1 of 1

EG&G
ENERGY MEASUREMENTS

EGG 11265-1073
UC-708

YUCCA MOUNTAIN BIOLOGICAL RESOURCES MONITORING PROGRAM

PROGRESS REPORT OCTOBER 1992-DECEMBER 1993

MAY 1994

DISCLAIMER

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, Tennessee 37831; prices available from (615) 576-8401.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal, Springfield, Virginia 22161.

EG&G ENERGY MEASUREMENTS

EGG 11265-1073
MAY 1994

YUCCA MOUNTAIN BIOLOGICAL RESOURCES MONITORING PROGRAM

PROGRESS REPORT OCTOBER 1992-DECEMBER 1993

REVIEWED BY

W. Kent Ostler

W. K. Ostler, Director
Environmental Sciences Division

This Document is UNCLASSIFIED

C. K. Mitchell

C. K. Mitchell
Classification Officer

This work was performed by EG&G/EM for the United States Department of Energy under Contract Number DE-AC08-93NV11265.

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

ACKNOWLEDGEMENTS

Permission to handle and attach radio transmitters to desert tortoises was granted by the U.S. Fish and Wildlife Service (FWS) through permits PRT-683011 and PRT-781234 and permits S 6941 and S 9060 granted by the Nevada Department of Wildlife. Permission to capture, mark, and collect mammals, reptiles, and quail was provided by the Nevada Department of Wildlife through permits S 6941 and S 9060. Maps (except Fig. 1) were produced by the EG&G/EM Remote Sensing Laboratory, Yucca Mountain Support Office. These maps were produced in December 1993, using the Transverse Mercator projection. These maps should not be used for quality-affecting work.

This is a continuing program. Interpretation of data contained in this report may change as new information is acquired. Results should not be cited in scientific literature without consultation.

Environmental Studies Program
T. P. O'Farrell
Manager

Environmental Sciences Division
W. K. Ostler
Director

V. R. Kelly
Administrative Assistant
I. Jones, Clerk A
R. McCarl, Clerk B

Population Monitoring Section
R. A. Green
Manager

D. L.	Allen
A. M.	Ambos
M. K.	Cox
A. E.	Gabbert
K. L.	Herndon
C. A.	Korfmacher
S.	Leskie
L. L.	Lewis
T. A.	Lindemann
H. A.	Muller
D. L.	Pack
B. W.	Schultz
S. M.	Schultz
G. T.	Sharp
C. L.	Sowell
T. E.	Sue
M. D.	Walo
D. C.	Walrath

Reclamation Section
C. A. Wills
Manager

J. P.	Angerer
K. W.	Blomquist
S. R.	Blomquist
T. E.	Bond
T. E.	Burke
R. L.	Drumm
W. D.	Gabbert
P. F.	Hall
D. H.	Livingston
G. E.	Lyon
J. C.	Medrano
K. D.	Minniefield
B. A.	Rea
C. R.	Stanley
V. K.	Winkel

Desert Tortoise Section
D. L. Rakestraw
Manager

M. M.	Annear
G. A.	Brown
C. A.	Callison
T. S.	Campbell
M. W.	Fariss
R. G.	Goodwin
E. A.	Holt
A. L.	Hughes
M. W.	Janis
J. M.	Mueller
K. R.	Naifeh
K. R.	Rautenstrauch
L. J.	Taylor
D. L.	Thomson
K. K.	Zander

TABLE OF CONTENTS

FIGURES

TABLES

1. INTRODUCTION

The U. S. Department of Energy (DOE) is required by the Nuclear Waste Policy Act of 1982 (as amended in 1987) to study and characterize the suitability of Yucca Mountain as a potential geologic repository for high-level nuclear waste. During site characterization, the DOE will conduct a variety of geotechnical, geochemical, geological, and hydrological studies to determine the suitability of Yucca Mountain as a potential repository. To ensure that site characterization activities do not adversely affect the environment at Yucca Mountain, a program has been implemented to monitor and mitigate potential impacts and ensure activities comply with applicable environmental regulations.

1.1 PROGRAM DESCRIPTION

This report describes the activities and accomplishments of EG&G Energy Measurements, Inc. (EG&G/EM) from October 1992 through December 1993 for six program areas within the Terrestrial Ecosystem component of the environmental program for the Yucca Mountain Site Characterization Project (YMP): Site Characterization Effects, Desert Tortoises *(Gopherus agassizii)*, Habitat Reclamation, Monitoring and Mitigation, Radiological Monitoring, and Biological Support.

1.2 STUDY AREA DESCRIPTION

The YMP study area is on the southwestern edge of the Nevada Test Site (NTS) in Nye County, Nevada, approximately 26 km north of the town of Amargosa Valley (formerly Lathrop Wells) (Fig. 1). The area is located exclusively on lands controlled by the federal government. Ownership and control of the land is divided among the DOE, which controls the eastern portion of the area through land withdrawn for use as the Nevada Test Site; the U. S. Air Force, which controls the northwestern portion of the site through land-use permits for the Nellis Air Force Range; and the Bureau of Land Management, which controls the southwestern portion of the site as public trust lands.

Yucca Mountain lies on the northern edge of the Mojave Desert in a region with rugged, linear mountain ranges that dissect broad valleys. That part of Yucca Mountain within the study area is a long, north-south volcanic ridge with a maximum elevation of about 1,500 m. It slopes steeply (15-30°) west to Crater Flat (ca. 1,175 m) and gradually (5-10°) east, in a series of highly dissected ridges, to Jackass Flats (ca. 1,100 m) and its associated drainage, Fortymile Wash.

The vegetation at Yucca Mountain is dominated by Mojave desert plant communities below 1,220 m and by transitional plant communities of Mojave and Great Basin desert flora at higher elevations. Vegetation associations are described by Beatley (1976) and O'Farrell and Collins (1984). The scientific and common names of plant species that have been found in the vicinity of Yucca Mountain are listed in EG&G/EM (1993).

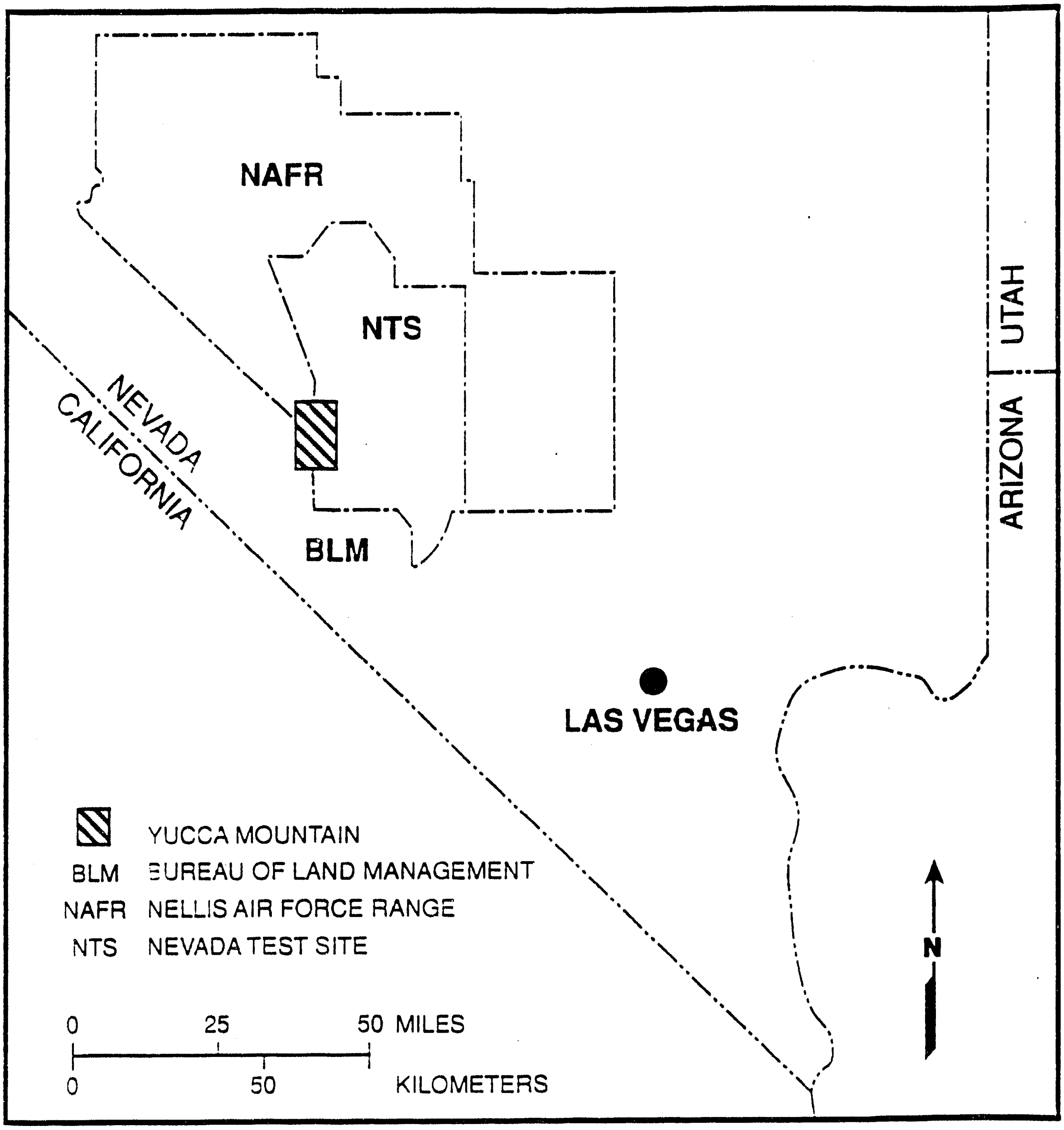


Fig. 1. Location of the Yucca Mountain Site Characterization Project, Nye County, Nevada.

2. SITE CHARACTERIZATION EFFECTS PROGRAM

The studies in the Site Characterization Effects Program were conducted to assess the effects of YMP on the terrestrial ecosystem by monitoring attributes of selected ecological components. The program includes studies of vegetation, small mammals, reptiles, disturbance levels, and abiotic conditions.

2.1 STUDY DESIGN

The study design for the Site Characterization Effects Program is described in EG&G/EM (1991, 1992, 1993) and Green, et al. (1991). The sampling units are 200- x 200-m ecological study plots (ESPs) stratified among four vegetation associations. Within each vegetation association, six study plots are located adjacent to disturbances (treatment), and six are located at least 200 m from disturbances (control). The criteria for selecting ESP locations are described in EG&G/EM (1991:3).

2.2 VEGETATION STUDIES

The goals of the vegetation studies are to characterize the vegetation associations at Yucca Mountain, develop an understanding of the community dynamics (recruitment, mortality, etc.) in these associations, evaluate the impacts of YMP on the plant communities, and provide information needed for reclamation and restoration. The study design is described in EG&G/EM (1991:3-6).

2.2.1 Sampling Design and Methods

Vegetative sampling in 1993 was different than that in 1991 and 1992. Vegetative cover was measured on all 48 ESPs, as in previous years. Production of annual and perennial plants and density of perennials were measured only on the 12 ESPs in the *Larrea-Lycium-Grayia* vegetation association. Production of annual plants also was measured in the other three vegetation associations on the six ESPs with small mammal trapping grids. Measurements were taken in the *Larrea-Lycium-Grayia* vegetation association because most YMP activities are occurring in this association. The procedures used to measure each vegetative attribute are described in EG&G/EM (1992:7-10).

2.2.2 Cover

Vegetative cover was measured on 48 ESPs. Vegetative cover in 1993 was similar to that measured in 1992 (Fig. 2). Percent cover was highest in the *Larrea-Lycium-Grayia* vegetation association (31.9%) and lowest in the *Larrea-Ambrosia* association (20.8%).

The similarity in vegetative cover from 1992 to 1993 probably resulted from the above average precipitation at Yucca Mountain during the winters of 1991-1992 and 1992-1993 (see Section 2.6). Plant communities have responded similarly to changes in environmental conditions from 1989 to 1993 (Fig. 2).

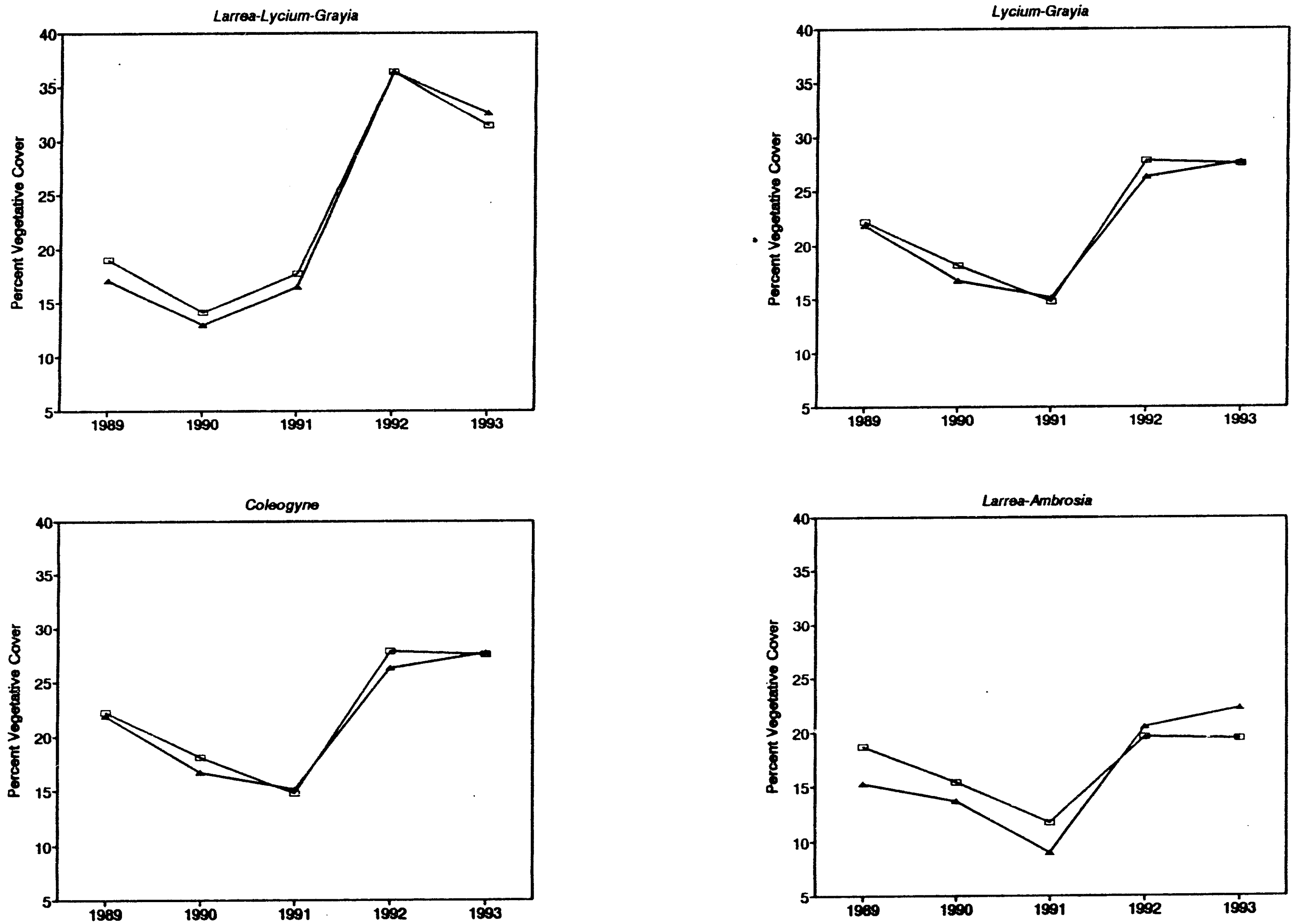


Fig. 2. Average percent vegetative cover in control (□) and treatment (▲) study plots in 1989 through 1993 in four vegetation associations at Yucca Mountain.

2.2.3 Production

Plant production was measured by clipping and weighing current annual growth in 32 and 40, 1- x 1-m quadrats on control and treatment ESPs, respectively. Harvested material was separated into perennial grasses, perennial forbs, shrubs, and annuals. Samples were weighed the day of collection to measure fresh (wet) biomass. Ocular estimates of biomass, recorded as a percentage relative to production in an adjacent harvested quadrat, were made in an additional 64 (control) and 80 (treatment) quadrats on each ESP. No summary or analysis of this data has been completed.

2.2.4 Density

Perennial Plants. Density of perennial plants was measured in 12 ESPs in the *Larrea-Lycium-Grayia* vegetation association. Plant-location maps, created from the 1991 data and revised in 1992, were used to locate all plants still alive in each transect, new plants, plants that died, and plants incorrectly identified in previous years. Changes were noted on the maps.

Data collected in 1992 were analyzed to evaluate differences in density of perennial plants among vegetation associations. The *Lycium-Grayia* and *Larrea-Ambrosia* associations had similar, but higher densities ($P < 0.05$, Student-Newman-Keuls multiple range test, $\alpha = 0.1$) than either the *Coleogyne* or *Larrea-Lycium-Grayia* association (Table 1).

Data collected in 1991-1993 in the *Larrea-Lycium-Grayia* vegetation association was analyzed to evaluate changes in density. Densities were greater ($P = 0.04$, two-way analysis of variance) on control than treatment plots. However, this difference did not change between years ($P = 0.84$, treatment by year interaction). No change occurred in the density of perennial plants from 1991 through 1993 for the ESPs adjacent to disturbances ($P = 0.99$, one-way analysis of variance) or the control ESPs ($P = 0.51$, one-way analysis of variance) (Table 2). From 1992 to 1993, density on

Table 1. The average number of perennial plants per 100 m^2 in 1992 in six treatment and six control plots in each of four vegetation associations at Yucca Mountain.

	Treatment		Control		All ESPs	
Vegetation association	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Coleogyne	83.6	17.0	67.7	10.4	75.6	15.8
Larrea-Ambrosia	135.4	66.5	142.1	36.2	138.7	51.2
Lycium-Grayia	122.3	21.0	157.0	49.8	139.6	40.7
Larrea-Lycium-Grayia	51.5	17.9	60.5	9.0	56.0	14.0

Table 2. The average number of perennial plants per 100 m^2 in the *Larrea-Lycium-Grayia* vegetation association at Yucca Mountain in 1991, 1992, and 1993.

		1991		1992		1993	
Plot Location	n	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Treatment	6	50.9	17.2	51.4	17.6	52.5	18.4
Control	6	60.2	7.7	60.5	8.9	67.1	16.2
All Plots	12	55.5	13.6	55.9	14.1	59.8	18.2

two ESPs (LLG5C and LLG7C) increased by 13 and 25 plants per 100 m^2, respectively. This was caused primarily by an increase in fluff grass (*Erioneuron pulchellum*). Plant density on the other 10 ESPs increased less than 2 plants per 100 m^2.

Perennial Seedlings. The density of perennial seedlings was first measured in 1992 to estimate the recruitment of new plants. Densities of seedlings were measured in five 1- x 1-m quadrats randomly located and permanently marked in each belt transect used to measure perennial plant density (EG&G/EM, 1993:6). Because of high precipitation, growing conditions in 1992 were favorable for germination and growth of new perennial plants for the first time in several years. Above average precipitation in January through March 1993 created good growing conditions for a second consecutive year. In 1993, the same quadrats measured in 1992 were re-measured to estimate survival of perennial plant seedlings. The data have not been verified and analyzed.

2.3 SMALL MAMMAL STUDY

The objective of this study is to monitor effects of YMP on small mammal populations and communities by measuring changes through time in demographic attributes of the most abundant species. Small mammals are useful species for monitoring changes to desert ecosystems because their home ranges are small, generation times short, and they are often abundant enough to permit statistical comparsions. Ecologically, small mammal communities are important because they are a major component of the granivore (seed-eaters) guild common throughout the Southwestern deserts and have important effects on plant community dynamics.

Small mammal populations at Yucca Mountain have been live-trapped since 1989 on one treatment and one control plot in each of the four vegetative associations. Each study plot consists of a 12- x 12-trap grid of 144 trap-stations (two live-traps/station) spaced at 15-m intervals. Plots were trapped only four times in 1993 instead of the usual five times. No plots were trapped in August because of safety concerns following a case of hantavirus in Nevada (See Section 7.5). Each trapping session was four days. The sampling effort for all the trap sessions was 36,864 trap-nights.

The second and third trap sessions were delayed by approximately two weeks in 1993 to better correspond with the first above-ground activity of juvenile long-tailed pocket mice. The second session, previously conducted in mid-May, was conducted in early June. The third session, previously conducted in late-June was conducted in mid-July. The May session occurred just prior to the first above-ground activity of juvenile long-tailed pocket mice. In previous years, when plots were re-trapped in late June (5-6 weeks later), many of these juveniles were near adult weight and difficult to distinguish from adults based on pelage characteristics. By shifting the trapping sessions in 1993, many of the juveniles were first caught in early June, when they were easily identified by pelage and weight. In mid-July, most of the first 1993 cohort had been previously marked and most of the animals with juvenile pelage were second cohort individuals that were relatively small and distinguishable.

Eleven small mammal species were captured (Table 3). The pinyon mouse (*Peromyscus truei*) was the only species not previously captured on these eight plots. The pinyon mouse previously had been captured on several of the monitoring plots for the Radiological Monitoring Program. The long-tailed pocket mouse (*Perognathus formosus*) and Merriam's kangaroo rat (*Dipodomys merriami*) were the most abundant species and were caught in all four vegetation associations. The species composition of the small mammal community was similar at all plots except the control in the *Larrea-Ambrosia* association. Only seven of eleven species were caught on this plot, and fewer then 4 individuals were captured for three of these seven species (Table 3). This site is isolated by Fortymile Wash from the other vegetation associations, preventing immigration by individuals of other species. This effect can be seen by comparing the control with the *Larrea-Ambrosia* treatment plot on the west side of Fortymile Wash, where adjacent vegetation associations can be a source of other species by immigration.

Populations of long-tailed pocket mice in 1993 were smaller on all plots in the *Larrea-Lycium-Grayia*, *Coleogyne*, and *Lycium-Grayia* vegetation associations than in 1992 (Fig. 3). Pocket mice are most abundant in mid-summer (June and July) because of recruitment through reproduction. In 1993, mid-summer populations were 45-70% lower than 1992 populations even though there was abundant February-March precipitation and good plant production.

Populations of Merriam's kangaroo rat, in contrast, continued to increase in 1993 in all vegetation associations (Fig. 4). Merriam's kangaroo rat was least abundant on the higher elevation *Lycium-Grayia* association along the crest of Yucca Mountain. Unlike the other three vegetation associations, where Merriam's kangaroo rats share numerical dominance of the small mammal community with either the long-tailed or little pocket mouse (*Perognathus longimembris*), three species, the desert woodrat (*Neotoma lepida*), canyon mouse (*Peromyscus crinitus*), and long-tailed pocket mouse were more common than Merriam's kangaroo rat in the *Lycium-Grayia* association.

Table 3. Number of individual small mammals captured on ecological study plots, April 1993-September 1993.

Species	Month	Vegetation association and plot number							
		Larrea-Ambrosia		*Coleogyne*		*Larrea-Lycium-Grayia*		*Lycium-Grayia*	
		Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Perognathus formosus Long-tailed pocket mouse	April	14		118	77	75	175	11	40
	June	13	4	179	136	107	209	59	48
	July	18		140	112	105	210	66	66
	September	15		111	94	92	177	66	66
Perognathus longimembris Little pocket mouse	April	66	52						
	June	62	78						
	July	71	119						
	September	30	13						
Dipodomys merriami Merriam's kangaroo rat	April	92	92	50	76	127	66	24	27
	June	127	106	44	72	90	60	14	19
	July	124	66	54	86	127	77	24	33
	September	99	53	54	84	128	76	30	43
Dipodomys microps Chisel-toothed kangaroo rat	April	5		14	16	19	5	6	13
	June	11		19	31	17	7	8	16
	July	15		26	29	19	14	12	16
	September	15		26	19	22	11	12	16

Table 3. Continued

Species	Month	*Larrea-Ambrosia* Treatment	*Larrea-Ambrosia* Control	*Coleogyne* Treatment	*Coleogyne* Control	*Larrea-Lycium-Grayia* Treatment	*Larrea-Lycium-Grayia* Control	*Lycium-Grayia* Treatment	*Lycium-Grayia* Control
Peromyscus crinitus Canyon mouse	April	1		6	5	1	5	47	69
	June	2		3		1	1	73	111
	July	11		2	2	7	3	82	96
	September	7		6	5	10	20	70	73
Peromyscus maniculatus Deer mouse	April			1	3			15	1
	June	2						14	1
	July	3		1				8	
	September	1		1	3	4	2	2	
Peromyscus eremicus Cactus mouse	April					2	6		2
	June			1		1	5		4
	July			1	2	12	11		2
	September		3	4	3	29	20	2	1
Peromyscus truei Pinyon mouse	April			1					
	June								
	July								
	September								

Table 3. Continued

Species	Month	Vegetation association and plot number							
		Larrea-Ambrosia		*Coleogyne*		*Larrea-Lycium-Grayia*		*Lycium-Grayia*	
		Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Onychomys torridus Southern grasshopper mouse	April	7	2	12	9	35	27	6	3
	June	11	3	12	12	14	13	11	6
	July	11	6	17	12	21	27	11	7
	September	9	6	8	10	10	18	9	2
Neotoma lepida Desert woodrat	April			1	1		3	5	3
	June	1		6	11	7	17	44	63
	July	5	2	10	24	15	25	57	79
	September	2		6	10	10	25	42	41
Ammospermophilus leucurus White-tailed antelope squirrel	April	4	1		2	1		3	2
	June	8	8		5	1		5	8
	July	23	16	11	16	7	5	2	9
	September	19	15	7	11	4	7	9	18
Totals for all species	April	189	147	203	189	260	287	117	160
	June	237	199	264	267	238	312	228	276
	July	281	209	262	283	313	372	262	308
	September	197	90	223	239	309	356	242	260

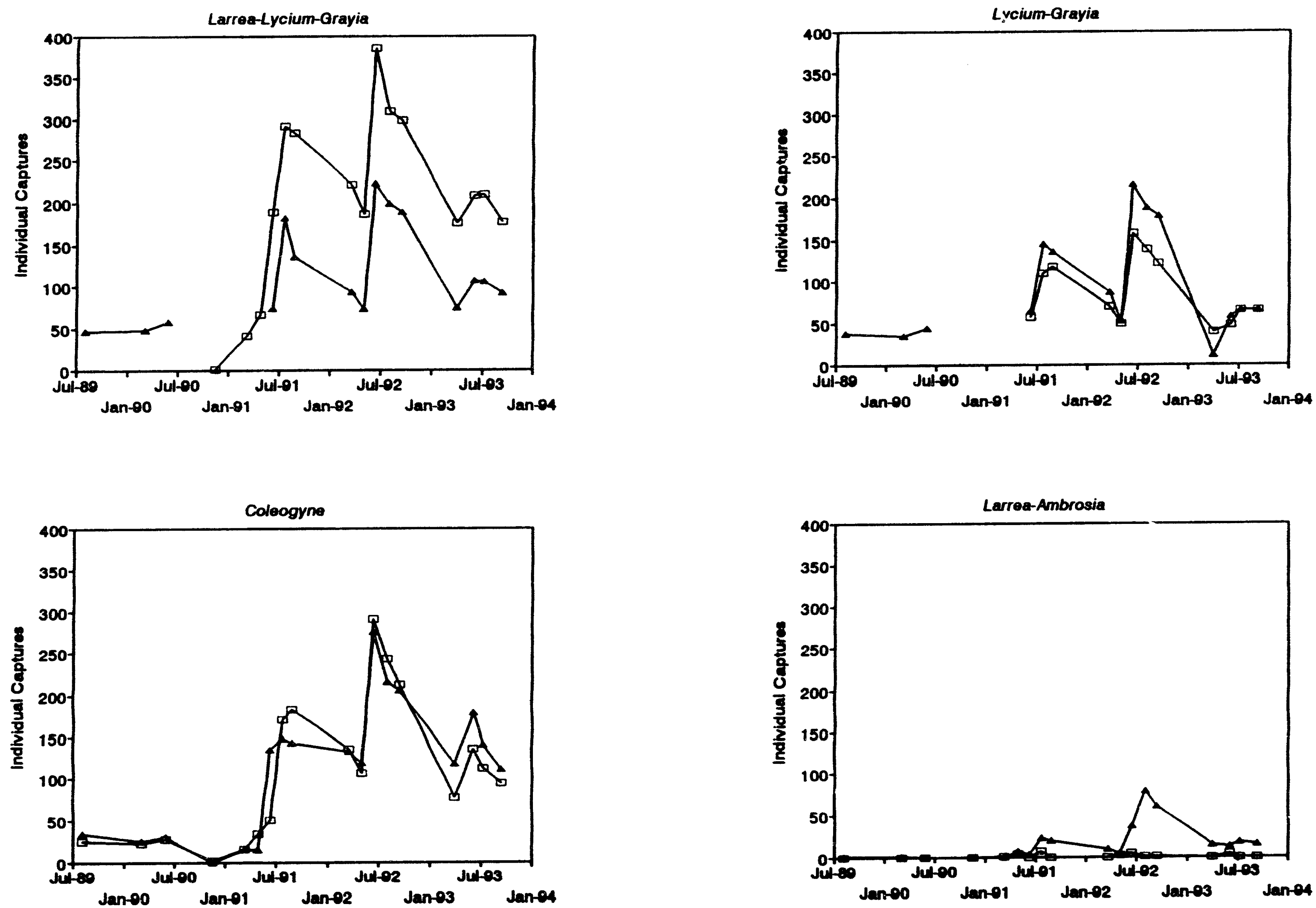


Fig. 3. Population trends of the long-tailed pocket mouse in control (□) and treatment (▲) study plots from August 1989 through September 1993 in four vegetation associations at Yucca Mountain.

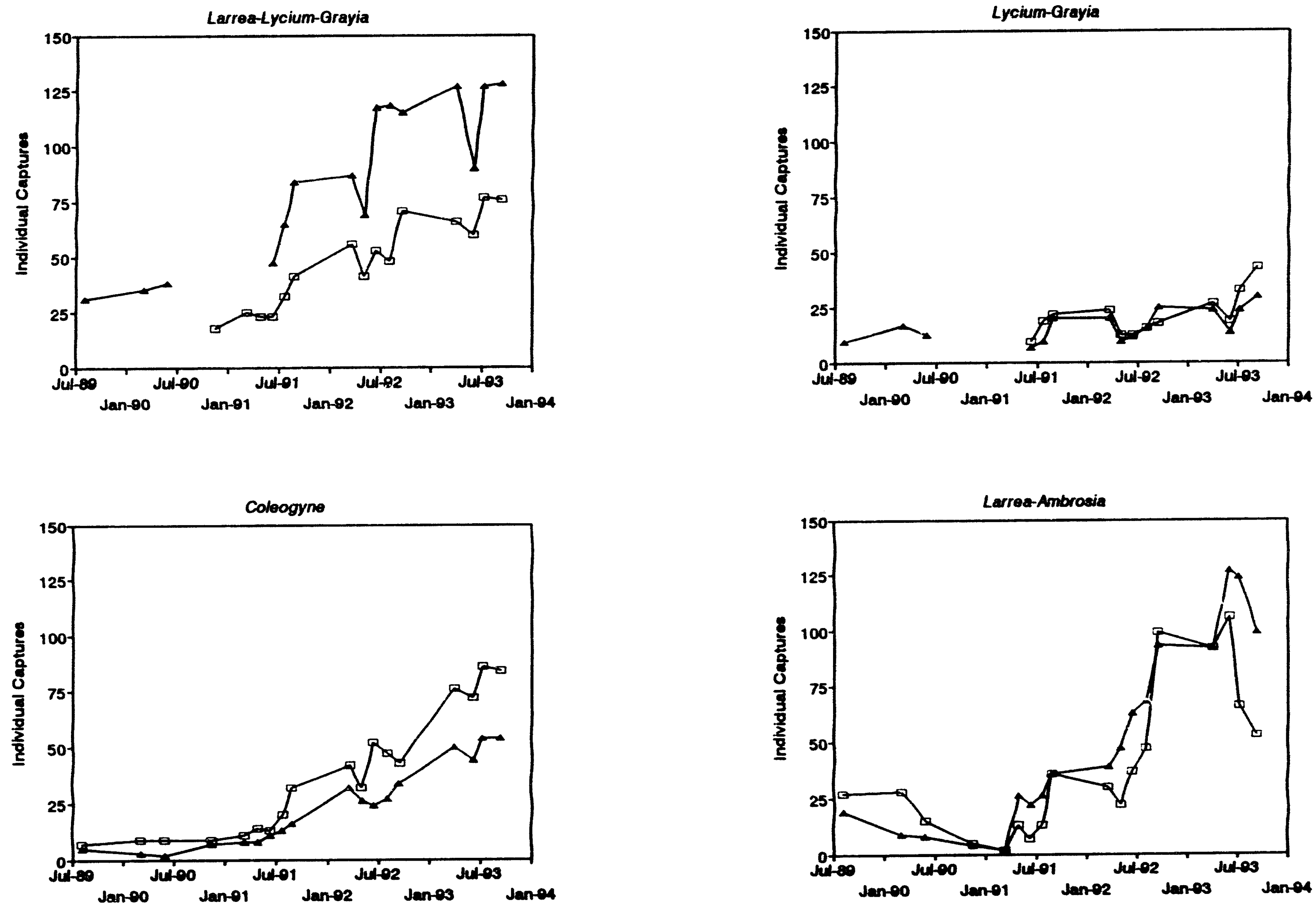


Fig. 4. Population trends of Merriam's kangaroo rat in control (□) and treatment (▲) study plots from August 1989 through September 1993 in four vegetation associations at Yucca Mountain.

The chisel-toothed kangaroo rat (*Dipodomys microps*) is the only other kangaroo rat that occurs in the Yucca Mountain area. Its abundance was relatively low compared to that of the Merriam's kangaroo rat. However, populations of the chisel-toothed kangaroo rat also continued to increase in 1993 (Fig. 5).

Populations of the larger-bodied desert woodrat, white-tailed antelope ground squirrel (*Ammospermophilus leucurus*), and the chisel-toothed kangaroo rat have all responded more slowly to favorable habitat conditions during the past three years than did the smaller bodied species such as the canyon mouse, long-tailed pocket mouse, and little pocket mouse. The smaller species responded quickly to average growing conditions in 1991 and continued to reproduce and increase in abundance during a second consecutive year of good plant production in 1992. The three larger-bodied species did not show substantial increases in population abundance until 1992. However, these species continued to increase in 1993 (Fig. 5). Among the common smaller species, long-tailed pocket mice declined in abundance, and numbers of little pocket mice and canyon mice in 1993 were similar to numbers captured in 1992 (Fig. 5).

Populations of Merriam's kangaroo rats and the long-tailed pocket mice continued to change similarly on control and treatment plots (Figs. 3 and 4) (EG&G/EM, 1993:14-15). Similar graphical analysis of numbers of desert woodrats, canyon mice, little pocket mice, and chisel-toothed kangaroo rats also indicate proportionate changes in abundance between control and treatment plots (Fig. 5).

2.4 REPTILE STUDIES

This study has two objectives: to determine the composition of the reptile community at Yucca Mountain and to monitor the effects of YMP activities on the reptile community. To achieve these objectives, three plots were sampled with pitfall and funnel traps along drift fences to estimate species composition, and nine plots were sampled to estimate and compare the survival and abundance of side-blotched lizards (*Uta stansburiana*) between study plots adjacent to disturbances (treatment) and distant from disturbances (control). The side-blotched lizard is a useful species for monitoring effects on desert ecosystems because it is abundant, has a relatively small home range, and has a short generation time. Because side-blotched lizards are insectivorous, their populations may be influenced by different factors than those affecting herbivorous small mammals, the other group of vertebrates being monitored.

Reptiles were captured in pitfall and funnel traps on three plots in May to determine species composition of the reptile community. Fourteen species of reptiles were caught (Table 4). The side-blotched lizard and western whiptail (*Cnemidophorus tigris*) were the most common species. The plot in the *Coleogyne* association had the most species of lizards (7) but the fewest snake species (2). The most snake species and individuals were captured on the study plot in the *Larrea-Lycium-Grayia* association. Thirteen reptiles representing ten species were collected as voucher specimens.

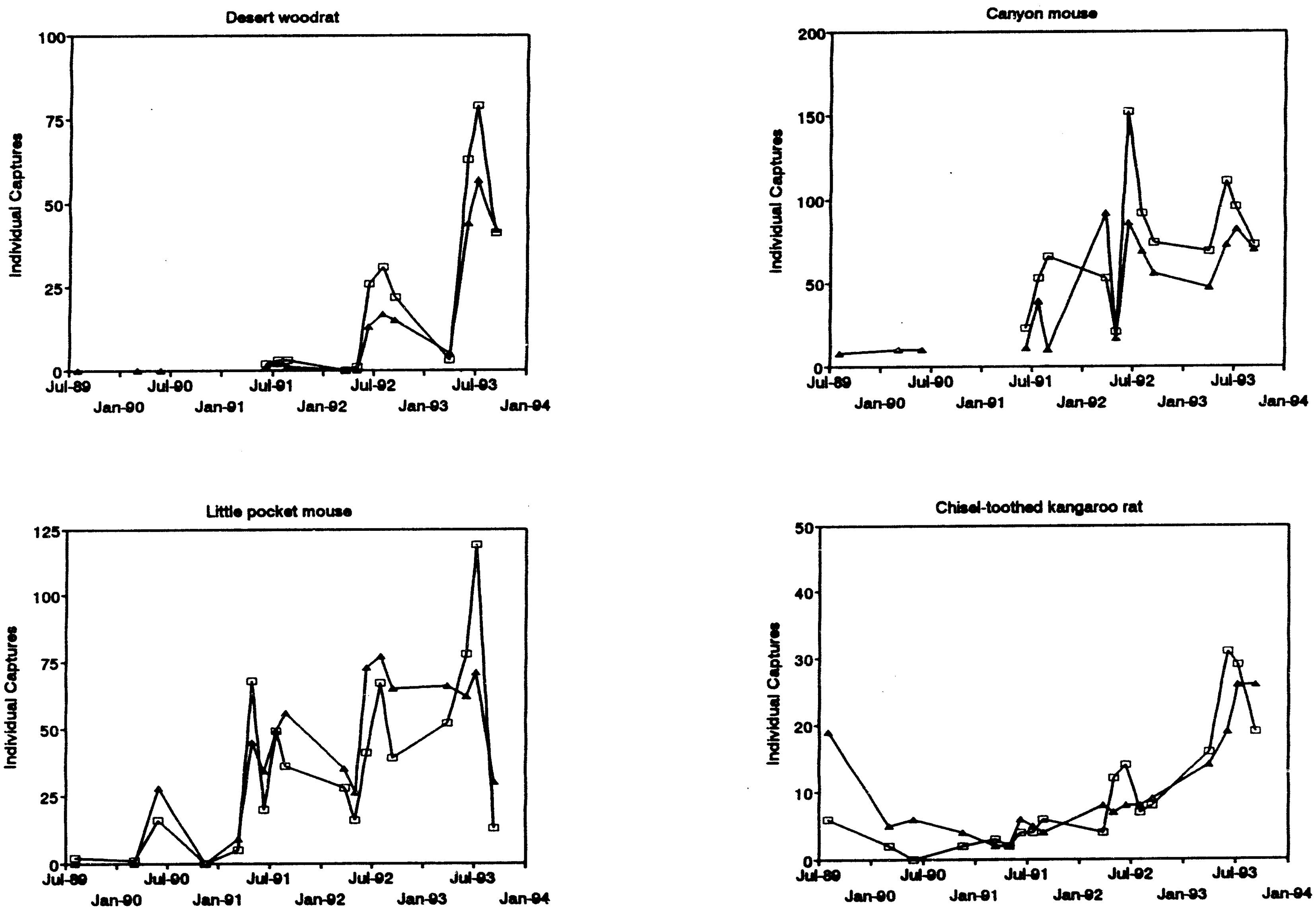


Fig. 5. Population trends of desert woodrats, canyon mice, little pocket mice, and chisel-toothed kangaroo rats in the *Coleogyne* vegetation association in control (□) and treatment (▲) study plots from August 1989 through September 1993 at Yucca Mountain.

Table 4. Number of individual reptiles captured on three study plots during a four-consecutive-day trapping period in May 1993.

Species	COL2T	LA3T	LLG2T
Lizards			
Uta stansburiana Side-blotched lizard	56	37	31
Cnemidophorus tigris Western whiptail	38	23	18
Phrynosoma platyrhinos Desert horned lizard	3		
Coleonyx variegatus Western banded gecko	1		
Gambelia wislizenii Longnose leopard lizard	1	1	
Sceloporus magister Desert spiny lizard	1		
Callisaurus draconoides Zebra-tailed lizard	1		
Snakes			
Crotalus mitchelli Speckled rattlesnake		1	1
Sonora semiannulata Ground snake	1		
Tantilla hobartsmithi Southwestern black-headed snake	1		
Rhinocheilus lecontei Longnose snake		3	4
Masticophis flagellum Coachwhip		1	5
Salvadora hexalepis Western patchnose snake			2
Pituophis melanoleucus Gopher snake		1	

The chuckwalla (*Sauromalus obesus*) was classified as a Category II candidate species in 1992 by the U.S. Fish and Wildlife Service. Observations of chuckwallas were recorded while conducting other field studies to help identify locations of chuckwallas and their habitat. Twenty-nine observations were recorded. One observation occurred in April, five in May, seventeen in June, and six in July. The majority of these observations occurred in rocky areas along the crests of Yucca Mountain and Fran Ridge.

Side-blotched lizards were captured using nooses on nine one-ha plots in March, May, and October. Three plots are adjacent to existing or proposed construction sites, three are adjacent to roads, and three are greater than 200 m from any disturbance. All plots are located in the *Larrea-Lycium-Grayia* vegetation association. During each capture session, plots were systematically searched and attempts were made to capture all side-blotched lizards seen. Captured lizards were marked by clipping toes and released. Each plot was searched for five days each session.

The number of side-blotched lizards captured on each study plot is listed in Table 5. Population abundance and survival will be calculated and compared among disturbance types to evaluate effects of YMP.

Table 5. Number of side-blotched lizards captured on nine study plots during March, May, and October 1993.

Disturbance Type	March	May	October
Large Disturbances			
Borrow Pit[1]	69	59	47
Muck Pile[2]	40	59	35
North Portal[1]	48	19	31
Roads			
LLG2T	85	42	41
LLG5T	56	53	37
SW Exile	36	33	32
Control Plots			
LLG8C	105	44	43
LLG4C	70	57	56
Fran	99	81	68

[1]These are extant disturbances
[2]The muck pile is a proposed disturbance

2.5 DISTURBANCE STUDIES

Disturbance monitoring studies are conducted to measure two types of disturbances caused by YMP: vehicle and construction equipment traffic, and deposition of fugitive dust immediately adjacent to disturbances.

2.5.1 Traffic Volume

The objective of this study is to measure vehicle activity at Yucca Mountain. Prior to March 1993, traffic volume was measured using 12 counters that were rotated weekly among 23 locations. After March 18, counters were used but were not moved. Counts at three locations (COL1T, COL6T, and LA1T) were estimated using counts from nearby locations. Counts at two ESPs in Crater Flats were discontinued in June 1993. Counts at some locations (LLG5T, LG2T, LA5T, and LLG4T) were probably low because counters were occasionally removed during road maintenance.

Traffic volume was expressed as average vehicle passes per day. Traffic volume was highest at LG2T in Drill Hole Wash ($\bar{x}$ = 63 passes/day) because of drilling operations at UZ 14 (Fig. 6). The road to the top of Yucca Mountain ($\bar{x}$ = 48 passes/day) and the road past LLG5T to the topsoil storage area and UZ-16 ($\bar{x}$ = 62 passes/day) also had a high volume of traffic. Little traffic occurred in Crater Flat (LA7T and LG5T,[$\bar{x}$ = 1 pass/day]) and the north and south end of Yucca Mountain (COL5T, [$\bar{x}$ = 3 passes/day] and LG4T, [$\bar{x}$ = 1 pass/day]), respectively.

Traffic throughout the Yucca Mountain area increased an average of 129% from 1992 to 1993. Traffic volume in 1993 increased by 2,100% on the access road to UZ 14 (LG2T), 400% on the road to the explosive storage area (LLG1T), and 272% on the road to the top of Yucca Mountain (LG3T). Traffic volume at other study plots was similar to that in 1992.

2.5.2 Fugitive Dust

Fugitive dust was one of several factors identified that could potentially affect biotic communities adjacent to sites disturbed by site characterization activities (Green et al., 1991). Dust samplers (petri dishes with filter paper) were placed on the 48 ESPs in 1992 to measure dust deposition. The objectives of this study were to compare the amounts of dust deposited on areas adjacent to disturbances with the amounts deposited on sites distant (>500 m) from disturbances, and to measure the amount of dust deposited at increasing distances from disturbances.

Methods used to measure deposition of dust are described in EG&G/EM (1992:28). Dust samplers were collected and replaced each month from June 1992, through September 1993. After September 1993, samplers were left on the ESPs and will be collected in February 1994.

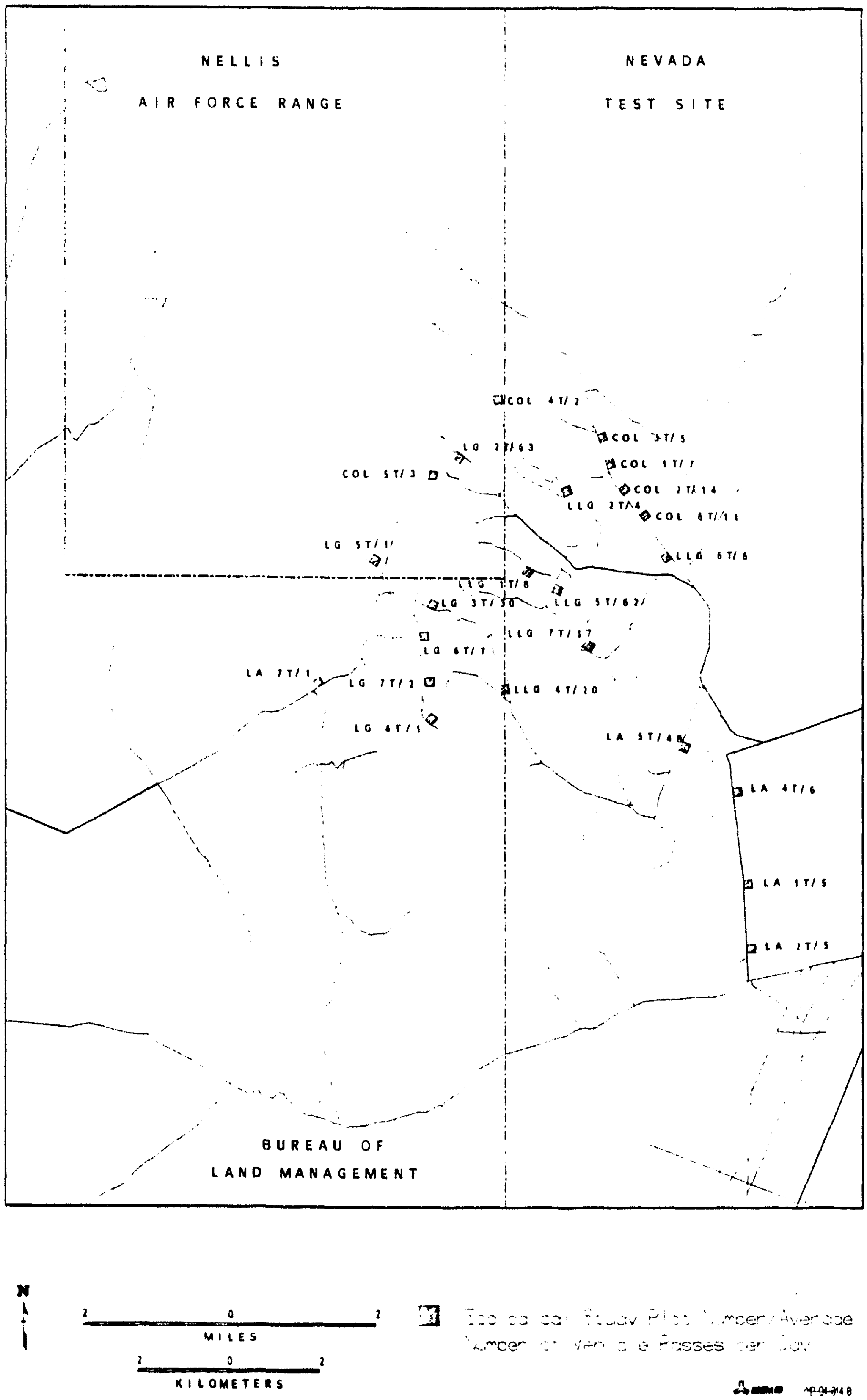


Fig. 6. Distribution of vehicle traffic at Yucca Mountain area from October 1992 - December 1993. Volume is expressed as average vehicle passes per day.

Results reported here are the cumulative dust deposited from June 1992 through September 1993. Average dust deposited during this period (16 months) was higher ($P = 0.03$, t test) on treatment plots ($\bar{x} = 18$ g/m^2, SD = 7.7) than on the control plots ($\bar{x} = 13.3$ g/m^2, SD = 7).

In the treatment plots, more dust was deposited near the disturbances ($P = 0.07$, two-way analysis of variance [ANOVA]). However, beyond 10 m, there was no difference in the amount of dust deposited (Student-Newman-Keuls multiple range test, $\alpha = 0.1$) (Fig. 7). There were differences in dust deposition among vegetation associations in the treatment plots ($P = 0.08$) but not in the control plots (P=0.93, one-way ANOVA) (Fig. 8). As expected, more dust was deposited in the *Larrea-Lycium-Grayia* association, where most of the YMP activities have occurred (Fig. 8).

Although differences were found among control and treatment plots, vegetation associations, and distances from disturbance, the amount of dust deposited from June 1992 through September 1993 was very small.

2.6 TEMPERATURE AND PRECIPITATION

Temperature and precipitation were measured weekly on all 48 ESPs from late February to July. This is the period when soil moisture, soil temperature, and air temperature are usually adequate for vegetation growth. During other months, one or more of these three factors usually limit plant growth so measurements were recorded monthly. Maximum and minimum air temperatures; precipitation; soil moisture; and soil temperature at 15-, 30-, and 45-cm depths were recorded.

Precipitation in 1993 was greater than in 1991 and 1992. Precipitation was highest in the *Larrea-Lycium-Grayia* and *Coleogyne* associations (Table 6). Variation in precipitation across the Yucca Mountain region was relatively large ranging from 184 to 324 mm. Soil moisture and temperature data have not been summarized.

Table 6. Precipitation (mm) at six control and six treatment ecological study plots in four vegetation associations at Yucca Mountain from October 1, 1992-December 16, 1993.

Vegetation association	Experimental unit	$\bar{x}$	SD	Range
Coleogyne	Control	314.3	13.0	290-324
	Treatment	295.8	9.6	284-307
Lycium-Grayia	Control	233.8	41.0	184-280
	Treatment	265.4	33.5	234-314
Larrea-Lycium-Grayia	Control	271.5	20.2	239-286
	Treatment	296.7	8.3	288-308
Larrea-Ambrosia	Control	235.5	20.0	209-253
	Treatment	253.3	14.6	225-268

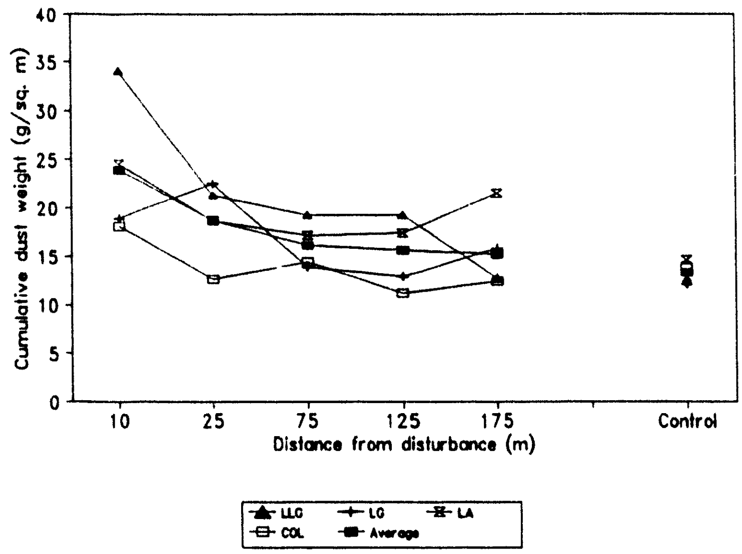


Fig. 7. Cumulative dust deposited (g/m²) on treatment plots by distance from disturbance and on control plots from June 1992 to September 1993.

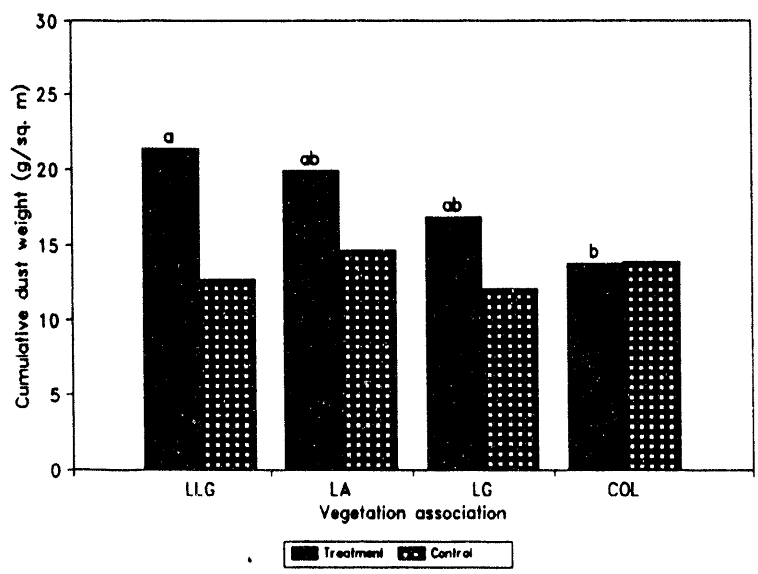


Fig. 8. Average cumulative dust deposited (g/m²) on treatment and control plots in four vegetation associations from June 1992 to September 1993. Different letters above the bars indicate significant differences (α = 0.1, Student-Newman-Keuls multiple range test) between vegetation associations.

3. DESERT TORTOISE PROGRAM

The objectives of the desert tortoise program are to monitor and assess the impacts of YMP on tortoises, mitigate impacts of YMP to minimize incidental take, develop and test the efficacy of mitigation techniques, obtain site-specific information on the biology of desert tortoises needed to achieve these other objectives, and ensure compliance with federal and state regulations. The program design developed to achieve these goals is described in EG&G/EM (1992, 1993) and Rautenstrauch et al. (1991).

Seven studies conducted in 1992 were continued in 1993. An eighth study conducted in 1992, population monitoring, was separated into two studies in 1993: reproduction and survival. A new study to assess the effects of ground motion on tortoises and their burrows was developed in 1993.

The first five studies described in this chapter were designed to evaluate impacts of YMP activities by measuring and comparing parameters from three sampling populations of desert tortoises representing three levels of impacts. These levels are (1) impacts of long-term, large-scale disturbances, hereafter referred to as "high-impact"; (2) impacts of small, widely-scattered disturbances, hereafter referred to as "area-wide"; (3) and no impacts, or control. For a more in-depth discussion, see EG&G/EM (1992:31-33).

While conducting work on these and other studies during 1993, 144 previously unmarked desert tortoises were captured and marked; 59 were hatchlings. Radio transmitters were attached to 29 hatchlings and 35 older tortoises that were not previously radiomarked. During 1989-1993, 374 tortoises have been captured and marked (Fig. 9); 91 of these were hatchlings captured at nests. Transmitters have been attached to 236 tortoises. One hundred fifteen of these radiomarked tortoises still were being monitored at the end of 1993. The others had died (n = 40), could not be found (n = 40), their transmitters fell off (n = 15), or their transmitters were removed (n = 26). Figure 10 shows the last known location prior to November 15, 1993, of all tortoises found on or near Yucca Mountain during 1989-1993.

3.1 REPRODUCTION STUDY

The objectives of the Reproduction Study are to evaluate the effects of YMP on reproductive success of desert tortoises and to learn site-specific attributes of desert tortoise reproduction at Yucca Mountain. This study included tortoises from only the high-impact and control samples; tortoises from the area-wide sample will be added next year.

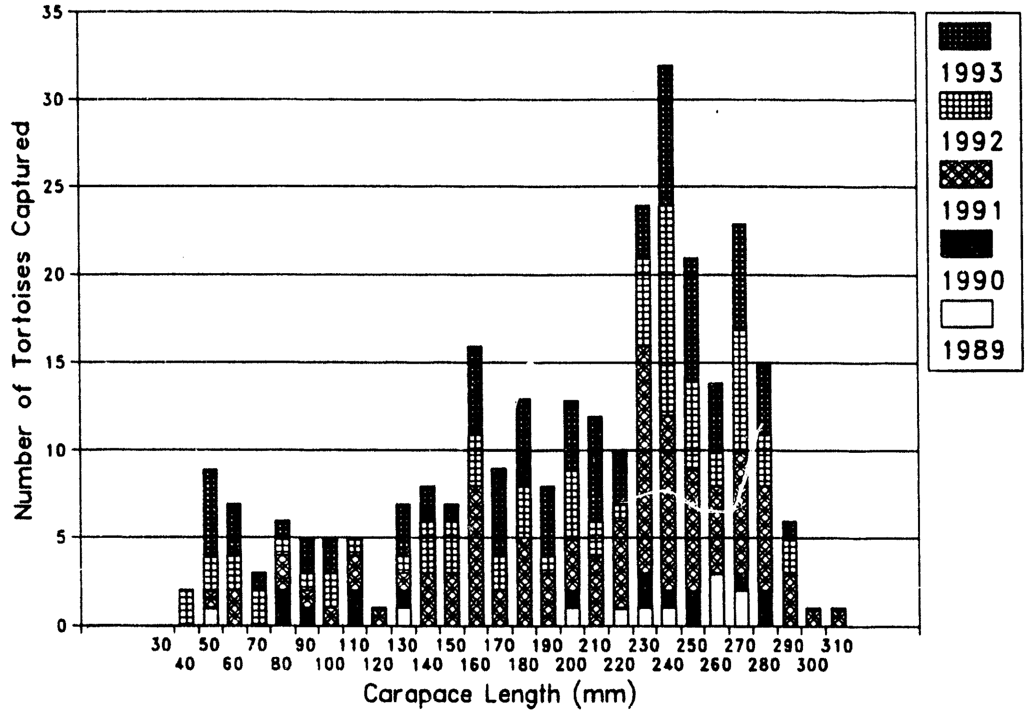


Fig. 9. Number of desert tortoises marked at Yucca Mountain during 1989-1993 in 10-mm size classes. The figure does not include 91 hatchlings (35-50-mm mid-carapace length) marked at nests from 1991 through 1993.

Thread trailers were attached to seven female tortoises in each of these samples to locate nests. Tortoises were located and weighed daily beginning May 3. When a weight loss was detected, the thread trail was followed, and all potential nest sites were searched. Nests were excavated; the eggs were counted, measured, and weighed; and the eggs were replaced in their original location along with a temperature data logger. Tortoises were not monitored for three weeks following oviposition. In June, the U.S. Fish and Wildlife Service issued an amendment to EG&G/EM's threatened/endangered species permit allowing tortoises to be x-rayed to determine clutch size. Following this, only gravid tortoises were monitored daily using thread trailers. Tortoises were x-rayed three weeks following oviposition and at two-week intervals until July 15.

Ten nests were found in the high-impact sample and nine nests were found in the control sample. Clutch size averaged 4.2 eggs (range = 1-7 eggs) in the high-impact sample and 4.6 eggs (range = 1-6 eggs) in the control sample. Because females could not be x-rayed when first clutches were being laid, number of clutches, size of first clutches, and therefore total number of eggs produced per female, could only be determined for nine females for which the first nest was found. These nine females all layed two clutches. The average number of eggs produced per female was 8.2

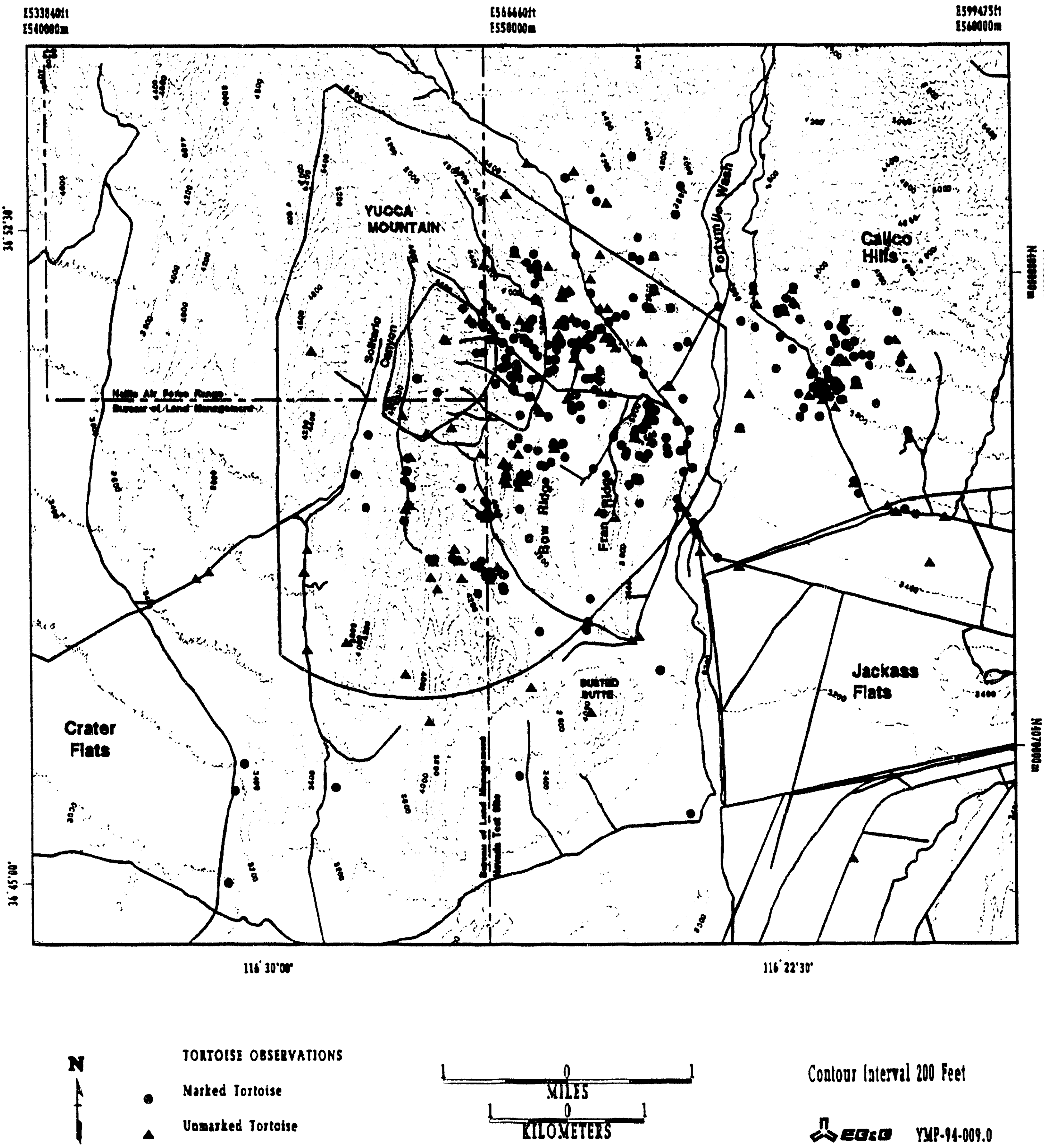


Fig. 10. The location of all tortoises found at Yucca Mountain and the adjacent control area from 1989-1993. The most recent location is shown for all tortoises found > 1 time.

(n=5, SD=2.9) for the high-impact sample and 8.3 (n=4, SD=2.1) for the control sample. Egg mass ranged from 17.8 to 41.7 g ($\bar{x}$=31.8 g). Clutch mass ranged from 26 to 210 g ($\bar{x}$=139.1 g). Weight loss by the females during the period when oviposition occurred ranged from 45 to 242 g ($\bar{x}$=147.0 g).

3.2 SURVIVAL STUDY

The objectives of the Survival Study are to evaluate the effects of YMP activities on survival of desert tortoises and to determine age-specific survival for the tortoise population at Yucca Mountain. To evaluate the effects of YMP, the study measured survival at three stages in the desert tortoise's life history: egg, hatchling, and adult (greater than 180-mm, mid-carapace length [MCL]). Egg survival was divided into two components: nest survival and egg viability. Eggs and hatchlings monitored for this study were from nests found during the Reproduction Study. The adult tortoises were the same animals used for the other studies comparing radiomarked tortoises in the three treatment populations. To compare juvenile and sub-adult survival among the three treatment levels would require sample sizes equivalent to those for hatchlings and adults. For this reason, information on survival of juvenile and sub-adults (i.e., tortoises more than one year old but less than 180-mm MCL) will only be used to determine age-specific survival for tortoises at Yucca Mountain.

3.2.1 Nest Survival

Nests found during the Reproduction Study were checked once per week for signs of predation. When eggs in a tortoise nest are eaten by predators, typically all eggs in the nest are destroyed. Thus, nest predation was determined as the proportion of nests destroyed by predators rather than the proportion of eggs destroyed.

None of ten nests in the high-impact sample and one of nine nests in the control sample were destroyed by predators.

3.2.2 Egg Viability

Egg viability was calculated as the proportion of eggs not destroyed by predation that produced viable offspring. Hardware-cloth cages were placed over nests 75-85 days after oviposition so hatchlings could be captured as they emerged. Cages were removed after the last hatchling emerged or seven days after the first hatchling emerged. Hatchlings were considered viable if they emerged from the nest. Nests were excavated more than three weeks after the first hatchling emerged, or in early November, to determine the status of hatchlings that were not captured. Incubation time was calculated as the time interval between oviposition and emergence of the first hatchling.

Four outcomes were possible for eggs. First, an egg may not have hatched. Second, the egg may have hatched, but the hatchling died before reaching the surface; this determination required finding a carcass. Third, the egg may have hatched and the hatchling was captured. Fourth, the egg may have hatched and the hatchling emerged, but was not captured. If no unhatched eggs or carcasses were found, it was assumed that all hatchlings emerged successfully.

In the high-impact sample, viable young hatched from 29 of 42 eggs (69%); 10 eggs in 7 nests failed to hatch and 3 eggs in 2 nests hatched but the animals died before emerging. In the control sample, viable young hatched from 32 of 36 eggs (89%); four eggs in two nests failed to hatch. Incubation time of sixteen nests was 79 to 112 days ($\bar{x}$=91 days).

3.2.3 Hatchling Survival

Hatchlings captured in nest enclosures were measured, marked with paint, and radiomarked if transmitter weight did not exceed 10% of body weight. Hatchlings were placed in artificial burrows outside of the fenced nest after handling.

Twenty-nine hatchlings were radiomarked. By December 31, 1993, 5 had died, 3 had lost their transmitters, 7 were missing, and 14 were believed to be alive in their hibernacula. Four of the dead hatchlings showed evidence of being killed by fire ants (*Solenopsis* sp.). One of these was found covered with ants while still alive in a burrow. Two were found while being scavenged by ants, one in a burrow and one on the surface in the open. The fourth was found with similar wounds in a burrow. The fifth hatchling found dead was in a rodent burrow. Its carapace was partially eaten, and rodents were suspected of scavenging and/or killing this animal.

Three of seventeen radiomarked hatchlings from the 1992 cohort were still alive at the beginning of the 1993 activity period. Of these, one in the control sample was killed by a vehicle on a road in April 1993, and one in the high-impact population was displaced in November 1992 and found dead from unknown causes in July 1993. The third survived through 1993. Therefore, survival to one year for this cohort sample was 6%.

Six other small (<75-mm MCL) radiomarked tortoises died in 1993. One of these showed signs of mammalian predation/scavenging, one showed signs of avian predation/scavenging, one died as a result of vegetation puncturing the skin around both hindlimbs and causing necrosis of muscle around both femurs, and the others died of unknown causes.

3.2.4 Adult Survival

No adult tortoises in the three samples died. However, tortoise 298, from the high-impact sample, will be treated as having died. This adult female's hibernaculum collapsed following rain and snow in December and January and the soil covering her hardened. Believing she was dead, biologists unburied her to retrieve the transmitter after all other tortoises had emerged from hibernation. She was found alive but unable to move in a small, uncollapsed chamber at the end of the burrow tunnel. She was removed from the chamber and still was being monitored at the end of 1993. Only one large tortoise (number 460) radiomarked for other studies died (see Section 3.8).

3.3 MOVEMENTS AND HABITAT USE STUDY

The objectives of the Movements and Habitat Use Study are to evaluate the effects of YMP activities on the movements, habitat use, and behavior of desert tortoises; monitor the reaction of individual tortoises to disturbances within or near their home ranges; and study selected aspects of the behavior and habitat use of tortoises for which more knowledge is required to better conserve this species at Yucca Mountain.

Tortoises monitored for this study were located at least once every other week during hibernation and twice per week the rest of the year. Each time these radiomarked tortoises were located, information on their location, behavior, burrow (if used), and habitat was recorded. The information reported here is from 76 tortoises that were not displaced or relocated and were monitored during the entire 1993 activity period.

These tortoises were located an average of 82 times during 1993. They entered hibernation in the fall of 1992 between September 25 and November 18 ($\bar{x}$ = October 25), emerged from hibernation the following spring between March 5 and April 25 ($\bar{x}$ = March 25), and entered hibernation in the fall of 1993 between August 18 and November 19 ($\bar{x}$ = October 17). Length of hibernation during the winter of 1992-1993 did not differ among the three treatment groups ($P = 0.18$, single classification ANOVA).

During 1993, tortoises used 6 to 23 burrows ($\bar{x}$ = 14). Burrows were defined as any subterranean chamber greater than half the length of the tortoise using it. The number of burrows used per tortoise did not differ among the three treatment groups ($P = 0.88$, Kruskal-Wallis test).

Tortoises were observed active (e.g., walking, digging, feeding, interacting with other tortoises) in 14% of all observations during the period when tortoises were not hibernating. This percentage did not differ among the three treatment groups ($P = 0.48$, single classification ANOVA).

To further evaluate the effects of YMP on tortoises, the following parameters also will be calculated and compared among the control, area-wide, and high-impact samples: home-range size, home-range and core-area overlap from the previous year, and shift in center of activity.

To achieve the second objective of this study, changes in movements and behavior of tortoises that had disturbances >0.5 ha within their home ranges will be compared to changes in the movements and behavior of tortoises that did not have disturbances within their home ranges.

For the third objective, information collected while monitoring tortoises for this study will be compiled and analyzed to better understand the ecology of the tortoise population at Yucca Mountain. For example, 90 tortoise hibernacula used by 99 tortoises were measured during the winter of 1992-1993 to determine characteristics that may be useful for identifying potential hibernacula.

In addition, the movements and habitat use of 29 radiomarked tortoises from the 1993 cohort were studied to develop better methods for finding and protecting small tortoises. Fourteen tortoises that survived until hibernation used from 1 to 12 burrows ($\bar{x}$ = 5.7). Of 116 burrows used by all hatchlings, 49 were originally constructed by rodents, 19 were constructed or modified by the hatchlings, 31 were natural cavities under rocks or roots of shrubs, and the origin of 17 could not be determined. The 14 hatchlings that were still being located in December had moved 5 to 225 m ($\bar{x}$ = 98 m) from their nests.

3.4 HEALTH MONITORING STUDY

The objective of the Health Monitoring Study is to evaluate the effects of YMP on the desert tortoise population at Yucca Mountain by monitoring changes in the health of radiomarked tortoises. In 1993, three sets of parameters were measured for the three treatment groups: growth, exposure to upper respiratory tract disease, and blood profiles.

Annual growth (increase in MCL from September-October 1992 to September-October 1993) was calculated for 31, 20, and 21 high-impact, area-wide, and control radiomarked tortoises, respectively. Based on an analysis of covariance, with length as the covariate, growth did not differ among the three treatment groups ($P = 0.18$).

Tortoises were examined for potential signs of upper respiratory tract disease (Jacobson et al., 1991) (e.g., wet nose, cloudy eyes, wheezing) each time they were handled. One tortoise was observed with a possible sign of this disease. Tortoise #413 had mucus on her nares on September 23, 1993, approximately one hour after being captured and transported to the field laboratory for blood collection. This is the third time since 1989 that a tortoise at Yucca Mountain has been observed with this possible sign of upper respiratory tract disease. In addition, blood was collected from 49 tortoises in September 1993 and evaluated for presence of antibodies to *Mycoplasma agassizii,* as described by Schumacher et al. (1993). *M. agassizii* is believed to be the cause of upper respiratory tract disease. Four of 18 high-impact tortoises, two of 14 area-wide tortoises, and one of 14 control tortoises tested positive for presence of antibodies to *M. agassizii*. These proportions did not differ among the treatment groups ($0.25 < P < 0.50$, Comparison-of-proportions test).

Third, 40 standard measures of blood chemistry and cell counts were made from blood collected during September 1993. Eighteen, fourteen, and fourteen high-impact, area-wide, and control tortoises, respectively, were sampled.

3.5 FOOD HABITS STUDY

Site characterization may alter plant communities by denuding plant cover and/or causing an increase in exotic plant species. Tortoises depend on grasses and forbs not only for food but for maintaining their water balance. Little is known about tortoise food habits in the local plant communities at Yucca Mountain. The Food Habits Study was implemented to determine local tortoise diet, relative nutritional and quantitative importance of forage components, and large-scale effects of YMP on tortoise diet.

3.5.1 Field Observations

The number of bites taken from each plant species eaten were counted when radiomarked desert tortoises were observed foraging. Tortoises were observed taking 6,291 bites from 29 plant species during 99 feeding bouts. Data were summarized as the percentage of bites of each species as well as the percentage of feeding bouts during which each species was consumed (i.e., frequency). Low trefoil (*Lotus humistratus*) and red brome (*Bromus rubens)* were eaten the most during these observations (Table 7).

Table 7. The percent of bites (n=6,291) and the percent frequency of occurrence of food items in desert tortoise feeding bouts (n=99) at Yucca Mountain during 1993. Only the nine most frequentiy eaten food items are presented.

Species	Bites (%)	Frequency (%)
Low trefoil (*Lotus humistratus*)	47	56
Red brome (*Bromus rubens*)	12	42
Fiddleneck (*Amsinckia tessellata*)	7	17
Blazing star (*Mentzelia obscura*)	6	1
Desert globemallow (*Sphaeralcea ambigua*)	6	11
Storksbill (*Erodium cicutarium*)	3	2
Yellow-eye lupine (*Lupinus flavoculatus*)	2	2
Straggling mariposa (*Calochortus flexuosus*)	2	5
Cushion cryptantha (*Cryptantha circumscissa*)	1	1

3.5.2 Scat

One hundred fifty-four fresh desert tortoise scats were collected during 1993: 65 from tortoises in the control population, 7 from tortoises in the area-wide population, 54 from tortoises in the high-impact population, and 28 from other tortoises. Of these samples, 116 were from females, 18 from males, and 20 from tortoises of unknown sex. Samples were biased towards females in the control and high-impact populations for two reasons. First, scats from these animals were often found by following the thread trails used in the Reproduction Study. Second, these animals often defecated when being transported for x-rays during the Reproduction Study. Scat samples collected during 1993 were sent to a laboratory for microhistological analysis of plant species composition.

3.5.3 Analysis of 1990 and 1991 Scat

Results of microhistological analysis of scat collected in 1990 and 1991 were received during 1993. Percent composition ($\bar{x}$ percent composition for all scat having a food item) and percent frequency of occurence (percent of all scat containing a food item) were calculated for both years (Table 8). During 1990, red brome, fluffgrass, and cacti had the highest percent composition and frequency of occurence. In 1991, seed, desert globemallow (*Sphaeralcea ambigua*), and red brome had the highest frequency and desert globemallow, lupine (*Lupinus* spp.), seed, and fluffgrass had the highest percent composition.

Table 8. Percent composition (COMP) and percent frequency (FREQ) of occurrence of food items in desert tortoise scat collected at Yucca Mountain during 1990 (n=27) and 1991 (n=30). Only the 10 most frequently eaten food items for each year are presented.

Species	1990		1991	
	% COMP	% FREQ	% COMP	% FREQ
Red brome (*Bromus rubens*)	41	70	4	67
Fluffgrass (*Erioneuron pulchellum*)	14	44	12	37
Cactus	11	56	4	27
Spine	8	44		
Three-awn grass (*Aristida* spp.)	5	15	>1	3
Desert globemallow (*Sphaeralcea ambigua*)	3	26	20	70
Unknown forb	3	37		
Ratany (*Krameria parvifolia*)	2	11	>1	13
Saltbush (*Atriplex* spp.)	2	26	4	13
Galleta grass (*Hilaria jamesii*)	2	22	3	13
Winterfat (*Ceratoides lanata*)	1	7	3	13
Seed	>1	4	16	80
Lupine (*Lupinus* spp.)			16	43
Storksbill (*Erodium cicutarium*)			6	37

3.6 IMPACT MITIGATION STUDY

Most YMP activities will be small (<2 ha), short-term, and have relatively minor impacts on tortoises. Some activities, however, will disturb large areas, last throughout site characterization, and therefore may have greater impacts on tortoises. To effectively mitigate these impacts, information is needed on the abundance, movements, and habitat use of tortoises in areas where large-scale and long-term activities will occur. The Impact Mitigation Study was developed to collect this information.

To meet the objective of this study, areas where large-scale and long-term activities will occur are searched. All tortoises found during these searches and during subsequent work in that area are radiomarked. These radiomarked tortoises then are located often enough (usually 2-8 times per month) to develop an understanding of their movements and habitat use. This information is used during the preactivity survey process to develop plans for mitigating impacts and protecting those tortoises.

Three study sites were established prior to October 1992. The first, in Midway Valley around and east of Exile Hill, was searched in 1990 for tortoises that might be impacted by a series of large trenches. The site was expanded and re-surveyed in 1991 to include tortoises that might be impacted by the North Portal Facilities. By October 1992, 20 tortoises were being monitored. During 1993, one of these tortoises was displaced, one was missing, two had transmitters removed because they moved out of the area, and two new tortoises were found and radiomarked. Therefore, at the end of 1993, 18 tortoises were being monitored.

The second site, in Drill Hole Wash, was searched in 1991 for tortoises that might be impacted by the proposed Exploratory Shaft Facility and ongoing activities in that wash, such as the Subdock. In October 1992, 15 tortoises were being monitored. During 1993, one tortoise lost its transmitter and another could not be found. Because an Exploratory Shaft Facility was no longer planned for the area, transmitters were removed from six tortoises consistently located more than 200 m from ongoing activities. At the end of 1993, seven tortoises were still being monitored.

The third site, at the southwest end of Midway Valley, was first searched in April-June 1992 to find tortoises that might be affected by the South Portal Facility and topsoil/muck storage areas. During that search and subsequent work in the area during 1992, eight tortoises were found and radiomarked. During February 1993, burrows found during the search conducted during the spring of 1992 were re-examined to find unmarked tortoises that may have moved into the area to hibernate. One hundred ten of the 116 burrows found in 1992 were searched; the other six were not found or had been collapsed intentionally prior to construction activities. Two unmarked tortoises were found and radiomarked. Three other tortoises were found in the area later in 1993 and radiomarked. Three of the radiomarked tortoises in this site could not be found as of October 1993. At the end of 1993, ten tortoises were being monitored.

3.7 DISPLACEMENT AND RELOCATION STUDY

The Displacement and Relocation Study is being conducted to move tortoises from areas where they may be injured or killed and to evaluate the efficacy of moving tortoises. Displacement is defined as moving tortoises within or as close as possible to their existing home ranges. Relocation is defined as moving tortoises away from Yucca Mountain to distant locations such as Jackass Flats or Rock Valley.

Prior to the 1993 field season, the plans for determining whether tortoises should be displaced or relocated were revised. In 1992, the plan was to relocate any tortoise to a distant site if more than about 25% of its home range was to be destroyed. It was decided in 1993 that tortoises will be displaced to undisturbed areas within their home ranges when possible. If that will not be possible because a large portion of a tortoise's home range will be disturbed, the tortoise will be displaced to a safe area as close as possible to its home range. Tortoises will be relocated only if they continue to return to construction sites or other unsafe areas after being displaced. These modifications were made after reviewing the movements of tortoise 423, which moved >31 km after being relocated in 1992 (EG&G/EM, 1993:40). It was decided that keeping tortoises as close as possible to their original home ranges could be less stressing than relocating them to distant, unfamiliar sites. Keeping tortoises at Yucca Mountain also will reduce the population-level effects caused by removing tortoises from the area.

From October 1992 to December 1993, 15 desert tortoises were displaced, and none were relocated from construction sites at Yucca Mountain. All tortoises were radiomarked prior to being moved. After being moved, they were located at least twice per day during land clearing and grading and at least twice per week after land clearing was completed.

Two tortoises were within 10 m of the proposed site of drill pad NRG-6 in Drill Hole Wash when land clearing was to begin in October 1992. Because the drill pad could not be modified or moved, tortoises 181 (60-mm MCL) and 480 (108-mm MCL) were displaced 60 and 110 m, respectively, away from the pad. Tortoise 181 stayed 40-100 m from the drill pad until at least October 21, 1993, when its transmitter failed. Tortoise 480 stayed >50 m from the pad for most of the summer but returned to within 10 m by October 1993. Because drilling was completed by this time, tortoise 480 was no longer in danger and was not displaced again.

Two tortoises were displaced from the North Portal Facility at Exile Hill. Tortoise 443, a 45-mm MCL tortoise that hatched in October 1992, was within the area to be cleared for the North Portal Facility in November 1992. Therefore, this tortoise was moved 500 m, to the north end of Exile Hill. It died of unknown causes in July

1993. Tortoise 211 (268-mm MCL) hibernated about 50 m from the edge of the North Portal Facility during the winter of 1992-1993 and then moved to within 2 m of construction activities at the North Portal Facility by March 23. Because >50% of the known home range of this tortoise had been or was to be disturbed for the North Portal Facility, she was displaced 2 km north to an area where an adult female had died in 1992. Tortoise 211 remained within 1.3 km of the release site during the remainder of 1993 and did not return to within 1 km of the North Portal Facility.

Tortoise 460 (200-mm MCL) was found in the path of the proposed access road to drill pad NRG-4 on Azreal Ridge on May 17, 1993, when the access road was being constructed. The tortoise was moved about 200 m from the road site and monitored twice daily. On May 19, tortoise 460 returned to the access road and was run over and killed by an earthmover. An EG&G/EM biologist was trying to locate this tortoise when it was killed. Because of this mortality, the procedures for displacing and monitoring tortoises were modified. All adult tortoises to be displaced from unfenced construction sites now are moved at least 300 m from those sites and are checked before construction or other potentially harmful activities start each day.

Ten tortoises were removed from the borrow pit northeast of Fran Ridge. Five tortoises were found hibernating in the proposed site of this borrow pit in January 1993. Because the borrow pit could not be moved to a new location, the five tortoises (180 [102-mm MCL], 105 [145-mm MCL], 248 [157-mm MCL], 113 [246-mm MCL], and 121 [246-mm MCL]) were removed from their hibernacula on February 1, 1993, and placed in similar-sized burrows on Fran Ridge. The 32-ha borrow pit was fenced in February 1992, to prevent tortoises from entering the site, as required in the Free Use Permit issued to the Project Office by the U.S. Bureau of Land Management. However, coyotes or other large mammals made holes in the fence that tortoises later used to enter the site. During April-November 1993, one previously moved tortoise (113) and five other tortoises (451 [54-mm MCL], 453 [169-mm MCL], 119 [192-mm MCL], 405 [220-mm MCL], and 414 [279-mm MCL]) were found inside the fenced area. These tortoises were moved 30-300 m outside of the fence and released into burrows. By the end of 1993, seven of the 10 tortoises displaced from the borrow pit were still being located. Six of the seven were hibernating within 500 m of the borrow pit and the seventh (414) was about 800 m away. The other three tortoises could not be found, probably because their transmitters failed. Two of these three missing tortoises (248 and 451) were within 200 m of the borrow pit when they were last located. The third (119) had travelled >3.5 km north of the borrow pit when last located.

3.8 ROADWAY MONITORING STUDY

The objectives of the Roadway Monitoring Study are to monitor sightings and mortalities of tortoises along roads and, if necessary, develop, test, and implement methods for reducing the potential for mortalities along roads.

All personnel working on YMP are required to report sightings of desert tortoises to the Field Operations Center. These reports are given to EG&G/EM for compilation and, when possible, EG&G/EM biologists are sent to mark the tortoises. Information on mortalities and sightings of tortoises along roads were reviewed annually to identify mitigation measures needed to reduce mortalities.

In December 1992, EG&G/EM biologists reviewed the tortoise sightings and mortalities along roads in 1992. It was recommended that signs reminding drivers to watch for tortoises in roadways be placed along two sections of roads (H Road at Fortymile Wash and the road to Split Wash) where many tortoises have been seen.

Seventy-three observations were reported of desert tortoises on or adjacent to roads in the YMP area (Fig. 11). Three of these animals were captured, marked, and radiomarked; 19 were captured and marked only; 35 had been radiomarked previously; 10 had been captured and marked previously; and 6 were not captured. Most sightings were on roads in and around Midway Valley, along the H Road extension leading from Jackass Flats to Midway Valley, and on or next to the road around the borrow pit. In addition to these 73 sightings, 15 tortoises were reported on roads frequently used by YMP personnel but located outside of the YMP area. Two of these were near the T11S/12S boundary (approximately 2 km north of Beatty), which has been mentioned as the approximate northern boundary of the range of the desert tortoise in Nye County (Karl, 1981). The remainder of the tortoise sightings were along Solitario Canyon Road and elsewhere in Crater Flat.

Two desert tortoises were killed on roads by vehicles in the Yucca Mountain area during 1993. On April 20, 1993, a small radiomarked tortoise (441, 48-mm MCL) was found crushed on the unpaved power-line access road 3 km north of the Canyon Substation. This road is travelled by personnel working on YMP and other DOE projects. Therefore, it could not be determined whether this tortoise was killed by a YMP worker. On May 19, 1993, tortoise 460 (162-mm MCL) was crushed by an earthmover on the newly graded road to NRG-4 (see Section 3.8).

3.9 RAVEN MONITORING STUDY

The objectives of the Raven Monitoring Study are to determine if YMP causes an increase in raven abundance, identify facilities where ravens congregate, and evaluate the efficacy of raven deterrent equipment if installed on YMP facilities in the future.

Road surveys were conducted simultaneously along 40-km treatment (YMP area) and control routes on five randomly selected weekdays every other month. During 1993, 135 ravens were counted along the YMP route and 108 ravens along the control route. Figure 12 shows the number of ravens counted per sampling period from August 1991 to December 1993.

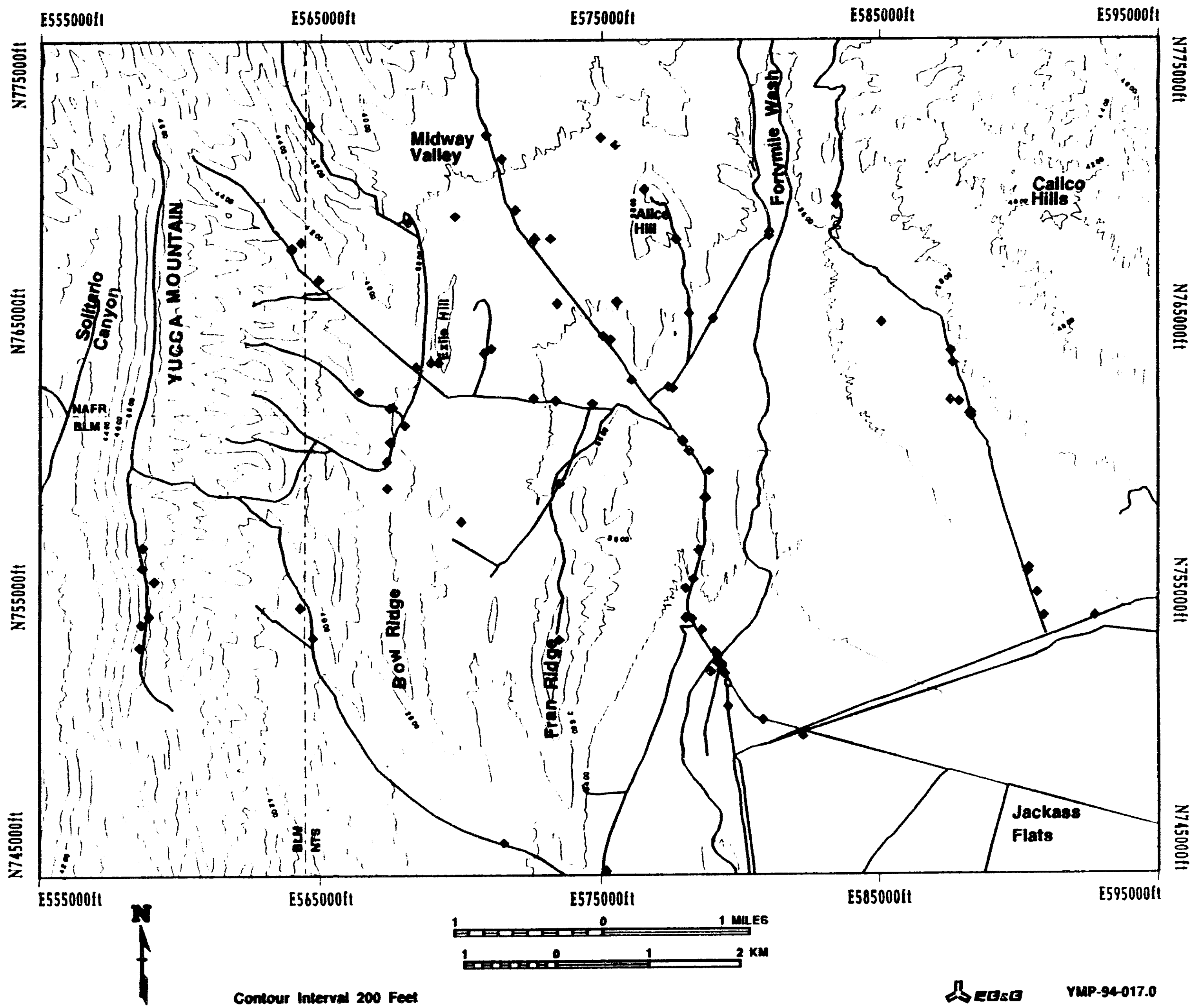


Fig. 11. Locations of desert tortoises observed on roads at or near Yucca Mountain during 1993. This map does not include observations of radiomarked tortoises found on roads while being located for other studies.

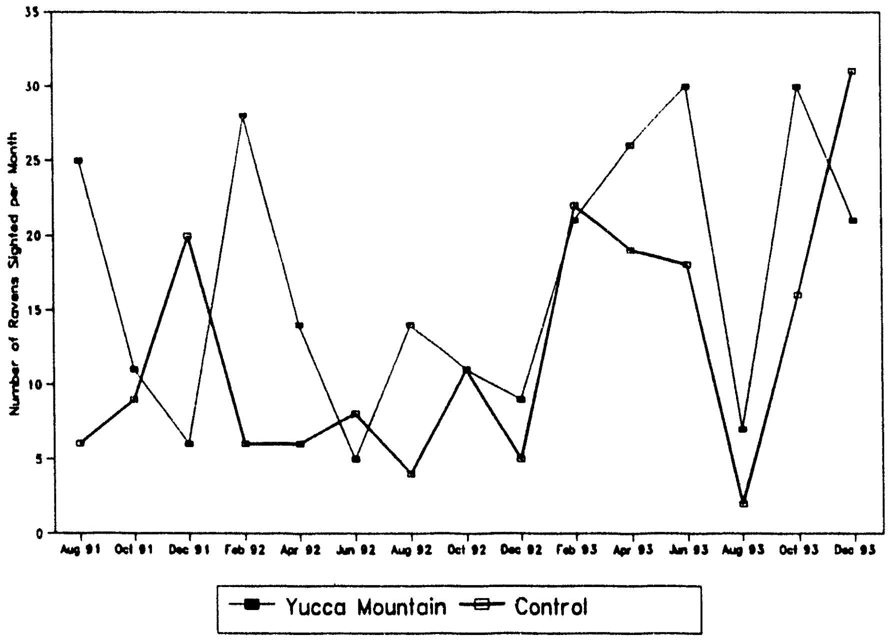


Fig. 12. Number of ravens counted on five 25-km raven surveys per month at Yucca Mountain and a control area, August 1991 - December 1993.

While conducting raven surveys during 1993, 5 ravens along the control route and 24 along the treatment route were seen using man-made facilities. The most frequently used facilities at Yucca Mountain were the roads/drill pads ($n=7$) and utility poles ($n=8$).

3.10 GROUND MOTION EFFECTS STUDY

YMP will be conducting blasting, seismic reflection studies, and other activities that will cause ground motion within desert tortoise habitat. This ground motion may cause tortoise burrows to collapse. It also may cause tortoises to exit their hibernacula or change their behavior. The effects of this type of ground motion on tortoises have never been evaluated. The Ground Motion Effects Study was initiated in 1993 to ensure that tortoises near ground-motion-causing activities are not trapped in burrows, evaluate effects of ground motion on tortoises, and obtain information needed to develop mitigation plans for future activities that cause ground motion.

To ensure that tortoises are not trapped in burrows collapsed by ground motion, all radiomarked tortoises near activities causing ground motion are monitored during or immediately after these activities. To evaluate the effects of ground motion on tortoises, two parameters are measured. First, the dimensions of burrows found near ground-motion-causing activities are measured before, one week after, and six months after the ground motion to determine if those burrows collapsed. A sample of similar, control burrows located > 100 m from the source of ground motion also are measured for comparison. Second, the behaviors of tortoises near these activities are monitored and compared to the behavior of tortoises distant from the activities to determine if tortoises alter their behavior during or as a result of ground motion.

During 1993, thirteen burrows located 8 to 91 m from seismic-study sites in Crater Flats were measured. There was no change in the dimensions of these burrows before and one week after ground motion. No burrows collapsed at any of the locations studied.

4. HABITAT RECLAMATION PROGRAM

EG&G/EM has been tasked to conduct disturbed-habitat studies, initiate reclamation feasibility trials, and implement site-specific reclamation actions for YMP. The objective of the Habitat Reclamation Program is to restore sites disturbed by YMP to a state of similar form and productivity as the predisturbance state (DOE, 1989)

4.1 DISTURBED HABITAT STUDY

Roads, drill pads, trenches, and other construction disturbances were created in the late 1970s and early 1980s during site investigations to evaluate Yucca Mountain as a study site for a potential nuclear waste repository. These disturbances provide the opportunity to study natural revegetation (i.e., plant succession) at Yucca Mountain. Results from these studies can provide insight into factors that control plant establishment, aid in the development of reclamation studies, and ultimately aid in the development of techniques for reclaiming disturbed sites. The Disturbed Habitat Study was designed to inventory past disturbances, identify the dominant plant species on disturbed sites, compare species on disturbed sites with those species present in undisturbed areas, and describe plant succession at Yucca Mountain.

Fifty-seven disturbed sites greater than 0.012 hectares were identified. The disturbance type (e.g., cut slope, drill pad) and vegetation association present prior to disturbance were recorded for each site. During 1991 and 1992, three to six, 2- x 20-m belt transects were randomly located at each disturbed site. The number of plants in each belt transect was counted, and average density (plants/100 m^2) for each species was calculated. Densities measured in 1992 were compared with densities from the undisturbed ESPs (see Section 2.2.4).

Average density on all disturbed sites was 69.2 plants/100 m^2, which was approximately one sixth that on ESPs (389.8 plants/100 m^2). Needleleaf rabbitbrush (*Chrysothamnus teretifolius*) was the most common plant in disturbed areas followed by white bursage (*Ambrosia dumosa),* desert trumpet (*Eriogonum inflatum*), wirelettuce (*Stephanomeria pauciflora*), goldenweed (*Happlopappus linearifolius*), and rubber rabbitbrush (*Chrysothamnus nauseousus*) (Fig. 13). With the exception of white bursage, these species were minor (less than 10 plants/ 100 m^2) components in undisturbed areas (Fig. 13). Nevada ephedra (*Ephedra nevadensis*), ratany (*Krameria parvifolia*), blackbrush (*Coleogyne ramosissima*), spiny menodora (*Menodora spinescens*), and Shockley goldenrod (*Acamptopappus shockleyi*) also were found at disturbed sites, but each comprised less than 1% of the total density.

Plant species common in disturbed areas were uncommon in undisturbed areas. Six to twelve years after disturbance, vegetation density is still substantially less than in undisturbed sites. Succession is progressing slowly on these disturbed sites. The disturbances altered the micro-environment to an extent that plant species which rarely occur in a plant community, now dominate the plant assemblage.

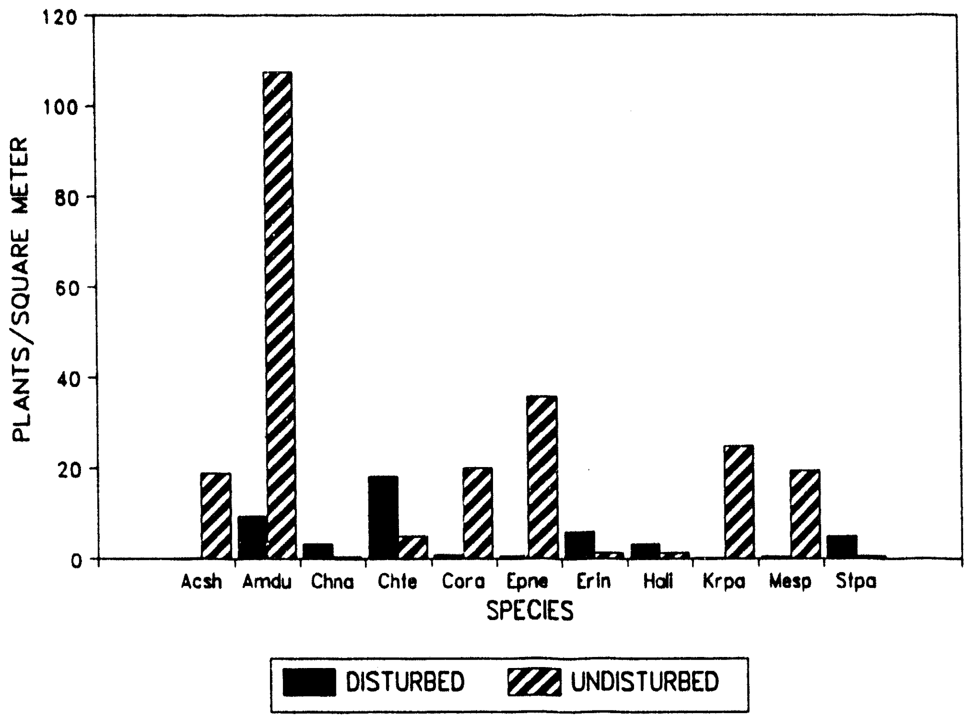


Fig. 13. Average density (plants/m²) of species found in 57 disturbed sites and 48 undisturbed Ecological Study Plots at Yucca Mountain during 1991-1992. The species shown are the six most abundant species on disturbed sites (*Ambrosia dumosa* [AMDU], *Chrysothamnus nauseousus* [CHNA], *Chrysothamnus teretifolius* [CHTE], *Eriogonum inflatum* [ERIN], *Happlopappus linearifolius* [HALI], and *Stephanomeria pauciflora* [STPA]) and undisturbed sites (*Acamptopappus shockleyi* [ASCH], *Ambrosia dumosa* [AMDU], *Coleogyne ramosissima* [CORA], *Ephedra nevadensis* [EPNE], *Krameria parvifolia* [KRPA], and *Menodora spinescens* [MESP]).

Needleleaf rabbitbrush and white bursage comprised 40% of the plant density on disturbed sites. The abundance of these two species on disturbed sites suggests that these species may be good for revegetation of disturbed areas at Yucca Mountain.

4.2 RECLAMATION TRIALS

Field trials were conducted to evaluate techniques and plant materials used to reclaim disturbed sites. Results of these trials are used to improve techniques for stabilizing and revegetating salvaged topsoil and sites released for final reclamation. During 1991, five previously disturbed sites were selected for reclamation trials (EG&G/EM, 1993:48). These sites are at elevations ranging from 1,015 to 1,460 m and are in all four vegetative associations found at Yucca Mountain. The soils at the five sites range from shallow (0-20 cm) to deep (>60 cm). Disturbances at these sites include a borrow pit, scraped areas, drill pads, an old roadbed, and a staging area.

4.2.1. Seeding and Mulch Study at Reclamation Trial Site 1

A pilot study was established at Reclamation Trial Site 1 in 1992 to evaluate two reclamation techniques: broadcast versus drill seeding and straw mulch versus no mulch (EG&G/EM, 1993:47). The Trial Site is located in the *Coleogyne* vegetation association and was seeded in March 1992. Seedling density was measured in November 1992, excluding the non-seeded control plots, and averaged 0.44 plant/m^2 (SD = 1.23). Only 108 (18%) of 600 quadrats sampled had plants. Broadcast-seeded and drill-seeded plots had average densities of 0.54 (SD = 1.31) and 0.35 (SD = 1.15) plants/m^2, respectively. Mulched and unmulched plots had average densities of 0.65 (SD = 1.60) and 0.24 plants/m^2 (SD = 0.65), respectively. The depth of the topsoil was recorded at each of the 108 quadrats containing plants. Average soil depth was 12 cm (SD = 8.95). The results suggested that none of treatments were suitable given the shallow soils.

4.2.2 Soil Quality and Depth Study at Reclamation Trial Site 1

The poor success in the pilot study at Site 1 (Section 4.2.1) suggested the importance of soil depth and quality for successful revegetation. Many of the disturbances created at Yucca Mountain prior to 1989 have no salvaged topsoil or have shallow caps of subsoil used to smooth the ground surface (e.g., drill pads). To meet the reclamation goals set by the Project Office, soil may have to be imported to some of these sites. Since topsoil is scarce in the desert, lower-quality soils may have to be used.

A study was implemented at Reclamation Trial Site 1 to test the effects of soil quality and depth on seedling emergence and long-term (>5 years) survival. The study's statistical design is a completely randomized 2- x 4-factorial design with seven replicates. The two treatment factors are soil type and soil depth.

In November 1992, a road grader was used to remove all remaining soil down to bedrock at the site. Fifty-six 5- x 7.5-m plots were then created. Two soils of different qualities, subsoil and a mix of topsoil and subsoil, were spread over the plots in four depths: 5±5, 15±5, 25±5, and 35±5 cm. The subsoil, poor quality soil, was from a borrow pit on the east side of Yucca Mountain. The mixture of topsoil and subsoil was originally removed from the site and was similar to material that would have been salvaged prior to disturbance. Samples from both soil types were analyzed for physical and chemical factors (Table 9).

Table 9. Physical and chemical properties of subsoil and topsoil at Reclamation Trial Site 1. Properties followed by an * did not differ ($P > 0.05$) between subsoil and topsoil using a Wilcoxon two sample test.

Soil property	Subsoil ($n=5$)	Topsoil ($n=4$)
Nitrogen (ppm)	2	11
Phosphorus (ppm)	0.1	2.4
Potassium (ppm) *	604	514
Percent organic matter	0.2	1.5
Percent gravel >2mm	57	44.5
Percent sand	88	64
Percent silt	2	24
Percent clay *	10	13
Soil type	Loamy sand	Sandy loam
Percent water at 1/10 bar	15	22
Percent water at 15 bars	9.2	15.3
Cation exchange capacity	10.6	21
pH *	8.0	8.0
Electrical conductivity	1.38	0.8

Plots were seeded with a mix of 14 species at a rate of 18.4 pure live seed (PLS) kg/ha. All seed was drilled except winterfat (*Ceratoides lanata*), which was broadcast. Plots were mulched with wheat straw at a rate of 2,803 kg/ha. The straw was tackified with a commercially-available tackifier at a rate of 112 kg/ha and wood fiber at a rate of 168 kg/ha. A total of 0.64 cm of supplemental water was applied to the plots after mulching. Seedling density was measured in June and September 1993, in 10 1-m^2 quadrats on a transect centered within each plot.

Average density during September for all treatments was 8.8 plants/m^2 (SD = 7.2). Replicates within treatment combinations often had large ranges of means. Seven of the 14 species seeded did not emerge or had fewer than 12 individuals counted in the 560 sample quadrats. Two species, California buckwheat (*Eriogonum californica*) and winterfat made up 86.5% percent of the density in September. Seedling density did not differ among soil types and soil depths ($P < 0.05$); however, the interaction of the two treatments was significant ($P < 0.001$). Treatment differences and interactions were determined using an extension of the single factor Kruskal-Wallis test. In topsoil, density was higher in deeper soils. In subsoil, density was lower in

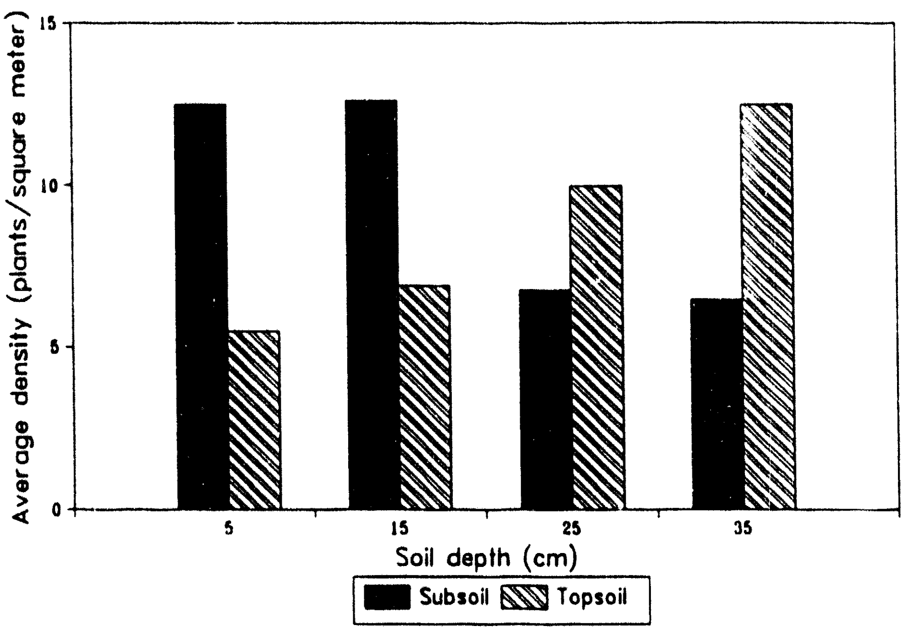


Fig. 14. Average plant density (plants/m^2) on four soil depths and two soil types (subsoil and topsoil) at Reclamation Trial Site 1. Each bar is the average of seven replicates. Data was collected during September 1993, at the Soil Quality and Depth study site.

deeper soils (Fig. 14). Seedling density will be measured again in 1994, and soil moisture will be measured at two depths in each treatment combination to better understand the effects of the treatments on soil moisture and seedling density.

4.2.3 Soil Quality and Amendment Study at Reclamation Trial Site 1

Subsoils from Borrow Pit #1 may have to be used at disturbed sites because topsoil was not salvaged during initial site investigations, and it is not readily available from other sources. Soil amendments such as organic matter and fertilizers may be added to these subsoils to increase their suitability for plant growth. Little information is available on the effects of amendments to soils in the Mojave Desert. Adding soil to a site (whether topsoil or subsoil) is expensive; therefore, the amount imported should be minimized. Less soil will be needed if plants can be grown on shallower soil with amendments.

A study was implemented in November 1993, at Reclamation Trial Site 1 to determine 1) if subsoils amended with fertilizer, polyacrylamide gel, organic material, and combinations of these amendments will increase seedling emergence and plant establishment; 2) if depth of soil affects seedling emergence and plant establishment; and 3) which combination of soil type, depth, and amendments results in the highest seedling emergence and plant establishment.

The statistical design for this experiment is a 2- x 2- x 8-factorial design with five replications. The factors are soil type, soil depth, and amendment combination. The two soil types are the topsoil/subsoil mix already present at the site and fill material taken from the borrow pit. The topsoil/subsoil mix represents a disturbed soil with a portion of the organic matter, microbes, and nutrient base present. The fill material is an alluvial subsoil taken from approximately a 5-m depth. The two soil depths are 5 and 20 cm. The eight amendments are: control (no amendments added); polyacrylamide gel; fertilizer (15-15-0); organic matter (chopped alfalfa); polyacrylamide gel and fertilizer; polyacrylamide gel and organic matter; fertilizer and organic matter; and polyacrylamide gel, fertilizer, and organic matter.

Much of the topsoil was removed from the site and used as road fill. Little topsoil and subsoil remained on the exposed bedrock, which is typical of higher-elevation disturbances at Yucca Mountain. The remaining topsoil and subsoil was scraped from half of the plots and used to create the 20-cm-deep topsoil/subsoil mix. The 5-cm-deep topsoil/subsoil mix was already in place, and a road grader was used to remove large rocks and level that soil. The plots receiving the 20-cm-deep soil were scraped to bedrock before the fill material was placed. The material was then leveled to the appropriate depth.

The plots were harrowed to scarify the soil surface and broadcast seeded at 42 PLS kg/ha with a seed mix containing species found in the adjacent plant community. Polyacrylamide gel granules were broadcast onto plots receiving this treatment. All plots were then harrowed to cover the seed and gel granules. Organic matter was added by spreading chopped alfalfa. Fertilizers will be added after seeds have germinated. Straw mulch was applied to all plots with a strawblower at a rate of 2,200 kg/ha. The mulch was tackified with a slurry of water, wood fiber mulch (1,100 kg/ha), and commercially available tackifier (112 kg/ha).

4.2.4 Demonstration Plots at Reclamation Trial Site 3

Reclamation Trial Site 3 was the first reclamation trial site established at Yucca Mountain. The Trial Site is located in the *Larrea-Ambrosia* vegetation association. Demonstration plots were set up at this site in February 1992, to evaluate techniques that may be used for reclaiming disturbed areas. Fifty-nine 4- x 15-m plots and 12 4- x 10-m plots were established for 33 treatment combinations (EG&G/EM, 1993:49-51).

Plant density was measured in May 1992; October 1992; and May 1993. Average density in October 1992 across all treatments was 5.5 plants/m^2 (SD = 6.0), an 82% decrease from the previous spring (EG&G/EM, 1993:49). Average density increased in May 1993, to 8.6 plants/m² (SD = 7.9) due to emergence of new seedlings. The presence of these seedlings one year after planting suggests that the full effect of seeding may not occur for two or more years. Native plants of several species fruited in 1993 so seedling recruitment may no longer be solely dependent on planted seeds.

Fenced and unfenced plots had average densities of 9.8 (SD = 7.9) and 7.4 (SD = 7.7) plants/m², respectively. Although small, the difference between the fenced and unfenced plots is visible. Lagomorphs have grazed the plants in the unfenced plots to or near the ground surface, while plants in the fenced plots are taller than 0.5 m.

Treatments 5, 28, 4, 2, and 3 (EG&G/EM, 1993:50-51) had the highest densities in spring 1993, ranging from 12.6 to 17.8 plants/m². The remaining treatments had densities of less than 11.9 plants m². Treatment plots 5, 4, and 3 were broadcast seeded. The consistently high densities found in these plots suggests that this seeding method may be preferred. Treatment 2 is a control plot that was seeded but had no mulch or other amendment. The polyacrylamide gel amendment (treatment 28) appears to be the only amendment that aided plant establishment.

4.2.5 Soil Depth/Mixing Study at Reclamation Trial Site 4

A study was implemented at Reclamation Trial Site 4 in March 1993, to study the influence of topsoil depth on plant establishment and survival, and to determine if mixing different amounts of topsoil into the subsoil affected plant establishment and survival. Five topsoil depths were used: 0, 5, 10, 15, and 20 cm. Topsoil was laid over the existing soil on half of the plots receiving 5, 10, or 15 cm of topsoil; on the other half of the plots, topsoil was disked into the existing subsoil to a depth of 20 cm. Disking was not required for the 0-cm and 20-cm topsoil treatments. Five 4- x 10-m plots were established for each treatment combination. All plots were mulched with wheat straw at a rate of 2,803 kg/ha, which was anchored to the ground by crimping. A mix of 16 species was seeded at a rate of 18.63 PLS kg/ha. All plots were fenced to exclude grazing. Sixteen 1-m² quadrats were established in each plot to measure seedling density.

Seedling density was measured during May and October 1993. The overall average seedling density was 27.6 (SD = 18.40) plants/m² in May and 6.3 (SD = 7.55) plants/m² in October. After the first summer, the mixed topsoil treatments had higher seedling survival (Fig. 15). Thirty percent of the original seedlings were still alive in plots with that treatment compared with 20% in plots with the layered topsoil treatment. The 5-cm soil depth for both the mixed and layered soils had higher plant densities than the 10-, 15-, and 20-cm depths (Fig. 15). This response was similar to that observed on the subsoil plots of the soil depth and quality study at Reclamation Trial Site 1 (Fig. 14).

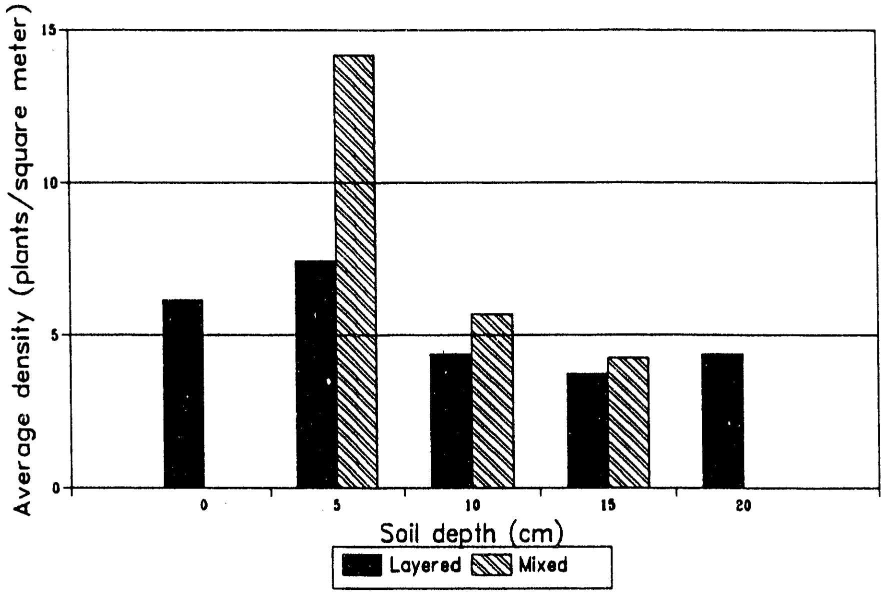


Fig. 15. Average plant density (plants/m²) in October 1993, at Reclamation Trial Site 4 for five topsoil depths that were layered over the subsoil or mixed into the subsoil by disking. Each bar is the average of five replicates.

Four species made up 90% of the total density during May: California buckwheat (67%), winterfat (13%), Nevada ephedra (5.6%), and rubber rabbitbrush (5%). Seven of the seeded species made up less than 1% of the seedling density on all plots. In October, California buckwheat, winterfat, and Nevada ephedra had similar or higher relative density, as in May. Rubber rabbitbrush decreased to 2% of the total density. Plant density will be measured again in 1994.

4.2.6 Water Harvesting Study at Reclamation Trial Site 5

Precipitation is a dominant factor controlling revegetation success. It is generally believed that 22.5 cm of annual precipitation is necessary for seeding to be successful (Plummer et al., 1968; Vallentine, 1989). Although much of the Mojave Desert receives less than 18 cm of precipitation annually, plants have been established by seeding in the Mojave Desert and other regions receiving less annual precipitation (Graves et al., 1978; Kay, 1979; Anderson, 1987). To aid seed germination and seedling establishment, several techniques that modify soil microtopography to concentrate precipitation have been developed and used successfully in the arid southwest. A study was implemented at Reclamation Trial Site 5 in March 1993, to evaluate two of these methods: land imprinting and pitting, and to determine if sites should be imprinted or pitted before or after topsoil is spread.

Reclamation Trial Site 5 was first ripped to reduce soil compaction, and 42 4- x 10-m plots were created. A split plot design was used with seven replications. Topsoil was spread over the two whole plots before and after the water harvesting techniques were implemented. The split plots were imprinting, pitting, and control.

All plots were broadcast seeded with a 16-species seed mix at a rate of 18.6 PLS kg/ha. All plots were fenced to exclude grazing. To look specifically at the effect of imprinting or pitting, no mulch was used. Seedling density was measured during May and October 1993, in 16 1-m^2 quadrats per plot. Seedling density averaged 11.8 plants/m^2 (SD = 9.6) in May. Plots that had water harvesting treatments applied before the topsoil was laid down had the highest densities (Fig. 16). California buckwheat had the highest density, making up 75% of the total seedling density.

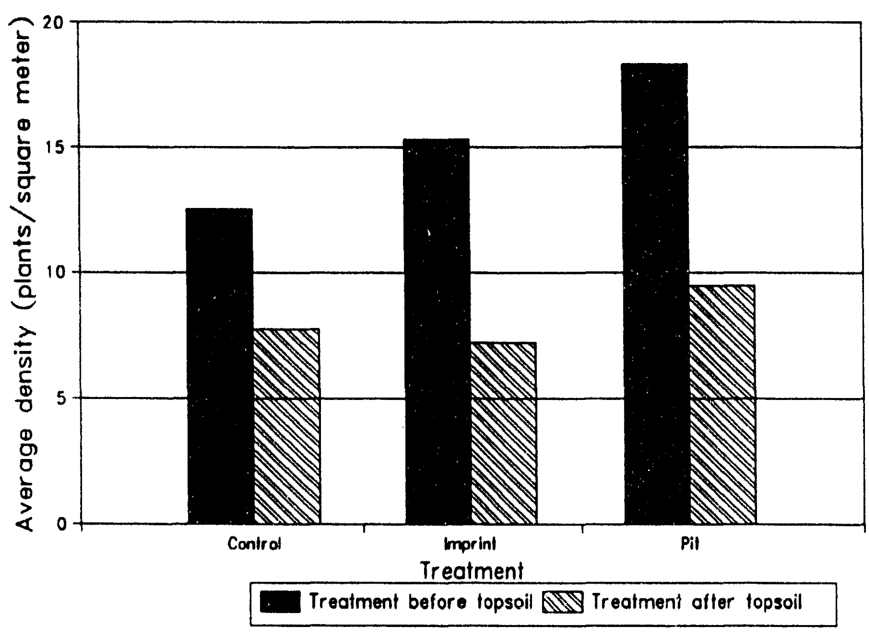


Fig. 16. Average plant density (plants/m^2) in May 1993, for three treatments at the Reclamation Trial Site 5. Each bar is an average of seven replicates.

Plant density in all treatments was less than 0.9 plant/m² (SD = 1.4) in October (a 93% decrease). The lack of mulch protection may have been the reason for the high mortality from May to October. Because seedling survival was low, the study will be repeated in 1994 with a straw mulch treatment.

4.3 TOPSOIL STOCKPILE STUDIES

Research in arid land reclamation conclusively suggests that one of the major limiting factors of habitat restoration in Mojave Desert ecosystems is the lack of a suitable substrate or growth medium (Wallace et al., 1980). Salvaging even minimal amounts of topsoil in desert ecosystems is critical for successful reclamation (Ostler and Allred, 1987). Therefore, salvaging topsoil is a high priority at sites disturbed by YMP activities. However, stockpiling of topsoil disrupts nutrient cycles, reduces organic matter, increases bulk density, and disturbs the soil microbial populations (Schuman and Power, 1981; Trappe, 1981; Allen, 1984; Hargis and Redente, 1984). EG&G/EM presently recommends that topsoil to be stored longer than six months be revegetated to maintain microbial viability. This recommendation is based on studies conducted in more mesic environments or in arid areas other than the Mojave Desert. No data are available on viability of topsoil in stockpiles at Yucca Mountain. Studies were implemented at two sites in 1993 to determine the effects of stockpiling topsoil at Yucca Mountain. Other studies with similar objectives will be implemented in the future as new topsoil stockpiles are created.

4.3.1 Topsoil Stockpile Study at Borrow Pit #1

A study was initiated in May 1993, at the topsoil stockpile for Borrow Pit #1. The objectives were to: 1) estimate short- and long-term effects of topsoil stockpiling on microbial activity and biomass, 2) evaluate the effect of depth of the topsoil stockpile, and 3) determine the influence of different plant species on soil microbial components and physical/chemical properties of the soil.

The topsoil stockpile at the borrow pit was created from topsoil removed at the North Portal. Topsoil removal began in January 1993, and the stockpile was completed in March 1993. The stockpile is approximately 1.9 ha and 2 m deep. This topsoil stockpile is scheduled to be in place for at least five years.

Soil samples were collected monthly from May to October 1993, and analyzed for total and active bacterial numbers and biomass to ascertain the short-term effects of topsoil stockpiling. Information from this study will aid in determining the rate of decline in microbial populations after creation of stockpiles. Active and total bacteria, active and total fungi, nematodes, mycorrhizal spores, and CO_2 respiration will continue to be measured every six months for the next several years to assess the long-term effects of stockpiling. This information will be used to improve techniques for maintaining the viability of topsoil stockpiles at Yucca Mountain.

To assess the effect of topsoil depth on viability, biological activity was measured in soil samples collected at four depths within the stockpile (0-20, 50-70, 100-120, and 160-180 cm below the stockpile surface) and from the original topsoil beneath the stockpile (210-230 cm below the stockpile surface). Soil samples were also collected in undisturbed areas adjacent to the stockpile so viability of the stockpile could be compared to undisturbed soils.

To evaluate the effect of plant species on soil microbes and physical/chemical properties, four combinations of plants species were evaluated: 1) a seed mix with proportions of species comparable to native plant communities, 2) a mix with a greater proportion of shallow-rooted species, 3) a mix with a greater proportion of deep-rooted species, and 4) a mix with legume species instead of the deep rooted species. Seeded plant species on the stockpile will also be collected to determine the presence or absence of mycorrhizal fungi on the roots of these plants.

All samples were sent to Microbial Biomass Service at Oregon State University. Measures of carbon dioxide respiration, total/active bacteria, total/active fungi, and mycorrhizal spores for samples collected in May 1993, have been received. The remaining data are being analyzed and should be received early in 1994. Samples collected for measurement of soil physical/chemical properties were sent to Colorado State University. This data should be received in early 1994.

4.3.2 Topsoil Stockpile Study at NRG-6

A study at the topsoil stockpile at NRG-6 was implemented in 1993 to determine the effects of plant species, stockpile age, and topsoil depth on microbial activity in stockpiled topsoil. The stockpile was formed from topsoil removed to make the NRG-6 drill pad and was completed in November 1992. In February 1993, one-half of the stockpile was seeded with a mix of shrub species. The other half was seeded with a mix of shrubs and grasses. Both mixes were broadcast seeded and then harrowed to cover the seed.

In May and December 1993, soil in the stockpile was collected from four depths (0-20, 40-60, 80-100, and 120-140 cm). The samples were sent to laboratories for analysis of total and active bacteria, total and active fungi, mycorrhizal spores, nematodes, and CO_2 respiration. Data for total bacteria, active bacteria, and mycorrhizal spores for the May samples were received in 1993. The remaining samples are being analyzed and results should be received in 1994. Samples will be taken at six-month intervals in 1994.

4.4 RECLAMATION IMPLEMENTATION

The Yucca Mountain Site Characterization Project has committed to reclamation of areas disturbed as a result of Project activities (DOE, 1989). A reclamation inventory is performed prior to any proposed activity to record pertinent information such as existing vegetative cover, soil depth, soil texture, and soil erodability. This information is used to prepare a Reclamation Stipulation Report which includes recommendations for salvaging, storing, and managing topsoil to prevent wind and water erosion and maintain soil viability. Interim reclamation may occur prior to the completion of all activities at a site and may include seeding, mulching, or chemical stabilization. After all activities have been completed on a site, the Project Office releases the site for final reclamation.

4.4.1 Reclamation Inventories

EG&G/EM received 39 preactivity survey requests during 1993 that required reclamation inventories (Table 10). These 39 requests included 95 separate sites. Forty-six of the 95 sites inventoried have not yet been disturbed. Disturbances at eight sites were minor and revegetation was not needed.

Soil samples were collected during 17 reclamation inventories at 53 sites. The other sites were not sampled because either they were close to other activities where soils had been sampled, or they were so small that samples were not needed. Soil samples were analyzed at Colorado State University for physical and chemical properties important for plant growth. A database was created for all reclamation inventory information collected since 1989, including the results of soil analyses. A total of 227 soil samples were analyzed by December 1993.

4.4.2 Interim Reclamation Activities

Interim reclamation was completed on 43 sites. The chemical Soil Master™ was used to stabilize disturbed soils on 26 sites and soils at the other 17 sites were stabilized by seeding. An additional 22 sites are scheduled for stabilization during 1994. Sites where a chemical soil stabilizer was used were periodically monitored to ensure that the stabilizer was working and to determine if additional applications were necessary. No additional applications were necessary in 1993.

Twenty-four of the 43 sites stabilized in 1993 (Table 10) were inventoried prior to 1993. They included 11 topsoil stockpiles, which were chemically stabilized, and 10 borehole sites, two topsoil stockpiles and one seismic site, which were seeded.

4.4.3 Final Reclamation Activities

Well JF3 and Trench A'2 were released for final reclamation in 1992. Demonstration plots were established at these sites in 1993. Thirty-five Ground Surface Facility (GSF) pits were released for final reclamation in 1993. The pits were backfilled in the summer of 1993 and released for final reclamation in October 1993. Final reclamation was implemented on these sites in November 1993. The 35 GSF pit topsoil stockpiles were harrowed, broadcast seeded, mulched with wheat straw, and tackified with M-bindor. They will be monitored to assess reclamation success.

Table 10. Status of reclamation on all sites where reclamation inventories were conducted. The number of sites reclaimed in 1993, but inventoried prior to 1993, is shown in parenthesis.

					Interim reclamation			
Project type	Number of inventories requested	Number of sites inventoried	Sites not disturbed to date	Stabilization not required	Soil Master™	Seeded	Planned 1994	Final reclamation
Boreholes/infiltration tests	11	16	8	1		11 (10)	6	
Hydrological studies								(1)
Soil/volcanism studies	5	43	22	2	14 (11)	3 (2)	4	(36)
Seismic studies/stations	1	1		1		1 (1)		
Radiological monitoring stations/plots								
Facility improvements, road access/repair	2	2	1	1				
Borrow pits								
Pavement studies	1	1					1	
Exploratory studies	12	15	8	3	1	2	1	
Fault studies	3	9	2				7	
C-well	1	1	1					
Other	3	7	4				3	
Total-1993	39	95	46	8	26 (11)	17 (13)	22	(37)

4.4.3.1 Well JF-3 Final Reclamation

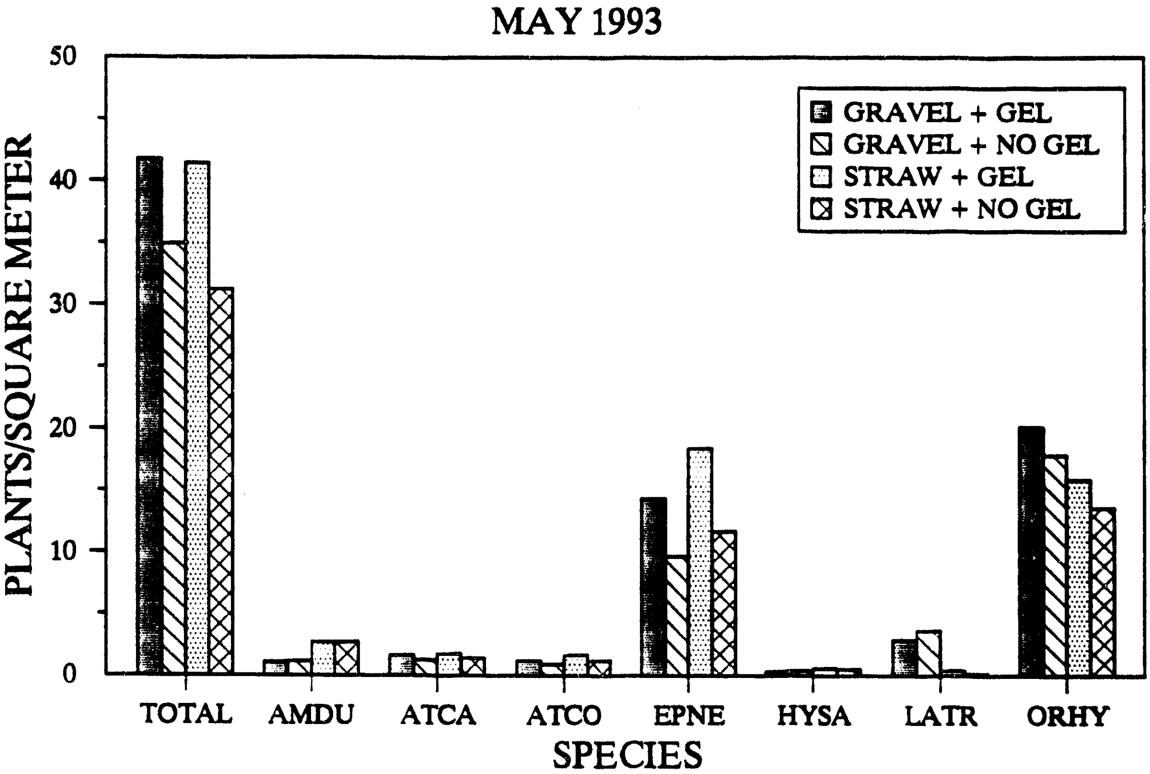
Well JF-3 was drilled for the U.S. Geological Survey's Water Resources Environmental Monitoring Program in 1991-1992. The drill pad for this well was 82 x 82 m (0.67 ha) and was cleared of all vegetation. Soil on the drill pad was compacted to support drilling equipment. Based on data from the demonstration plots at Reclamation Trial Site 3 and research conducted elsewhere on the Nevada Test Site, a study was initiated at Well JF-3 to determine the effects of the following three treatments on the emergence and establishment of seeded perennial plants: polyacrylamide gel application, gravel and straw mulch, and polyacrylamide gel in combination with gravel and straw mulch.

The experimental design for this study was a completely randomized 2 x 2 factorial with four replicates. The first factor was type of mulch (straw or gravel) and the second factor was polyacrylamide gel application (gel or no gel). Variables and interactions were tested using analysis of variance. Means were separated using Fisher's Least Significant Difference. Differences in means were considered significant if $P < 0.05$.

The drill pad, except for a short access road (12 x 38 m) to the well head, was ripped in May 1992, with a road grader to alleviate soil compaction. The plots were scarified with a harrow to loosen clods and prepare a firm seedbed. The pad was divided into 16 7- x 33-m plots. A seed mixture that matched vegetation adjacent to the site was broadcast onto the plots at a rate of 42 PLS kg/ha. Polyacrylamide gel was broadcast at a rate of 22.4 kg/ha onto 8 plots. All plots were then harrowed. Wheat straw mulch was applied with a straw blower at a rate of 5,000 kg/ha to half of the plots. The straw was then crimped with a disk-type crimper. A 2.5-cm layer of gravel was applied with a front-end loader to the other half of the plots.

Seedling density was counted in 48 1- x 1-m quadrats within each plot during May and September 1993. In May, the average density on plots receiving the gel application was higher than on plots with no gel, regardless of mulch treatment (Fig. 17). In September average density within the gravel and straw mulch treatments was higher on the gel-treated plots. Density of Nevada ephedra was greater in plots with gel than those with no gel (Fig. 17). The straw + gel combination had significantly higher densities of Nevada ephedra than all other treatment combinations. Polyacrylamide gel application appeared to have a negative effect on creosotebush (*Larrea tridentata*) densities in the gravel treatment; the no gel treatment had significantly more creosotebush than the gel treatment.

In September, the average density was greater on plots with straw than on plots with gravel, regardless of polyacrylamide application (Fig. 17). Density declined 50% in the straw plots from May to September, whereas density in those with gravel declined 72%. Density of white bursage and Indian ricegrass (*Oryzopsis hymenoides*) was



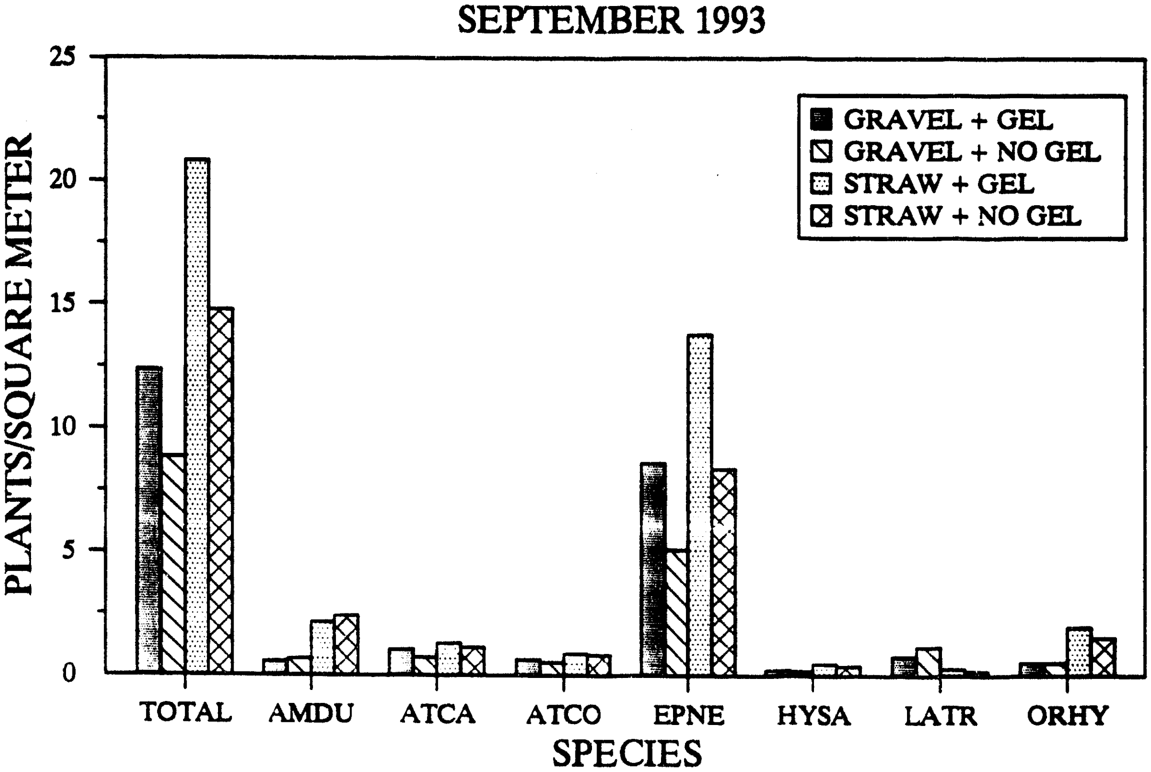


Fig. 17. Average seedling density (plant/m^2) in May and September 1993 on Well JF3. (AMDU = *Ambrosia dumosa*, ATCA = *Atriplex canescens*, ATCO = *A. convertifolia*, EPNE = *Ephedra nevadensis*, HYSA = *Hymenoclea salsola*, LATR = *Larrea tridentata*, ORHY = *Oryzopsis hymenoides*)

significantly greater in the straw treatments (Fig. 17), regardless of gel treatment. Density of creosotebush was significantly greater in the gravel treatments in May and September (Fig. 17).

In May 1993, the application of polyacrylamide gel (gel) appeared to increase seedling density, regardless of the type of mulch. Although the type of mulch did not have an effect on seeded species density in May, it appears that straw mulch was more effective in reducing the number of seeded plants lost during the dry season. The polyacrylamide gel appears to increase plant numbers during the early spring when precipitation is more frequent. Straw mulch appears to provide a more favorable micro-environment that reduces seedling desiccation during hot, dry summer months. Results from this study indicate that the combination of straw mulch and polyacrylamide (straw + gel) may be an appropriate technique for reclamation on similar soils at Yucca Mountain.

4.4.3.2 Trench A'2 Final Reclamation

Trench A'2 was excavated in 1991. The area disturbed during trenching was approximately 20 x 180 m (0.36 ha). A study was conducted at this site to evaluate reclamation procedures that were successful at Reclamation Trial Site 3. The site was divided into 16 10- x 20-m plots, and each plot received a combination of seeding method (broadcast or drill) and mulching type (straw or no straw). During November 1992, the site was ripped with a road grader and then scarified with a harrow to loosen clods and prepare a suitable seedbed. The site was seeded in November 1992 at 21 PLS kg/ha with a mixture similar to vegetation adjacent to the site. One-half of the plots at Trench A'2 were mulched with straw at a rate of 5,000 kg/ha and then crimped. The other half of the plots received no mulch.

Seedling density was measured in late September 1993. The overall seedling density was low, but treatment differences were apparent. The broadcast seeded + straw mulch treatments had significantly higher average seedling densities than the next best treatment combination (Fig. 18). Density in plots with that treatment combination was almost double that in any other treatment combinations. The drill seeded + straw mulch combination had the second highest response. Plots receiving broadcast seed and drill seed with no mulch were lowest and had comparable seedling densities. Responses by species were similar for all treatment combinations. Nevada ephedra and white burrobush (*Hymenoclea salsola*) had significantly higher densities in the broadcast seeded + straw mulch treatment (Fig. 18). White bursage had higher densities in straw mulch treatments regardless of the type of seeding method.

Although seedling density was low at this site, results indicate that straw mulch, especially in combination with broadcast seeding, improves survival of seeded species.

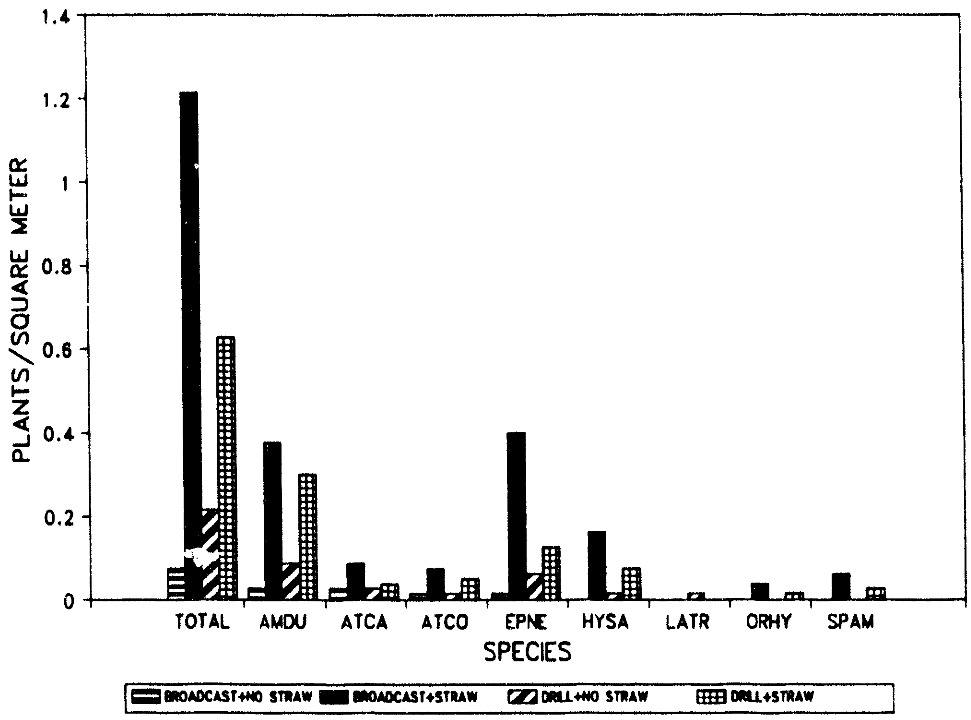


Fig. 18. Average seedling density (plant/m^2) in September 1993, at Trench A'2. (AMDU = *Ambrosia dumosa*, ATCA = *Atriplex canescens*, ATCO = *A. convertifolia*, EPNE = *Ephedra nevadensis*, HYSA = *Hymenoclea salsola*, LATR = *Larrea tridentata*, ORHY = *Oryzopsis hymenoides*, SPAM = *Sphaeralcea ambigua*).

5. MONITORING AND MITIGATION PROGRAM

The goal of the Monitoring and Mitigation Program is to minimize negative impacts of YMP on important plant and animal species, their associated habitat, and important biological resources (e.g., topsoil) (DOE, 1992). Important species include species protected under state or federal regulations.

Preactivity surveys are conducted to identify potential effects of each YMP activity on important species and to develop mitigation recommendations, such as resurveys and monitoring. Postactivity surveys are conducted after each land-disturbing activity has been completed and sites are ready for reclamation. A description of these procedures is in the Terrestrial Ecosystems Environmental Field Activity Plan (DOE, 1992).

5.1 PREACTIVITY SURVEYS

Fifty-five requests for preactivity surveys were received from the Project Office between October 1, 1992, and December 31, 1993. Sixty-three preactivity surveys were conducted for 180 separate sites. An activity may disturb more than one site, and several surveys may be conducted per survey request. Approximately 1,055 ha were surveyed, including approximately 185 ha along 70 km of roads (Table 11). Fifty-two percent of the total area surveyed was for Seismic Reflection Studies.

All surveys were conducted within the range of the desert tortoise. Nineteen tortoises and 12 chuckwallas were found (Table 11). There were 0.8 tortoise sign/km along roads. For all other surveys conducted in tortoise habitat, there were 0.3 tortoise sign/ha. No important plant species were observed during preactivity surveys. Ecological Study Plots, small mammal trapping plots, or reptile sampling plots were present in six sites.

5.2 PREACTIVITY SURVEY REPORTS AND MITIGATION RECOMMENDATIONS

EG&G/EM submitted 66 preactivity survey reports to the Project Office (more than one report was required for some activities). Seventy-seven recommendations were made to minimize the possibility of harming tortoises (Table 12). These included 57 recommendations to conduct resurveys for tortoises prior to construction, 15 recommendations to monitor radiomarked tortoises during construction, and 3 recommendations to move tortoises prior to construction. Two recommendations were made to move or modify proposed activities to avoid Ecological Study Plots.

Table 11. Area surveyed and biological resources found from October 1, 1992, through December 31, 1993.

			Amount surveyed		Survey findings			
Project type	Requests	Sites	Area (ha)	Distance along roads (km)	Tortoises	Tortoise sign	Chuckwallas	Biological Research Plots
Boreholes/infiltration tests	16	19	81.0	3.9		47		1
Hydrological studies	7	29	93.8	9.9		2		
Soil studies/ volcanism studies	3	12	70.5					
Seismic studies/ stations	4	68	546.3	46.8	9	35		
Radiological monitoring stations	1	1	2.0			1		
Facility improvements, road repair/access	4	4	9.1	.3				
Pavement studies	1	1	8.3	.4		1	3	
Exploratory Studies Facility	8	10	121.4	2.7	6	88	2	4
Fault studies	6	21	38.8	.3	3	12	1	
C-Well	2	4	48.6	3.1	1	6		1
Other	3	11	35.5	3.0		2	6	1
Total	55	180	1,055.3	70.4	19	194	12	7

Table 12. Mitigation recommendations made for YMP activities from October 1992 through December 1993.

Project type	Requests received	Sites	Relocate or redesign activity	Tortoise resurvey	Tortoise monitoring	Displace or relocate tortoises	Salvage topsoil
Boreholes/ infiltration tests	16	19	1	13	[illegible]		11
Hydrological studies	7	29		8			
Soil studies/ volcanism studies	3	12		3			3
Seismic studies/ stations	4	68		8	1		
Radiological monitoring stations	1	1					
Facility improvements, road repair/access	4	4		2			2
Pavement studies	1	1		1			1
Exploratory Studies Facility	8	10		11	5	3	9
Fault studies	6	21		3	4		6
C-Well	2	4	1	3			1
Other	3	11		5	1		4
Total	55	180	2	57	15	3	37

5.3 MITIGATION ACTIONS

Biologists conducted resurveys one to ten days prior to ground clearing for 26 activities (Table 13). During these resurveys, biologists collapsed 62 unoccupied tortoise burrows and five other burrows after tortoises were removed. Fifteen tortoises were displaced from four construction areas (Table 13). See Section 3.8 for a description of these displacements. Radiomarked tortoises were monitored at 13 sites (Table 13). No burrows were collapsed during tortoise monitoring. No tortoises entered construction areas during activities.

Table 13. Mitigation actions taken from October 1, 1992, through December 1, 1993, for YMP activities.

Project Type	Topsoil stabilized	Tortoise resurveys conducted	Tortoise monitoring conducted	Tortoises displaced or relocated	Post-activity surveys conducted
Boreholes /infiltration tests	1	6	3	3	2
Soil Studies/ Volcanism Studies	15				1
Seismic Studies/ Stations		2	1		
Borrow Pits		1	1	10	
Pavement Studies		1	1		
Exploratory Studies Facility	3	6	5	2	
Fault Studies		8	2		
Other		2			
Total	19	26	13	15	3

5.4 INCIDENTAL TAKE

One tortoise was killed during construction activities. Tortoise #460 was run over by construction equipment along the access road to the NRG-4 drill pad on May 19, 1993. As required in the Biological Opinion for YMP, the U.S. Fish and Wildlife Service was immediately informed of this mortality.

5.5 RECLAMATION INVENTORIES

Reclamation Inventories were conducted for 39 activities. Reclamation stipulation reports were prepared for each activity and topsoil salvaging was recommended for 37 of these activities. Topsoil stockpiles were stabilized at 19 sites (See Section 4.3.2).

5.6 POST-ACTIVITY SURVEYS

Thirty-seven disturbed sites from two activities were released for final reclamation. Postactivity surveys were conducted and final reclamation plans were prepared for these sites.

6. RADIOLOGICAL MONITORING PROGRAM

The objectives of the Radiological Monitoring Program are to collect plant and animal specimens for measurement of radionuclide concentrations in tissues and to monitor populations of animals that are being collected or may be collected in the future. Small mammals, deer forage, and livestock forage were collected in 1993. Small mammal, lagomorph, predator, and quail populations were monitored.

6.1 SMALL MAMMAL COLLECTION AND MONITORING STUDY

Small mammals continued to be used as indicator species to characterize existing radionuclide levels in the environment as well as to monitor unsuspected release pathways. Small mammals were collected on six near-field (NF) treatment plots, one near-field control plot (NF12), and one far-field control plot (FF58).

Study plots were established within the Yucca Mountain area in 1988 and 1989 to monitor planned activities. Since then, locations of activities have changed, and new small mammal collection plots were established adjacent to new locations of extant or proposed activities. Sites were established adjacent to the North Portal pad (NF107), the proposed South Portal (NF103), and the proposed muck storage area (NF110). Two existing monitoring plots (NF2 and NF5) were not trapped. These plots were associated with the original location of the Exploratory Shaft Facility in Drill Hole Wash. Two other sites (NF37 and NF69) were trapped once and are no longer being used. The muck storage that was proposed for these sites is now expected to occur near the new plot NF110.

Precipitation was above average from fall 1992 through spring 1993. This produced good annual plant growth and good habitat conditions for small mammal populations. Because Merriam's kangaroo rats and long-tailed pocket mice remained abundant, specimens of both species were collected on all existing plots in October 1992, and on all plots except NF37 and NF69 in April 1993 (Table 14). Collected specimens were placed in a super-cold storage freezer, and their custody was tranferred to Science Application International Corporation (SAIC). Results of the tissue analysis for radionuclide levels will be provided by SAIC. The new plots (NF103, NF107, and NF110) were also trapped in June and July to learn more about the abundance of Merriam's kangaroo rats and long-tailed pocket mice at these sites. These plots were first trapped in October 1992 or April 1993. Total sampling effort for 1993 was 16,068 trap-nights. This is a 22% reduction from 1992 because of the changes in monitoring plots.

6.2 DEER FORAGE COLLECTION

Mule deer (*Odocoileus hemionus*) occur in low numbers at Yucca Mountain. Because mule deer are a game species and are hunted on nearby public lands, they represent a

Table 14. Number of Merriam's kangaroo rats and long-tailed pocket mice captured on the radiological monitoring small mammal plots, October 1992-September 1993. Numbers in parentheses are individuals collected for analysis of radionuclide body-burdens.

Plot	Species	October	April	June	July
NF12	Merriam's kangaroo rat	109(11)	113(12)		
	Long-tailed pocket mouse	155(23)	69		
NF37	Merriam's kangaroo rat	96(16)			
	Long-tailed pocket mouse	279(27)			
FF58	Merriam's kangaroo rat	61(13)	172(36)		
	Long-tailed pocket mouse	30	42		
NF59	Merriam's kangaroo rat	134(20)	110(12)		
	Long-tailed pocket mouse	167(28)	168(20)		
NF69	Merriam's kangaroo rat	68(12)			
	Long-tailed pocket mouse	179(23)			
NF103	Merriam's kangaroo rat	57(13)	75(12)	75	61
	Long-tailed pocket mouse	165(26)	123(20)	144	103
NF107	Merriam's kangaroo rat	68(13)	77(11)	72	66
	Long-tailed pocket mouse	143(21)	76(20)	83	66
NF110[1]	Merriam's kangaroo rat		89(12)	95	84
	Long-tailed pocket mouse		94(19)	119	82

[1]NF110 was established in April 1993

potential pathway for radionuclides to humans. Deer move over an area much larger than Yucca Mountain, including portions of the NTS; therefore, it is impossible to attribute any detectable levels of radionuclides in deer tissue to the Yucca Mountain area. Hence, an indirect method was used to monitor existing levels of radionuclides in samples of forage species that may be consumed by deer.

In July 1993, 34 forage samples representing 11 plant species were collected from 26 sample plots. Samples were transferred to the custody of SAIC in July 1993. Results of the radionuclide analysis of the forage samples will be published by SAIC.

6.3 LIVESTOCK FORAGE COLLECTION

Cattle are grazed on public grazing allotments west and northwest of the Yucca Mountain project area. Radionuclides present on plants consumed by cattle are a potential pathway for radionuclides to humans. Plant species commonly eaten by cattle are being collected and analyzed to estimate existing levels of radionuclides in these areas. No grazing is allowed on the NTS; however, stray cattle have occasionally been observed in the Yucca Mountain area. No confirmed sightings have been reported during the past two years.

Seven sample locations were established in 1993, five in the Razorback grazing allotment and two in the Mt. Sterling grazing allotment. The Razorback allotment is the closest allotment to Yucca Mountain and is 12-28 km northwest of the Exploratory Studies Facility (ESF). The Mt. Sterling allotment is 52-68 km southeast of the ESF. The location of sample sites within the grazing allotments was determined by laying the circular sampling grid for the YMP Radiological Monitoring Program (RMP) over a map of the grazing allotments. The RMP sampling grid is centered on the ESF and divided into grid cells using polar coordinates (an angle and distance) (SAIC, 1990). One sample site was systematically selected within each grid cell that intersected a grazing allotment. Each site was marked with a metal t-post and labeled. Plant samples were collected by walking through the area surrounding the t-post (within 500 m) and clipping selected plant parts as they were encountered.

Grasses and four shrub species, Nevada ephedra, green ephedra (*Ephedra viridis*), winterfat, and big sagebrush (*Artemisia tridentata*), were selected as indicator species based on observations of grazing cattle and previous studies on NTS (Gilbert et al., 1988). Three plant species were collected at each site if they were present. Because the abundance of grasses was very low, grasses were collected as a composite sample containing two or more of the following species: desert needlegrass (*Stipa speciosa*), red brome, cheatgrass (*Bromus tectorum*), galleta, Sandberg's bluegrass (*Poa sandbergii*), Arabian Mediterranean grass (*Schismus arabicus*), and bottlebrush squirreltail (*Sitanion hystrix*). Cattle fecal samples were collected near the sample sites to better estimate diets through fecal analysis techniques. This information will be used to help make future decisions of which species to collect.

Fourteen forage samples were collected at seven locations in August 1993. Custody of the samples was transferred to SAIC for analysis.

6.4 LAGOMORPH SURVEYS

Spotlight surveys continued to be used to monitor lagomorph abundance. The Crater Flat route (31 km) (far-field control sample) and the Yucca Mountain route (40 km) (near-field sample) monitored in 1992 were again monitored in 1993. Routes were surveyed for three consecutive nights in July and August. Surveys were conducted with three people, one person on each side of the vehicle using spotlights and a third person driving at 5-10 mph.

Lagomorphs continued to increase in numbers in 1993 (Table 15). An average of 17.1 and 18.3 lagomorphs per 10 km of road were observed along the Crater Flat and Yucca Mountain routes, respectively. All lagomorphs seen were either black-tailed jackrabbits (*Lepus californicus*) or desert cottontails (*Sylvilagus audubonii*).

Kit foxes (*Vulpes velox macrotis*) and coyotes (*Canis latrans*) were observed at least once during each survey.

Table 15. Average number of lagomorphs[1] counted per 10 km during spotlight surveys at Yucca Mountain (40 km) and Crater Flat (31 km) in 1991, 1992, and 1993.

Date	Yucca Mountain	Crater Flat
May/June 1991	0.25	1.9
July 1992	10.3	8.0
July/August 1993	18.3	17.1

[1]Lagomorphs include black-tailed jackrabbits and desert cottontails

6.5 GAMEBIRD MONITORING

Mourning doves (*Zenaida macroura*) that nest in or migrate through the Yucca Mountain area are potential pathways for radionuclides to humans if they are harvested by hunters off of NTS. Because migratory mourning doves may be exposed to radionuclides outside of Yucca Mountain, it is difficult to attribute any radionuclides in doves to potential sources at Yucca Mountain. Therefore, Gambel's quail (*Callipepla gambelii*) are being used to model potential radionuclide body burdens in mourning doves. Gambel's quail have similar foraging habits to mourning doves and are residents at Yucca Mountain.

A study was started in 1992 to monitor Gambel's quail populations at Yucca Mountain to determine if quail could be collected from Yucca Mountain around the ESF and a potential control area 5 km east near the confluence of Fortymile and Sever Washes. A second objective was to determine if quail move between the ESF and the potential control site. If quail move between the two areas, the Fortymile/Sever Wash area can not be considered a near-field control area. In 1992, one of twelve radiomarked quail moved between the two areas. This study continued in 1993 to collect several specimens for the analysis of radionuclide body burdens, better determine if quail moved between the two sites, and monitor quail populations.

Quail were trapped in October 1992 and February 1993 using walk-in traps. Traps were prebaited two weeks prior to trapping. Captured quail were weighed, aged (using molt stage), sexed, and legbanded. A sample of quail was radiomarked with battery-powered radio transmitters attached to necklaces. The solar-powered transmitters used in 1992 proved to be unreliable.

Radiomarked quail were located daily during the first week after their capture to check whether the transmitters adversely affected behavior or movements. These quail were then located once each week. During the nesting season, number of eggs layed and hatched were recorded for each nest found.

Sixty quail were captured in October 1992 near the ESF. Three of these were collected for analysis of radionuclide body burdens. Thirteen males and eleven females were radiomarked. Two quail, both females radiomarked in March 1992, were still alive. Therefore, twenty-six quail were monitored. Twelve of these quail (eight males and four females) died between October 1992 and February 1993. The winter survival rate was 54%.

Five new quail were captured and radiomarked in February 1993. All were captured in the control area. These five and the surviving fourteen from October were monitored until July 1993. By July, eight females and five males were dead. Radio contact with two males and one female was lost; therefore, their fate was unknown. They were not included in the estimate of survival. Two males and one female (19%) survived through the nesting period. A survival rate this low is not uncommon in quail populations (Pollock et al., 1989). Direct causes of mortality were not confirmed but were thought to have been mammalian predators in most cases or possibly avian predators.

Five quail were located on nests in 1993. The earliest nesting date was May 5 and the latest was June 6. Four of the five clutches hatched. Clutch size ranged from 10 to 15 eggs ($\bar{x}=14$). Hatching success was 98% (n=53) for the four successful clutches.

Much of the quail activity at Yucca Mountain in 1993 occurred near the proposed site of the muck storage area. In 1992, quail congregated more around the subdock. One radiomarked quail moved from the ESF area to the potential control area in 1993. Although there was some movement between the Fortymile/Sever Wash area and the ESF (one radiomarked quail in each of 1992 and 1993), most radiomarked quail stayed within the area where they were caught.

6.6 COLLECTION OF BIOLOGICAL SPECIMENS

Biological specimens have been collected to determine radionuclide levels in plants and animals since 1989. The specimens collected each year have been summarized in annual reports (EG&G/EM, 1991; 1992; 1993). This information is compiled in Table 16 to provide a summary of collections made during the past five years. No collections are scheduled for 1994.

Small mammals were collected in all years except 1990. Population levels were low in the spring of 1990 because of drought conditions, and it was decided to collect samples in October. However, in July, the State of Nevada did not re-issue EG&G/EM's handling permit so collections could not be made then. As locations of the Exploratory Studies Facilities have changed, new collection sites (NF103, NF107, and NF110) were added, and some original sites (NF2, NF5, NF14, NF37, and

Table 16. Number of individual animals or samples of plant species collected for the YMP Radiological Monitoring Program during 1989-1993.

	Plot	Year 1989		1990		1991		1992		1993
		April	October	April[b]	October[c]	April	October	April	October	April
Small Mammals										
Long-tailed pocket mice	NF2		-[a]	-	-	-	26	20	-	-
	NF5	21			-	20	25	20	-	-
	NF12				-	-		21	23	
	NF14				-			20	-	-
	NF37	20			-	20	25	21	27	-
	FF58				-					
	NF59				-			21	28	20
	NF69		17		-	20	25	22	23	-
	NF103	-	-	-	-	-	-	-	26	20
	NF107	-	-	-	-	-	-	-	21	20
	NF110	-	-	-	-	-	-	-		19
Merriam's kangaroo rat	NF2	-	-	-	-	-			-	-
	NF5				-			12	-	-
	NF12	12			-	-	13	12	11	12
	NF14	12			-	12	14	11	-	-
	NF37				-			12	16	-
	FF58	12			-		14	12	13	36
	NF59	12			-	12	14	12	20	12
	NF69	5			-			12	12	-
	NF103	-	-	-	-	-	-	-	13	12
	NF107	-	-	-	-	-	-	-	13	11
	NF110	-	-	-	-	-	-	-		12
Deer Forage[d]		-[e]		17		30		33		34
Livestock Forage[d]		-		-		-		-		14
Lagomorphs		-		-		-		3[f]		-
Gambel's quail		-		-		-		3		-

[a](-) indicates that no collection effort was made

[b]No animals collected because of low population numbers; collections were postponed to October 1990.

[c]No trapping and collecting done in October 1990 because the State of Nevada withheld the EG&G/EM handling permit.

[d]Deer and livestock forage were collected in July and August

[e]No samples collected because of insufficient plant growth.

[f]All three were roadkilled black-tailed jackrabbits

NF69) were discontinued. Samples of deer forage have been collected for four years. No samples were collected in 1989 because of little plant growth. Livestock forage samples were first collected in 1993. Jackrabbits were collected opportunistically when fresh roadkilled individuals were found.

7. BIOLOGICAL SUPPORT

EG&G/EM completed special studies and reports, document reviews, presentations, tours, and permit acquisitions in support of YMP. Support also was provided for quality assurance, safety, and facility/equipment acquisition. These activities were conducted to assist the Project Office in complying with the Nuclear Waste Policy Act, Endangered Species Act, and DOE orders.

7.1 DOCUMENT REVIEW AND REVISION

EG&G/EM reviewed the Environmental Monitoring and Mitigation Plan Progress Report and the Site Environmental Report for calendar year 1992. Study designs for studies in the Terrestrial Ecosystem Program continued to be developed and revised to ensure that goals and objectives of the YMP Environmental Program were being met.

7.2 REPORTS AND SPECIAL REQUESTS

EG&G/EM provided the Project Office with weekly and monthly reports of activities and accomplishments. An annual report of progress and accomplishments for fiscal year 1992 was published as a topical report (EG&G/EM, 1993). The annual report of animals collected and handled under EG&G/EM's State of Nevada Scientific Collection Permit was submitted to the Nevada Department of Wildlife. Monthly reports were written prepared for the U.S. Fish and Wildlife Service describing displacements and relocations of tortoises at Yucca Mountain. An annual report was prepared for the U.S. Fish and Wildlife Service describing activities conducted under EG&G/EM's Federal Endangered and Threatened Species Handling Permit (PRT-683011). Budget estimates and scopes of work for fiscal year 94 were submitted to the Project Office. EG&G/EM participated in a mid-year financial review at the request of the Project Office.

7.3 PRESENTATIONS, MEETINGS, AND PUBLIC TOURS

EG&G/EM staff scientists presented two papers at the annual meeting of the Society for the Study of Amphibians and Reptiles. Both papers were based on tortoise studies being conducted at Yucca Mountain. Staff scientists also presented one paper and four posters at the Arid Lands Symposium held in Las Vegas. These presentations were based on vegetation and reclamation studies being conducted at Yucca Mountain. EG&G/EM also organized and conducted a field tour of the YMP reclamation sites for 34 symposium participants representing 23 federal, state, and private agencies and educational institutions.

EG&G/EM participated in several meetings and tours for the Nuclear Waste Technical Review Board (TRB). In April 1993, the TRB toured Yucca Mountain. EG&G/EM scientists gave several briefings to tour participants on the terrestrial ecosystem program. In July EG&G/EM presented an overview to the TRB of the possible effects on the terrestrial ecosystem from increased ground temperatures that may be caused by long-term underground storage of nuclear waste. In November

1993, the Environment and Health Panel of the TRB met in Las Vegas to review the YMP Terrestrial Ecosystems Program. EG&G/EM staff scientists presented the program to the Panel and responded to questions from the Panel and their expert consultants.

EG&G/EM participated in 11 Public Outreach tours and the biannual public update meetings. Staff scientists presented a public talk on desert tortoise ecology and conservation at the Yucca Mountain Information Offices in Las Vegas and in Beatty. A mid-year review of the Biological Resources Monitoring Program was presented to the Project Office. Throughout the year, EG&G/EM participated in meetings to provide input to the budgeting process and assist with project planning.

7.4 QUALITY ASSURANCE

EG&G/EM continued to prepare Instructions for new studies and to review and revise existing Instructions to ensure that work was conducted according to accepted procedures. A management self-assessment was conducted in May to evaluate compliance for several Instructions. The self-assessment was conducted by the Director of the Environmental Sciences Division and Work Package Managers with support from EG&G/EM Quality Services Division.

7.5 SAFETY

Safety and compliance with established environmental and health standards have been priorities for EG&G/EM. Staff meetings have included discussions of operational safety. Monthly and quarterly YMP safety meetings were attended by EG&G/EM representatives to ensure compliance with the Environmental Safety Health Program Implementation Plan. EG&G/EM participated in a DOE environmental audit.

In the spring of 1993, an outbreak of respiratory infection in humans caused by a hantavirus occurred in the Four Corners region of the southwestern United States. The infection caused a number of deaths. The deer mouse was confirmed as one of the primary carriers of the hantavirus. In July 1993, the first case of human infection by hantavirus was confirmed in Nevada approximately 150 miles north of the Nevada Test Site. Because of the proximity and the lack of information about hantavirus infection, EG&G/EM stopped trapping small mammals at Yucca Mountain in late July. The Centers for Disease Control (CDC) and EG&G/EM conducted a field study to test for the presence of hantavirus antibodies in blood samples from small mammals at Yucca Mountain. The objective was to gather information on hantavirus infection rates in small mammal species commonly handled so more informed decisions on safety precautions could be made. In August, blood was drawn from 497 animals from nine rodent species, including deer mice. Results of blood tests were received from CDC in October. All blood samples tested negative for the presence of hantavirus antibodies, suggesting that these animals have not been exposed. Therefore, the risk of human infection is very low at Yucca Mountain. A decision on safety precautions to be followed when handling small mammals will be developed prior to trapping in 1994.

8. LITERATURE CITED

Allen, E. B. 1984. Role of mycorrhizae in mined land diversity. In F. F. Munshower and S. E. Fisher, eds. Proceedings of the Third Biennial Symposium on Surface Coal Mine Reclamation in the Great Plains.

Anderson, D. C. 1987. Evaluation of Habitat Restoration on the Naval Petroleum Reserve #1, Kern County, California. EG&G/EM Santa Barbara Operations, Report No. 10282-2179.

Beatley, J. C. 1976. Vascular Plants of the Nevada Test Site and Central-Southern Nevada: Ecological and Geographical Distributions. U. S. Energy Research and Development Administration Report TID-26881.

DOE (U.S. Department of Energy). 1989. Draft Reclamation Program Plan for Site Characterization. U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Washington, D.C., Report No. DOE/RW-0244.

DOE (U.S. Department of Energy). 1992. Environmental Field Activity Plan for Terrestrial Ecosystems. U.S. Department of Energy, Office of Civilian Radioactive Waste Management, Washington, D.C., Report No.YMP/91-41.

EG&G/EM (EG&G Energy Measurements, Inc). 1991. Yucca Mountain Biological Resources Monitoring Program Annual Report FY89 & FY90, EG&G/EM Santa Barbara Operations, Report No. 10617-2084.

EG&G/EM (EG&G Energy Measurements, Inc). 1992. Yucca Mountain Biological Resources Monitoring Program Annual Report FY91, EG&G/EM Santa Barbara Operations, Report No. 10617-2127.

EG&G/EM (EG&G Energy Measurements, Inc). 1993. Yucca Mountain Biological Resources Monitoring Program Annual Report FY92, EG&G/EM Santa Barbara Operations, Report No. 10617-2195.

Gilbert, R. O., J. H. Shinn, E. H. Essington, T. Tamura, E. M. Romney, K. S. Moor, and T. P. O'Farrell. 1988. Radionuclide transport from soil to air, native vegetation, kangaroo rats and grazing cattle on the Nevada Test Site. Health Physics 55:869-887.

Graves, W. L., B. L. Kay, and W. A. Williams. 1978. Revegetation of disturbed sites in the Mojave Desert with native shrubs. California Agriculture 32:4-5.

Green, R. A., M. K. Cox, T. B. Doerr, T. P. O'Farrell, W. K. Ostler, K. R. Rautenstrauch, and C. A. Wills. 1991. Assessing impacts on biological resources from site characterization activities of the Yucca Mountain Project. Proceedings of the High Level Radioactive Waste Management Conference 2:1456-1460.

Hargis, N. E., and E. F. Redente, 1984. Soil handling for surface mine reclamation. Journal of Soil and Water Conservation 39:300-305.

Jacobson, E. R., J. M. Gaskin, M. B. Brown, R. K. Harris, C. H. Gardiner, J. L. LaPointe, H. P. Adams, and C. Reggiardo. 1991. Chronic upper respiratory tract disease of free-ranging desert tortoises (*Xerobates agassizii*). Journal of Wildlife Diseases 27:296-316.

Karl, A. 1981. The distribution and relative densities of the desert tortoise, *Gopherus agassizi*, in Lincoln and Nye cunties, Nevada. Desert Tortoise Council Proceedings 1981:76-92.

Kay, B. L. 1979. Summary of Revegetation Attempts on the Second Los Angeles Aqueduct. University of California, Davis, Agronomy and Range Science Department, Mojave Revegation Notes No. 22.

O'Farrell, T. P., and E. Collins. 1984. 1983 Biotic Studies of Yucca Mountain, Nevada Test Site, Nye County, Nevada. EG&G/EM Santa Barbara Operations, Report No. 10282-2031.

Ostler, W. K., and K. L. Allred. 1987. Accelerated Recovery of Native Vegetation on Roadway Slopes Following Construction. Vol. 1, General Principles. U.S. Department of Transportation, Federal Highway Administration Report No. FHWA/DF-871005.

Plummer, A. P., D. R. Christensen, and S. B. Monsen. 1968. Restoring Big-game Range in Utah. Utah Division of Fish and Game Report No. 68-3.

Pollock, K. H., C. T. Moore, W. R. Davidson, F. E. Kellogg, G. L. Doster. 1989. Survival rates of bobwhite quail based on band recovery analyses. Journal of Wildlife Management 53:1-6.

Rautenstrauch, K. R., M. K. Cox, T. B. Doerr, R. A. Green, J. M. Mueller, T. P. O'Farrell, and D. L. Rakestraw. 1991. Management and research of desert tortoises for the Yucca Mountain Project. Proceedings of the High Level Radioactive Waste Management Conference 2:1449-1455.

SAIC (Science Application International Corporation). 1990. Radiological Environmental and Safety Monitoring Implementation Plan. SAIC, Las Vegas, Nev., Report No. TMSS/RFPD-90/003.

Schumacher, I. M., M. B. Brown, E. R. Jacobson, B. R. Collins, and P.A. Klein. 1993. Detection of antibodies to a pathogenic Mycoplasma in desert tortoises (*Gopherus agassizii)* with upper respiratory tract disease. Journal of Clinical Microbiology 31:1454-1460.

Schuman, G. E., and J. F. Power. 1981. Topsoil management on mined lands. Journal of Soil and Water Conservation 36:77-78.

Trappe, J. M. 1981. Mycorrhizae and productivity of arid and semiarid rangelands, In J. T. Manassha and E. J. Briskey, eds., Advances in Food Producing Systems for Arid and Semi Arid Lands. Academic Press, Inc., New York, pp. 581-599.

Vallentine, J. F. 1989. Range Development and Improvements, Third ed. Academic Press, Inc., San Diego.

Wallace, A., E. M. Romney, and R. B. Hunter, 1980. The challenge of a desert: revegetation of disturbed desert lands. Great Basin Naturalist Memoirs 4:216-225.

DISTRIBUTION

DOE/HQ

OSTI (2)

DOE/NV

Technical Information Officer (1)

DOE/YMP

W.R. Dixon (1)
R.M. Nelson (1)
M.E. Ryder (1)

SAIC

E.W. McCann (1)
J.K. Prince (1)
T.N. Pysto (1)
C.D. Sorenson (1)

EG&G/EM

P.H. Zavattaro (1)
Technical Information Center (1)

EG&G/EM SBO

L.A. Franks (1)

EG&G/EM YMP/RSL

J.W. Beckett (1)
D.W. Brickey (1)
C.E. Ezra (1)
S.M. Kowalkowski 1)

EG&G/EM ESD

D.C. Anderson (1)
J.P. Angerer (1)
M.M. Annear (1)
K.R. Balzer (1)
K.W. Blomquist (1)
S.R. Blomquist (1)
G.A. Brown (1)
C.A. Callison (1)
A.E. Gabbert (1)
W.D. Gabbert (1)
R.G. Goodwin (1)
R.A. Green (1)

EG&G/EM ESD (continued)

E.A. Holt (1)
A.L. Hughes (1)
T.T. Kato (1)
V.R. Kelly (1)
T.A. Lindemann (1)
G.E. Lyon (1)
J.M. Mueller (1)
T.P. O'Farrell (1)
W.K. Ostler (1)
D.L. Pack (1)
D.L. Rakestraw (1)
K.R. Rautenstrauch (1)
B.A. Rea (1)
J.H. Scrivner (1)
G.T. Sharp (1)
C.L. Sowell (1)
M.D. Walo (1)
C.A. Wills (1)
V.K. Winkel (1)
K.K. Zander (1)

REECo

R.B. Hunter (1)
B.D. Woodard (1)

DATE

FILMED

10/21/94

END