biomass. Aspen, Douglas fir, Englemann spruce, and limber pine account for 20.6%, 10.2%, 1.0%, and 1.0% respectively. The trees in the riparian community comprise approximately 3% collectively.

The total herbaceous layer aboveground biomass is 0.593 gm/ha. The herbaceous layer consisted of a total forb aboveground biomass of 0.328 gm/ha and a total graminoid aboveground biomass of 0.265 gm/ha.

4.6 Upper Guaje Canyon

This site is a conifer forest consisting of White fir and limber pine (*Pinus flexilis*) dominated by Englemann spruce (*Picea englemannii*) and Douglas fir. The dominant trees are 17 to 29 m tall. The younger trees are 2 to 9 m tall. The forest has a density of 595 trees/ha. The average DBH of the trees in this conifer forest is 15.8 cm. The sapling layer consisting of Gambel oak has a density of 63 stems/ha. Aspens (*Populus tremuloides*) in this forest have a density of 152 trees/ha and an average DBH of 10.8 cm.

A deciduous tree community of Rocky Mountain maple and alder trees and various shrubs lines the stream bank. The shrub layer of Rocky Mountain maple and alder have a density of 4015 stems /ha.

The total aboveground tree biomass is 239 metric tons/ha. Englemann spruce constitutes 38.7% of this biomass. Douglas fir, ponderosa pine, white fir, aspen, and limber pine account for 30.4%, 9.3%, 7.3%, 6.1%, and <1.0% respectively. The trees in the riparian community comprise approximately 10.2%.

The total herbaceous layer aboveground biomass is 0.728 gm/ha. The herbaceous layer consisted of a total forb aboveground biomass of 0.682 gm/ha, and a total graminoid aboveground biomass of 0.046 gm/ha.

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Table 1 Lower Los Alamos Canyon

				Cr.			DBH		%
Species	Tag#	Hgt.	HTO(m)	Dia.	Condition	# Stems	Trees	X(cm)	Cover
BEOC			0		GOOD	1		0	5
BEOC			0		GOOD	1	0.1	0.254	5
BEOC			0		GOOD	1		0	5
BEOC			0		GOOD	1	0.1	0.254	5
BEOC			0	6	GOOD	1	0.1	0.254	0.1
BEOC		23	7.0104	35.5	GOOD	33	2.4	6.096	70
BEOC		28	8.5344	14.5	GOOD	21	0.1	0.254	35
			0					0	
			0					0	
			0					0	
FONE		8	2.4384		GOOD	1		0	0.1
			0					0	
			0					0	
			0					0	
JUMO			0		GOOD	1	0.1	0.254	0.1
JUMO			0		GOOD	1	0.1	0.254	0.1
JUMO	115	12	3.6576	6.7	MISTLETO	1	7.8	19.812	5
JUMO			0		GOOD	3	0.1	0.254	
JUMO		15	4.572		SCRAGGLY	2	0.1	0.254	0.1
JUMO			0			1	0.1	0.254	
			0					0	
			0					0	
			0					0	
JUSC	117	13	3.9624	17.5	GOOD	1	10	25.4	15
			0					0	
			0					0	
			0					0	
PIPO	60	9	2.7432	22.2	GOOD	1	19.8	50.292	15
PIPO	112	29	8.8392	11.4	GOOD	1	7.1	18.034	
PIPO	132	48	14.6304	11	GOOD	1	22.6	57.404	
PIPO	133	50	15.24	13	GOOD	1	20.3	51.562	
PIPO			0			1	2.1	5.334	
PIPO			0			1	1.4	3.556	30

Table 1 (cont.) Lower Los Alamos Canyon

				Cr.			DBH		%
Species	Tag#	Hgt.	HTO(m)	Dia.	Condition	# Stems	Trees	X(cm)	Cover
PIPO			0			1	1.1	2.794	
PIPO	60	90	27.432	22.2	GOOD	1	19.8	50.292	15
PIPO	112	29	8.8392	11.4	GOOD	1	7.1	18.034	
PIPO	132	48	14.6304	11	GOOD	1	22.6	57.404	
PIPO	133	50	15.24	13	GOOD	1	20.3	51.562	
PIPO			0			1	2.1	5.334	
PIPO			0			1	1.4	3.556	30
PIPO			0			1	1.1	2.794	
PIPO	113	67	20.4216	19.7	GOOD	1	17.5	44.45	15
PIPO	114	22	6.7056	10	GOOD	1	6.9	17.526	
PIPO	121	60	18.288	24	GOOD	1	20.9	53.086	40
PIPO	122	24	7.3152	6	GOOD	1	6.4	16.256	
PIPO			0			1	2.3	5.842	
PIPO			0			1	3	7.62	
PIPO			0			1	0.1	0.254	40
PIPO			0			1	3.6	9.144	
PIPO			0			1	3.4	8.636	
PIPO	135	16	4.8768	6	GOOD	1	4	10.16	
PIPO			0			1	3.1	7.874	
PIPO	118	55	16.764	33	CREEPER	1	20.8	52.832	20
PIPO	125	65	19.812	11.5	GOOD	1	19.9	50.546	10
PIPO			0			1		0	0.1
PIPO	119	57.2	17.43456	22.5	GOOD	1	23.2	58.928	10
PIPO	126	65	19.812	45	GOOD	1	24.2	61.468	20
PIPO	136	20	6.096	11	BARK EAT	1	5.1	12.954	
PIPO	137	33	10.0584	12	GOOD	1	7.7	19.558	
PIPO	138	50	15.24	12	GOOD	1	19	48.26	25
			0					0	
			0					0	
			0					0	
POAN	123	32	9.7536	16.3	GOOD	1	7.9	20.066	10
POAN	124	30	9.144	14.8	GOOD	1	6.2	15.748	
			0					0	

Table 1 (cont.) Lower Los Alamos Canyon

				Cr.			DBH		%
Species	Tag#	Hgt.	HTO(m)	Dia.	Condition	# Stems	Trees	X(cm)	Cover
			0					0	
			0					0	
PSME			0			1	1	2.54	1
PSME			0			1	1	2.54	1
PSME		10	3.048		GOOD	1	2.3	5.842	5
PSME	134	34	10.3632	15	GOOD	1	9.2	23.368	15
PSME			0			1		0	0.1
PSME	127	28	8.5344	22	GOOD	1	7	17.78	40
PSME	129	30	9.144	15	GOOD	1	5.8	14.732	
			0					0	
			0					0	
			0					0	
QUGA	120	25	7.62	17	CREEPER	10	1.95	4.953	30
QUGA	120	25	7.62	17	CREEPER	10	1.95	4.953	30
QUGA			0		GOOD	15	0.1	0.254	20
QUGA	128	33	10.0584	13	GOOD	1	8.4	21.336	65
QUGA	130	15	4.572	17	GOOD	1	6.9	17.526	
QUGA	131	25	7.62	17.5	GOOD		9	22.86	
			0					0	
			0					0	
			0					0	
RONE			0		GOOD	10	0.1	0.254	5
RONE			0			1	0.1	0.254	
RONE			0		GOOD	3	0.1	0.254	2
			0					0	
			0					0	
			0					0	
SALX			0			19	2.3	5.842	
SALX			0			9	1.4	3.556	65
SALX			0			27	0.1	0.254	35

Table 2 Mid Los Alamos Canyon

Species	Tag#	Hgt.	HTO(m)	Cr. Dia.	Condition	# Stems Shrubs	DBH Trees	X(cm)	% Cover
ABCO		3.5	1.0668	4	GOOD		0.1	0.254	1
ABCO		5	1.524	5	GOOD		0.1	0.254	5
ABCO		5	1.524	5.5	GOOD		0.1	0.254	
ABCO	249	49	14.9352	25	GOOD		25.2	64.008	20
ABCO		4	1.2192	3.6	GOOD	1	0.1	0.254	5
ABCO		5	1.524	3.8	GOOD	1	0.1	0.254	
ABCO		4	1.2192	3	HALF NEE	1	0.1	0.254	
ABCO		14	4.2672	10	GOOD		2	5.08	15
ABCO	244	56	17.0688	23	GOOD		11.4	28.956	
ABCO	245	43	13.1064	15	GOOD		10	25.4	25
ABCO	246	39	11.8872	26	GOOD		12.4	31.496	
ABCO	298	51	15.5448	33	GOOD		24	60.96	35
ABCO		20	6.096	8	GOOD		2	5.08	
ABCO	297	65	19.812	36	GOOD		20.2	51.308	
ABCO		4	1.2192	2	GOOD	1	0.1	0.254	5
ABCO	255	35	10.668	18	GOOD		9.3	23.622	
ABCO	254	38	11.5824	20	GOOD		9.4	23.876	
ABCO		18	5.4864	4	ALMOST DEAD		1	2.54	
ABCO	261	30	9.144	15			6.3	16.002	
ABCO	260	32	9.7536	16	GOOD		8	20.32	
ABCO		25	7.62	6			3	7.62	
ABCO		25	7.62	14			3.5	8.89	
ABCO		4	1.2192	3		1	0.1	0.254	45
ACBO		10	3.048	3	GOOD		1	2.54	
			0					0	
			0					0	
			0					0	
ACGL			0		0.223607	5	0.1	0.254	5
ACGL			0		0.1	1	0.1	0.254	10
ACGL			0		0.141421	2	0.1	0.254	5
ACGL			0		0.1	1	0.1	0.254	10
ACGL			0		0.141421	2	0.1	0.254	5
ACGL			0		0.1	1	0.1	0.254	0.1

Table 2 (cont.) Mid Los Alamos Canyon

				Cr.		# Stems	DBH		%
Species	Tag#	Hgt.	HTO(m)	Dia.	Condition	Shrubs	Trees	X(cm)	Cover
			0					0	
			0					0	
			0					0	
ALTE			0					0	40
ALTE	239	29	8.8392	17	GOOD	5	3	7.62	50
ALTE			0			4	6.123724	15.55426	
ALTE	238	32	9.7536	12	GOOD	2	7.778175	19.75656	
ALTE			0			3	2.345208	5.956828	
ALTE	243	30	9.144	13	GOOD	4	5.634714	14.31217	
ALTE			0			1	2.5	6.35	
ALTE	241	25	7.62	10	GOOD	1	4	10.16	
ALTE	242	28	8.5344	15	TOP BROH	4	7.211103	18.3162	
ALTE	240	36	10.9728	20	GOOD	4	6.123724	15.55426	20
ALTE			0			0	0	0	10
ALTE	247	32	9.7536	45	GOOD	5	6.78233	17.22712	10
ALTE		14	4.2672	14	GOOD	5	2.560098	6.502648	30
ALTE			0		0.1	1	0.1	0.254	10
ALTE			0		0.173205	3	0.1	0.254	
			0					0	
			0					0	
			0					0	
PIEN	295	30	9.144	20	GOOD		6.3	16.002	20
PIEN	296	30	9.144	19	GOOD		5.5	13.97	
PIEN		4	1.2192	1.5		1	0.1	0.254	10
PIEN	252	18	5.4864	10	SPLIT TRUNK W/NEST		5.5	13.97	
PIEN		10	3.048	2.5	GOOD	1	0.1	0.254	20
			0					0	
			0					0	
			0					0	
PIPO		4	1.2192	2	GOOD		0.1	0.254	
			0					0	
			0					0	
			0					0	

Table 2 (cont.) Mid Los Alamos Canyon

				Cr.		# Stems	DBH		%
Species	Tag#	Hgt.	HTO(m)	Dia.	Condition	Shrubs	Trees	X(cm)	Cover
POTR	248	40	12.192	8	GOOD		4.4	111.76	20
POTR			0			1	1	25.4	
			0					0	
			0					0	
			0					0	
PSME	251	92	28.0416	33	GOOD		24	60.96	35
PSME	250	42	12.8016	15	GOOD		13.5	34.29	5
PSME		15	4.572	11	GOOD		2	5.08	1
PSME		3	0.9144	2	GOOD	1	0.1	0.254	5
PSME	253	30	9.144	6			3.7	9.398	
			0					0	
			0					0	
			0					0	5
QUGA			0				1.5	3.81	
QUGA			0			1	1	2.54	
QUGA			0			1	0.1	0.254	5
QUGA		10	3.048	7	GOOD	1	1	2.54	20
QUGA		18	5.4864	15			2.2	5.588	
QUGA		4	1.2192	5		1	0.1	0.254	
QUGA		8	2.4384	6		1	1	2.54	

Table 3 Upper Los Alamos Canyon

Species	Tag#	Hgt.	HTO(m)	Cr. Dia.	Condition	# Stems Shrubs	DBH Trees	X(cm)	% Cover
ABCO	256	38	11.5824	20			11.8	29.972	25
ABCO			0		GOOD		3.5	8.89	
ABCO	272	30	9.144	12	GOOD		5.1	12.954	
ABCO		4	1.2192	3			0.1	0.254	15
ABCO	268	23	7.0104	13			5	12.7	5
ABCO	275	20	6.096	12			4.5	11.43	
ABCO	271	23	7.0104	13			4	10.16	10
ABCO		10	3.048	4	LYING ON SIDE		2.5	6.35	0.1
ABCO		15	4.572	5			2	5.08	15
ABCO	269	35	10.668	14	GOOD		7.1	18.034	15
ABCO		4	1.2192	3.2	GOOD		0.1	0.254	
ABCO		6	1.8288	2.5	GOOD		1.2	3.048	
ABCO		9	2.7432	7	GOOD		1.7	4.318	
ABCO		8	2.4384	3	GOOD		1	2.54	
ABCO		10	3.048	5.2	GOOD		1.3	3.302	5
ABCO		6	1.8288	3	GOOD		0.1	0.254	
			0					0	
			0					0	
			0					0	
ACGL			0			12	0.1	0.254	
ACGL			0			6	0.1	0.254	20
ACGL		16	4.8768	6	GOOD		2.3	5.842	
ACGL		14	4.2672	6	GOOD		1.3	3.302	
ACGL			0			6	0.1	0.254	35
ACGL			0			6	0.1	0.254	
ACGL		14	4.2672	4			1	2.54	
ACGL			0			3	0.1	0.254	20
			0					0	
			0					0	
			0					0	
PIEN	259	45	13.716	18	GOOD		11	27.94	15
PIEN	258	49	14.9352	17	GOOD		13	33.02	5
PIEN		6	1.8288	4.5	GOOD	40	1	2.54	1

Table 3 (cont.) Upper Los Alamos Canyon

Species	Tag#	Hgt.	HTO(m)	Cr. Dia.	Condition	# Stems Shrubs	DBH Trees	X(cm)	% Cover
PIEN	264	35	10.668	7	GOOD		6.9	17.526	20
PIEN	263	35	10.668	7	2/3 MOCS COVER		8.5	21.59	25
PIEN		15	4.572	8	GOOD		2.4	6.096	10
PIEN	262		0	27	GOOOD		10.2	25.908	
PIEN	267	40	12.192	18	MOSS COVERED		13	33.02	
PIEN		20	6.096	8	GOOD		1.7	4.318	15
PIEN		14	4.2672	4	GOOD		2.7	6.858	5
PIEN	266	40	12.192	14	MOSS COVERED		14	35.56	1
PIEN		8	2.4384	5	GOOD		1	2.54	15
PIEN		10	3.048	6	GOOD		1.5	3.81	5
PIEN		15	4.572	5	GOOD		2	5.08	
PIEN	276	14	4.2672	38	GOOD		8.1	20.574	
PIEN			0		GOOD		0.1	0.254	15
PIEN		18	5.4864	8	GOOD		2.2	5.588	
PIEN		26	7.9248	8	GOOD		2	5.08	
PIEN	278	30	9.144	10	GOOD		4.7	11.938	
PIEN		25	7.62	12	LOW BRANCHES DEAD		3.9	9.906	
PIEN	280	38	11.5824	12	GOOD		8.8	22.352	20
PIEN		6	1.8288	3	GOOD		0.1	0.254	
PIEN		4	1.2192	2.9	GOOD		0.1	0.254	1
PIEN		7	2.1336	3.6	GOOD		1.5	3.81	
			0					0	
			0					0	
			0					0	
PIFL	265	16	4.8768	41	GOOD		10.5	26.67	10
PIFL		8	2.4384	3.4	GOOD		1.1	2.794	
PIFL		3	0.9144	2	GOOD		0.1	0.254	5
PIFL		5	1.524	12	GOOD		1.4	3.556	
			0						
			0						
			0						
POTR	257	40	12.192	12	GOOD		8.4	213.36	20
POTR	270	61	18.5928	25	GOOD		15	381	5

Table 3 (cont.) Upper Los Alamos Canyon

				Cr.		# Stems	DBH		%
Species	Tag#	Hgt.	HTO(m)	Dia.	Condition	Shrubs	Trees	X(cm)	Cover
POTR	274	55	16.764	32	SPLIT TRUNK		26.7	678.18	20
POTR	273	50	15.24	15			11.3	287.02	15
POTR		18	5.4864	6	BENT OVER		3.5	88.9	15
			0						
			0						
			0						
PSME	281	37	11.2776	19	GOOD		10.8	27.432	
PSME	279	84	25.6032	32	GOOD		20.4	51.816	
PSME	294	67	20.4216	15	GOOD		10.7	27.178	
PSME	277	48	14.6304	18	LEANING OVER		10.5	26.67	
								0	
								0	
								0	
QUGA						2	0.1	0.254	5
QUGA						1	0.1	0.254	5
QUGA						1	0.1	0.254	10
QUGA						1	0.1	0.254	
								0	
								0	
								0	
RONE						1	0.1	0.254	
								0	
								0	
								0	
SALIX		9.5		6		1	1.5	3.81	15
SALIX						1	0.1	0.254	10

Table 4 Lower Guaje Canyon

				Crown					
Species	Tag#	Hgt(ft)	HTO(m)	Dia.	Condition	Shrubs	DBH(in)	X(cm)	Cover
abco	140	71	21.6408	17	lowhalfburned		11.9	30.226	10
abco		3	0.9144	3	good		0.1	0.254	1
abco		22	6.7056	7.8	lowhalfdead		3.5	8.89	5
								0	
								0	
								0	
acgl	145	35	10.668	18	litestrk,topgone		15.7	39.878	40
acgl	146	7	2.1336	10	topgone		10.9	27.686	
acgl	147	32	9.7536	26	good		12.5	31.75	
acgl			0		0.360555	13	0.1	0.254	
acgl			0		1.732051	3	1	2.54	15
acgl			0		0.141421	2	0.1	0.254	
acgl			0		0.141421	2	0.1	0.254	1
acgl		14	4.2672	11	good		2	5.08	20
acgl		11	3.3528	13	good		2.6	6.604	
acgl	181	31	9.4488	19	good		5.1	12.954	10
acgl			0		0.316228	10	0.1	0.254	
acgl		9	2.7432	6.5			1	2.54	
acgl	177	23	7.0104	n/a	snag		11.9	30.226	
acgl	178	25	7.62	20	good		5.2	13.208	
acgl	179	42	12.8016	15	good		8.2	20.828	30
acgl			0		0.173205	3	0.1	0.254	
acgl	175	26	7.9248	10	good		4.8	12.192	15
acgl		5	1.524	6	topgone		2	5.08	
acgl			0		0.316228	10	0.1	0.254	
								0	
								0	
								0	
acne			0		0.1	1	0.1	0.254	0.1
acne			0					0	1.1

Table 4 (cont.) Lower Guaje Canyon

Species	Tag#	Hgt(ft)	HTO(m)	Crown Dia.	Condition	Shrubs	DBH(in)	X(cm)	Cover
alte	180	33	10.0584	19	12.64397	3	7.3	18.542	10
alte			0		0.223607	5	0.1	0.254	10
alte		4	1.2192		1	1	1	2.54	15
alte			0		0.387298	15	0.1	0.254	10
alte			0		4.4	1	4.4	11.176	
alte			0		3	1	3	7.62	35
alte			0		2	4	1	2.54	
alte			0		2.12132	4.5	1	2.54	
alte			0		0.2	4	0.1	0.254	
befe			0		0.547723	30	0.1	0.254	10
befe			0		0.547723	30	0.1	0.254	5
befe			0		0.547723	30	0.1	0.254	5
pipo	144	56	17.0688	17	good		12.1	30.734	
pipo	143	38	11.5824	25	good		14.4	36.576	
pipo		26	7.9248	7	good		3.8	9.652	15
pipo		16	4.8768	6	good		3.5	8.89	
pipo		3	0.9144	1	dying		0.1	0.254	0.1
pipo	149	52	15.8496	14	onlycrownhasneedles		12.1	30.734	5
pipo	152	33	10.0584	11	good		5.1	12.954	5
pipo	155	57	17.3736	16	good		10.5	26.67	10
pipo		11	3.3528	4	sparseneedles		1	2.54	1
pipo	174	24	7.3152	7.2	good		4.5	11.43	5
piposnag			0		dead		11.6	29.464	
			0					0	
			0					0	
			0					0	
poan	150	53	16.1544	20	good		10	25.4	20

Table 4 (cont.) Lower Guaje Canyon

				Crown					
Species	Tag#	Hgt(ft)	HTO(m)	Dia.	Condition	Shrubs	DBH(in)	X(cm)	Cover
poan	153	67	20.4216	41	good		32.6	82.804	
poan	154	48	14.6304	29	good		11.6	29.464	
poan			0					0	10
poan			0					0	20
poan	176	65	19.812	42	good		30.3	76.962	
poansnag			0		dead		14.8	37.592	
poansnag			0		dead		13.7	34.798	
poansnag			0		dead		12.9	32.766	
poansnag		23	7.0104		dead		20.1	51.054	
pofesnag			0		dead		17.8	45.212	
pofesnag			0		dead		13.9	35.306	
pofesnag			0		dead		19.9	50.546	
pofesnag		40	12.192		dead		19.5	49.53	
pofesnag			0		dead		16.6	42.164	1
pofrsnag	n/a	59	17.9832	n/a	dead		21.2	53.848	n/a
			0					0	
			0					0	
			0					0	
psme	139	68	20.7264	12	lowhalfburned		9.1	23.114	10
psme	141	35	10.668	8	good		13.8	35.052	35
psme	142	51	15.5448	22	good		6.6	16.764	
psme	148	56	17.0688	24	lowhalfdead		15.7	39.878	20
psme			0		0.173205	3	0.1	0.254	1
psme	151	57	17.3736	24	good		13.9	35.306	20
psme	182	57	17.3736				13.8	35.052	20
psme		10	3.048	5	good		1.5	3.81	1
psmesnag			0		dead		1.8	4.572	10
			0					0	
			0					0	
			0					0	
quga			0		0.1	1	0.1	0.254	0.1
			0					0	
			0					0	

Table 4 (cont.) Lower Guaje Canyon

				Crown					
Species	Tag#	Hgt(ft)	HTO(m)	Dia.	Condition	Shrubs	DBH(in)	X(cm)	Cover
			0					0	
rlin			0		0.387298	15	0.1	0.254	5
rlin			0		0.5	25	0.1	0.254	5
rlin			0		1	100	0.1	0.254	50
rlin			0		0.469042	22	0.1	0.254	5

Table 5 Mid Guaje Canyon

Species	Tag#	Hgt.	HTO(m)	Cr. Dia.	Condition	# Stems Shrubs	DBH Trees	X(cm)	% Cover
ABCO	202	43	13.1064	16	GOOD		8.2	20.828	10
ABCO		7	2.1336	5	SPLIT STEM 1 DEAD		3.4	8.636	5
ABCO	232	75	22.86	21	GOOD		18	45.72	40
ABCO	233	90	27.432	39	GOOD		33.7	85.598	
ABCO		12	3.6576	4	DYING		1.7	4.318	
abco	200		0		good		3.5	8.89	5
abco		3	0.9144	4	good	1	2	5.08	0.1
abco		4	1.2192	2.5	good		1	2.54	1
abco			0				2.1	5.334	
abco	167	79	24.0792	21.2	good		13.5	34.29	
abco			0				0.1	0.254	
ABCOSNAG			0		DEAD	3	0.1	0.254	
			0					0	
			0					0	
			0					0	
ACGL			0		0.1	1	0.1	0.254	0.1
ACGL		20	6.096	4	GOOD		2.7	6.858	20
ACGL		18	5.4864	5	GOOD		1.25	3.175	
ACGL		15	4.572	10	GOOD		2.2	5.588	
ACGL		12	3.6576	6	GOOD		1.7	4.318	
ACGL			0		0		0.1	0.254	
acgl			0		0.173205	3	0.1	0.254	0.1
acgl			0		0.1	1	0.1	0.254	0.1
acgl			0		2.828427	2	2	5.08	5
acgl			0		0.223607	5	0.1	0.254	5
agcl			0		0.173205	3	0.1	0.254	0.1
			0					0	
			0					0	
			0					0	
ALTE		4	1.2192	5	TOP CTU OFF		3.7	9.398	15
ALTE		4	1.2192	5	TOP CUT OFF		2.3	5.842	
ALTE		24	7.3152	19	GOOD		3.5	8.89	
ALTE		12	3.6576	7	GOOD		2.3	5.842	

Table 5 (cont.) Mid Guaje Canyon

				Cr.		# Stems	DBH		%
Species	Tag#	Hgt.	HTO(m)	Dia.	Condition	Shrubs	Trees	X(cm)	Cover
ALTE		13	3.9624	6	GOOD		1.9	4.826	
ALTE			0		0.244949	6	0.1	0.254	
ALTE	237	25	7.62	14	GOOD		6.2	15.748	30
ALTE	234	35	10.668	20	GOOD		5.5	13.97	
ALTE			0		0.316228	10	0.1	0.254	
ALTE			0		0.316228	10	0.1	0.254	40
alte			0		0.360555	13	0.1	0.254	
ALTESNAG			0		TOP CUT OFF		2.9	7.366	
			0					0	
			0					0	
			0					0	
beoc	162	29	8.8392	21	good		5.8	14.732	
beoc			0		2.2	1	2.2	5.588	
beoc			0		0.447214	20	0.1	0.254	
beoc	163	32	9.7536		good		4.2	10.668	
beoc	169	10	3.048		broken trunk		4.2	10.668	
beoc		31	9.4488		0		2.2	5.588	
beoc	170	35	10.668	16.9	good		6.3	16.002	5
beoc			0		0.244949	6	0.1	0.254	0.1
beoc			0		0.2	4	0.1	0.254	
beoc		11	3.3528	4.8	0		1.3	3.302	
beoc			0		0		2	5.08	10
beoc			0		0.1	1	0.1	0.254	5
			0					0	
			0					0	
			0					0	
			0					0	
			0					0	
			0					0	
JAAM			0		0.173205	3	0.1	0.254	5
JAAM			0		0.223607	5	0.1	0.254	10
jaam			0		0.264575	7	0.1	0.254	0.1
jaam			0		0.2	4	0.1	0.254	

Table 5 (cont.) Mid Guaje Canyon

				Cr.		# Stems	DBH		%
Species	Tag#	Hgt.	HTO(m)	Dia.	Condition	Shrubs	Trees	X(cm)	Cover
jaam			0		0.282843	8	0.1	0.254	
jaam			0		0.264575	7	0.1	0.254	5
jaam			0		0.282843	8	0.1	0.254	5
jaam			0		0.244949	6	0.1	0.254	5
			0					0	
			0					0	
			0					0	
PIEN		13	3.9624	10	GOOD		2.2	5.588	10
PIEN		10	3.048	7	GOOD		1.3	3.302	
PIEN		8	2.4384	8	GOOD		1.2	3.048	
pien		4	1.2192	3	good		1	2.54	1
pien		15	4.572	8	good		2.1	5.334	5
pien	157	38	11.5824	14	good		6.3	16.002	10
			0					0	
			0					0	
			0					0	
PIFL		3	0.9144	3	GOOD	1	0.1	0.254	0.1
pifl	201		0		good		3.5	8.89	5
pifl		3	0.9144	3	good		1	2.54	1
pifl	168	42	12.8016	8.9			4.6	11.684	
pifl	158	46	14.0208	16	good		6.9	17.526	10
piflsnag			0				2	5.08	0
piflsnag		199	60.6552				3	7.62	0
			0					0	
			0					0	
			0					0	
POTR		45	13.716	8	GOOD		3	76.2	10
POTR	235	42	12.8016	13	GOOD		8.4	213.36	20
POTR	236	37	11.2776	12	GOOD		5	127	
POTR	231	55	16.764	8	GOOD		5.9	149.86	10
potr	159	65	19.812	17	good		7	177.8	
potr	160	66	20.1168	14	good		6.5	165.1	
potr	161	65	19.812	13	good		6	152.4	25

Table 5 (cont.) Mid Guaje Canyon

Species	Tag#	Hgt.	HTO(m)	Cr. Dia.	Condition	# Stems Shrubs	DBH Trees	X(cm)	% Cover
potr	165	52	15.8496		good		21.6	548.64	
potr	164	93	28.3464		firescar		4.9	124.46	
potr			0		good	1	2	50.8	5
potr			0		good	1	2	50.8	
potr	171	96	29.2608	14	good		7.4	187.96	
potr	172	70	21.336	12	good		6.3	160.02	
potr	173	65	19.812	11	good		5.8	147.32	20
potr	166	82	24.9936	17	good		8.7	220.98	
potr	156	32	9.7536	12	good		4.5	114.3	5
potr			0			1	0.1	2.54	0.1
POTR SNAG			0		DEAD		3.7	93.98	
POTR SNAG			0		DEAD		3.8	96.52	
POTR SNAG			0		DEAD		1.5	38.1	
potrsnag			0				3.2	81.28	0
potrsnag			0				2.5	63.5	0
potrsnag			0				3	76.2	0
potrsnag			0				3.1	78.74	0
			0					0	
			0					0	
			0					0	
PSME		6	1.8288	7	GOOD	1	0.1	0.254	
PSME	203	85	25.908	25	GOOD		16.1	40.894	40
PSME		15	4.572	8	GOOD		2	5.08	
PSME	204	65	19.812	18	LOW BRANCHES DEAD		7.5	19.05	15
psme			0				0.1	0.254	
psmesnag			0		dead		17.4	44.196	0
			0					0	
			0					0	
			0					0	
QUGA			0		0.173205	3	0.1	0.254	0.1
QUGA			0		0.173205	3	0.1	0.254	5
			0					0	
			0					0	

Table 5 (cont.) Mid Guaje Canyon

				Cr.		# Stems	DBH		%
Species	Tag#	Hgt.	HTO(m)	Dia.	Condition	Shrubs	Trees	X(cm)	Cover
			0					0	
RIIN			0		0.173205	3	0.1	0.254	0.1
RIIN			0		0			0	1
riin			0		0.173205	3	0.1	0.254	0.1
riin			0		0.173205	3	0.1	0.254	
			0					0	
			0					0	
			0					0	
RONE			0		0.223607	5	0.1	0.254	10
rone			0		0.173205	3	0.1	0.254	
			0					0	
			0					0	
			0					0	
ROWO			0		0.2	4	0.1	0.254	5
ROWO			0		0.223607	5	0.1	0.254	5
ROWO			0		0.223607	5	0.1	0.254	
rowo			0		0.223607	5	0.1	0.254	1
rowo			0		0.173205	3	0.1	0.254	0.1
rowo			0		0.316228	10	0.1	0.254	
			0					0	
			0					0	
			0					0	
rust			0		0			0	
rust			0		0.141421	2	0.1	0.254	0.1
rust			0		0.173205	3	0.1	0.254	0.1
rust			0		0.2	4	0.1	0.254	
rust			0		0.173205	3	0.1	0.254	1

Table 6 Upper Guaje Canyon

				Cr.		# Stems	DBH		%
Species	Tag#	Hgt.	HTO(m)	Dia.	Condition	Shrubs	Trees	X(cm)	Cover
ABCO		8	2.4384	4.3	GOOD		1.5	3.81	5
ABCO	209	92	28.0416	11	GOOD		20.3	51.562	5
ABCO		4	1.2192	7.6	GOOD		3.5	8.89	5
ABCO		6	1.8288	4	GOOD		1.2	3.048	
ABCO		10	3.048	7.2	GOOD		1.2	3.048	5
ABCO		4	1.2192	3	TOP DEAD		0.1	0.254	1
ABCO		8	2.4384	5	GOOD		1.9	4.826	
ABCO		12	3.6576	3.5	GOOD		2.7	6.858	5
ABCO		6	1.8288	3	GOOD		1	2.54	10
ABCO		5	1.524	3	TOP GONE	1	1	2.54	
			0					0	
			0					0	
			0					0	
ACGL			0			1	1	2.54	
ACGL			0			8	0.1	0.254	
ACGL		16	4.8768	3	GOOD		1.6	4.064	5
ACGL		18	5.4864	6	GOOD		1.4	3.556	
ACGL			0			8	0.1	0.254	5
ACGL			0			2	0.1	0.254	0.1
ACGL			0			4	0.1	0.254	1
ACGL			0			3	0.1	0.254	5
ACGL			0			1	1	2.54	
ACGL			0			2	0.1	0.254	10
ACGL			0			1	0.1	0.254	5
ACGL		13	3.9624	19	GOOD	5	4.361192	11.07743	20
ACGL			0			6	0.1	0.254	
ACGL			0			9	0.1	0.254	5
ACGL			0			1	0.1	0.254	0.1
ACGL			0			20	0.1	0.254	15
ACGL			0			10	0.1	0.254	20
			0					0	
			0					0	
			0					0	

Table 6 (cont.) Upper Guaje Canyon

				Cr.		# Stems	DBH		%
Species	Tag#	Hgt.	HTO(m)	Dia.	Condition	Shrubs	Trees	X(cm)	Cover
ALTE			0			3	1.805547	4.586089	30
ALTE			0		GOOD		2	5.08	
ALTE		14	4.2672	6.9	GOOD		2.2	5.588	
ALTE			0			55	0.1	0.254	
ALTE			0		GOOD		4.2	10.668	
ALTE	206	19	5.7912	11	LYING ON SIDE		4.5	11.43	
ALTE			0			4	0.1	0.254	60
ALTE			0					0	5
ALTE	213	30	9.144	15	GOOD		5.2	13.208	
ALTE			0			100	0.1	0.254	
ALTE			0		GOOD	3	2	5.08	50
ALTE		15	4.572	10	GOOD	3	2.420744	6.148689	20
ALTE			0			5	0.1	0.254	
ALTE		16	4.8768	8	GOOD		2.3	5.842	
ALTE			0			7	0.1	0.254	
ALTE		11	3.3528	4	TOP HALF BENT OVER		1.5	3.81	10
ALTE	219	28	8.5344	20	GOOD	9	7.939144	20.16542	50
ALTE			0			10	0.1	0.254	
ALTE			0			6	0.1	0.254	20
ALTE		25	7.62	7	LYING ON GROUND		3.5	8.89	10
ALTE		25	7.62	16	SCAR ON MID		3.3	8.382	
ALTE		20	6.096	12	GOOD		2.6	6.604	
ALTE		25	7.62	13	GOOD		3.7	9.398	25
ALTE			0			11	0.1	0.254	
ALTE	230	18	5.4864	19	GOOD		5.5	13.97	15
ALTE		25	7.62	18	GOOD	6	6.031584	15.32022	
ALTE			0			18	0.1	0.254	
			0			4066		0	
			0					0	
			0					0	
PIEN	205	18	5.4864	8	GOOD		5.2	13.208	25
PIEN		8	2.4384	5	GOOD		2.3	5.842	
PIEN	207	100	30.48	21	SPLIT TRUNK		25.2	64.008	20

Table 6 (cont.) Upper Guaje Canyon

Species	Tag#	Hgt.	HTO(m)	Cr. Dia.	Condition	# Stems Shrubs	DBH Trees	X(cm)	% Cover
PIEN		9	2.7432	4	LYING ON SIDE		0.1	0.254	5
PIEN		12	3.6576	4	LYING ON SIDE		3.5	8.89	
PIEN		25	7.62	11	GOOD		3.2	8.128	
PIEN	217	85	25.908	14	GOOD		13.2	33.528	20
PIEN		7	2.1336	5	GOOD		1.1	2.794	
PIEN	221	89	27.1272	20	GOOD		17.7	44.958	25
PIEN		3	0.9144	3.5	GOOD		0.1	0.254	20
PIEN	220	27	8.2296	15	GOOD		6.2	15.748	
PIEN		10	3.048	3	LYING ON GROUND		2	5.08	
PIEN		6	1.8288	6	GOOD		0.1	0.254	40
PIEN	218	67	20.4216	17	GOOD		10	25.4	
PIEN	223	58	17.6784	16	GOOD		14.8	37.592	25
PIEN		12	3.6576	8	GOOD		2.8	7.112	10
PIEN		5	1.524	5	GOOD		0.1	0.254	
PIEN	228	23	7.0104	12	GOOD		5.2	13.208	15
PIEN	229	50	15.24	23	GOOD		15.7	39.878	20
PIEN		3.5	1.0668	3	GOOD		0.1	0.254	
PIEN		8	2.4384	6	GOOD		0.1	0.254	
			0					0	
			0					0	
			0					0	
PIFL		13	3.9624	8	GOOD		2.2	5.588	5
PIFL		3	0.9144	2	GOOD		1	2.54	1
			0					0	
			0					0	
			0					0	
PIPO	222	68	20.7264	20	GOOD		23.3	59.182	10
PIPO	226	60	18.288	21	GOOD		19.5	49.53	25
			0					0	
			0					0	
			0					0	
POTR	214	98	29.8704	7	SCAR ON LOW TRUN		8.3	210.82	
POTR	215	95	28.956	18	GOOD		14	355.6	

Table 6 (cont.) Upper Guaje Canyon

Species	Tag#	Hgt.	HTO(m)	Cr. Dia.	Condition	# Stems Shrubs	DBH Trees	X(cm)	% Cover
POTR	216	96	29.2608	23	GOOD		7.5	190.5	25
POTR			0					0	10
POTR	224	55	16.764	15	GOOD		11.2	284.48	10
POTR			0			5	0.1	2.54	
POTR	225	50	15.24	19	GOOD		11.4	289.56	
POTR			0			2	0.1	2.54	0.1
			0					0	
			0					0	
			0					0	
PSME		16	4.8768	6.1	LYING ON SIDE		2.4	6.096	20
PSME		10	3.048	3.5	LYING ON SIDE		1.3	3.302	
PSME		8	2.4384	3	GOOD		1.3	3.302	
PSME	208	80	24.384	13	GOOD		11.2	28.448	
PSME	210	94	28.6512	15	GOOD		16.2	41.148	35
PSME	211	31	9.4488	4	GOOD		4.4	11.176	
PSME		6	1.8288	2	GOOD	1	0.1	0.254	
PSME	212	95	28.956	21	GOOD		23.4	59.436	
PSME		3	0.9144	3	GOOD		0.1	0.254	5
PSME		5	1.524	4	GOOD		0.1	0.254	
PSME		17	5.1816	4.5	45DEGREE LEAN		2.2	5.588	5
PSME		5	1.524	3.5	GOOD		0.1	0.254	5
PSME	227	58	17.6784	23	GOOD		21.5	54.61	10

Table 1 Herbaceous Dry Weights by Species and Transect

Lower Los Alamos Summer 1993				
		Sample	Dry weight (gm/m^2)	
Species	Weight	Dry weight	Forbs	Graminoids
Agal	152.23	126.61		1266.1
Agal	256.35	230.73		2307.3
Agal	126.33	100.71		1007.1
FORB	78.85	53.23	532.3	
FORB	33.09	7.47	74.7	
Avg wt (14 samples/transect)=			43.4	327.2

Middle Los Alamos Canyon Summer 1993				
		Sample	Dry weight (gm/m^2)	
Species	Weight	Dry weight	Forbs	Graminoids
AGAL	45.92	20.3		203.0
BRIN	41.46	15.84		158.4
AGAL	42.37	16.75		167.5
FORBS	41.98	16.36	163.6	
Grasses	43.25	17.63		176.3
Avg wt (14 samples/transect)=			11.7	50.4

Upper Los Alamos Canyon Summer 1993				
		Sample	Dry weight (gm/m^2)	
Species	Weight	Dry weight	Forbs	Graminoids
FORB	32.64	7.02	70.2	
FORB	34.22	8.6	86	
FORB	32.09	6.47	64.7	
FORB	51.49	25.87	258.7	
FORB	35.61	9.99	99.9	
FORB	26.29	0.67	6.7	
FORBS	31.31	5.69	56.9	
FORBS	39.16	13.54	135.4	
FORBS	47.81	22.19	221.9	
FORBS	35.62	10	100	
FORBS	46.13	20.51	205.1	
FORBS	30.37	4.75	47.5	
FORBS	41.41	15.79	157.9	
Grass	30.39	4.77		47.7
Grass	39.16	13.54		135.4
Grass	35.62	10		100
Grass	46.13	20.51		205.1
Grass	30.65	5.03		50.3
Grass	31.45	5.83		58.3
Grass	37.6	11.98		119.8
Grass	30.71	5.09		50.9
Grass	51.49	25.87		258.7
Grass	32.73	7.11		71.1
Grass	31.15	5.53		55.3
Grass	35.61	9.99		99.9
Grasses	31.31	5.69		56.9
Grasses	32.28	6.66		66.6
Grasses	47.81	22.19		221.9
Grasses	30.48	4.86		48.6
Grasses	29.41	3.79		37.9
Avg wt (14 samples/transect)=			107.9	120.3

Lower Guaje Canyon Summer 1993				
		Sample	Dry weight (gm/m^2)	
Species	Weight	Dry weight	Forbs	Graminoids
ACLA	33.16	7.54	75.4	
ANPA	33.16	7.54	75.4	
FAPM	33.16	7.54	75.4	
Grass	59.51	33.89		338.9
Juncus	59.51	33.89		338.9
Juncus	39.2	13.58		135.8
Grass	36.81	11.19		111.9
MOME	36.03	10.41	104.1	
Amco	36.03	10.41	104.1	
Melu	44.7	19.08	190.8	
CRFO	44.7	19.08	190.8	
EQAR	44.7	19.08	190.8	
Grass	31.6	5.98		59.8
IPAG	44.7	19.08	190.8	
Viola	44.7	19.08	190.8	
Avg wt (14 samples/transect)=			99.2	70.4

Mid Guaje Canyon Summer 1993				
		Sample	Dry weight (gm/m^2)	
Species	Weight	Dry weight	Forbs	Graminoids
Forbs	30.92	5.3	53	
Forb	30.55	4.93	49.3	
Forbs	30.66	5.04	50.42	
Forbs	29.57	3.95	39.52	
FORB	31.21	5.59	55.9	
Forbs	26.03	0.41	4.1	
Forb	31.21	5.59	55.9	
Grasses	40.97	15.35		153.5
FORBS	32.7	7.08	70.8	
Forbs	33.65	8.03	80.3	
Grasses	41.49	15.87		158.7
Grass	31.48	5.86		58.6
Avg wt (14 samples/transect)=			32.8	26.5

Upper Guaje Summer 1993				
		Sample	Dry Weight (mg/m^2)	
Species	Weight	Dry Weigh	Forbs	Grasses
litter	216.46	190.84		
BRIX	32.08	6.46		64.6
CARO	30.9	5.28	52.8	
FRAM	38.45	12.83	128.3	
FRAM	30.9	5.28	52.8	
GERI	37.62	12	120	
ANPA	36.55	10.93	109.3	
OXVI	32.08	6.46	64.6	
OXVI	38.52	12.9	129	
PTFR	37.67	12.05	120.5	
TROF	30.9	5.28	52.8	
VAAC	32.81	7.19	71.9	
VICA	30.9	5.28	52.8	
Avg wt (14 samples/transect)=			68.2	4.6

CHAPTER 4

AQUATIC MACROINVERTEBRATES AND WATER QUALITY IN GUAJE AND LOS ALAMOS CANYONS, (1993 AND 1994)

by

Saul Cross

ABSTRACT

The Ecological Studies Team (EST) of ESH-20 at Los Alamos National Laboratory (LANL) collected aquatic samples from the streams within Guaje and Los Alamos Canyons during two six-month sampling seasons in 1993 and 1994. The Team measured water quality parameters and collected aquatic macroinvertebrates from permanent sampling stations. In this study, the relatively undisturbed stream in Guaje Canyon was used as a control to evaluate impacts to the stream in Los Alamos Canyon.

EST established and monitored three sampling stations in Guaje Canyon (G1, G2, and G3) and three comparable stations in Los Alamos Canyon (LA1, LA2, and LA3). All monthly pH, conductivity, and dissolved oxygen measurements taken in both streams were within acceptable water quality ranges as defined by Battelle (1972). The Los Alamos Canyon Reservoir impounds all incoming water except for warmed overflow, which significantly elevates water temperatures at the two lower Los Alamos stations. At times, this dam design caused the stream to completely dry up at LA2 and LA3, eliminating resident macroinvertebrate communities at these stations. Undoubtedly, this seasonal drought produces the most significant impact to downstream invertebrate communities in Los Alamos Canyon.

Rapid Biological Protocols (RBP) III analysis shows that aquatic communities are richer and more complex in Guaje Canyon than Los Alamos Canyon, supporting EST's use of the Guaje stream as a control. The data also suggest that within each canyon, diversity and density, decrease with distance downstream; but this trend is not as pronounced because the middle Guaje station had higher diversities and densities than Guaje's lowest station. According to RBP III metrics analysis, which are endorsed by the US Environmental Protection Agency (US EPA), water quality is nonimpaired at LA1, severely impaired at LA2, and severely impaired at LA3.

1 INTRODUCTION

In the summers of 1993 and 1994, the Ecological Studies Team (EST) conducted an ecological-risk study comparing aquatic macroinvertebrates and water quality in two Los Alamos County canyons. Los Alamos Canyon is affected by a well-traveled road, a reservoir, and effluents from the Omega Site in Technical Area 2 (TA-2). EST used Guaje Canyon as a control site because public access to this canyon is limited, and it receives no effluent discharges. EST collected data on water conditions and aquatic macroinvertebrate samples to assess potential stream impairment.

Physical parameters (water temperature, dissolved oxygen, pH, and conductivity) of both streams were monitored monthly, simultaneously with the collection of aquatic macroinvertebrates. In reviewing these measures, this report refers to many environmental quality ratings developed by Battelle Columbus Laboratories (Battelle 1972). Battelle outlined a comprehensive and interdisclipinary Environmental Evaluation System, which uses physical, chemical, and biological parameters to assess possible environmental impacts of water resource projects.

Water temperature directly influences aquatic organisms' physiological functions such as metabolism, growth, emergence, and reproduction (Anderson and Wallace 1984). Because water absorbs greater amounts of oxygen at lower temperatures, temperature is inversely related to oxygen solubility. While aquatic organisms can tolerate wide fluctuations in pH and conductivity, a change in water temperature of a single degree Celsius can have a significant impact (Lehmkuhl 1979).

The pH scale measures acidity and basicity with low values indicative of acidity, middle values (around 7.0) indicatative of neutrality, and high values indicative of basicity. A departure of ±1 from the normal pH is considered to be insignificant to aquatic macroinvertebrates (Lehmkuhl 1979). The normal pH of natural surface waters in the United States ranges from 6.5 to 9.0 (Canter and Hill 1979). In general, acidic waters limit species richness, evenness, and abundance. Some aquatic organisms, such as mayflies, are very sensitive to low pH, which can be caused by accidental acid spills or acid rain deposition.

Depressed oxygen environments often indicate the presence of organic wastes. The amount of dissolved oxygen (DO) in water has a direct and immediate effect on invertebrates using tracheal gills for respiration (such as the larvae of mayflies, caddisflies, and stoneflies). Oxygen is present in the atmosphere at levels greater than 200,000 parts per million (ppm), but its maximum value in water is only 15 ppm (Eriksen et al. 1984). Although aquatic insects require more oxygen for metabolism at elevated temperatures, less is available due to decreased solubility (Gaufin et al. 1974). Certain stages, such as emergence, in the life cycle of aquatic invertebrates will not occur unless sufficient oxygen is present (Bell 1971). Cold-water mayflies and stoneflies cannot tolerate DO concentrations much below 5 mg/l (Nebeker 1972).

Conductivity measures the ability of water to carry an electrical current and reflects the concentration of ionized substance in water. The conductivity of potable water in the United States ranges from 50 to 1,500 micro-mhos per centimeter (µmho/cm), while the conductivity of industrial waste may be as high as 10,000 µmhos/cm. A rough approximation of the total dissolved solids (TDS) of freshwater in mg/l can be obtained by multiplying the conductivity by a factor of 0.66. The upper limit of TDS that aquatic organisms can tolerate ranges from 5,000 to 10,000 mg/l (Battelle 1972).

Aquatic macroinvertebrates have been used extensively as water quality indicators. The term “macroinvertebrate” refers to invertebrates large enough to be seen with the unaided eye. This report uses the terms “macroinvertebrate” and “invertebrate” interchangeably. These organisms, especially the stream-dwelling insects, are well suited to this purpose due to their

- abundance in virtually all freshwater streams,
- small size and total immersion in the water environment,
- relatively sedentary life styles, making them good indicators of local conditions,
- differential sensitivities to various types of impairment, including non-point source pollution,
- life cycles that are frequently at least one-year long, allowing long-term detection of past disturbance, and
- relative ease of collection and identification to family or genus level.

In general, monitoring only the physical and chemical characteristics of water provides little information on conditions before the sampling date. Failure of chemical criteria to protect aquatic life has necessitated incorporating biological criteria into water resource management (Karr 1991). Shifts in the numbers of individuals, species, and functional feeding groups present may indicate prior disturbances. These disturbances could result from infrequent discharges of waste that might remain undetected through a water quality monitoring program that did not incorporate biological data (Weber 1973). Changes in macroinvertebrate communities thus reflect water quality over a much longer period than chemical monitoring.

Many early water-quality investigators compiled extensive indicator species lists and attempted to measure species-specific tolerances to pollution (Beck 1955). These methods are prone to erroneous interpretations since species-level identification is difficult to ascertain, tolerances of some species vary greatly under differing environmental conditions, and "intolerant" species may be found in polluted areas due to drift, i.e., transport by water currents. Use of a biotic index overcomes these problems by allowing higher level identifications and weighting taxa according to the number present.

Recent studies have emphasized the importance of community structure in evaluating water quality (Gaufin and Tarzwell 1956; Hilsenhoff 1977; Schwenneker and Hellenthal 1984; and Jacobi 1989). Examination of macroinvertebrate functional feeding groups provides an understanding of community structure and complexity. Insects are the overwhelmingly dominant group in most streams; and aquatic research has therefore concentrated on this widespread arthropod class.

When feeding, aquatic insects select organic particles primarily due to their size rather than their origin. Thus, the familiar trophic (feeding) categories of herbivore, carnivore, and omnivore have little application to aquatic macroinvertebrates. To more accurately describe the trophic relations of aquatic insects, a series of functional feeding groups, or trophic categories, has been developed (Cummins and Merritt 1984). These categories are determined by feeding mechanism (Table 1).

Table 1 Aquatic Insect Functional Feeding Groups

Functional Group	**Dominant Food**
Collector-filterers	Water-borne fine particulate organic matter
Collector-gatherers	Sedimentary fine particulate organic matter
Shredders	Coarse particulate organic matter
Scrapers	Attached algae and associated material
Predators	Engulfers or piercers feeding on living animal tissue

Indices of species richness, evenness, and diversity have been developed to allow numerical comparisons of whole communities. Unpolluted environments have greater species richness, evenness, and diversity than polluted environments, which tend to be dominated by relatively few intolerant species.

2 DESCRIPTION OF THE SAMPLING STATIONS

The streams in Los Alamos and Guaje Canyons flow through the approximate centers of their canyons and are less than 1 m (3.3 ft) wide. Both streams occur in Los Alamos County, originate in the Jemez Mountains, are impounded at high-elevation reservoirs, and ultimately discharge into the Rio Grande. The approximate elevation at the Los Alamos Reservoir is 2,320 m (7,600 ft) asl (above sea level). The approximate elevation at the Guaje Reservoir is 2,430 m (8,020 ft) asl.

In May 1993, three permanent sample stations were placed in each of the canyons (Fig. 1). A fourth downstream station was monitored in middle Guaje Canyon from July to October 1993. The results obtained from this station are not reported herein because drought prohibited the establishment of a comparable station in Los Alamos Canyon. All stations are referred to by the first letter(s) of the canyon's name and a number. Number 1 is assigned to the station farthest upstream; number 2 is assigned to the middle station; and number 3 is assigned to the station farthest downstream. Hence, LA2 refers to the middle sampling station in Los Alamos Canyon.

The term "sampling station" refers to a 150-m (492-ft) stream reach, while "sampling site" refers to a particular location within a sampling area. All sampling sites were in riffle areas with some shading and a varied substrate. Such sites tend to have high macroinvertebrate diversities and provide the best opportunities for collecting the greatest number of taxa that a stream is capable of supporting. In both canyons, sampling sites were selected for similarities in stream reaches, shading, on-bank vegetative cover, substrates, and surrounding plant communities. In each canyon

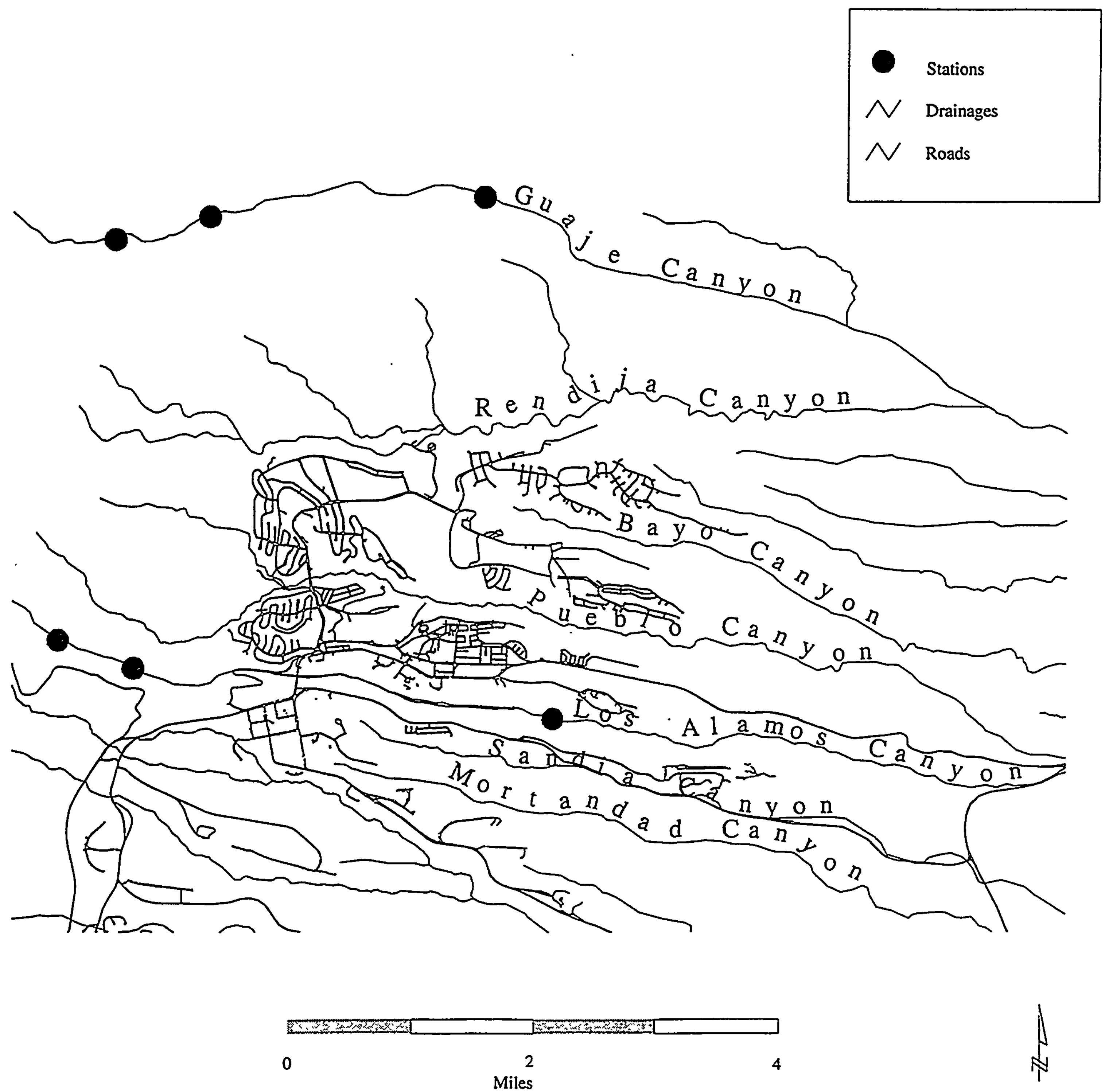


Fig. 1 Locations of Aquatic Invertebrate Stations

- sampling station 1 was located in spruce-fir approximately 0.4 km (0.25 mile) above the reservoir,
- sampling station 2 was approximately 1.1 km (0.7 mile) below the reservoir in mixed conifer, and
- sampling station 3 was at least 3.5 km (2.2 mile) below the reservoir in mixed conifer.

Reduced snowfall in Los Alamos County during the winter of 1993–1994 caused a reduction in the subsequent 1994 spring runoff. This runoff was not forceful enough to flush sand, gravel, and other fine sediments downstream as normally occurs. Therefore, all sampling stations had significantly more of these small particles present in 1994 than in 1993. Such fine materials can block the interstitial spaces that aquatic macroinvertebrates require for protection from predators and currents. This can lead to a reduction in the number of available habitats and taxa diversity (March 1976).

2.1 Los Alamos Canyon

Upper Los Alamos Canyon is within the Santa Fe National Forest (SFNF) in an area frequented by hikers, joggers, campers, and fishers. In the upper canyon, the stream flows into a fish-stocked reservoir. Middle and lower Los Alamos Canyon pass through LANL property. The lower two sampling stations could be affected by traffic on nearby roads, a public ice-skating rink, and operations at TA-2, which contains the Omega reactor and a wastewater outfall that discharges into the stream.

None of EST's Los Alamos Canyon sampling stations contained exposed bedrock. The stream channel supported little or no emergent vegetation. The 3 stations showed differences in surrounding vegetation, stream flow, and substrate.

At an approximate elevation of 2,380 m (7,860 ft) asl, LA1 is in the SFNF and approximately 0.6 km (0.4 mile) above the Los Alamos Reservoir. A heavily used footpath begins at the approximately 2.0-acre reservoir and runs beside the stream up to and beyond LA1. In this area, several large logs have fallen into the stream which forms a series of alternating riffles and shallow pools. LA1 is in the spruce-fir plant community with Engelmann spruce (*Picia engelmannii*), aspen (*Populus tremuloides*), and (*Jamesia americana*) as the dominant trees and shrubs. The streamside understory is primarily cutleaf coneflower (*Rudbeckia laciniata*), nodding brome (*Bromus anomalus*), redtop (*Agrostis alba*), wild raspberry (*Rubus strigosus*), Junegrass (*Koelaria cristata*), and horsetails (*Equisetum* sp.). The stream bed consists of cobbles of various sizes and small amounts of sand and gravel. Stream flow was fairly consistent at this station during our six-month sampling program.

At an approximate elevation of 2,250 m (7,420 ft) asl, LA2 is in the SFNF and approximately 1.1 km (0.7 mile) below the reservoir. An unpaved road runs along the stream, and traffic from this roadway contributes to stream sedimentation. LA2 is within the spruce-fir plant community and is shaded by a nearby steep slope to the south. The dominant trees are white fir (*Abies concolor*), water birch (*Betula occidentalis*), Douglas-fir (*Pseudotsuga menziesii*), and Engelmann spruce. The streamside understory consists of nodding brome, redtop, smooth brome (*Bromus inermis*), cutleaf coneflower, Fendler's rose (*Rosa woodsii*), and horsetails. The flow at LA2 varied greatly during both years and the stream bed was dry in August and October of 1993 and July and October of 1994. Periodic torrents had cut the stream channel much deeper than at LA1. The stream bed substrate consisted primarily of large rocks and large amounts of sand.

At an approximate elevation of 2,070 m (6,840 ft) asl, LA3 is in LANL's Operable Unit 1098 and approximately 4.8 km (3.0 miles) downstream from LA2. LA3 is located along a dirt road just downstream from TA-2 where a wastewater outfall empties into the stream. The outfall has introduced radionuclides into the stream during accidental spills, as recently as 1993. LA3 is within the mixed-conifer plant community. The dominant trees are Ponderosa pine (*Pinus ponderosa*), Douglas-fir, and Gambel's oak (*Quercus gambelii*). The streamside understory vegetation is Canadian wildrye (*Elymus canadensis*), redtop, Colorado barberry (*Berberis fendleri*), and bromegrass (*Bromus* sp.). The stream substrate consisted of rocks, silts, and sands. The flow at LA3 during 1993 was highly variable, and the stream channel was dry in July, September, and October of 1993 and July through August of 1994.

2.2 Guaje Canyon

All Guaje Canyon sampling stations are within the SFNF, and access to the area is periodically restricted. It is considerably less disturbed than Los Alamos Canyon and was used as a control in this study. None of the stations within Guaje Canyon contained exposed bedrock. The stream flow at all stations was very consistent, and none of the stations were dry during the two six-month sampling periods. Some logs were in the stream at all stations, but there were differences in surrounding vegetation, stream flow, and substrate.

At an approximate elevation of 2,450 m (8,100 ft) asl, G1 is approximately 0.3 km (0.2 mile) above the Guaje Canyon reservoir. A footpath runs along the stream above the reservoir, but it receives much less use than the path above Los Alamos Reservoir. A steep outcrop of rock to the south shades much of this stream stretch. G1 is within the spruce-fir plant community. Dominant trees and shrubs are white fir, limber pine (*Pinus flexilis*), Engelmann spruce, Rocky Mountain maple (*Acer glabrum*), and cliffbush. The streamside understory is nodding brome, mountain parsley (*Pseudocymopterus* *montanus*), Junegrass, cutleaf coneflower, and bluebunch wheatgrass (*Agropyron spicatum*). The substrate consisted of various-sized stones with sand accumulating in slower flowing areas.

At an approximate elevation of 2,375 m (7,840 ft) asl, G2 is approximately 1.1 km (0.7 mile) downstream from the approximately 0.125-acre reservoir. Below the reservoir, an infrequently used dirt road is near the stream and it crosses the stream channel several times. G2 is within the spruce-fir plant community. The dominant trees and shrubs are Douglas-fir, white fir, Engelmann spruce, limber pine, and cliffbush. The streamside understory is common timothy (*Phleum pratense*), bluebunch wheatgrass, cutleaf coneflower, nodding brome, redtop, and gooseberry (*Ribes inerme*). The stream substrate consisted of various-sized cobbles and some gravel.

At an approximate elevation of 2,250 m (7,430 ft) asl, G3 is approximately 2.5 km (1.5 mile) downstream from G2. G3 is within the mixed conifer plant community and is bordered by a northern hillside and a southern level area. The dominant trees and shrubs are water birch, Douglas-fir, ponderosa pine, and cliffbush. The streamside understory consists of nodding brome, redtop, Fendler's rose, mountain parsley, and raspberry. The substrate contained large amounts of sand and gravel with scattered large rocks and pockets of cobbles.

3 METHODOLOGY

3.1 Habitat Evaluation

In 1993, EST recorded qualitative habitat descriptions at each sampling site monthly. These parameters included substrate composition, bedrock, aquatic vascular plants, logs in the stream, shading, overhanging plant species, and other narrative characteristics. This data may someday be useful in determining specific aquatic macroinvertebrate habitat preferences and associations, but it has not yet been systematically reviewed.

The US EPA has developed a series of measures to assess the quality of aquatic habitat in stream riffle and run areas (Plafkin et al. 1989). These parameters assess conditions at specific sites and larger stream reaches. According to their relative influence on stream habitat, the twelve habitat parameters (Appendix 4-A) are divided into three groups:

- primary — bottom substrate instream cover, embeddedness, flow, and canopy cover (shading);
- secondary — channel alteration, bottom scouring and deposition, pool riffle and run ratio, and lower bank channel capacity;
- tertiary — upper bank stability, bank vegetative protection, streamside cover, and riparian vegetative zone.

The groups are scored so that primary parameters receive the greatest weight and tertiary parameters the least. Each parameter is assigned a score from a table of values, with higher scores reflecting higher quality habitat. The scores are then summed to yield an overall numerical habitat assessment. This sum is not intended to directly translate into narrative categories of habitat quality. Instead, the score provides a means of combining several habitat parameters into a single value that provides a comparative method to evaluate stream habitat.

EPA recommends that a single individual perform all comparative habitat assessments to standardize any prejudices and/or preferences that may influence the scoring. I, therefore, personally conducted all habitat assessments in both canyons. Flow rates at all sampling sites were too low to assess with the provided table of values, and this parameter was discarded from the summations.

3.2 Water Quality Measurements

During the 1993 and 1994 sampling seasons, six sampling stations were monitored monthly in Guaje and Los Alamos Canyons. Measurements of water temperature, pH, DO, and conductivity of stream water were taken with calibrated instruments in accordance with the manufacturer's specifications. All measurements were taken at least three times, and the averaged monthly values are reported. If a measurement differed greatly from the other two taken at a site, one or two further measurements were taken and the average computed from all four or five values.

Water temperature was measured in degrees Celsius with the temperature probe of a Yellow Springs Instrument model 57 DO meter. All pH measurements were taken with an Orion SA 250 pH meter set to the tenths scale. Conductivity was measured with a VWR digital conductivity meter which displays the conductivity in units of μmhos/cm.

DO was measured in units of mg/l with a Yellow Springs Instrument model 57. DO is temperature and altitude dependent. To correct for altitude, we multiplied the calibration readings by 0.78, the compensation value for 2047 m (6717 ft). The percent saturation was calculated by dividing the corrected DO reading by the saturation value at the appropriate water temperature.

3.3 Aquatic Macroinvertebrate Sampling

Aquatic macroinvertebrates were collected monthly at the same time that water quality parameters were measured. Sample sites had cobble substrates in stream riffles, which were subjectively determined to be the best available habitats. Aquatic invertebrates were collected with a 0.47-m (18.5-in) wide rectangular kick net with a mesh size of 800 X 800 microns. One person positioned the net across the stream and against the bottom while another agitated the substrate in front of the net. Clinging and attached invertebrates were dislodged and carried by the stream current into the net. We used a scrub brush to remove resistant invertebrates from rocks in the sample site. Larger rocks were visually inspected to ensure that no invertebrates had been overlooked. We sampled a contiguous streambed area measuring approximately 0.25 m^2 (0.30 yd^2).

Collected debris, sand, gravel, and invertebrates were rinsed into a bucket of stream water. As one person swirled and poured the water from the bucket, the other held the net to catch the lighter debris and suspended invertebrates. Several rinses were made, and the material remaining in the bucket was carefully inspected for invertebrates not washed into the net. All debris and invertebrates washed into the net were placed in a labeled 500-ml Nalgene bottle, preserved in 70% ethanol, and taken to the lab for analysis.

Three replicate samples were taken from each sampling area. These were kept separate from one another, i.e., no compositing occurred. The canyons were sampled monthly and within 7 days of each other. All sampling sites were clearly marked with flagging to avoid taking consecutive monthly samples at the same site. In general, sites should not be resampled for at least 6 weeks to allow adequate time for recolonization.

The "best" sample, i.e., the one containing the greatest numbers or variety of macroinvertebrates, of the three taken from each sampling site was analyzed. If samples appeared to be similar, the one taken farthest upstream was analyzed. In the lab, the alcohol was carefully poured into a sorting tray and checked for invertebrates. The alcohol was then poured into a disposal container labelled as containing hazardous waste. Water was added to the Nalgene bottle and the sample poured into sorting trays. Pickers separated invertebrates from the organic detritus and rocks present in the sample. Invertebrates were placed in scintillation vials of 70% ethanol to await identification. All sorting trays were checked under magnification before being discarded.

Identification was accomplished with a Bausch and Lomb Stereozoom dissecting binocular microscope. A trained entomologist identified specimens using standard references, including Baumann et al. 1977, Edmunds 1976, Merritt and Cummins 1984, Pennak 1978, and Wiggins 1977. Specimens were identified to genus when possible and stored in vials of 70% ethanol in the EST invertebrate collection. Identifications were confirmed by Gerald Z. Jacobi of New Mexico Highlands University, who has conducted numerous aquatic invertebrate studies throughout New Mexico. All macroinvertebrates collected in this study were archived in EST's permanent collection.

3.4 Macroinvertebrate Analysis

Rapid Bioassessment Protocols. The US EPA recently published the *Rapid Bioassessment Protocols for Use in Streams and Rivers* (Plafkin et al. 1989). The protocols are a series of integrated analytical techniques for using macroinvertebrate data to assess the degree of stream impact. A primary goal of the Rapid Bioassessment Protocols (RBPs) is to allow nationwide comparisons of streams and stream conditions.

This study uses the RBP III metrics, which require genus-level identifications for most specimens. Seven semi-quantitative measures, or "metrics," of the aquatic environment were computed. In all metrics except "percent contribution of dominant taxon," the study site (in Los Alamos Canyon) is compared to a reference site (in Guaje Canyon). EST calculated all metrics for both Guaje and Los Alamos Canyons monthly to provide a thorough comparison of the streams. The *Rapid Bioassessment Protocols for Use in Streams and Rivers* emphasizes that these measures may require modification for use in a particular area; and the current study modified metrics 2 and 4. A brief explanation of the 7 RBP III metrics follows.

Metric 1: Taxa Richness

This metric reflects the health of the community by measuring the numbers of taxa present. Taxa richness generally increases with improving water quality, habitat diversity, and/or habitat suitability.

Metric 2: Modified Hilsenhoff Biotic Index (Community Tolerance Quotient)

Hilsenhoff's tolerance values range from 0 to 10, increasing as water quality decreases. This metric was performed on the family level because of difficulty in determining genera of Chironomidae (order Diptera) present. The formula for the index is

$$HBI = \Sigma(xt)/n$$

where
- x = number of individuals within a species,
- t = tolerance value of a taxon (found in a published table of values), and
- n = total number of organisms in the sample.

After computation for all samples collected in 1993, the modified Hilsenhoff biotic index was dropped from further consideration. The calculated values for all stations during all months were very high (even when all other metrics were 0), and thus afforded little insight into the relative condition of the streams. The Hilsenhoff biotic index was developed for higher-order streams of Wisconsin and may have little applicability to first-order streams of New Mexico.

In analyzing the 1994 data, we included a Community Tolerance Quotient developed to assess the impacts of nonpoint source pollution in the western United States (Winget and Mangum 1979). This system has been previously used in the Jemez Mountains to effectively evaluate stream quality (Jacobi 1989, 1990, and 1992). Tolerance quotients for aquatic macroinvertebrate taxa range from 6 (the most sensitive) to 108 (the least sensitive) and are based upon tolerances to alkalinity, sulfates, and sedimentation (see Appendix 4-B). The Community Tolerance Quotient is computed using the HBI formula with Winget and Mangum's list of tolerances. The scoring criteria developed for the HBI are then used to assign a biological condition score.

Metric 3: Ratio of Scrapers to Filtering Collectors

The proportion of these feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source. Scrapers increase with increased diatom abundance and decrease as filamentous algae and aquatic mosses increase. However, filamentous algae and aquatic mosses provide good attachment sites for filtering collectors; and the organic enrichment often responsible for overabundance of filamentous algae provide fine particulate organic matter used by the filterers. Therefore, sites subjected to organic enrichment have lower metric 3 values than undisturbed sites.

Metric 4: Ratio of EPT to Chironomidae Abundances (Total Number of EPT Individuals)

The Ephemeroptera, Plecoptera, Trichoptera (EPT) and Chironomidae abundance ratio uses relative abundance of these indicator groups as a measure of community balance. Skewed populations with a disproportionate number of the generally tolerant Chironomidae relative to the more sensitive EPT groups may indicate environmental stress. Most of the samples collected in this study contained few, if any, Chironomids. Therefore, this metric was changed to compare totals of EPT individuals collected at the two sites. Henceforth, Metric 4 will be referred to as "Total Number of EPT Individuals".

Metric 5: Percent Contribution of Dominant Taxon

This metric gives an indication of community balance at the lowest positive taxonomic level. A community dominated by relatively few species would indicate environmental stress.

Metric 6: EPT Index

The EPT Index is the total number of distinct taxa within the pollution-sensitive Ephemeroptera, Plecoptera, and Trichoptera orders. The index value generally increases with increasing water quality.

Metric 7: Community Loss Index

The Community Loss Index measures the loss of benthic species between a reference station and a study station. Plafkin (1989) offers three methods of computing community dissimilarity. Based on our preliminary data analysis, the Community Loss Index provided greater discrimination between sites than Jaccard's Coefficient of Community or the Index of Similarity (Klemm 1990). The Community Loss Index is calculated as follows:

$$CLI = (d-a)/e$$

where a = number of taxa common to both samples,
d = total number of taxa present at reference station, and
e = total number of taxa present at study station.

Biological Condition Score

Each metric is calculated independently of the others. In most cases, the computed value for the study site is divided by the computed value for the reference site to yield a percent similarity value. This percent value is assigned a biological condition score of either 0, 2, 4, or 6 from a reference chart that evaluates each metric separately. The biological condition score assesses the degree of community impairment. A score of 6 signifies no impairment, while a score of 0 signifies severe impairment.

The biological condition scores from all metrics are totaled and compared to the total possible. This final comparison between total scores provides an overall monthly bioassessment of the study site (Table 2). In order to provide more general comparisons and conclusions, we also reported six-month and two-year averages of the biological condition totals.

Table 2 Interpretative Chart for the Total Biological Condition Scores and Associated Impairment Categories from Plafkin et al. (1989)

Percentage Comparison to Reference Score	**Biological Condition Category**	**Attributes**
>83%	Nonimpaired	Comparable to the best situation to be expected within an ecoregion. Balanced trophic structure. Optimum community structure (composition and dominance) for stream size and habitat quality.
54 - 79%	Slightly impaired	Community structure less than expected. Composition (species richness) lower than expected due to loss of some intolerant forms. Percent contribution of tolerant forms increases.
21 - 50%	Moderately impaired	Fewer species due to loss of most intolerant forms. Reduction in EPT index.
<17%	Severely impaired	Few species present. If high densities of organisms, then dominated by one or two taxa.

Other Measures of Macroinvertebrate Communities. Utilization of the EPA RBP's requires two streams: a reference and a study stream. The middle and lower Los Alamos stations were completely dry on several sampling dates, eliminating the possibility of collecting samples there. However, samples were taken in Guaje Canyon throughout the two six-month sampling seasons. In order to compare these collections to the other samples, two additional measures of the aquatic community were computed: standing crop and a biodiversity index.

Standing Crop. Standing crop is a measure of macroinvertebrate density expressed as the number of macroinvertebrates/m^2. Our sampling methodology is considered to be semi-quantitative: the accuracy of our reported densities is uncertain. Although standing crop is related to productivity, it should be noted that a single large stonefly (Plecoptera) larva can possess more than fifty times the size and mass of an early-instar midge (Chironomidae) larva.

Biodiversity Index. A biodiversity index was calculated monthly for each station using the equation discussed by Wilhm (1967):

$$D = (S-1) / \ln N$$

where D= the taxa diversity index,
S = the number of taxa, and
N = the number of individuals.

The derived number gives a much better single assessment of a site's species richness and evenness than any single RBP metric. A diversity index value of less than 1 indicates heavy pollution, between 1 and 3 indicates moderate pollution, and greater than 3 indicates clean water. However, biodiversity values for low-order montane streams are notoriously low and should not be compared to higher-order and lower elevation streams.

A special effort was made to ensure that taxa were not counted twice; and if a counting error occurred, it was due to under-counting rather than over-counting. Therefore, we only counted one taxon in a sample for the following cases:

- different life stages of a taxon present,
- specimen(s) keyed to the family level and another specimen(s) in the same family identified to a lower level, and
- possible different instars of a genus assigned separate descriptive, rather than taxonomic, identifications.

4 RESULTS AND DISCUSSION

4.1 Habitat Assessment

In 1994, habitat assessments for riffle and run stream areas were conducted monthly in Los Alamos Canyon from June through September and in Guaje Canyon from July through September (Table 3). All Guaje stations and LA1 were roughly similar in their assessment totals, and I judge the aquatic habitat at these stations to be high quality when compared to other first-order streams in the area. LA2 and LA3 scored lower than the other stations, and it is significant that these stations were dry on some sampling dates.

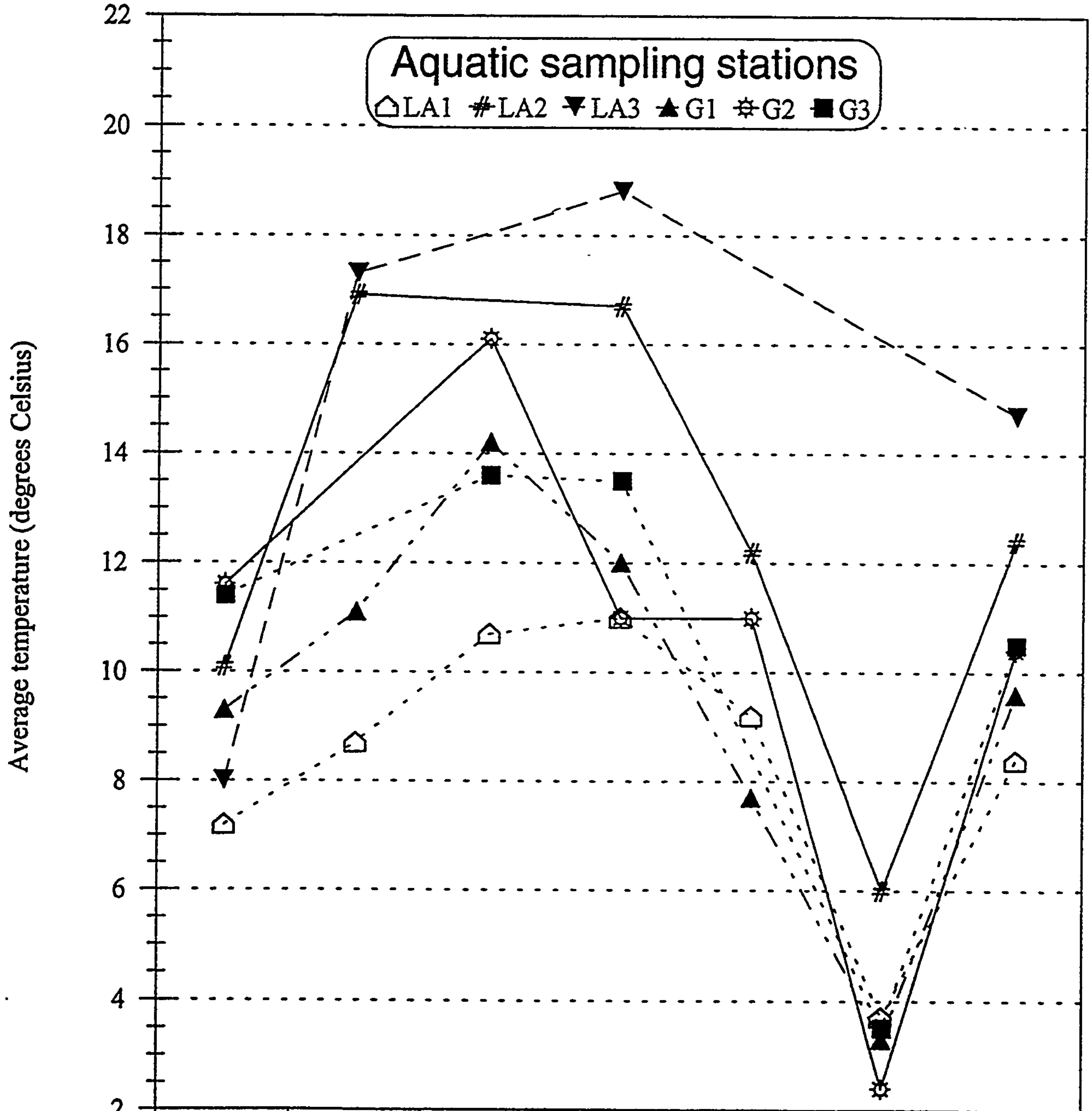
Table 3 Habitat Assessment Summations for the 1994 Sampling Stations

Station	June	July	August	September	Average*
LA1	112	128	106	122	117
LA2	91	dry	97	119	102
LA3	107	dry	dry	dry	107
G1	not assessed	121	116	115	117
G2	not assessed	113	126	119	119
G3	not assessed	115	117	120	117

* when water was present

4.2 Water Quality Measurements

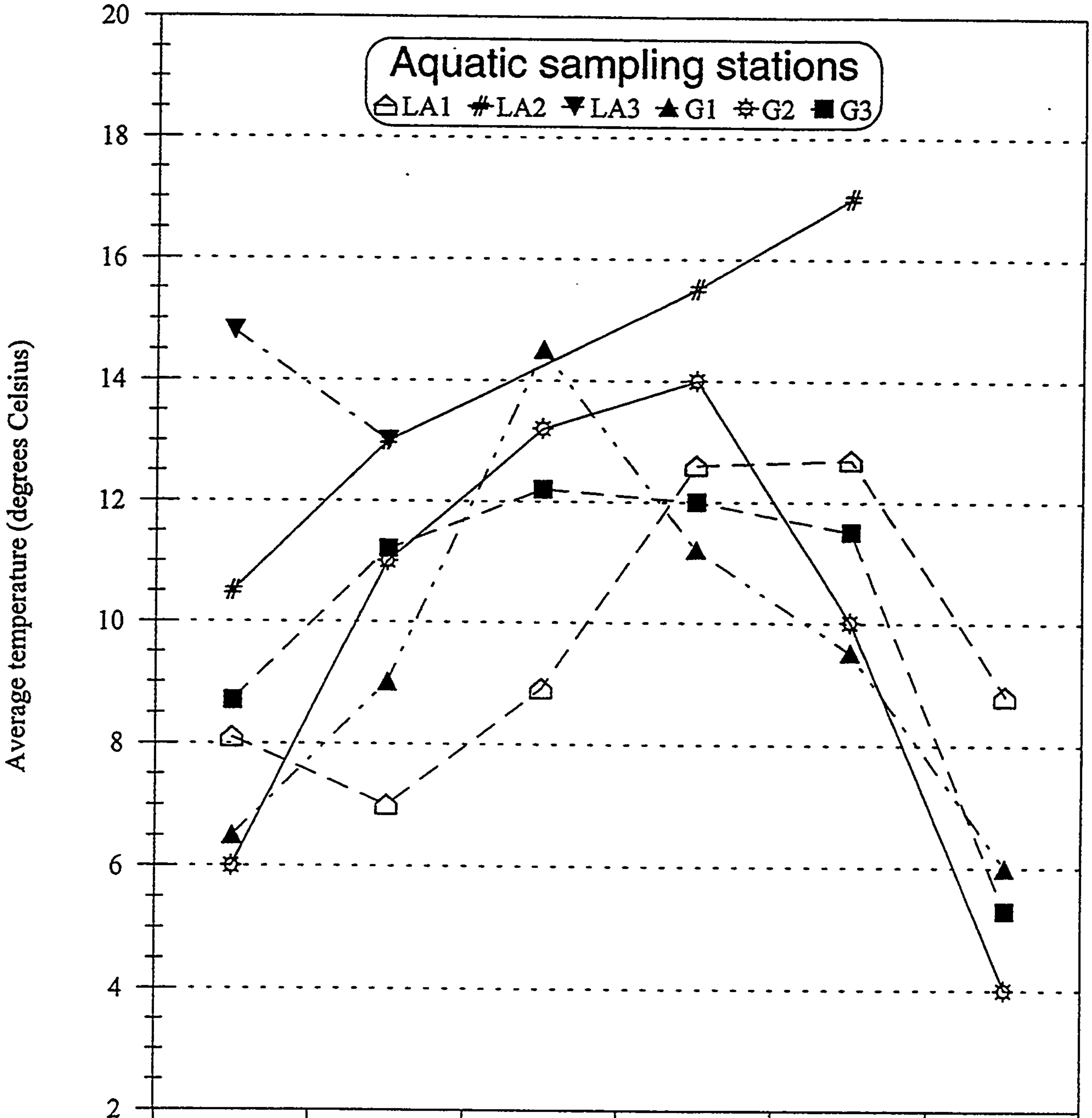
Temperature. Figures 2 and 3 show the monthly water temperatures for both canyons. The six-month and two-year average temperatures are listed in Table 4. In both streams, the lowest temperatures occurred upstream and the highest downstream. In terms of the two-year averages, the temperatures at comparable stations were slightly higher in



	May	June	July	August	September	October	Average
LA1	7.2	8.7	10.7	11	9.2	3.7	8.4
LA2	10.1	16.9	dry	16.7	12.2	6	12.4
LA3	8	17.3	dry	18.8	dry	dry	14.7
G1	9.3	11.1	14.2	12	7.7	3.3	9.6
G2	11.6		16.1	11	11	2.4	10.4
G3	11.4		13.6	13.5		3.5	10.5

Month sampled

Fig. 2 Monthly 1993 Water Temperatures



	May	June	July	August	September	October
LA1	8.1	7	8.9	12.6	12.7	8.8
LA2	10.5	13	dry	15.5	17	dry
LA3	14.8	13	dry	dry	dry	dry
G1	6.5	9	14.5	11.2	9.5	6
G2	6	11	13.2	14	10	4
G3	8.7	11.2	12.2	12	11.5	5.3

Month sampled

Fig. 3 Monthly 1994 Water Temperatures

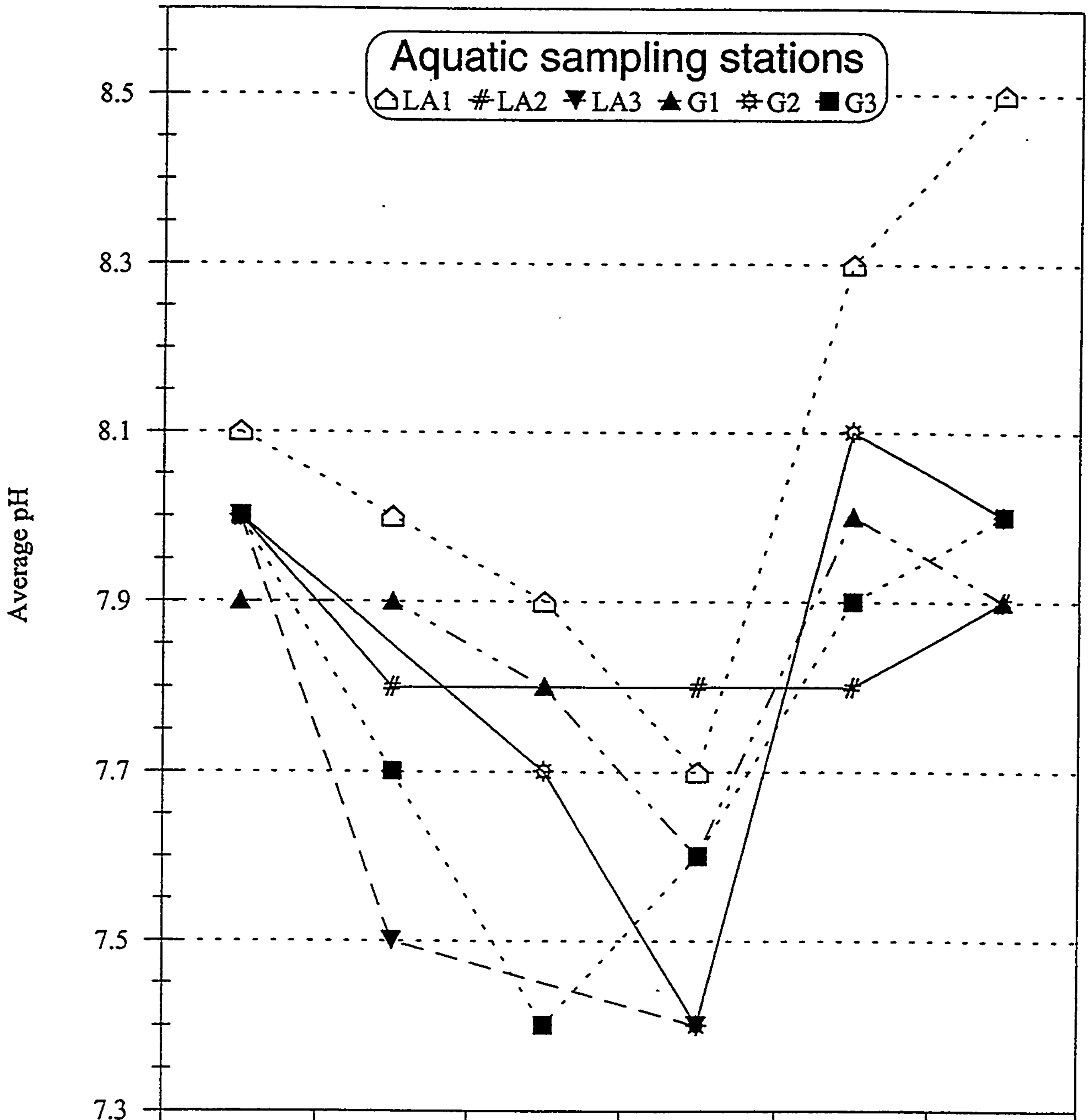
upper Guaje (0.5°C) and considerably higher in middle (3.2°C) and lower Los Alamos (3.9°C). The differences at the middle and lower stations would be even greater, but the stream completely dried up, preventing temperature readings during some of the warmest months.

The thermal increase at the downstream Los Alamos Canyon stations is not due to LANL operations because the greatest variance occurred between LA1 and LA2, both within the SFNF. Instead, the observed high temperatures are caused by the large reservoir in Los Alamos Canyon, which is situated between LA1 and LA2. The Los Alamos Reservoir impounds water behind a large dam, allowing only warmed surface water to escape over the spillway. The dam is also responsible for the summer stream drought because it impedes water movement downstream except during periods of peak flow. These downstream droughts are undoubtedly the most serious impacts to LA2 and LA3, periodically eliminating their macroinvertebrate communities.

Table 4 Average Water Temperatures in Degrees Celsius for the 1993 and 1994 Sampling Seasons

Sampling Station	Los Alamos 1993, 1994	Los Alamos, Two-year	Guaje 1993, 1994	Guaje, Two-year
1	8.4, 9.7	9.0	9.6, 9.4	9.5
2	12.4, 14.0	13.2	10.4, 9.7	10.0
3	14.7, 13.9	14.3	10.5, 10.2	10.4

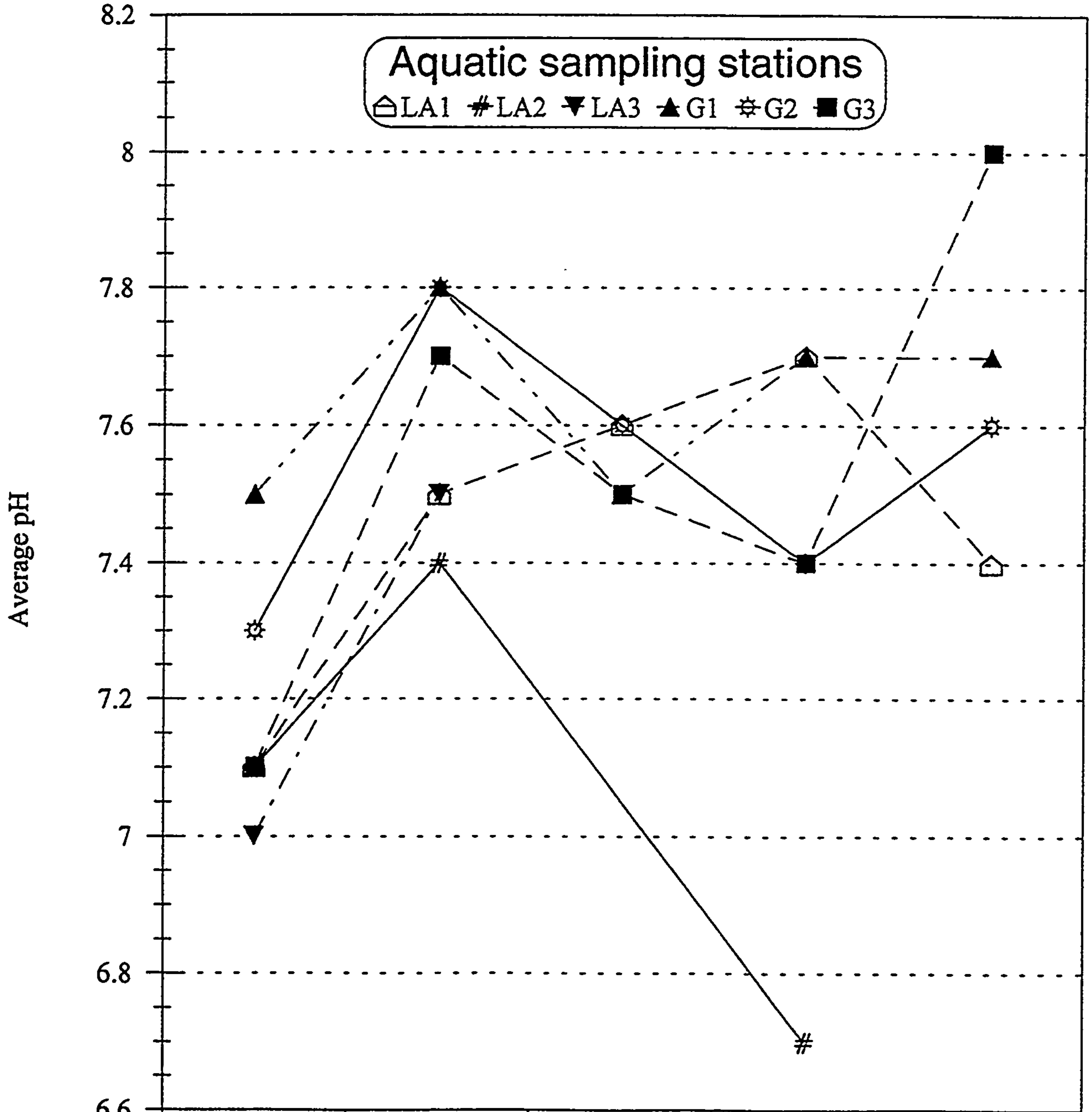
pH. In Los Alamos Canyon, the pH of natural surface waters ranges between 7.8 and 8.2 (LANL 1990). The average monthly pH readings of both streams showed little overall variance (Figs. 4 and 5), especially in Guaje Canyon. The greatest extreme variance in pH (0.8) recorded at a station in 1 year occurred at LA1. In Los Alamos Canyon, values tended to decrease downstream (Table 5). All pH readings in both canyons fall within the "excellent" range of the environmental water quality index based on pH (Batelle 1972; Fig. 6). The highest (8.5 from LA1 in October 1993) and the lowest



	May	June	July	Aug	Sep	Oct
LA1	8.1	8	7.9	7.7	8.3	8.5
LA2	8	7.8	dry	7.8	7.8	7.9
LA3	8	7.5	dry	7.4	dry	dry
G1	7.9	7.9	7.8	7.6	8	7.9
G2	8		7.7	7.4	8.1	8
G3	8	7.7	7.4	7.6	7.9	8

Month sampled

Fig. 4 Monthly 1993 pH



	May	June	July	August	October
LA1	7.1	7.5	7.6	7.7	7.4
LA2	7.1	7.4	dry	6.7	dry
LA3	7	7.5	dry	dry	dry
G1	7.5	7.8	7.5	7.7	7.7
G2	7.3	7.8	7.6	7.4	7.6
G3	7.1	7.7	7.5	7.4	8

Month sampled

Fig. 5 Monthly 1994 pH

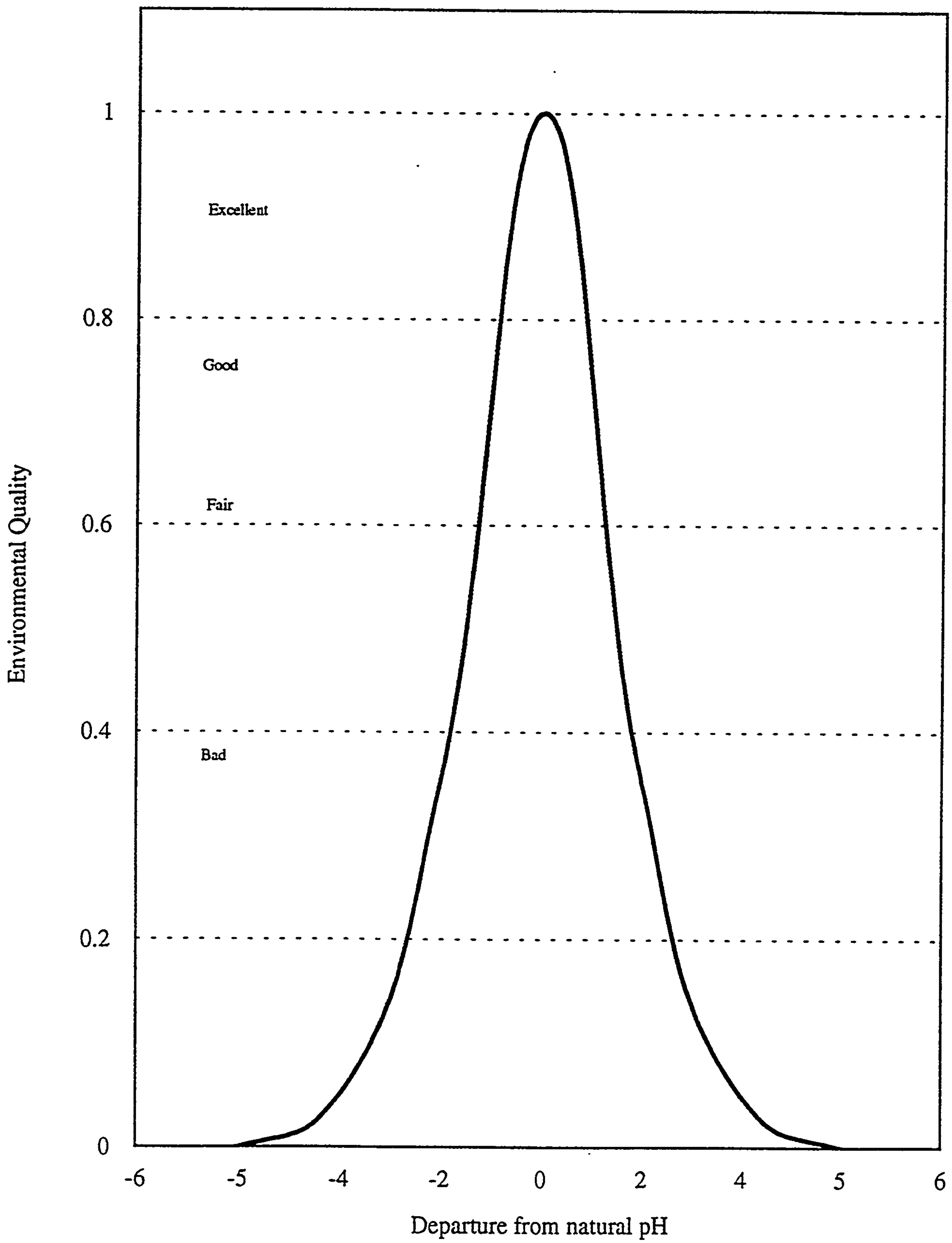


Fig. 6 Departure from Natural pH versus an Environmental Quality Index (Battelle 1972)

(6.7 from LA2 in August 1994) average monthly pH readings are both within the current New Mexico Water Quality Control Commission's limits for high-quality coldwater fisheries (State of New Mexico 1995).

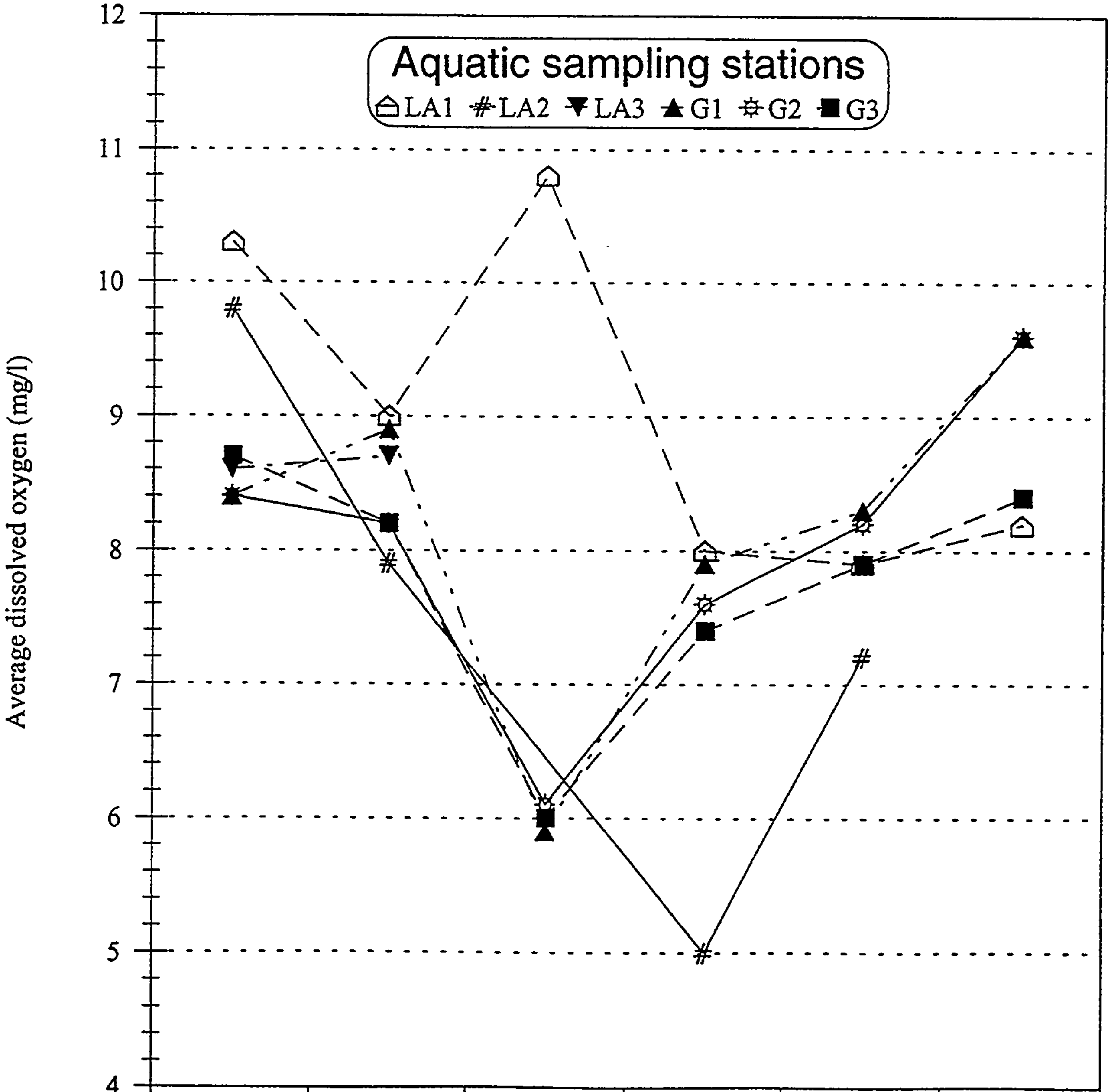
Table 5 Average pH for the 1993 and 1994 Sampling Seasons

Sampling Station	Los Alamos, 1993, 1994	Los Alamos, Two-year	Guaje, 1993, 1994	Guaje, Two-year
1	8.1, 7.5	7.8	7.8, 7.6	7.7
2	7.9, 7.1	7.5	7.8, 7.5	7.6
3	7.6, 7.2	7.4	7.8, 7.6	7.7

Dissolved Oxygen (DO) and Percent Dissolved Oxygen Saturation. Due to mechanical problems with the EST's DO meter, all 1993 DO measurements were deemed unreliable and are not included in this report.

In 1994, EST purchased a new YSI model 57 DO meter. The field readings of mg/l (Fig. 7) were converted to percent DO saturation (Fig. 8). Using the standards developed by Battelle (Fig. 9), the percent DO saturation was in the excellent range 70% of the time and the lowest saturation values recorded were in the fair range. The 6-month averages were LA1 79%, LA2 72%, LA3 84%, G1 70%, G2 71%, and G3 70%.

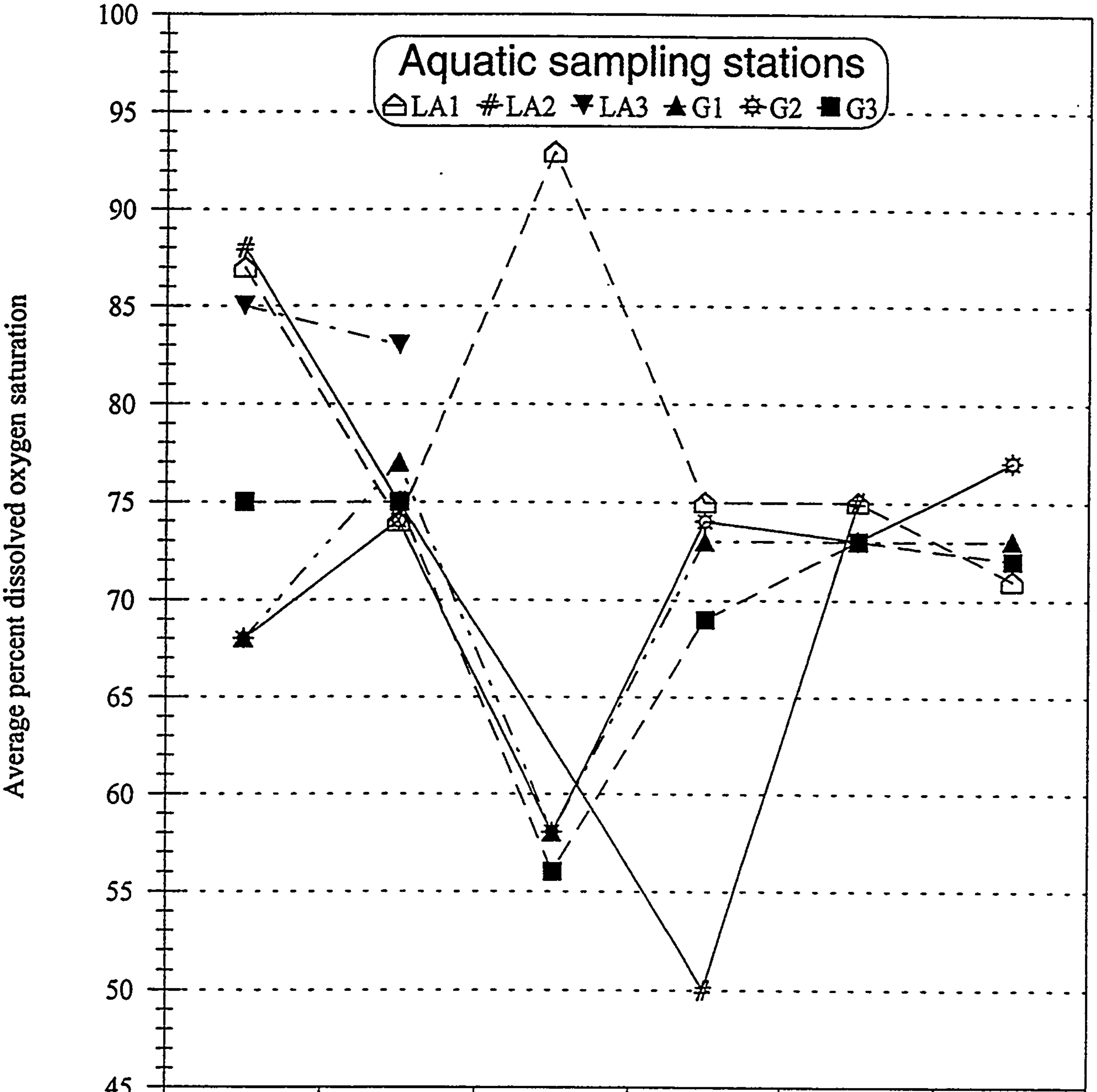
The DO values recorded for all Guaje stations in July were low and lowered the averages for these stations from the excellent range to the good range. Although the new meter was calibrated in the lab before each use, the accuracy of these DO measurements is uncertain. EST has ordered a new DO meter from a different manufacturer and will use it in future field studies.



	May	June	July	August	September	October
LA1	10.3	9	10.8	8	7.9	8.2
LA2	9.8	7.9	dry	5	7.2	dry
LA3	8.6	8.7	dry	dry	dry	dry
G1	8.4	8.9	5.9	7.9	8.3	9.6
G2	8.4	8.2	6.1	7.6	8.2	9.6
G3	8.7	8.2	6	7.4	7.9	8.4

Month sampled

Fig. 7 Monthly Dissolved Oxygen During 1994



	May	June	July	August	September	October
LA1	87	74	93	75	75	71
LA2	88	75	dry	50	75	dry
LA3	85	83	dry	dry	dry	dry
G1	68	77	58	73	73	73
G2	68	74	58	74	73	77
G3	75	75	56	69	73	72

Month sampled

Fig. 8 Monthly 1994 Percent Dissolved Oxygen Saturation

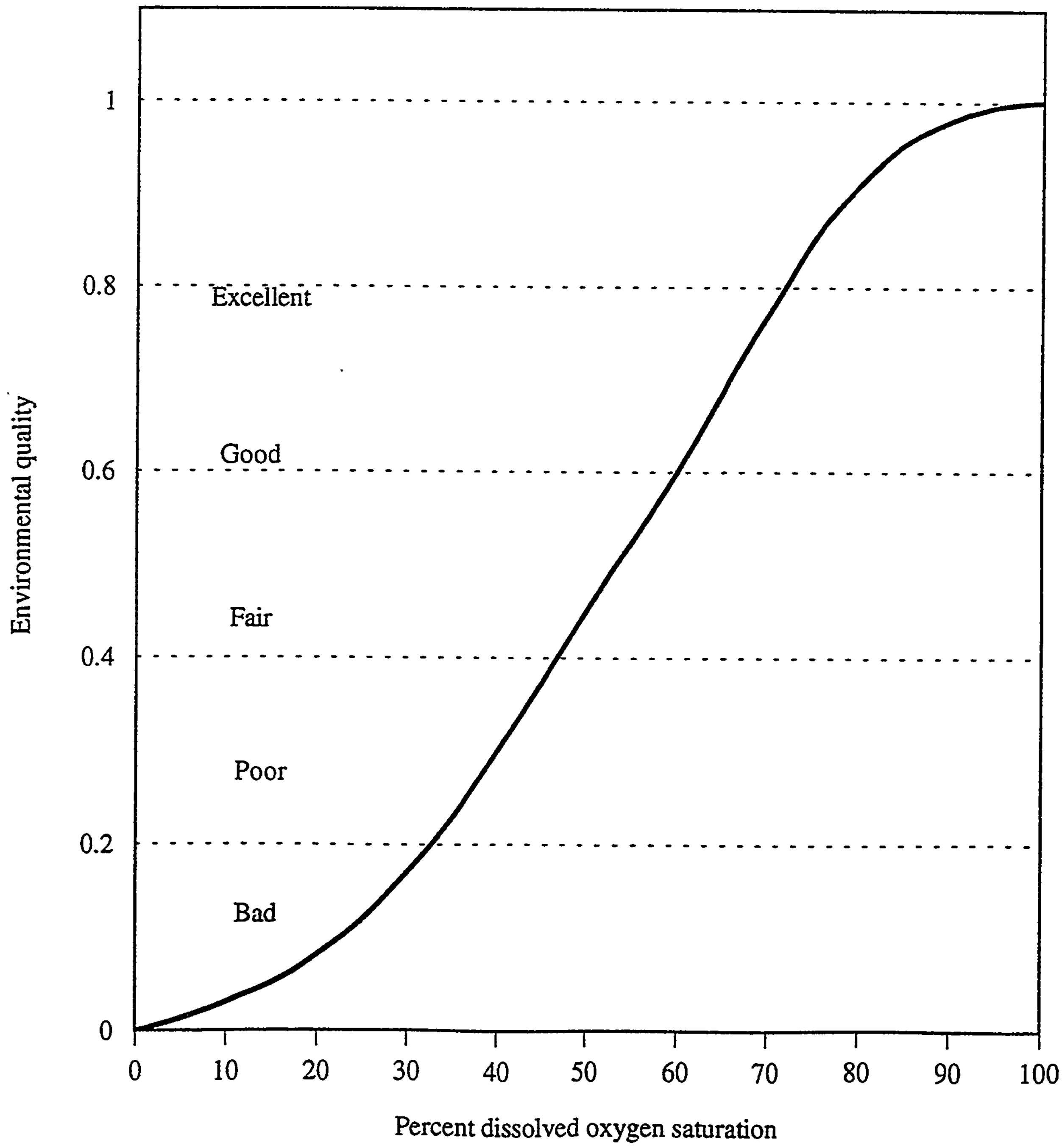


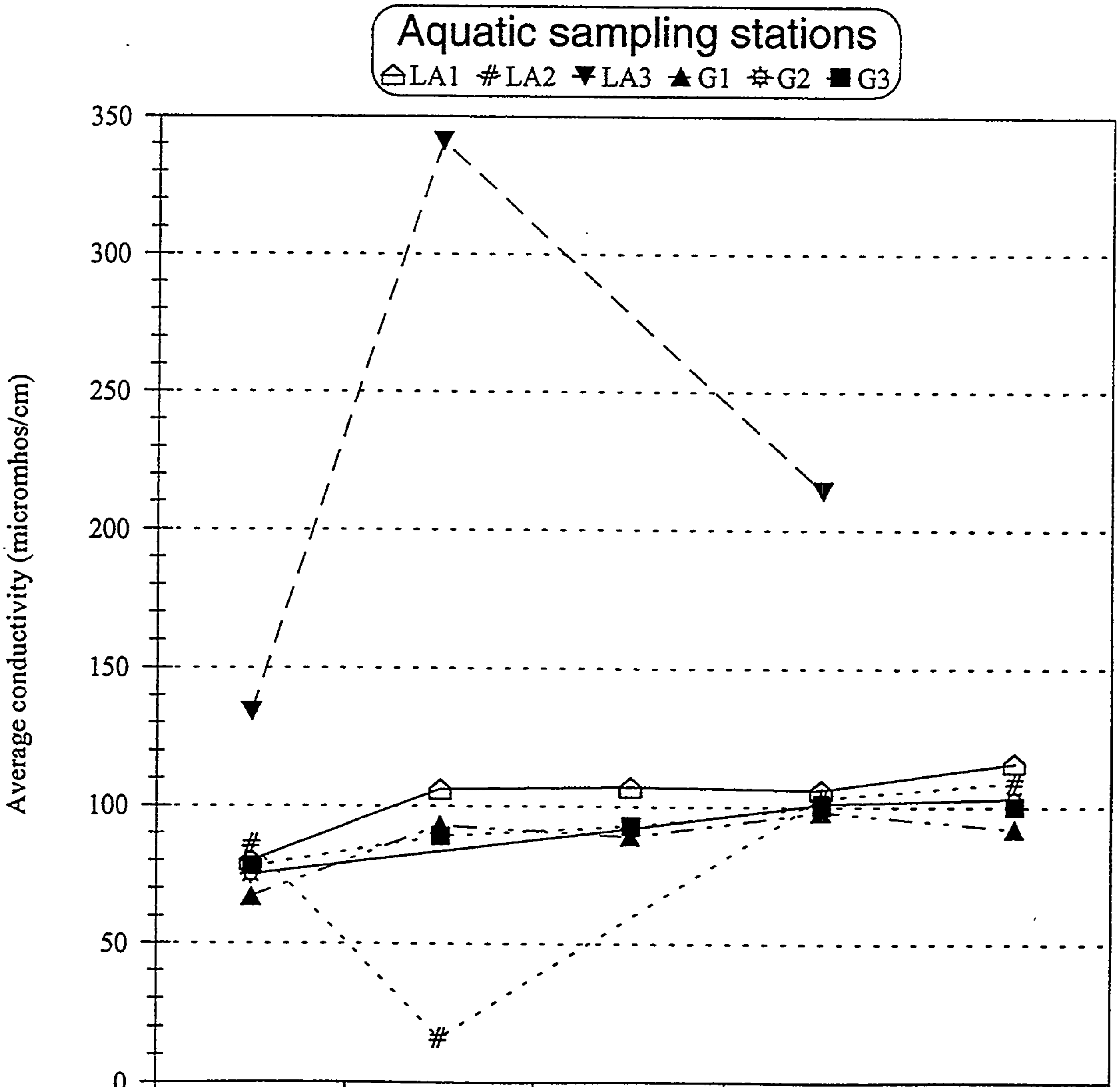
Fig. 9 Percent Dissolved Oxygen Saturation versus an Environmental Quality Index (Battelle 1972)

Conductivity and Total Dissolved Solids (TDS). The three highest monthly conductivity averages (225, 341, and 308 µmhos/cm) all occurred at LA3 (Figs. 10 and 11) and may be attributable to the outfall that discharges above the sampling station. However, the current New Mexico Water Quality Control Commission places the upper-permissible-conductivity limits for high-quality coldwater fisheries at 1,500 µmhos/cm (State of New Mexico 1995), depending on natural background levels. Thus, these seemingly high numbers actually represent acceptable conductivity readings.

A rough approximation of milligrams of TDS per liter of freshwater can be obtained by multiplying the conductivity by 0.66. Figures 12 and 13 illustrate estimated monthly TDS concentrations from both streams. Six-month averages clearly show that LA3 had significantly increased TDS values (Table 6). However, the TDS concentrations of all stations are well within the "excellent" range of the environmental water quality index developed by Battelle (1972) (Fig. 14). Aquatic organisms can generally tolerate TDS concentrations as high as 5000 mg/l, a concentration much higher than any found at the sample stations.

4.3 Macroinvertebrate Sampling

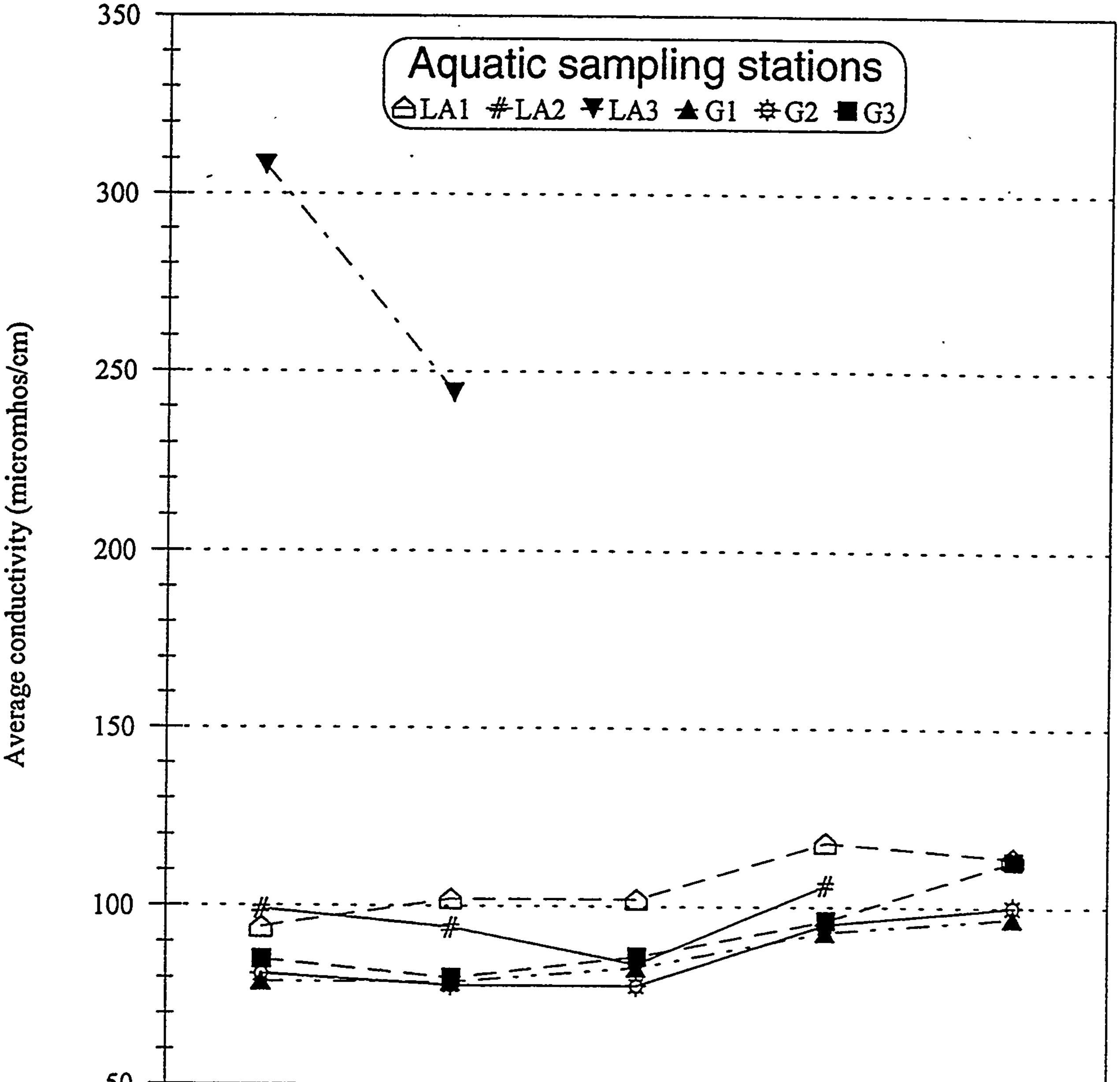
Our sampling program collected, identified, and analyzed over 35,000 aquatic macroinvertebrates. A total of 81 taxa of aquatic macroinvertebrates were collected in Guaje Canyon (Appendix 4-C) and 63 were collected in Los Alamos Canyon (Appendix 4-D).



	May	June	July	Aug	Sep
LA1	80	106	107	106	116
LA2	86	16	dry	103	109
LA3	134	341	dry	214	dry
G1	67	93	89	98	92
G2	75		92	101	103
G3	78	89	93	100	100

Month sampled

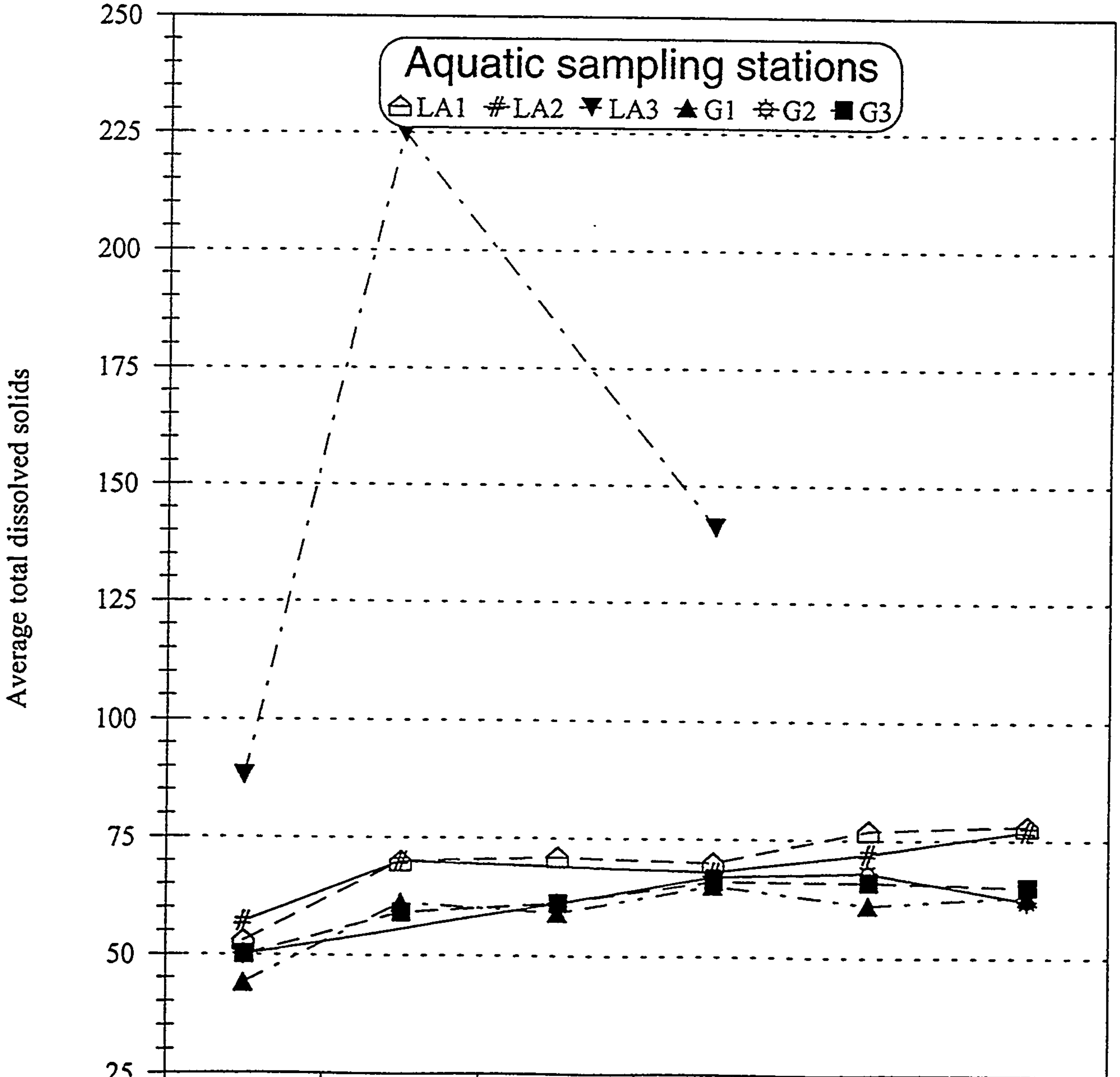
Fig. 10 Monthly 1993 Conductivity



	May	June	August	September	October
LA1	94	102	102	118	114
LA2	99	94	84	106	dry
LA3	308	244	dry	dry	dry
G1	79	79	83	93	97
G2	81	78	78	95	100
G3	85	80	86	96	113

Month sampled

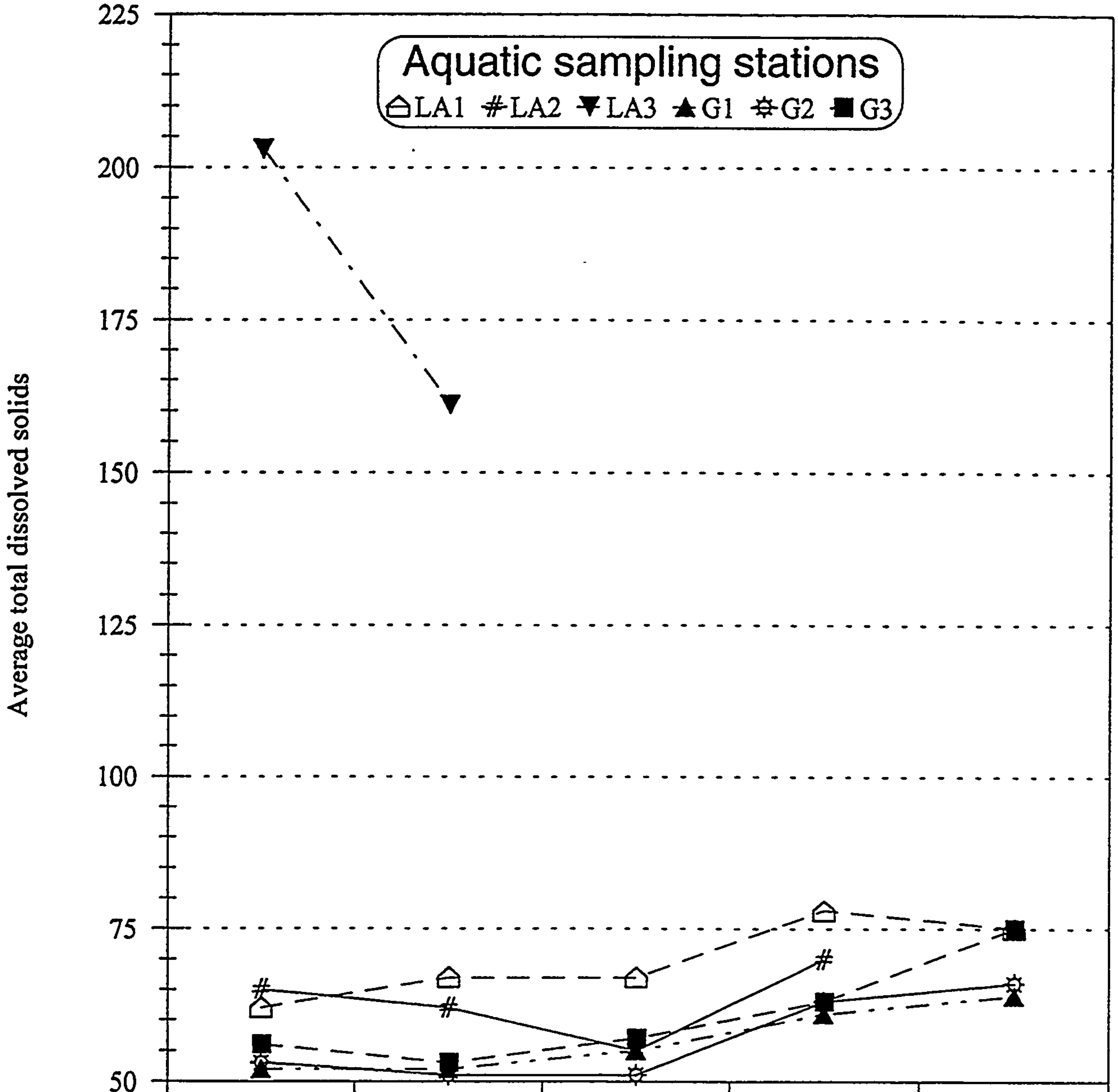
Fig. 11 Monthly 1994 Conductivity



	May	June	July	August	September	October
LA1	53	70	71	70	77	78
LA2	57	70	dry	68	72	77
LA3	88	225	dry	141	dry	dry
G1	44	61	59	65	61	63
G2	50		61	67	68	62
G3	50	59	61	66	66	65

Month sampled

Fig. 12 Monthly 1993 Total Dissolved Solids



	May	June	August	September	October
LA1	62	67	67	78	75
LA2	65	62	55	70	dry
LA3	203	161	dry	dry	dry
G1	52	52	55	61	64
G2	53	51	51	63	66
G3	56	53	57	63	75

Month sampled

Fig. 13 Monthly 1994 Total Dissolved Solids

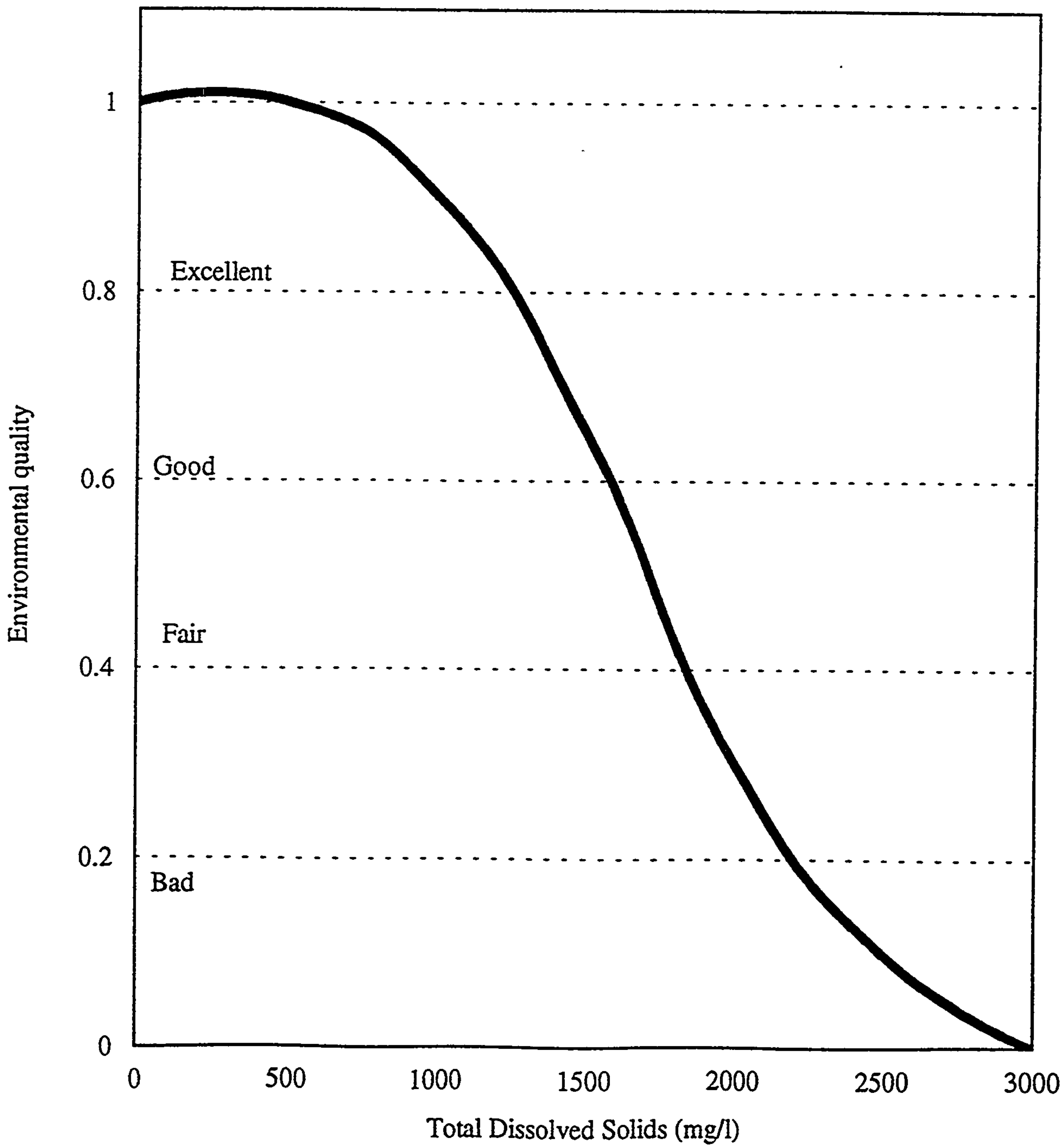


Fig. 14 Total Dissolved Solids versus an Environmental Quality Index (Battelle 1972)

Table 6 Average TDS (mg/l) for the 1993 and 1994 Sampling Seasons

Sampling Station	Los Alamos, 1993, 1994	Los Alamos, Two-year	Guaje, 1993, 1994	Guaje, Two-year
1	70, 70	70	59, 57	58
2	69, 63	66	62, 57	60
3	151, 182	166	62, 61	61

Many of these taxa have been previously reported from Los Alamos County and its surrounding watersheds (Appendix 4-E).

The samples included 48 taxa that were present in a canyon during 1, but not both, of the sampling years. In 42% (20/48) of these cases, the taxon was represented by a single individual. These rare taxa underscore the importance of maintaining yearly collections to accurately document resident aquatic communities.

Standing Crop. The six-month averages of standing crop per square meter show a pattern of decreasing macroinvertebrate numbers downstream except at G3 in 1994 (Table 7). In 1993, greater numbers of macroinvertebrates were collected at each of the Guaje Canyon stations when compared to their Los Alamos Canyon counterparts. In 1994, two of the Los Alamos stations had higher six-month averages, although the high LA2 average is primarily due to the large number of blackflies (Simulidae) present in the June sample.

Table 7 Monthly Standing Crop per Square Meter and Yearly Averages

Month Year	G1	G2	G3	LA1	LA2	LA3
May 1993	736	2204	1140	668	1710	182
June 1993	1412	860	976	640	2624	588
July 1993	2684	1336	960	612	dry	dry
Aug 1993	2808	1424	940	820	136	92
Sept 1993	2340	2872	1652	1232	248	dry
Oct 1993	2664	2856	2196	3172	dry	dry

Table 7 (cont.)

1993 Average *	**2107**	**1925**	**1311**	**1191**	**786**	**144**
May 1994	2228	3108	5348	2676	4228	280
June 1994	1840	2620	2568	2104	10440	576
July 1994	2368	1768	3604	7304	dry	dry
Aug 1994	4016	3056	1760	1968	252	dry
Sept 1994	2540	1748	2216	2788	1196	dry
Oct 1994	3516	2536	3760	4088	dry	dry
1994 Average*	**2751**	**2473**	**3209**	**3488**	**2686**	**143**
Two-year average	**2429**	**2199**	**2260**	**2340**	**1736**	**144**

* dry months counted as 0

Both streams contained significantly more sands and silts in 1994 than the previous year. The subsequent reduction of interstitial spaces required by many aquatic macroinvertebrates for protection from dislodgment by streamflow and refugia from predators was expected to be reflected in lower standing crops and taxa richness. However, the standing crop averages from both canyons were much higher overall in 1994 (taxa richness was also higher at the "best" sampling stations - G1, G2, G3, and LA1). The standing crop totals from each station are shown graphically for 1993 (Fig. 15) and 1994 (Fig. 16).

The Los Alamos Reservoir restricts the movement of fish downstream, and no fish were observed below its spillway during our sampling season. In contrast, numerous small brook trout (*Salvelinus fontinalis*) were seen throughout the length of the Guaje Canyon stream. A study conducted in Colorado (Allan 1975) found invertebrate densities to be two to six times greater in stream reaches from which trout were absent than in adjacent reaches containing trout. However, a later Colorado study by the same researcher (Allan 1982) found that trout exclusion had no significant effect on resident

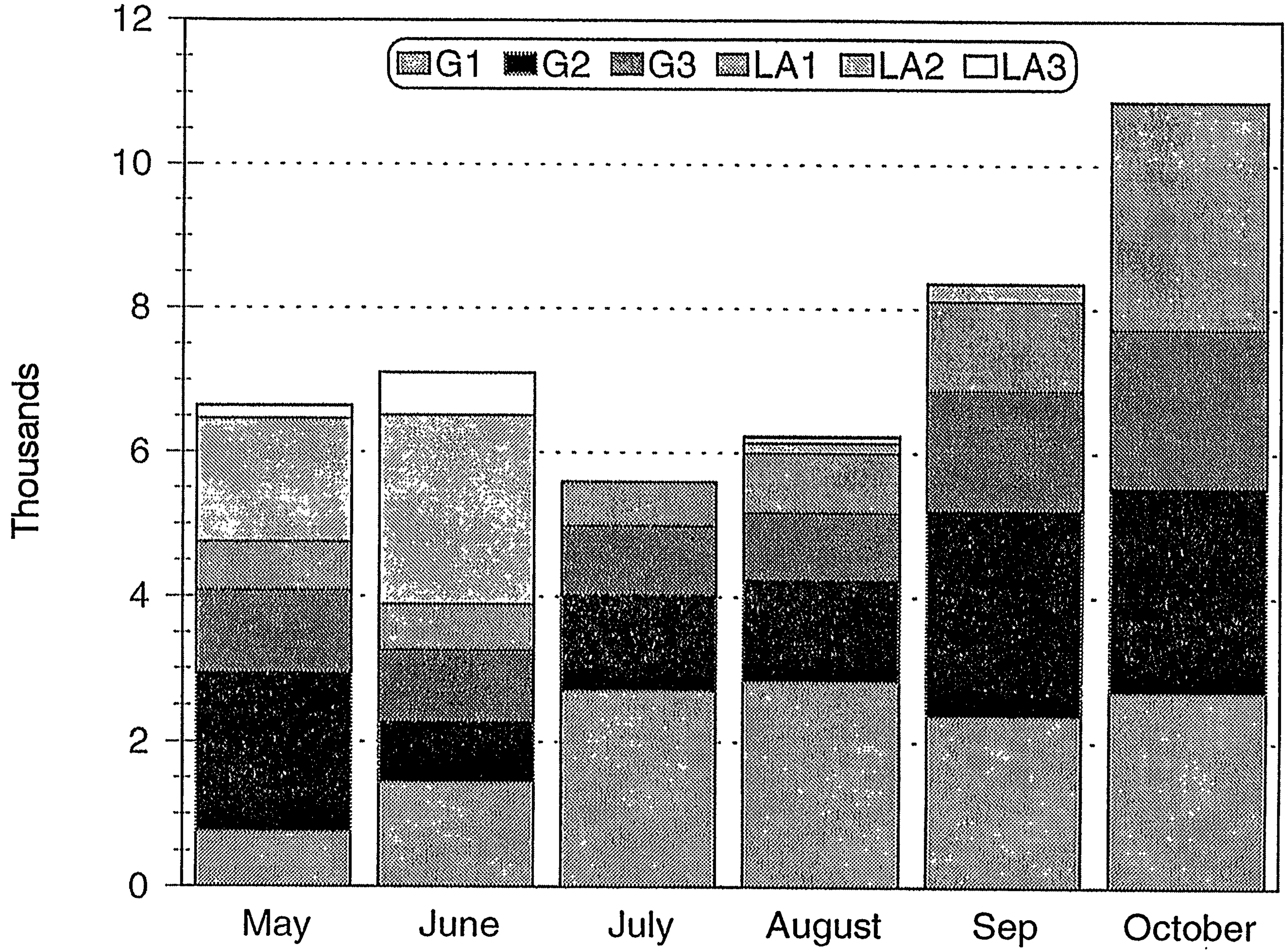


Fig. 15 Monthly 1993 Standing Crop per Square Meter

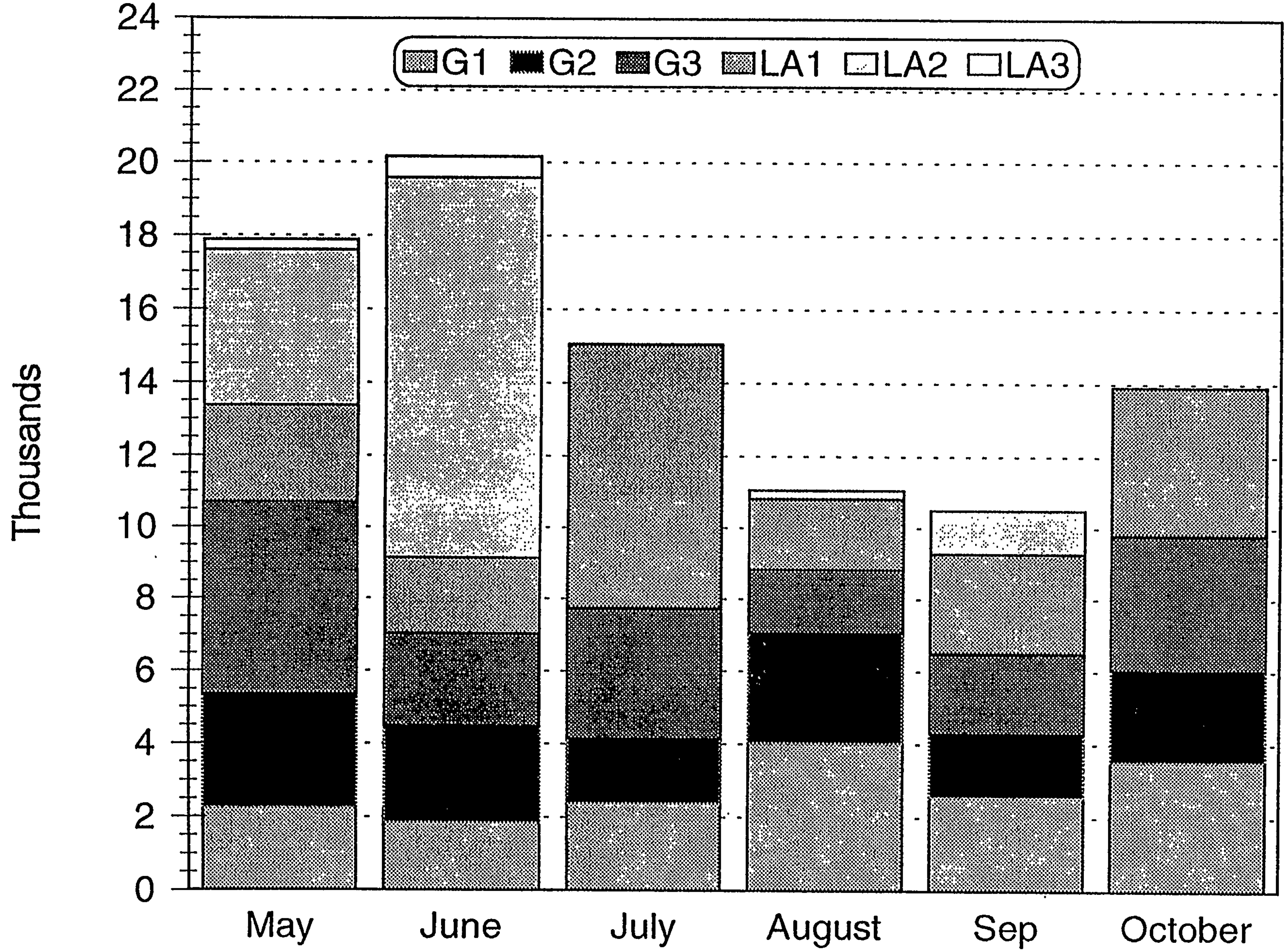


Fig. 16 Monthly 1994 Standing Crop per Square Meter

prey populations. At present, it is unclear what effect, if any, brook trout in Guaje Canyon have on macroinvertebrate densities.

Biodiversity. Wilhm's biodiversity index was computed monthly for each sampling site that was not dry (Table 8). The Guaje stations had higher diversity indices than their Los Alamos counterparts in 22 of 25 comparisons, the 3 exceptions all occurring at Station 1. This finding coupled with the higher standing crops recorded in Guaje validates our selection of Guaje as a reference site. With only one exception (G2), the highest biodiversities occurred at the upstream stations and the lowest occurred at the downstream stations.

Table 8 Wilhm's Monthly Biodiversity Values and Yearly Averages

Month Year	G1	G2	G3	LA1	LA2	LA3
May 1993	2.49	3.64	3.36	2.41	1.78	1.33
June 1993	3.23	2.61	2.91	3.15	2.00	2.20
July 1993	4.92	2.93	3.20	3.43	dry	dry
Aug 1993	5.19	3.91	4.21	3.76	0.85	1.91
Sept 1993	4.08	3.91	3.98	4.71	1.94	dry
Oct 1993	3.85	3.65	4.91	4.49	dry	dry
1993 Average*	**3.96**	**3.44**	**3.76**	**3.66**	**1.64**	**1.81**
May 1994	4.59	4.05	4.17	4.30	0.86	1.18
June 1994	5.38	4.01	3.87	4.15	1.27	1.41
July 1994	3.76	3.45	3.97	4.13	dry	dry
Aug 1994	4.20	4.82	4.60	3.72	1.45	dry
Sept 1994	4.50	3.45	4.75	3.66	2.98	dry
Oct 1994	3.98	4.96	4.23	3.61	dry	dry
1994 Average*	**4.40**	**4.12**	**4.26**	**3.92**	**1.64**	**1.30**
Two-year average*	**4.18**	**3.78**	**4.01**	**3.79**	**1.64**	**1.56**

* dry months not included in averages

The diversity of a community relates to the density of organisms (standing crop), the number of taxa present (taxa richness), and the proportion of individuals occurring in each taxa (taxa diversity). Grouping related aquatic macroinvertebrate taxa into large faunal assemblages can also elucidate community structure. We conducted such an analysis by grouping collected macroinvertebrates into 5 insect orders and a category of non-insects. During both years, all Guaje sampling stations and LA1 contained a variety of aquatic macroinvertebrate groups (Figs. 17, 18, 19, and 20), indicative of a healthy community. In contrast, LA2 contained a great preponderance of Dipterans (Figs. 18 and 20), flies that tend to be rapid colonizers and indicators of previous disturbance. LA3 had the lowest numbers of collected macroinvertebrates in all categories during both sampling seasons.

Rapid Biological Protocol Metrics. Several RBP metrics require analysis of functional feeding groups. Appendix 4-E lists these groups for the aquatic insects collected in Guaje and Los Alamos Canyons. Several taxa have more than one feeding group, reflecting diversity of species or feeding behaviors within the taxon. The primary feeding group is listed first and is used to analyze community complexity. Only aquatic insects are used in functional feeding group comparisons, but non-insects are included in the computation of other metrics (taxa richness, percentage contribution of dominant taxon, and community loss index).

A station completely dominated by a single functional feeding group, as LA2 was dominated by collector-filterers in 1994 (Fig. 22), has a poorly developed community structure and usually indicates a high level of disturbance. In 1994, over 99% of the insects collected at LA3 were from only two groups, another example of a depauperate community. Collector-gatherers was the most numerous functional feeding group at the other four stations, but not to the exclusion of other groups (Figs. 21 and 22). These last stations (G1, G2, G3, and LA1) have comparatively balanced communities, denoting an absence of recent disturbance.

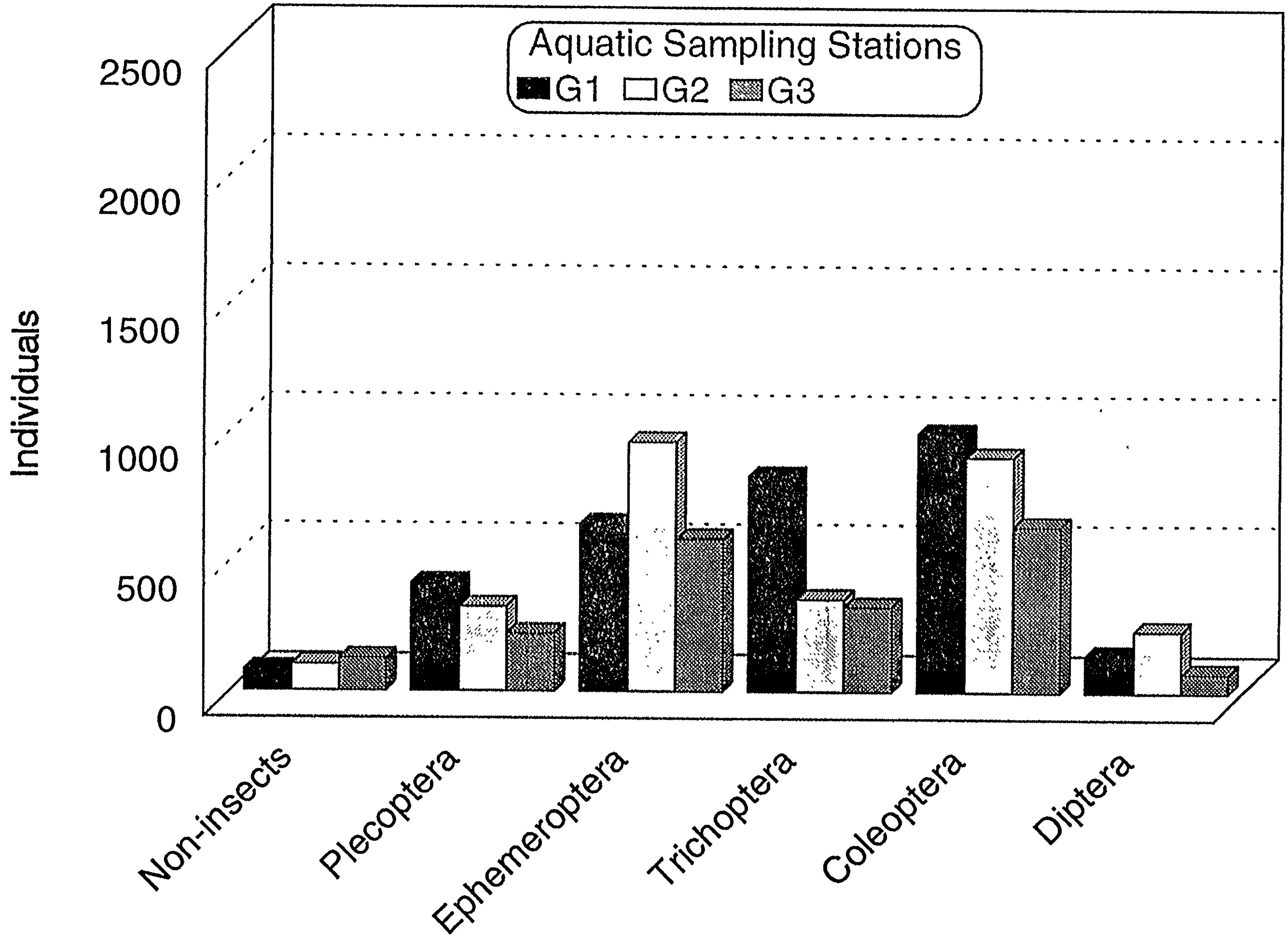


Fig. 17 1993 Guaje Canyon Aquatic Invertebrate Groups

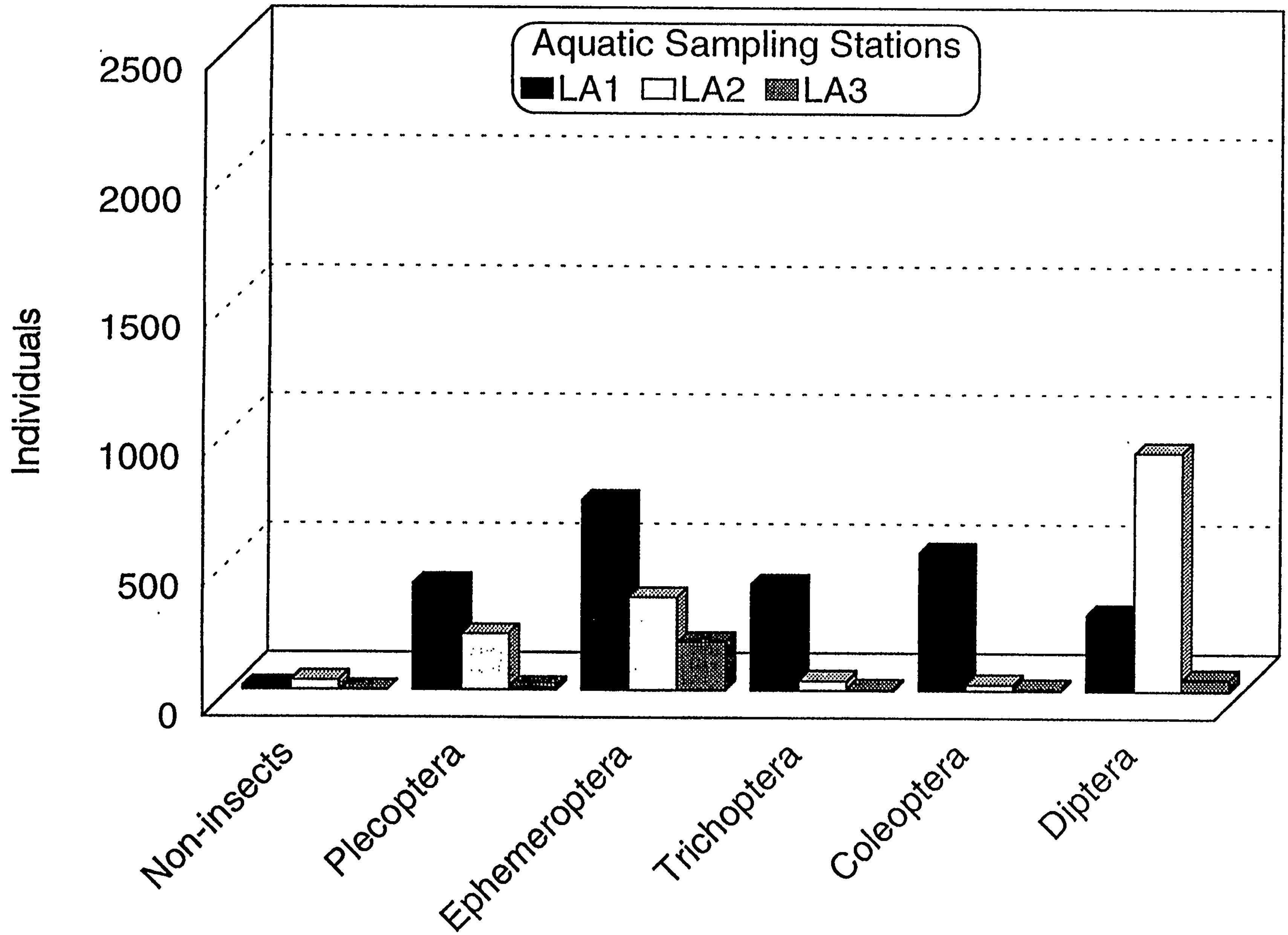


Fig. 18 1993 Los Alamos Canyon Aquatic Invertebrate Groups

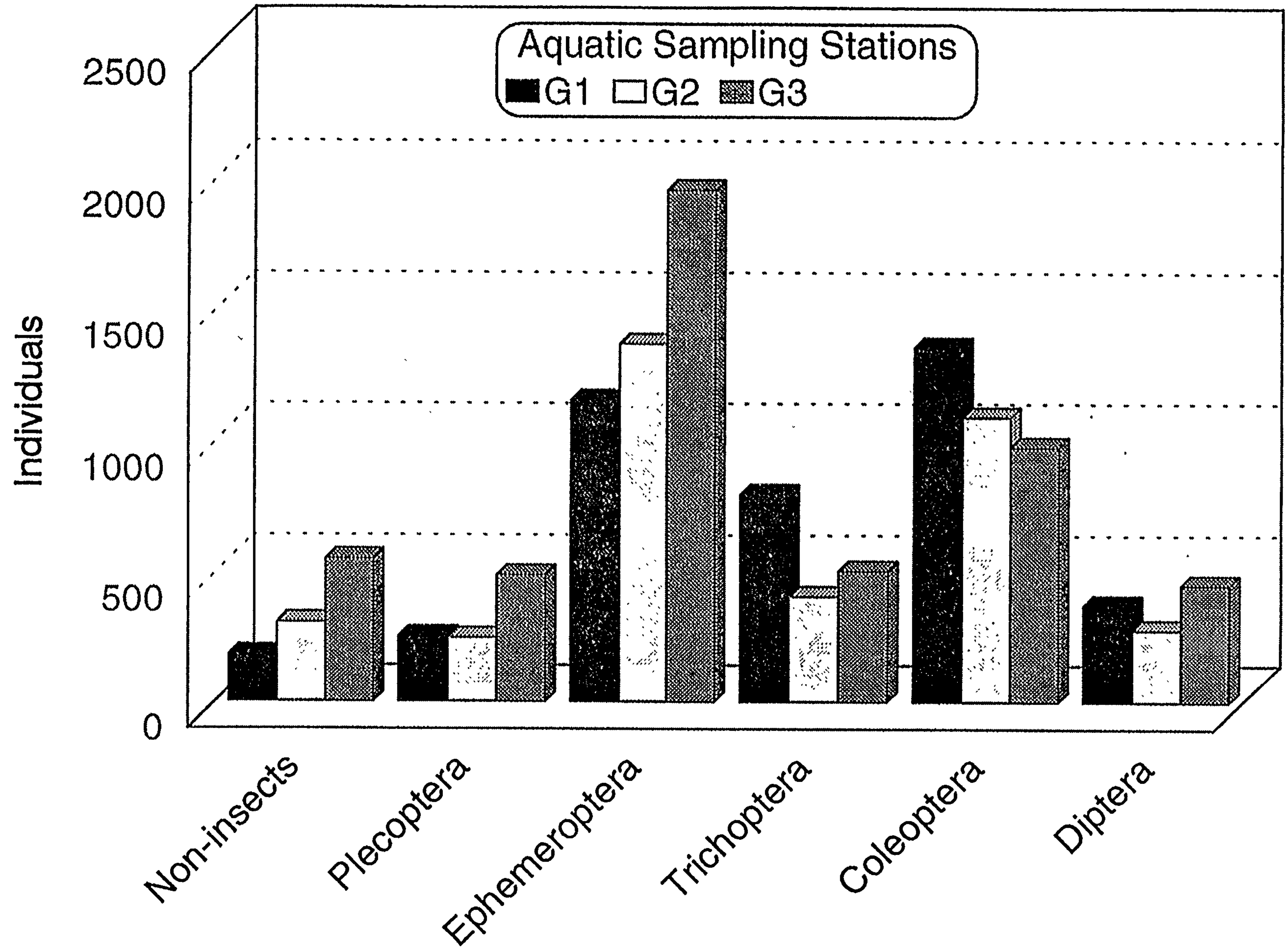


Fig. 19 1994 Guaje Canyon Aquatic Invertebrate Groups

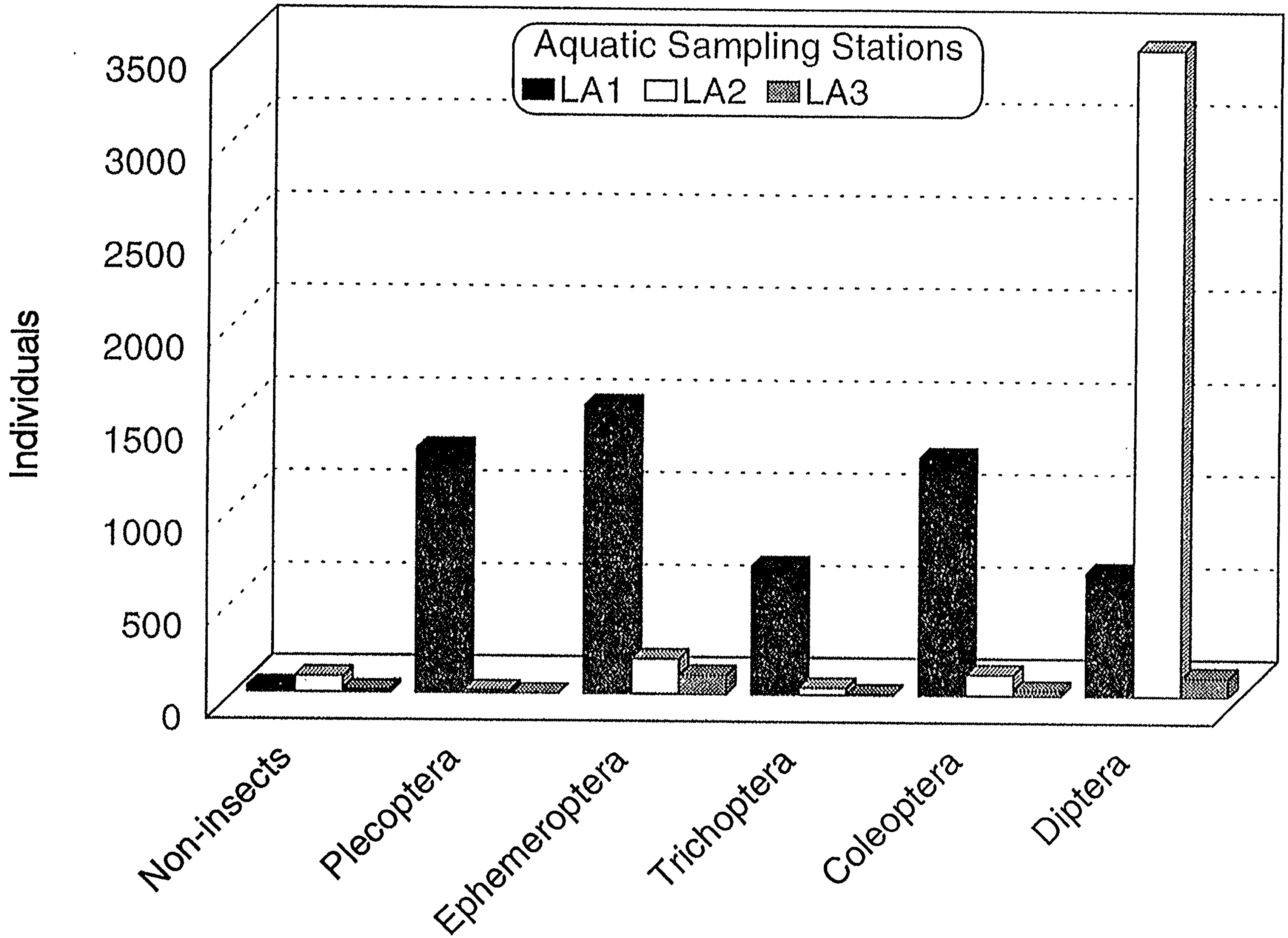


Fig. 20 1994 Los Alamos Canyon Áquatic Invertebrate Groups

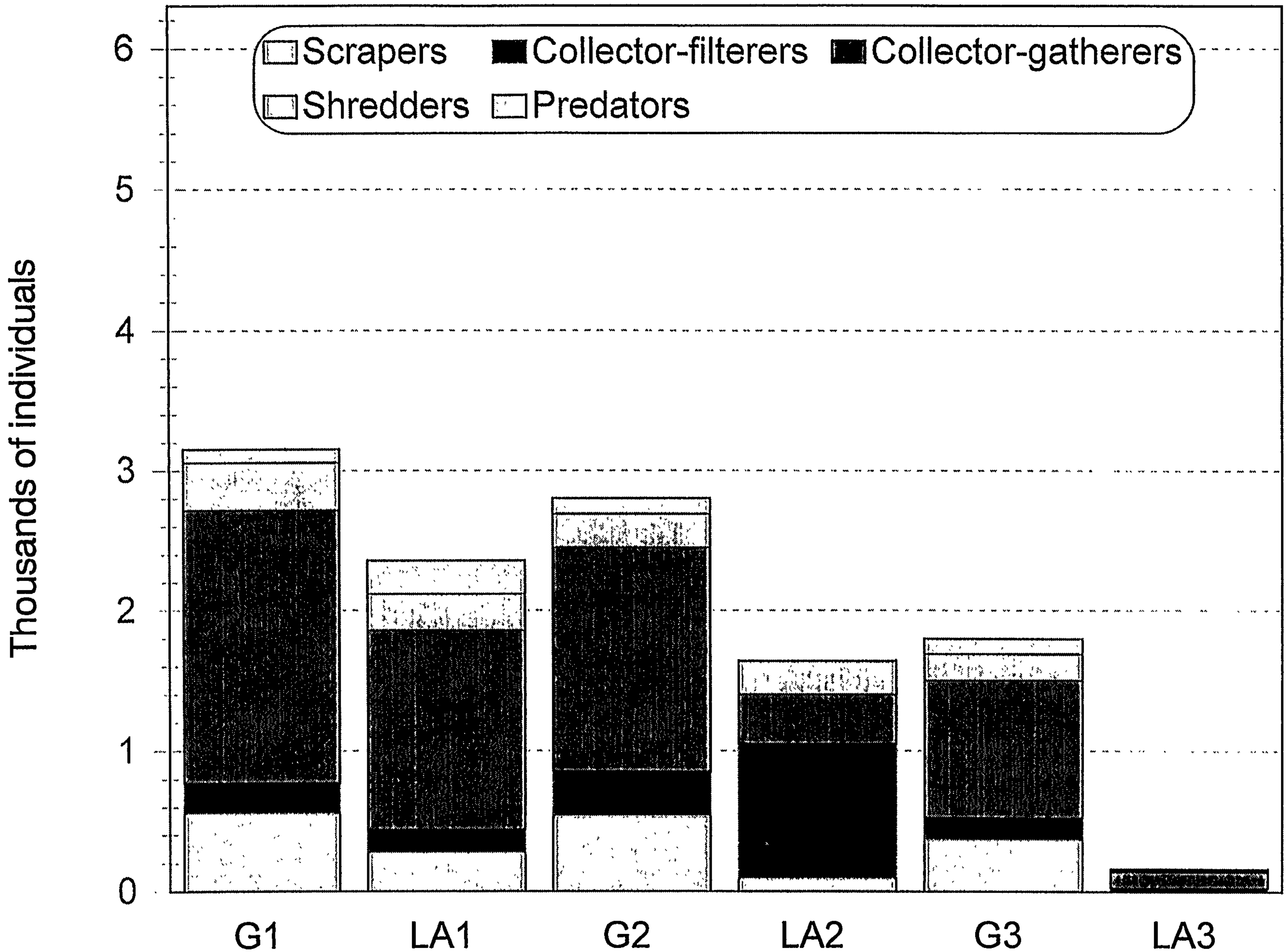


Fig. 21 1993 Functional Feeding Groups by Sampling Station

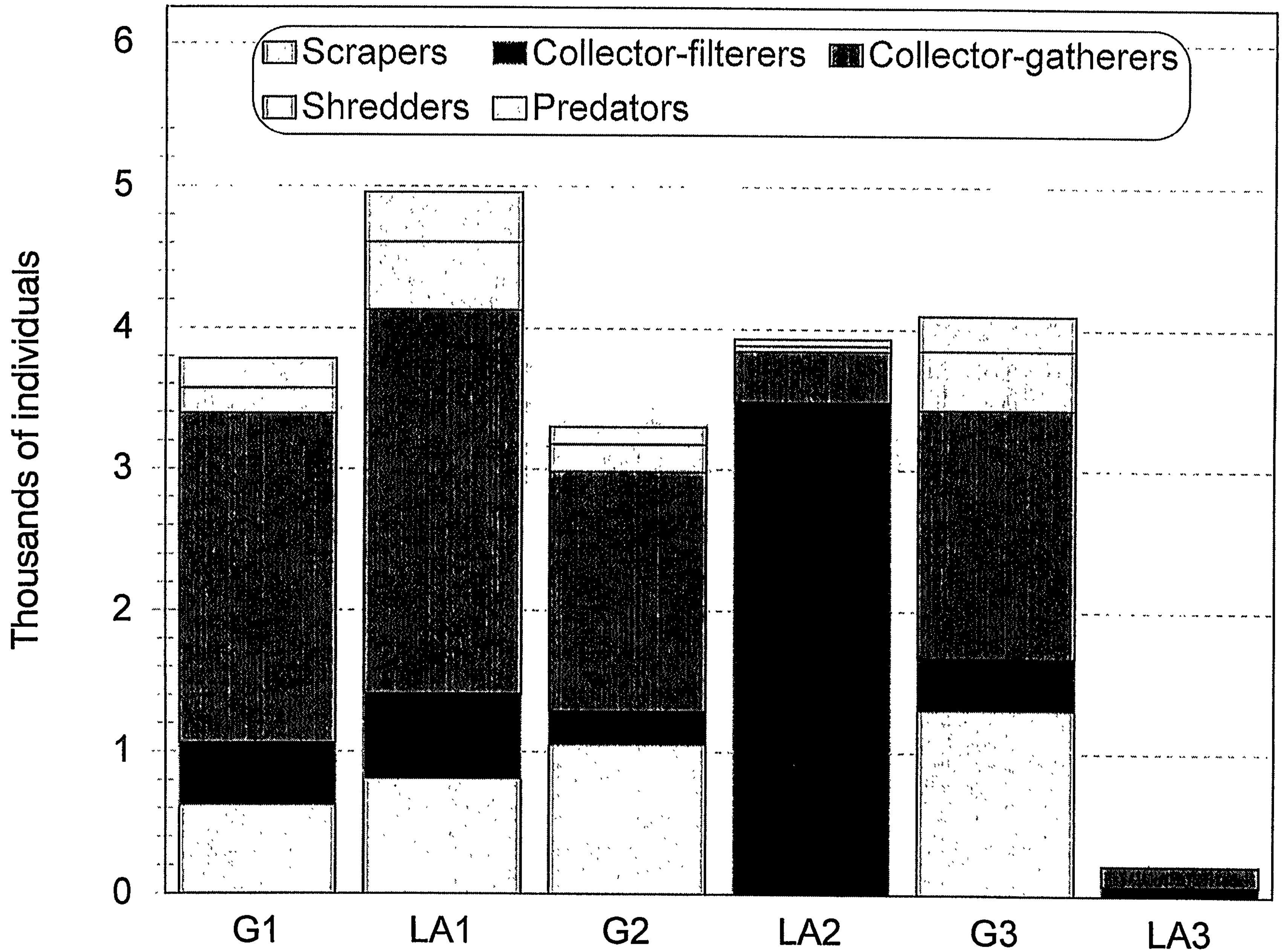


Fig. 22 1994 Functional Feeding Groups by Sampling Station

Table 9 lists the RBP III biological condition scores and totals by month (More complete data is included in Appendix 4-G). The RBP metrics are comparative measures requiring two sampling areas: a reference site (Guaje) and a study site (Los Alamos). The scores range from 0 to 6, with 0 indicative of severe impairment at the Los Alamos station and 6 indicative of an unimpaired condition at the Los Alamos station. The biological condition score is intended to reflect aquatic community health, with total elimination of aquatic life as the most degraded condition. Therefore, when drought in Los Alamos Canyon eliminated a sampling station and its resident macroinvertebrate community, each metric was assigned a zero.

Table 9 Monthly Biological Condition Scores for the Los Alamos Canyon Sampling Stations

Date - Station	Metric 1	Metric 2	Metric 3	Metric 4	Metric 5	Metric 6	Metric 7	Total score
5/93-1	6	6	6	6	4	0	4	32
5/93-2	4	2	0	2	0	2	4	14
5/93-3	0	2	0	2	2	0	2	8
6/93-1	4	4	0	2	2	6	4	22
6/93-2	6	6	0	6	2	6	4	30
6/93-3	4	6	6	4	0	2	4	26
7/93-1	4	4	6	6	6	4	4	34
7/93-2	0	0	0	0	0	0	0	0
7/93-3	0	0	0	0	0	0	0	0
8/93-1	4	6	6	0	2	0	4	22
8/93-2	0	6	0	0	0	0	0	6
8/93-3	0	0	0	0	0	0	0	0
9/93-1	6	6	4	4	2	4	6	32
9/93-2	0	2	0	0	2	0	2	6
9/93-3	0	0	0	0	0	0	0	0
10/93-1	6	6	4	6	4	6	4	36
10/93-2	0	0	0	0	0	0	0	0
10/93-3	0	0	0	0	0	0	0	0
5/94-1	6	6	6	6	4	6	6	40
5/94-2	0	2	0	0	0	0	2	4
5/94-3	0	0	0	0	0	0	0	0
6/94-1	6	6	2	6	4	0	4	28

Table 9 (cont.)

Date - Station	Metric 1	Metric 2	Metric 3	Metric 4	Metric 5	Metric 6	Metric 7	Total score
6/94-2	2	2	0	4	0	0	2	10
6/94-3	0	4	0	0	0	0	2	6
7/94-1	6	2	6	6	4	6	6	36
7/94-2	0	0	0	0	0	0	0	0
7/94-3	0	0	0	0	0	0	0	0
8/94-1	4	6	6	6	4	6	4	36
8/94-2	0	0	0	0	2	0	0	2
8/94-3	0	0	0	0	0	0	0	0
9/94-1	6	4	2	6	2	2	6	28
9/94-2	4	4	0	2	4	0	4	18
9/94-3	0	0	0	0	0	0	0	0
10/94-1	6	6	0	6	4	4	6	32
10/94-2	0	0	0	0	0	0	0	0
10/94-3	0	0	0	0	0	0	0	0

Averages of the biological condition scores for each station throughout the sampling seasons show a clear pattern of increasing downstream impairment in Los Alamos Canyon (Table 10). This pattern persisted throughout the two-year sampling period, with little change.

Table 10 Summary of Total RBP Biological Condition Scores for Los Alamos Canyon

Station, Year	Lowest Total Monthly Score (42 possible)	Highest Total Monthly Score (42 possible)	Percent of Possible Total (216) for All Months	Biological Condition Category
LA1, 93	22	36	82	Nonimpaired
LA2, 93	0	30	26	Moderately impaired
LA3, 93	0	26	16	Severely impaired
LA1, 94	22	34	79	Slightly impaired
LA2, 94	0	14	12	Severely impaired
LA3, 94	0	6	3	Severely impaired
LA1, 93 & 94	22	34	81	Nonimpaired
LA2, 93 & 94	0	30	19	Severely impaired

Table 10 (cont.)

Station, Year	Lowest Total Monthly Score (42 possible)	Highest Total Monthly Score (42 possible)	Percent of Possible Total (216) for All Months	Biological Condition Category
LA3, 93 & 94	0	26	9	Severely impaired

The sampling season was drier in 1994 than in 1993, due in large part to a small snowpack. In comparing the two years, the total biological condition scores fell at all Los Alamos sampling stations, with the greatest reduction occurring downstream: LA1 lowered by 4%, LA2 by 14%, and LA3 by 16%. Thus, the aforementioned effects of the reservoir dam in Los Alamos Canyon on downstream sites appear to be magnified in dry years.

In 1993, the total biological condition score for LA1 fell between the range of slight impairment and nonimpairment. This author assigned it to the nonimpaired category because many of the individual RBP scores throughout the year exceeded the scores of its Guaje reference site. The lowest scores recorded at LA1 in 1993 were in metrics 4 (EPT abundances), 5 (percent contribution of dominant taxon), and 6 (EPT index). In 1994, LA1 was in the upper range of slight impairment, its lowest scores recorded in metrics 3 (ratio scrapers to filtering-collectors), 4 (number of EPT individuals), and 5 (percent contribution of dominant taxon). The two-year average at LA1 again fell between nonimpairment and slight impairment, and I assigned LA1 to the nonimpaired category.

In 1993, LA2 scored in the lower range of moderate impairment, each metric receiving a score of zero at least once. In 1994, the station was evaluated as severely impaired; and each metric again received a zero score at least once. The two-year average places LA2 between the moderate and severe impairment categories. I assigned it to the severe impairment category because the streambed was completely dry in 4 of the 12 sampling months.

The streambed at LA3 was too dry to sample in three of the six sampling months in 1993 and in four of the six sampling months in 1994. LA3 received a total biological condition score in the high range of severe impairment in 1993 and in the mid-range of severe impairment in 1994. Even during the months when the stream flowed at the lowest station, only two metrics received a score higher than zero during 1994 (in May, the Community Tolerance Quotient was 4 and the Community Loss Index was 2). Although the two-year average clearly places LA3 in the severe impairment rating, it probably could support a diverse macroinvertebrate community if the hydrology there had more consistent flows and water temperatures.

5 CONCLUSIONS

All monthly pH measurements taken during 1993 and 1994 were within the ranges currently defined for high quality coldwater fisheries (State of New Mexico 1995) and the excellent range as defined by Batelle (Batelle 1972). No monthly conductivity measurements exceeded the upper permissable limit for New Mexico high-quality coldwater fisheries and all fell within the excellent range as defined by Batelle. Dissolved oxygen levels were usually in the excellent range (Batelle 1972) and were never less than "fair". The temperatures at the two lower Los Alamos stations were significantly elevated due to the spillway nature of the reservoir dam. The Los Alamos dam also accounted for stream drought at LA2 (four of twelve sampling months) and LA3 (seven of twelve sampling months), which eliminated their resident macroinvertebrate communities. This artificial seasonal drought is undoubtedly the most significant impact to these downstream communities.

The data show that aquatic communities are more diverse and richer in Guaje than Los Alamos, justifying EST's use of the Guaje stream as a control in RBP III analysis. The data also suggest that within each canyon, diversity and density decrease with distance downstream. However, this trend is not as pronounced since the middle station in Guaje had higher diversities and densities than the downstream station. The EPA sanctioned RBP III metrics rates water quality as nonimpaired at LA1, severely impaired at LA2, and severely impaired at LA3.

6 ACKNOWLEDGMENTS

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APPENDIX 4-A

Table 1 Habitat Assessment Field Data Sheet, Riffle/Run Prevalence

Habitat Parameter	Category: Optimal	Sub-Optimal	Marginal	Poor
1. Bottom substrate-instream cover (a)	Greater than 50% mix of rubble, gravel, submerged logs, undercut banks, or other stable habitat. 16–20	30–50% mix of rubble, gravel, or other stable habitat. Adequate habitat. 11–15	10–30% mix of rubble, gravel, or other stable habitat. Habitat availability less than desirable. 6–10	Less than 10% rubble, gravel, or other stable habitat. Lack of habitat is obvious. 0–5
2. Embeddedness (b)	Gravel, cobble, and boulder particles are between 0–25% surrounded by fine sediment. 16–20	Gravel, cobble, and boulder particles are between 25–50% surrounded by fine sediment. 11–15	Gravel, cobble, and boulder particles are between 50–75% surrounded by fine sediment. 6–10	Gravel, cobble, and boulder particles are over 75% surrounded by fine sediment. 0–5
3. ≤0.15 cms (5 cfs)—Flow at rep. low	Cold >0.05 cms (2 cfs) Warm >0.15 cms (5 cfs) 16–20	0.03–0.05 cms (1–2 cfs) 0.05–0.15 cms (2–5 cfs) 11–15	0.01–0.03 cms (.5–1 cfs) 0.03–0.05 cms (1–cfs) 6–10	<0.01 cms (.5 cfs) <0.03 cms (1 cfs) 0–5
OR >0.15 cms (5 cfs)—velocity-depth	Slow (<0.3 m/s), deep (>0.5 m); slow, shallow (<0.5 m); fast (>0.3 m/s), deep; fast, shallow habitats all present. 16–20	Only 3 of the 4 habitat categories present (missing riffles or runs receive lower score than missing pools). 11–15	Only 2 of the 4 habitat categories present (missing riffles or runs receive lower score). 6–10	Dominated by 1 velocity depth category (usually pools). 0–5
4. Canopy cover (shading) (c) (d) (g)	A mixture of conditions where some areas of water surface fully exposed to sunlight, and other receiving various degrees of filtered light. 16–20	Covered by sparse canopy; entire water surface receiving filtered light. 11–15	Completely covered by dense canopy; water surface completely shaded OR nearly full sunlight reaching water surface. Shading limited to <3 hours per day. 6–10	Lack of canopy, full sunlight reaching water surface. 0–5
5. Channel alteration (a)	Little or no enlargement of islands or point bars, and/or no channelization. 12–15	Some new increase in bar formation, mostly from coarse gravel; and or some channelization present. 8–11	Moderate deposition of new gravel, coarse sand on old and new bars; and or embankments on both banks. 4–7	Heavy deposits of fine material, increased bar development; and or extensive channelization. 0–3
6. Bottom scouring and deposition (a)	Less than 5% of the bottom affected by scouring and or deposition. 12–15	5–30% affected. Scour at constrictions and where grades steepen. Some deposition in pools. 8–11	30–50% affected. Deposits and or scour at obstructions, constrictions, and bends. Filling of pools prevalent. 4–7	More than 50% of the bottom changing frequently. Pools almost absent due to deposition. Only large rocks in riffle exposed. 0–3
7. Pool riffle, run/bend ratio (a) (distance between riffles divided by stream width)	Ratio: 5–7. Variety of habitat. Repeat pattern of sequence relatively frequent. 12–15	7–15. Infrequent repeat pattern. Variety of macrohabitat less than optimal. 8–11	15–25. Occasional riffle or bend. Bottom contours provide some habitat. 4–7	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 0–3
8. Lower bank channel capacity (b)	Overbank (lower) flows rare. Lower bank W/D ratio <7. (Channel width divided by depth or height of lower bank.) 12–15	Overbank (lower) flows occasional. W/D ratio 8–15. 8–11	Overbank (lower) flows common. W/D ratio 15–25. 4–7	Peak flows not contained or contained through channelization. W/D ratio >25. 0–3

Table 1 (cont.)

Habitat Parameter	Category: Optimal	Sub-Optimal	Marginal	Poor
9. Upper bank stability (a)	Upper bank stable. No evidence of erosion or bank failure. Side slopes generally <30°. Little potential for future problems. 9–10	Moderately stable. Infrequent, small areas of erosion mostly healed over. Side slopes up to 40° on one bank. Slight potential in extreme floods. 6–8	Moderately unstable. Moderate frequency and size of erosional areas. Side slopes up to 60° on some banks. High erosion potential during extreme high flow. 3–5	Unstable. Many eroded areas. "Raw" areas frequent along straight sections and bends. Side slopes >60° common. 0–2
10. Bank vegetative protection (d)	Over 90% of the streambank surfaces covered by vegetation. 9–10	70–89% of the streambank surfaces covered by vegetation. 6–8	50–79% of the streambank surfaces covered by vegetation. 3–5	Less than 50% of the streambank surfaces covered by vegetation. 0–2
OR Grazing or other disruptive pressure (b)	Vegetative disruption minimal or not evident. Almost all potential plant biomass at present stage of development remains. 9–10	Disruption evident but not affecting community vigor. Vegetative use is moderate, and at least one-half of the potential plant biomass remains. 6–8	Disruption obvious: some patches of bare soil or closely cropped vegetation present. Less than one-half of the potential plant biomass remains. 3–5	Disruption of streambank vegetation is very high. Vegetation has been removed to 2 inches or less in average stubble height. 0–2
11. Streamside cover (b)	Dominant vegetation is shrub. 9–10	Dominant vegetation is of tree form. 6–8	Dominant vegetation is grass or forbes. 3–5	Over 50% of the streambank has no vegetation and dominant material is soil, rock, bridge materials, culverts, or mine tailings. 0–2
12. Riparian vegetative zone width (least buffered side) (e) (f) (g)	>18 meters. 9–10	Between 12 and 18 meters. 6–8	Between 6 and 12 meters. 3–5	<6 meters. 0–2
Column Totals	___	___	___	___
Score ______				

(a) From Ball 1982.
(b) From Platts et al. 1983.
(c) From EPA 1983.
(d) From Hamilton and Bergersen 1984.
(e) From Lafferty 1987.
(f) From Schueler 1987.
(g) From Bartholow 1989.

APPENDIX 4-B

Table 1 Tolerance Quotients for the Aquatic Invertebrates of Guaje and Los Alamos Canyons (modified from Winget and Mangum 1989)

Order	Family	Genus (species)	Tolerance quotient
Plecoptera	Chloroperlidae		24
	Nemouridae	Amphinemura	6
	Nemouridae	Malenka	36
	Nemouridae	Podmosta	12
	Nemouridae	Zapada	16
	Perlidae	Hesperoperla (pacifica)	18
	Perlodidae	Cultus (aestivalis)	12
	Perlodidae	Isoperla	24
	Perlodidae	Kogotus (modestus)	18
	Pteronarcyidae	Pteronarcella (badia)	24
	Pteronarcyidae	Pteronarcys	21
Ephemeroptera	Baetidae	Baetis	72
	Baetidae	Callibaetis	72
	Ephemerellidae	Drunella (coloradensis)	18
	Ephemerellidae	Drunella (doddsi)	4
	Ephemerellidae	Drunella (grandis)	24
	Ephemerellidae	Ephemerella (inermis)	48
	Ephemerellidae	Ephemerella (infrequens)	48
	Heptageniidae	Cinygmula	21
	Heptageniidae	Epeorus	21
	Leptophlebiidae	Paraleptophlebia	24
	Siphlonuridae	Ameletus	48
	Siphlonuridae	Siphlonurus	72
	Tricorythidae	Tricorythodes	108
Odonata	Aeshnidae		72
Hemiptera	Gerridae	Gerris	72
	Veliidae	Microvelia	72
Trichoptera	Brachycentridae	Micrasema	24
	Glossosomatidae		32
	Glossosomatidae	Glossosoma	24
	Hydropsychidae	Arctopsyche	18
	Hydropsychidae	Cheumatopsyche	108
	Hydropsychidae	Hydropsyche	108
	Lepidostomatidae	Lepidostoma	18
	Leptoceridae		54

Table 1 (cont.)

Order	Family	Genus (species)	Tolerance quotient
	Limnephilidae	Hesperophylax	108
	Limnephilidae	Limnephilus	108
	Limnephilidae	Oligophlebodes	24
	Philopotamidae	Dolophilodes	24
	Rhyacophilidae	Rhyacophila	18
Lepidoptera	Pyralidae		72
Coleoptera	Amphizoidae	Amphizoa	24
	Dytiscidae	Agabus	72
	Dytiscidae adults	Laccophilus	72
	Dytiscidae adults		72
	Elmidae	all genera found	108
	Elmidae adults	all genera found	108
	Hydrophilidae	Ametor	72
	Hydrophilidae adults	Ametor	72
	Hydrophilidae	Helophorus	72
	Hydrophilidae	Hydrobius	72
	Hydrophilidae		72
Diptera	Ceratopogonidae		108
	Chironomidae	all taxa found	108
	Dixidae	Dixa	108
	Dixidae	Dixa A	108
	Empididae		108
	Empididae	Hemerodromia	108
	Muscidae	Limnophora	108
	Psychodidae	Maruina	36
	Psychodidae	Pericoma	36
	Simulidae		108
	Stratiomyiidae		108
	Tipulidae	Antocha	24
		Dicranota	24
		Tipula	36
		Tipula B	36

Table 2 Non-Insect Macroinvertebrates of Guaje Canyon, 1993 and 1994

Phylum	Class, etc.	Tolerance Quotient
Annelida	Lumbriculidae	108
Mollusca	Gastropoda	108
Platyhelminthes	Turbellaria	108

APPENDIX 4-C

Table 1 Aquatic Macroinvertebrate Taxa of Guaje Canyon, 1993 and 1994 (All specimens are larval unless otherwise noted.)

Order	Family	Genus (species)	Station
Plecoptera	Chloroperlidae		1, 2, 3
	Nemouridae	Amphinemura	1, 2, 3
	Nemouridae	Malenka	1, 3
	Nemouridae	Podmosta (delicatula)	3
	Perlodidae	Cultus (aestivalis)	1, 2, 3
	Perlodidae	Isoperla	1, 2, 3
	Perlodidae	Kogotus (modestus)	1, 2, 3
	Pteronarcyidae	Pteronarcella (badia)	1, 2, 3
	Pteronarcyidae	Pteronarcys	1, 2, 3
Ephemeroptera	Baetidae	Baetis	1, 2, 3
	Baetidae	Callibaetis	3
	Ephemerellidae	Drunella (coloradensis)	1, 2, 3
	Ephemerellidae	Drunella (doddsi)	1, 2, 3
	Ephemerellidae	Drunella (grandis grandis)	3
	Ephemerellidae	Ephemerella (inermis)	1, 2, 3
	Ephemerellidae	Ephemerella (infrequens)	1, 2, 3
	Heptageniidae	Cinygmula	1, 2, 3
	Heptageniidae	Epeorus (longimanus)	1, 2, 3
	Leptophlebiidae	Paraleptophlebia	3
	Siphlonuridae	Ameletus	2, 3
	Tricorythidae	Tricorythodes (minutus)	1
Hemiptera	Gerridae	Gerris	2, 3
	Veliidae	Microvelia	3
Trichoptera	Brachycentridae	Micrasema	1, 2, 3
	Brachycentridae pupae	Micrasema	2
	Glossosomatidae	Agapetus	2, 3
	Glossosomatidae	Glossosoma	1, 2, 3
	Hydropsychidae	Arctopsyche (grandis)	1, 2, 3
	Hydropsychidae	Cheumatopsyche	2
	Hydropsychidae	Hydropsyche	1, 2, 3
	Lepidostomatidae	Lepidostoma	1, 2, 3
	Leptoceridae	Oecetis?	1, 2, 3
	Limnephilidae	Hesperophylax	3
	Limnephilidae pupae	Hesperophylax	3
	Limnephilidae	Limnephilus	2, 3
	Limnephilidae	Oligophlebodes	1, 2, 3
	Limnephilidae pupae	Oligophlebodes	2, 3
	Odontoceridae	Namamyia	1

Table 1 (cont.)

Order	Family	Genus (species)	Station
	Philopotamididae	Dolophilodes	1, 2, 3
	Rhyacophilidae	Rhyacophila (brunnea complex)	1, 2, 3
	Rhyacophilidae pupae	Rhyacophila (brunnea complex)	1, 2, 3
Lepidoptera	Noctuidae		2
	Pyralidae		3
Coleoptera	Amphizoidae	Amphizoa	3
	Curculionidae adult		3
	Dryopidae adult	Helichus	1, 2, 3
	Dytiscidae adult	Hydaticus	2
	Elmidae	Heterlimnius (corpulentis)	1, 2, 3
	Elmidae adults	Heterlimnius (corpulentis)	1, 2, 3
	Elmidae	Narpus	1, 2, 3
	Elmidae adults	Narpus	1, 2, 3
	Elmidae	Zaitzevia	1, 2, 3
	Elmidae adults	Zaitzevia	1, 2, 3
	Helodidae	Prionocyphon	3
	Hydrophilidae	Ametor	1, 2, 3
	Hydrophilidae adult	Ametor	2, 3
	Hydrophilidae adult	Enochrus?	3
	Hydrophilidae	Hydrochus	2
	Psephenidae		1
Diptera	Chironomidae	A	1, 2, 3
	Chironomidae	B	1, 2
	Chironomidae	C	1, 2
	Chironomidae	E	1, 2, 3
	Chironomidae	F	1, 2, 3
	Chironomidae	F	1
	Chironomidae	G	1, 2, 3
	Chironomidae pupae	G	1
	Chironomidae pupae		1, 2, 3
	Chironomidae pupae	PA	3
	Dixidae	Dixa	1, 2, 3
	Dixidae	Dixa A	2, 3
	Empididae	Chelifera	2
	Empididae	Oreogeton	1, 2
	Empididae pupae	Hemerodromia	3
	Psychodidae	Maruina	1
	Psychodidae	Pericoma	1, 2, 3
	Ptychopteridae	Ptychoptera	3
	Simulidae		1, 2, 3

Table 1 (cont.)

Order	Family	Genus (species)	Station
	Simulidae pupae		1, 2, 3
	Simulidae pupae	PA	2
	Stratiomyidae	Odontomyia	2
	Stratiomyidae		1
	Tipulidae	Antocha	1, 2, 3
	Tipulidae	Dicranota	1, 2, 3
	Tipulidae	Tipula	1, 2, 3
	Tipulidae	Tipula B	1, 2, 3

Table 2 Non-Insect Macroinvertebrates of Guaje Canyon, 1993 and 1994

Phylum	Class, etc.	Station
Annelida	Lumbriculidae	1, 2, 3
Annelida	Naididae	1, 3
Arthropoda	Arachnoidea, Hydracarina	1, 2, 3
Mollusca	Gastropoda A	2, 3
Mollusca	Gastropoda, Gyralus parvus	3
Mollusca	Sphaeriidae, Pisidium casertanum	1, 2, 3
Nematoda		1, 2, 3
Nematomorpha	Gordioidea, Gordiidae, Gordius	1
Nematomorpha		1, 2
Platyhelminthes	Turbellaria	1, 2, 3

APPENDIX 4-D

Table 1 Aquatic Macroinvertebrates of Los Alamos Canyon, 1993 and 1994 (All specimens are larval unless otherwise noted.)

Order	Family	Genus (species)	Station
Plecoptera	Chloroperlidae		1, 2
	Nemouridae	Amphinemura	1, 2, 3
	Nemouridae	Zapada (frigida)	1
	Perlidae	Hesperoperla (pacifica)	1
	Perlodidae	Cultus (aestivalis)	1
	Perlodidae	Kogotus (modestus)	1
Ephemeroptera	Baetidae	Baetis	1, 2, 3
	Baetidae	Callibaetis	1, 3
	Ephemerellidae	Drunella (coloradensis)	2
	Ephemerellidae	Ephemerella (inermis)	1
	Heptageniidae	Cinygmula	1, 2, 3
	Heptageniidae	Epeorus (longimanus)	1, 2, 3
	Leptophlebiidae	Paraleptophlebia	1, 2
	Siphlonuridae	Ameletus	1, 2, 3
	Siphlonuridae	Siphlonurus	2, 3
Odonata	Aeshnidae	Boyeria	2, 3
Hemiptera	Gerridae	Gerris	2
	Veliidae	Microvelia	1, 2
Trichoptera	Brachycentridae	Micrasema	1, 2
	Glossosomatidae	Glossosoma	1
	Hydropsychidae	Arctopsyche (grandis)	1, 2
	Hydropsychidae	Hydropsyche	1
	Lepidostomatidae	Lepidostoma	1
	Leptoceridae	Oecetis?	1
	Limnephilidae	Hesperophylax	1, 2, 3
	Limnephilidae	Limnephilus	1, 2
	Limnephilidae	Oligophlebodes	1
	Limnephilidae		1, 2, 3
	Philopotamidae	Dolophilodes	1
	Rhyacophilidae	Rhyacophila (brunnea complex)	1, 2
	Rhyacophilidae pupae	Rhyacophila (brunnea complex)	1
Lepidoptera	Noctuidae		2
Coleoptera	Dytiscidae	Agabus	2
	Dytiscidae	Copelatus?	1
	Dytiscidae adults		2, 3
	Dryopidae adults	Helichus	1, 3

Table 1 (cont.)

Order	Family	Genus (species)	Station
	Elmidae	Heterlimnius (corpulentus)	1, 2
	Elmidae adults	Heterlimnius (corpulentus)	1, 2
	Elmidae	Narpus	1, 2, 3
	Elmidae adults	Narpus	1, 3
	Elmidae	Zaitzevia	1, 2
	Elmidae adults	Zaitzevia	1, 2, 3
	Hydrophilidae	Ametor	1
	Hydrophilidae	Helophorus	1
	Hydrophilidae	Hydrobius	1
Diptera	Ceratopogonidae	Bezzia	1
	Chironomidae	A	1, 2, 3
	Chironomidae pupae	A	1
	Chironomidae	B	1, 2, 3
	Chironomidae	C	1, 2, 3
	Chironomidae	E	1
	Chironomidae	F	1
	Chironomidae pupae	F	1
	Chironomidae	G	1
	Chironomidae	H	3
	Chironomidae pupae		1, 2, 3
	Dixidae	Dixa	1, 2
	Empididae	Oreogeton	1
	Muscidae	Limnophora	3
	Psychodidae	Maruina	1
	Psychodidae	Pericoma	1, 3
	Simulidae		1, 2, 3
	Simulidae	pupae	1, 2
	Tipulidae	Antocha	1
	Tipulidae	Dicranota	1, 2, 3
	Tipulidae	Tipula	1
	Tipulidae	Tipula B	1

Table 2 Non-Insect Macroinvertebrates of Los Alamos Canyon, 1993 and 1994

Phylum	Class, etc.	Station
Annelida	Lumbriculidae	1, 2, 3
Annelida	Naididae	1, 2
Arthropoda	Arachnoidea, Hydracarina	1
Mollusca	Gastropoda A	1
Mollusca	Sphaeriidae, Pisidium casertanum	1
Nematomorpha		1, 2, 3
Nematomorpha	Gordiidae, Gordius	1, 2

APPENDIX 4-E

Table 1 Aquatic Insects Collected from Los Alamos County and Adjacent Watersheds (* = life stage not known, all specimens are larval unless otherwise noted.)

ORDER	FAMILY	GENUS	SPECIES	LOCATION **
Plecoptera (Stoneflies)	Capniidae	*Capnia*		F
	Capniidae			F
	Chloroperlidae	*Chloroperla*		F
	Chloroperlidae	*Paraperla*	*frontalis*	G,L
	Chloroperlidae	*Paraperla*		F
	Chloroperlidae	*Sweltsa*	*coloradensis*	F
	Chloroperlidae	*Sweltsa a*	*lamba*	F
	Chloroperlidae	*Sweltsa*		F,G
	Chloroperlidae	*Suwallia*		G,L
	Chloroperlidae			F,G,L,SG
	Leuctridae	*Paraleuctra*	*vershina*	F
	Nemouridae	*Amphinemura*		F
	Nemouridae	*Amphinemura*	*banksi*	F,G,L.PW.SG
	Nemouridae	*Malenka*	*coloradensis*	F
	Nemouridae	*Malenka*		G,L
	Nemouridae	*Nemoura*		F
	Nemouridae	*Zapada*	*cinctipes*	F
	Perlidae	*Acroneuria*	*abnormis*	F
	Perlidae	*Hesperoperla*	*pacifica*	F,L,SG
	Perlodidae	*Cultus*		G
	Perlodidae	*Isoperla*	*fulva*	F
	Perlodidae	*Isoperla*	*quinquepunct ata*	F
	Perlodidae	*Isoperla*		F,G,L,S
	Perlodidae	*Kogotus*	*modestus*	G,L
	Perlodidae	*Skwala*	*parallela*	G
	Pteronarcyidae	*Pteronarcella*	*badia*	F,G
	Pteronarcyidae	*Pteronarcella*		F
	Pteronarcyidae	*Pteronarcys*	*californica*	G
	Taeniopterygidae	*Taenionema*		F
Ephemeroptera (Mayflies)	Baetidae	*Baetis*	*bicaudata*	F

Table 1 (cont.)

	Baetidae	*Baetis*	*insignificans*	F
	Baetidae	*Baetis*	*tricaudatus*	A,D,F,G,L, PS,S
	Baetidae	*Baetis*		A,C,F,G,H,L, PW,PS,S,SG, 128
	Baetidae	*Callibaetis*		G,L,PW,PS,S, 48
	Ephemerellidae	*Drunella*	*coloradensis*	G,L
	Ephemerellidae	*Drunella*	*doddsi*	F,G
	Ephemerellidae	*Drunella*	*grandis*	F,G
	Ephemerellidae	*Ephemerella*	*grandis grandis*	F
	Ephemerellidae	*Ephemerella*	*inermis*	F,G,L
	Ephemerellidae	*Ephemerella*	*infrequens*	F,G
	Ephemerellidae	*Ephemerella*		F
	Heptageniidae	*Cinygmula*		F,G,L
	Heptageniidae	*Epeorus*	*longimanus*	F,G
	Heptageniidae	*Epeorus*		F,G,L
	Heptageniidae	*Heptagenia*		G
	Heptageniidae	*Nixe*	*simplicoides*	L
	Heptageniidae	*Rhithrogena*		F
	Leptophlebiidae	*Paraleptophlebia*		F,G,L
	Siphlonuridae	*Ameletus*		F,G,L,S,SG
	Siphlonuridae	*Siphlonurus*	*occidentalis*	F,L
	Siphlonuridae	*Siphlonurus*		F
	Siphlonuridae			A
	Tricorythidae	*Tricorythodes*	*minutus*	S
	Tricorythidae	*Tricorythodes*		A,F
Odonata				
suborder Anisoptera (Dragonflies)	Aeshnidae	*Aeshna*		A,C,F,I,S
	Aeshnidae	*Anax*		H,P,S,48
	Aeshnidae	*Boyeria*		S
	Cordulegastridae	*Cordulegaster*		F,S
	Corduliidae	*Belonia*?		A,C,PW
	Gomphidae			L,PW
	Libellulidae	*Leuchorrhina*		I
	Libellulidae	*Libellula*		PS
	Libellulidae	*Pantala*		A,C
	Libellulidae	*Platyhemis*?		PW
	Libellulidae	*Sympetrum*?		PS

Table 1 (cont.)

	Libellulidae			A,F,PS
suborder Zygoptera (Damselflies)	Agriidae	*Argion*		A
	Agriidae	*Hetaerina*		A,PS
	Coenagrionidae	*Argia*		A,C,F,PW,S, PS
	Coenagrionidae	*Enallagma*		I
	Coenagrionidae	*Hyponeura*		F
	Coenagrionidae	*Ishnura*	*perparua*	F
	Coenagrionidae	*Ishnura*		H,S
	Coenagrionidae	*Zoniagrion*		S
	Lestidae	*Archilestes*		PS,S
Hemiptera (True bugs)	Corixidae	*Corisella*		F
	Corixidae	*Sigara*		F
	Corixidae	*Trichocorixa*		A,PW,S
	Gerridae	*Gerris*	*marginatus*	F
	Gerridae	*Gerris*	*notabilis*	F
	Gerridae	*Gerris*		A,D,F,G,H,I, L,PS,S
	Gerridae	*Metrobates*		PS
	Gerridae	*Trepobates*		H
	Naucoridae	*Ambrysus*	*mormon*	A,C,PS
	Notonectidae	*Notonecta*	*undulata*	F
	Notonectidae	*Notonecta*		C,S
	Veliidae	*Microvelia*		F,G
	Veliidae	*Rhagovelia*		S
	Veliidae			A,PS
Trichoptera (Caddisflies)	Brachycentridae	*Amiocentrus*		F
	Brachycentridae	*Brachycentrus*	*americanus*	F
	Brachycentridae	*Brachycentrus*		F
	Brachycentridae	*Micrasema*		F,G,L
	Calamoceratidae	*Phylloicus*		F
	Glossomatidae	*Agapetus*		G
	Glossosomatidae	*Anagapetus*		G
	Glosssosomatidae	*Glossosoma*		F,G,L
	Helicosychidae	*Helicopsyche*	*borealis*	G,L,PS
	Helicopsychidae	*Helicopsyche*		F
	Hydropsychidae	*Arctopsyche*	*grandis*	A,F,G,L,S,PS
	Hydropsychidae	*Cheumatopsyche*		G,PS
	Hydropsychidae	*Hydropsyche*	*occentalis*	PS

Table 1 (cont.)

	Hydropsychidae	*Hydropsyche*	*oslari*	A,F
	Hydropsychidae	*Hydropsyche*		F
	Hydrospsychidae	*Hydropsyche*		F,G,PS,S,SG
	Hydroptilidae	*Alisotrichia*		PS
	Hydroptilidae	*Hydroptila*		A,PW,PS,S
	Hydroptilidae	*Leucotrichia*		PS
	Hydroptilidae	*Ochrotrichia*		F,G,L
	Hydroptilidae	*Stactobiella*		A,PS
	Lepidostomatidae	*Lepidostoma*		F,G,L,S,SG
	Lepidostomatidae			G
	Leptoceridae	*Oecetis*		L,PW,S
	Limnephilidae	*Dicosmoecus*		F
	Limnephilidae	*Hesperophylax*		G,L,PW,S,SG
	Limnephilidae	*Limnephilus*		F,G,L,PW,S
	Limnephilidae	*Oligophlebodes*		F,G,L,PW,S
	Limnephilidae	*Psychoronia*		F,G
	Limnephilidae			G,L,PW
	Philopotamidae	*Chimarra*		A,PS
	Philopotamidae	*Dolophilodes*	*aequalis*	F
	Philopotamidae	*Dolophilodes*	*sortosa*	F,G
	Philopotamidae	*Dolophilodes*		G,L
	Philopotamidae	*Wormaldia*		F,PS
	Polycentropidae	*Polycentropus*		F
	Rhyacophilidae	*Rhyacophila*	*acropedes*	F,G
	Rhyacophilidae	*Rhyacophila*	*brunnea* complex	F,G
	Rhyacophilidae	*Rhyacophila*	*hyalinata*	F,G
	Rhyacophilidae	*Rhyacophila*	*valuma*	F,G
	Rhyacophilidae	*Rhyacophila*		F
	Rhyacophilidae	*Rhyacophila*	Type A	A
Megaloptera (Nerve-wings)	Corydalidae	*Neohermes*?		G,L
Lepidoptera (Butterflies and moths)	Noctuidae			G,PS
	Pyralidae			S
	Pyralidae	*Paraponyx*		PS
	Pyralidae	*Parargyractis*	*kearfottalis*	F,PS
	Pyralidae	*Petrophyla*		PS
Coleoptera (Beetles)	Curculionidae	*Phytonomus*		G,L,S
	Curculionidae			D,F
	Dryopidae	*Helichus*	*suturalis**	F

Table 1 (cont.)

	Dryopidae	*Helichus*	*striatus**	F
	Dryopidae (adults)	*Helichus*		F,L,PW,PS
	Dryopidae (adults)			S
	Dytiscidae	*Agabus*	*cordatus**	F
	Dytiscidae	*Agabus*	*tristus**	F
	Dytiscidae	*Agabus*		A,C,D,L,PW, S
	Dytiscidae	*Deronectes*	*striatellus**	F
	Dytiscidae	*Deronectes**		L
	Dytiscidae	*Dytiscus**		F
	Dytiscidae	*Hydroporus*	*vilis**	F
	Dytiscidae			L,S
	Dytiscidae (adults)			G,PS,S
	Dytiscidae (adults)		Type A	M
	Dytiscidae (adults)		Type B	M
	Dytiscidae (adults)	*Hydaticus*		G,L,PS,S
	Elmidae	*Cleptelmis addenda**		F
	Elmidae	*Cylloepus*		F
	Elmidae	*Dubiraphia**		G
	Elmidae	*Heterlimnius*	*corpulentis*	F,G,L,PS,SG
	Elmidae (adults)	*Heterlimnius*	*corpulentis*	G,L,PS,SG
	Elmidae	*Microcylloepus**		PS
	Elmidae	*Narpus* *	*concolor*	F
	Elmidae	*Narpus*		F,G,L
	Elmidae (adults)	*Narpus*		G,L
	Elmidae	*Optioservus*	*castanipennis* *	F
	Elmidae	*Optioservus*	*divergens**	F
	Elmidae	*Optioservus**		D,F,L,PS,S
	Elmidae	*Rhizelmis*		F
	Elmidae	*Zaitzevia*	*parvula*	D,F,L
	Elmidae	*Zaitzevia*		G,L
	Elmidae (adults)	*Zaitzevia*		C,G,L,S
	Elmidae			G,L,S
	Elmidae (adults)			C,S,PS
	Gyrinidae (adults)	*Gyrinus*		A,F,S,PS

Table 1 (cont.)

	Haliplidae	*Haliplus*		IC
	Haliplidae	*Peltodytes*		G
	Haliplidae (adults)			S
	Helodidae			PW
	Hydrophilidae	*Ametor*	*scabrosus**	F
	Hydrophilidae	*Ametor*		A,C
	Hydrophilidae (adults)	*Ametor*		G
	Hydrophilidae	*Berosus*	*styliferous*	F
	Hydrophilidae	*Crenitis**		F
	Hydrophilidae	*Cymbiodyta*	*dorsalis**	F
	Hydrophilidae (adults)	*Hydrochus*		G
	Hydrophilidae			G,L,PW
	Hydrophilidae (adults)			G
	Psephenidae	*Psphenus*?		C,PW,48
Diptera (Flies)	Blephariceridae			F
	Ceratopogonidae (Heleidae)	*Bezzia*		G,S
	Ceratopogonidae (Heleidae)			F,G,PW,PS,S
	Chironomidae	*Ablabesmyia*		F
	Chironomidae	*Brillia*		F,L,S
	Chironomidae	*Cardiocladius*		F,G
	Chironomidae	*Crichotopus*		F
	Chironomidae	*Chironomus*		F
	Chironomidae	*Corynoneura*		PS
	Chironomidae	*Cricotopus*		A,F,G.PS
	Chironomidae	*Cryptochironomus*		F
	Chironomidae	*Eukiefferiella*		A,F,G,L
	Chironomidae	*Micropsectra*		A,F
	Chironomidae	*Microtendipes*		D,F
	Chironomidae	*Nanocladius*		F
	Chironomidae	*Pagastia*		L
	Chironomidae	*Polypedilum*		A,F
	Chironomidae	*Procladius*		F
	Chironomidae	*Pseudochironomus*		A
	Chironomidae	*Pseudosmittia*		G
	Chironomidae	*Rheotanytarsus*		A,F,PS
	Chironomidae	*Thienemannimyia*		A,S
	Chironomidae	*Thienimanniella*		A

Table 1 (cont.)

	Chironomidae	*Zavrelia*		F
	Chironomidae	Type A		C,H,L,PW, PS,S,SG, 128
	Chironomidae	Type B		G,L,PW,S,PS
	Chironomidae	Type C		H,PW,S,128
	Chironomidae	Type D		G,L,PW,PS,S
	Chironomidae	Type E		L,PS
	Chironomidae	Type F		G,L,S
	Chironomidae	Type G		A,C,G,H,L,P W,PS,S
	Chironomidae	Type H		S
	Chironomidae	Type I		SG
	Chironomidae (pupae)			C,I,S
	Chironomidae (pupae)	Type PB		S
	Culicidae	*Aedes*		F
	Culicidae	*Chaoborus*		I,48
	Culicidae	*Culex*		F,H,128
	Culicidae	*Culiseta*		D,H,M,48,12 8
	Culicidae (pupae)			H,M,G,L,128
	Culicidae			S
	Dixidae	*Dixa*	*californica*	F
	Dixidae	*Dixa*		F,G,L,PS
	Dixidae	*Dixa*	Type A	G,L,PW,PS
	Empididae	*Chelifera*		F,G,L
	Empididae	*Oreogeton*		C,F,G,PW,S
	Empididae			H
	Ephydridae	*Brachydeutera*		S
	Ephydridae (pupae)			S
	Muscidae	*Limnophora*	*aequifrons*	F
	Muscidae	*Limnophora*		A,D,L,S,SG
	Psychodidae	*Maruina*		G,L
	Psychodidae	*Pericoma*		F,G,L
	Psychodidae (pupae)			S
	Ptychopteridae	*Bittacomorpha*		A,G,L,S
	Ptychopteridae			F
	Simuliidae	*Prosimilium*		A,F,G,L,S
	Simuliidae	*Simulium*		F,L
	Simuliidae			D,F,G,L,S,SG

Table 1 (cont.)

	Simuliidae (pupae)			S
	Stratiomyidae	*Eulalia*		F
	Stratiomyidae	*Odontomyia*?		PS,S
	Stratiomyidae			A,F
	Syrphidae	*Tubifera*	*bastardii*	F
	Tabanidae	*Chrysops*		H,M
	Tabanidae	*Tabanus*		128,PW
	Tabanidae			F,G,L
	Tanyderidae	*Protanyderus*		F
	Tipulidae	*Antocha*	*monticola*	F,G
	Tipulidae	*Antocha*		G,L
	Tipulidae	*Dicranota*		F,G,L,PS,S,S G
	Tipulidae	*Hexatoma*		F
	Tipulidae	*Holorusia*	*grandis*	F
	Tipulidae	*Limonia*		F
	Tipulidae	*Pedicia*		F
	Tipulidae	*Tipula*		D,F,G,L,PS,S
	Tipulidae	*Tipula*	Type B	S

Table 2 Non-Insect Aquatic Invertebrates Collected in Los Alamos County and Adjacent Watersheds

PHYLUM or SUBPHYLUM	CLASS, ETC	COMMON NAME	LOCATION **
Annelida (Segmented worms)	Naididae	Coil worms	F,L,S
	Oligochaeta, Lumbriculidae *Eiseniella tetraedra*	Aquatic earthworms	F
	Oligochaeta, Lumbriculidae	Aquatic earthworms	A,F,G,L,PS, S,SG
	Oligochaeta B, Lumbriculidae	Aquatic earthworms	G
	Hirudinea	Leeches	A,F
Arthropoda, Arachnoidea (Spiders, ticks, and mites)	family Hydracarina	Water mites	C,F,G,PS,SG
Aschelminthes (Round worms and hairworms)	Nematomorpha	Horsehair worm	C,F,G.L,PW,

Table 2 (cont.)

	Nematomorpha, *Gordius*	Horsehair worm	F
Crustacea (Crustaceans)	Amphipoda, *Hyatella azteca*	Scuds	A,C,PS
	Cladocera	Water fleas	O
	Copepoda	Copedpods	S
	Ostracoda, Candoniidae	Seed shrimp	S
	Ostracoda, Cyprididae	Seed shrimp	C,S,SG
	family Palaemonidae	Scuds	A,C
Mollusca (Mollusks)	Gastropoda, *Gyralus parvus*	Snails	G,IC,S
	Lymnaeidae, *Lymnaea*	Snails	A,G,L,PW,S
	Physidae, *Physella*	Snails	A
	Physidae, *Physa*	Snails	F,S
	Gastropoda	Snails	SG
	Pelecypodae, *Pisidium casertanum*	Clams	F,G,L
	Pelecypoda, *Pisidium compressa*	Clams	H
	Sphaeridae	Clams	F
Nematoda (Round worms)		Free-living round worm	F,S
Platyhelminthes (Flatworms)	Turbellaria	Planaria	A,C,F,G,PS, S,SG

**Locations:

A = Ancho Canyon
C = Chaquehui Canyon
D = DP Canyon
F = Rio Frijoles and Frijoles Canyon
G = Guaje Canyon
H = High Explosives wastewater stream
I = Ice House pond, off West Jemez Road
L = Los Alamos Canyon
O = Otowi firestation pond
M = Mortandad
PW = Pajarito Wetlands
PS = Pajarito Springs
S = Sandia Canyon
SG = Starmer's Gulch
48 = TA-48 pond
128 = outfall 128

APPENDIX 4-F

Table 1 Functional Feeding Groups for the Aquatic Insects of Guaje and Los Alamos Canyons (modified from Merrit and Cummins 1984, All specimens are larval unless otherwise noted.)

Order	Family	Genus (species)	Feeding grp*	Canyon
Plecoptera	Chloroperlidae		CG, SC	G, LA
	Nemouridae	Amphinemura	SH	G, LA
	Nemouridae	Malenka	?	G
	Nemouridae	Podmosta (delicatula)	?	G
	Nemouridae	Zapada (frigida)	SH	LA
	Perlidae	Hesperoperla (pacifica)	P	LA
	Perlodidae	Cultus (aestivalis)	P	G, LA
	Perlodidae	Isoperla	P	G, LA
	Perlodidae	Kogotus (modestus)	P	G, LA
	Pteronarcyidae	Pteronarcella (badia)	SH	G
	Pteronarcyidae	Pteronarcys	SH	G
Ephemeroptera	Baetidae	Baetis	CG, SC	G, LA
	Baetidae	Callibaetis	CG	G, LA
	Ephemerellidae	Drunella (coloradensis)	SC, P?	G, LA
	Ephemerellidae	Drunella (doddsi)	SC, P?	G
	Ephemerellidae	Drunella (grandis grandis)	SC	G
	Ephemerellidae	Ephemerella (inermis)	CG, SC	G, LA
	Ephemerellidae	Ephemerella (infrequens)	SH	G
	Heptageniidae	Cinygmula	SC, CG	G, LA
	Heptageniidae	Epeorus (longimanus)	CG, SC	G, LA
	Leptophlebiidae	Paraleptophlebia	CG, SH	G, LA
	Siphlonuridae	Ameletus	CG	G, LA
	Siphlonuridae	Siphlonurus	CG, SH, P	LA
	Tricorythidae	Tricorythodes (minutus)	CG	G
Odonata	Aeshnidae	Boyeria	P	LA
Hemiptera	Gerridae	Gerris	P	G, LA
	Veliidae	Microvelia	P	G, LA
Trichoptera	Brachycentridae	Micrasema	CG	G, LA
	Glossosomatidae	Agapetus	SC, CG	G
	Glossosomatidae	Glossosoma	SC	G, LA
	Hydropsychidae	Arctopsyche (grandis)	CF	G, LA
	Hydropsychidae	Cheumatopsyche	CF	G
	Hydropsychidae	Hydropsyche	CF	G, LA

Table 1 (cont.)

Order	Family	Genus (species)	Feeding grp*	Canyon
	Lepidostomatidae	Lepidostoma	SH	G, LA
	Leptoceridae	Oecetis ?	P, SH	G, LA
	Limnephilidae	Hesperophylax	SH	G, LA
	Limenphilidae	Limnephilus	SH, CG	G, LA
	Limnephilidae	Oligophlebodes	SC, CG	G, LA
	Odontoceridae	Namamyia	CG?	G
	Philopotamidae	Dolophilodes	CF	G, LA
	Rhyacophilidae	Rhyacophila brunnea complex	P	G, LA
Lepidoptera	Noctuidae		SH	G, LA
	Pyralidae		SH	G
Coleoptera	Amphizoidae	Amphizoa	P	G
	Curculionidae adult		SH	G
	Dryopidae adult	Helichus	SC	G, LA
	Dytiscidae	Agabus	P	LA
	Dytiscidae	Copelatus?	P	LA
	Dytiscidae	Hydaticus	P	G, LA
	Dytiscidae adults	Laccophilus	P	LA
	Dytiscidae adults		P	LA
	Elmidae	all genera found	CG, SC	G, LA
	Elmidae adults	all genera found	CG, SC	G, LA
	Helodidae	Prionocyphon	SC, CG	G
	Hydrophilidae	Ametor	P	G, LA
	Hydrophilidae adults	Ametor	P	G
	Hydrophilidae	Helophorus	SH	LA
	Hydrophilidae	Hydrobius	?	LA
	Hydrophilidae	Hydrochus	SH	G
	Hydrophilidae		P	G
	Psephenidae		SC	G
Diptera	Ceratopogonidae	Bezzia	P	LA
	Chironomidae	all taxa found	CG, CF	G, LA
	Dixidae	Dixa	CG	G, LA
	Dixidae	Dixa A	CG	G
	Empididae	Chelifera	?	G
	Empididae	Hemerodromia	P, CG	G
	Empididae	Oreogeton	P	G, LA
	Muscidae	Limnophora	P	LA
	Psychodidae	Maruina	SC, CG	G, LA
	Psychodidae	Pericoma	CG	G, LA
	Ptychopteridae	Ptychoptera	CG	G, LA

Table 1 (cont.)

Order	Family	Genus (species)	Feeding grp*	Canyon
	Simulidae		CF	G, LA
	Stratiomyiidae	Odontomyia	CG	G
	Tipulidae	Antocha	CG	G, LA
		Dicranota	P	G, LA
		Tipula	SH, CG	G, LA
		Tipula B	SH, CG	G, LA

***Codes For Functional Feeding Groups:**

CF = collector filterer
CG =collector gatherer
P = predator
PH = piercer-herbivore
SC = scraper
SH = shredder

APPENDIX 4-G

Table 1 Rapid Bioassessment Protocol Worksheets for Guaje and Los Alamos Canyons

<u>Month, Year: May, 1993</u>

Samples:	G1 √	G2 √	G3 √
	LA1 √	LA2 √	LA3 √

Metric: 1. Taxa Richness = (LA/G) X 100

Station	Los Alamos taxa	Guaje taxa	Percentage	Score
1	15	16	94	6
2	17	23	74	4
3	7	19	37	0

Metric: 2. Community Tolerance Quotient = (G/LA) X 100

Station	Guaje Tolerance Quotient	Los Alamos Tolerance Quotient	Percentage	Score
1	44.0	51.2	86	6
2	65.6	103.4	63	2
3	54.5	80.7	68	2

Metric: 3. Ratio Scrapers/Filtering Collectors = (LA/G) X 100

Station	Los Alamos SC/FC	Guaje SC/FC	Percentage	Score
1	7.8	14.4	54	6
2	0.09	1.7	5	0
3	1.1	8.0	14	0

Table 1 (cont.)

Month, Year: May, 1993

Metric: 4. Total Number of EPT Individuals = (LA/G) X 100

Station	Los Alamos EPT individuals	Guaje EPT individuals	Percentage	Score
1	260	144	8	6
2	93	162	2	2
3	46	98	3	2

Metric: 5. Percent Contribution of Dominant Taxon

Station	Los Alamos percentage	Score
1	28.7	4
2	85.8	0
3	37.3	2

Metric: 6. EPT Index = (LA/G) X 100

Station	Los Alamos EPT Index	Guaje EPT Index	Percentage	Score
1	6	10	60	0
2	10	13	77	2
3	3	12	25	0

Metric: 7. Community Loss Index

Station	Loss Index	Score
1	0.64	4
2	0.87	4
3	2.14	2

Bioassessment

Station	Total biological condition score	Percentage score	Assessment
1	32	76	Slightly impaired
2	14	33	Moderately impaired
3	8	19	Severely impaired

Table 1 (cont.)

Month, Year: June, 1993

Samples:	G1 √	G2 √	G3 √
	LA1 √	LA2 √	LA3 √

Metric: 1. Taxa Richness = (LA/G) X 100

Station	Los Alamos taxa	Guaje taxa	Percentage	Score
1	15	21	71	4
2	14	16	88	6
3	13	19	68	4

Metric: 2. Community Tolerance Quotient = (G/LA) X 100

Station	Guaje Tolerance Quotient	Los Alamos Tolerance Quotient	Percentage	Score
1	56.6	72	79	4
2	46.9	45.9	102	6
3	43.8	37.1	118	6

Metric: 3. Ratio Scrapers/Filtering Collectors = (LA/G) X 100

Station	Los Alamos SC/FC	Guaje SC/FC	Percentage	Score
1	0.64	109.7	0.6	0
2	2.7	88.5	3	0
3	42	31.8	132	6

Metric: 4. Total Number of EPT Individuals = (LA/G) X 100

Station	Los Alamos EPT individuals	Guaje EPT individuals	Percentage	Score
1	74	219	34	2
2	519	165	315	6
3	138	187	74	4

Table 1 (cont.)

Metric: 5. Percent Contribution of Dominant Taxon

Station	Los Alamos percentage	Score
1	37	2
2	32	2
3	63	0

Month, Year: June, 1993

Metric: 6. EPT Index = (LA/G) X 100

Station	Los Alamos EPT Index	Guaje EPT Index	Percentage	Score
1	11	11	100	6
2	10	11	91	6
3	7	10	70	2

Metric: 7. Community Loss Index

Station	Loss Index	Score
1	0.65	4
2	0.50	4
3	0.91	4

Bioassessment

Station	Total biological condition score	Percentage score	Assessment
1	22	52	Slightly impaired
2	30	71	Slightly impaired
3	26	62	Slightly impaired

Table 1 (cont.)

Month, Year: July, 1993

Samples:	G1 √	G2 √	G3 √
	LA1 √	LA2 Dry	LA3 Dry

Metric: 1. Taxa Richness = (LA/G) X 100

Station	Los Alamos taxa	Guaje taxa	Percentage	Score
1	24	34	71	4
2	0	32	0	0
3	0	18	0	0

Metric: 2. Community Tolerance Quotient = (G/LA) X 100

Station	Guaje Tolerance Quotient	Los Alamos Tolerance Quotient	Percentage	Score
1	57.3	74.1	77	4
2	64.4	0	0	0
3	39.9	0	0	0

Metric: 3. Ratio Scrapers/Filtering Collectors = (LA/G) X 100

Station	Los Alamos SC/FC	Guaje SC/FC	Percentage	Score
1	2.40	4.35	55	6
2	0	11.1	0	0
3	0	1.02	0	0

Metric: 4. Total Number of EPT Individuals = (LA/G) X 100

Station	Los Alamos EPT individuals	Guaje EPT individuals	Percentage	Score
1	348	375	93	6
2	0	165	0	0
3	0	188	0	0

Table 1 (cont.)

Month, Year: July, 1993

Metric: 5. Percent Contribution of Dominant Taxon

Station	Los Alamos percentage	Score
1	18	6
2	0	0
3	0	0

Metric: 6. EPT Index = (LA/G) X 100

Station	Los Alamos EPT Index	Guaje EPT Index	Percentage	Score
1	12	15	80	4
2	0	11	0	0
3	0	14	0	0

Metric: 7. Community Loss Index = (d-a)/e

where

d = # G taxa

e = # LA taxa

a = # taxa in common

Station	d	a	e	Loss Index	Score
1	33	16	24	0.71	4
2	32	0	0	-	0
3	18	0	0	-	0

Bioassessment

Station	Total biological condition score	Percentage score	Assessment
1	34	81	Nonimpaired
2	0	0	Severely impaired
3	0	0	Severely impaired

Table 1 (cont.)

Month, Year: August, 1993

Samples:	G1 √	G2 √	G3 √
	LA1 √	LA2 √	LA3 √

Metric: 1. Taxa Richness = (LA/G) X 100

Station	Los Alamos taxa	Guaje taxa	Percentage	Score
1	21	35	60	4
2	4	24	17	0
3	6	24	25	0

Metric: 2. Community Tolerance Quotient = (G/LA) X 100

Station	Guaje Tolerance Quotient	Los Alamos Tolerance Quotient	Percentage	Score
1	61.7	72.9	85	6
2	62.8	66.9	94	6
3	68.2	0	0	0

Metric: 3. Ratio Scrapers/Filtering Collectors = (LA/G) X 100

Station	Los Alamos SC/FC	Guaje SC/FC	Percentage	Score
1	23.5	3.82	6.15	6
2	0	6.31	0	0
3	0	60	0	0

Metric: 4. Total Number of EPT Individuals = (LA/G) X 100

Station	Los Alamos EPT individuals	Guaje EPT individuals	Percentage	Score
1	94	396	24	0
2	0	196	0	0
3	18	110	16	0

Table 1 (cont.)

Month, Year: August, 1993

Metric: 5. Percent Contribution of Dominant Taxon

Station	Los Alamos percentage	Score
1	31	2
2	76	0
3	70	0

Metric: 6. EPT Index = (LA/G) X 100

Station	Los Alamos EPT Index	Guaje EPT Index	Percentage	Score
1	9	15	60	0
2	0	13	0	0
3	4	14	29	0

Metric: 7. Community Loss Index = (d-a)/e

where

d = # G taxa

e = # LA taxa

a = # taxa in common

Station	d	a	e	Loss Index	Score
1	35	11	21	1.1	4
2	25	2	4	5.8	0
3	24	3	5	4.2	0

Bioassessment

Station	Total biological condition score	Percentage score	Assessment
1	22	62	Slightly impaired
2	6	14	Severely impaired
3	0	0	Severely impaired

Table 1 (cont.)

Month, Year: September, 1993

Samples:	G1	√	G2	√	G3	√
	LA1	√	LA2	√	LA3	Dry

Metric: 1. Taxa Richness = (LA/G) X 100

Station	Los Alamos taxa	Guaje taxa	Percentage	Score
1	27	28	96	6
2	9	35	26	0
3	0	25	0	0

Metric: 2. Community Tolerance Quotient = (G/LA) X 100

Station	Guaje Tolerance Quotient	Los Alamos Tolerance Quotient	Percentage	Score
1	57.0	53.4	107	6
2	58.6	105.4	56	2
3	68.0	0	0	0

Metric: 3. Ratio Scrapers/Filtering Collectors = (LA/G) X 100

Station	Los Alamos SC/FC	Guaje SC/FC	Percentage	Score
1	5.54	15.24	36	4
2	0.51	6.09	8	0
3	0	3.48	0	0

Metric: 4. Total Number of EPT Individuals = (LA/G) X 100

Station	Los Alamos EPT individuals	Guaje EPT individuals	Percentage	Score
1	238	345	69	4
2	1	90.6	0.2	0
3	0	220	0	0

Table 1 (cont.)

Month, Year: September, 1993

Metric: 5. Percent Contribution of Dominant Taxon

Station	Los Alamos percentage	Score
1	32	2
2	36	2
3	0	0

Metric: 6. EPT Index = (LA/G) X 100

Station	Los Alamos EPT Index	Guaje EPT Index	Percentage	Score
1	15	17	88	4
2	1	17	6	0
3	0	16	0	0

Metric: 7. Community Loss Index

Station	Loss Index	Score
1	0.32	6
2	2.7	2
3	-	0

Bioassessment

Station	Total biological condition score	Percentage score	Assessment
1	32	76	Slightly impaired
2	6	14	Severely impaired
3	0	0	Severely impaired

Table 1 (cont.)

Month, Year: October, 1993

Samples:	G1	√	G2	√	G3	√
	LA1	√	LA2	Dry	LA3	Dry

Metric: 1. Taxa Richness = (LA/G) X 100

Station	Los Alamos taxa	Guaje taxa	Percentage	Score
1	32	26	123	6
2	0	24	0	0
3	0	19	0	0

Metric: 2. Community Tolerance Quotient = (G/LA) X 100

Station	Guaje Tolerance Quotient	Los Alamos Tolerance Quotient	Percentage	Score
1	59.8	52.9	113	6
2	67.0	0	0	0
3	71.2	0	0	0

Metric: 3. Ratio Scrapers/Filtering Collectors = (LA/G) X 100

Station	Los Alamos SC/FC	Guaje SC/FC	Percentage	Score
1	3.13	8.93	35	4
2	0	0.15	0	0
3	0	0.02	0	0

Metric: 4. Total Number of EPT Individuals = (LA/G) X 100

Station	Los Alamos EPT individuals	Guaje EPT individuals	Percentage	Score
1	544	438	124	6
2	0	341	0	0
3	0	227	0	0

Table 1 (cont.)

Month, Year: October, 1993

Metric: 5. Percent Contribution of Dominant Taxon

Station	Los Alamos percentage	Score
1	23	4
2	0	0
3	0	0

Metric: 6. EPT Index = (LA/G) X 100

Station	Los Alamos EPT Index	Guaje EPT Index	Percentage	Score
1	19	18	105	6
2	0	15	0	0
3	15	15	0	0

Metric: 7. Community Loss Index = (d-a)/e
where
d = # G taxa
e = # LA taxa
a = # taxa in common

Station	d	a	e	Loss Index	Score
1	26	18	32	0.25	4
2	24	0	0	-	0
3	19	0	0	-	0

Bioassessment

Station	Total biological condition score	Percentage score	Assessment
1	36	86	Nonimpaired
2	0	0	Severely impaired
3	0	0	Severely impaired

Table 1 (cont.)

Month, Year: May, 1994

Samples:	G1 √	G2 √	G3 √
	LA1 √	LA2 √	LA3 √

Metric: 1. Taxa Richness = (LA/G) X 100

Station	Los Alamos taxa	Guaje taxa	Percentage	Score
1	30	30	100	6
2	7	28	25	0
3	6	30	20	0

Metric: 2. Community Tolerance Quotient = (G/LA) X 100

Station	Guaje Tolerance Quotient	Los Alamos Tolerance Quotient	Percentage	Score
1	66	52	127	6
2	56	108	52	2
3	50	107	47	0

Metric: 3. Ratio Scrapers/Filtering Collectors = (LA/G) X 100

Station	Los Alamos SC/FC	Guaje SC/FC	Percentage	Score
1	2.09	1.15	182	6
2	0	3.65	0	0
3	0	6.91	0	0

Metric: 4. Total Number of EPT Individuals = (LA/G) X 100

Station	Los Alamos EPT individuals	Guaje EPT individuals	Percentage	Score
1	474	299	156	6
2	4	476	0.8	0
3	1	931	0.1	0

Table 1 (cont.)

Month, Year: May, 1994

Metric: 5. Percent Contribution of Dominant Taxon

Station	Los Alamos percentage	Score
1	28	4
2	95	0
3	51	0

Metric: 6. EPT Index = (LA/G) X 100

Station	Los Alamos EPT Index	Guaje EPT Index	Percentage	Score
1	16	15	107	6
2	2	17	12	0
3	1	17	6	0

Metric: 7. Community Loss Index = (d-a)/e

where

d = # G taxa

e = # LA taxa

a = # taxa in common

Station	d	a	e	Loss Index	Score
1	30	17	30	0.43	6
2	28	4	7	3.43	2
3	30	3	6	4.5	0

Bioassessment

Station	Total biological condition score	Percentage score	Assessment
1	40	95	Nonimpaired
2	4	0.1	Severely impaired
3	0	0	Severely impaired

Table 1 (cont.)

Month, Year: June, 1994

Samples:	G1 √	G2 √	G3 √
	LA1 √	LA2 √	LA3 √

Metric: 1. Taxa Richness = (LA/G) X 100

Station	Los Alamos taxa	Guaje taxa	Percentage	Score
1	29	34	85	6
2	12	27	44	2
3	9	27	30	0

Metric: 2. Community Tolerance Quotient = (G/LA) X 100

Station	Guaje Tolerance Quotient	Los Alamos Tolerance Quotient	Percentage	Score
1	54	51	106	6
2	65	105	62	2
3	65	81	80	4

Metric: 3. Ratio Scrapers/Filtering Collectors = (LA/G) X 100

Station	Los Alamos SC/FC	Guaje SC/FC	Percentage	Score
1	6.9	28.4	24	2
2	0.0004	2.79	0.014	0
3	0.03	0.76	3.95	0

Metric: 4. Total Number of EPT Individuals = (LA/G) X 100

Station	Los Alamos EPT individuals	Guaje EPT individuals	Percentage	Score
1	432	250	173	6
2	178	336	53	4
3	0	106	0	0

Table 1 (cont.)

Month, Year: June, 1994

Metric: 5. Percent Contribution of Dominant Taxon

Station	Los Alamos percentage	Score
1	29	4
2	87	0
3	72	0

Metric: 6. EPT Index = (LA/G) X 100

Station	Los Alamos EPT Index	Guaje EPT Index	Percentage	Score
1	13	19	68	0
2	11	19	58	0
3	8	18	44	0

Metric: 7. Community Loss Index = (d-a)/e

where

d = # G taxa

e = # LA taxa

a = # taxa in common

Station	d	a	e	Loss Index	Score
1	34	18	29	0.55	4
2	27	8	12	1.58	2
3	27	5	8	2.75	2

Bioassessment

Station	Total biological condition score	Percentage score	Assessment
1	28	67	Slightly impaired
2	10	24	Moderately impaired
3	6	14	Severely impaired

Table 1 (cont.)

Month, Year: July, 1994

Samples:	G1 √	G2 √	G3 √
	LA1 √	LA2 Dry	LA3 Dry

Metric: 1. Taxa Richness = (LA/G) X 100

Station	Los Alamos taxa	Guaje taxa	Percentage	Score
1	33	25	132	6
2	0	22	0	0
3	0	28	0	0

Metric: 2. Community Tolerance Quotient = (G/LA) X 100

Station	Guaje Tolerance Quotient	Los Alamos Tolerance Quotient	Percentage	Score
1	54	77	70	2
2	53	0	-	0
3	59	0	-	0

Metric: 3. Ratio Scrapers/Filtering Collectors = (LA/G) X 100

Station	Los Alamos SC/FC	Guaje SC/FC	Percentage	Score
1	2.64	4.26	62	6
2	0	204.00	0	0
3	0	38.67	0	0

Metric: 4. Total Number of EPT Individuals = (LA/G) X 100

Station	Los Alamos EPT individuals	Guaje EPT individuals	Percentage	Score
1	906	384	236	6
2	0	300	0	0
3	0	530	0	0

Table 1 (cont.)

Month, Year: July, 1994

Metric: 5. Percent Contribution of Dominant Taxon

Station	Los Alamos percentage	Score
1	28	4
2	0	0
3	0	0

Metric: 6. EPT Index = (LA/G) X 100

Station	Los Alamos EPT Index	Guaje EPT Index	Percentage	Score
1	12	13	92	6
2	0	13	0	0
3	0	16	0	0

Metric: 7. Community Loss Index = (d-a)/e

where

d = # G taxa

e = # LA taxa

a = # taxa in common

Station	d	a	e	Loss Index	Score
1	25	16	33	0.27	6
2	22	0	0	-	0
3	28	0	0	-	0

Bioassessment

Station	Total biological condition score	Percentage score	Assessment
1	36	86	Nonimpaired
2	0	0	Severely impaired
3	0	0	Severely impaired

Table 1 (cont.)

Month, Year: August, 1994

Samples:	G1 √	G2 √	G3 √
	LA1 √	LA2 √	LA3 Dry

Metric: 1. Taxa Richness = (LA/G) X 100

Station	Los Alamos taxa	Guaje taxa	Percentage	Score
1	24	30	80	4
2	7	33	21	0
3	0	30	0	0

Metric: 2. Community Tolerance Quotient = (G/LA) X 100

Station	Guaje Tolerance Quotient	Los Alamos Tolerance Quotient	Percentage	Score
1	75	71	106	6
2	51	108	47	0
3	51	0	-	0

Metric: 3. Ratio Scrapers/Filtering Collectors = (LA/G) X 100

Station	Los Alamos SC/FC	Guaje SC/FC	Percentage	Score
1	90	78	115	6
2	0	7067	0	0
3	0	2.55	0	0

Metric: 4. Total Number of EPT Individuals = (LA/G) X 100

Station	Los Alamos EPT individuals	Guaje EPT individuals	Percentage	Score
1	286	374	76	6
2	5	409	1.2	0
3	0	303	0	0

Table 1 (cont.)

Month, Year: August, 1994

Metric: 5. Percent Contribution of Dominant Taxon

Station	Los Alamos percentage	Score
1	24	4
2	32	2
3	0	0

Metric: 6. EPT Index = (LA/G) X 100

Station	Los Alamos EPT Index	Guaje EPT Index	Percentage	Score
1	15	15	100	6
2	1	20	5	0
3	0	17	0	0

Metric: 7. Community Loss Index = (d-a)/e

where

d = # G taxa

e = # LA taxa

a = # taxa in common

Station	d	a	e	Loss Index	Score
1	30	16	24	0.58	4
2	33	4	7	4.14	0
3	30	0	0	-	0

Bioassessment

Station	Total biological condition score	Percentage score	Assessment
1	36	86	Nonimpaired
2	2	5	Severely impaired
3	0	0	Severely impaired

Table 1 (cont.)

Month, Year: September, 1994

Samples:	G1 √	G2 √	G3 √
	LA1 √	LA2 √	LA3 Dry

Metric: 1. Taxa Richness = (LA/G) X 100

Station	Los Alamos taxa	Guaje taxa	Percentage	Score
1	25	30	83	6
2	16	22	73	4
3	0	28	0	0

Metric: 2. Community Tolerance Quotient = (G/LA) X 100

Station	Guaje Tolerance Quotient	Los Alamos Tolerance Quotient	Percentage	Score
1	57	78	73	4
2	68	92	74	4
3	75	0	-	0

Metric: 3. Ratio Scrapers/Filtering Collectors = (LA/G) X 100

Station	Los Alamos SC/FC	Guaje SC/FC	Percentage	Score
1	0.10	0.41	24	2
2	0	4.88	0	0
3	0	2.56	0	0

Metric: 4. Total Number of EPT Individuals = (LA/G) X 100

Station	Los Alamos EPT individuals	Guaje EPT individuals	Percentage	Score
1	355	407	87	6
2	67	198	34	2
3	0	326	0	0

Table 1 (cont.)

Month, Year: September, 1994

Metric: 5. **Percent Contribution of Dominant Taxon**

Station	Los Alamos percentage	Score
1	35	2
2	25	4
3	0	0

Metric: 6. **EPT Index** = (LA/G) X 100

Station	Los Alamos EPT Index	Guaje EPT Index	Percentage	Score
1	12	17	71	2
2	7	12	58	0
3	0	12	0	0

Metric: 7. **Community Loss Index** = (d-a)/e

where

d = # G taxa

e = # LA taxa

a = # taxa in common

Station	d	a	e	Loss Index	Score
1	30	18	25	0.48	6
2	22	10	16	0.75	4
3	28	0	0	-	0

Bioassessment

Station	Total biological condition score	Percentage score	Assessment
1	28	67	Slightly impaired
2	18	43	Moderately impaired
3	0	0	Severely impaired

Table 1 (cont.)

Month, Year: October, 1994

Samples:	G1 √	G2 √	G3 √
	LA1 √	LA2 Dry	LA3 Dry

Metric: 1. Taxa Richness = (LA/G) X 100

Station	Los Alamos taxa	Guaje taxa	Percentage	Score
1	26	29	90	6
2	0	32	0	0
3	0	30	0	0

Metric: 2. Community Tolerance Quotient = (G/LA) X 100

Station	Guaje Tolerance Quotient	Los Alamos Tolerance Quotient	Percentage	Score
1	58	53	109	6
2	66	0	-	0
3	66	0	-	0

Metric: 3. Ratio Scrapers/Filtering Collectors = (LA/G) X 100

Station	Los Alamos SC/FC	Guaje SC/FC	Percentage	Score
1	0.21	1.73	12	0
2	0	0.31	0	0
3	0	0.39	0	0

Metric: 4. Total Number of EPT Individuals = (LA/G) X 100

Station	Los Alamos EPT individuals	Guaje EPT individuals	Percentage	Score
1	781	496	157	6
2	0	311	0	0
3	0	504	0	0

Table 1 (cont.)

<u>**Month, Year: October, 1994**</u>

Metric: 5. Percent Contribution of Dominant Taxon

Station	Los Alamos percentage	Score
1	30	4
2	0	0
3	0	0

Metric: 6. EPT Index = (LA/G) X 100

Station	Los Alamos EPT Index	Guaje EPT Index	Percentage	Score
1	13	16	81	4
2	0	18	0	0
3	0	18	0	0

Metric: 7. Community Loss Index = (d-a)/e
where
d = # G taxa
e = # LA taxa
a = # taxa in common

Station	d	a	e	Loss Index	Score
1	29	17	26	0.46	6
2	32	0	0	-	0
3	30	0	0	-	0

Bioassessment

Station	Total biological condition score	Percentage score	Assessment
1	26	72	Slightly impaired
2	0	0	Severely impaired
3	0	0	Severely impaired

CHAPTER 5

TERRESTRIAL MOLLUSKS OF GUAJE AND LOS ALAMOS CANYONS

by

SAUL CROSS

ABSTRACT

In 1993 and 1994, 6 plant litter samples were collected from below deciduous trees or shrubs in Guaje and Los Alamos Canyons. Using standardized sorting and identification techniques, a total of 997 individual snails representing 8 families and 13 species were sorted and identified. Species richness and numbers of individuals varied greatly between samples. Species diversity was high in 4 of the 6 samples.

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1 INTRODUCTION

Snails are the most abundant terrestrial mollusks in the Los Alamos area. They are useful environmental indicators in that snails

- respond to a wide variety of impacts,
- occur in small areas, and thus are good representives of conditions in those areas, and
- may be identified to genus or species with relative ease.

2 METHODOLOGY

Soil litter samples were collected below deciduous trees or shrubs growing near the Ecological Studies Team's (EST) permanent aquatic sampling stations (S1, S2, and S3) in Guaje and Los Alamos Canyons. We deliberately selected optimal sampling sites, ones thought to support large and varied snail populations. At all sampling sites, decomposing leaves from the deciduous trees or shrubs provide a food base, and the nearby streams ensure adequate moisture. The season and year of collection do not affect overall results because most snails collected will have previously died, and identification is based solely on shell morphology.

After discarding the dry surface material, we scraped plant litter below deciduous trees or shrubs down to the mineral soil. Sufficient litter was gathered to fill a standard-sized zip-lock bag. EST collected a single 1-gallon sample in 1993 to determine the number of individuals present and the associated processing time. In 1994, we collected a total of five 1-quart samples to reduce sorting and identification time. In the lab, samples were thoroughly dried and then sifted with a series of soil sieves to facilitate snail collection. Snail shells were separated from soil and plant materials in the sample and placed in appropriately labeled glass vials. To reduce the risk of breakage, we removed fragile snail shells from the litter with a small water-color paintbrush.

All snails were identified using a Bausch and Lomb StereoZoom 7 dissecting microscope and appropriate references (Burch 1962; Metcalf and Smartt, in press; Smartt, unpublished). Specimens were identified by Saul Cross, and all identifications were confirmed by Dr. Richard Smartt, Curator of Zoology, New Mexico Museum of Natural History, Albuquerque, N.M. All identified specimens were placed in vials and archived in EST's permanent mollusk collection. All archived vials were labeled with sampling location, date of collection, and species name.

3 RESULTS

During the summer of 1993, EST took two 1-gallon soil samples from Guaje Canyon. Both samples were collected from below Rocky Mountain maples (*Acer glabrum*) near S1. We sorted and identified one of the samples, which contained 320 individual snails representing 4 families and 7 genera (Table 1).

During the summer of 1994, five 1-qt samples were collected from Guaje and Los Alamos Canyons. All collections in Guaje were taken from under water birch (*Betula* *occidentalis*) to standardize the samples. The 1994 Guaje samples had similar species richness despite large variations in numbers of individuals (Table 1). No single deciduous tree or shrub species was present at both Los Alamos stations; and we collected the 1994 S1 sample under baneberry (*Actaea arguta*) and the S3 sample under willow (*Salix* sp.). It

Table 1 Numbers of Snail Individuals and Species Collected from Guaje and Los Alamos Canyons

Canyon, Station, Year	Size of Sample	Collected Below	Total Number of Individuals	Number of Species
Guaje, S1, 1993	1 gallon	Rocky Mountain maple	320	7
Guaje, S1, 1994	1 quart	Water birch	294	4
Guaje, S2, 1994	1 quart	Water birch	22	5
Guaje, S3, 1994	1 quart	Water birch	165	8
Los Alamos, S1, 1994	1 quart	Baneberry	182	7
Los Alamos, S3, 1994	1 quart	Willow	14	2

is unclear how greatly the difference in overstory species contributed to the large variations in species richness and numbers of individuals in these samples.

4 DISCUSSION

Typically, many terrestrial snail species are found in the mountains of North America, although species distributions may form a mosaic due to irregularities in plant distributions, topography, soil, and moisture (Solem 1983). Our samples contained a total of 8 families and 13 species of snails (Table 2). EST had previously collected all of these species within Los Alamos County. More sampling is required before the number of snail species occurring in the county can be reliably estimated.

Table 2 Snail Species Found in Guaje and Los Alamos Canyons

Family	Species	Canyon(s)
Discidae	*Discus whitneyi*	Guaje, Los Alamos
Euconulidae	*Euconulus fulvus*	Guaje, Los Alamos
Pupillidae	*Gastrocopta pilsburyana*	Guaje
Pupillidae	*Pupilla blandi*	Guaje

Table 2 (cont.)

Family	Species	Canyon(s)
Sagdidae	*Microphysula ingersolli*	Guaje, Los Alamos
Valloniidae	*Vallonia cyclophorella*	Los Alamos
Valloniidae	*Vallonia gracilicosta*	Los Alamos
Valloniidae	*Vallonia perspectiva*	Guaje
Vertiginidae	*Columella columella alticola*	Guaje
Vertiginidae	*Vertigo gouldi* group	Guaje, Los Alamos
Vitrinidae	*Vitrina pellucida alaskana*	Guaje, Los Alamos
Zonitidae	*Glyphayalina (Retinella) indentata*	Guaje, Los Alamos
Zonitidae	*Zonitoides arboreus*	Guaje, Los Alamos

A diversity index was calculated for each sample (Table 3) using the equation discussed by Wilhm (1967):

$$D = (S-1)/\ln N$$

where D = the species diversity index,
S = the number of species, and
N = the number of individuals.

Although this index was originally developed for aquatic invertebrates, it also provides a meaningful basis of comparison for terrestrial invertebrates.

Table 3 Wilhm's Diversity Index for each Snail Sample.

Sample	S	N	D
Guaje, S1, 1993	7	320	1.04
Guaje, S1, 1994	4	294	0.53
Guaje, S2, 1994	5	22	1.29
Guaje, S3, 1994	8	165	1.37
Los Alamos, S1, 1994	7	182	1.15
Los Alamos, S3, 1994	2	14	0.38

The lowest diversity value occurred at Los Alamos Canyon S3 and the highest occurred at Guaje Canyon S2. The LA-S3 sample contained large amounts of soil and undecomposed leaves. It clearly did not exhibit the desired "optimal habitat" characteristics and underscores the spotty nature of snail distributions. The G-S2 sample also contained a large amount of soil, but despite its low number of total individuals, it had a high species richness and a corresponding high species diversity.

All samples except Los Alamos S3 and Guaje S1 (1994) had high diversity indices. Only 3 of EST's 12 previous mollusk samples from Los Alamos County displayed such high snail diversities. The large numbers of individuals and the high diversities may result from clumps of moss that occurred in most of the Guaje and Los Alamos samples. These moss clumps provide well-aerated and relatively humid refugia to the snails.

EST's initial snail surveys confirm the presence of large numbers and corresponding high species diversities in Guaje and Los Alamos Canyons. The 1993 and 1994 data provide a good basis for future terrestrial mollusk research in these canyons. Further sampling is required to more thoroughly elucidate and document snail distributions within the canyon systems and throughout Los Alamos County.

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APPENDIX 5-A

Table 1 Snail Taxa Collected in Guaje and Los Alamos Canyons

Canyon, Station, Year	Family	Species	Number of Individuals
Guaje, S1, 1993	Euconulidae	*Euconulus fulvus*	59
	Pupillidae	*Gastrocopta* sp.	11
	Pupillidae	*Pupilla blandi*	19
	Sagdidae	*Microphysula ingersolli*	48
	Valloniidae	*Vallonia perspectiva*	11
	Vertiginidae	*Vertigo gouldi* group	167
	Vitrinidae	*Vitrina pellucida alaskana*	5
Guaje, S1, 1994	Vertiginidae	*Columella columella alticola*	1
	Vertiginidae	*Vertigo gouldi* group	254
	Vitrinidae	*Vitrina pellucida alaskana*	34
	Zonitidae	*Zonitoides arboreus*	3
	unidentifiable juveniles and fragments		2
Guaje, S2, 1994	Discidae	*Discus whitneyi*	1
	Vertiginidae	*Vertigo gouldi* group	1
	Vitrinidae	*Vitrina pellucida alaskana*	18
	Zonitidae	*Glyphayalina (Retinella) indentata*	1
	Zonitidae	*Zonitoides arboreus*	1
	unidentifiable juveniles and fragments		1
Guaje, S3, 1994	Discidae	*Discus whitneyi*	67
	Euconulidae	*Euconulus fulvus*	14
	Pupillidae	*Gastrocopta pilsburyana*	2
	Sagdidae	*Microphysula ingersolli*	9
	Vertiginidae	*Vertigo gouldi* group	24
	Vitrinidae	*Vitrina pellucida alaskana*	29
	Zonitidae	*Glyphayalina (Retinella) indentata*	1
	Zonitidae	*Zonitoides arboreus*	23

Table 1 (cont.)

Canyon, Station, Year	**Family**	**Species**	**Number of Individuals**
	unindentifiable fragments and juveniles		9
Los Alamos, S1, 1994	Discidae	*Discus whitneyi*	4
	Euconulidae	*Euconulus fulvus*	29
	Sagdidae	*Microphysula ingersolli*	2
	Vertiginidae	*Vertigo gouldi* group	129
	Vitrinidae	*Vitrina pellucida alaskana*	7
	Zonitidae	*Glyphayalinia (Retinella) indentata*	1
	Zonitidae	*Zonitoides arboreus*	10
	unidentifiable fragments and juveniles		11
Los Alamos, S3, 1994	Valloniidae	*Vallonia cyclophorella*	5
	Valloniidae	*Vallonia gracilicosta*	9

CHAPTER 6

STREAM CHANNEL CHARACTERISTICS IN LOS ALAMOS AND GUAJE CANYONS

by

MARY SALISBURY

ABSTRACT

During the summer of 1992, stream channel surveys were conducted by the Biological Resource Evaluations Team (BRET) of the Environmental Protection Group (ESH-8) within Los Alamos and Guaje Canyons.

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1 PROJECT AREA

Characterizations were conducted at six survey locations, three within each canyon. Survey sites were considered to be in the lower, mid, and upper (above the reservoir) sections of both canyons. Of the six surveys only the lower Los Alamos Canyon location was within Laboratory boundaries. All other survey sites were located on National Forest lands. Surveys were conducted at approximately 7000 ft and 7200 ft for lower, 7500 ft and 7900 ft for mid, 7800 ft and 8200 ft for upper Los Alamos and Guaje Canyons respectively.

2 METHODS

Data was collected every forty feet for approximately 1005 feet. Data included channel and water depths, channel and stream widths, bank heights and under cuts, bottom characterizations, and tree and shrub species at each survey point. Data was averaged for each location.

Velocity was measured at random intervals. Velocity was calculated by dividing the distance a floating object (fishing bobber and shredded paper) traveled by the time required to travel that distance. Velocities were not calculated for all survey locations due to no water or large quantities of debris.

Bank height was measured at the observable high-water mark on each bank. While channel width was measured between corresponding high-water marks. Channel height as measured using a string stretched between high-water marks and measured to the string at mid stream. Stream width was measured from water's edge to water's edge.

Observations were made on stream bottom type at each data collection point. Flow was considered to be either none, pools, riffles (normal), or rapid (areas of boulder or debris). Stream bottoms were noted to be rock (boulders), gravel, sand , or a combination of several.

Tree and shrub species within three feet of data collection points were noted.

3 RESULTS

Survey locations within Los Alamos Canyon were at elevations approximately 200 to 400 ft lower than Guaje Canyon locations.

Velocity was consistent throughout all locations where measured (Figure 1), except within lower Los Alamos Canyon. This discrepancy is due to the use of a fishing bobber to measure velocity. It was noted that the bobber caught in debris while the shredded paper used in all other velocities measurements did not catch as often. Zero average velocities indicate that no measurements were taken at that survey location.

Average stream widths and depths were similar between Los Alamos and Guaje Canyons except within the mid-canyon range due to no water flow within Los Alamos Canyon (Figures 2 and 3).

Tree species noted along the Los Alamos stream channel could be characterized as more ponderosa pine/mixed confer (ponderosa pine, white fir, Douglas fir) while the Guaje stream channel could be characterized as a mostly riparian (water birch, Rocky Mountain maple, willow, aspen). Although both stream channels had a mix of ponderosa pine/mixed conifer and riparian type vegetation. Shrub species were similar between Los Alamos and Guaje Canyons with a mix of raspberry, cliffbush, and New Mexico locust, rose and oak.

Stream bottoms were also similar between Los Alamos and Guaje Canyons, both had a mix of sand, gravel, and large rock that become lodged with debris.

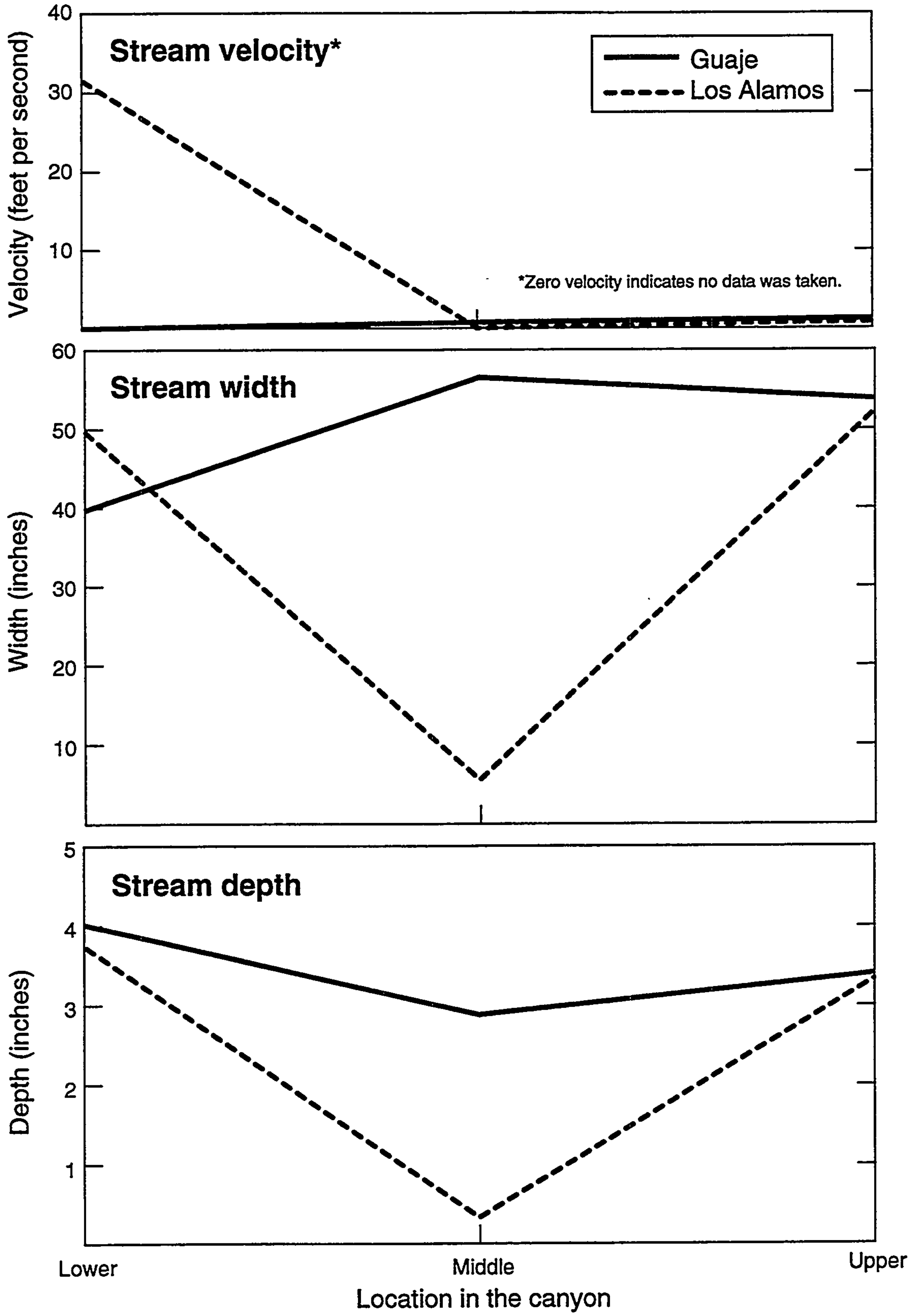


Fig. 1 Average Stream Velocities, Widths, and Depths for the Lower, Middle, and Upper Sections of Guaje and Los Alamos Canyon

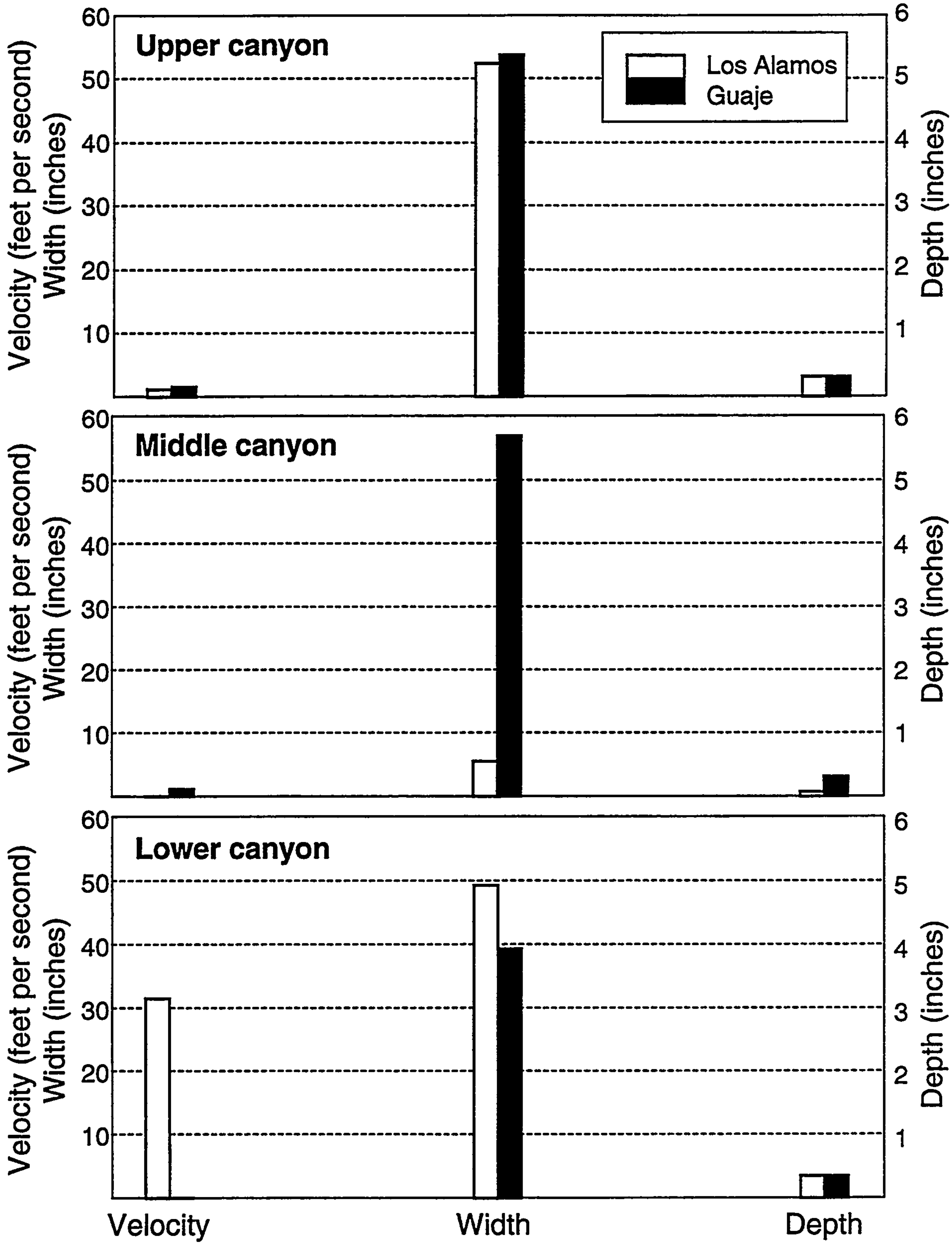


Fig. 2 Average Values for Stream Velocity, Stream Width, and Stream Depth for the Upper, Middle, and Lower Sections of Guaje and Los Alamos Canyons

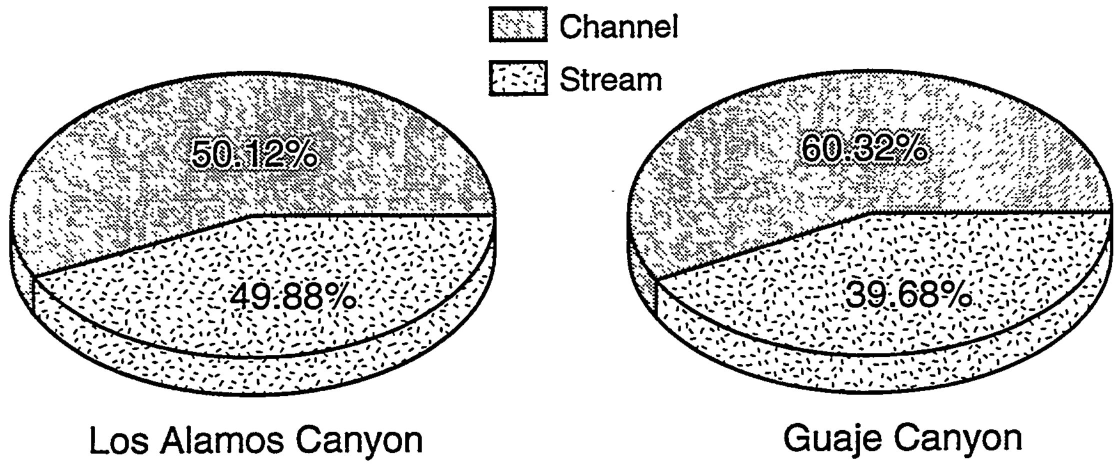


Fig. 3 Average Stream vs Channel Widths for the Lower Sections of Guaje and Los Alamos Canyons

CHAPTER 7

SURVEY OF TERRESTRIAL ARTHROPODS IN LOS ALAMOS AND GUAJE CANYONS (1993)

by

TIMOTHY HAARMANN

ABSTRACT

Chapters 7 and 8 of this report are the 1993 and 1994 terrestrial arthropod studies. For two consecutive years terrestrial arthropod studies were conducted in Los Alamos and Guaje Canyons. Guaje Canyon was considered the control canyon for the experiments. A total of more than 22,500 arthropods were captured and identified. All arthropods were identified down to the family level.

Relative abundance comparisons were made between the canyons. Comparisons were made between the insects caught in 1993 in the two canyons. Likewise, the insects caught in 1994 were compared to each other. No comparisons were made between 1993 and 1994, since there were too many factors that could have contributed to insect population numbers. No significant differences were found between the arthropods of Los Alamos Canyon and those in Guaje Canyon during either 1993 or 1994.

Pitfall traps were used to capture terrestrial arthropods and were placed in three distinct vegetative zones in each of the two canyons. The arthropods were collected and identified to determine if there was a significant difference between Los Alamos Canyon and Guaje Canyon. However, there were some interesting patterns that could be observed when comparing the two canyons.

1 INTRODUCTION

When gathering information on a particular location, it is often useful to study the arthropod populations of the area in question. Arthropods provide information on the health of an area, as well as insights into populations of other organisms within the same ecosystem. At Los Alamos National Laboratory, the types of arthropods that inhabit Laboratory property are relatively unknown. The purpose of this study was to compare the number of arthropods captured in traps in a canyon on LANL property with those captured in a control canyon distant from the influences of Laboratory activities. By doing this type of experiment, one can more fully understand the influences of LANL on the arthropod composition of the area, as well as obtain information which can be used to understand the Laboratory's influence on other organisms.

2 ENVIRONMENTAL SETTING

2.1 Description of the Study Sites

The trapping sites were located in three habitat types; Ponderosa pine, Mixed-Conifer and Pinyon-Juniper.

Upper Guaje Canyon is characterized by Mixed-Conifer vegetation consisting of an overstory of Douglas fir (*Psuedostuga menziesii*), spruce (*Picea englemanii*), thinleaf alder (*Alnus tenuifolia*), and, in lesser quantity, ponderosa pine. Shrubs included cliffbush (*Jamesia americana*), serviceberry (*Amelanchier* sp.), and oak (*Quercus* spp.). The most common understory species include cutleaf coneflower (*Rudbeckia laciniata*) and several species of grasses and forbs. The upper area of Los Alamos Canyon was similar in overstory composition and shrubs with the additional common species of white fir (*Abies concolor*). Geranium (*Geranium jamesii*) and strawberry (*Fragaria americana*) were common understory species.

The middle trapping area is characterized by an open ponderosa pine habitat. Ponderosa pine was the most common overstory species with lesser amounts of juniper (*Juniperus monosperma*). Common shrubs include barberry (*Berberis fendleri*), oak (*Quercus* spp.), and rose (*Rosa woodsii*). Understory species were more sparse and included mostly grasses. Lower Guaje Canyon had a comparatively greater understory cover than lower Los Alamos Canyon.

The lower trapping areas for both canyons consisted of Pinyon-Juniper woodlands. Shrubs consisted mostly of big sagebrush (*Artemisia tridentata*), rabbit brush

(*Chrysothamnus nauseosus*), and mountain mahogony (*Cercocarpus montanus*). Understory species consisted mostly of blue grama (*Bouteloua gracilis*), black grama (*Bouteloua eriopoda*), and galleta (*hilaria jamesii*).

The terrain in the upper areas is steep and relatively narrow compared to the middle and lower areas. A stream channel runs through all sites, however, water was constantly flowing only in the upper portions of both canyons. In the middle and lower areas, water flow was intermittent.

3 METHODS

Data was collected over a three month period in 1993. During July--September in Los Alamos Canyon and Guaje Canyon insect pitfall traps were used to capture terrestrial arthropods. The pitfalls consisted of cups buried in the soil at ground level. Ethanol was placed in the cups so that any arthropod that fell into the trap would be killed and preserved. The traps were left open for a total of 7 to 13 days. In Los Alamos Canyon as well as Guaje Canyon, a total of 30 traps were used. Traps were placed in three distinct vegetative areas: 10 traps in a mixed conifer area, 10 traps in a ponderosa area, and 10 traps in a pinyon-juniper location.

At the end of the 7 to 14 days all the arthropods were collected and later identified. All arthropods were identified to Order and most were identified down to Family (Borror et al. 1989, Arnett 1993). The numbers of arthropods per area were numerically adjusted according to how many trapping days the traps were left open. This was done so that a comparison could be made between all areas.

In an attempt to quantitatively compare relative insect populations between the two canyons, a statistical analysis was performed. Comparisons were done at the order and/or family level. Comparisons were made between all three sites within each canyon, as well as between equivalent sites in the two canyons. In other words, the three Guaje sites were compared against each other, as well as comparing the Guaje mixed conifer site with the Los Alamos mixed conifer site and so forth. All data points were plotted to determine the distribution of the data. The data were then analyzed using a T-test, a two sample test, a sign test, or the Mann-Whitney procedure. The appropriate test was done based on the distribution of the data points, as well as taking into account the assumptions and limitations of the various methods.

4 RESULTS

The following arthropods were identified and incorporated into the study and are listed in Table 1:

Order Thysanura (Bristletails)
O. Collembola (Springtails)
O. Orthroptera (Grasshoppers and Crickets)
  Family Acrididae (Grasshoppers)
  F. Gryllidae (Crickets)
  F. Gryllacrididae (Camel Crickets and relatives)
    Subfamily Rhaphidophorinae (Camel Crickets)
    Sf. Stenopelmatinae (Jerusalem Crickets)
O. Homoptera (Plant Hoppers and relatives)
O. Hemiptera (True Bugs)
  F. Pentatomidae (Shield Backed Bugs)
O. Colepotera (Beetles)
  F. Tenebrionidae (Darkling Beetles)
  F. Carabidae (Ground Beetles)
  F. Elateridae (Click Beetles)
  F. Silphidae (Carrion Beetles)
  F. Scarabaeidae (Scarab Beetles)
  F. Buprestidae (Metallic Wood Boring Beetles)
O. Lepidoptera (Butterflies and Moths)
 Suborder Rhopalocera (Butterflies)
 So. Heterocera (Moths)
O. Diptera (Flies)
O. Hymenoptera (Wasps, Ants, Bees)
  F. Formicidae (Ants)
   Superfamily Apoidea (Bees)
   Wasps
O. Isopoda (Isopods)
O. Araneae (Spiders)
  F. Lycosidae (Wolf Spiders)

Class Chilopoda (Centipede)
C. Diplopoda (Millipede)
O. Solfugae (Windscorpions)

A total of more than 15,000 individual arthropods were trapped and identified. The results of the analysis indicated that at a 95% confidence interval, there is no significant difference in the arthropods of Los Alàmos Canyon and those in Guaje Canyon for equivalent time periods and equivalent number of trapping days. Not surprising, the biggest difference although not statistically significant, was found between the arthropod compositions within different vegetation zones. In other words, the arthropods in Guaje Pinyon/Juniper appeared different than the arthropods in Guaje mixed conifer.

While statistically no differences were found between the two study areas, there are a few notable differences that can be seen in the graphs (Figures 1-10). There were two families of beetles that differed between the two canyons. Both the *Tenebrionidae* (Darkling Beetles) and the *Carabidae* (Ground Beetles) yielded a higher number of individuals in Guaje Canyon when compared to Los Alamos Canyon (Figures 3 and 4). Likewise, a family of spiders, the *Lycosidae*, were also higher in Guaje Canyon (Figure 9). The three most obvious differences were found in windscorpions, bees, and Isopods. The pitfalls yielded many more bees in Guaje Canyon (Figure 7) and more Isopods in Los Alamos Canyon (Figure 10). Windscorpions were only trapped in Los Alamos Canyon and not in Guaje Canyon.

5 DISCUSSION

It is not surprising that there was no significant difference between the insect families of Los Alamos Canyon and Guaje Canyon. The areas within the two canyons where I placed my traps are relatively similar in vegetation, elevation, and biota. There does not appear to be a large difference between the numbers of arthropods in the two canyons. If the arthropods in Los Alamos Canyon are exposed to contamination, it does not appear to be in doses strong enough to affect population numbers.

While some arthropod numbers were higher in Guaje, these were only seen during one week, and would not qualify as an observable trend over an extended period of time. The fact that almost no Isopods were found in Guaje is very interesting. I cannot think of an obvious explanation for this, and deserves further investigation. Likewise, the fact that more bees were caught in Guaje Canyon than in Los Alamos Canyon has no obvious explanation. Bees caught in terrestrial pitfall traps are termed incidentals. Because they are a flying insect, they are not what one expects to catch in terrestrial pitfalls. Unfortunately, some species of bees are attracted to the ethanol in the pitfalls and are consequently drowned when they fly into the traps. The fact that more bees were caught in Guaje Canyon than in Los Alamos Canyon could simply be the result of Guaje having a greater number of ethanol attracted species. However, it may also indicate the obvious: that there really are more bees in Guaje Canyon than Los Alamos Canyon. Because bee species are a very mobile organism, and are very likely to come in contact with environmental contaminants, they are good indicators of degree of contamination within a study area.

5.1 Research Needs

The most important investigation to be done in the future is to continue using pitfalls to study the arthropods of LANL. The more data we have, and the more years we collect data, the stronger our study will become. By repeating similar baseline type studies, our information base will increase in accuracy. Beehives are presently being used to analyze the degree of contamination in arthropods at LANL. This is an excellent study and one that we are well advised to continue. However, the study needs to be drastically reconsidered, expanded, and done in a more scientific manner. Besides only bees as monitors of environmental contamination, I would also suggest studying other arthropods. Isopods could be collected and analyzed much the same way as bees. In order to do a more complete eco-risk analysis, we would need to determine where and how fast some of the contaminants are being released once the arthropods have died. This could be accomplished by doing simple arthropod decomposition studies.

Insects are import primary indicators of contamination at LANL. It is important to continue research on the insect populations of LANL as well as using these insects as monitors of environmental degradation. Through a better understanding the amount of contaminants present in the arthropods of LANL, we can better understand the degree of contamination of other biota in the area.

6 REFERENCES

Arnett R.H. *American Insects* (Sandhill Crane Press, Inc. Gainesville, 1993).

Borror D.J., C.A. Triplehorn and N.F. Johnson *An Introduction to the Study of Insects* (Saunders College Publishing New York, 1989)

Table 1 Arthropods captured (adjusted for 7 trapping days)

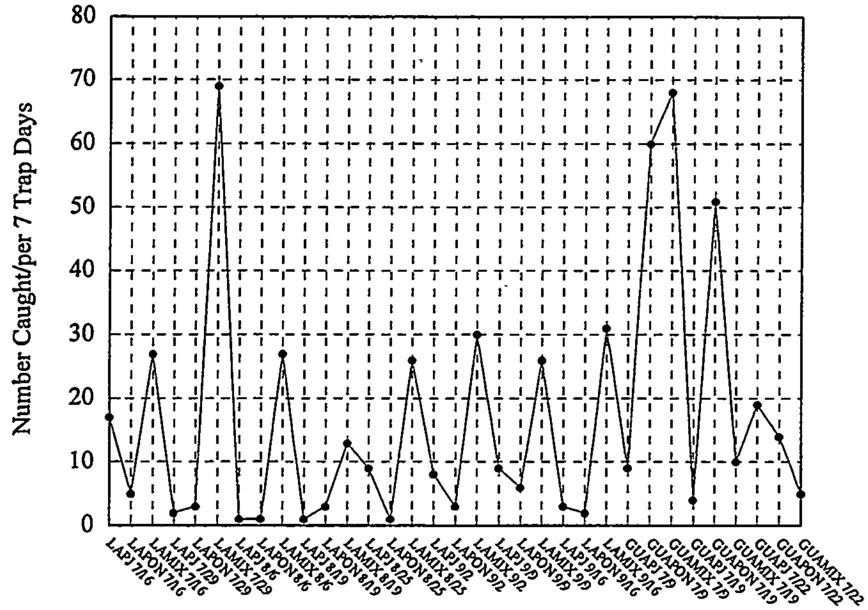
	LPJ 7/16	LPO 7\16	LMX 7\16	LPJ 7/29	LPO 7/29	LMX 7/29	LPJ 8/6	LPO 8/6	LMX 8/6	LPJ 8/19	LPO 8/19
Arthropods											
Thysanura	19			2			2			2	
Collembola	8		1	2	1						1
Orthoptera											
Acrididae		1					1			2	
Gryllidae										1	
Gryllacrididae										1	
Camel Crick.	17	5	27	2	3	69	1	1	27	1	3
Jeru. Crick.				1	1						1
Homoptera	2	8	1			1		4	22	1	1
Hemiptera	1		1	1		1	1	1	3		
Pentatomidae											
Coleoptera	2	21	22	3	5	11		10	42	5	2
Tenebrionidae	5		1	3		1	4		1	3	1
Carabidae		2	3	1	8	41	1	2	20	3	13
Elateridae							1			1	
Silphidae	2			2	20		1	1		2	18
Scarabaeidae	2	2	1	3	2	1	4	6	1	2	
Buprestidae											
Lepidoptera											
Butterfly											
Moth	2					2					1
Diptera	9	68	39	2	15	72	3	30	175	18	52
Hymenoptera											
Formicidae	1361	109	28	246	41	19	175	25	65	299	17
Wasps	4	8	5		2	3	1	3	2	1	8
Bees	12	12	2	1	8	3	1	4	2	9	4
Isopod			10		1	64			28		
Arachnid	12	8	26	2	3	80	3	8	49	1	3
Lycosidae	9	41	3	1	15	6	2	35	8	2	18
Chilopoda	2										
Diplopoda											
Solpugida				1						1	

Table 1 (cont.) Arthropods captured (adjusted for 7 trapping days)

	LMX 8/19	LPJ 8/25	LPO 8/25	LMX 8/25	LPJ 9/2	LPO 9/2	LMX 9/2	LPJ 9/9	LPO 9/9	LMX 9/9	LPJ 9/16
Arthropods											
Thysanura		3			2			9		2	4
Collembola				27			10	3	4	3	11
Orthoptera					1						
Acrididae		1			1			4			2
Gryllidae		2					9	1		1	
Gryllacrididae											
Camel Crick.	13	9	1	26	8	3	30	9	6	26	3
Jeru. Crick.											
Homoptera	1	1	1			3	2	6	6	4	6
Hemiptera					2		2	2			
Pentatomidae											
Coleoptera	2	4	3	4	1	1	12	3	4	11	3
Tenebrionidae		1	1		2					1	
Carabidae	8	1	5	9	1				1	6	2
Elateridae			2								
Silphidae	5		30			1					1
Scarabaeidae	1	2	2		3				3		2
Buprestidae			1								
Lepidoptera											
Butterfly											
Moth	1	1							1		
Diptera	32	28	129	135	51	48	46	37	156	112	21
Hymenoptera								1			
Formicidae	18	378	24	25	472	23	18	467	47	34	308
Wasps		3	5	5	4	2	1	7	1	12	2
Bees	1	6	4	7	1			7	2		2
Isopod	24			15			7			12	
Arachnid	19	8	12	30	10	10	31	19	14	39	15
Lycosidae	3	1	2	2		1		2		2	1
Chilopoda		3			1						
Diplopoda											
Solpugida		1									

Table 1 (cont.) Arthropods captured (adjusted for 7 trapping days)

	LPO 9/16	LMX 9/16	GPJ 7/9	GPO 7/9	GMX 7/9	GPJ 7/19	GPO 7/19	GMX 7/19	GPJ 7/22	GPO 7/22	GMX 7/22
Arthropods											
Thysanura		1		1	1				2		
Collembola	6	86		2			506			292	
Orthoptera											
Acrididae				1			1		2		
Gryllidae									5		
Gryllacrididae											
Camel Crick.	2	31	9	60	68	4	51	10	19	14	5
Jeru. Crick.			4			2					
Homoptera	12	1		23	3		37	4	16	12	
Hemiptera			2	12	3		3			5	
Pentatomidae				1							
Coleoptera	10	14	3	51	223	3	29	292	56	35	1097
Tenebrionidae		2	11	2	2	6			2		
Carabidae		1	1	33	2	1	86	2	2	51	2
Elateridae										2	
Silphidae				2	2	2	2	2	5	2	
Scarabaeidae				1		1			2		
Buprestidae						4			12		
Lepidoptera											
Butterfly				1	2			2			2
Moth		1	1	2	2		1	1		7	2
Diptera	72	47	1	56	62	1	99	79	51	23	135
Hymenoptera											
Formicidae	35	16	393	171	42	358	76	26	1239	103	82
Wasps	3	7		6		2	2	4	5	5	2
Bees				15	47	2	16	45	42	26	35
Isopod		4			1						
Arachnid	10	47		53	75		24	9	33	16	21
Lycosidae	5	2		142	32		25	3	28	21	
Chilopoda			1	1	1		1				
Diplopoda				1	1						
Solpugida											



LA= Los Alamos GUA= Guaje PJ= Pinyon Juniper PON= Ponderosa MIX= Mixed-Conifer

Fig.1 Camel Crickets

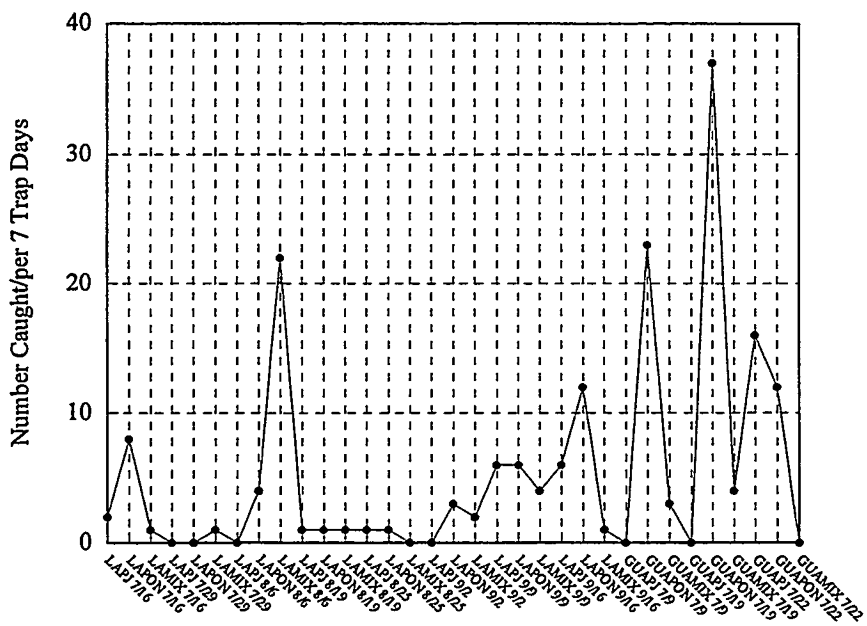


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Fig. 2 Homoptera

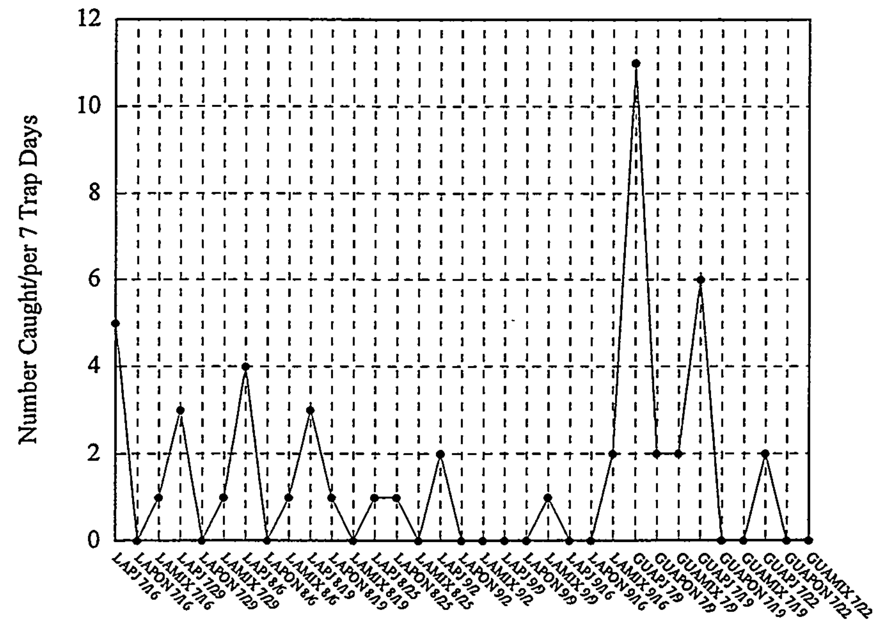

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Fig. 3 Tenebrionidae

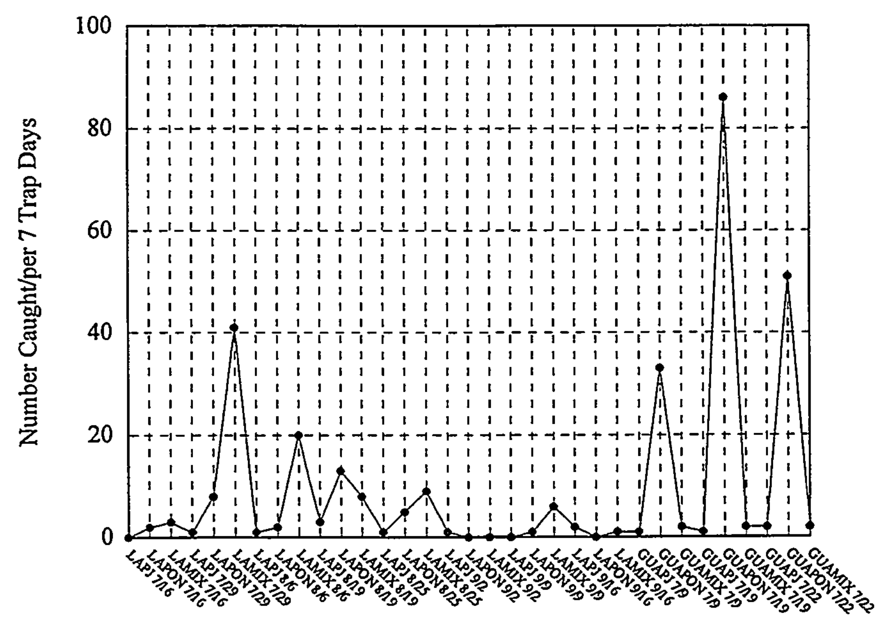

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Fig. 4 Carabidae

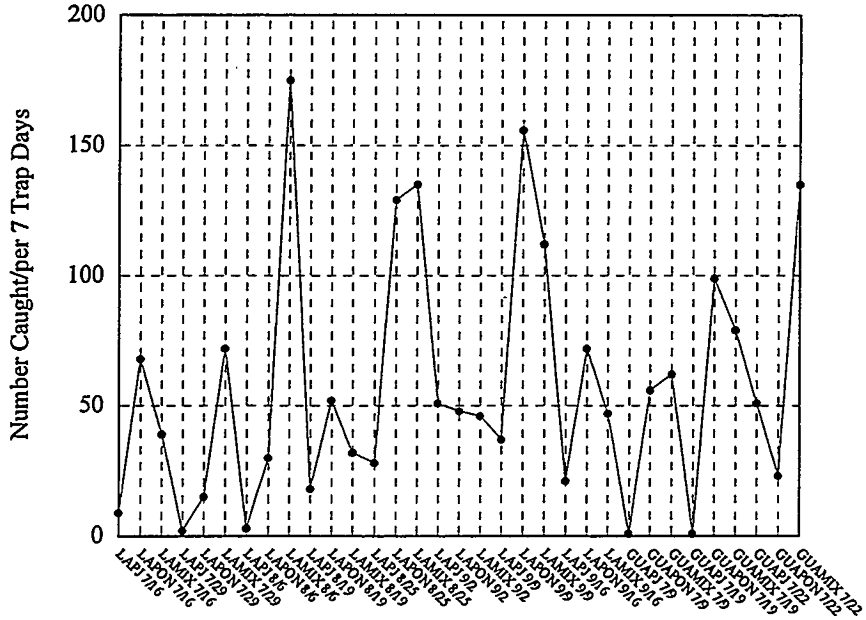

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Fig. 5 Diptera

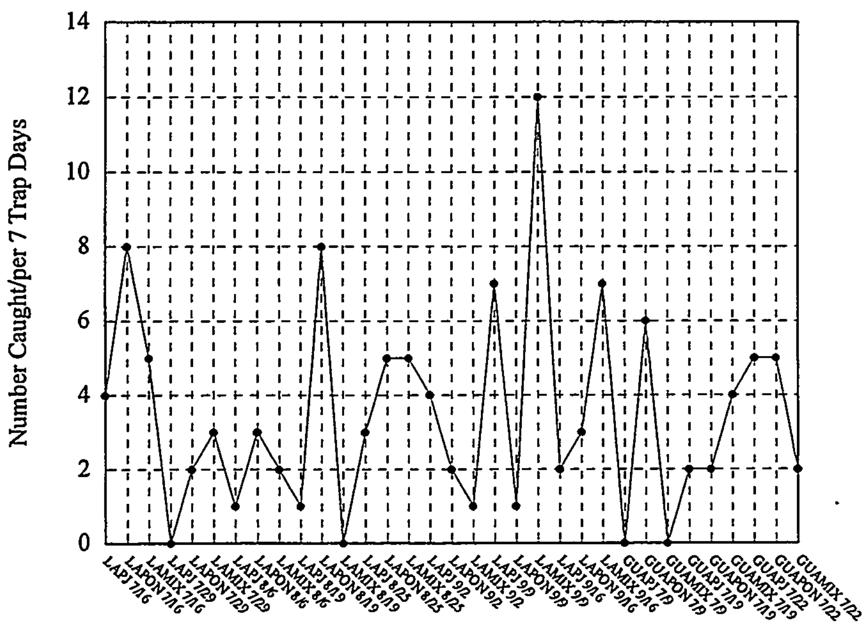

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Fig. 6 Wasps

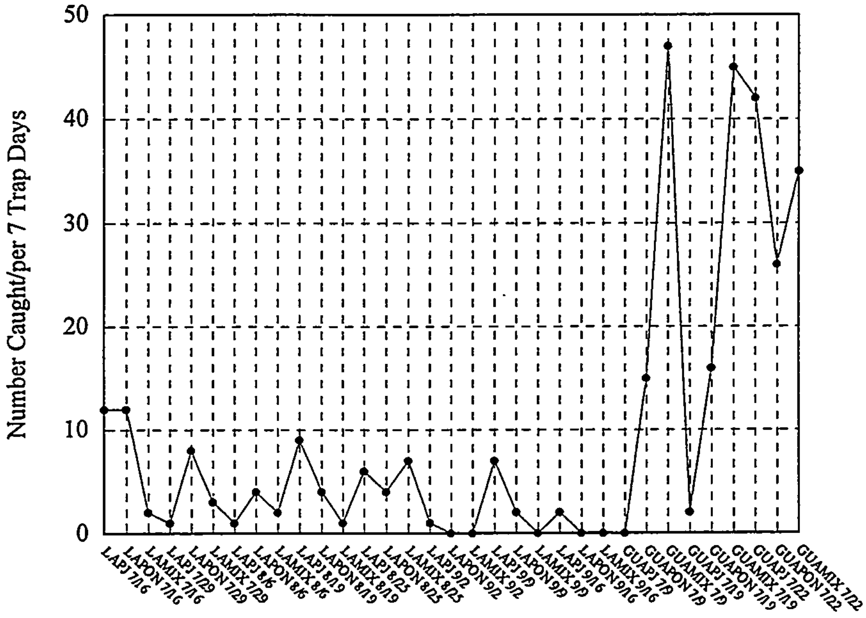

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Fig. 7 Bees

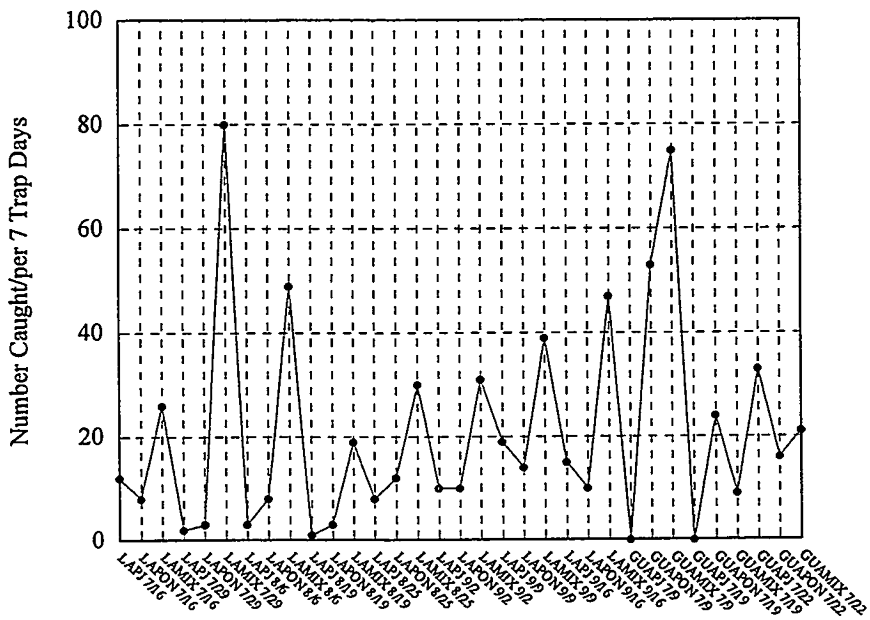

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Fig. 8 Arachnids (excluding Lycosidae)

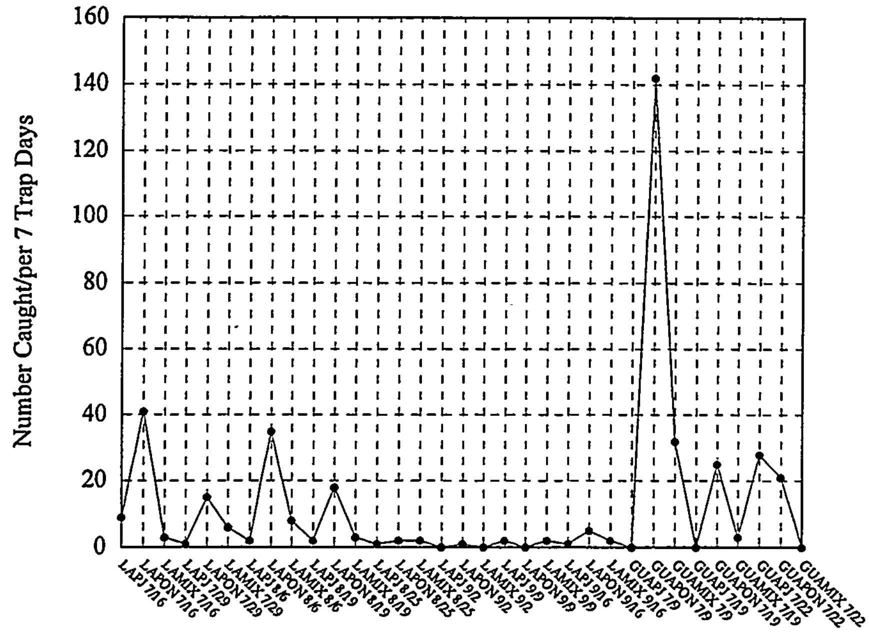

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Fig. 9 Lycosidae

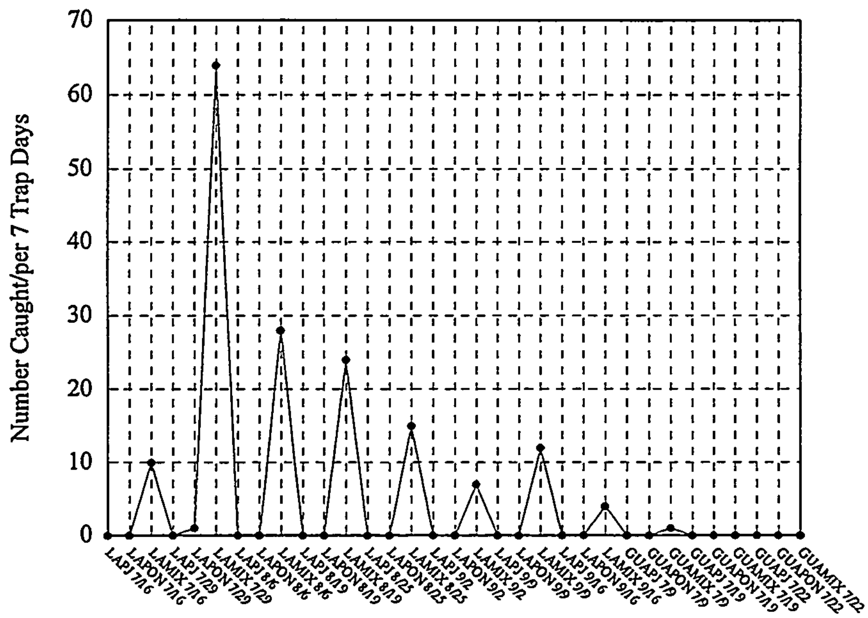

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Fig. 10 Isopods

CHAPTER 8

SURVEY OF TERRESTRIAL ARTHROPODS IN LOS ALAMOS AND GUAJE CANYONS (1994)

by

TIMOTHY HAARMANN

ABSTRACT

Chapters 7 and 8 of this report are the 1993 and 1994 terrestrial arthropod studies. For two consecutive years terrestrial arthropod studies were conducted in Los Alamos and Guaje Canyons. Guaje Canyon was considered the control canyon for the experiments. A total of more than 22,500 arthropods were captured and identified. All arthropods were identified down to the family level.

Relative abundance comparisons were made between the canyons. Comparisons were made between the insects caught in 1993 in the two canyons. Likewise, the insects caught in 1994 were compared to each other. No comparisons were made between 1993 and 1994, since there were too many factors that could have contributed to insect population numbers. No significant differences were found between the arthropods of Los Alamos Canyon and those in Guaje Canyon during either 1993 or 1994.

Pitfall traps were used to capture terrestrial arthropods and were placed in three distinct vegetative zones in each of the two canyons. The arthropods were collected and identified to determine if there was a significant difference between Los Alamos Canyon and Guaje Canyon. However, there were some interesting patterns that could be observed when comparing the two canyons.

1 INTRODUCTION

As mentioned in the 1993 report, it is an essential part of any ecological study to investigate the arthropod populations of the area in question. Arthropods provide information on the health of an area, as well as insights into populations of other organisms within the same ecosystem. The purpose of this two-year study was to compare the number of arthropods captured in traps in a canyon on LANL property with those captured in a control canyon distant from the influences of Laboratory activities. By doing this type of experiment, one can more fully understand the influences of LANL on the arthropod composition of the area, as well as obtain information which can be used to understand the Laboratory's influence on other organisms.

2 ENVIRONMENTAL SETTING

2.1 Description of the Study Sites

The trapping sites were located in three habitat types; Ponderosa pine, Mixed-Conifer, and Pinyon-Juniper.

Upper Guaje Canyon is characterized by Mixed-Conifer vegetation consisting of an overstory of Douglas fir (*Psuedostuga menziesii*), spruce (*Picea englemannii*), thinleaf alder (*Alnus tenuifolia*), and , in lesser quantity, ponderosa pine. Shrubs included cliffbush (*Jamesia americana*), serviceberry (*Amelanchier* sp.), and oak (*Quercus* spp.). The most common understory species include cutleaf coneflower (*Rudbeckia laciniata*) and several species of grasses and forbs. The upper area of Los Alamos Canyon was similar in overstory composition and shrubs with the additional common species of white fir (*Abies concolor*). Geranium (*Geranuim jamesii*) and strawberry (*Fragaria americana*) were common understory species.

The middle trapping area is characterized by an open ponderosa pine habitat. Ponderosa pine was the most common overstory species with lesser amounts of juniper (*Juniperus monosperma*). Common shrubs include barberry (*Berberis fendleri*), oak (*Quercus* spp.), and rose (*Rosa woodsii*). Understory species were more sparse and included mostly grasses. Lower Guaje Canyon had a comparatively greater understory cover than lower Los Alamos Canyon.

The lower trapping areas for both canyons consisted of Pinyon-Juniper woodlands. Shrubs consisted mostly of big sagebrush (*Artemisia tridentata*), rabbit brush (*Chrysothamnus nauseosus*), and mountain mahogony (*Cercocarpus montanus*).

Understory species consisted mostly of blue grama (*Bouteloua gracilis*), black grama (*Bouteloua eriopoda*), and galleta (*hilaria jamesii*).

The terrain in the upper areas is steep and relatively narrow compared to the middle and lower areas. A stream channel runs through all sites, however, water was constantly flowing only in the upper portions of both canyons. In the middle and lower areas, water flow was intermittent.

3 METHODS

Data was collected over a three-month period in 1994. During the time periods of 6-28-94 through 10-17-94 in Los Alamos Canyon and 7-15-94 through 9-22-94 in Guaje Canyon, insect pitfall traps were used to capture terrestrial arthropods. The pitfalls consisted of cups buried in the soil at ground level. Propylene glycol was placed in the cups so that any arthropod that fell into the trap would be killed and preserved. The traps were left open for the total trapping period. In Los Alamos Canyon as well as Guaje Canyon, a total of 30 traps were used. Traps were placed in three distinct vegetative areas: 10 traps in a mixed conifer area, 10 traps in a ponderosa area, and ten traps in a pinyon-juniper location.

Periodically throughout the trapping periods, the traps were emptied of arthropods. At the end of the study, all the arthropods were identified. All arthropods were identified to Order and most were identified down to Family. The numbers of arthropods per area were numerically adjusted according to how many trapping days the traps were left open. This was done so that a comparison could be made between all areas. Equal to that done in 1993, a statistical analysis was conducted to compare the number of arthropods in Los Alamos Canyon with those in Guaje Canyon. The data were analyzed using a T-test, a two sample test, a sign test, or the Mann-Whitney procedure.

The appropriate test was done based on the distribution of the data points, as well as taking into account the assumptions and limitations of the various methods.

4 RESULTS

The following arthropods were identified and incorporated into the 1994 study and are listed in Table 1:

Order Thysanura (Bristletails)
O. Collembola (Springtails)
O. Orthroptera (Grasshoppers and Crickets)
  Family Acrididae (Grasshoppers)
  F. Gryllidae (Crickets)
  F Gryllacrididae (Camel Crickets and relatives)
    Subfamily Rhaphidophorinae (Camel Crickets)
    Sf. Stenopelmatinae (Jerusalem Crickets)
O. Homoptera (Plant Hoppers and relatives)
O. Hemiptera (True Bugs)
  F. Pentatomidae (Shield Backed Bugs)
O. Colepotera (Beetles)
  F. Tenebrionidae (Darkling Beetles)
  F. Carabidae (Ground Beetles)
  F. Elateridae (Click Beetles)
  F. Siliphidae (Carrion Beetles)
  F. Scarabaeidae (Scarab Beetles)
  F. Buprestidae (Metallic Wood Boring Beetles)
O. Lepidoptera (Butterflies)
  Suborder Rhopalocera (Butterflies)
  So. Heterocera (Moths)
O. Diptera (Flies)
O. Hymenoptera (Wasps, Ants, Bees)
  F. Formicidae (Ants)
    Superfamily Apoidea (Bees)
O. Isopoda (Ispopods)
O. Araneae (Spiders)
  F.Lycosidae (Wolf Spiders)
Class Chilopoda (Centipede)
C.Diploda (Millipede)
O. Solfugae (Windscorpions)

A total of more than 7,500 individual arthropods were trapped and identified in 1994. The results of the analysis indicated that at a 95% confidence interval, there is no significant difference in the arthropods of Los Alamos Canyon and those in Guaje Canyon for equivalent time periods and equivalent number of trapping days. Much like the findings in 1993 the most visible differences (although not statistically significant) were not between canyons, but rather between the three vegetative zones. The arthropod compositions between vegetative zones is expected to be slightly different.

Again for a second year, although no differences could be found statistically, a few trends could be seen when the information was graphed (Figures 1-10). Camel Crickets were higher in Guaje Canyon than in Los Alamos Canyon (Fig. 1). The Carabidae (Ground Beetles) were higher in Guaje Canyon when compared to Los Alamos Canyon (Fig. 4). The Scarabaeidae were higher in Los Alamos Canyon (Fig. 5). The opposite of 1993, a family of spiders, the Lycosidae, were higher in Los Alamos Canyon (Fig. 10). All other spider families were more abundant in Guaje Canyon (Fig. 9).

5 DISCUSSION

For two consecutive years, no significant difference was found between the terrestrial arthropods trapped in Los Alamos Canyon and those trapped in Guaje Canyon. Due to the fact that the canyons are relatively similar, one would expect the general numbers of arthropods to be similar. There were few consistencies when the two years were compared. In other words, one year wolf spiders were higher in Guaje Canyon, than the next year they were higher in Los Alamos Canyon. This indicates that a comparison between only two years will not produce clear patterns.

Again, there appears to be no non-natural factors that contributed to a notable difference in insect abundance between the two canyons.

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Table 1 Adjusted Terrestrial Arthropod Pitfall Data 1994. Guaje, Los Alamos and Puye (Per 87 Trapping Days, 30 traps total).

	LPJ 8/15	LPO 8\15	LMX 7\22	LPJ 10/17	LPO 10/17	LMX 10/17	GPJ 9/22	GPO 9/22	GMX 9/22
Arthropods									
Thysanura	38			22			14		
Collembola									
Orthoptera									
Acrididae	15			9			4		1
Gryllidae				8			2		
Gryllacrididae									
Camel Crick.	55	74	411	16	58	47	175	300	50
Jeru. Crick.	5	3		2			8		.
Homoptera		1	2				2		
Hemiptera						1		1	1
Pentatomidae									
Neuroptera		1					11		
Coleoptera	3	36	22	1	1	2	6	8	4
Tenebrionidae	17	4	23	1		2	26		
Carabidae	1	20	11	3	14	11	2	167	28
Elateridae	1		3					1	
Silphidae	2								13
Scarabaeidae	15	10		9	5		7		2
Buprestidae									
Lepidoptera		1			3	1			1
Butterfly									
Moth	2	8			1		2	1	
Diptera	73	40	26	35	497	85	128	72	203
Hymenoptera									
Formicidae	625	486	84	152	44	10	299	43	55
Wasps		10		3	4	13	1	36	1
Bees		1				1			2
Isopod			477			264			
Arachnid	25	39	89	60	11	33	112	236	53
Lycosidae	8	97	22	5	9	4	18	25	12
Chilopoda	3			2		1	1	4	7
Diplopoda								53	8
Solpugida	19	1					2		
Scorpions							3		

Table 1 (cont.) Adjusted Terrestrial Arthropod Pitfall Data 1994. Guaje, Los Alamos and Puye (Per 87 Trapping Days, 30 traps total).

	PLow 8/4	PMid 8/3	PUpp 8/3	PLow 9/6	PMid 9/6	PUpp 9/6
Arthropods						
Thysanura	17	172	182	4	4	14
Collembola						
Orthoptera		2	1		2	
Acrididae	35	28	20	31	28	11
Gryllidae	8	23		39	40	
Gryllacrididae						
Camel Crick.	59	289	222	50	46	105
Jeru. Crick.	1		2	3	2	1
Homoptera	2	1				
Hemiptera		2	4	1		2
Pentatomidae						
Neuroptera	10	1	1			
Coleoptera		8	2			1
Tenebrionidae	11	61	33	1	2	7
Carabidae	2	4	4	3	7	79
Elateridae			1			
Silphidae	2	2	1			
Scarabaeidae	14	14	34	8	11	8
Buprestidae						
Lepidoptera						1
Butterfly						
Moth	3	2	7			1
Diptera	105	102	231	26	57	84
Hymenoptera						
Formicidae	1487	290	182	385	81	111
Wasps	7	13	2	11	3	3
Bees						1
Isopod						
Arachnid	41	18	77	28	29	55
Lycosidae	42	51	46	3	5	11
Chilopoda	1	1	3	2		
Diplopoda						
Solpugida	39	65	37	13	3	7
Scorpions						

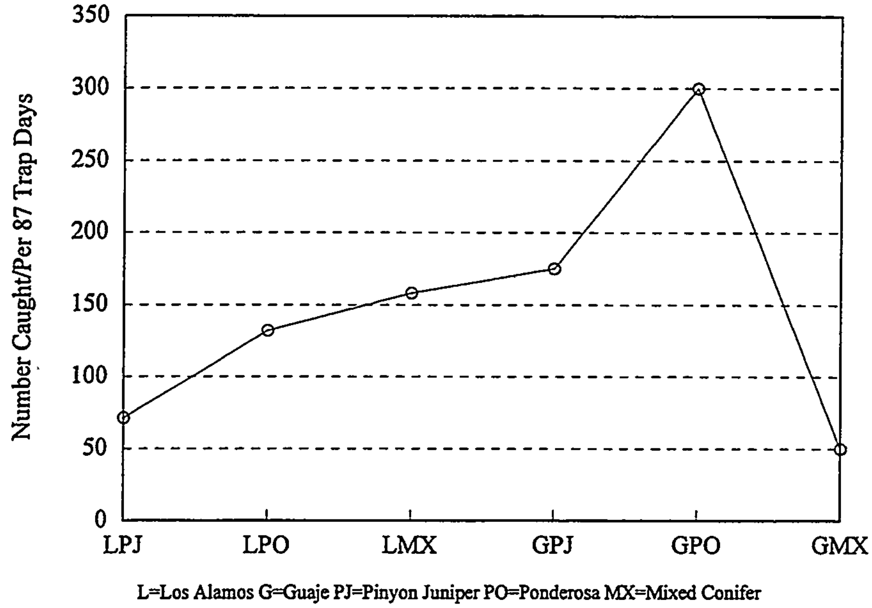


Fig. 1 Camel Crickets

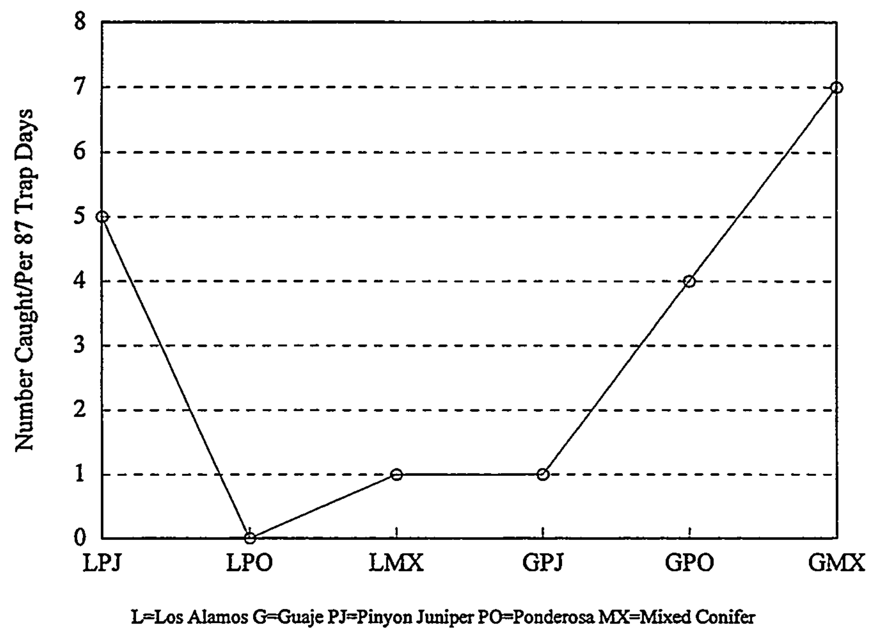


Fig. 2 Chilopoda

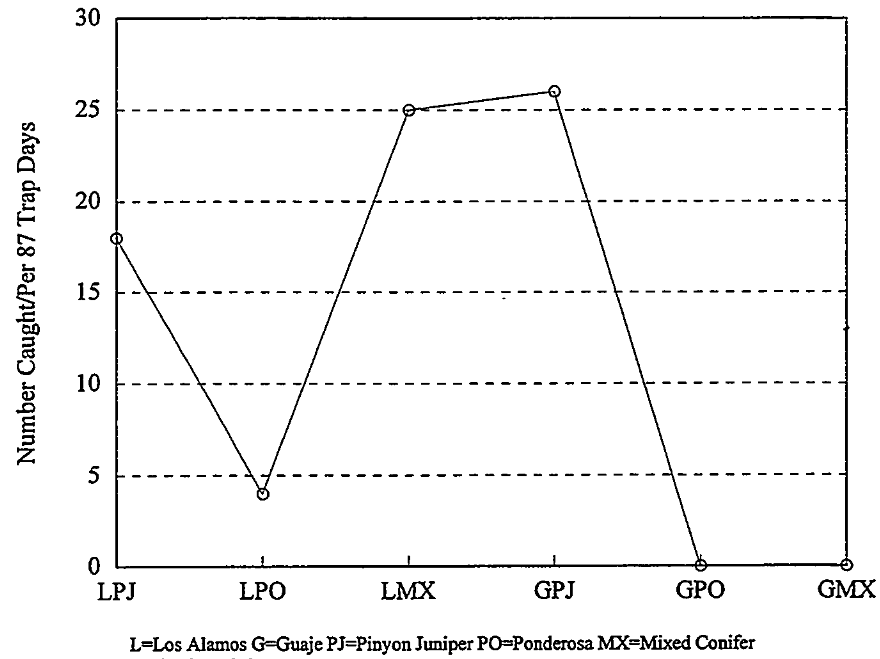


Fig. 3 Tenebrionidae

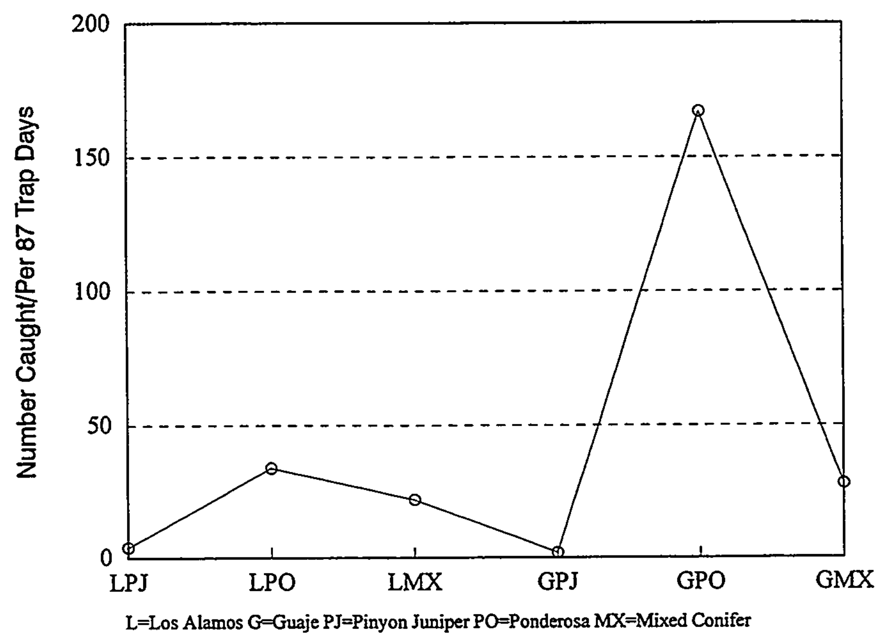
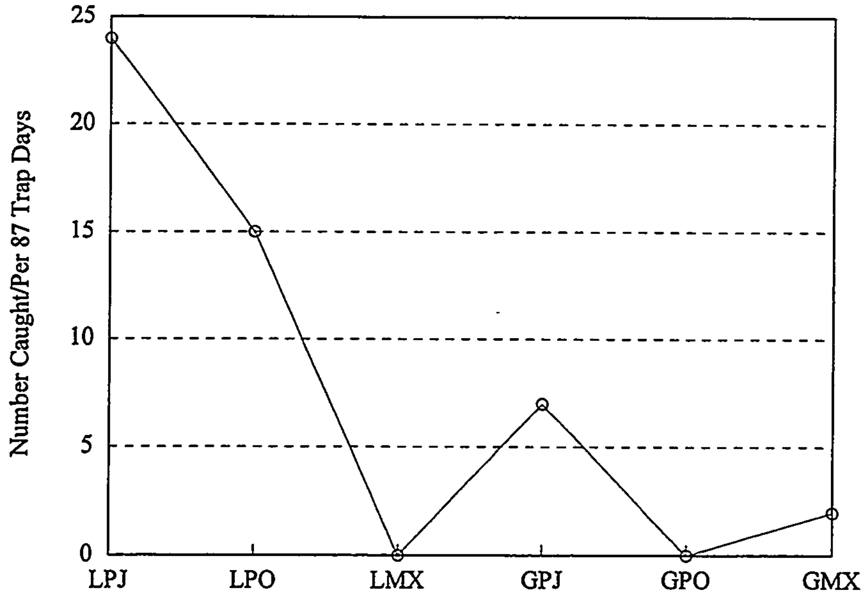
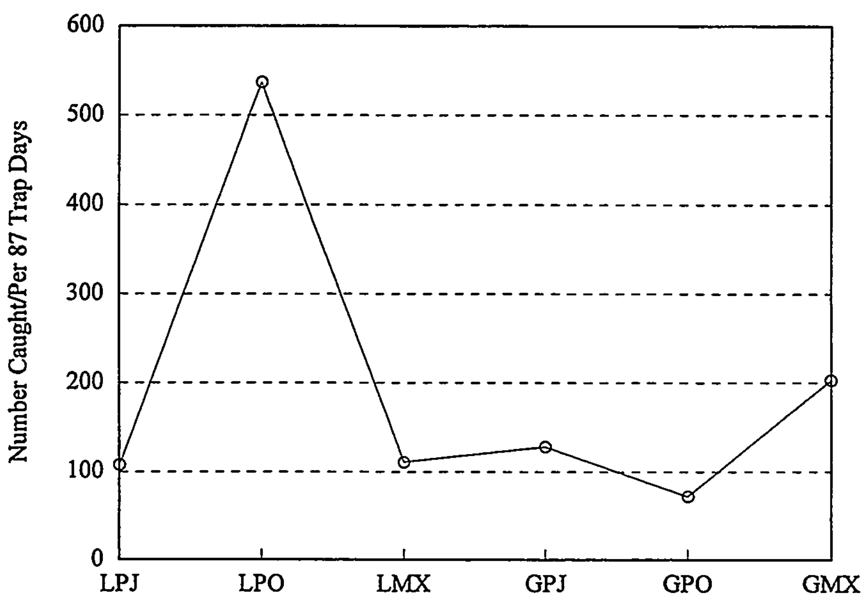


Fig. 4 Carabidae



L=Los Alamos G=Guaje PJ=Pinyon Juniper PO=Ponderosa MX=Mixed Conifer

Fig. 5 Scarabaeidae



L=Los Alamos G=Guaje PJ=Pinyon Juniper PO=Ponderosa MX=Mixed Conifer

Fig. 6 Diptera

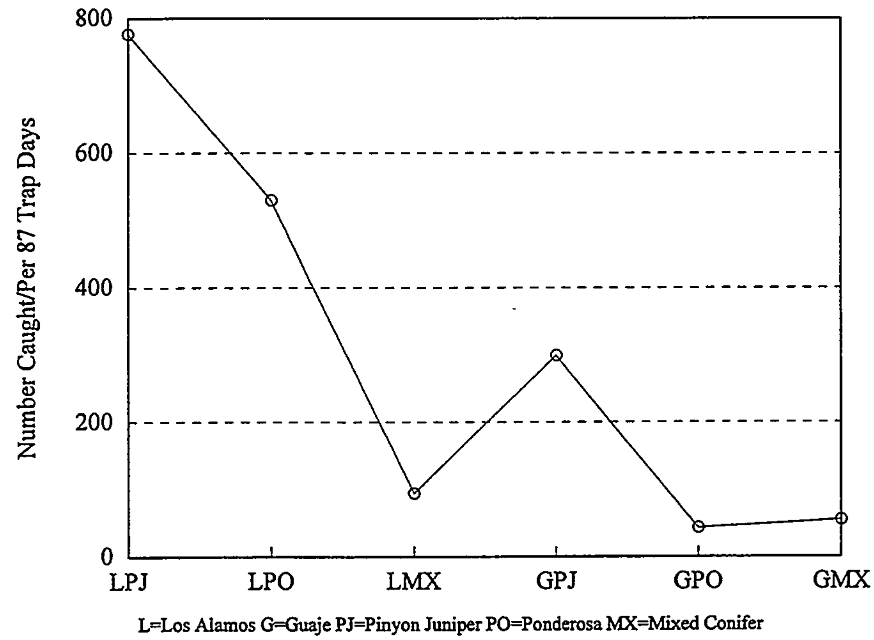


Fig. 7 Formicidae

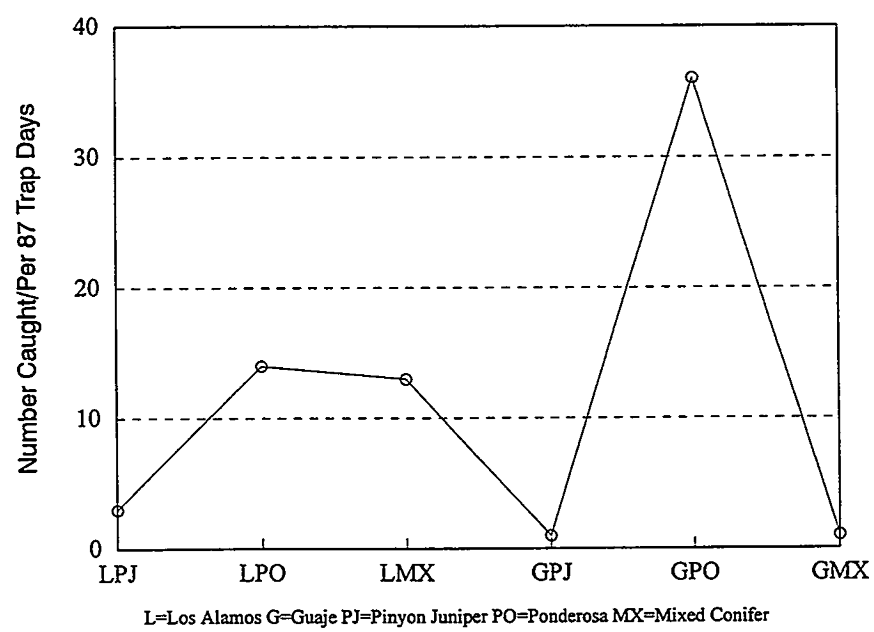


Fig. 8 Wasps

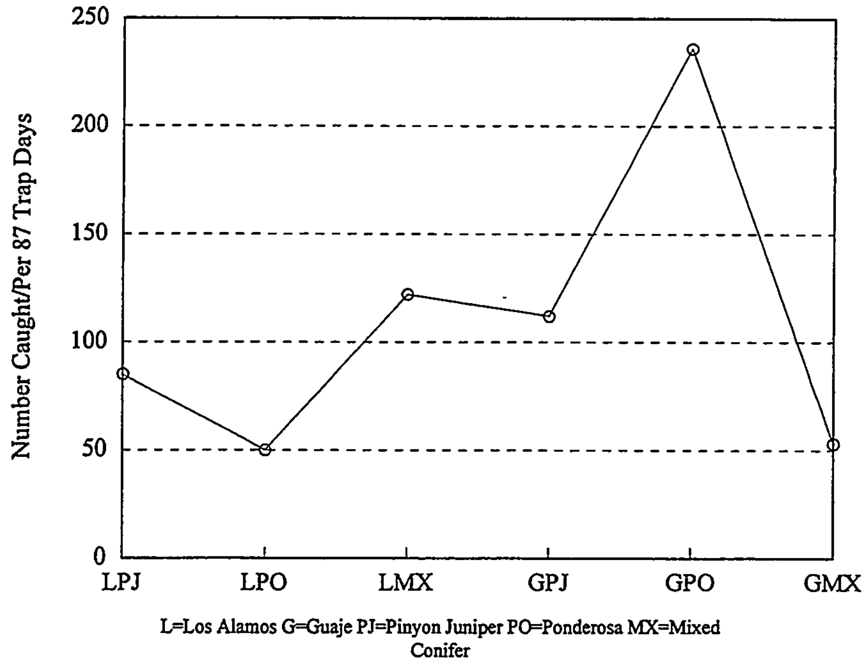


Fig. 9 Arachnid (Excluding Lycosidae)

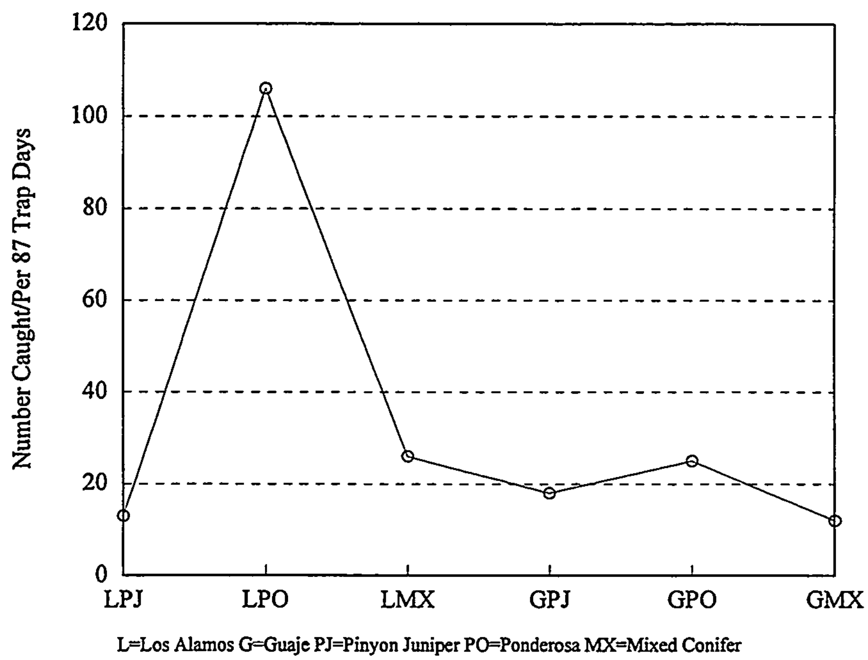


Fig. 10 Lycosidae

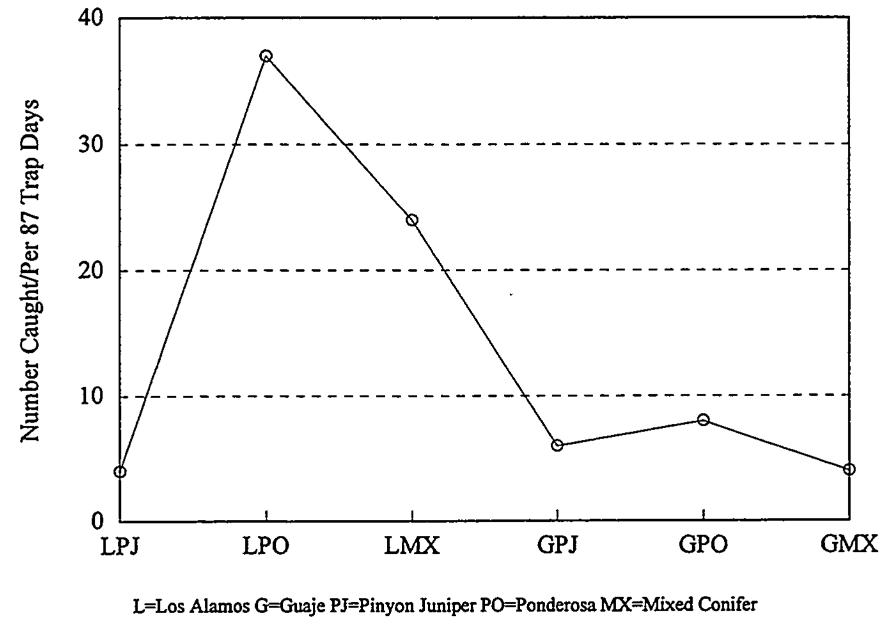


Fig. 11 Coleoptera

CHAPTER 9

RESULTS OF BIRD SURVEYS CONDUCTED AT GUAJE CANYON, LOS ALAMOS CANYON, AND PUYE MESA IN THE SUMMERS OF 1993 AND 1994

by

DAVID C. KELLER

ABSTRACT

Many birds are important indicator species; changes in species diversity and population size may signal environmental change. The Ecological Studies Team (EST) conducted surveys of the birds in Guaje Canyon, Los Alamos Canyon, and Puye Mesa to determine the use of these locations by birds. The study of these three locations, Guaje Canyon off LANL property, and both Los Alamos Canyon and Puye Mesa on LANL property, should provide a measure of the human effects on avian populations. As a result of the censuses conducted in the summers of 1993 and 1994, we found statistically significant differences between these locations. EST in 1993 found 48 species and 669 birds during the censuses in Guaje Canyon and 44 species and 569 birds in Los Alamos Canyon. In 1994, EST found 27 species and 220 birds during the censuses in Guaje Canyon and 42 species and 568 birds in Los Alamos Canyon. During 1994, Puye Mesa was added to the surveys. On Puye Mesa researchers found 30 species and 167 birds. During the preliminary work conducted in the last two years, we found that Los Alamos Canyon has the greatest bird numbers.

1 INTRODUCTION

In 1993, the Ecological Studies Team (EST) conducted bird surveys in Guaje and Los Alamos Canyons in association with the ecological-risk project. In 1994, these locations were repeated and Puye Mesa was added as an additional site. The censuses conducted in these locations sought to determine any effect of human activity on bird populations. Los Alamos Canyon and Puye Mesa could possibly have disturbance from a great deal of human activity. Guaje Canyon should provide a control area to allow for comparisons. Changes in avian species diversity or total population in a canyon could indicate ecological change.

2 ENVIRONMENTAL SETTING

2.1 Description of the Study Sites

EST divided the locations used for this project into upper and lower canyon for comparisons; the mesa was considered one area. The western ends of each canyon are characterized by increased elevation, greater availability of water, and denser plant growth. Puye Mesa was treated as a single location and the habitat is uniform at this site.

Upper Guaje Canyon. Upper Guaje Canyon is 183 to 91 m (600 to 300 ft) deep with a permanent stream. The areas near the stream are riparian and the tree communities in the canyon dominate the stream and the sides of the canyon. During bird censuses, EST noted that a majority of the bird activity occurred away from the stream in the vegetation on canyon sides. There are four predominant tree types in the bottom of this canyon. From higher elevations to lower, the habitats grade from mixed-conifer (*Abies concolor-Pseudotsuga menziesii-Picea engelmannii-Pinus flexilis-Pinus ponderosa*) with aspen (*Populus tremuloides*) to mixed-conifer to ponderosa pine (*Pinus ponderosa*).

Lower Guaje Canyon. Lower Guaje Canyon is 91 to 46 m (300 to 150 ft) deep with a permanent stream. The areas adjacent to the stream are riparian and the tree communities dominate the stream and the sides of the canyon. EST noted during this bird census that a majority of the bird activity occurred away from the stream, on the sides of the canyon. There are three predominant tree types in the bottom of this canyon. From higher elevations to lower the habitats change from mixed-conifer to ponderosa pine, then becomes a mixture of ponderosa pine and pinyon-juniper (*Pinus edulis-Juniperus monosperma-Juniperus scopulorum*).

Upper Los Alamos Canyon. Upper Los Alamos Canyon is 213 to 152 m (700 to 500 ft) deep with a permanent stream to the reservoir. The areas next to the stream are riparian but the tree communities away from the stream dominate the stream and the canyon sides. The permanent stream influences are greater above Los Alamos Reservoir rather than below where the stream is seasonal. The census conducted by EST placed an equal number of observation points above and below the reservoir. There are two major tree types in the bottom of the canyon. From higher elevations to lower, tree types change from mixed-conifer with aspen to mixed-conifer.

Lower Los Alamos Canyon. Lower Los Alamos canyon is 91 to 61 m (300 to 200 ft) deep with a seasonal stream. The areas adjacent to the stream are moderately riparian and the tree communities dominant the stream bed and the canyon sides. The stream is ephemeral below Omega Site (TA-2) and runs during wetter times of the year and when water is released. There are four predominate tree types in the bottom of this canyon. Higher elevations to lower, the habitats grade from mixed-conifer to ponderosa pine to a mixture of ponderosa pine and pinyon pine (*Pinus edulis)* to a mixture of pinyon pine and juniper (*Juniperus monosperma-Juniperus scopulorum*).

Puye Mesa. Puye Mesa is a short mesa top less than 1.6 km (1 mi) wide and 2.4 km (1.5 mi) long. There are two deep (61 to 91 m [200 to 300 ft]) canyons, Mortandad to the north and Cañada del Buey to the south, near this location. No permanent water sources are available in this location. The three dominant tree types on this mesa are pinyon pine, mixed with one-seed juniper (*Juniperus monosperma*) and a few scattered ponderosa pines.

3 METHODS

An EST biologist systematically walked Guaje and Los Alamos Canyons and Puye Mesa with approximately 200 meters between each observation point to determine the bird populations in these locations. EST conducted 30 observation points in each section of the canyons and 17 points on Puye Mesa during all censuses. A census starts soon after daybreak and ends before 11 AM. The survey team used a similar method at each point to determine the birds present. Observations at a point are conducted for six minutes, and during that time all the species heard and seen are recorded. Each observation of a species encountered is recorded with the following information: species code (Appendix 9-A), sex, age, and distance from observation point. The team recorded habitat type and meteorological information at each observation point. EST marked each point to relocate the same location for each subsequent census. Any unknown birds are looked up immediately in a field guide (National Geographic Society 1983) or upon return to the lab (Ehrilich et al. 1983 and Travis 1992). A single factor ANOVA and a t-test determined any differences between the censuses and populations. The program DISTANCE (Buckland et al. 1993) was used to estimate population density for each location.

4 RESULTS

EST discovered statistically significant differences between each location used for this ecological risk project (Appendix 9-B). Los Alamos Canyon (1993, 1994) and Puye Mesa (1994) had significantly more species and numbers of birds than Guaje Canyon. The comparison of all four locations determined lower Los Alamos Canyon had significantly more birds and species than all other locations (Figure 1). Teams conducted more surveys in upper Guaje Canyon in 1993 than the other locations.

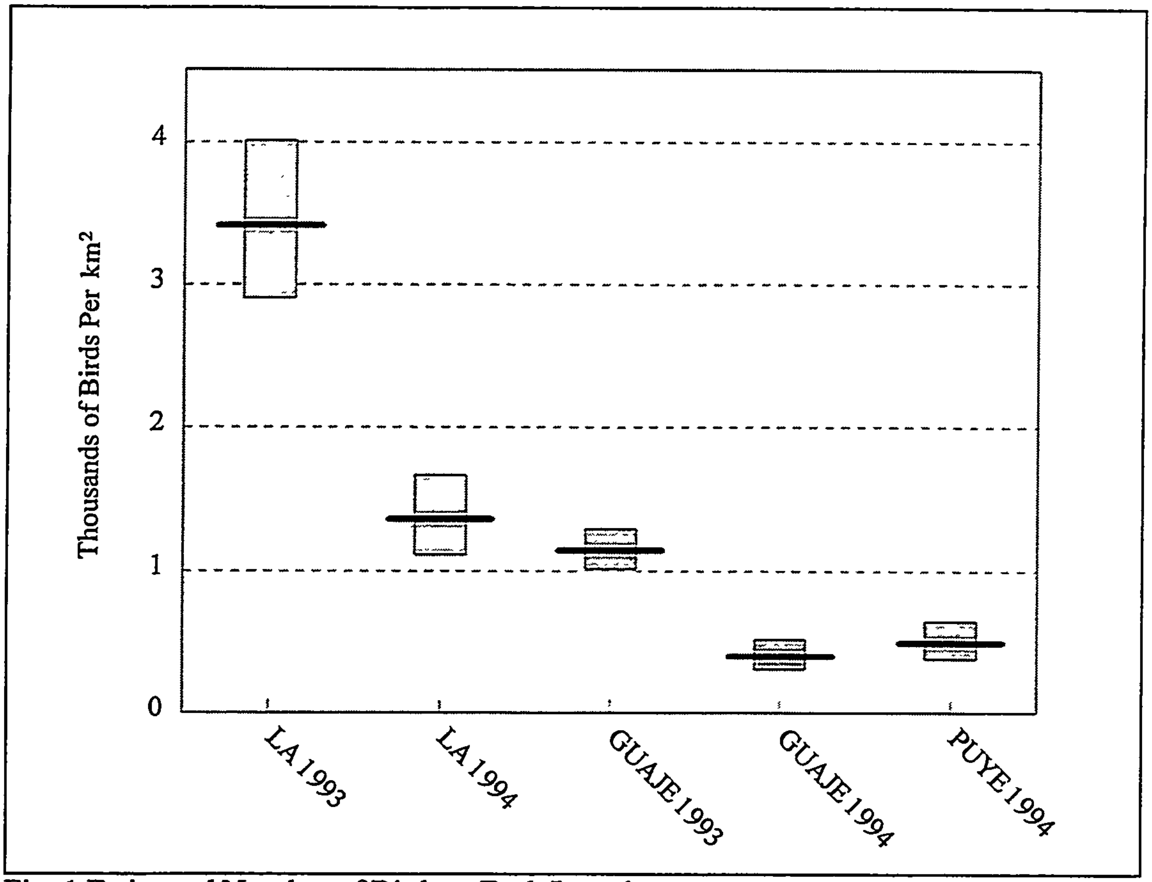


Fig. 1 Estimated Number of Birds at Each Location

Upper Guaje Canyon. The predominant bird species in this area of the canyon include Steller's Jay (*Cyanocitta stelleri*), Mountain Chickadee (*Parus gambeli*), White-breasted Nuthatch (*Sitta carolinensis*), Northern Flicker (*Colaptes auratus*), American Robin (*Turdus migratorius*), and Gray Flycatcher (*Empidonax wrightii*) (Figure 2). All the species were encountered in upper Guaje Canyon during three separate surveys in the summer of 1993.

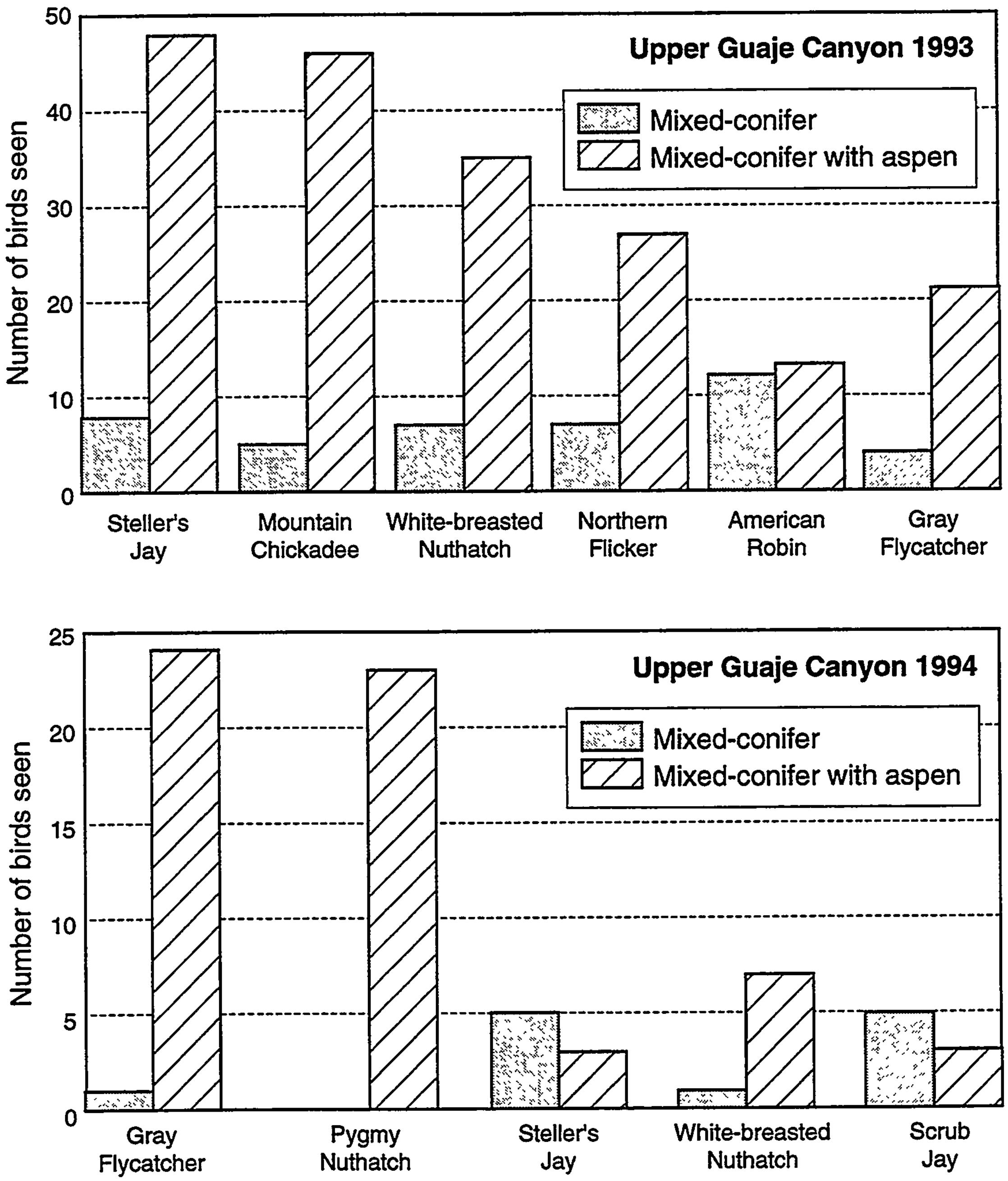


Fig. 2 Number of Birds Seen in Upper Guaje Canyon During 1993 and 1994

Lower Guaje Canyon. The predominant bird species in this area of the canyon include the Pygmy Nuthatch (*Sitta pygmaea*), Gray Flycatcher (*Empidonax wrightii*), Broad-tailed Hummingbird (*Selasphorus platycercus*), Mountain Chickadee (*Parus gambeli*), Steller's Jay (*Cyanocitta stelleri*), Northern Flicker (*Colaptes auratus*), and Scrub Jay (*Aphelocoma coerulescens*) (Figure 3). Violet-green swallows (*Tachycineta* *thalassina*) are in greater numbers in this area of the canyon and are not found at all in the upper canyon. All the species were encountered in lower Guaje Canyon during these surveys in the summers of 1993 and 1994.

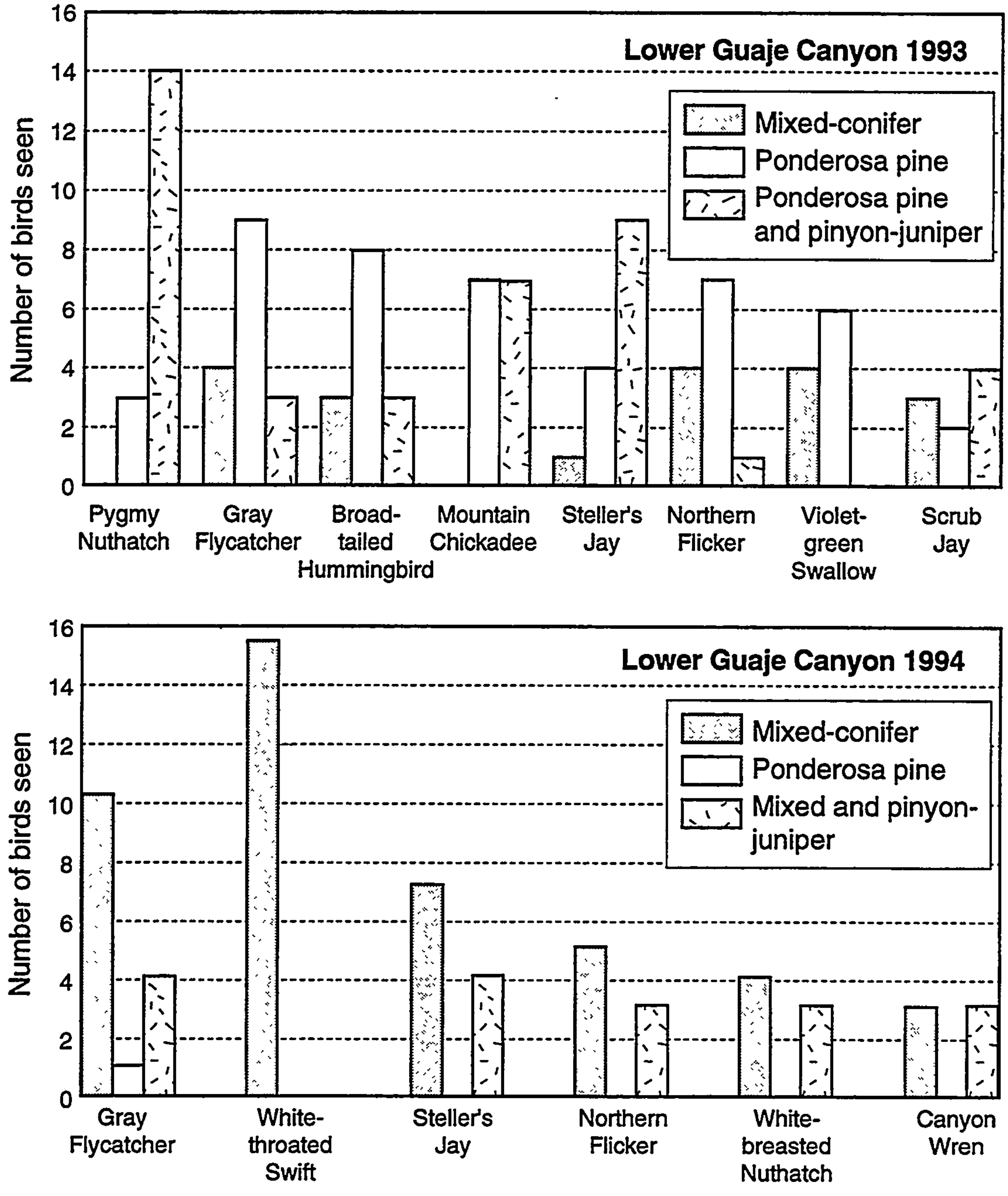


Fig. 3 Number of Birds Seen in Lower Guaje Canyon During 1993 and 1994

Upper Los Alamos Canyon. The predominant bird species in this area of the canyon include the Northern Flicker (*Colaptes auratus*), Common Raven (*Corvus corax*), Hermit Thrush (*Catharus guttatus*), Gray Flycatcher (*Empidonax wrightii*), Steller's Jay (*Cyanocitta stelleri*), Violet-green Swallow (*Tachycineta thalassina*), Virginia's Warbler (*Vermivora virginiae*), and White-breasted Nuthatch (*Sitta carolinensis*) (Figure 4). All the species were encountered in upper Los Alamos Canyon during these surveys in the summers of 1993 and 1994.

Lower Los Alamos Canyon. The predominant bird species in this area of the canyon include Pygmy Nuthatch (*Sitta pygmaea*), Violet-green Swallow (*Tachycineta thalassina*), Western Wood-Pewee (Contopus sordidulus), Bushtit (*Psaltriparus minimus*), Northern Flicker (*Colaptes auratus*) and Rufous-sided Towhee (*Pipilo erythrophthalmus*) (Figure 5). All the species were encountered in lower Los Alamos Canyon during these surveys in the summers of 1993 and 1994.

Puye Mesa. The predominant bird species on this mesa include Scrub Jay, Rufous-sided Towhee (*Pipilo erythrophthalmus*), White-throated Swift, Violet-green Swallow (*Tachycineta thalassina*), and Western Bluebird (Figure 6). All the species were encountered on Puye Mesa during this census in the summer of 1994.

5 DISCUSSION

Los Alamos and Guaje Canyons have large bird populations and species diversity. With the preliminary surveys conducted in the summers of 1993 and 1994, there appears to be more birds and species in Los Alamos Canyon. Guaje Canyon had fewer birds encountered on each of the surveys conducted. Guaje's thick vegetation and large amounts of downed dead material could limit the usefulness of this canyon for bird and animal foraging. Studies done in following years should determine if there is any effect on the Los Alamos Canyon system by human disturbance. The lower bird populations in Guaje Canyon should be censused in following years to determine the trend in bird

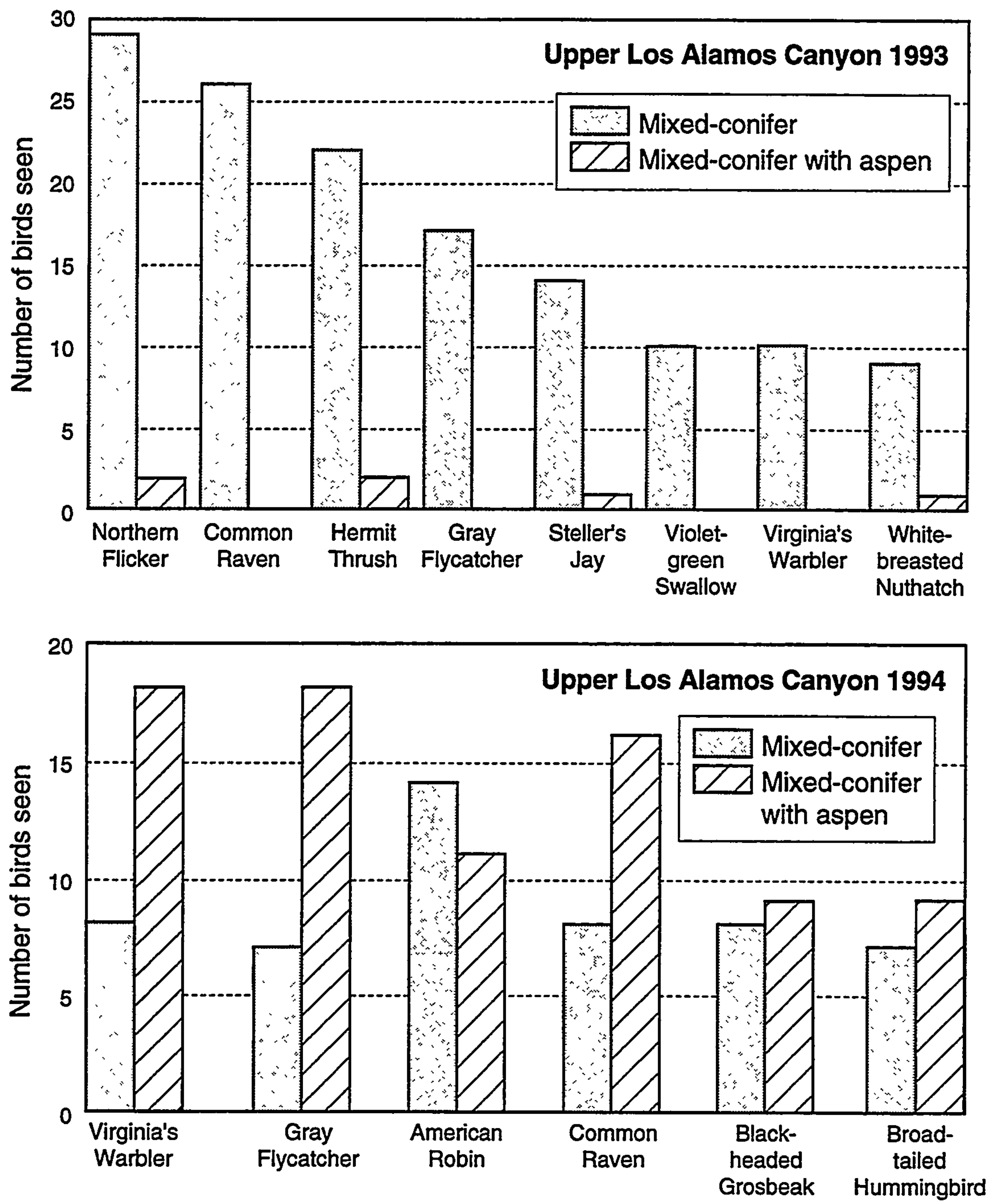


Fig. 4 Number of Birds Seen in Upper Los Alamos Canyon During 1993 and 1994

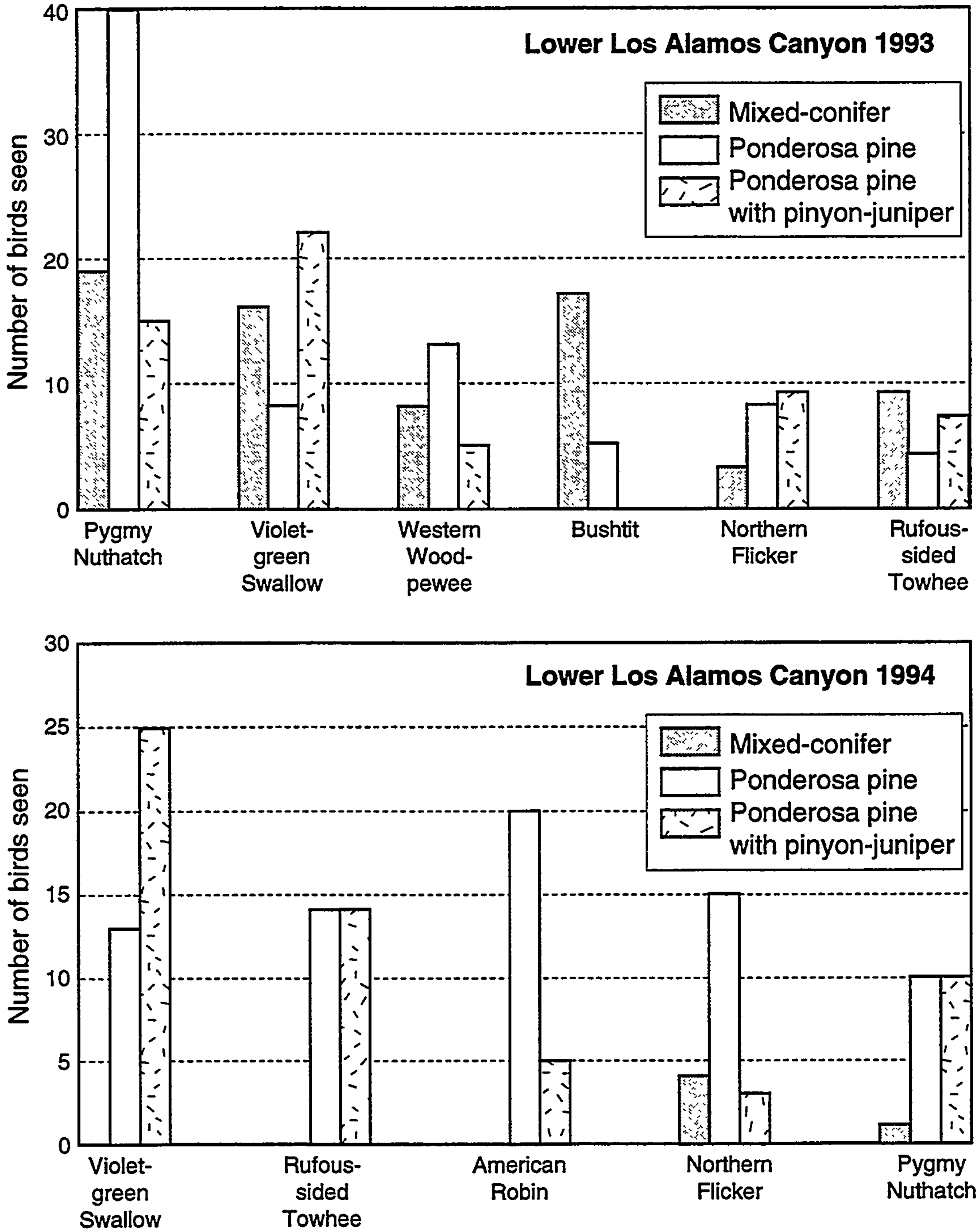


Fig. 5 Number of Birds Seen in Lower Los Alamos Canyon During 1993 and 1994

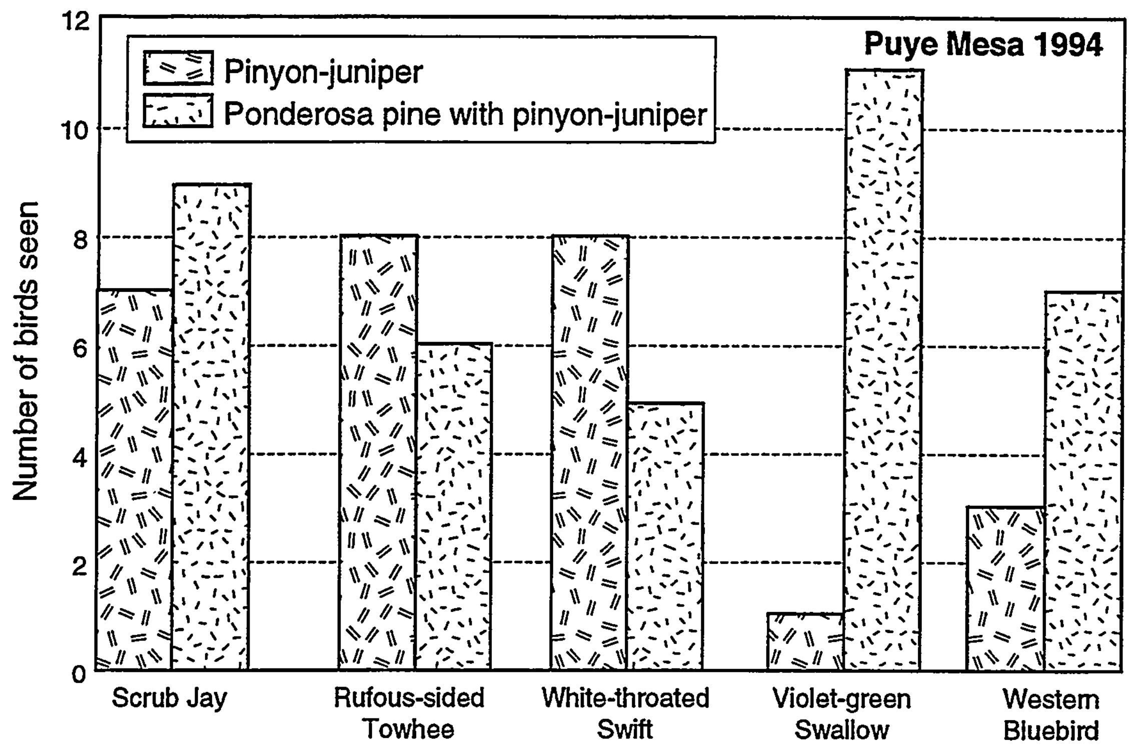


Fig. 6 Number of Birds Seen on Puye Mesa in 1994

population and determine if it was just a bad year or if there is a smaller population in this canyon.

To determine the effects of Los Alamos National Laboratory on bird communities, the censusing of Guaje and Los Alamos Canyons and Puye Mesa needs to continue. Additional censusing of each of these canyons will provide information on any changes that are occurring. Yearly censusing of each canyon will provide a basis to determine any changes that are taking place as a result of human activity. Yearly netting and censusing of these areas is recommended. Netting and banding of the birds in these canyons will provide a basis for the survivorship of individual birds and provide population estimates of each individual species. The change in populations of individual species will provide an index to the type of habitat change that is taking place based on the diet of the effected bird species.

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APPENDIX 9-A

Table 1 Species Code

Species Code	*Common Name*	*Scientific Name*
ACWO	Acorn Woodpecker	*Melanerpes formicivorus*
AMRO	American Robin	*Turdus migratorius*
ATFL	Ash-throated Flycatcher	*Myiarchus cinerascens*
BHCO	Brown-headed Cowbird	*Molothrus ater*
BHGR	Black-headed Grosbeak	*Pheucticus melanocephalus*
BTHU	Broad-tailed Hummingbird	*Selasphorus platycercus*
BUSH	Bushtit	*Psaltriparus minimus*
CATO	Canyon Towhee	*Pipilo fuscus*
CAWR	Canyon Wren	*Catherpes mexicanus*
CHSP	Chipping Sparrow	*Spizella passerina*
CLNU	Clark's Nutcracker	*Nucifraga columbiana*
CORA	Common Raven	*Corvus corax*
DEJU	Dark-eyed Junco	*Junco hyemalis*
DOWO	Downy Woodpecker	*Picoides pubescens*
DUFL	Dusky Flycatcher	*Empidonax oberholseri*
GHOW	Great-horned Owl	*Bubo virginianus*
GRFL	Gray Flycatcher	*Empidonax wrightii*
GRWA	Grace's Warbler	*Dendroica graciae*
HAWO	Hairy Woodpecker	*Picoides villosus*
HETH	Hermit Thrush	*Catharus guttatus*
HOFI	House Finch	*Carpodacus mexicanus*
HOSP	House Sparrow	*Passer domesticus*
HOWR	House Wren	*Troglodytes aedon*
LEGO	Lesser Goldfinch	*Carduelis psaltria*
MAWA	MacGillivray's Warbler	*Oporornis tolmiei*
MOCH	Mountain Chickadee	*Parus gambeli*
MODO	Mourning Dove	*Zenaida macroura*
NOFL	Northern Flicker	*Colaptes auratus*
PIJA	Piñon Jay	*Gymnorhinus cyanocephalus*
PISI	Pine Siskin	*Carduelis pinus*
PLTI	Plain Titmouse	*Parus inornatus*
PYNU	Pygmy Nuthatch	*Sitta pygmaea*
RBNU	Red-breasted Nuthatch	*Sitta canadensis*
RCKI	Ruby-crowned Kinglet	*Regulus calendula*
RSTO	Rufous-sided Towhee	*Pipilo erythrophthalmus*
RTHA	Red-tailed Hawk	*Buteo jamaicensis*
RUHU	Rufous Hummingbird	*Selasphorus rufus*
SCJA	Scrub Jay	*Aphelocoma coerulescens*
SOVI	Solitary Vireo	*Vireo solitarius*
STJA	Steller's Jay	*Cyanocitta stelleri*
SUTA	Summer Tanager	*Piranga ruber*
TOSO	Townsend's Solitaire	*Myadestes townsendi*
TUVU	Turkey Vulture	*Cathartes aura*
VGSW	Violet-green Swallow	*Tachycineta thalassina*
VIWA	Virginia's Warbler	*Vermivora virginiae*
WAVI	Warbling Vireo	*Vireo gilvus*
WBNU	White-breasted Nuthatch	*Sitta carolinensis*
WETA	Western Tanager	*Piranga ludoviciana*
WISA	Williamson's Sapsucker	*Sphyrapicus thyroideus*
WIWA	Wilson's Warbler	*Wilsonia pusilla*

Table 1 (cont.)

Species Code	*Common Name*	*Scientific Name*
WTSW	White-throated Swift	*Aeronautes saxatalis*
WWPE	Western Wood-Pewee	*Contopus sordidulus*
YEWA	Yellow Warbler	*Dendroica petechia*
YRWA	Yellow-rumped Warbler	*Dendroica coronata*

APPENDIX 9-B

Table 1 Values to Compare Difference Between Number of Birds to Number of Species

Locations			Year	*Test*	Statistic Value	P-value	Critical Value	*Significant*	*Larger Number*
Guaje	*Number*	*Los Alamos*	1993	*T*	-5.657	7.08 X 10^{-8}	1.660	*Y*	*Los Alamos*
LG	*Number*	*ULA*	1993	*T*	-1.936	0.0291	1.674	*Y*	*ULA*
LG	*Number*	*LLA*	1993	*T*	-7.284	5.4 X 10^{-10}	1.672	*Y*	*LLA*
UG	*Number*	*LG*	1993	*T*	1.150	0.1270	1.675	*N*	
UG	*Number*	*ULA*	1993	*T*	-1.090	0.1395	1.668	*N*	
UG	*Number*	*LLA*	1993	*T*	-7.459	9.4 X 10^{-10}	1.679	*Y*	*LLA*
ULA	*Number*	*LLA*	1993	*T*	-6.369	3.2 X 10^{-8}	1.677	*Y*	*LLA*
Guaje	*Species*	*Los Alamos*	1993	*T*	-6.305	2.11 X 10^{-9}	1.657	*Y*	*Los Alamos*
LG	*Species*	*ULA*	1993	*T*	-3.231	0.0010	1.672	*Y*	*ULA*
LG	*Species*	*LLA*	1993	*T*	-7.170	9.067 X 10^{-10}	1.673	*Y*	*LLA*
UG	*Species*	*ULA*	1993	*T*	-2.225	0.0148	1.669	*Y*	*ULA*
UG	*Species*	*LLA*	1993	*T*	-6.989	9.078 X 10^{-10}	1.669	*Y*	*LLA*
ULA	*Species*	*LLA*	1993	*T*	-4.250	3.84 X 10^{-5}	1.671	*Y*	*LLA*
Guaje	*Number*	*Los Alamos*	1994	*T*	-7.270	3.596 X 10^{-11}	1.660	*Y*	*Los Alamos*
Guaje	*Number*	*Puye*	1994	*T*	4.025	0.0003	1.725	*Y*	*Puye*
LG	*Number*	*UG*	1994	*T*	-0.638	0.2635	1.683	*N*	
LG	*Number*	*ULA*	1994	*T*	-3.779	0.0002	1.681	*Y*	*ULA*
LG	*Number*	*LLA*	1994	*T*	-7.529	6.48 X 10^{-10}	1.678	*Y*	*LLA*
Puye	*Number*	*Los Alamos*	1994	*T*	0.285	0.3890	1.717	*N*	
UG	*Number*	*ULA*	1994	*T*	-3.271	0.0010	1.675	*Y*	*ULA*
UG	*Number*	*LLA*	1994	*T*	-7.202	1.066 X 10^{-9}	1.674	*Y*	*LLA*
ULA	*Number*	*LLA*	1994	*T*	-3.623	0.0006	1.699	*Y*	*LLA*
ULA	*Number*	*LLA*	1994	*T*	-4.430	2.265 X 10^{-5}	1.673	*Y*	*LLA*
Guaje	*Species*	*Los Alamos*	1994	*T*	-11.177	1.72 X 10^{-19}	1.661	*Y*	*Los Alamos*
Guaje	*Species*	*Puye*	1994	*T*	-6.723	7.657 X 10^{-7}	1.725	*Y*	*Puye*
LG	*Species*	*ULA*	1994	*T*	-5.761	2.899 X 10^{-7}	1.677	*Y*	*ULA*
Puye	*Species*	*Los Alamos*	1994	*T*	-0.180	0.4290	1.708	*N*	
UG	*Species*	*LG*	1994	*T*	-0.233	0.4086	1.684	*N*	
UG	*Species*	*ULA*	1994	*T*	-6.287	4.225 X 10^{-8}	1.677	*Y*	*ULA*
UG	*Species*	*LLA*	1994	*T*	-11.465	4.98 X 10^{-16}	1.675	*Y*	*LLA*
ULA	*Species*	*LLA*	1994	*T*	-3.902	0.0001	1.672	*Y*	*LLA*
ULA	*Species*	*LLA*	1994	*T*	-3.633	0.0005	1.699	*Y*	*LLA*
Los Alamos	*Number*	*Los Alamos*	1993/1994	*T*	-0.410	0.3411	1.658	*N*	
Los Alamos	*Species*	*Los Alamos*	1993/1994	*T*	1.162	0.1238	1.658	*N*	
Guaje	*Species*	*Guaje*	1993/1994	*T*	-4.106	3.622 X 10^{-5}	1.657	*Y*	*1993*
Guaje	*Number*	*Guaje*	1993/199	*T*	-2.215	0.0145	1.660	*Y*	*1993*

Table 1 (cont.)

Locations			*Year*	*Test*	*Statistic value*	*P-value*	*Critical Value*	*Significant*	*Larger Number*
Puye	*Species*	*UG*	1994	*T*	6.533	5.75×10^{-7}	1.714	*Y*	*Puye*
Puye	*Species*	*LG*	1994	*T*	6.184	9.10×10^{-7}	1.708	*Y*	*Puye*
Puye	*Species*	*ULA*	1994	*T*	1.648	0.0547	1.696	*N*	
Puye	*Species*	*LLA*	1994	*T*	-1.358	0.0926	1.701	*N*	
Puye	*Number*	*LG*	1994	*T*	4.006	0.0003	1.711	*Y*	*PUYE*
Puye	*Number*	*UG*	1994	*T*	3.668	0.0006	1.714	*Y*	*PUYE*
Puye	*Number*	*ULA*	1994	*T*	1.752	0.0465	1.714	*Y*	*PUYE*
Puye	*Number*	*LLA*	1994	*T*	-1.132	0.1339	1.703	*N*	

CHAPTER 10

SMALL MAMMAL POPULATION STUDIES FOR ECOLOGICAL RISK ASSESSMENTS

by

JAMES BIGGS

ABSTRACT

In July and August of 1993 and 1994, the Biological Resource Evaluations Team conducted field surveys in Guaje and Los Alamos Canyons, Los Alamos County. Biological data for the ecological risk assessment was collected and included conducting live-capture and release studies on rodent populations. The primary purpose of collecting small mammal data was to obtain sufficient information to estimate population size, density, and species diversity. The trapping sites were located in two habitat types; mixed conifer and ponderosa pine, and a transition zone of these two. Four to six 12 x 12 grids with 144 trap stations at each was laid out in the canyon bottoms. Program CAPTURE was used to estimate population size and density. Very poor capture rates were experienced during both years of trapping which was not only evident in these trapping locations but elsewhere at the Laboratory during other live-trap sampling. Analysis (Anlysis of Variance and Student-Newman Keuls multiple range test) showed that the mean daily capture rates observed during the four consecutive years are statistically different (alpha=0.05). Capture rates for 1991 were significantly higher than the subsequent years, and 1992 rates were significantly higher than 1993 and 1994. Capture rates were not significantly different between 1993 and 1994. Deer mice were captured in all trapping locations except middle Los Alamos Canyon. Shrews and voles were only captured in the upper locations of each canyon and deer mice and a small number of harvest mice were the only species captured in the ponderosa pine habitat of the lower portions of each canyon. The upper portions of the canyon systems had a much higher species diversity and a much greater number of captures compared to the lower areas resulting in higher population estimates and densities in those locations. The relative percentage of males was much higher than females but overall mean body weights appeared similar. The mean body weights of males ranged from 9.8 grams for harvest mice to 19.3, 14.4, and 27.3 g for brush mice, deer mice, and long-tailed voles, respectively. Mean body weights for females ranged from 8.7, 22.3, 15.6, and 31 g, for harvest mice, brush mice, deer mice, and long-tailed voles, respectively. The upper areas of both canyons had the highest species diversity with essentially only one species being recorded in the middle portions of each canyon. The overall species diversity was similar for both canyons. The mean body weights of all nocturnal species combined were compared between canyons and by year. There were no significant differences in 1993 between upper Guaje Canyon and upper Los Alamos Canyon and there were no significant differences between the mean body weights of lower Guaje Canyon and lower Los Alamos Canyon. However, there was a significant difference in the mean body weights between the upper canyon sites compared to the lower canyon sites. In 1994, there were no significant differences in mean body weights between sites.

1 INTRODUCTION

During the summers of 1993 and 1994, the Biological Resource Evaluations Team conducted field surveys in two canyon systems in Los Alamos County, Guaje and Los Alamos Canyons. The trapping locations were set up on United States Forest Service and Laboratory properties and are similar in habitat descriptions but are separated from each other. A field camp was established at one of the study areas, Guaje Canyon, due to the remoteness of its location. Various biological data for ecological risk assessment were collected and included conducting live-capture and release studies on rodent populations. The primary purpose of this portion of the field studies was to obtain sufficient data to estimate population size and density of small mammals for future baseline comparisons. In addition, data on sex ratios and physical measurements of species captured were collected and analyzed in this document. Furthermore, the 1993 data was the first collected for the ecological risk assessment and was used to assess possible modifications in the design for the remaining portion of the small mammal study. In 1993, the Center for Disease Control requested that we collect blood samples from rodents during the small mammal population studies to obtain information on hantavirus seroprevalence in this area due to the recent outbreak of this disease. Just prior to initiation of the field studies, procedures to collect blood samples from the mammals were incorporated into the project design.

2 ENVIRONMENTAL SETTING

2.1 Description of the Study Sites

The trapping sites were located in two distinct habitat types, ponderosa pine and mixed-conifer, with a third grid located within a transition zone of these two.

The upper area of Guaje Canyon is characterized by mixed-conifer vegetation that consists of an overstory of Douglas fir (*Psuedostuga menziesii*), spruce (*Picea* *englemanii*), thinleaf alder (*Alnus tenuifolia*), and, in lesser quantity, ponderosa pine (*Pinus ponderosa*). Shrubs include cliffbush (*Jamesia americana*), serviceberry (*Amelanchier* sp.), and oak (*Quercus* spp.). The most common understory species include cutleaf coneflower (*Rudbeckia laciniata*) and several species of grasses and forbs. The upper area of Los Alamos Canyon is similar in overstory composition and shrubs with the addition of white fir (*Abies concolor*). Geranium (*Geranium jamesii*) and strawberry (*Fragaria americana*) were common understory species.

In 1993, grids were established only in two locations within each canyon, upper and lower. In 1994, the study design was modified to include a third trapping grid placed between the other two in each canyon. This area is characterized by ponderosa pine outside of and north of the stream channel, spruce, limber pine (*Pinus flexilis*), and Douglas fir within and south of the stream channel, and water-birch (Betula occidentalis), aspen (*Populus tremuloides*), Rocky Mountain maple (*Acer glabrum*), thinleaf alder, and white fir, along the stream channel. Common shrubs and understory species include Gambel oak (*Quercus gambelii*), gooseberry (*Ribes inerme*), wild rose (*Rosa woodsii*), New Mexico locust (*Robinia neomexicana*), cliffbush, wild raspberry (*Rubus strigosus*), chokecherry (*Prunus virginia*), serviceberry (*Amelanchier utahensis*), Richardson's geranium, cutleaf coneflower (*Rudbeckia laciniata*), thimbleberry (*Rubus parviflorus*), *Galium* sp., and various grasses.

The lower areas are characterized by an open ponderosa pine habitat. Ponderosa pine is the most common overstory species with lesser amounts of juniper (*Juniperus monosperma*). Common shrubs include barberry (*Berberis fendleri*), oak, and rose. Understory species were more sparse and included mostly grasses. Lower Guaje Canyon has a comparatively greater understory cover than lower Los Alamos Canyon.

The terrain in the upper areas is steep and relatively narrow compared to the middle and lower areas. A stream channel runs through all sites, however, water was constantly flowing only in the upper portions of both canyons. In the middle and lower areas, water flow was intermittent.

3 METHODS

Although the primary focus of this study was to collect small mammal population data, it was necessary to incorporate new techniques to allow for the collection of blood samples and, at the same time, address health and safety issues associated with the hantavirus. The procedures for bleeding and processing animals for bleeding and the personal protective equipment used in association with the collection of blood samples are not discussed in great detail in this report. A detailed description of these procedures is given in Mills, et al. (*In prep.*) and Biggs and Bennett (*In prep.*).

In 1993, four 12 x 12 grids (two in each canyon system) with 144 trap stations at each was laid out across the canyon bottom at two sites; one in the upper portions of Guaje and Los Alamos Canyons and one in their lower portions. In 1994, a third site was trapped in each canyon with the sites located between the other two grids. Only general field clothes and no extraordinary procedures were required for setting up grids and traps. Additional clothing requirements were necessary, due to the hantavirus issue, for the remaining portion of the study. Two Sherman live-traps were placed within 2 m of each trap station. Traps were placed at least 1 m from obvious deer, elk, or other large mammal trails or bedding sites. Where possible, traps were set next to small mammal burrows or tracks, or near rocks, logs, brush, etc. Traps were baited with sweet feed (a molasses coated horse feed) rather than the traditional peanut butter and oats mixture. The use of sweet feed has not appeared to affect capture rates during other sampling sessions. Sweet feed is used to reduce the amount of field time needed to bait and clean traps.

For purposes of data analysis, traps were assigned two numbers corresponding to an x-y coordinate (i.e., 1-1, 1-2, 1-3, etc.) with the first station (1-1) located at the northwest corner of the grid. The numbers were printed on pin flags placed at each trap station (the x-y coordinate). Additional flagging was placed above the trap station for ease in relocating. Species name, weight, body length, tail length, ear length, foot length, and location of capture (x-y coordinate) were recorded. Animals were marked with size #FF rodent ear tags from the Salt Lake Stamp Co., Salt Lake City, Utah.

Program CAPTURE (White et al. 1982) was used to estimate population size and density. A nested grid methodology was used to estimate density. Due to insufficient sample sizes of most species, only species specific capture-recapture data on the deer mouse was used for density estimates. However, data for all species were pooled for density estimates of rodents for each session. Use of the nested grid methodology compensates for possible "edge effect" (animals being drawn into the trap grid that would normally not occur there). The x-y coordinates for each capture were input to program CAPTURE for use in density estimates. Program CAPTURE also calculated the average and maximum distance moved by each animal based on the recapture location. Trapping took place over 4 consecutive nights for a total of approximately 8,060 trap nights for 1993-94. Traps were baited in late afternoon and checked in early morning to record nocturnal species.

The Statistical Analysis System was used to analyze data on capture/recapture rates and for all analyses on sex and physical measurement data. A one-way parametric Analysis of Variance (AOV) and Student-Newman Keuls (SNK) multiple range test were used to determine if mean daily small mammal capture rates were statistically different between years. A one-way AOV was also used to analyze recapture data to determine if handling procedures significantly affected recapture rates.

Species diversity indices were calculated using the Shannon-Wiener (also known as Shannon-Weaver) method (Hair 1980). Diversity indices were calculated for each grid by year and for both years of data pooled. Species diversity indices were also calculated for each canyon system.

4 RESULTS

Figure 1 shows mean daily capture rates recorded for 1991 to 1994. As shown in the graph, capture rates (includes recaptures) in 1991 and 1992 were moderate ranging from about 15–25%. In 1993 and 1994, however, we experienced very poor capture rates which was not only evident in the ecorisk trapping locations but elsewhere at the Laboratory during similar live-trapping sampling. Analysis (AOV and SNK multiple range test) showed that the mean daily capture rates observed during the four consecutive years are statistically different (alpha=0.05). Capture rates for 1991 were significantly higher than the subsequent years, and 1992 rates were significantly higher than 1993 and 1994. Capture rates were not significantly different between 1993 and 1994.

Due to the implementation of new techniques (i.e., bleeding, anesthetizing of animals) added to the small mammal population study, concerns arose about the possibility of additional stress factors affecting recapture rates. Daily recapture rates (total # of tagged animals/total # of animals captured) for these studies and for some of the studies in 1992 have been plotted and are shown in Figure 2. Only two nights of data were collected in 1992. Analysis of recapture data showed no significant differences between days when comparing between years.

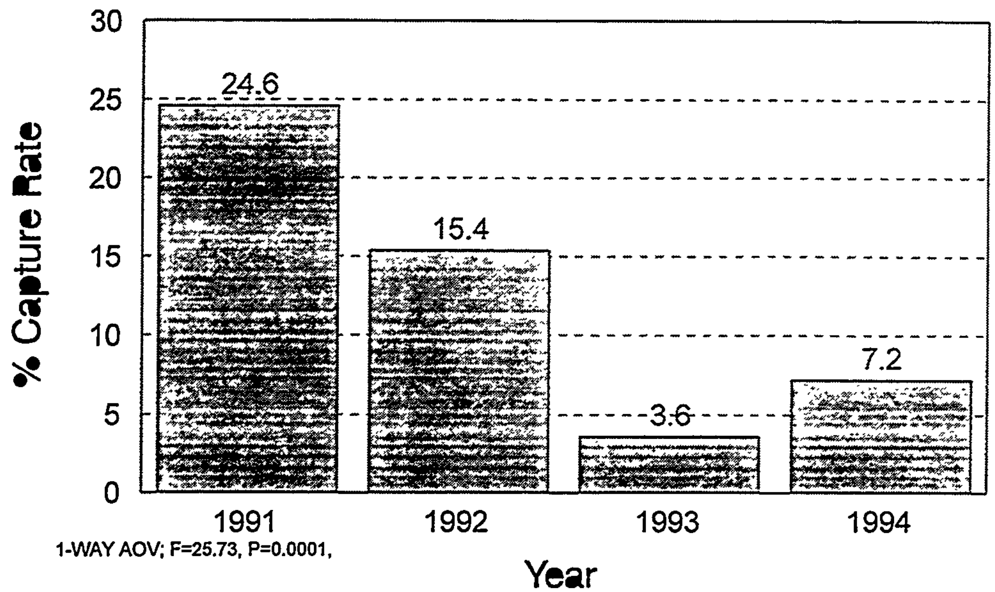

Fig. 1 Mean Daily Small Mammal Capture Rates, Los Alamos County 1991–94

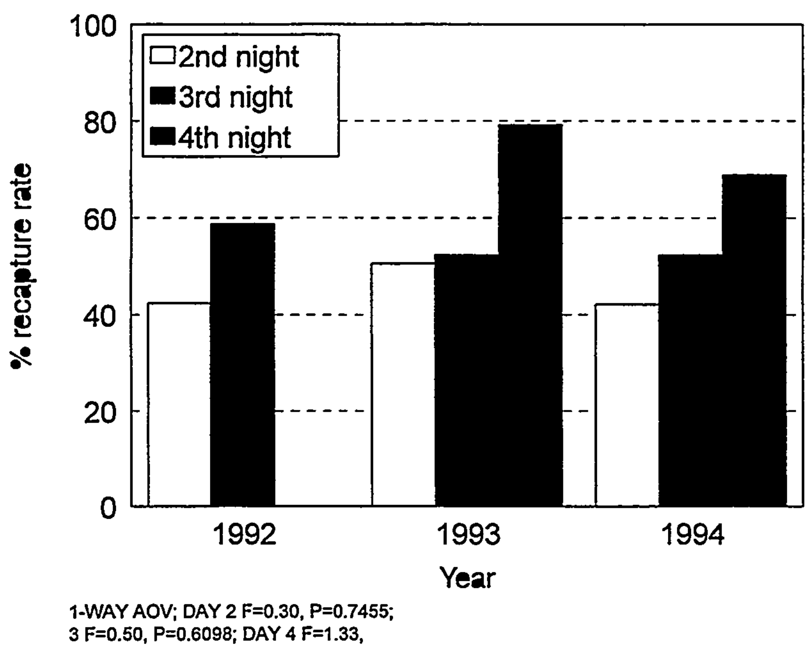

Fig. 2 Daily Recapture Rates for Small Mammal Studies, Los Alamos County, 1992–94

Table 1 lists all small mammal species captured during trapping sessions in Los Alamos and Guaje Canyons. This list also includes incidental captures of diurnal species. Table 2 lists each species by the habitat they were captured in, either ponderosa pine, mixed-conifer, or the transition area between these two. Deer mice were captured in all trapping locations except middle Los Alamos Canyon. Shrews and voles were only captured in the upper locations of each canyon and deer mice and a small number of harvest mice were the only species captured in the ponderosa pine habitat of the lower portions of each canyon.

Table 1 Small Mammal Species Captured During the 1993-94 Ecological Risk Studies, Los Alamos and Guaje Canyons

Least chipmunk	*Eutamias minimus*
Colorado chipmunk	*Eutamias quadrivatattus*
Long-tailed vole	*Microtus longicaudus*
Weasel	*Mustela frenata*
Mexican woodrat	*Neotoma mexicana*
Brush mouse	*Peromyscus boylii*
Deer mouse	*Peromyscus maniculatus*
Harvest mouse	*Reithrodontomys megalotis*
Water shrew	*Sorex palustrus*
Vagrant shrew	*Sorex vagrans*

Table 2 Small Mammal Species Captured During the 1993-94 Ecological Risk Studies, Los Alamos and Guaje Canyons, By Habitat

			Habitat				
Species	**Ponderosa Pine**			**Transition Area**		**Mixed Conifer**	
	LG	**LLA**	**MG**	**MLA**	**UG**	**ULA**	
Least chipmunk						x	
Colorado chipmunk				x		x	
Long-tailed vole						x	x
Weasel						x	
Mexican woodrat					x		
Brush mouse				x	x	x	
Deer mouse	x	x	x		x	x	
Harvest mouse		x					
Water shrew					x		
Vagrant shrew					x		
Shrew (unidentified species)						x	

Table 3 provides information on population estimates and density estimates for small mammals captured during the study. Insufficient sample sizes prevented analysis from being conducted on all individual species except deer mice. Data was pooled for all species to obtain overall small mammal population and density estimates.

Table 3 Small Mammal Population and Density Estimates for Guaje and Los Alamos Canyons, Los Alamos County, 1993-1994

SITE	POPULATION ESTIMATE	SE	DENSITY ESTIMATE animals/ha	SE
Lower Guaje Canyon				
1993	*		*	
1994	19	1.65	*	
Middle Guaje Canyon				
1994	21	4.50	*	
Upper Guaje Canyon				
1993	48	6.58	39	11.54
1994	24	2.88	7.5	5.41
Lower Los Alamos C.				
1993	*		*	
1994	10	1.85	7.6	3.71
Middle Los Alamos C.				
1994	11	1.49	*	
Upper Los Alamos C.				
1993	38	4.24	25	7.95
1994	14	1.90		

1 Deer mice were the only species captured at this location.
* Indicates sample size insufficient to run population and density estimate program.

A species diversity index (Hair 1980) was calculated for each grid by year (Figure 3), each grid for both years of data combined (Figure 4), and by canyon (Figure 5). The upper areas of both canyons had the highest species diversity with essentially only one species being recorded in the middle portions of each canyon. The overall species diversity was similar for both canyons.

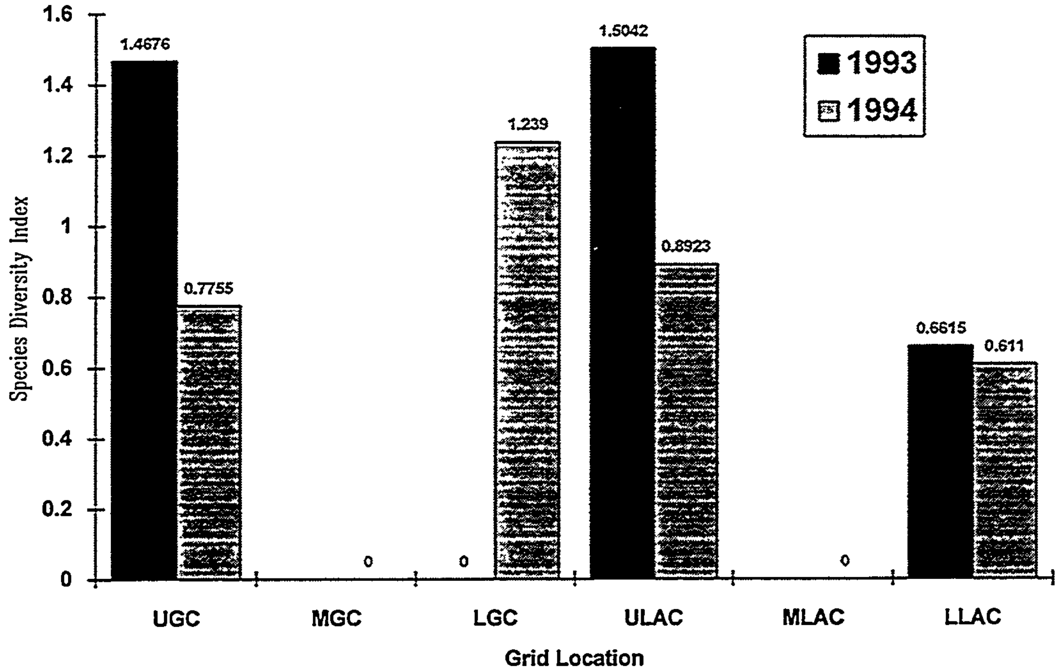

Fig. 3 Small Mammal Species Diversity Indices, by Grid

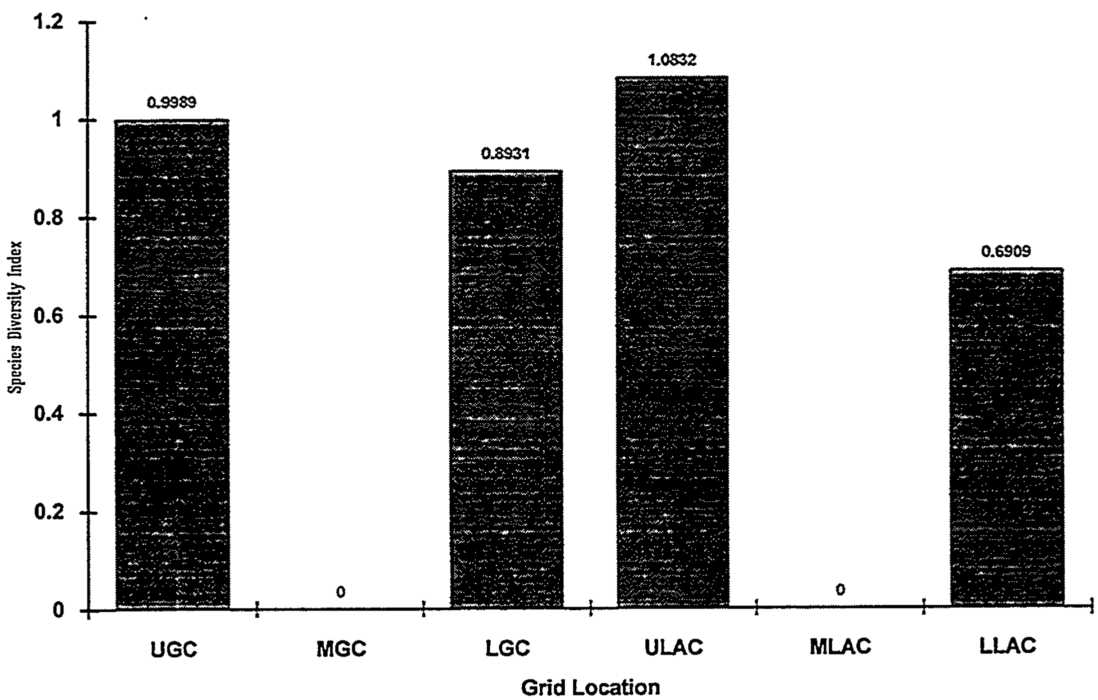

Fig. 4 Small Mammal Species Diversity Indices for Combined Data, 1993-94

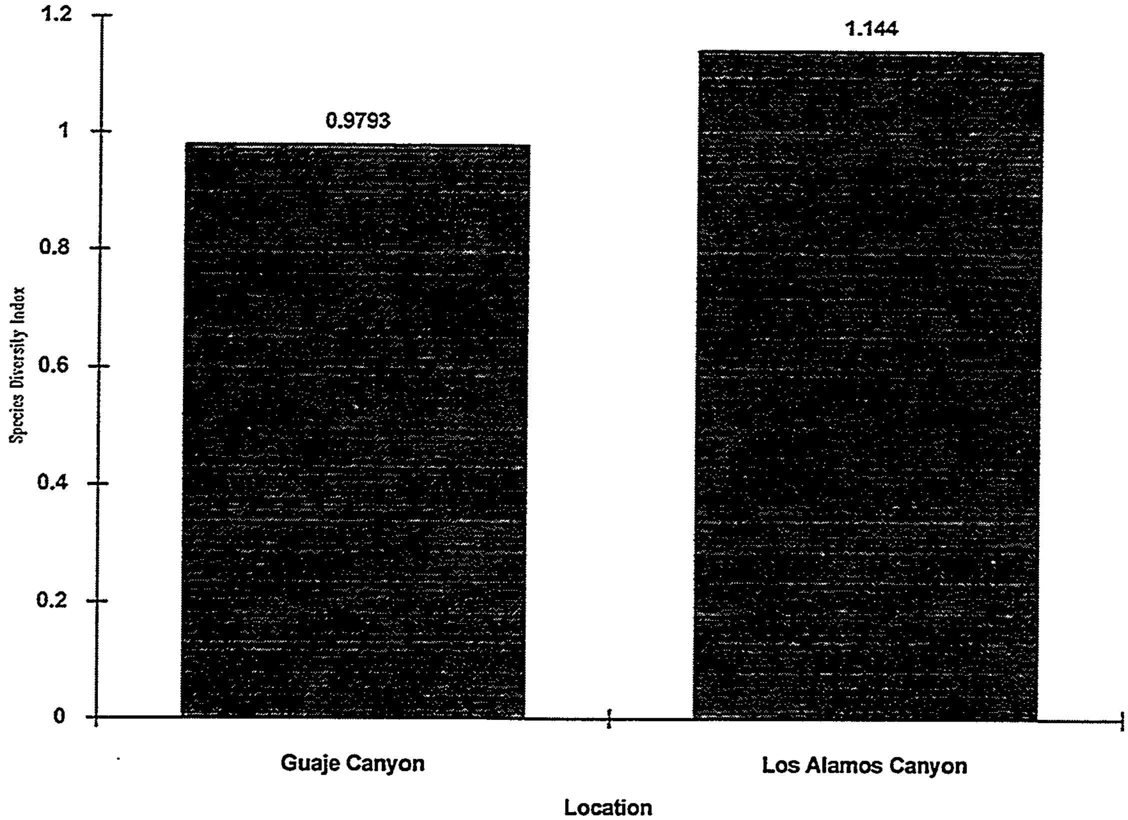

Fig. 5 Small Mammal Species Diversity Indices by Canyon, 1993-94

Total number of males and females captured for each species by site and year is given in Table 4 and overall sex ratios for the most commonly captured species for both years combined is shown in Figure 6.

Table 4 Total Number of Males and Females by Species for 1993-94 Ecological Risk Assessment, Guaje and Los Alamos Canyons

SPECIES	SITE											
	UG		MG		LG		ULA		MLA		LLA	
	m	f	m	f	m	f	m	f	m	f	m	f
Deer mouse	28	12	10	7	11	13	23	10	0	0	7	1
Brush mouse	1	0	0	0	1	1	3	2	8	4	3	4
White-footed mouse	0	0	0	0	2	0	0	0	0	0	0	0
Harvest mouse	0	0	0	0	1	1	0	0	0	0	1	2
Mexican woodrat	1	0	0	0	0	0	1	0	0	0	0	0
White-throated woodrat	2	1	0	0	0	0	0	0	0	0	0	0
Long-tailed vole	10	5	0	0	1	0	6	3	0	0	0	0
TOTALS	41	18	10	7	16	15	33	15	8	4	11	7

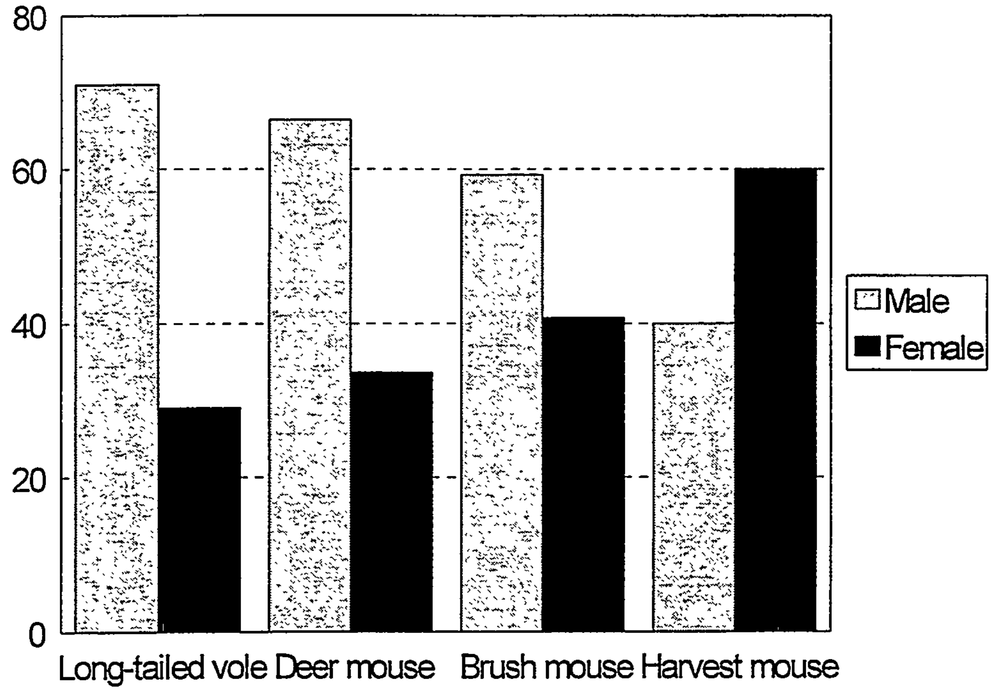

Fig. 6 Relative Percentage of Females and Males by Species for Combined Data

Mean body weights for each of the most commonly captured species, by sex, were compared by year and canyon. Tables 5 and 6 show mean body weights for males and females, respectively, with the accompanying standard error.

Table 5 Male Mean Body Weights of Small Mammal Species for Both Canyons and 1993-94 Data Combined

SPECIES			
	Sample Size	Mean Body Weight	Standard Error
Long-tailed vole	17	27.3235	1.6748
Deer mouse	78	14.3590	0.4687
Brush mouse	16	19.3313	0.6777
Harvest mouse	2	9.75	1.2500

Table 6 Female Mean Body Weights of Small Mammal Species for Both Canyons and 1993-94 Data Combined

SPECIES			
	Sample Size	Mean Body Weight	Standard Error
Long-tailed vole	7	31.0000	3.3022
Deer mouse	39	15.6282	0.7287
Brush mouse	11	22.3182	1.3556
Harvest mouse	3	8.6667	1.9221

Although not statistically analyzed, mean body weights appear to be similar for males and females of each species. The mean body weights of all nocturnal species combined were compared between canyons and by year (Table 7). There were no significant differences in 1993 between upper Guaje Canyon (mean = 23.335) and upper Los Alamos Canyon (mean = 21.012) and there were no significant differences between the mean body weights of lower Guaje Canyon (mean = 14.385) and lower Los Alamos Canyon (mean = 12.313). However, there was a significant difference in the mean body weights between the upper canyon sites compared to the lower canyon sites (F=5.14; p=0.0025). In 1994, there were no significant differences in mean body weights between sites (F=1.52; p=0.1893).

Table 7 Comparison of Mean Body Weights of Nocturnal Small Mammals by Site for 1993 and 1994.

LOCATION	**NO. OF SAMPLES**	**MEAN BODY WEIGHT**	**SNK GROUPING[1]**
1993			
Upper Guaje Canyon	37	23.335	A
Lower Guaje Canyon	13	14.385	B
Upper Los Alamos Canyon	40	21.012	A
Lower Los Alamos Canyon	8	12.313	B
[1] SNK groupings: means with same letter are not significantly different. F=5.14; p=0.0025			
1994			
Upper Guaje Canyon	28	22.054	A
Middle Guaje Canyon	16	13.625	A
Lower Guaje Canyon	19	13.947	A
Upper Los Alamos Canyon	16	31.375	A
Middle Los Alamos Canyon	13	23.408	A

Table 7 (cont.)

LOCATION	NO. OF SAMPLES	MEAN BODY WEIGHT	SNK GROUPING[1]
Lower Los Alamos Canyon	11	19.545	A
[1] SNK groupings: means with same letter are not significantly different. F=1.52; p=0.1893			

5 DISCUSSION

When we set out to conduct the trapping sessions we had to rely on capture rates obtained from 1991 and 1992 surveys which showed fairly good success. This was not the case for our 1993 and 1994 surveys as we had very low sample sizes. As shown in Table 3, most of the estimates appear reasonable with generally acceptable standard errors with the exception of a couple of the density estimates. However, the modeling procedure of program CAPTURE selected in most cases, the null estimator. As stated in the literature, program CAPTURE loses its strength as the population size decreases, particularly population sizes under 50 (White et al. 1982). Since our estimates were under 50, the estimates calculated by CAPTURE may not be completely reliable. However, this data can be used to show base relative comparisons between each area. It is anticipated that modifications will be necessary if further studies are planned. These are discussed below (Research Needs) and will be necessary to increase sample sizes to more accurately estimate populations and densities of small mammals in the study areas.

Although the overall capture rates were comparatively less for these studies relative to previous years studies, some trends were observed. The upper portions of the canyon systems (mixed-conifer habitat) had higher species diversity compared to the middle and lower areas. The upper areas also had a much greater number of captures indicating higher population estimates and densities in those locations. The lack of ground cover and potential forage species in the ponderosa pine habitat may be a contributing factor. In addition, the presence of perennially flowing streams in both upper areas provides habitat suitable to species more commonly associated with riparian or water habitats, such as shrews. This in combination with a greater diversity of microhabitats such as rock outcrops, thick felled material, and a greater amount of potential forage species, allows for both a greater diversity of species and greater densities.

Overall, almost twice as many males were captured than females and was particularly evident in species of *Microtus* and *Peromyscus*. Due to small sample sizes, body weights by species and sex could not be compared. However, mean body weights did not appear to differ between the sexes. Therefore, body weights were combined to provide sufficient sample sizes to compare mean body weights between sites and years. No significant differences were observed between the lower sites of each canyon or between the upper sites of each canyon. Because of similarities in mean body weights and species diversity indices between canyons, it appears these canyons are similar enough in microhabitat parameters that Guaje Canyon could be used as an off-site control for ecological risk assessments conducted on Laboratory property.

The use of the bleeding procedure was of concern during our study due to the possible affects it may have on behavioral trap responses by the animals. Based on the statistical analysis conducted on capture/recapture rates, there was no affect.

5.1 Research Needs

As previously mentioned, modifications may be necessary to the study design in order to more accurately describe population parameters such as size and density. These modifications could include increasing the number of trapping grids. This may also be accomplished by either adding a third year of data collection to the study or performing trapping sessions in a third similar canyon system. Regardless of the method of choice, larger sample sizes must be obtained to present more accurate estimates of population parameters. More accurate density estimates will also provide for more accurate biomass estimates which may be desirable for total contaminant uptake and transport of radioactive contaminants. Additional studies can be designed to ascertain information on mortality, reproductivity, and survivability rates for long-term monitoring.

If the bleeding procedure is used in future studies, it may be desirable to determine if it is affecting overall capture and recapture rates during the course of the trapping session. This could be accomplished through the use of two grids in similar habitats but separated from each other. These would be trapped simultaneously using bleeding procedures at one grid only and subsequently compared to the other grid to determine if significant differences exist between each.

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CHAPTER 11

USE OF GEOGRAPHIC POSITIONING SYSTEM AND GEOGRAPHIC INFORMATION SYSTEM IN AN ECOLOGICAL RISK STUDY

by

KATHRYN BENNETT

ABSTRACT

As part of the Ecological Risk Study conducted in Los Alamos and Guaje Canyons coordinate data for all study plots were obtained with a Global Positioning System. These coordinates were then transferred to a Geographic Information System (Arc/Info) and maps of the locations were generated. In the next coming year, attribute data collected during the ecorisk study will be linked to the spatial data of the plots for further analysis.

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1 INTRODUCTION

For the Ecological Risk Study conducted in Los Alamos and Guaje Canyons a Global Positioning System (GPS) was used to collect coordinate information on the various ecorisk plots. These coordinates were transferred to a Geographic Information System (GIS) and data collected for each of the plots will soon be entered into a database linked to the spatial data collected with the GPS. The goal for FY 1993 was to collect all spatial data, transfer to a GIS (Arc/Info), produce maps of study locations, and begin to develop the database for attribute information.

GPS is a geographic-based data collection system. GPS uses a network of satellites to provide position and time information anywhere on the globe. GPS positions are computed by a receiver, recorded on a datalogger, transferred to a personnel computer (PC) for post-processing, and then transferred to a GIS system for storage, retrieval, data management, manipulation, and presentation. GPS measurements are accurate to within 2 meters.

GIS are powerful tools for the collection, storage, retrieval, transformation and displaying of spatial data. A GIS has three basic components: computer hardware, sets of application software modules, and appropriate organizational content. A GIS is often confused with a computerized drafting system or CAD. However, the major differences between a GIS and CAD system are the much greater volume and diversity of the data input into a GIS system and the specialized nature of the analysis methods used. GIS should be thought of as representing a model of the real world. Because these data can be accessed, transformed, and manipulated interactively in a GIS they can serve as a test for studying ecological and environmental processes or analysis of trends. (Burrough, 1988)

The use of GPS and GIS in an ecological risk study is an important feature. GPS allows for study plot locations to be documented within a 2-meter accuracy. In addition, a GPS allows for the easy field location of the study plots in subsequent years.

GIS allows for data or attribute information collected during the study to be directly linked to the spatial data so analysis can be performed not only on the spatial coordinates, but the attribute information Results of this analysis can be displayed in a spatial context or in tabular form. GIS also allows the opportunity to look at the past and predict the future by modeling various parameters. For ecological risk the questions of possible impacts to the ecosystem lend themselves easily to GIS modeling. GIS also allows for the spatial data to be displayed in map form.

2 METHODOLOGY

2.1 Global Position System

At each survey point location, the GPS positions were computed by the GPS (Trimble Pathfinder Professional) receiver and recorded on the datalogger. Data were collected for three minutes at the rate of once per second. After collecting the coordinate data, the data were transferred to a PC and manipulated with GPS post-processing software (PFinder).

All data collected were differentially corrected using the Trimble Pathfinder PC software PFinder. Correction involves the simultaneous collection of coordinate data from a stationary base station (Trimble Community Base Station) and a field GPS or rover unit. The base station calculates the combined error in the satellite range data. This correction is applied to the rover unit's data to improve accuracy by eliminating error in measurements.

2.2 Geographical Information System

After field data were corrected, the data were converted to a GIS (Arc/Info) format and down loaded to a floppy disk. The data were uploaded to a UNIX-based workstation with the use of a software application, SoftPC. SoftPC converts DOS file format to UNIX file format.

The field data were then read into Arc/Info using the "Create" command. The point data were then used to create an Arc/Info coverage using the Arc command "Build". Attribute information was attached to the spatial data by using the Arc subroutine "Tables".

A map composition was created in the Arc subroutine "Arcplot" and maps of the ecorisk plots were generated. Generation of maps as accomplished by converting a Arc/Info graphics file to an encapsulated postscript file. The postscript file was downloaded from UNIX using SoftPC to a DOS formatted floppy disk. The maps were printed from a PC to a NEC color postscript printer. In the future, maps will be directly sent to a Summagraphics Plotter connected directly to the UNIX workstation.

Methodology is not included for the analysis of attribute data using Arc/Info. This analysis will be conducted in future years and the methods will be described in future reports.

3 RESULTS

Maps showing the locations of all the ecorisk plots are shown in Figure 1. Map projection is North American Datum (NAD) 1983. The coordinates are in New Mexico State Plane, Central New Mexico. The units are in feet. This is the standard projection and coordinate system used at Los Alamos National Laboratory.

4 CONCLUSION

Coordinate locations of study plots used in the ecorisk study were determined by the use of a GPS. These coordinates were than differentially corrected using post-processing software and base station coordinates to improve their accuracy. Data were then converted and transferred to a UNIX-based workstation to a GIS (Arc/Info) system. Maps of the study plot locations were generated.

5 RESEARCH NEEDS

For FY 94, data collected during the individual studies for ecorisk needs to be entered into a database and linked to the spatial data. Study questions requiring GIS analysis should also be developed at this time and the analysis performed.

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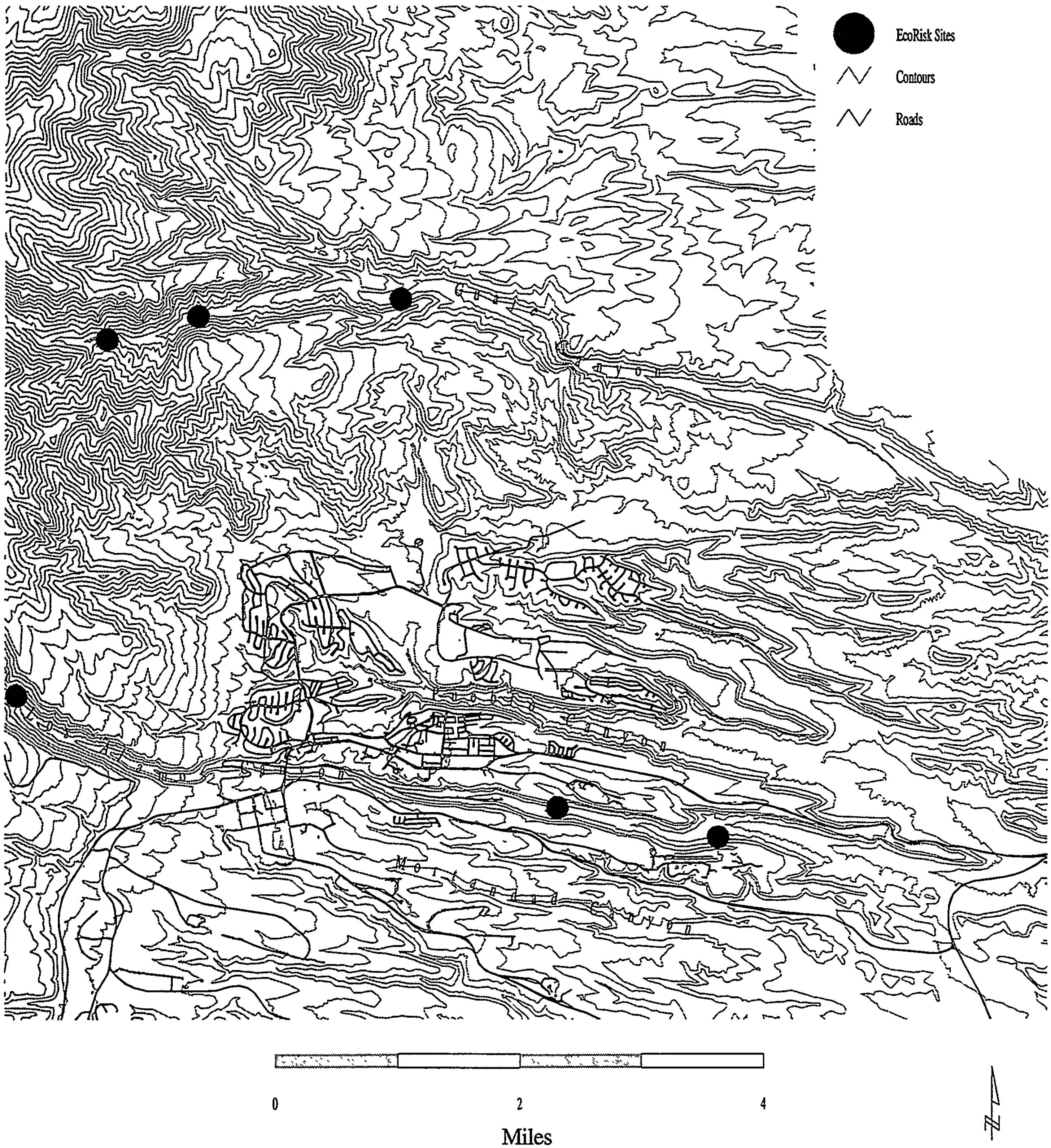

Fig. 1 Locations of the ecological risk study sites.

CHAPTER 12

ENDANGERED AND THREATENED SPECIES POTENTIALLY OCCURRING IN LOS ALAMOS AND GUAJE CANYONS

by

KATHRYN BENNETT

ABSTRACT

The Biological Resource Evaluations Team (BRET) maintains a threatened and endangered species database of all species potentially occurring in Los Alamos and surrounding counties. This database was searched to develop a list of threatened or endangered species that might be present in Los Alamos and Guaje Canyons where an Ecological Risk Study was being conducted. Twenty-three species were identified. However, only 4 species (Mexican spotted owl, spotted bat, meadow jumping mouse, and Jemez Mountains salamander) have a high, or high to moderate, potential for actually occurring within these two canyons. In addition, eight species were identified that more data were required to determine their presence in either canyon system.

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1 INTRODUCTION

Information was gathered on threatened and endangered species potentially occurring in Los Alamos and Guaje Canyons for an Ecological Risk study. Federal and State laws (Federal Endangered Species Act, New Mexico's Wildlife Conservation Act, and New Mexico's Endangered Plant Species Act) mandate the protection of plants and wildlife designated as endangered or threatened. Due to this mandate, it is important that the presence of threatened or endangered species be identified in a project area. Additionally in ecological risk studies, risk to threatened and endangered species must be considered.

2 METHODOLOGY

The Biological Resource Evaluations Team (BRET), of ESH-8 maintains a threatened and endangered species database. This database contains all state, federal, and candidate plant and animal species that potentially occur in Los Alamos County and surrounding counties. BRET searched the database using the general habitats and elevations of the ecorisk survey areas in Los Alamos and Guaje Canyons as search criteria. A list of protected species that might use the general habitats of these two canyons was generated.

Once a listing of species was generated, quantitative survey data collected during the vegetation ecoplots were used to further determine habitat suitability for the protected species. If all required habitat components were present for a species; studies were conducted to determine its presence. These studies included field surveys, literature review, and consultation with species experts.

During 1993, field surveys were conducted for meadow jumping mouse (*Zapus hudsonius*), spotted bat (*Euderma maculatum*), and Mexican spotted owl (*Strix occidentalis).*

2.1 Meadow Jumping Mouse

BRET conducted small mammal surveys in Los Alamos and Guaje Canyons. These surveys were not specific to meadow jumping mouse and so general inventory data were collected as well as population estimates. A grid-based design of 288 Sherman traps was used for each trapping area. BRET tagged, weighed, and measured all small mammals before releasing (See Chapter on Small Mammals).

2.2 Spotted Bat

3D Environmental Services, Inc., under contract to BRET, conducted bat mist net surveys in Los Alamos and Guaje Canyons. Personnel from 3D set up nets at dusk and ran them for several hours into the night (2 to 4 a.m.). Nets were closely monitored and continually checked for captures. Captured bats were removed from the net, identified, and measured before release.

2.3 Mexican Spotted Owl

The U.S. Forest Service hired a consultant, Terrell Johnson, to conduct Mexican spotted owl surveys in Guaje Canyon. Surveys were conducted in accordance to Forest Service Interim Directive No. 2 (USFS Manual, 2676.2).

3 RESULTS

Table 1 provides a list of protected species that use similar general habitats found in Los Alamos and Gauje Canyons. Of the 23 species listed, 11 have low potential for occurrence, 8 have a moderate potential (includes 2 species with low-moderate) and 4 have a high potential (includes 3 species with moderate-high). A low potential of occurrence for a species means no recent sighting of the species has been reported and important habitat components required for the species existence are not present in the area. A species has a moderate potential for occurrence when no recent observations have been made, but all necessary habitat components required by the species are available in the area. If a species has a high potential for occurrence in the area, then BRET has recent confirmation of its presence.

3.1 Meadow Jumping Mouse

BRET did not capture any meadow jumping mice during the small mammal studies conducted in Los Alamos and Guaje Canyons. However, there are unsubstantiated reports of meadow jumping mice captures near the Reservoir in Los Alamos Canyon during the late 1980s.

3.2 Spotted Bat

Table 2 lists the species captured and identified from mist net surveys in Los Alamos and Guaje Canyons. No spotted bats were netted. However, with the use of a bat detector and recording equipment, 3D Environmental recorded what appeared to be echolocation signals of spotted bat. Currently, personnel of 3D Environmental are analyzing these recordings and comparing them with master tapes of known echolocation signals of *Euderma maculatum*. Confirmation of the presence of spotted bat can not be determined until analysis is complete. It is our consultants (K. Tyrell, 3D Environmental, Inc.) expert opinion that these recordings are echolocation signals of spotted bats.

Table 1 Threatened and Endangered Species Occurring in Los Alamos and Guaje Canyons Based on Habitat

COMMON NAME	SCIENTIFIC NAME	LEGAL STATUS	HABITAT	POTENTIAL FOR OCCURRENCE
Western Toad	*Bufo boreas*	State Endangered	Lakes-Ponds	Low
Jemez Mountains Salamander	*Plethodon neomexicanus*	State Endangered C1 Candidate for Federal listing	Spruce-Fir to Mixed conifer	Moderate to High
Mexican Spotted Owl	*Strix occidentalis lucida*	Federally Threatened	Mixed-Conifer	High
Northern Goshawk	*Accipiter gentilis*	C2 Candidate for Federal Listing	Ponderosa	Moderate
Common Black Hawk	*Buteogallus anthracinus*	State Endangered	Riparian Zones	Low
Bald Eagle	*Haliaeetus leucocephalus*	Federally Endangered and State Endangered	Riparian Zones	Low
Mississippi Kite	*Ictinia mississippiensis*	State Endangered	Riparian Zones	Low
Peregrine Falcon	*Falco peregrinus*	Federally Endangered and State Endangered	Ponderosa-Pinion	Moderate
Whooping Crane	*Grus americana*	Federally Endangered	Rivers-Streams	Low
Least Tern	*Sterna antillarum*	Federally Endangered and State Endangered	Rivers-Streams	Low
White-Faced Ibis	*Plegadis chihi*	C2 Candidate for Federal Listing	Wetland	Low
Broad-Billed Hummingbird	*Cynanthus latirostris*	State Endangered	Riparian Zones	Low to Moderate
Willow Flycatcher	*Empidonax traillii*	Federally Endangered and State Endangered	Riparian Zones	Low
Rio Grande Silvery Minnow	*Hybognathus amarus*	Federally Proposed and State Endangered	Rivers-Streams	Low
Bluntnose Shiner	*Notropis simus*	State Endangered	Rivers-Streams	Low
Pine Marten	*Martes americana*	State endangered	Spruce-Fir	Moderate
Spotted Bat	*Euderma maculatum*	C2 Candidate for Federal Listing and State Endangered	Riparian Zones, Ponderosa, Spruce-Fir and Pinion-Juniper	Moderate to High

Table 1 (cont.)

COMMON NAME	SCIENTIFIC NAME	LEGAL STATUS	HABITAT	POTENTIAL FOR OCCURRENCE
Occult Little Brown Bat	*Myotis lucifugus occultus*	C2 Candidate for Federal Listing and State Endangered	Rivers-Streams	Moderate
Meadow Jumping Mouse	*Zapus hudsonius*	C2 Candidate for Federal Listing and State Endangered	Wetland	Moderate-High
Say's Pond Snail	*Lymnaea caperata*	State endangered	Wetland	Low
Lilljeborg's Pea-Clam	*Pisidium lilljeborgi*	State Endangered	Lakes-Ponds	Low to Moderate
Helleborine Orchid	*Epipactis gigantea*	State Endangered	Riparian Zones	Moderate
Wood Lily	*Lilium philadelphicum*	C2 Candidate for Federal Listing and State Endangered	Mixed Conifer in moist areas	Moderate

Table 2 Number of individuals per each species captured at Los Alamos and Guaje Canyon during mist net surveys in 1993.

SPECIES	LOS ALAMOS	GUAJE
Antrozous pallidus	02	00
Eptesicus fuscus	01	09
Lasionycteris noctivagans	5	28
Lasiurus cinereus	1	8
Myotis californicus	6	3
Myotis evotis	7	7
Myotis leibii	8	9
Myotis thysanodes	2	24
Myotis volans	8	8
Myotis yumanensis	4	0
Pipistrellus hesperus	4	0
Tadarida brasiliensis	0	2
TOTALS		
Individuals	45	98
Species	11	09
Net nights	17	15

3.3 Mexican Spotted Owl

The survey conducted in Guaje Canyon for Mexican spotted owl has confirmed the presence of nesting owls. In the case of Los Alamos Canyon, Terrel Johnson (1993), state expert on owls developed a computer-based habitat suitability model for the spotted owl. Johnson's model indicates that Los Alamos Canyon may have some suitable habitat for nesting, but is more suitable for perching. Spotted owls have not been identified in Los Alamos Canyon.

3.4 Jemez Mountains Salamander

During the summer of 1993, BRET did not conduct surveys for the Jemez Mountains salamander in Los Alamos or Guaje Canyons. Because of dry summer conditions, surveys for salamanders were not valid. Ramotnik (1986) found Jemez Mountains salamanders in Los Alamos Canyon. Surveys conducted by BRET, although not comprehensive have not found salamanders in this Canyon (Bennett 1991; and Bennett 1992).

4 CONCLUSION AND RESEARCH NEEDS

The Mexican spotted owl and Jemez Mountains salamander are known to occur in upper Los Alamos and/or Guaje Canyons. In addition, spotted bats may have been detected in Los Alamos Canyon during the surveys conducted by 3D Environmental Services, Inc. Confirmation of meadow jumping mouse in Los Alamos Canyon has not been made. However, habitat above the Los Alamos Reservoir is highly suitable and there are unsubstantiated reports of its presence. Capture-release sessions using Sherman traps are not the most efficient method of trapping meadow jumping mice. Therefore, additional surveys need to be conducted using the more efficient snap-trap method.

There is potential for at least eight other protected species in these two canyons. Habitat components exist for the species, but BRET has not conducted extensive surveys.

BRET needs to conduct further studies and surveys on these species to determine their actual presence.

BRET should conduct additional surveys for the spotted bat, meadow jumping mouse, and the Jemez Mountains salamander to confirm their presence in both canyon systems.

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