EG&G ENERGY MEASUREMENTS

EGG 11265-1136
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YUCCA MOUNTAIN BIOLOGICAL RESOURCES MONITORING PROGRAM

PROGRESS REPORT JANUARY 1994-DECEMBER 1994

JULY 1995

LAS VEGAS AREA OPERATIONS
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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 permit S 9480 granted by the Nevada Department of Wildlife. Permission to capture, mark, and collect mammals, and reptiles was provided by the Nevada Department of Wildlife through permit S 9480. Maps (except Fig. 1) were produced by the EG&G/EM Remote Sensing Laboratory, Yucca Mountain Support Office. These maps were produced in December 1994 and January 1995, 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. The use of brand names in this report does not constitute endorsement by the U. S. Department of Energy.

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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 January 1994 through December 1994 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. 1.1). 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) and Niles et al. (1994).

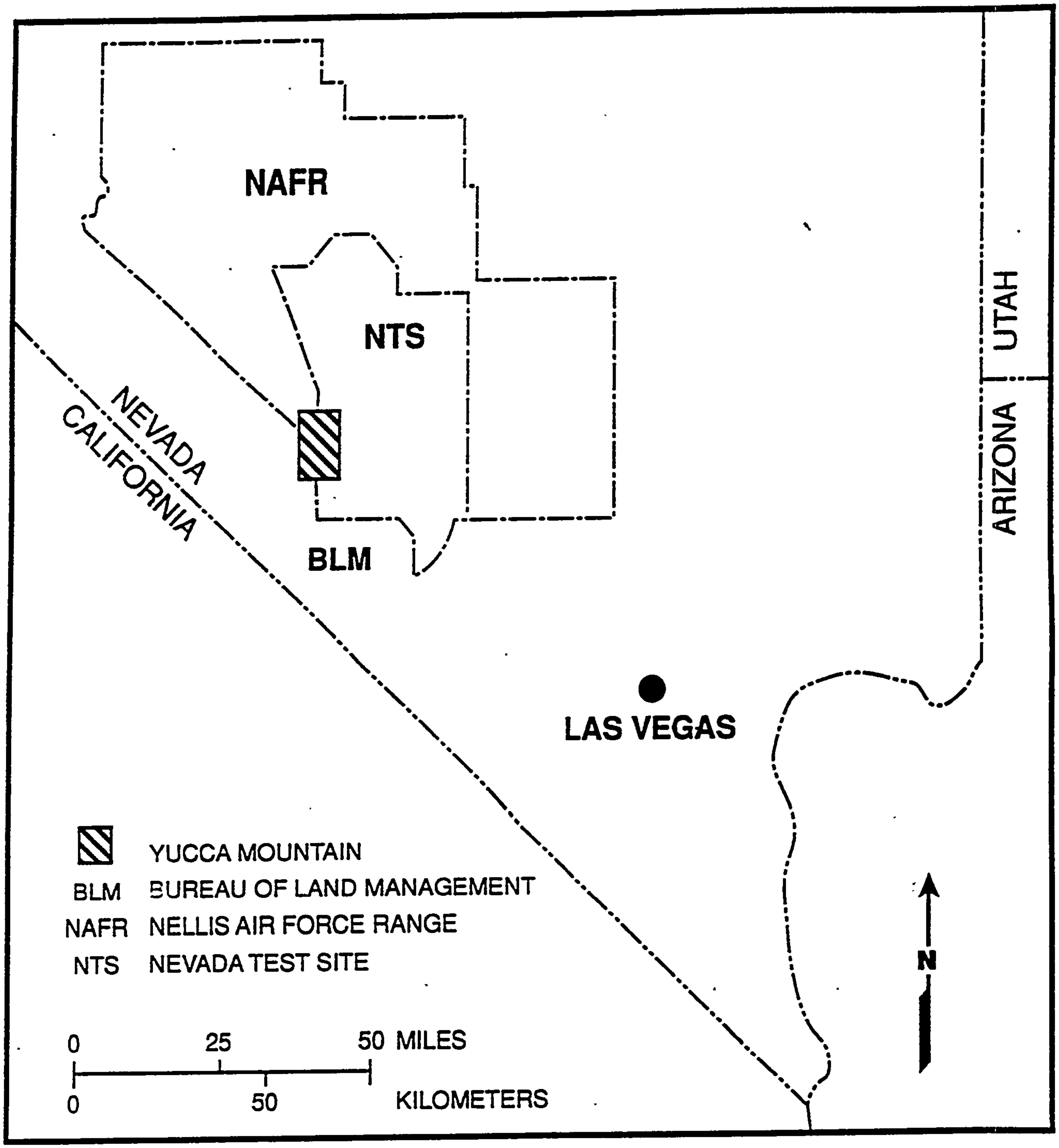

Fig. 1.1. Location of the Yucca Mountain Site Characterization Project, Nye County, Nevada.

2. SITE CHARACTERIZATION EFFECTS PROGRAM

The studies in the Site Characterization Effects Program (SCEP) are 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

Data were collected using the design described in EG&G/EM (1991, 1992, 1993) and Green et al. (1991). The sample units are 200- x 200-m ecological study plots (ESPs) stratified among four vegetation associations. Within each association, six plots are located adjacent to disturbances (treatment) and six are located at least 200 m from disturbances (control).

A major accomplishment during 1994 was redesigning the SCEP. The redesign incorporates suggestions made by the Nuclear Waste Technical Review Board (NWTRB 1994) to discontinue monitoring areas that now are known not to be near major site characterization activities, and only monitor areas of greatest activity, locating new ESPs in these areas if necessary. The board also recommended establishing far-field control ESPs to help evaluate whether the existing control plots are too close to disturbances.

There were three primary reasons for redesigning the SCEP. First, after monitoring biotic communities at Yucca Mountain for six years, no evidence of significant impacts have been detected. Second, the location of the major disturbances expected from site characterization are better known. The design of the site characterization studies have changed since the SCEP was first designed. During 1994, the location of several expected major disturbances (muck storage area, and general support facility) were identified and surveyed in the field. Third, most of the disturbances during site characterization will occur in the *Larrea-Lycium-Grayia* vegetation association. Therefore, there is little need to continue an extensive monitoring program in all four vegetation associations.

Sampling will be restricted to the *Larrea-Lycium-Grayia* vegetation association near the Exploratory Study Facilities where most of the construction activity is planned. Starting in 1995, 18 ESPs will be monitored: 6 treatment plots, 6 existing control plots, and 6 new far-field control plots (Fig. 2.1). Included in the 18 plots are two of the existing *Larrea-Lycium-Grayia* treatment ESPs and the existing six control ESPs. Four new treatment ESPs were located adjacent to anticipated construction zones: general support facility site, the muck storage area for the exploratory tunnel, the north portal facility, and the south portal site. These sites were selected because it is likely that indirect disturbance would be greatest adjacent to these large (greater than several hectares) disturbances. Treatment ESPs are designed to measure effects of indirect disturbances such as dust, noise, and water run-off from direct disturbances (removal of vegetation and construction activity). The south portal ESP was not established pending better information on the exact location of the portal pad.

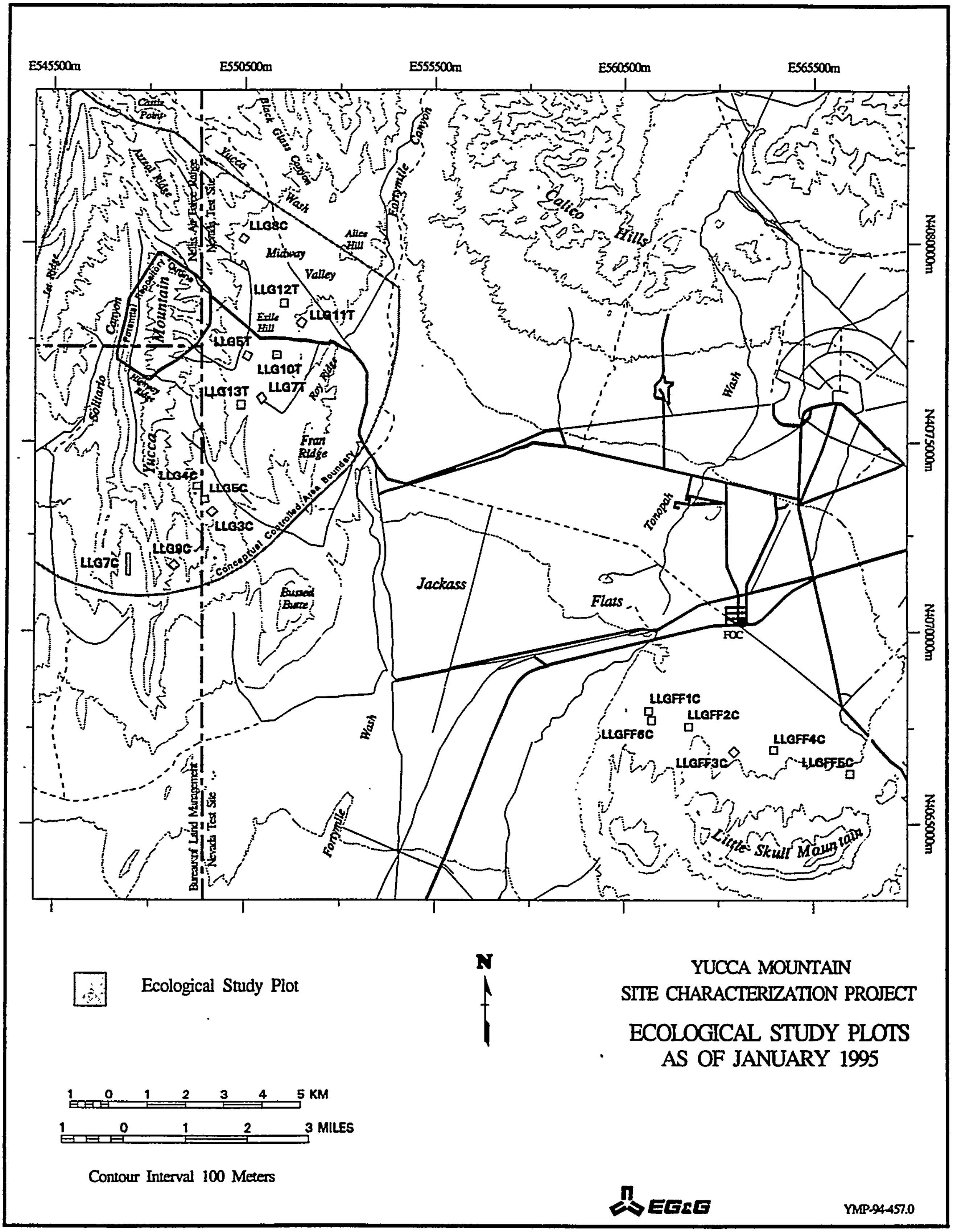

Fig. 2.1. Location of ecological study plots for the redesigned Site Characterization Effects Program.

The new far-field controls were located with the following constraints: 1) located 10 to 30 km from Yucca Mountain, 2) located in similar *Larrea-Lycium-Grayia* vegetation, 3) accessible to field workers, 4) located at least 200 m from dirt or paved roads, and 5) located randomly. Potential areas meeting these criteria were located in the vicinity of Little Skull Mountain approximately 15 km southeast of Yucca Mountain. Suitable vegetation was mapped using a combination of field visitation and statistical ordination of sample data. All potential *Larrea-Lycium-Grayia* vegetation in the vicinity of Little Skull Mountain was delineated and stratified into six blocks of approximately equal area. One far-field control ESP was located randomly within each block by selecting random x-y coordinates on a grid overlay of each block.

Matching vegetation in the far-field control plots to plots near Yucca Mountain was important because potential impacts at Yucca Mountain could alter the species composition rather than change the amount of vegetation. Similarity of vegetation was assessed primarily by detrended correspondence analysis (DCA) ordination (Gauch 1982, and Pielou 1984), and augmented by field observations and discriminant analysis (Manly 1986). Ordination is used to project data from a large number of species onto a graph that reveals intrinsic patterns among locations (Pielou 1984). The percent cover of 43 species of shrubs and perennial grasses from ESPs at Yucca Mountain was condensed into three DCA axes that explained 43% of the variation in species composition among ESPs. Figure 2.2 is a graph of the 48 ESPs on the basis of their DCA axis scores. Generally, the 12 ESPs from each vegetation association are clustered on the graph, indicating that the four vegetation associations are different. To determine the vegetation association of unknown areas, such as Little Skull Mountain, percent cover was measured in the field, and then projected onto the graph. Annotations 1 through 4 on Figure 2.2 show examples of sample data that have been projected onto the DCA ordination. Ordination has previously been shown to be a valuable tool in assessing Mojave Desert vegetation (El-Ghonemy et al. 1980).

Far-field control ESPs were relocated if the vegetation was dissimilar (based on DCA and discriminant analysis) to the vegetation on the new treatment ESPs. All ESPs, both control and treatment locations, have the same dimensions and transect spacings as existing ESPs.

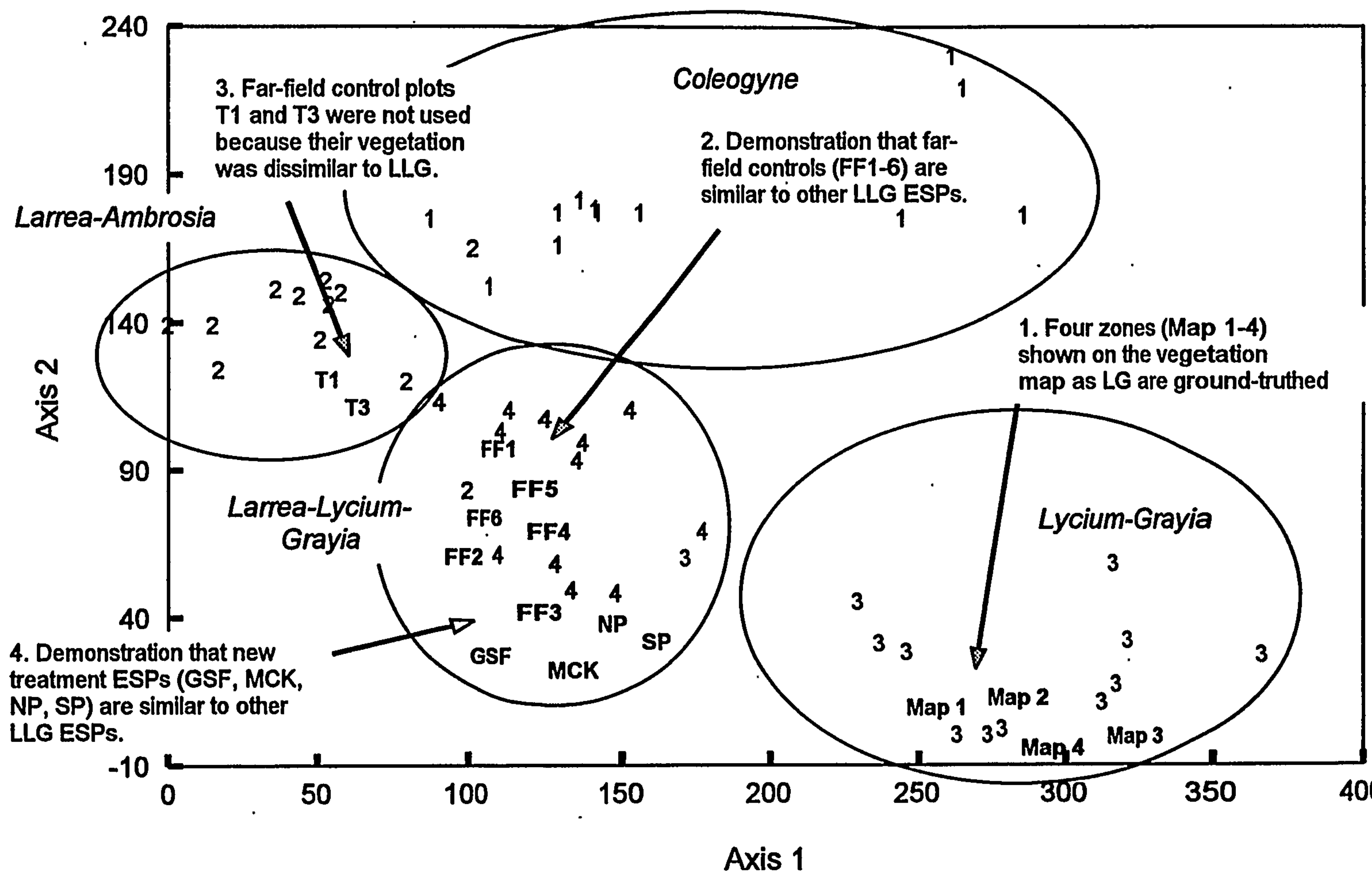

Fig. 2.2. DCA (Detrended Correspondence Analysis) ordination of 48 ESPs from 4 vegetation associations, labelled 1 - 4. This graph demonstrates how multivariate statistical techniques such as DCA were used to assess similarity in species composition. In each of the 4 annotated examples, cover data from unclassified vegetation was projected onto the ordination of the original 48 ESPs, for which the vegetation association is already known. The position of the census points, relative to the position of the known vegetation associations, is used to classify the field vegetation. The borders of each vegetation association are subjective and overlap slightly. For this reason, DCA is used in conjunction with Discriminant Analysis and field observation.

2.2 TEMPERATURE and PRECIPITATION

Temperature and precipitation were measured weekly from March through May, 1994, on all 48 ESPs. In June, ESPs were monitored weekly until soil moisture measurements were low (electrical resistance > 200 ohms). ESPs were then sampled once each month. Maximum temperature, minimum temperature, ambient temperature, soil moisture, soil temperature, and precipitation were recorded at each ESP. Precipitation was summed over a yearly interval beginning and ending on October 15, so that precipitation would more closely match the phenology of plants.

Precipitation in 1994 was substantially less than in the previous three years (Fig. 2.3). On average, precipitation was greater in the *Coleogyne* and *Larrea-Lycium-Grayia* vegetation associations. There was less precipitation in the *Lycium-Grayia* association than the *Larrea-Lycium-Grayia* association even though it occurs at higher elevations. Precipitation varied greatly across the four vegetation associations, with average precipitation ranging from 67 to 111 mm. Variation in precipitation among ESPs, regardless of vegetation association, was greater with annual totals ranging from 54 mm to 119 mm.

Soil moisture and temperature data have not been summarized.

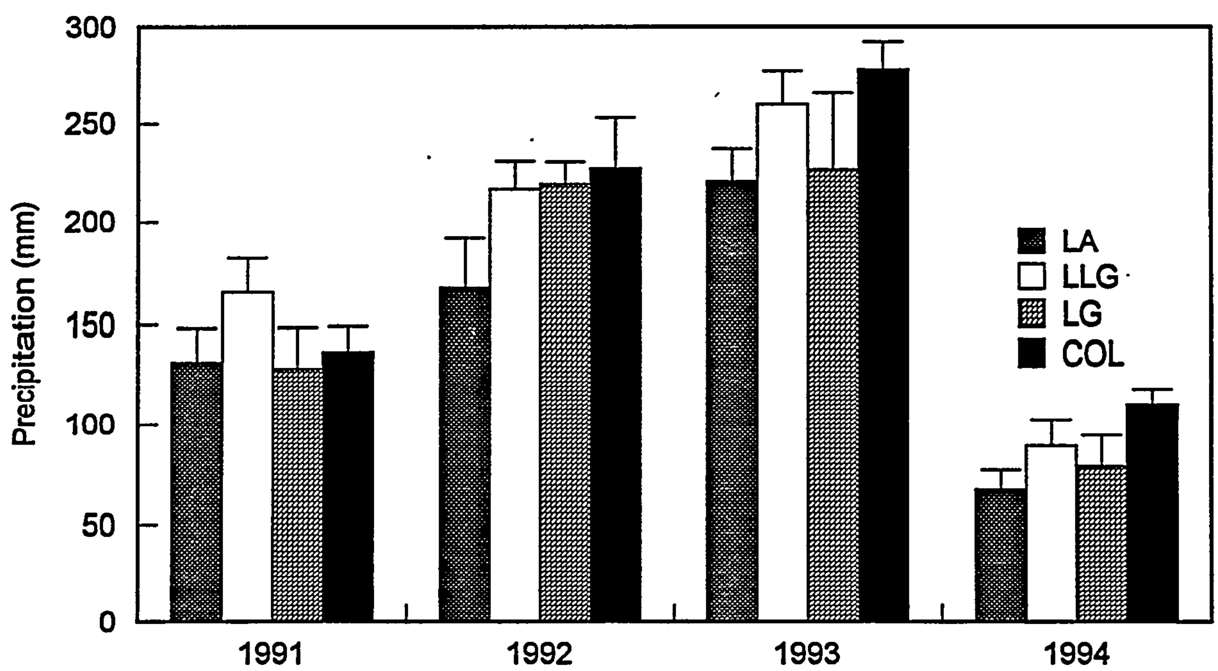

Fig. 2.3. Average annual precipitation in the four vegetation associations at Yucca Mountain. The standard deviation measures variation among the twelve ESPs within each vegetation association. The yearly interval is from October 15 (of the previous year) to October 15.

2.3 VEGETATION STUDIES

The objectives of the vegetation studies are to quantitatively describe the dynamics of plant communities, such as recruitment, growth, and mortality and to assess the impact of site characterization activities (SCA) on vegetation communities. This information will be useful for predicting the response of vegetation to future impacts. Parameters of the major plant communities at Yucca Mountain now have been measured for six consecutive years, three before and three during SCA. The effect of SCA on vegetation, and the distance over which the effect persists, can now be statistically evaluated. Vegetation measurements from undisturbed ESPs also have been used to evaluate the rate and composition of natural plant succession at YMP disturbances (Angerer et al.1995).

2.3.1 Sampling Design and Methods

Vegetation monitoring was reduced during 1994. The density of perennial shrubs does not fluctuate greatly from year to year and was not measured. Production was measured in 12 ESPs within the *Larrea-Lycium-Grayia* vegetation association, in keeping with plans to focus future monitoring efforts in this association. Production also was measured on one control and one treatment ESPs in each of the *Coleogyne*, *Larrea-Ambrosia*, and *Lycium-Grayia* associations where small mammal populations also are being monitored. Cover was measured on all 48 ESPs. The procedures used to measure vegetation are described in EG&G/EM (1992:7-10).

2.3.2 Cover

The amount of plant cover in plant communities at Yucca Mountain has fluctuated during the past six years in association with yearly variation in precipitation (Section 2.2). Plant cover, averaged over all ESPs, decreased from 27% in 1993 to 19% in 1994. Presumably, this decrease was caused by the relatively dry winter of 1993 and spring of 1994. Variation in vegetative cover among ESPs ranged from 12 to 32%. Vegetation associations also are a source of variation, and each association responds differently to yearly conditions (Fig. 2.4). However, only a small amount of the variation in cover is caused by differences between treatment and control ESPs. This does not indicate that SCA has no effect on plants; it indicates that only a careful statistical analysis, such as the before-after-control-interaction experimental design, (Green et al. 1991, Osenberg et al. 1994; Underwood 1994) is needed to detect any effect.

In addition to differences in plant cover that are caused by climate, vegetation association, and location of individual ESPs, different life-forms of plants also cause variation in plant cover. Following Beatley (1976), plants were categorized as either shrubs (including cacti and suffrutescents), annuals, or perennial forbs and grasses. Differences among life-forms over the 6 years of monitoring are shown in Fig. 2.5. The reduction of vegetative cover in 1994 was caused by the poor growth of annuals; shrub cover was greater than in the previous two

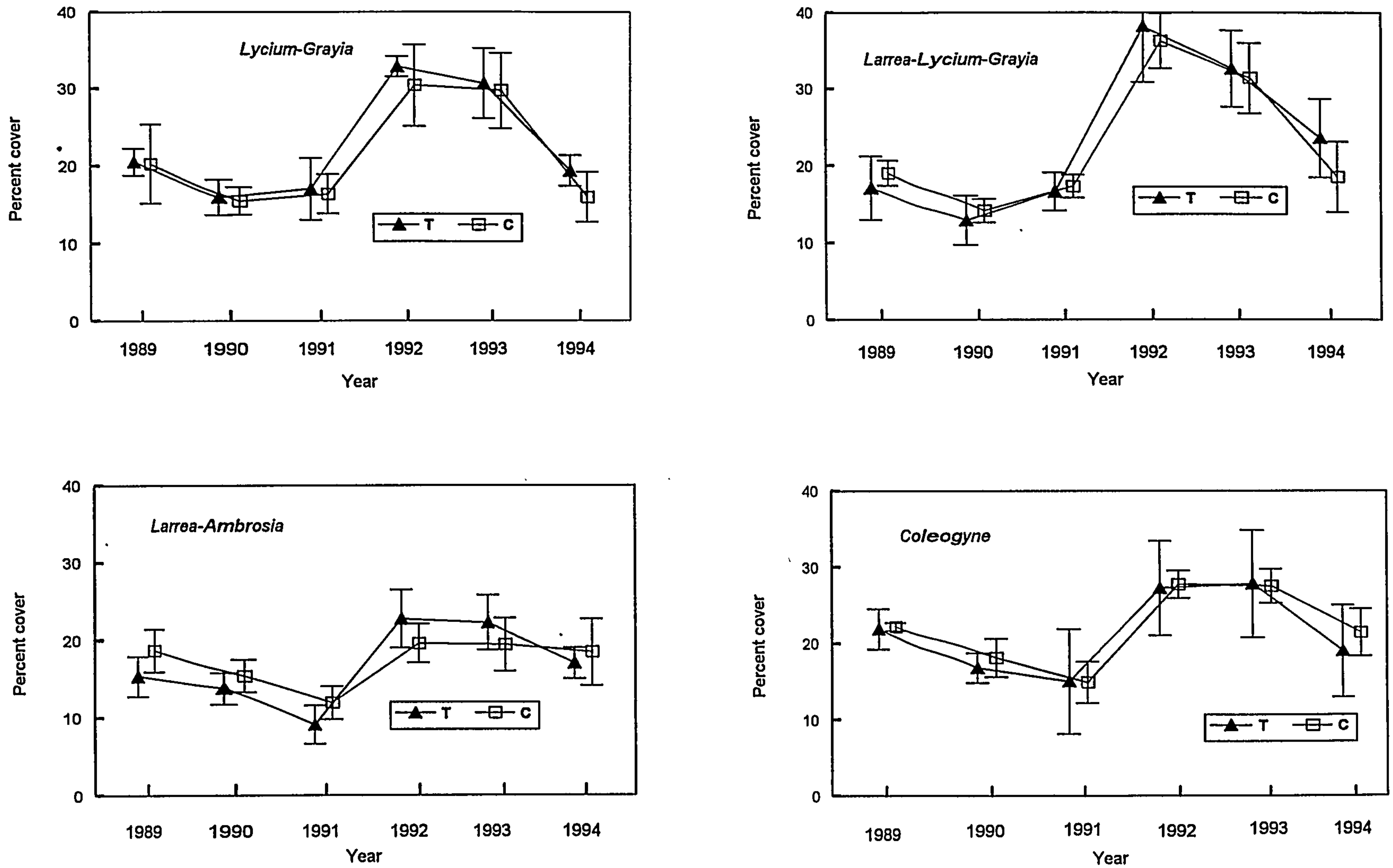

Fig. 2.4. Comparisons of vegetative cover on treatment (T) versus control (C) ESPs in each vegetation association. Each mean is the average of 6 ESPs.

years. The decrease in annual cover could be explained by precipitation levels lower than the preceding three years (see Section 2.2), the delayed onset of spring rain, the irregular intervals between rains, or a combination of these factors. Regardless of the exact cause, perennial shrubs responded to the limited rainfall, but annuals did not. These relationships between season of precipitation, amount of precipitation, and type of vegetation illustrate the complexity of predicting the response of plants to environmental change at Yucca Mountain.

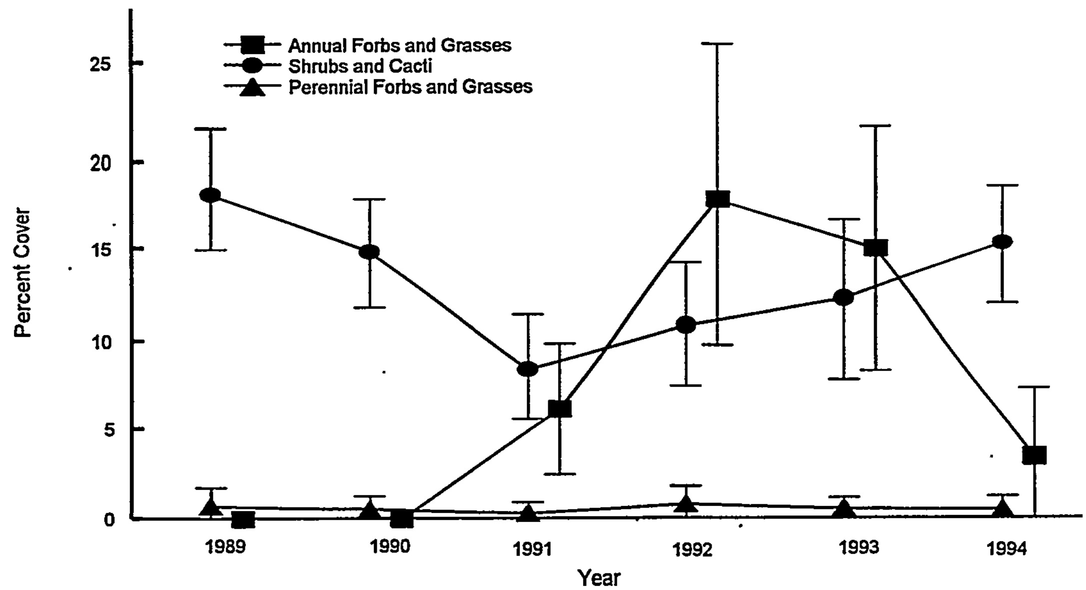

Fig. 2.5. Annual vegetative cover by plant categories averaged across the four vegetation associations at Yucca Mountain (±1 SD, n=48). Annual cover values for each category within a year are offset to increase legibility.

2.3.3 Production

Plant production was measured on the twelve *Larrea-Lycium-Grayia* ESPs, and on six additional ESPs where small mammal populations are being monitored (COL1T, COL 2C, LA5T, LA2C, LG6T, and LG4C). Shrub biomass is more difficult to collect than grass and forb biomass and is less responsive to fine scale environmental conditions. Therefore, perennial shrub production was not measured, and sampling was limited to annuals, perennial grasses, and perennial forbs. Biomass was harvested in 40 1-m^2 quadrats at each treatment ESP and in 32 1-m^2 quadrats in each control ESP. Visual estimates of biomass also were made, as a percentage of the harvested quadrat, in two adjacent quadrats.

2.3.4 Density

The density of perennial plants in a community does not respond as rapidly to environmental change as cover or production. Density was measured only on *Larrea-Lycium-Grayia* ESPs in 1993 and not at all in 1994.

2.3.5 Vegetation Mapping

Efforts were started to map the vegetation communities at Yucca Mountain. The map will have several uses. A primary use of the vegetation map will be to make ecological inferences from sampled (e.g., ESPs, tortoise locations) to unsampled areas with similar vegetation. A second use is to provide a baseline for gauging future vegetation change. Third, the map will be used with a geographic information system database to document the amount and location of vegetation disturbed by site characterization activities. This information can also be used to decide what vegetation should be seeded for reclamation.

The mapped area encompasses the main body of Yucca Mountain (from UTM E545500 to E 556000, and from UTM N406700 to N408400), and the elevation ranges from 975 m in Fortymile Wash to 1585 m on the east slope of Jet Ridge (west of Yucca Mountain). The topography of this area is a series of north-to-south ridge systems separated by flat valleys. Areas within approximately 4 km of the repository will be mapped at a fine scale, with a minimum map unit of approximately 4 hectares.

The mapping process includes several steps. First, a vegetation classification scheme was adopted that incorporated map unit size, potential uses of the map, and the ability of field ecologists to detect differences among vegetation classes. Vegetation categories are based on the four vegetation associations previously identified at Yucca Mountain (Section 2.3.2). The second step is drawing the boundaries between vegetation associations onto clear acetate sheets overlaying aerial orthophotographs. This step is done through a combination of field reconnaisance surveys and aerial photograph interpretation. As of December 1994, a vegetation classification scheme has been standardized and approximately half of the target area has been mapped onto acetate overlays.

The third step in the mapping process is to test for accuracy. Vegetation cover data will be collected from a range of randomly sampled locations and compared to map classifications. Classification accuracy will be tested statistically using a combination of DCA ordination (section 2.1) and discriminant analysis (Manly, 1986). Fig. 2.2 shows an example of testing classification accuracy. Four test areas, Map 1 - 4, that were field-classified as *Lycium-Grayia,* were plotted and compared to the 12 *Lycium-Grayia* ESPs. The test areas were similar to the ESPs, verifying the field classification. A second method of map evaluation will be to have a plant ecologist independently map selected areas to determine whether they classify the vegetation the same way. That is, are the mapped associations recognizable by other trained ecologists?

2.4 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, they are a major prey for carnivores, and they 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 five times for four consecutive days during each trap session.

Ten small mammal species were captured (Table 2.1). The long-tailed pocket mouse (*Chaetodipus 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 plot in the *Larrea-Ambrosia* association. Only three of the ten species were consistently caught on this plot. Three species were not captured here, and only one or two individuals were captured of four species (Table 2.1). This site is isolated by Fortymile Wash from the other vegetation associations preventing immigration by individuals of other species from different habitats.

Populations of long-tailed pocket mice continued to decline in the *Larrea-Lycium-Grayia* and *Coleogyne* vegetation associations while population levels in the *Lycium-Grayia* association were similar to those in 1993 (Fig. 2.6). Populations of Merriam's kangaroo rats declined in 1994 for the first time since 1990 in all vegetation associations (Fig. 2.7). Spring populations were similar or larger than fall populations from the previous year. However, population numbers declined throughout 1994.

Four species, the desert woodrat (*Neotoma lepida*), canyon mouse (*Peromyscus crinitus*), little pocket mouse (*Perognathus longimembris*), and chisel-toothed kangaroo rat (*Dipodomys microps*) are common only in specific habitats (Fig. 2.8). All four species declined in abundance in 1994. Precipitation in 1994 was below average (Fig. 2.3), and production of winter annuals was very low as indicated by percent cover measurements (Fig. 2.5). The reduced production of annual forbs and grasses was probably one of the contributing factors to the population declines in all species.

Populations of all species responded similarly on both control and treatment plots suggesting that responses were related to natural causes and not to effects of site characterization activities. Additional analyses must be completed before impacts of site characterization can be fully evaluated.

Table 2.1. Number of individual small mammals captured on ecological study plots, April 1994 - September 1994.

Species	Month	Vegetation Association and Plot Location							
		Larrea-Ambrosia		*Coleogyne*		*Larrea-Lycium-Grayia*		*Lycium-Grayia*	
		Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Chaetodipus formosus Long-tailed pocket mouse	April	7	1	105	85	68	173	53	71
	June	5		91	54	50	129	43	56
	July	3		72	43	46	105	36	51
	August	5		69	35	38	93	36	49
	September	3		57	34	32	86	30	45
Perognathus longimembris Little pocket mouse	April	26	67						
	June	62	77		2				
	July	58	56						
	August	29	16						
	September	1	3						
Dipodomys merriami Merriam's kangaroo rat	April	98	70	61	92	151	88	39	67
	June	35	21	52	68	120	81	33	55
	July	36	16	40	56	104	71	24	49
	August	34	17	31	49	96	61	22	48
	September	34	17	29	50	95	65	24	40
Dipodomys microps Chisel-toothed kangaroo rat	April	17		39	37	29	13	12	18
	June	11		38	26	33	15	22	21
	July	11		28	18	27	12	21	18
	August	8		18	14	19	9	15	17
	September	5	1	16	17	28	12	17	15

Table 2.1. 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
Onychomys torridus Southern grasshopper mouse	April	1		2	8	13	12	3	3
	June	2		3	4	6	7	5	2
	July	1		5	4	6	8	3	2
	August	1	1	2	4	4	1	1	1
	September	1	2	1	4	2	3	1	2
Peromyscus crinitus Canyon mouse	April			4	3	1	6	40	57
	June					2	3	23	72
	July	11			1		4	25	31
	August	1			3	1	3	20	24
	September	1		1	3	1	2	21	25
Peromyscus maniculatus Deer mouse	April			1	6	8		4	2
	June				1	1		1	
	July							8	
	August								
	September								
Peromyscus eremicus Cactus mouse	April		1			3	6	2	
	June					12	4		
	July				1	7	7	1	
	August					5	6		
	September					4	4		

Table 2.1 . 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
Neotoma lepida Desert woodrat	April			3	2	2	4	8	6
	June	4		4	1	9	8	24	18
	July			3	2	2	5	19	22
	August			4	1	2	3	12	16
	September			3		1	2	8	9
Ammospermophilus leucurus White-tailed antelope squirrel	April	1	19	5	8	4	5	7	13
	June	6	6	7		11		9	10
	July	6	6	7	1	8	3	4	10
	August	7	4	7	2	6	3	9	9
	September	4	5	8	4	6	2	6	10
Totals for all species	April	220	241	150	158	279	307	168	237
	June	195	156	125	104	244	247	160	234
	July	155	126	118	78	200	215	133	183
	August	131	108	85	38	171	179	115	164
	September	115	112	49	28	169	176	107	146

Vegetation Association and Plot Location

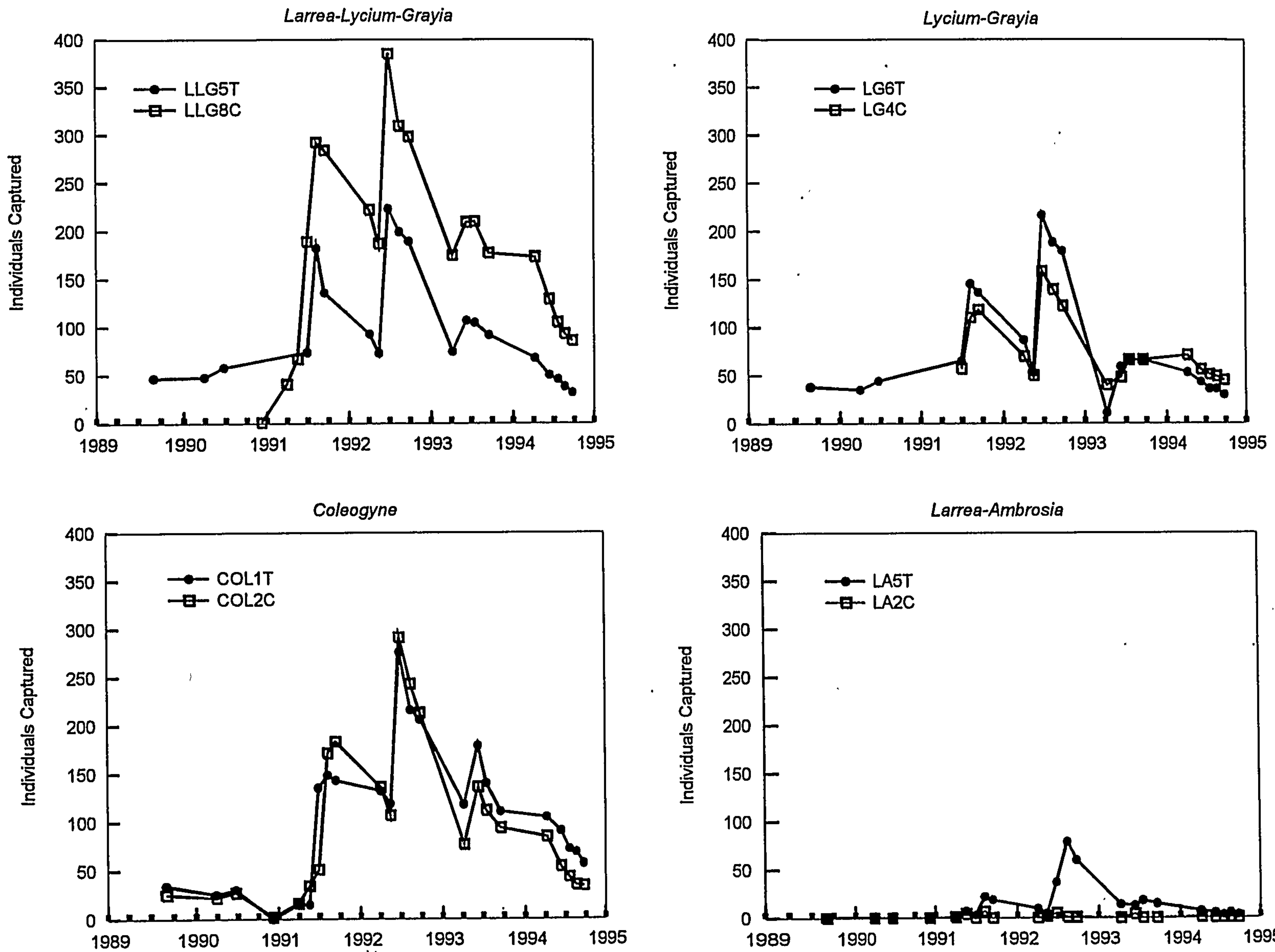

Fig. 2.6. Population trends of the long-tailed pocket mouse in control (□) and treatment (●) study plots from August 1989 through September 1994 in four vegetation associations at Yucca Mountain.

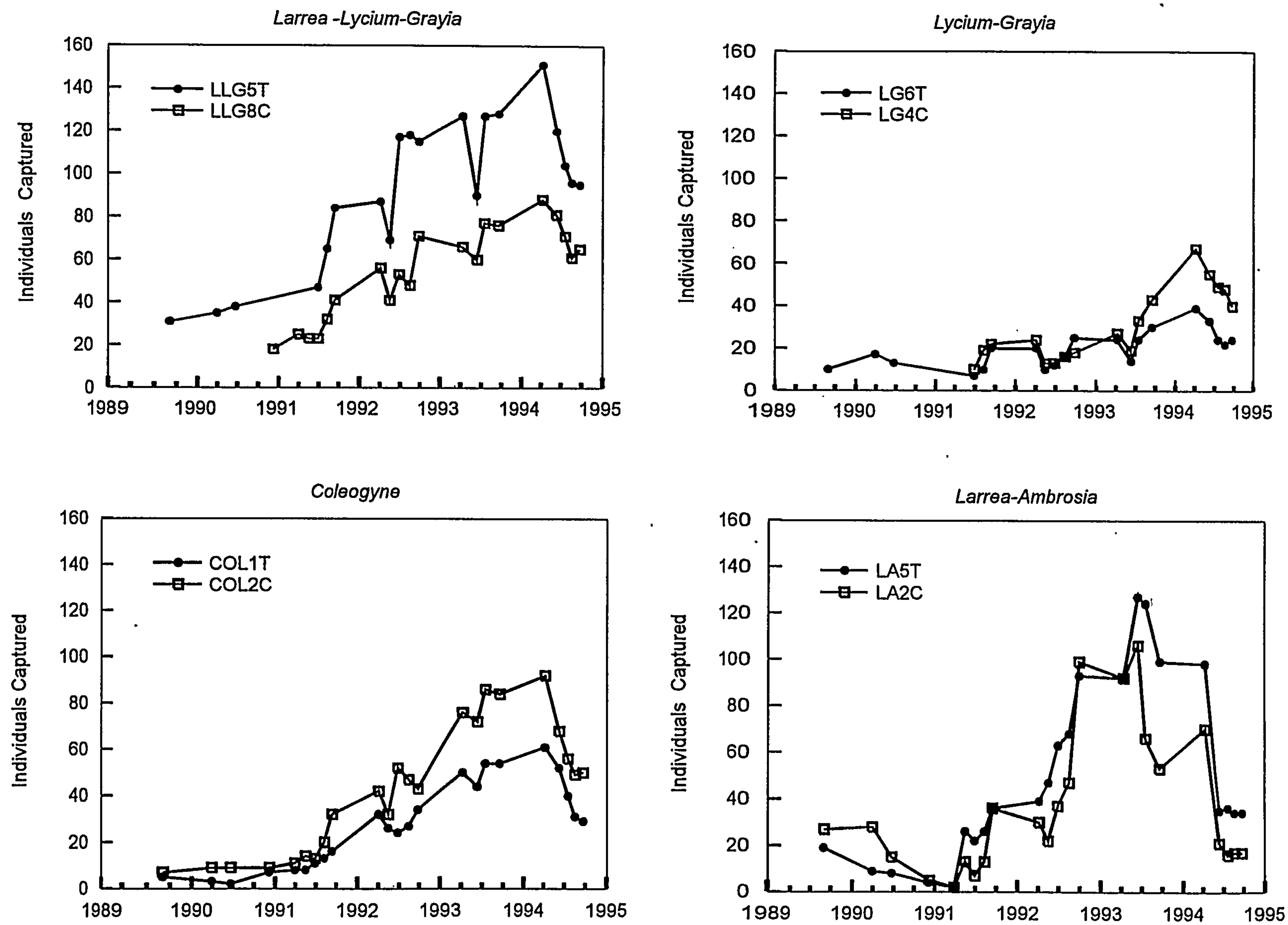

Fig 2.7. Population trends of Merriam's kangaroo rat in control (□) and treatment (•) study plots from August 1989 through September 1993 in four vegetation associations at Yucca Mountain.

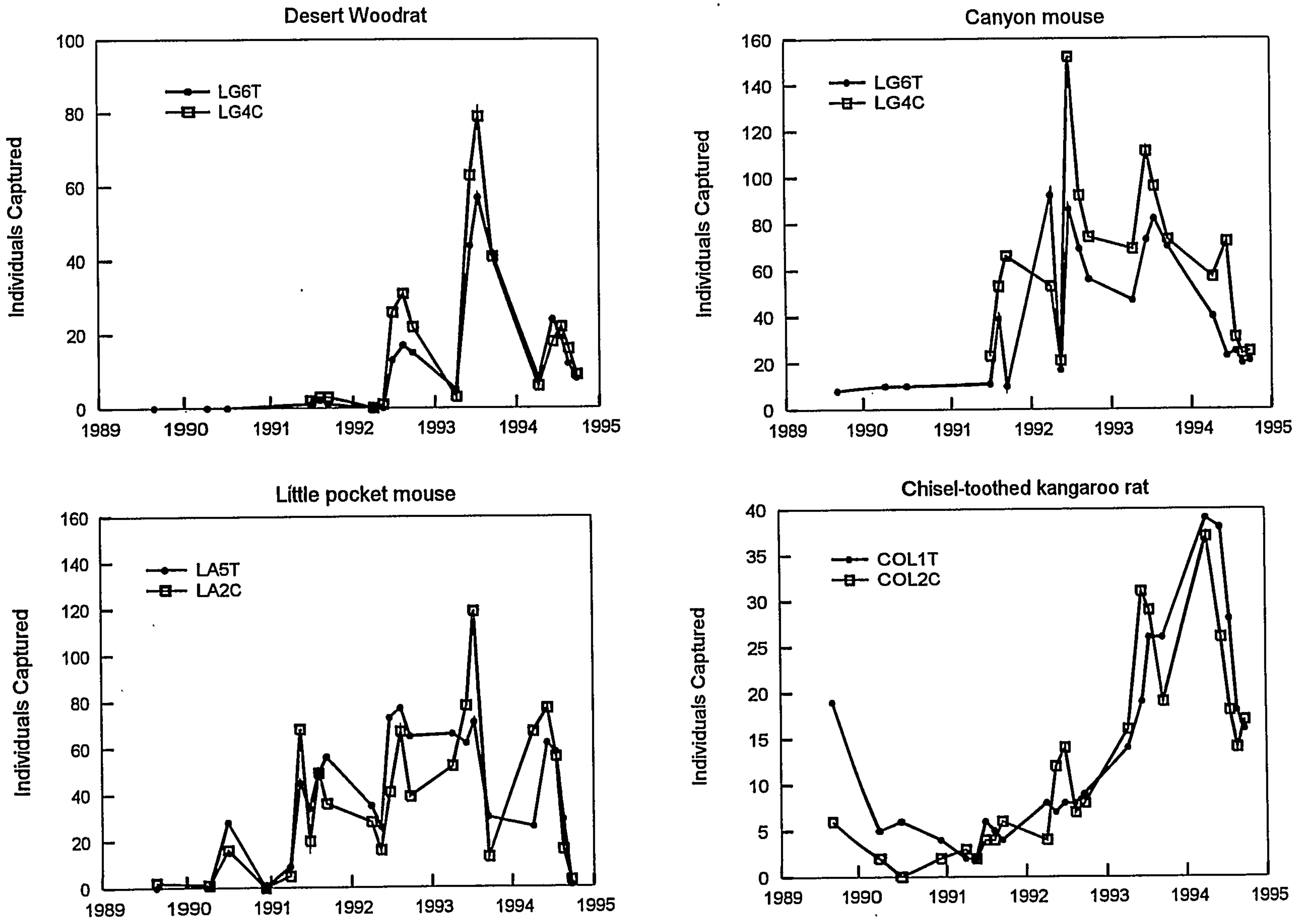

Fig. 2.8. Population trends of desert woodrats and canyon mice in *Lycium-Grayia* vegetation, little pocket mice in *Larrea-Ambrosia* vegetation , and chisel-toothed kangaroo rats in *Coleogyne* vegetation in control (□) and treatment (●) study plots from August 1989 through September 1994 at Yucca Mountain.

2.5 REPTILE STUDY

The reptile study has two objectives: to determine the composition of the reptile community at Yucca Mountain, and to monitor the effects of site characterization activities on the reptile community. To achieve these objectives, species composition was determined at three 1-ha sites. Nine 1-ha sites were sampled to estimate and compare the survival and abundance of side-blotched lizards (*Uta stansburiana*) between study sites 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.

To obtain species composition, trapping was conducted in May using pitfall and funnel traps. Eleven species of reptiles were caught (Table 2.2). The side-blotched lizard and western whiptail (*Cnemidophorus tigris*) were the most common species. The number of side-blotched lizards on LLG2T decreased from 31 in 1993 to 1 in 1994. The number on LA3T remained the same as in 1993 while the number of side-blotched lizards declined by 50% on COL2T (EG&G/EM, 1994). The longnosed leopard lizard (*Gambelia wislizenii*), zebra-tailed lizard (*Callisaurus draconoides*), southwestern black-headed snake (*Tantilla hobartsmithi*), western patchnose snake (*Salvadora hexalepis*), and gopher snake (*Pituophis melanoleucus*) were captured in 1993 but not in 1994.

Estimates of side-blotched lizard abundance were obtained by using nooses to capture individuals on nine 1-ha sites in March, May, and October. Three sites are adjacent to existing or proposed construction sites, three are adjacent to roads, and three are greater than 200 m from any disturbance. All sites are located in the *Larrea-Lycium-Grayia* vegetation association. The North Portal site was moved to a new location in 1994, approximately 500 m south of the 1993 location, because of construction on the previous location. During each capture session, sites were systematically searched and attempts were made to capture all side-blotched lizards observed. Captured lizards were marked, measured, weighed and then released. Each site was searched for four days during each two-week session. Plots were not searched on consecutive days to reduce avoidance behavior by lizards toward the biologist.

The number of side-blotched lizards captured in each of the three treatment locations has declined since March of 1993 (Fig. 2.9). Turner et al. (1973) reported a positive relationship between the production of winter annuals and clutch frequency of side-blotched lizards. As indicated by percent cover of annual forbs and grasses (Fig. 2.5), production of winter annuals was higher in 1992 and 1993 than in 1994 because of greater precipitation (Fig. 2.3). This may explain the decline in numbers in 1994. Populations declined similarly on control plots and plots adjacent to site characterization activities suggesting a response to area-wide environmental conditions opposed to any effect of site characterization. Additional analyses must be completed before effects of site characterization can be fully evaluated.

Table 2.2. Number of individual reptiles captured on three sites during a one week trapping period in May 1994.

Species	COL2T	LA3T	LLG2T
Lizards			
Uta stansburiana Side-blotched lizard	26	37	1
Cnemidophorus tigris Western whiptail	31	29	14
Coleonyx variegatus Western banded gecko			1
Sceloporus magister Desert spiny lizard		3	
Phrynosoma platyrhinos Desert horned lizard	1	1	
Snakes			
Crotalus mitchellii Speckled rattlesnake			1
Sonora semiannulata Ground snake		1	1
Hypsiglena torquata Night snake			1
Rhinocheilus lecontei Longnose snake		1	
Masticophis flagellum Coachwhip	6	1	5
Lampropeltis getulus California kingsnake			1

The chuckwalla (*Sauromalus obesus*) was listed as a candidate for federal protection under the Endangered Species Act in 1992 by the U.S. Fish and Wildlife Service. Chuckwalla observations were recorded in 1993 and 1994 while conducting other field studies to help identify locations of chuckwallas and their habitat. Twenty-nine observations were recorded in 1993 and eighteen in 1994. Most observations occurred in rocky habitat near the crest of Yucca Mountain, on the road to Castle Point, and on Fran Ridge (Fig. 2.10). Observations were made from late April to July with the most observations occurring in May and June of each year.

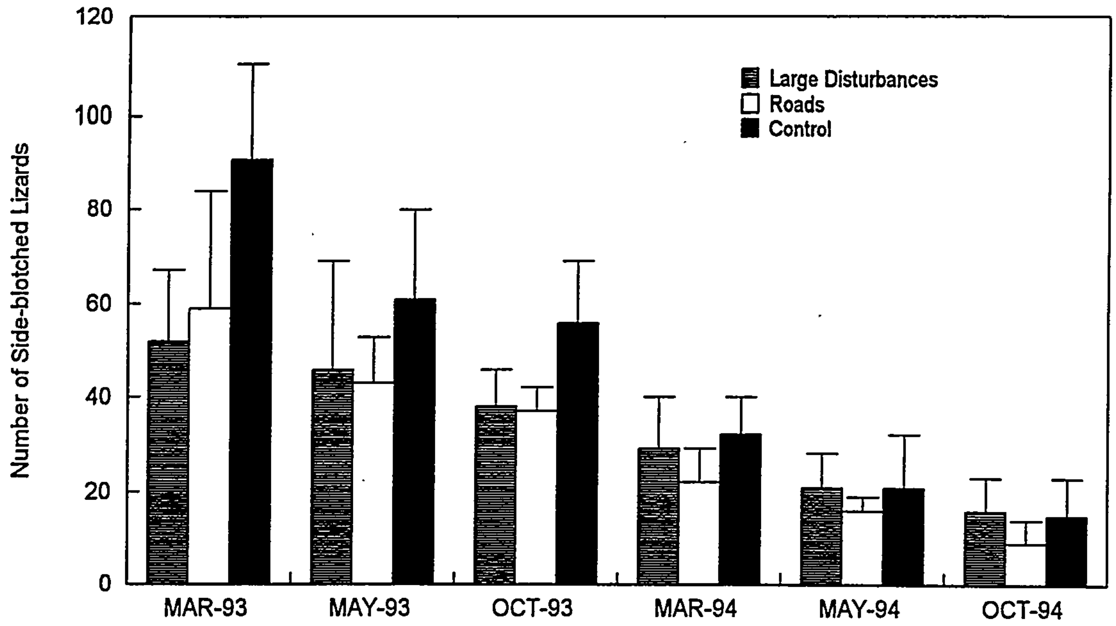

Fig. 2.9. Average number (± 1 SD, $n=3$) of side-blotched lizards captured in three treatment areas in 1993 and 1994 at Yucca Mountain.

2.6 DISTURBANCE MONITORING

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

2.6.1 Fugitive Dust

Fugitive dust is one of the most visible impacts created by construction activity. Past annual reports have reported that while the total amount of dust being deposited is small, significant differences in deposition can be detected between treatment and control ESPs, and between transects at different distances from roads. The data from 1994 follow this pattern closely.

Dust sampling in 1994 was limited to the 12 ESPs within the *Larrea-Lycium-Grayia* vegetation association. Deposition was measured by allowing dust to collect on pieces of filter paper held in petri dishes. Each month the filter paper was collected, replaced, and weighed. The weight of dust deposited was calculated by subtracting the filter paper weight from the final weight of paper and dust. A total of 10 dust samples, two samples from each of five distances, were sampled from each treatment ESP. Because there is no distance effect on control ESPs, only two samples were taken. Dust deposition is expressed as the total yearly accumulation of dust per square meter. Methodology is described in more detail in EG&G/EM (1992:28).

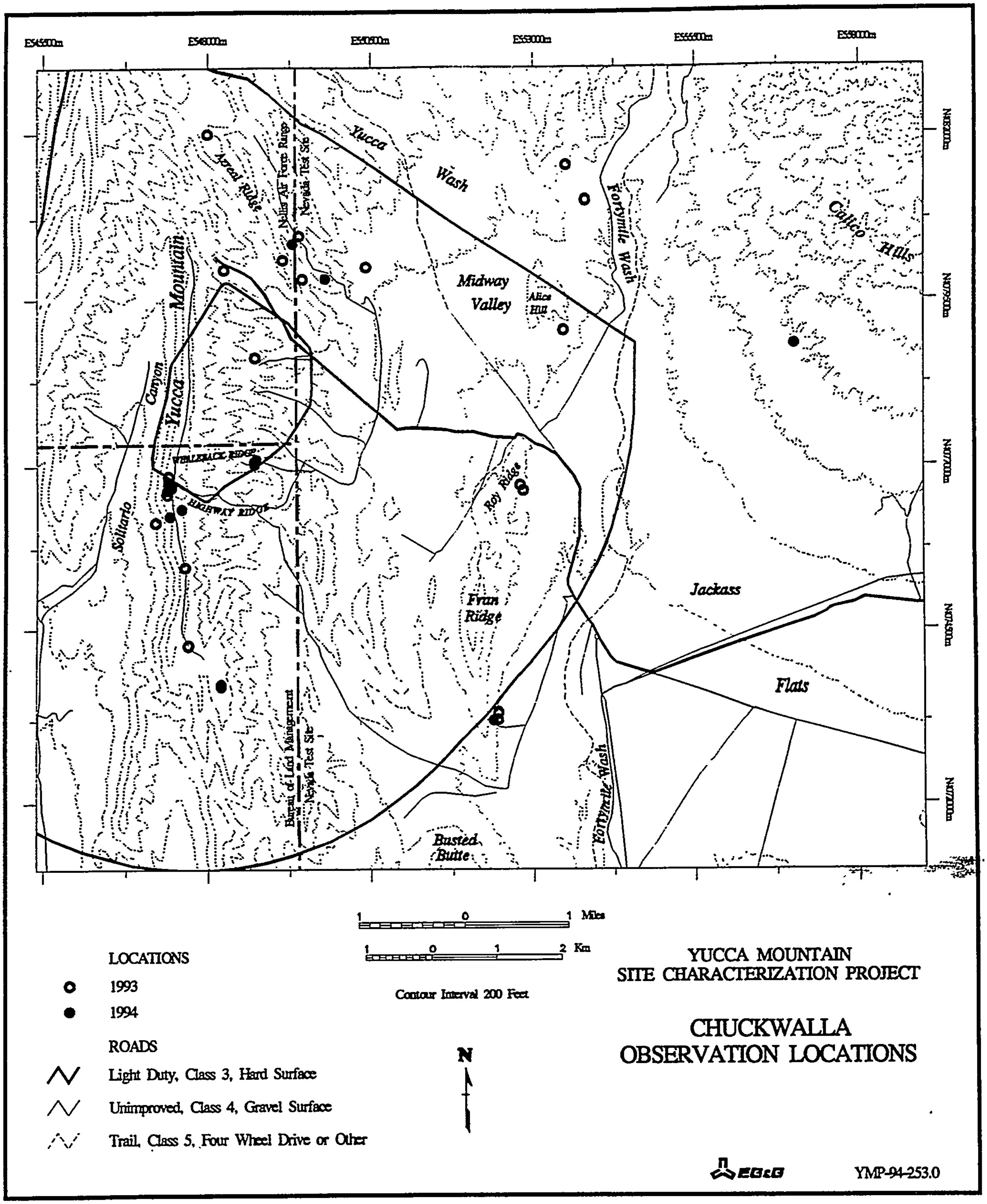

Fig. 2.10. Location of chuckwalla observations at Yucca Mountain in 1993 and 1994.

Total dust deposited, averaged over all distances, was significantly higher on treatment plots than on the control plots ($\bar{x}_{treatment} = 11.53$ g/m^2, n = 6, SD = 3.65; $\bar{x}_{control} = 6.89$ g/m^2, n = 6, SD = 1.52; $P < 0.03$, *t*-test).

On the treatment plots, the amount of dust deposited decreased as distance from the disturbance increased (Fig. 2.11). Differences in dust deposition among the five distances were statistically significant (SNK multiple range test, $P = .05$, df = 25).

Those ESPs located nearest the zones of intensive site characterization activity had the greatest amount of dust deposition. For example, ESP LLG5T is located in an area of frequent dirt road traffic (EG&G/EM 1993, Section 2.5.1) and had the greatest dust deposition. In contrast, ESP LLG2T is located in an area of little activity and had the lowest dust deposition.

Although significant effects were found to be caused by treatment and distance, the amount of dust deposited was small.

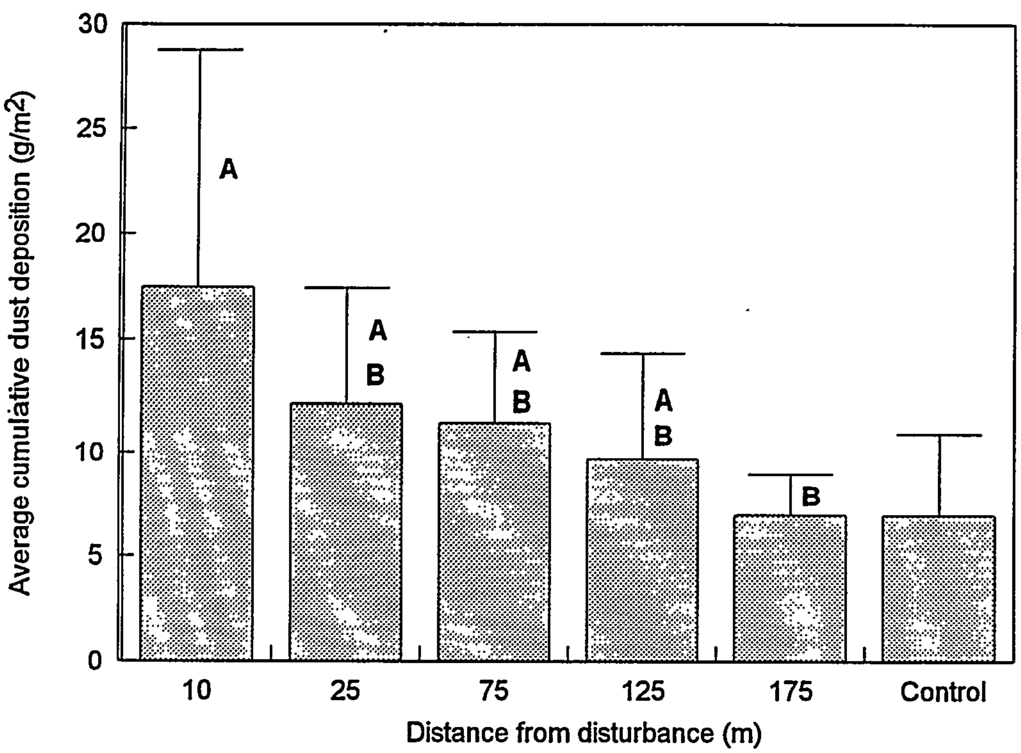

Fig. 2.11. Average cumulative weight of dust deposited on control study plots and at different distances from disturbance in treatment study plots (± 1 SD, $n=6$) in 1994 at Yucca Mountain in the *Larrea-Lycium-Grayia* vegetation association. Means with different letters are significantly different at $P <$ 0.05 using the SNK multiple range test

2.6.2 Traffic Volume

Traffic volume was measured using 19 traffic counters (TCs). The counters remained stationary at each location rather than being rotated between locations as was done in 1991 and 1992. The traffic count at three ESPs (LA1T, COL6T, and COL1T) was estimated by averaging the counts from two adjacent ESPs, one in each direction from the ESP. The number of ESPs sampled in 1994 was 22. Traffic counts are probably low at some locations because counters were occasionally removed during road maintenance.

Traffic volume was expressed as average vehicle passes per day. Traffic volume was highest at LLG5T, averaging 127 passes per day (Fig. 2.11). This was due to drilling operations near UZ-16 in Split Wash. Two other areas of high traffic volume were the road to the top of Yucca Mountain (LG3T, LA5T, and LLG4T) and the road past LG2T in Drill Hole Wash. The traffic counter in Crater Flat was monitored less frequently than those at Yucca Mountain due to low traffic volume. Other locations of low vehicle passes were at the far north and south end of Yucca Mountain (COL5T and LG4T).

Traffic volume in 1994 increased by over 100% on the access road to UZ-16 (LLG5T). Traffic volume at other ESPs was similar to that obtained in 1993. Average traffic volume throughout the Yucca Mountain area was about the same in 1993 and 1994.

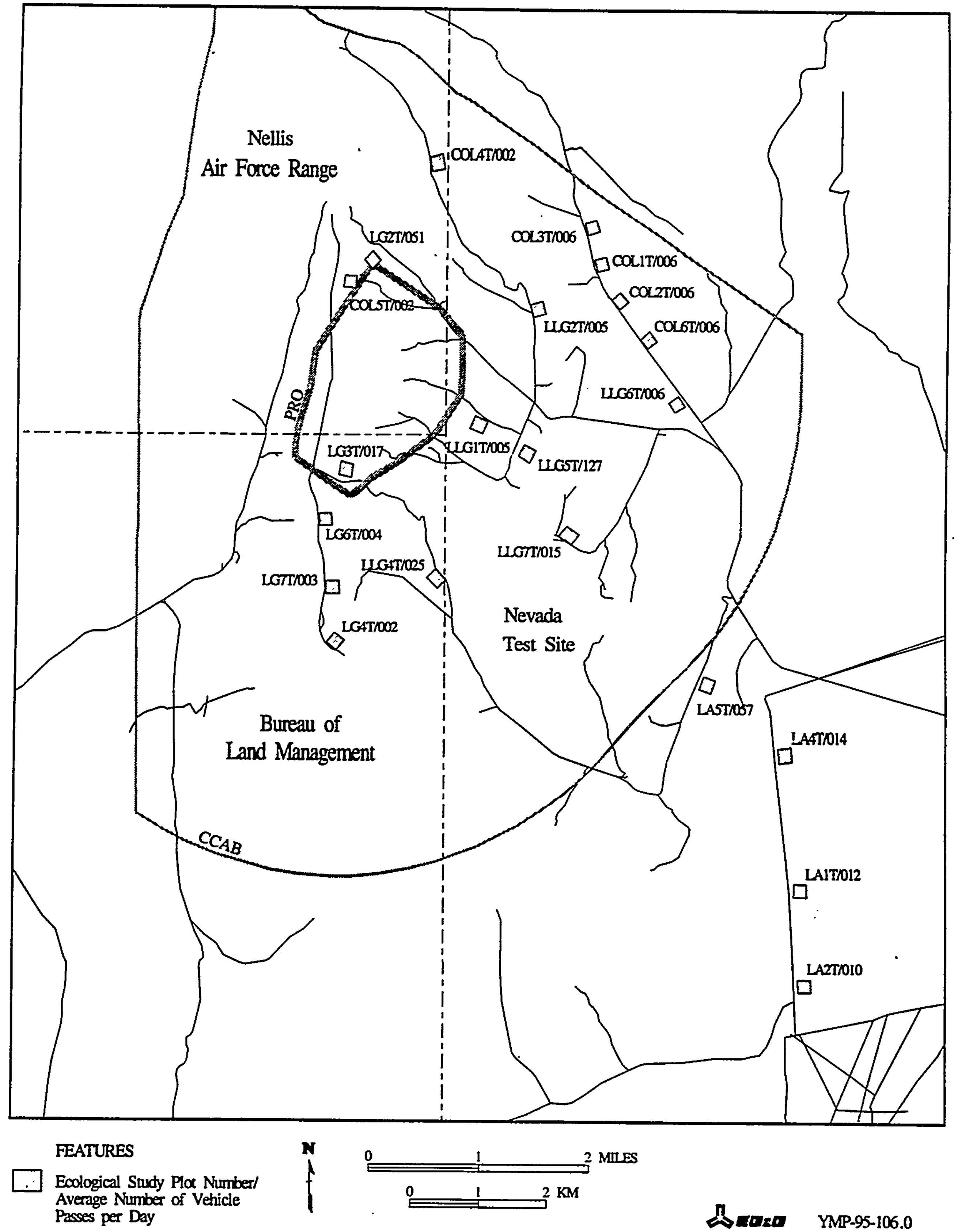

Fig. 2.12. Distribution of vehicle traffic at Yucca Mountain area in 1994. Volume is expressed as average vehicle passes per day.

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 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, 1994) and Rautenstrauch et al. (1991). Ten studies conducted in 1993 (EG&G/EM 1994) were continued in 1994. No new studies were started.

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"; and (3) no impacts, or control. For a more in-depth discussion, see EG&G/EM (1992:31-33). Tortoises were first radiomarked for these impact-evaluation studies during 1989-1991. Because the locations of proposed activities changed, the boundaries of the high-impact areas were redrawn and the treatment classification (i.e., sampling populations) of all radiomarked tortoises at Yucca Mountain was reevaluated.

Originally, the areas where long-term, large-scale disturbances were planned included the area surrounding the proposed Exploratory Shaft Facility in Drill Hole Wash, the North Portal Facilities and a series of large trenches east of Exile Hill, and the muck storage area and South Portal in southwestern Midway Valley (EG&G/EM, 1992:35). Since then, the Exploratory Shaft Facility has been canceled and replaced with the north portal and support facilities. The muck storage area has been moved and a borrow pit has been excavated and fenced near Fran Ridge. Based on these changes, the high-impact areas were identified in 1994 as the areas that have been or will be disturbed by the North Portal Facilities, South Portal, borrow pit, muck storage area, topsoil storage area, and General Support Facilities including a 200-m buffer around these sites. Tortoises were classified in the high-impact population if ≥25% of their active-season locations were within one of those areas. The classification of 17 adult tortoises changed; 14 of these were reclassified as members of the area-wide sampling population. Because of the surplus of radiomarked adult tortoises in this sampling population, transmitters will be removed from 10 tortoises after they emerge from hibernation in the spring of 1995.

For the Desert Tortoise and Monitoring and Mitigation (Chapter 5) programs in 1994, 112 previously unmarked desert tortoises were captured and marked; 58 were hatchlings captured at nests. Radio transmitters were attached to 20 hatchlings and 17 older tortoises that were not previously radiomarked. During 1989-1994, 486 tortoises have been captured and marked (Fig. 3.1); 145 of these were hatchlings. Transmitters have been attached to 277 tortoises

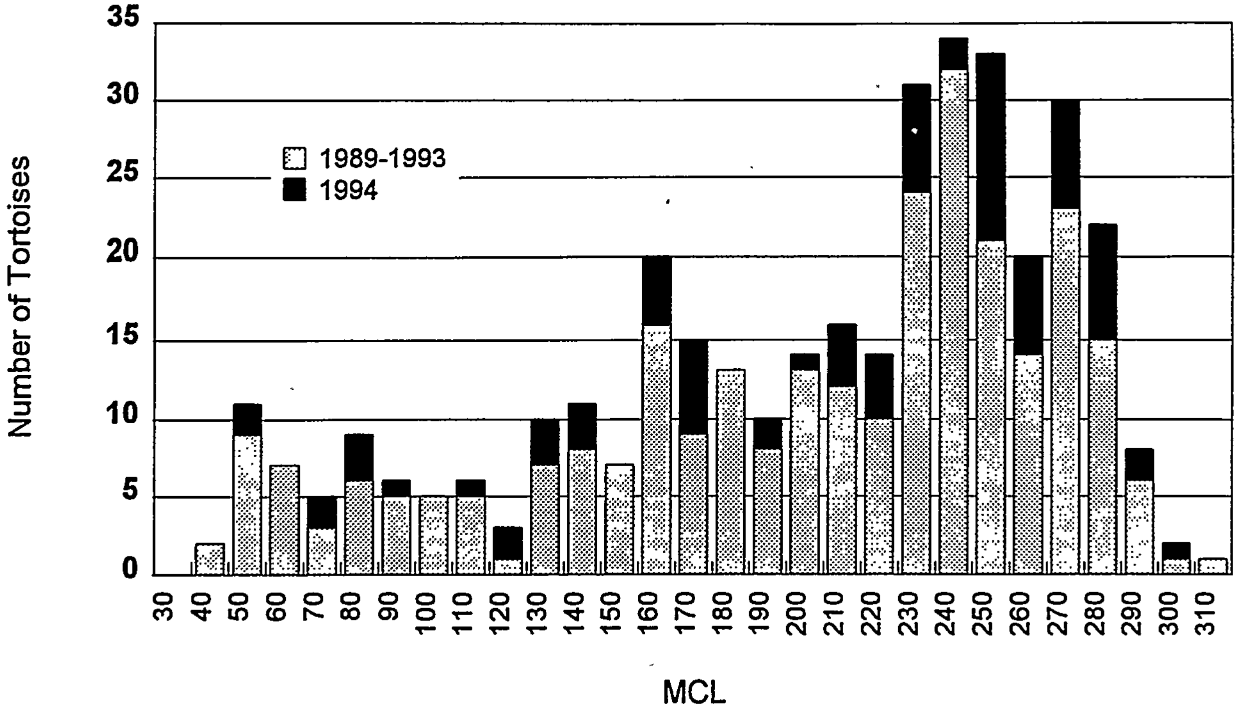

Fig. 3.1. Number of tortoises marked at Yucca Mountain during 1989-1994 in 10-mm size classes. The figure does not include 145 hatchlings (35-50-mm mid-carapace length) marked at nests from 1991-1994.

since 1989. One hundred thirty-four of these radiomarked tortoises were being monitored at the end of 1994. The others had died (n = 46), could not be found (n = 54), lost their transmitters (n = 16), or had their transmitters removed (n = 27). Tortoises have been found throughout the YMP area and the control area established in the southern Calico Hills (Figure 3.2).

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 that may improve mitigation techniques and promote recovery of the species.

To achieve the first objective, annual egg production of tortoises was compared among the three treatment levels to evaluate impacts of YMP. Adult female tortoises (mid-carapace lengths >200 mm) were x-rayed every two weeks from the first week in May through the first week in July. Nine tortoises from the high-impact population, twelve tortoises from the area-wide population, and seven tortoises from the control population were monitored. The average number of eggs produced per female was 8.0 (SD = 3.6). Annual egg production did not differ among populations (ANOVA; F = 2.0; 2,25 df; P = 0.15).

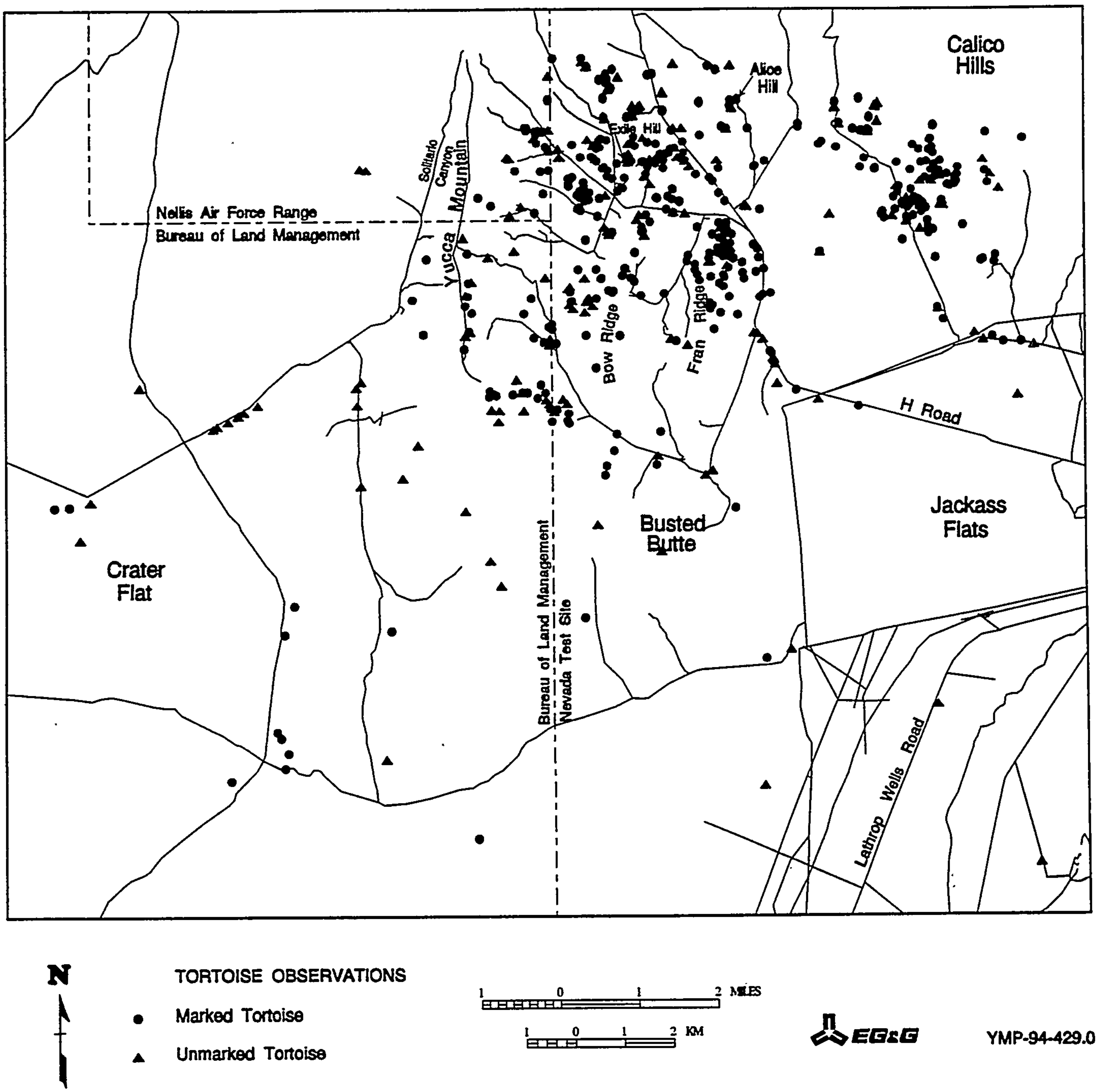

Fig. 3.2. The location of tortoises found at Yucca Mountain and the adjacent control area from 1989-1994. The most recent location is shown for all tortoises found > 1 time.

Additional data were collected to achieve the second objective. Nests were located so that nest, egg, and hatchling survival could be determined (see Sections 3.2.1 and 3.2.2). Nests were described to provide data for improving the mitigation technique of searching for and relocating tortoise nests. The timing of egg laying and incubation duration were determined to identify the period when nests should be searched for during clearance surveys. Size-specific fecundity was determined so that future analyses of annual egg production might be able to include tortoise size as a covariate and to provide data for modeling tortoise population dynamics.

Nests were located and timing of oviposition was determined by weighing a subsample of gravid tortoises daily and tracking their movements with thread trailers (see EG&G/EM, 1994:22). Twenty-seven tortoise nests were found, of which 22 were associated with burrows. Nests that were not associated with burrows were under the canopy of shrubs. The location of nests associated with burrows ranged from 37 cm outside the burrow entrance to 49 cm within the entrance ($\bar{x}$ = 2 cm within the entrance, SD = 24.3, n = 21). Depth to the top egg ranged from 4 to 17 cm ($\bar{x}$ = 10.8 cm, SD = 2.9 cm, n = 23). Egg mass ranged from 25.4 to 40.4 g ($\bar{x}$ = 32.3 g, SD = 3.0, n = 117). Clutch mass ranged from 101.0 to 275.0 g ($\bar{x}$ = 164.3 g, SD = 41.9, n = 22).

First clutches were laid May 14-June 12 ($\bar{x}$ = May 29, SD = 9 days, n = 18) and second clutches were laid June 10-29 ($\bar{x}$ = June 20, SD = 7 days, n = 9). One tortoise did not lay any eggs, and none laid more than two clutches. Incubation duration was calculated as the time interval between oviposition and emergence of the first hatchling. Incubation duration of 16 nests ranged from 75 to 97 days ($\bar{x}$= 86 days, SD = 6.6).

To determine size-specific fecundity, data collected for the first objective were supplemented by x-raying 7 additional tortoises of different sizes. The smallest gravid tortoise was 210 mm in MCL; none of six known female tortoises (based on plasma testosterone levels) between 164 and 194 mm MCL produced eggs. Tortoise size and fecundity were positively correlated (Fig. 3.3).

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 meet the first objective, survival of eggs, hatchlings, and adults (>180-mm MCL) were compared among the three treatment levels to evaluate impacts of YMP. To achieve the second objective, data collected for the first objective were supplemented by measuring survival of juveniles (tortoises older than hatchlings but <180 mm MCL).

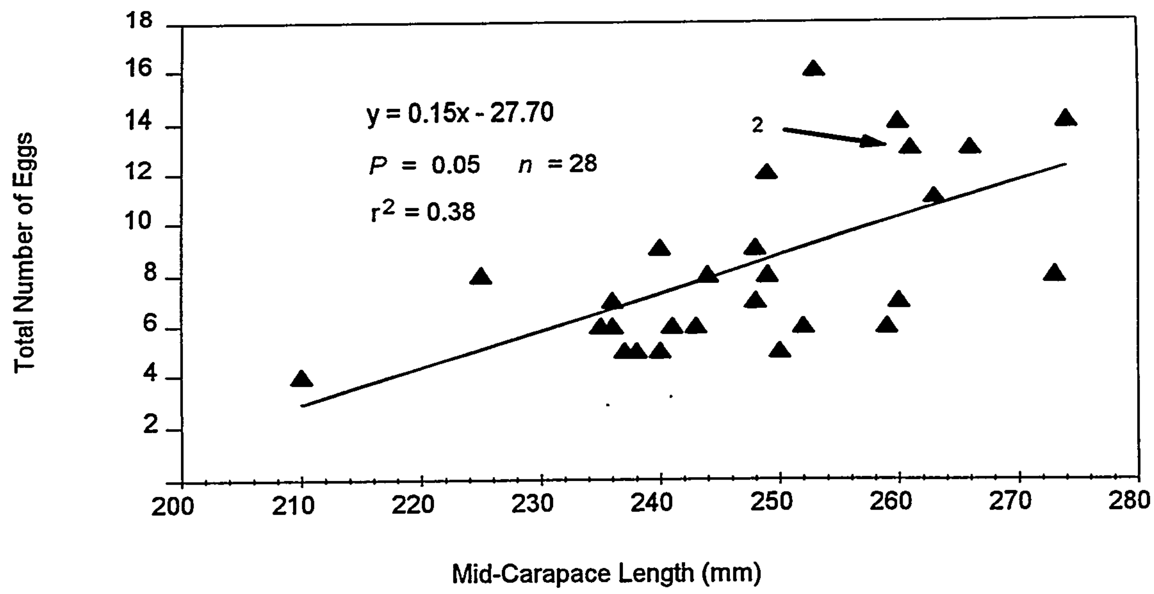

Fig. 3.3. Relationship between size of 28 desert tortoises and number of eggs produced in 1994.

3.2.1 Egg Survival

Nests were located by attaching thread trailers to gravid female tortoises from the reproduction study (EG&G/EM, 1994:22). Nests were checked weekly for signs of predation. Hardware-cloth cages were placed over nests 70-85 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. If a whole egg or a carcass was not found, it was assumed that the egg hatched and the hatchling emerged.

Egg survival was divided into two components: nest survival and egg viability. Nest survival was estimated as the proportion of nests not destroyed by predators. Egg viability was calculated as the proportion of eggs not destroyed by predation that produced viable offspring.

Twenty-seven nests were found: ten laid by tortoises in the high-impact population, eight laid by tortoises in the area-wide population, and nine laid by tortoises in the control population. Seven nests were destroyed by predators. Nest survival did not differ among treatments (comparison-of-proportions test, X^2 = 3.8, 2 df, P = 0.16).

The nests that were not destroyed contained 99 eggs: 44 in the high-impact population, 23 in the area-wide population, and 32 in the control population. Seventy-five eggs produced viable offspring. Egg viability did not differ among treatments (comparison-of-proportions test, X^2 = 0.3, 2 df, P = 0.80).

3.2.2 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.

The method for comparing survival of hatchlings among the treatment levels will be determined in 1995.

Transmitters were attached to seven hatchlings from the high-impact population, five hatchlings from the area-wide population, and eight hatchlings from the control population. By the end of 1994, 4 had died, 1 had lost its transmitter, and 15 were believed to be alive in their hibernacula. One dead hatchling had signs of mammalian predation/scavenging, one probably died of exposure when it became stranded in the lower branches of a shrub, one died of unknown causes, and one died one day after falling into trench NRT-1 on the west side of Exile Hill. The conclusion of the necropsy on the hatchling that fell into the trench was that the tortoise was in overall poor nutritional status and probably died from dehydration or inanition brought on before the fall.

At the end of 1993, 14 of 28 hatchlings radiomarked that fall were still being located. Four hatchlings had died and ten were missing prior to hibernation. Only eight of the fourteen hatchlings were found alive in Spring 1994. Two were found dead in their hibernacula and four were missing. At the end of 1994, three more hatchlings were missing and five were still being monitored. The remaining hatchling from the 1992 cohort still alive at the beginning of the 1994 activity season died, probably from predation.

Information collected on the 1994 cohort of hatchling tortoises probably is not directly comparable to data collected in previous years. During 1992 and 1993, at least 15 of 56 radiomarked hatchlings were lost, probably because their transmitters failed or the tortoises moved out of signal range. During 1994, transmitters with greater reliability and power were used. As a result, no hatchlings were lost due to transmitter failure or long-distance movements.

3.2.3 Adult Survival

Of 28 adult tortoises from the high-impact, 34 from the area-wide, and 19 from the control populations that were monitored during 1994, none are known to have died. Of these 81 adult tortoises, seventy-five were in their hibernacula and thought to be alive as of December 31, 1994. The remaining were either missing or had their transmitters removed.

3.2.4 Juvenile Survival

Survival of juveniles was measured only to meet the second objective, to determine age-specific survival. Two juvenile radiomarked tortoises died during 1994. Tortoise 538 (81 mm) was found 15 m from its hibernaculum with all four limbs bitten off. Tortoise 9486, a hatchling that was not monitored for the hatchling study, was found crushed on the access road to the SD-9 borehole 12 days after it had been found on that road and radiomarked (see Section 5.4).

3.3 MOVEMENTS AND HABITAT USE STUDY

The objectives of the Movements and Habitat Use Study are to evaluate the effects of YMP 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.

To meet the first objective, the following parameters were measured in 1994: number of burrows used, number of new burrows used, percent of times tortoises were observed active, length of hibernation, home range size, and shift in home range. These parameters will be compared among the three treatment levels to evaluate impacts of YMP. Radiomarked tortoises monitored for this study were located at least once every other week during hibernation and twice per week during the rest of the year. Each time these radiomarked tortoises were located, information on their location, behavior, burrow (if used), and habitat was recorded.

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

To meet the third objective of this study, estimates of home range size, movements, and hibernation during 1989-1994 were analyzed in detail to develop more effective research, management, and mitigation techniques and to learn more about the ecology of desert tortoises at Yucca Mountain.

Six calculations used to measure home range size were evaluated to identify the best methods for quantifying movements of tortoises at Yucca Mountain. It was concluded that the 100% minimum convex polygon method is a valid method for identifying the maximum area used by tortoises during one year if those tortoises were located ≥60 times during an activity season. To measure the areas tortoises use most during a year (i.e., core area), home range calculations that identify multiple centers of activity should be used. This is because the general pattern of movement of desert tortoises at Yucca Mountain is to use an area centered around a burrow or group of burrows for a time and then move to other, sometimes distant groups of burrows throughout the activity season. Of three such techniques evaluated (cluster method [Kenward 1987], harmonic mean analysis [Dixon and Chapman 1980], and kernel analysis [Worton 1989]), the cluster method describes movement patterns of desert tortoises best. The bivariate normal ellipse (Jennrich and Turner 1969) and weighted bivariate normal ellipse (Samuel and Garton 1985) calculations should not be used to calculate home range size of desert tortoises because they are based on an assumption that is not met by the movement patterns of desert tortoises we studied. The sample size correction factor presented by Jennrich and Turner (1969) also should not be used because it overestimated home range size by as much as 200%. Based on this information, annual MCP and cluster home range size was determined for radiomarked tortoises at Yucca Mountain. Comparisons between the treatment groups will be completed in 1995.

Timing of hibernation was analyzed to identify the time of year when desert tortoises near construction activities at Yucca Mountain should be monitored (see Section 5.3) to minimize the likelihood of death or injury. The average date tortoises entered their hibernacula during 1991-1993 was October 23 (SD = 13.9, range = August 18 - December 7, n = 273). Five percent entered before October 1, 24% before October 15, 68% before November 1, and 96% before November 15. Tortoises entered hibernacula after November 21 only twice. The average date of entry differed among years (ANOVA; $F = 10.33$; 2, 264 df; $P < 0.001$). The average date of entry during 1993 was 7 days earlier than 1991 and 1992. Average date of entry also differed among sex/size classes (ANOVA; $F = 9.15$; 2, 4 df; $P = 0.026$). Females entered hibernation an average of 4 days earlier than males and 3 days earlier than immature tortoises.

The average date tortoises exited their hibernacula during 1992-1994 was March 24 (SD = 13.6, range = February 27 - May 4, n = 247). Two percent exited before March 1, 32% before March 15, 72% before April 1, 93% before April 15, and 99% before May 1. The average date of exit differed among years (ANOVA, $F = 10.9$; 2, 238 df; $P < 0.001$). In 1994, tortoises exited hibernation an average of 10 days earlier than in 1992 and 6 days earlier than in 1993. Average date of exit also differed among sex/size classes (ANOVA, $F = 38.2$; 2, 4 df; $P = 0.002$). Males exited an average of 8 days later than female and 9 days later than immature tortoises.

Based on this information, construction monitoring was not scheduled from November 15 through March 1.

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 1994, condition index, exposure to upper respiratory tract disease (URTD), growth, and blood profiles were measured. Comparisons among the three treatment levels were made for condition index and exposure to URTD. Methods for these comparisons using growth and blood profiles will be developed in 1995.

A condition index (i.e., mass/[height x width x length]) was calculated in September-October for radiomarked tortoises >100 mm long in the high-impact (31 tortoises), area-wide (42 tortoises), and control (22 tortoises) samples. This index primarily reflects the relative hydration of tortoises. Hydration of tortoises probably is affected most by rainfall, but YMP activities could also affect this parameter (e.g., if activities prevented tortoises from drinking or modified availability of water in plants). Condition index differed among the three samples (ANOVA; $F = 3.93$; 2, 86 df; $P = 0.02$). The high-impact sample of tortoises had a higher average condition index ($\bar{x} = 0.52$, SD = 0.05), and therefore may have had more water available to them, than the control sample of tortoises ($\bar{x} = 0.48$, SD = 0.03). The average condition index for the area-wide sample ($\bar{x} = 0.50$, SD = 0.05) was intermediate between, and did not differ from, the other two sample groups.

Blood was collected from 59 tortoises at Yucca Mountain in June and 91 tortoises in September. An Enzyme-Linked Immunosorbent Assay (ELISA) (Schumacher et al. 1993) was used to test these samples for the presence of antibodies to *Mycoplasma agassizii*, which is believed to be the cause of URTD. In June, the proportion of tortoises that had these antibodies did not differ (comparison-of-proportions test, $X^2 = 0.07$, 2 df, $P = 0.96$) between the high-impact (3 of 19 tortoises), area wide (4 of 21 tortoises), and control (3 of 17 tortoises) samples. In September, the proportion of tortoises that had the antibodies also did not differ ($X^2 = 1.9$, 2 df, $P = 0.39$) between the high-impact (5 of 25 tortoises), area wide (9 of 38 tortoises), and control (7 of 21 tortoises) samples.

Tortoises were examined for potential signs of URTD (e.g., wet nares, cloudy eyes, wheezing) (Jacobson et al. 1991) each time they were handled. Two tortoises were observed with wet nares during 1994: tortoise 413 on March 18 and tortoise 484 on June 6. Between 1989-1994, five tortoises have been observed with this possible sign of URTD. Blood was collected from four of these five tortoises in September 1994 and tested for antibodies to *M. agassizii*. Three of these four tortoises tested negative. The fourth tortoise (tortoise 133), observed with wet nares in August 1992, tested positive in September 1994 but had tested negative in September 1993. Based on this information and Schumacher et al. (1993), wet nares alone do not indicate URTD.

Twenty-five duplicate blood samples collected in June and 15 collected in September were analyzed to evaluate the repeatability of the ELISA test. All results from duplicate samples were the same as those from the original samples.

3.5 FOOD HABITS STUDY

Site characterization may alter plant communities by denuding plant cover and/or causing an increase in exotic plant species. Desert tortoises depend on grasses and forbs not only for food but for maintaining their water balance. The objectives of the Food Habits Study are to determine local tortoise diet, relative nutritional and quantitative importance of forage components, and large-scale effects of YMP on tortoise diet. Diet of tortoises was quantified by recording the plant species eaten by radiomarked tortoises that were observed foraging, and by collecting and analyzing scats.

3.5.1 Foraging Observations

Tortoises were observed taking 4,334 bites from 18 plant species during 89 feeding observations. Data were summarized as the percentage of total bites of each species as well as the percentage of feeding observations during which each species was consumed (i.e., frequency). As in 1993, red brome (*Bromus rubens*) and low trefoil (*Lotus humistratus*) were eaten the most (Table 3.1).

3.5.2 Scat Analysis

One hundred fifty fresh tortoise scats were collected: 61 from tortoises in the high-impact sample, 26 from tortoises in the area-wide sample, 49 from tortoises in the control sample, and 14 from other tortoises. Ninety-six of the scats were from females, 40 from males, and 14 from tortoises of unknown sex. Samples were biased towards females 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 1994 will be sent to a laboratory for microhistological analysis of plant species composition.

Results of microhistological analysis of scat collected in 1992 and 1993 were received during 1994. Average composition and frequency of occurrence were calculated for both years (Table 3.2). During 1992, desert globemallow (*Sphaeralcea ambigua*), trefoil (*Lotus* spp.)-lupine (*Lupinus* spp.), red brome, Arabian schismus (*Schismus arabicus*), and seed had the highest percent composition and frequencies of occurrence. In 1993, trefoil-lupine, desert globemallow, borage (*Boraginacea* spp.), and grass seed and glumes had the highest percent composition and frequency of occurrence. Based on species availability and field observations, the category trefoil-lupine in Table 3.2 is probably comprised mostly of low trefoil, and the category borage is probably all bristly fiddleneck (*Amsinckia tessellata*).

Table 3.1. The percent of total bites (n = 4,334) and the frequency of occurrence in feeding observations (n = 89) of the ten most frequently eaten food items of desert tortoise at Yucca Mountain during 1994.

Plant Species	Bites (%)	Frequency (%)
Red brome (*Bromus rubens*)	46	67
Low trefoil (*Lotus humistratus*)	17	24
Desert globemallow (*Sphaeralcea ambigua*)	12	8
Fiddleneck (*Amsinckia tessellata*)	4	14
Small wirelettuce (*Stephanomeria exigua*)	4	2
Fluffgrass (*Erioneuron pulchellum*)	4	3
Storksbill (*Erodium cicutarium*)	4	10
Rattlesnake weed (*Euphorbia albomarginata*)	2	1
Desert trumpet (*Eriogonum inflatum*)	2	2
Pectocarya (*Pectocarya platycarpa*)	1	1

Table 3.2. Average composition (COMP) and frequency (FREQ) of occurrence of food items in desert tortoise scat collected at Yucca Mountain during 1992 (n = 88) and 1993 (n = 93). Only the 10 most frequently eaten food items for each year are presented.

	1992		1993	
Species	% COMP[a]	% FREQ[b]	% COMP	% FREQ
Desert globemallow (*Sphaeralcea ambigua*)	26	75	19	55
Trefoil (*Lotus* spp.)-lupine (*Lupinus* spp.)	16	51	31	56
Red brome (*Bromus rubens*)	16	78	2	41
Arabian schismus (*Schismus arabicus*)	7	35		
Unknown Seed I	5	61	2	55
Borage (*Boraginacea* spp.)	3	32	14	75
Arthropod parts	3	33	1	20
Storksbill (*Erodium cicutarium*)	2	28	4	31
Cactus	2	24		
Grass seed and glumes	2	28	11	87
Unknown Grass I			3	20
Sand dropseed (*Sporobolus cryptandrus*)			2	16
Unknown Seed II			2	55

[a] average percent composition of all scats having a food item
[b] percent of all scats containing a food item

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 the areas where large-scale and long-term activities will occur. The Impact Mitigation Study was developed to collect this information.

To meet the study objectives, areas where large-scale and long-term activities will occur are searched. All tortoises found during those searches and during subsequent work in that area are radiomarked. These tortoises then are located 2-8 times per month to help understand their movements and habitat use. That information is used during the preactivity survey process to develop plans for mitigating impacts and protecting those tortoises.

Four sites where large-scale impacts were to occur were identified and searched prior to 1994. The first, in Midway Valley east of Exile Hill, was searched in 1990 for tortoises that might be impacted by a series of large trenches. This site was expanded and resurveyed in 1991 to include tortoises that might be impacted by the North Portal Facilities. Sixteen tortoises were being monitored in this site at the start of 1994. During 1994, the boundaries of this site were redrawn. The area was expanded to the south and southeast to include the proposed location of the General Support Facilities and the new location for muck storage. A large area 600-1,000 m east of Exile Hill was eliminated because the trenches planned for this area will be much smaller than anticipated. During 1994, three new tortoises were found and radiomarked near Exile Hill, and three hatchlings were radiomarked at nests in the area. Of the 22 tortoises monitored in this area during 1994, one (a hatchling) died, one was missing at the end of the year, and eight were dropped from this study because they were in the area that was eliminated from the study site. Twelve tortoises were being monitored in this area at the end of 1994.

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. By 1994, nine tortoises were being monitored in this area. Because the Exploratory Shaft Facility is no longer planned, tortoises there will no longer be monitored for the Impact Mitigation Study. Some of the nine tortoises monitored in this area during 1994 may be included in the area-wide sample for the impact evaluation studies in 1995. The transmitters will be removed from the others when they come out of hibernation in 1995.

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. At the start of 1994, 12 tortoises were being monitored in this site. During 1994, one of these tortoises died, one was dropped from this study because it had moved out of the site, and two hatchlings were radiomarked in the site. Therefore, 12 tortoises were being monitored there at the end of 1994.

The fourth site, at the borrow pit on the northeast side of Fran Ridge, was first searched in 1992. At the start of 1994, 17 tortoises were being monitored there. During 1994, three tortoises (two of which were hatchlings) were radiomarked in the area, one tortoise (a hatchling) died, one tortoise could not be found, and one moved from the area and was no longer monitored. Seventeen tortoises were being monitored at this site at the end of 1994.

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.

During 1994 no tortoises were relocated and eight were displaced from construction sites at Yucca Mountain. All of these tortoises, except three hatchlings found in a nest, were radiomarked prior to being displaced or were already radiomarked for other studies. After being moved, the radiomarked tortoises were located at least twice daily during land clearing and grading, and at least twice weekly after land clearing was completed.

Tortoise 453 (174-mm male) was found inside the borrow pit fence in April 1994; it had been removed twice in 1993. The tortoise was moved 150 m south of the fence and placed under a bush. This tortoise remained south of the borrow pit fence during the remainder of 1994.

Two tortoises were displaced during August from the site of the eight-inch water line and water tank at the south end of Exile Hill. On August 18, tortoise 229 (285-mm male) was found on the pad being cleared for the water tank. The tortoise was displaced 150 m to a burrow it had used earlier that morning. The next day 229 was back on the pad so it was moved about 1,000 m to its 1993 hibernaculum. On August 22, tortoise 280 (235-mm male) was found on the access road and was displaced about 150 m to a burrow it had used previously. Within 1-3 weeks both tortoises had returned to the south end of Exile Hill, but neither entered the construction site.

Tortoises 753 (163-mm juvenile) and 819 (203-mm male) were found during October within the path of a road being cleared for seismic studies in Crater Flats. Both were moved 100-200 m and placed under shrubs.

Three deformed hatchling tortoises were found in a nest that was excavated in November to determine the fate of hatchlings that had not emerged. Because this nest was within that part of Midway Valley that was to be cleared during January-February 1995 for the ESF muck storage area, these three hatchlings were moved to an artificial nest 800 m to the northeast. All three had abnormal depressions in their plastrons where the yolk sack was connected and in the center of their carapaces. Their artificial nest will be fenced in February 1995; these tortoises will be radiomarked and monitored if they emerge from hibernation.

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, biologists are sent to mark the tortoises. Information on mortalities and sightings of tortoises along roads are reviewed annually to identify mitigation measures needed to reduce mortalities.

Personnel reported 44 observations of desert tortoises on or adjacent to roads in the YMP area (Fig. 3.4) and five tortoises on other roads frequently used by YMP personnel. Most sightings were on the Lathrop Wells Road southwest of the Field Operations Center, on the SD-9 access road, and along the H-Road extension leading from Jackass Flats to Midway Valley.

One tortoise was killed on a road by a vehicle in the YMP area (see Section 5.4).

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 (see EG&G/EM, 1992:45-46) routes every other month. Ravens were counted for one minute at stops spaced 0.8 km apart.

The study was modified in October 1994, following a review of the goal of the study and the statistical requirements to reach that goal. The first step in this review was to analyze the power of the sampling design to detect increases in the raven population at Yucca Mountain. These results then were evaluated relative to the level of increase in the raven population we wanted to be able to detect. Because so few ravens have been seen at Yucca Mountain (the average is about 3.5 ravens per survey) and because ravens do not appear to be impacting the desert tortoise population at Yucca Mountain, it was concluded that a reasonable goal of the study was to detect a doubling in the number of ravens at the site. It was determined that conducting surveys on three days per month will achieve this goal with a power of 0.9 (i.e., there is a 90% probability of detecting a doubling in the difference in the number of ravens seen on the treatment and control route). Therefore, in October the number of survey days each month was reduced from five to three.

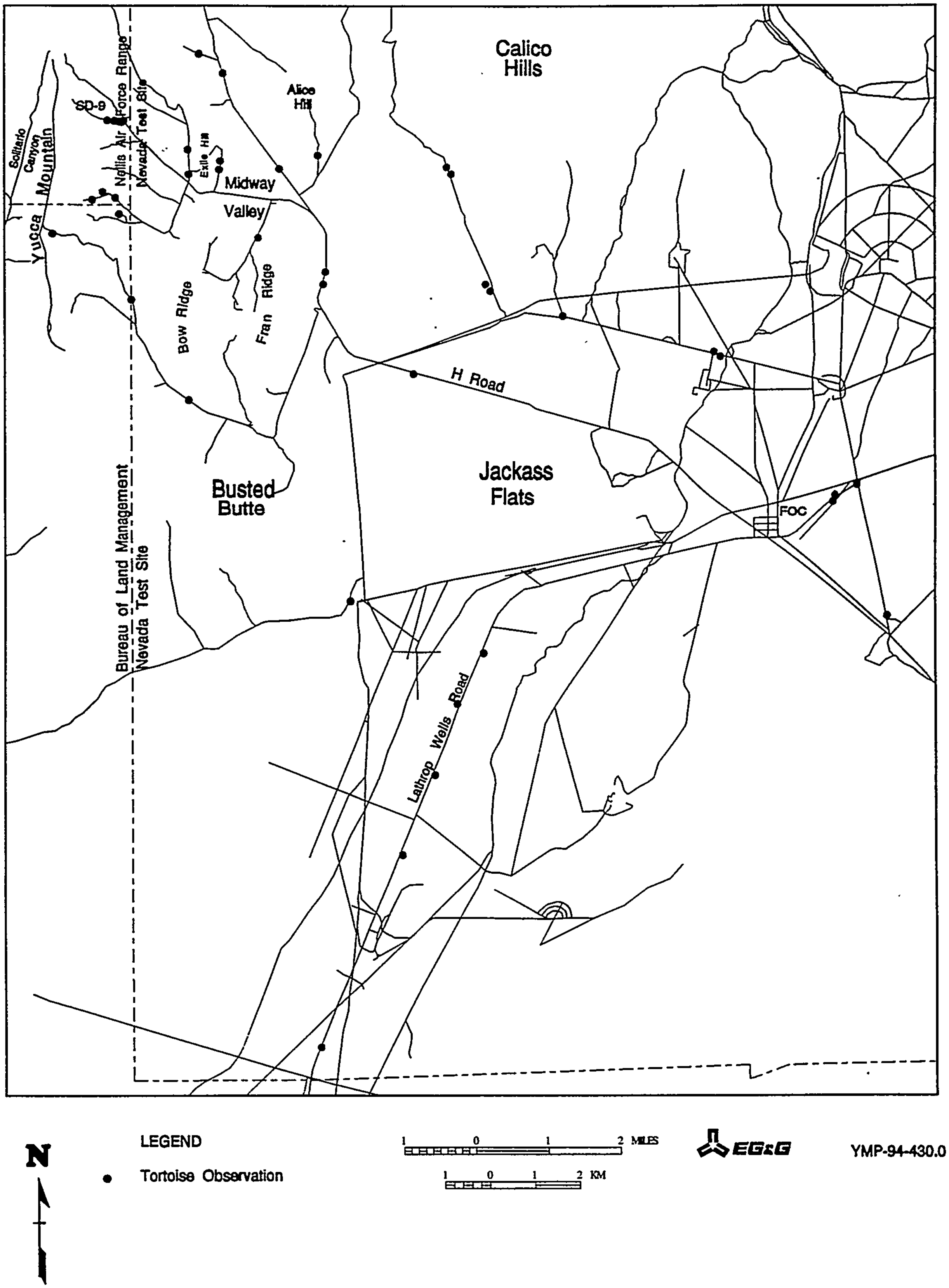

Fig. 3.4. Location of tortoises observed on roads at or near Yucca Mountain during 1994. This map does not include observations of radiomarked tortoise found on roads while being located for other studies.

The study also was reviewed to assess whether surveys should be suspended until raven abundance appears to have increased. It was decided to continue the surveys for at least one more year for two reasons. First, raven abundance increased on both the treatment and control routes when major ground-clearing activities began at YMP (Holt and Mueller, In Press). If raven abundance had not been monitored at a control site, this increase could have been falsely attributed to YMP rather than natural population fluctuations. Second, a major increase in facility construction will occur in 1995, and this increase in man-made facilities could attract ravens.

During 1994, 91 ravens were counted along the YMP route and 70 ravens along the control route. Of these, 25 ravens along the YMP route and 5 along the control route were seen using man-made facilities or disturbances. The most frequently used facilities/disturbances at Yucca Mountain were the Site 5 ($n = 6$) and Site 1 ($n = 4$) reclamation sites (see Chapter 4), flag poles at survey benchmarks ($n = 4$), and utility poles ($n = 3$). The availability of man-made facilities and disturbances along both routes is being monitored, but has not yet been analyzed.

To determine whether YMP caused an increase in raven abundance, the difference between the number of ravens observed on each route was calculated for each survey. This difference was then averaged for each month and the monthly averages were compared for three survey years, each having six survey months, starting December 1991 and ending October 1994. There was no change in the difference between the number of ravens observed among the three survey years (ANOVA, $F = 0.1$; 2,15 df; $P = 0.90$), indicating that YMP has not caused an increase in raven abundance.

3.10 GROUND MOTION EFFECTS STUDY

To evaluate the effects on tortoises of ground motion from YMP activities, two parameters are measured. First, the dimensions of a sample of burrows at different distances from ground-motion-causing activities are measured before, one week after, and six months after the ground motion to determine if those burrows collapsed. 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 1994, burrow measurements were taken for the Windy Wash Seismic Study (initiated in 1993) and the Seismic Reflections Study (initiated in 1994). Behavior was not measured since few tortoises were near these activities, so impacts on behavior could not be evaluated.

Twelve burrows near the Windy Wash Seismic Study which had been conducted in 1993 were measured again in 1994, six months after that activity occurred. One of two burrows located <50 m from the disturbance had collapsed. One of ten burrows located >50 m from the disturbance had collapsed.

During 1994, 36 burrows located within 100 m of Seismic Reflection Study sites were measured. There was no change in the dimensions of the burrows one week after ground motion activities. These burrows will be measured again in 1995, six months after the activity occurred.

There is no way to determine if seismic activities caused the burrows at Windy Wash to collapse. However, since it is not uncommon to find naturally collapsed burrows similar in structure to those that collapsed at Windy Wash, these results suggest that seismic activities caused little effect on tortoise burrows.

4. HABITAT RECLAMATION PROGRAM

The objective of the Habitat Reclamation Program is to restore lands disturbed by Site Characterization Activities (SCA) to a condition that is ecologically similar in form and productivity to undisturbed or predisturbance conditions (DOE 1989). The Habitat Reclamation Program includes interim or final reclamation activities (DOE 1991a), and reclamation feasibility studies (DOE 1990). Interim and final reclamation activities include reclamation surveys, site specific reclamation plans, reclamation implementation, and reclamation monitoring. Reclamation feasibility studies include disturbed habitat investigations, soil viability studies, and testing and evaluating reclamation techniques.

Eight ongoing reclamation field trials were evaluated in 1994 and four new field trials were initiated. In addition, two interim reclamation sites are being used to evaluate different irrigation strategies. Final reclamation at two sites (JF3 Well and Trench A'2) was implemented using demonstration plots to obtain additional information on effectiveness of different reclamation techniques. These sites were monitored in 1994.

4.1 RECLAMATION INVENTORIES

EG&G/EM conducted 18 reclamation inventories during 1994 that included 34 separate sites(Table 4.1). To date, requested activities have only occurred on 17 of these 34 sites.

Table 4.1. Summary of reclamation inventories conducted in 1994.

Project type	Number of inventories requested	Number of sites inventoried	Sites not disturbed to date
Boreholes/infiltration tests	3	4	3
Hydrological studies	1	1	1
Soil/volcanism studies	1	6	6
Seismic studies/stations	3	10	0
Facility improvements, road access/repair	1	1	1
Exploratory studies	6	6	3
Fault studies	3	6	3
Total-1994	18	34	17

Pertinent information such as existing vegetative cover, soil depth, soil texture, and soil

Pertinent information such as existing vegetative cover, soil depth, soil texture, and soil erosion was recorded during the reclamation inventory and used to prepare a Reclamation Stipulation Report. The Reclamation Stipulation Report includes recommendations for salvaging, storing, and managing topsoil to prevent wind and water erosion, and maintaining soil viability. Soil samples were collected from 29 of the sites. The other five sites were not sampled because they were either near other activities where soils had been sampled, or so small that samples were not needed. Soil samples were analyzed by a commercial soil laboratory for physical and chemical properties important for plant growth.

4.2 RECLAMATION IMPLEMENTATION

The Yucca Mountain Site Characterization Project (YMP) will reclaim areas disturbed by Project activities (DOE 1989). Interim reclamation may occur before the completion of all activities at a site and may include seeding, mulching, or chemical stabilization. The objective of interim reclamation is to prevent erosion and maintain a viable soil. Once activities have been completed on a site, YMP releases the site for final reclamation. Final reclamation includes decommissioning the site, contouring, and revegetation. The objective is to return the site, as near as possible, to predisturbance conditions.

4.2.1 Interim Reclamation Activities

Interim reclamation was completed on 50 topsoil stockpiles created by site characterization activities. The chemical soil stabilizer, Soil Master WR™, was used to stabilize 29 topsoil stockpiles. Twenty-seven topsoil stockpiles were stabilized by seeding. Six of the 27 seeded topsoil stockpiles were previously stabilized with Soil Master WR™ . Forty-eight of the 50 topsoil stockpiles stabilized in 1994 were constructed before 1994.

4.2.2 Final Reclamation Activities

Four sites were released for final reclamation in the fall of 1994, Trench NRT-1, Borehole UZN #85, C-Well discharge line, and the Large Rocks collection site. Reclamation stipulations were prepared for each site and disturbed areas were seeded in December 1994. Revegetation included site preparation, seeding with a mixture of native plant species, mulching with straw, and stabilizing the straw with a chemical tackifier. Seedling density and vascular plant cover will be measured in future years to evaluate reclamation success.

4.3 RECLAMATION MONITORING

Interim reclamation sites were monitored during the year to evaluate the success or failure of the two erosion control measures used. Final reclamation sites were also monitored to assess plant establishment and soil stability. Seedling density is measured during the spring and evaluated to determine if additional reclamation measures are necessary. Soil stability is subjectively evaluated based on the evidence of rilling or gullying on the site.

4.3.1 Interim Reclamation Sites

In 1994, 61 interim reclamation sites were monitored. Forty-eight of the sites were topsoil stockpiles and 13 were neutron boreholes. All 61 sites were revegetated in either 1992 or 1993. Because access to the neutron borehole sites is still necessary, final reclamation has not been started at these sites. None of the neutron boreholes required remedial reclamation work. However, 31 of the 48 topsoil stockpiles monitored in 1994 required additional erosion control measures. Twenty-two sites had been previously stabilized with Soil Master WR™ and required a second application in August to maintain soil stability. Nine, long-term (>6 months), topsoil stockpiles were reseeded and mulched in November 1994 to avoid degradation of the stockpile.

4.3.2 Final Reclamation Sites

Well JF3 and Trench A'2 were released for final reclamation in 1992. As part of the final reclamation stipulation, demonstration plots were established to evaluate different revegetation methods (EG&G/EM 1994:50-53). The 35 Ground Surface Facilities (GSF) sites were released for final reclamation in 1993 and were revegetated in November 1993 (EG&G/EM 1994:48).

4.3.2.1 Well JF-3 Final Reclamation

In 1993 a study was initiated at Well JF-3 to determine the effects of polyacrylamide gel and mulch type on emergence and establishment of seeded perennial plants (EG&G/EM 1993:50). The polyacrylamide gel is applied to the soil in crystal form. The crystals act as sponges and can absorb 50-400 times their weight in water, which theoretically increases the water-holding capacity of the soil. The increased amounts of soil water may improve seedling emergence and plant establishment. Seedling density was measured at Well JF-3 during April 1994 and compared with similar data collected in May and September 1993.

In May 1993, the average density on plots with the polyacrylamide gel was higher than on plots with no polyacrylamide gel, regardless of mulch treatment. However, in September 1993 and April 1994 the plots with straw mulch, regardless of polyacrylamide gel application, had higher densities than the gravel mulch (Fig. 4.1).

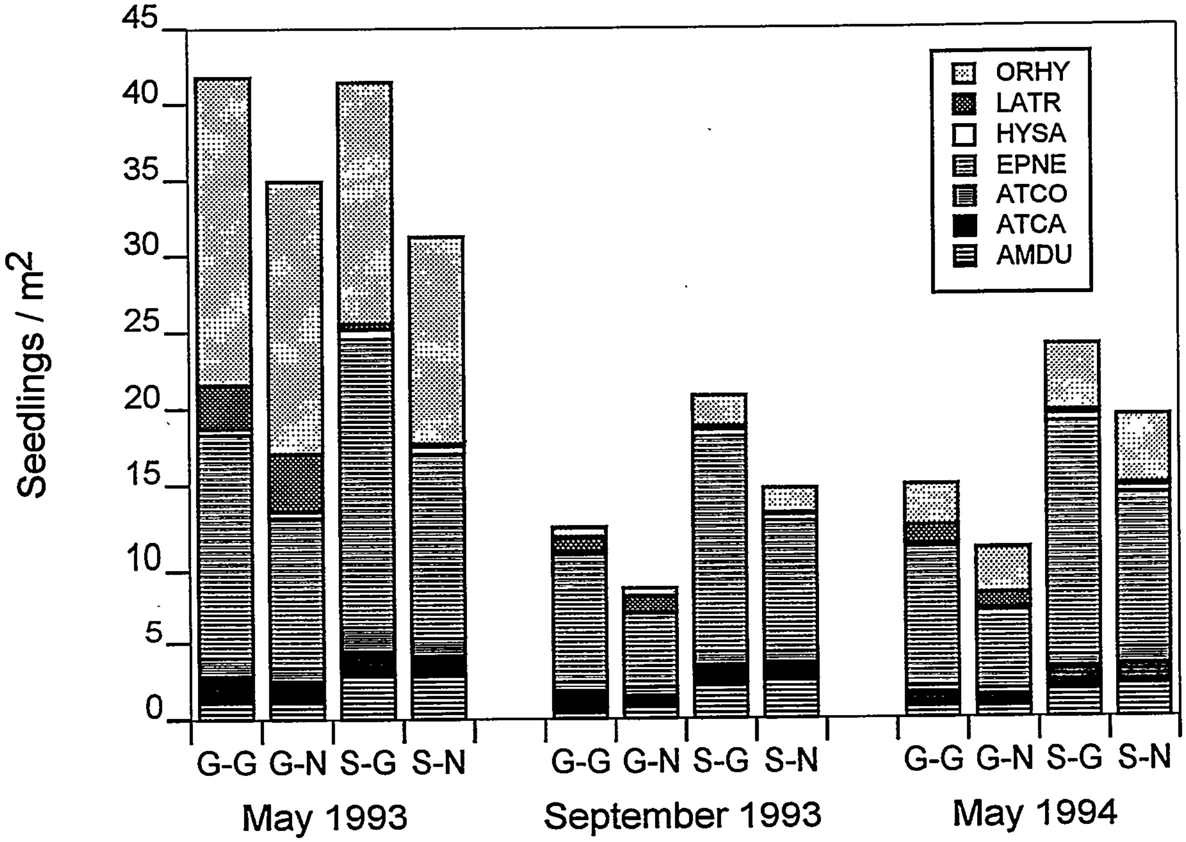

Fig. 4.1. Average seedling density of seeded species at Well JF-3 in May and September 1993, and May 1994. Treatments were as follows: gravel mulch, polyacrylamide gel (G-G); gravel mulch, no polyacrylamide gel (G-N); straw mulch, polyacrylamide gel (S-G); and straw mulch, no polyacrylamide gel (S-N). Seeded species were white bursage (AMDU), fourwing saltbush (ATCA), shadscale (ATCO), Nevada ephedra (EPNE), burrobush (HYSA), creosotebush (LATR), and Indian ricegrass (ORHY).

In May 1993, the average density was 40.9 plants/m^2. Indian ricegrass (*Oryzopsis hymenoides)* and Nevada ephedra (*Ephedra nevadensis*) were the most abundant species comprising 45% and 36% of the total composition respectively (Fig. 4.1). White bursage (*Ambrosia dumosa*), creosotebush (*Larrea tridentata*), fourwing saltbush (*Atriplex canescens*), shadscale (*A. confertifolia*), and burrobush (*Hymenoclea salsola*) each comprised 5% or less of the total composition. Average plant density measured in September 1993 and April 1994, was 15.7 plants/m^2 and 18.8 plants/m^2, respectively. Nevada ephedra was the most abundant, comprising greater than 50% of the species composition, whereas Indian ricegrass comprised less than 20% of the total composition. Indian ricegrass had greater emergence on the gravel mulch in the spring of 1993. However, its survival was lower in the gravel mulch. All other species, except creosotebush, emerged and established better in the straw mulched plots. Creosotebush responded differently than all other species. It emerged best with gravel mulch, although overall survival was poor (Fig. 4.1).

Seedling density on the straw treatments in September 1993 was 47 to 50% of the seedling density measured in May 1993. Seedling density on the plots mulched with gravel was 25 to 30% of that measured in May 1993 (Fig. 4.1). The increased survival on the straw mulch suggests that straw mulch may be more effective than a gravel mulch in ameliorating the hot and dry conditions typical of the period from May to September.

In May 1994, recruitment of new seedlings, from the seed bank was evident. Average recruitment across treatments was 3.1 plants/m^2. Straw treatments generally had greater recruitment, although this trend was not statistically significant.

Present results from this study suggest that polyacrylamide gel may be beneficial in the enhancement of seedling emergence, but may not reduce seedling mortality during the dry summer, or improve recruitment of seedlings the second spring. Mulch treatments in this study do not appear to influence seedling emergence, but the straw mulch appears to benefit both survival and recruitment of new seedlings.

4.3.2.2 Trench A'2

Final reclamation at Trench A'2 was implemented in November 1992. Seedling density in September 1993 was approximately 0.5 seedlings/m^2 (EG&G/EM 1994:52-53). Due to the low seedling density at Trench A'2, 588 containerized plants were transplanted on the site during March 1994. Nine, 180 m, linear transects were placed over the disturbance, approximately 2 m apart. At 2.5 m intervals along each transect, holes 23 cm in diameter were bored. In one-half of the holes, 10 g of polyacrylamide gel were applied. Seven perennial shrub species, fourwing saltbush, creosotebush, white bursage, wolfberry (*Lycium andersonii*), California buckwheat (*Eriogonum fasciculatum*), snakeweed (*Gutierrezia sarothrae*), and Nevada ephedra, were randomly transplanted into the holes. The transplants were watered one week and four weeks after planting.

During July 1994 the transplants were monitored to determine percent survival. Survival of all transplants averaged 87%. Survival for transplants with polyacrylamide gel was 86%, and 88% for those without polyacrylamide gel. Survival rates were high for all species: fourwing saltbush, 94%; creosotebush, 78%; white bursage, 70%; wolfberry, 99.5%; California buckwheat, 70.3%; snakeweed, 93%; and Nevada ephedra, 87%. These transplants will continue to be monitored to evaluate the feasibility of using transplants for reclaiming disturbed lands in the YMP area.

4.3.2.3 Ground Surface Facility Test Pits

In 1992 locations for Ground Surface Facility (GSF) test pits were surveyed. Information from the test pits is used to investigate soil profiles, evaluate ability of soil to support structures, determine permeability of soil for leach field design, and evaluate sources for concrete aggregate. Each trench was approximately 1.3 m wide, up to 7 m long, and as deep as 5 m. An area up to 17 m around each pit was also disturbed during excavation.

Thirty-five sites disturbed by the excavation of test pits were released for final reclamation in 1993 and were revegetated in November 1993. Each site was monitored in the spring and fall of 1994 to determine if seeds had germinated and plants established. Seedling emergence was noted on the 35 GSF sites in the spring of 1994. However, by the fall of 1994 few seedlings were observed. Monitoring will continue on these 35 sites until the fall of 1995, when a decision will be made whether to continue monitoring or reseed the sites. The straw mulch was still intact at these sites, so erosion is not a concern. A possible explanation for the poor seedling survival is the above normal temperatures experienced during the summer of 1994, which may have intensified the already harsh growing conditions experienced during the summer months. The presence of lagomorph pellets indicated that browsing occurred, which may have contributed to the low number of seedlings found in the fall of 1994.

4.4 RECLAMATION TRIALS

In 1991, five disturbed sites were selected for reclamation trials (EG&G/EM 1993:48). The trials were designed to evaluate techniques and plant materials used to reclaim disturbed sites. These sites are at elevations ranging from 1,015 to 1,460 m and at least one site is in each of the four vegetative associations found at Yucca Mountain (Section 2.3). 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. Several reclamation field trials have been designed and implemented on these disturbances since 1991. Results of these trials are used to improve techniques for stabilizing and revegetating salvaged topsoil and sites released for final reclamation.

4.4.1 Soil Quality and Soil Depth Study

A study was started in 1993 at Reclamation Trial Site 1, which is located along the ridge top of Yucca Mountain, to test the effects of soil quality and soil depth on seedling emergence and plant establishment (EG&G/EM 1994:39). Two soils of different qualities, subsoil and a mix of topsoil and subsoil, were spread over plots in four depths: 5 ± 5, 15 ± 5, 25 ± 5, 35 ± 5 cm. Subsoils were used as poor quality soils and a mixture of subsoil and topsoil was used for a good quality soil.

Seedling density was measured in June and September 1993, and in May 1994. Plant density averaged over all treatments was 9.75 plants/m² (SD = 6.49, n = 560) in May 1994. Eleven of the 14 species seeded were present in the plots; however, three species, California buckwheat (*Eriogonum californica*), winterfat (*Ceratoides lanata*), and Nevada ephedra made up 88% of the total density.

Seedling density in May 1994 differed between soil quality treatments ($P < 0.0001$, ANOVA) but not soil depth treatments ($P > 0.05$, ANOVA). Average seedling density for soil quality treatments was 8.10 plants/m² (SD = 5.64, n = 280) on plots with good soils (topsoil+subsoil) and 11.42 plants/m² (SD = 6.85, n = 280) on plots with poor soils (subsoil). On plots with poor soils, plant densities were highest with 15 cm of soil ($P <$ 0.0032, ANOVA). Plant densities were not significantly different on the other three soil depths (5 cm, 25 cm, and 35 cm) ($P < 0.0001$, SNK) (Fig. 4.2). The interaction of the two treatments (soil quality and depth) was significant ($P < 0.0001$, ANOVA). Plant densities on plots with the topsoil-subsoil mixture were higher on plots with deeper soil depths (Fig. 4.2). Results from this study indicate that poor soils (subsoils), especially at 15 cm in depth, produced greater numbers of seedlings after 1 year since implementation than good soils. However, good soils at increasing depths produced comparable numbers of plants when compared to poor soils at these same depths (Fig. 4.2). Plant densities on these treatments will continue to be monitored to determine if this trend continues in the future.

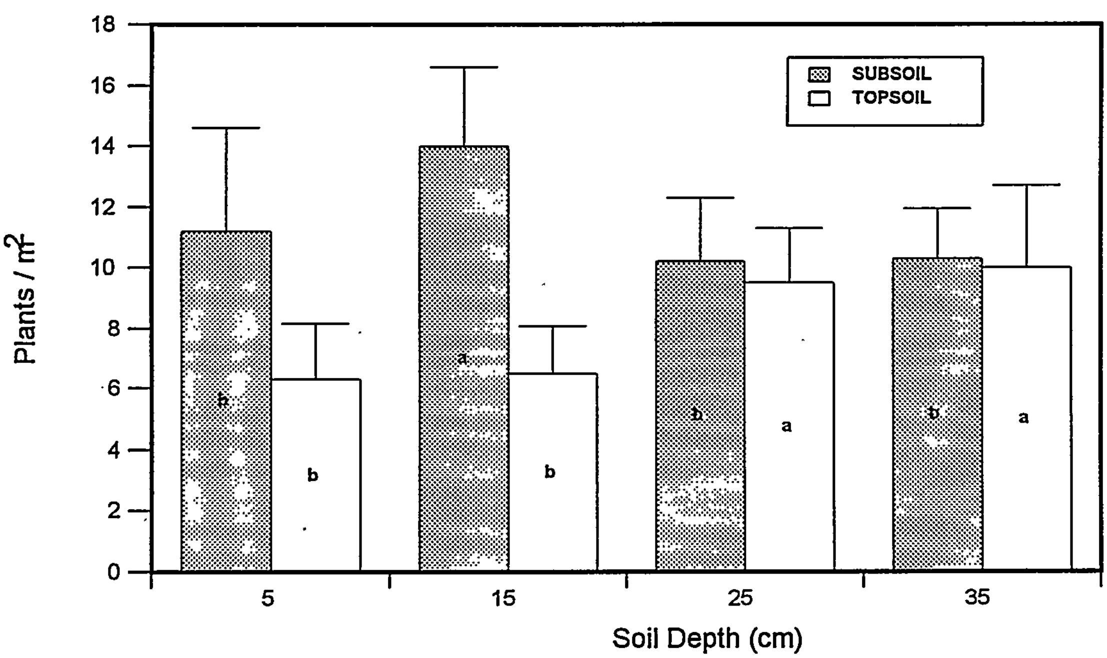

Fig. 4.2. Average plant density (plants/m²) for four soil depths and two soil types (subsoil and topsoil) at Reclamation Trial Site 1 - West. Letters represent significant differences in depths within soil type at the $P < 0.05$ level (SNK Mean Separation Test, n = 7).

4.4.2 Soil Quality and Amendment Study

Subsoils 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 need to 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 (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, but with amendments.

A study was implemented in November 1993, at Reclamation Trial Site 1, east of the soil quality and soil depth study site, to determine: (1) if fill material (subsoil) amended with fertilizer, polyacrylamide gel, organic material, or a combination of these amendments is suitable for plant growth, (2) if depth and quality of soil affects seedling emergence and plant establishment, and (3) which combination of soil quality, depth, and amendments results in the highest seedling emergence and plant establishment (EG&G/EM 1993:41-42). All treatments were seeded; the seed bank was a negligible source of emerging seedlings. Because fertilizer addition generally does not benefit germination of seedlings, the fertilizer treatments were not started until December 1994, therefore, the effects of fertilizer addition are not discussed in this summary.

In June 1994, seedling density on plots with 5-cm fill material were significantly higher ($P<0.05$, LSD Test, n = 800) than on all other soil quality and soil depth treatment plots. The two topsoil treatments had significantly lower ($P<0.05$; ANOVA, n = 1,600) seedling densities than the fill treatments and were not significantly different from each other ($P<0.05$; ANOVA, n = 800) (Fig. 4.3). This same trend in soil quality treatments was apparent when seedling density was measured in September 1994 (Fig. 4.3).

Within soil quality and depth treatments, there were apparent differences due to soil amendments in June 1994. Seedling density on plots with polyacrylamide gel were significantly greater ($P<0.05$, ANOVA, n = 800) on the 5-cm fill material plots than on the other treatments plots (Fig. 4.3). However, on plots with 20-cm of fill material, there were significantly greater ($P<0.05$, ANOVA, n = 800) number of seedlings on the control plots (Fig. 4.3). Seedling densities within the 5-cm topsoil treatment were highest on plots with organic matter plus polyacrylamide gel and organic matter treatment. No significant differences existed between the treatments of the 20-cm topsoil ($P<0.05$, ANOVA, n = 800) (Fig.4.3).

Differences in seedling densities within soil amendment treatments were not as apparent in September 1994. Within the 5-cm fill material, no significant differences existed among the control, polyacrylamide gel, or the organic matter plus polyacrylamide gel treatments (Fig. 4.3), but the number of seedlings on plots with organic matter only was significantly lower ($P<0.05$, ANOVA, n = 800). Within the 20-cm fill treatment, the control treatment had significantly greater seedling density than any of the amendments. In topsoil, there were no

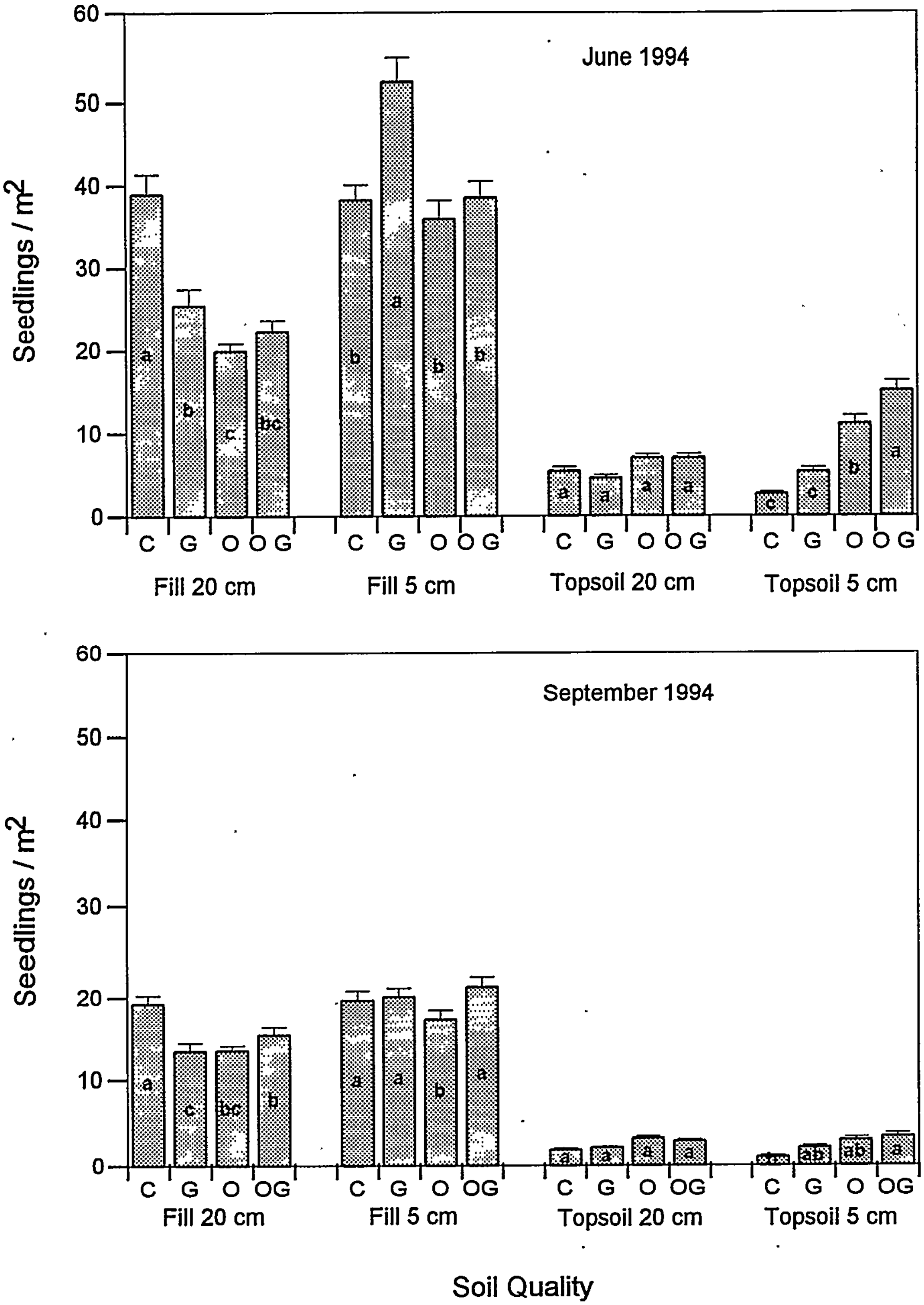

Fig. 4.3. Average seedling density on soil quality study plots at Reclamation Trial Site 1 in June and September 1994. Treatments were control (C), polyacrylamide gel (G), organic matter (O), and polyacrylamide gel plus organic matter (OG). Letters represent differences in soil amendments within soil quality treatments at $\alpha = 0.05$ (LSD test, n = 200).

significant differences among amendments except for the organic matter plus polyacrylamide gel and the control at the 5 cm depth (Fig. 4.3).

Seedling survival from June to September 1994 was greatest in the 20-cm fill material treatment (57%). Seedling survival rates on the 5-cm fill, 20-cm topsoil and 5-cm topsoil treatments, were 48%, 44%, and 29%, respectively. Within soil depth and quality, the greatest survival occurred when organic matter was used. Survival rates on the 20-cm fill material with organic matter plus polyacrylamide gel was 69%, and with organic matter, 67%.

Results from this study indicate that fill material supported higher seedling densities, regardless of soil amendment, than native topsoil. Imported fill material had 8 to 10 times more plants than did the topsoil treatments, with the shallow fill material having the greatest numbers of plants. Emergence of seedlings in the shallow 5-cm fill material appeared to be enhanced by polyacrylamide gel during the spring, however, this enhancement did not carry over into the fall. The beneficial effect of polyacrylamide gel was previously documented at Well JF-3 (EG&G/EM 1994). Apparently, the polyacrylamide aids in retaining water for establishment of seedlings during the spring months, but provides no benefit during the dry summer months. The greater response of plants to polyacrylamide with 5-cm fill material and the lack of response to the polyacrylamide with the 20-cm fill may be caused by differences in soil depth and water infiltration. These soil treatments were applied over bedrock. The polyacrylamide gel in 5-cm of fill material may have had a greater opportunity to absorb rain water because infiltrating water may have perched on the bedrock, thus allowing more time for the polyacrylamide to absorb the water. In the 20-cm fill material the water may have infiltrated past the polyacrylamide and not allowed the crystals to absorb the water. The organic matter treatments had generally higher seedling emergence in the spring for the topsoil treatments. Apparently, this amendment provided a more favorable microenvironment for seedling emergence in the topsoil treatments. Preliminary results from this study indicate that fill soil with soil amendments is a viable alternative for plant establishment on sites where native topsoil is no longer present.

4.4.3 Seeding Rate and Seeding Method Study

A study was initiated in December 1994 to determine the optimal seeding rate and method of seeding for reclaiming disturbed sites at Yucca Mountain. Seeding rates for past studies conducted by EG&G/EM have not exceeded 42 kg/ha of pure live seed (PLS). Although rates equal to and below 42 kg/ha PLS have been successful, it is not known whether increasing the seeding rate above this rate will lead to greater densities of seedlings.

Regardless of the seeding rate used in reclamation studies at Yucca Mountain, only 30 to 60% of the seedlings present during the first spring after seeding, survive the summer months. If increasing the seeding rate can lead to greater numbers of seedlings, it is possible that a greater number of seedlings could survive the first summer months. An increase in the number of seedlings surviving over the summer could improve the chances of successful reclamation.

Results of broadcast and drill seeding studies at Yucca Mountain vary. The variability may be related to the placement of seeds in the seedbed. Drill seeding generally places seeds at the same depth and in rows. Broadcast seeding, in combination with harrowing, generally places seeds at random depths and locations. Using a combination of these seeding methods at a site may improve success. By using both methods, species that respond well to drill seeding and do not respond well to broadcasting and vice versa could lead to an increase in plant densities and species diversity at a reclamation site.

This study was done at an 80- x 50-m disturbed area at Reclamation Trial Site 1. The experimental design was a 2 by 3 factorial with 2 replications. The first factor was the seeding rate (21, 42, and 84 PLS kg/ha), and the second factor was the seeding method (drill seed, broadcast seed, and drill seed/broadcast seed). The site was disked before seeding. Plots that were broadcast seeded were harrowed with a drag harrow after seeding. On plots that were drill and broadcast seeded, the drill seeder was modified so that large seeded species were drilled and the fluffy and small seeded species were broadcast. After the plots were seeded, the site was mulched with straw at a rate of 2,800 kg/ha. The straw was tackified with M-Binder at a rate of 134 kg/ha to hold the mulch in place.

4.4.4 Demonstration Plots at Reclamation Trial Site 3

Demonstration plots at Reclamation Trial Site 3 were started in February 1992, to evaluate irrigation and fencing practices 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 (Table 4.2) (EG&G/EM 1994:42-43). Trial Site 3 is located in the *Larrea-Ambrosia* vegetation association. Plant density was measured for all plots in May 1992, October 1992, and May 1993 and was documented in EG&G/EM (1993:49) and EG&G/EM (1994:42-43). During May 1994, vegetative cover was measured on all plots. Percent vegetative cover of seeded species across all plots averaged 6.2 (SD = 5.2, n = 66). Percent vegetative cover of seeded species in the fenced and unfenced plots averaged 8.3 (SD = 5.0, n = 33) and 3.9 (SD = 4.4, n = 33), respectively. The fenced, seeded and transplanted plot (Treatment 33; Table 4.2) had the highest percent vegetative cover at 24.1%. Unfenced treatments 22 and 26 (Table 4.2) had percent vegetative cover between 15% and 20%. Fenced treatments 2, 6, 9, 13, 14, 21, 27, 31, and unfenced treatment 20 (Table 4.2) had percent vegetative cover between 10% and 15%. Vegetative cover on the remaining treatments was below 10%.

The high plant densities recorded in spring 1993 for treatments 2, 3, 4, 5, and 28 (Table 4.2) (EG&G/EM 1994:43) did not translate into higher cover values in 1994. Only treatments 2 and 28 (Table 4.2) had higher than average percent cover values at 7.1% and 6.7%, respectively.

Vegetative cover was increased in plots where lagomorphs were excluded by fences. In 23 out of 32 comparisons (72%) the fenced plot had higher cover than the unfenced plot. No single soil amendment appeared to increase vegetative cover.

Table 4.2. Reclamation treatment combinations used at reclamation trial site 3.

Treatment Number	Surface Preparation	TRT #	Soil Amendments	Revegetation Treatment	Mulch	Irrigation
1.	Rip/Harrow	None	None	Not Seeded	None	None
2.	Rip/Harrow	None	None	Drillseed 21 PLS kg/ha	None	None
3.	Rip/Harrow	None	None	Broadcast 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
4.	Rip/Harrow	None	None	Broadcast 31.5 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
5.	Rip/Harrow	None	None	Broadcast 42 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
6.	Rip/Harrow	None	Compaction level 1	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
7.	Rip/Harrow	None	Compaction level 2	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
8.	Rip/Harrow	None	None	Drillseed 10.5 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
9.	Rip/Harrow	None	None	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
10.	Rip/Harrow	None	None	Drillseed 42 PLS kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
11.	Rip/Harrow	None	None	Drillseed 21 PLS Kg/ha	Straw mulch/Net 5,000 kg/ha	None
12.	Rip/Harrow	None	None	Drillseed 21 PLS Kg/ha	Straw mulch/Tackify 5,000 kg/ha	None
13.	Rip/Harrow	None	None	Drillseed 21 PLS Kg/ha	Gravel Mulch level 1	None
14.	Rip/Harrow	None	None	Drillseed 21 PLS Kg/ha	Gravel Mulch level 2	None
15.	Rip/Harrow	Imprint	None	Drillseed 21 PLS KG/ha	Straw mulch/Crimp 5,000 kg/ha	None
16.	Rip/Harrow	Pit	None	Drillseed 21 PLS Kg/ha	Straw mulch/Net 5,000 kg/ha	None
17.	Rip/Harrow	Desert Strips	None	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
18.	Rip/Harrow	None	None	Drillseed 21 PLS kg/ha	Straw mulch/Crimp 5,000 kg/ha	0.635 cm
19.	Rip/Harrow	None	None	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	1.27 cm
20.	Rip/Harrow	None	Fertilizer 44.8 kg/ha	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
21.	Rip/Harrow	None	Fertilizer 89.7 kg/ha	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
22.	Rip/Harrow	None	Fertilizer 44.8 kg/ha	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	0.635 cm
23.	Rip/Harrow	None	Fertilizer 89.7 kg/ha	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	1.27 cm
24.	Rip/Harrow	None	None	Transplants	None	None
25.	Rip/Harrow	None	None	Transplants	None	0.635 cm
26.	Rip/Harrow	None	None	Transplants	None	1.27 cm
27.	Rip/Harrow	None	Live Earth 1,121 kg/ha	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
28.	Rip/Harrow	None	Polyacrylamide gel 22.4 kg/ha	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
29.	Rip/Harrow	None	Live Earth 2,242 kg/ha	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
30.	Rip/Harrow	None	Polyacryamide gel 44.8 kg/ha	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
31.	Rip/Harrow	None	Topsoil 40% OM	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
32.	Rip/Harrow	None	Topsoil 40% OM & Polyacryamide gel 44.8 kg/ha	Drillseed 21 PLS Kg/ha	Straw mulch/Crimp 5,000 kg/ha	None
33.	Rip/Harrow	None	None	Drillseed 21 PLS Kg/ha & Transplants	Straw mulch/Crimp 5,000 kg/ha	None

A comparison of fenced and unfenced plots was initiated in 1994 to determine whether two year old plants can tolerate lagomorph browsing and whether fencing will improve plant cover on previously revegetated areas. This comparison will indicate how long fencing is required for plant establishment. To evaluate the effect of fencing, density and cover measurements were recorded for treatments 3, 9, 11, and 13 (Table 4.2) in August 1994. Following data collection the fence was removed on half of the fenced plots for treatments 9 and 11 (Table 4.2), and half of the unfenced plots for treatments 3 and 13 (Table 4.2) were fenced. Density and cover will be measured in the future on these plots and compared with the August 1994 data.

4.4.5 Soil Depth/Soil Mixing Study

A study was started at Reclamation Trial Site 4 in March 1993 to study the influence of topsoil depth and mixing on plant establishment and survival (EG&G/EM 1994:43-44). Seedling density was measured in May and October 1993, and May 1994. For the purposes of this report, the change in seedling density from October 1993 to May 1994 will be discussed. Results and discussion of the May 1993 and October 1993 seedling density measurements have been previously reported (EG&G/EM 1994). Seedling density measured in May 1994 was greater for all treatments when compared with the previous fall densities (Fig. 4.4). Like the previous results, the 5-cm mixed soil had the highest seedling density (Fig. 4.4). However, seedling densities on all other treatments were less than those on the 0-cm soil. The 0-cm soil

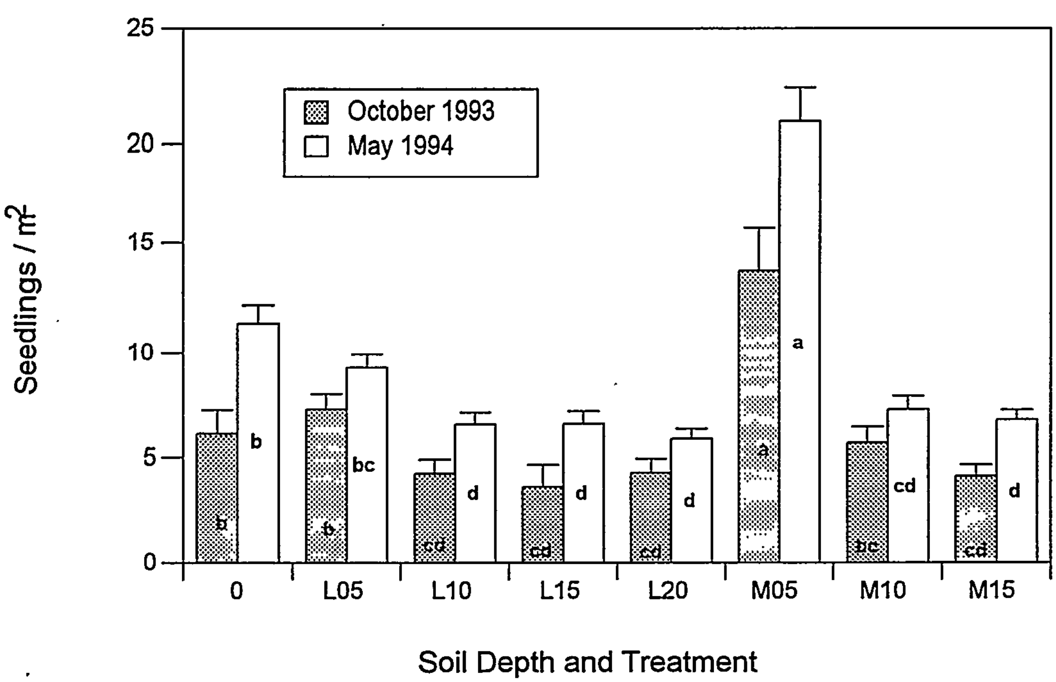

Fig. 4.4. Average seedling density on soil depth and treatment plots at Reclamation Trial Site 4 in October 1993 and May 1994. Treatments were mixed soil (M) and layered with no mixing (L). Soil depths were 0 cm, 5 cm, 10 cm, 15 cm, and 20 cm. Letters represent differences in soil treatments within a sampling period using an LSD test at $\alpha = 0.05$ (n = 80).

plots were subsoils and acted as the control. The 5-cm soil depth for both the mixed and layered soils had a general trend of higher plant densities than did the 10-, 15-, and 20-cm depths. This response was similar to that observed on the subsoil plots of the soil depth and quality study, and the soil quality and amendment study at Reclamation Trial Site 1 (Sections 4.5.1 and 4.5.2, respectively). The increase in plant densities from October 1993 to May 1994, especially in 5-cm mixed and the 0-cm treatments, was unexpected. Apparently, residual seed from the previous years' seeding germinated during this period. New seedling recruitment ranged from 7.2 plants/m^2 in the 5-cm mixed soil to approximately 1.5 plants/m^2 for the 20-cm layered (all topsoil) treatment.

Species composition across treatments was similar to that reported previously (EG&G/EM 1994). In spring 1994, California buckwheat comprised 66% of total seedling density followed by Nevada ephedra (11%), winterfat (8%), fourwing saltbush (3%), desert saltbush (*Atriplex polycarpa*) (3%), burrobush (2%) and Indian ricegrass (2%).

Preliminary results from this study show that the topsoil spread onto a site to a depth of 5 cm and mixed into the existing subsoil by disking is beneficial in increasing plant numbers. Seedling density will be measured again in 1995 to determine if this trend continues.

4.4.6 Water Harvesting Study

Several techniques, such as land imprinting and pitting, modify the soil surface to concentrate precipitation. These techniques can aid in the germination and establishment of plant species seeded during reclamation. A study was started at Reclamation Trial Site 5 to evaluate land imprinting and pitting, and to determine if sites should be imprinted or pitted before or after topsoil is spread. An additional treatment was added to determine if plots imprinted after topsoil addition benefit from the addition of straw mulch (EG&G/EM 1994:4446).

Seedling density was measured during May 1994 on all plots. Seedling density across all plots were lower than expected. Seedling density was significantly higher (4.89 plants/m^2) on plots where topsoil placement preceded ripping, seeding and mulching (Fig. 4.5). No significant differences were detected between the treatments that had topsoil layered over the water harvesting method. These treatments averaged approximately 3 plants/m^2 (Fig. 4.5). Treatments with imprinting after topsoil addition had the lowest seedling densities regardless of mulch application (Fig. 4.5).

The overall species composition of seedlings was Indian ricegrass (23%), winterfat (18%), desert saltbush (15%), California buckwheat (14%), fourwing saltbush (9%), Nevada ephedra (7%), shadscale (6%), and blackbrush (*Coleogyne ramosissima*) (6%). The remaining species each comprised less than 1%each of the total composition.

The preliminary results suggest a ripped topsoil with straw mulch is beneficial. They also suggest imprinting may hinder seedling emergence, perhaps because of soil compaction. Water harvesting technique, both before and after topsoil application, affected seedling density. The treatment with topsoil ripped, seeded and mulched, but no imprinting or pitting, had almost four times as many seedlings as the treatments using imprinting. The effects, if any, from a water harvesting technique below the topsoil may be realized in long-term establishment of plants, rather than seedling emergence.

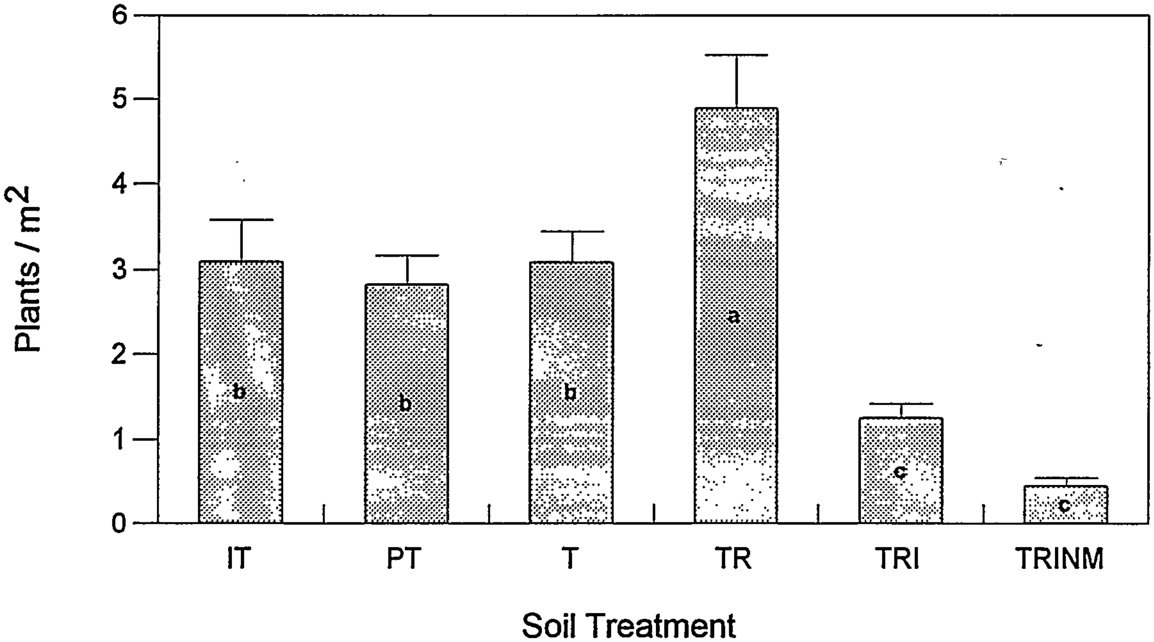

Fig. 4.5. Average seedling density for water harvesting study at Reclamation Trial Site 5 in May 1994. Treatments were imprinting followed by planting and mulching (IT), pitting followed by planting and mulching (PT), planting and mulching only (T), planting and mulching followed by ripping (TR), planting and mulching followed by ripping and imprinting (TRI), and planting and mulching followed by ripping, imprinting and seeding (TRINM). Significant differences were determined using an LSD test at $\alpha = 0.05$ ($n = 112$).

4.4.7 Concrete Batch Plant Demonstration Plots

During February, 1994, a demonstration plot located on the concrete batch plant topsoil stockpile was implemented to evaluate the effects of (1) seeding date, (2) irrigation at time of seeding, and (3) amount and timing of irrigation events after seeding, on seedling emergence and plant establishment.

Before implementation, the stockpile was ripped to alleviate compaction and disked to smooth the seedbed. Treatment combinations were applied (3 seeding dates x 3 initial irrigation amounts x 5 subsequent irrigation amounts) to 45 2- x 5-m plots. The three seeding dates were February 1, March 1, and April 1, 1994. The three initial irrigation amounts applied at the time of seeding were 0 cm, 2.5 cm, and 5 cm. Five irrigation amounts were subsequently applied: no additional irrigation, 1 application of 1.25 cm, 2 applications of 1.25 cm (totaling 2.5 cm), 3 applications of 1.25 cm (3.75 cm), and 4 applications of 1.25 cm (5.0 cm). Subsequent irrigations for the three planting dates were biweekly, weekly, and twice weekly, respectively.

Each 2- x 5-m plot was divided into 10 1- x 1-m plots. Each 1- x 1-m plot was broadcast seeded with one of the following species: white bursage, shadscale, four-wing saltbush, winterfat, spiny hopsage (*Grayia spinosa*), burrobush, creosotebush, wolfberry, Indian ricegrass, or globemallow (*Sphaeralcea ambigua*) at a rate of 80 PLS kg/ha. The seed was raked into the soil, and the plots were mulched with wheat straw at a rate of 4,500 kg/ha, and the straw crimped into the soil.

Seedling density was measured on each plot in May 1994. No seedlings were found. The reasons for this are unclear. Poor quality water (high salt concentration) was considered a possible cause for poor seedling emergence. High concentrations of salts could harden the soil surface. However, the irrigation water was sampled and the sodium adsorption ratio was 4.6, and electrical conductivity was 0.4 mmhos/cm, both below concentrations considered high. High salt concentrations are indicated by high sodium adsorption ratios (>15) and/or high electrical conductivity (>4 mmhos/cm).

Another possible explanation is the compaction of soil caused by applying large quantities of water in a relatively short period. The soil had no structure and the application of the water may have created a crust that impeded seedling emergence. Irrigation may be an important tool to attain reclamation success at Yucca Mountain. Different irrigation strategies will be tested in future years to address the problem of soil crusting as it is related to seedling emergence and plant establishment.

4.4.8 Irrigation Study at the Precast Yard Topsoil Stockpile

The precast yard was constructed adjacent to the concrete batch plant in the spring of 1994. Prior to construction, the surface 30 cm of soil, including vegetation, was stockpiled at the southern edge of the construction site. The topsoil stockpile created at the precast yard will be used to test the effect of irrigation on seedling emergence and plant establishment for three broadcast-seeding rates, 10, 21 and 42 PLS kg/ha. The experimental design for this study is a single factor (seeding rate), completely randomized design with three replications. The objective of this study is to determine what seeding rate will be required to ensure adequate plant establishment when using irrigation.

After ripping the topsoil stockpile to alleviate compaction, nine 4- x 24-m plots were established and three randomly placed replications of each seeding rate were seeded with the same mixture of 16 plant species. The site was harrowed to cover the seed, mulched with straw at a rate of 2,800 kg/ha and then chemically tackified with a solution of water, organic tackifier, and wood fiber. Following application of the treatments, the trial area will be enclosed with a poultry wire fence to exclude rabbits.

Irrigation to promote spring germination will begin March 1, 1995 and last until seed germination is complete. The site will be irrigated every other day with 5 mm of supplemental water. Establishment irrigation may also be implemented after seedling emergence has occurred. Establishment irrigation will consist of 25 mm of supplemental water every two weeks from May 15 through June 15.

Seedling density of both seeded species and the major species present in the seedbank before seeding, will be measured to determine differences between treatments.

4.4.9 Exploratory Studies Facility Topsoil Stockpile Irrigation Study

A second irrigation study was begun during the fall of 1994 at the Exploratory Studies Facility (ESF) topsoil stockpile to determine the benefits of supplemental irrigation on seedling emergence and plant establishment for two seeding/mulching treatments on topsoil stockpiles. The experimental design is a split-split-plot. Whole plots are irrigation treatments, split plots are seeding/mulching treatments, and species is the split-split plot factor. The design has three factors with 19 levels (2 irrigations, 2 seeding/mulches, and15 species) and three replications. Whole plots are completely randomized, and split plots are randomized within whole plots.

The trial area was ripped to relieve compaction and divided into six 8- x 25-m whole plots. Each whole plot was then divided into two 4- x 25-m split plots. Each split plot was treated with one of the following seedbed preparation treatments.

1) Broadcast seeded-straw mulch-tackifier. Plots were broadcast-seeded with a drill seeder, mulched with 3,360 kg/ha of wheat straw, and then tackified with a mixture of organic tackifier and wood fiber.

2) Drill seeded-straw mulch-crimp. Plots were disked and harrowed, drill-seeded with a drill seeder, mulched with 3,360 kg/ha of wheat straw, and crimped with a disk-type crimper.

Each split plot was seeded with a seed mixture of 15 species at a rate of 22 PLS kg/ha. Following application of the treatments, the trial area will be enclosed with a poultry wire fence to exclude rabbits.

Whole plots will be either irrigated (three plots) or not irrigated (three plots). The irrigation treatment is described below.

1) Pre-Irrigation. Irrigated plots will receive approximately 80 mm of supplemental irrigation during a 1-2 week period in winter 1994-95. This treatment will be initiated to recharge the soil profile with water prior to the growing season. Control plots will not receive any irrigation.

2) Germination Irrigation. Irrigated plots will receive 5 mm of supplemental irrigation approximately every other day beginning in early spring 1995. Germination irrigation will continue until germination is complete (approximately 3-4 weeks).

3) Establishment Irrigation. Irrigated plots will receive approximately 25 mm of supplemental irrigation every two weeks from the end of germination irrigation until approximately August 1, 1995.

Seedling emergence and establishment of seeded species and the seedbank will be monitored.

A data logger system will be used to collect continuous climatological data at the site. Data will include precipitation, air and soil temperature, and soil water. Precipitation and air temperature will be collected with a tipping-bucket rain gage and thermocouple thermometer, respectively. Soil temperature and soil water data will be collected using soil water/temperature cells connected to the data logger. In selected plots, cells will be buried at 2, 15, and 40 cm below the soil surface.

4.4.10 Cut Slope Revegetation

Cut slopes at Yucca Mountain, especially those created before 1987, are generally too steep for conventional reclamation equipment to access. Cut slopes that are not accessible to reclamation equipment could be contoured or shaped. However, this can lead to the creation of a larger disturbance that would have to be reclaimed. Cut slopes could also be reclaimed, as is, by using a hydro-seeder or by using manual labor to hand broadcast and rake seed into the soil. The use of a hydro-seeder would be the least labor intensive, but hydro-seeding may not provide good soil-to-seed contact required for seed to germinate and establish. Hand seeding and raking can provide good soil-to-seed contact if done properly, but is labor intensive and time consuming, especially on large areas.

Cut slopes also pose a problem for mulching after seeding. Mulching has been found to increase seedling survival at Yucca Mountain, so the use of mulch would be beneficial on cut slopes. The steepness of the cut slope can cause poorly anchored mulch to slide to the bottom of the slope or blow away. Techniques that anchor mulch against the soil would probably enhance reclamation success at these sites. Mulch that could be anchored via a tackifier sprayed from a hydromulcher would be the least labor intensive. However, tackifiers may break down too quickly or not be able to hold the mulch on the slope. Plastic netting or erosion blankets are generally effective in keeping mulch in place, but the use of these is labor intensive and can be dangerous when installing on very steep slopes. Also, netting and blankets are not as effective on sites with rock outcrops.

A study was implemented in December 1994 to determine: (1) the effectiveness of hydro-seeding versus hand seeding and raking on revegetation of cut slopes, (2) the effectiveness of plastic netted versus tackified (using M-binder) straw mulch on revegetation of cut slopes, and (3) the interaction of these effects.

Eight study plots were installed at Reclamation Trial Sites 2 and 4 (a total of 16 study plots). The experimental design at each site was a 2 x 2 factorial with 2 replications. One factor was seeding method (hand broadcast or hydroseeded) and the second was method of tackifying the straw mulch (plastic netting or a chemical binding agent). Seed was applied at a rate of 42 PLS kg/ha. Seed mixes based on the species composition of surrounding vegetation were used at the two Reclamation Trial Sites. Site 2 is in the *Larrea-Grayia* vegetation association and Site 4 is in the *Larrea-Lycium-Grayia* association. Sites that were hand broadcast seeded were raked. Straw mulch, at a rate of 2,800 kg/ha, was applied to all plots. Plots requiring tackifier were hydromulched with M-Binder at a rate of 134 kg/ha. Plastic netting (2 cm grid) was stretched across plots with this treatment and anchored with wire staples and rocks. Study plots will be monitored to determine initial seedling densities.

4.5 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 topsoil is a high priority at sites disturbed by YMP activities (Section 4.1). However, stockpiling of topsoil disrupts nutrient cycles, reduces organic matter, increases the bulk density, and disturbs the soil microbial populations (Schuman and Power 1981, Trappe 1981, Allen 1984, Hargis and Redente 1984). Studies were implemented at two sites in 1993 to determine the effects of stockpiling topsoils on soil viability.

4.5.1 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 on microbial activity and biomass, and (3) determine the influence of different plant species on soil microbial components and physical/chemical properties of the soil.

The topsoil stockpile was created during excavation of Borrow Pit #1. Topsoil removal and stockpiling began in January 1993, and 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.

To assess the effect of topsoil depth on soil 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 different vegetation covers on soil microbes and physical/chemical properties, four combinations of seed mixes were evaluated: (1) a seed mixture with proportions of species comparable to native plant communities, (2) a mixture with a greater proportion of shallow-rooted species, (3) a mixture with a greater proportion of deep-rooted species, and (4) a mixture with leguminous, nitrogen-fixing species instead of the deep-rooted species.

Soil samples were collected monthly from May to December 1993 and then every six months, thereafter. Samples collected during June through November 1993 were analyzed by a commercial soil testing laboratory for total and active bacterial numbers and biomass to ascertain the short-term effects of topsoil stockpiling. Samples collected during May 1993, December 1994 and May 1994 were analyzed by the same laboratory for active and total bacteria, active and total fungi, nematodes, mycorrhizal spores, and CO_2 respiration.

Active bacterial biomass at all depths in the stockpile was less than the undisturbed soils 40 days after stockpile completion (Fig. 4.6). Apparently, the excavation and stockpiling of topsoil substantially reduced the activity of bacteria. However, active bacterial biomass increased substantially at all depths of the stockpile between 60 and 90 days (June 1993) after stockpile completion. The 0-20 cm and the 50-70 cm depths in the stockpile had significantly greater active bacterial biomass than the baseline soils (undisturbed) and the other stockpile depths during this period (Fig. 4.6). This increase in active bacterial biomass is consistent with that reported in the literature. Harris and Birch (1990) reported that microbial activity generally increases 30 to 90 days after stockpile completion and that this may be attributed to roots, leaves, and other plant material decomposition. After this initial flush of activity, active bacterial biomass declined for all stockpile depths when compared with the undisturbed area, until approximately 200 days after stockpile completion (October 1993)(Fig. 4.6). At this time, the active bacterial biomass in baseline soils was comparable to the other depths. Active bacterial biomass increased between 200 and 400 days after stockpile completion. However, active bacterial biomass at all depths in the stockpile was lower than in the undisturbed soil (Fig. 4.6).

There was a general trend of decreasing active bacterial biomass with increasing topsoil stockpile depth over time (Fig. 4.6). The top meter of the topsoil stockpile generally had greater active bacterial biomass than the lower depths of the stockpile.

Initial results from this study suggest that active bacterial biomass is reduced during the initial removal and stockpiling of topsoil. However, active bacterial biomass, especially in the top 50 cm of the stockpile, increased during the 60- to 90-day period after stockpile completion. For all sampling periods after this initial flush of activity except one (October 1993), active bacterial biomass at all depths in the topsoil stockpile was significantly less than that of the undisturbed soil ($P < 0.05$, LSD). During the next year, the remaining microbial parameters will be analyzed to determine if they respond similarly to that of bacteria.

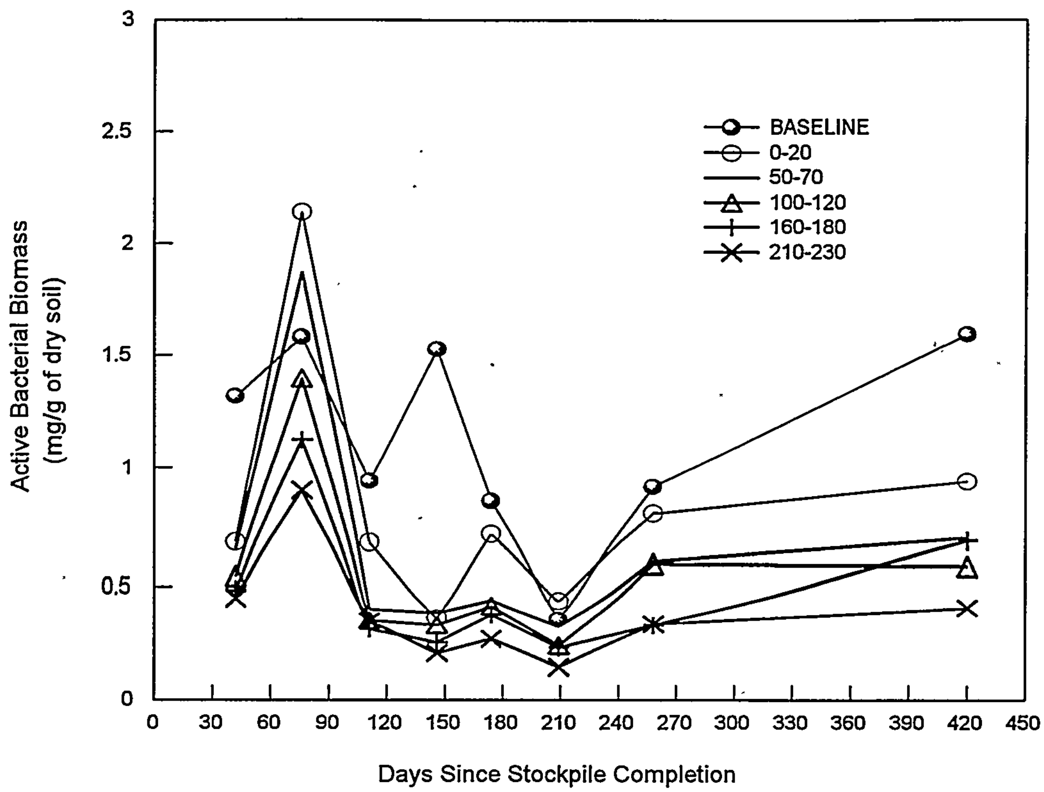

Fig. 4.6. Active bacterial biomass for soils collected from Borrow Pit #1. Soils were collected at 5 depths in the stockpile and in adjacent undisturbed areas (baseline) over time.

4.5.2 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 in November 1992 to make the NRG-6 drill pad. 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.

In May 1993, December 1993, and May 1994, soil in the stockpile was collected from four depths (0-20, 40-60, 80-100, and 120-140 cm). The samples were sent to a commercial soil testing laboratory for analysis of total and active bacteria, total and active fungi, mycorrhizal spores, nematodes, and CO_2 respiration.

At the first sampling period there was little active bacterial biomass at any depth (Fig. 4.7). Sampling results at 400 days after stockpile completion showed that little difference existed in active bacterial biomass in the topsoil stockpile depths. However, the stockpile topsoil had less active bacterial biomass than the adjacent undisturbed soil. Active bacterial biomass increased slightly at all depths of the stockpile from 400 to 560 days after completion of the stockpile. During the same period active bacterial biomass in the undisturbed areas declined slightly (Fig. 4.7). However, the active bacterial biomass in the stockpile at all depths was significantly less than that of the undisturbed soil ($P<0.05$; *t*-test).

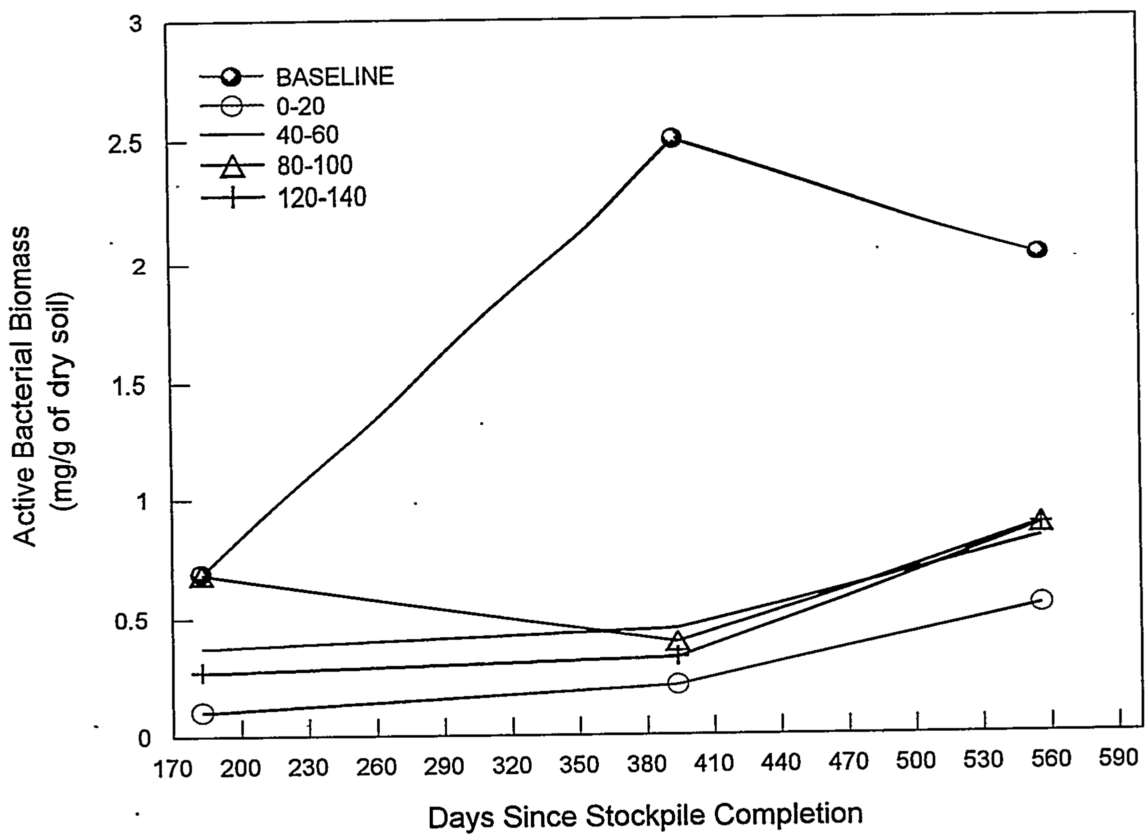

Fig. 4.7. Active bacterial biomass at the NRG-6 topsoil stockpile for three sampling events. Soil was collected at four depths in the topsoi stockpile and in undisturbed soil (baseline).

Results for active bacterial biomass in the NRG-6 stockpile were slightly different from that observed for the Borrow Pit #1 topsoil stockpile. In the topsoil stockpile, the upper layers of the stockpile had greater activity than the lower depths, especially in the 0- to 20-cm depth (Fig. 4.7). However, at NRG-6, the 0- to 20-cm depth had the lowest active bacterial biomass when compared to other depths (Fig. 4.7). The discrepancies in the active bacterial biomass in the 0- to 20-cm layer between the two stockpiles may be related to soil moisture at the time of stockpiling, soil excavation methods, and/or differences in the soil physical and chemical characteristics between the two sites. Soil microbiology will be statistically analyzed and compared in future years. Also, comparisons will be conducted to determine reasons for differences in the microbial parameters between topsoil stockpiles.

4.6 DISTURBED HABITAT STUDIES

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 provided an opportunity to study natural revegetation (i.e., plant succession) at Yucca Mountain. A study began in 1991 with three objectives: (1) determine the rate and success of secondary plant succession, (2) identify plant species found in disturbances that may be suitable for site-specific reclamation, and (3) identify environmental variables that influence succession on disturbed sites. During 1991 and 1992, fifty-seven disturbed sites were located. Vegetation, disturbance characteristics and environmental variables were measured at each site (EG&G/EM 1993, 1994). Vegetation parameters on the disturbed sites were compared with those on undisturbed sites to evaluate plant succession.

During 1994, a topical report was prepared (Angerer et al. In press) to report the findings of the disturbed habitat study. Results indicated that vegetation on disturbed sites, after an average of ten years, was quite different from undisturbed areas. White bursage, needleleaf rabbitbrush (*Chrysothamnus teretifolius*), burrobush, snake weed, shadscale, fourwing saltbush, and wirelettuce (*Stephanomeria pauciflora*) were the most dominant plants across all disturbed sites. Except for white bursage, these species were generally minor components of the undisturbed vegetation. Elevation, soil compaction, soil potassium, and amounts of sand and gravel in the soil were significant environmental variables influencing species composition and abundance of perennial plants at disturbed sites. The recovery rate for disturbed site secondary succession was estimated. Using a linear function (which would represent optimal conditions), the recovery rate for perennial plant cover, regardless of which species comprised the cover, was estimated to be 20 years. However, when a logarithmic function (which would represent the most probable conditions) was used, the recovery rate was estimated to be approximately 800 years.

4.7 HABITAT RECLAMATION SUMMARY

Reclamation studies at Yucca Mountain have identified several techniques that show promise or warrant further studies to determine whether they are viable strategies for use in site-specific reclamation. Polyacrylamide gel, as a soil amendment, has been found to increase seedling emergence in sandy soils. This amendment should continue to be tested at a variety of sites and soil types at Yucca Mountain to determine if it should be used as amendment during final reclamation of sites. Use of straw mulch increases the number of seedlings during the first year after planting. Seedling density was greater on straw versus gravel mulched plots after the first summer. Recruitment of new seedlings also was higher on straw mulched plots during the following winter and early spring.

Preliminary trials on effects of soil quality (topsoil vs. subsoil) suggests that seedling germination and plant establishment were better on the poorer quality subsoil. However, these results should not be interpreted to mean that topsoil is not needed for long-term plant establishment. The sites where fill materials were used had unique conditions. The trial site was underlain with bedrock. This may have restricted water movement and perched water in the soil above the bedrock. The large pore spaces of the sandier subsoil and perched water probably created a more favorable microenvironment for seed germination. The lack of pore space in the topsoil, which had a much higher clay content, could have restricted seed germination. It is premature to judge the success of subsoil over that of native topsoil. Under drought conditions, the subsoil may not be as successful in maintaining higher plant numbers, especially for the shallower soil depths. The lack of clay (lower water-holding capacity) in the subsoil may cause plants to be more susceptible to long-term drought. Continued monitoring is needed to evaluate subsoil as a viable alternative to topsoil.

Studies of topsoil stockpiles indicate that viability (as measured by active bacteria) is reduced during initial removal and stockpiling of topsoil. Viability of stockpiled topsoil at the Borrow Pit declined during the first 200 days but then increased slightly during the next 200 days. Viability was still less than undisturbed soil. Continued studies are needed to determine long-term effects of stockpiling on viability and whether plant establishment on the stockpile improves viability.

Preliminary results from field trials indicate that several techniques (mulches and soil amendments) show promise in improving seed germination and plant establishment. However, these results are preliminary and more time will be required to determine if these techniques increase the recovery rate of plant communities.

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 1992a). 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 1992a).

5.1 PREACTIVITY SURVEYS

Sixteen requests for preactivity surveys were received from the Project Office between January 1 and December 31, 1994. Sixteen preactivity surveys were conducted for 27 separate sites. An activity may disturb more than one site, and several surveys may be conducted per survey request. Approximately 252 ha were surveyed, including approximately 2.8 ha along 1.4 km of roads (Table 5.1). Thirty-five percent of the total area surveyed was for the Exploratory Studies Facility.

All surveys were conducted within the range of the desert tortoise. Seven tortoises were found (Table 5.1). There were 0.14 tortoise sign/km along roads. For all other surveys conducted in tortoise habitat, there were 0.4 tortoise sign/ha. Cacti, protected by the State of Nevada, were found at three sites during preactivity surveys. Ecological study plots, small mammal trapping plots, or reptile sampling plots were present in three sites.

5.2 PREACTIVITY SURVEY REPORTS AND MITIGATION RECOMMENDATIONS

EG&G/EM submitted 16 preactivity survey reports to the Yucca Mountain Site Characterization Project Office. Nineteen recommendations were made to minimize the possibility of harming tortoises (Table 5.2). These included 16 recommendations to conduct resurveys for tortoises prior to construction, three recommendations to monitor radiomarked tortoises during construction, and one recommendation to move tortoises prior to construction. One recommendation was made to place netting over the proposed Mine Waste Water Pond to prevent birds and other wildlife from entering the pond. No recommendations were made to move or modify proposed activities to avoid ecological study plots.

Table 5.1. Area surveyed and biological resources found from January 1 through December 31, 1994.

			Amount surveyed		Survey findings		
	Requests	Sites	Project type (ha)	Distance along roads (km)	Tortoises	Tortoise sign	Biological Research Plots
Boreholes/infiltration tests	3	3	15.6	5.6		1	
Soil studies/ volcanism studies	1	3	16.3			2	
Facility improvements, road repair/access	2	2	5.0	1.2			
Exploratory Studies Facility	5	5	88.7	5.0	7	92	3
Fault studies	3	7	46.0	2.2		8	
Seismic studies	1	6	77.2			18	1
C-Well	1	1	2.7				
Total	16	27	251.5	14.0	7	121	4

Table 5.2. Mitigation recommendations made for YMP activities from January 1 through December 31, 1994.

Project type	Requests received	Sites	Relocate or redesign activity	Tortoise resurvey	Tortoise monitoring	Displace or relocate tortoises	Salvage topsoil
Boreholes/ infiltration tests	3	3		3			2
Soil studies/ volcanism studies	1	3	1	1			1
Facility improvements, road repair/access	2	2		2			
Exploratory Studies Facility	5	5	1	5	2	1	5
Fault studies	3	7	1	3			3
Seismic studies	1	6	1				
C-Well	1	1					
Total	16	27	4	14	2	1	11

5.3 MITIGATION ACTIONS

Biologists conducted 44 resurveys prior to ground clearing for 16 activities at 42 separate sites (Table 5.3). Because of delays to construction activities, more than one resurvey was conducted at some sites. During these resurveys, biologists collapsed 16 unoccupied burrows after ensuring the burrows were unoccupied or removing tortoises from the burrows. Three tortoises were displaced from construction areas (Table 5.3). See Section 3.7 for a description of these displacements.

Radiomarked tortoises were monitored during four activities (Table 5.3): seismic reflection studies, the 8-inch waterline trench, the C-Well surface pipeline, and the ESF water tanks and waterline on Exile Hill. One burrow was collapsed during tortoise monitoring. No tortoises entered construction areas during activities. Additional mitigation actions implemented during 1994 for Seismic Reflection Studies, the 8-inch waterline trench, and the C-Well above-ground pipeline are described below.

Table 5.3. Mitigation actions taken from January 1, through December 31, 1994, for YMP activities.

Project Type	Tortoise resurveys conducted	Tortoise monitoring conducted	Tortoises displaced or relocated
Boreholes and Infiltration tests	5		
Seismic Lines and Stations	23	1	2
Exploratory Studies Facility	7	2	1
Fault Studies	7		
C-Well	2	1	
Total	44	4	3

5.3.1 Seismic Reflection Studies

From August 1 - November 11, 1994, EG&G/EM biologists implemented mitigation actions to protect tortoises and other important species in support of the Seismic Reflection Studies conducted in Crater Flat and Area 25. Real-time surveys for mini-shot holes, poulter detonations, and off-road driving were provided each day such activities occurred. Biologists also conducted resurveys of deep shot hole sites and line 2SW as needed. Two tortoises found during the resurvey for line 2SW were fitted with radiotransmitters and monitored during activities on Line 2SW. In addition, EG&G/EM recommended covering water pits created during drilling of some deep shot holes in Crater Flat to prevent attracting migratory birds.

5.3.2 C-Well Surface Pipeline and ESF 8-Inch Waterline Trench

In early 1994, YMP initiated construction of the 8-inch waterline trench and installation of the C-Well surface pipeline. Because the trench and pipeline may have been barriers to tortoise movements, EG&G/EM recommended that the trench be filled as soon as possible and that the surface pipeline be raised 20 to 30 cm every 30 - 40 m to allow tortoises to walk under the pipe. Until these actions were taken in mid-1994, EG&G/EM biologists monitored the C-Well pipeline and the ESF 8-inch waterline trench. This monitoring was conducted to assess whether the 2.7-km-long pipeline and 5.2-km-long trench were barriers to tortoise movements and to remove tortoises that may have fallen into the trench.

Twice each weekday between April 14 and June 23, 1994, biologists walked the length of the pipeline and trench looking for tortoises. To assess whether the pipeline and trench were barriers to tortoise movements, EG&G/EM reviewed the results of the pipeline and trench monitoring as well as radiomarked tortoise location data.

Between April 14 and June 23, eight radiomarked tortoises were found within 50 m of the pipeline and the trench for the underground waterline. Two tortoises moved over or under the aboveground pipeline in May and June. One tortoise is known to have moved across the trench in late May or in June when most of the trench had been backfilled. No tortoises were found in the 8-inch waterline trench.

5.4 INCIDENTAL TAKE

One tortoise was killed due to construction activities. Tortoise 9486, a hatchling found on the unpaved access road to SD-9 on September 8, 1994, was found run over by a vehicle on that road on September 21, 1994. This is the second confirmed incidental take under the current Biological Opinion for YMP.

5.5 POSTACTIVITY SURVEYS

Postactivity surveys were conducted for five activities completed in 1994. The postactivity surveys were conducted to document the extent and severity of the disturbance of each of the four activities. The projected area to be disturbed was less than or equal to the actual area disturbed on three of the five activities (Table 5.4). Topsoil was salvaged for the C-Well and Trench NRT-1 activities, and portions of an access road for the seismic shotholes. No other mitigation actions were required.

Table 5.4. Area (ha) projected to be disturbed for five Site Characterization Activities and the area actually disturbed.

Activity	Projected Disturbed Area (ha)	Actual Area Disturbed (ha)
C-Well Discharge Line	0.33	0.064
Trench NRT-1	0.68	0.90
Large Rock Collection Site	0.65	0.16
Borehole UZN#85	0.20	0.20
Seismic Shotholes	2.72	3.79
Total Area Disturbed	4.58	5.114

5.6 DISTURBANCE DOCUMENTATION STUDY

The goal of the Disturbance Documentation study is to estimate the amount of area disturbed by YMP activities. This study is being conducted in two phases. In the first phase, the area disturbed by site characterization activities between July 1991 and December 31, 1994, was measured. This represents the time since permits were obtained to conduct the current phase of site characterization. This effort was started in November 1994. Site Characterization Progress Reports 3, 4, and 5 (DOE 1991b, 1991c, and 1992b) were reviewed to verify that no surface disturbing YMP activities occurred before July 1991. The amount of land disturbed prior to July 1991 was then estimated from orthophotographs of the Yucca Mountain area taken in July 1990. The amount of area disturbed between July 1991 and July 1993 was measured from color infrared photos taken of the Yucca Mountain area on July 24 and 25, 1993. Differential GPS readings were taken of areas that had been disturbed since July 1993. The amount of area disturbed between July 25, 1993, and December 31, 1994, was calculated from this data. The results indicate approximately 89 ha (220 acres) were disturbed by site characterization activities between July 1991 and December 31, 1994.

The second phase of the study is to develop a procedure to document and measure the amount of area disturbed each year. This effort will be started in 1995.

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. No funding was provided in 1994 to collect plant or animal tissues. Lagomorphs (jackrabbits and cottontails) and predator populations continued to be monitored even though no specimens were collected. These surveys provide information useful to other monitoring programs. The biological opinion for the desert tortoise states that predators should be monitored.

Jackrabbits and cottontails are the largest abundant herbivores at Yucca Mountain and have had effects on reclamation efforts by consuming seedlings and transplants. The spotlight surveys provide a relative index of abundance and can be used to estimate the amount of damage that may occur on reclaimed sites.

6.1 LAGOMORPH and PREDATOR SURVEYS

Spotlight surveys were 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 1993 were again monitored in 1994. 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.

The number of lagomorphs observed decreased in 1994 (Fig. 6.1). The decline was probably related to decreased precipitation (Fig. 2.3) and reduced production of annual forbs and grasses as indicated by percent cover measurements (Fig. 2.5). An average of 6.9 (n=3, SD=4.6) and 14.3 (n=3, SD=2.7) lagomorphs per 10 km of road were observed along the Crater Flat and Yucca Mountain routes, respectively. Black-tailed jackrabbits (*Lepus californicus*) comprised 92% of lagomorph observations. The other 8% were desert cottontails (*Sylvilagus audubonii*). The desert cottontails were observed more in the high elevation blackbrush (*Coleogyne ramosissima*) communities. Black-tailed jackrabbits were found primarily in the *Larrea-Lycium-Grayia* and *Larrea-Ambrosia* vegetation associations.

Kit foxes (*Vulpes velox macrotis*) and coyotes (*Canis latrans*) were observed at least once during each survey. One bobcat (*Lynx rufus*) was observed during the August survey in Crater Flats.

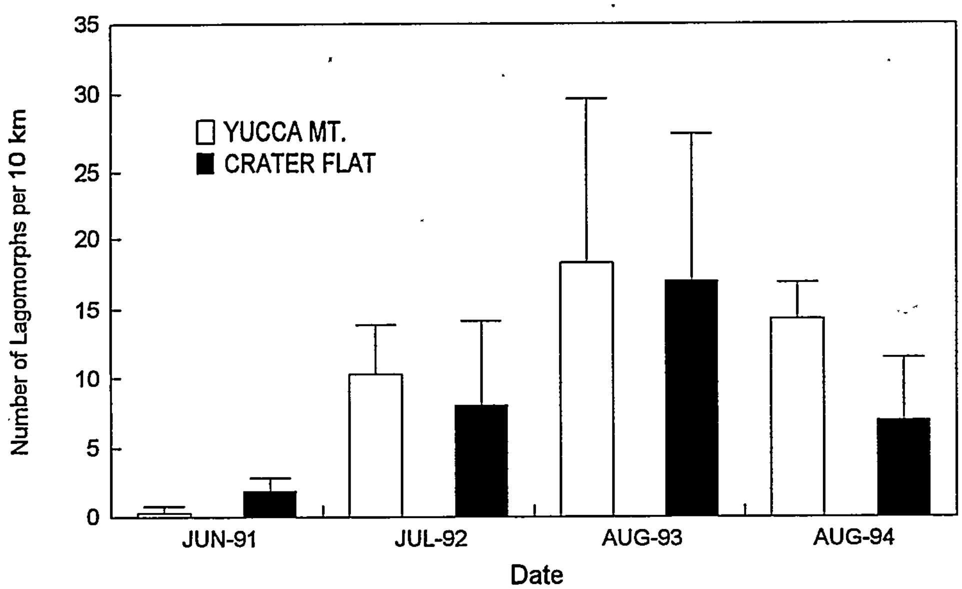

Fig. 6.1. Average number of lagomorphs (n=3 days, ±1 SD) observed per 10 km along two survey routes from 1991 through 1994.

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 1993. 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 October 1992 through December 1993 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. Reports were 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 and 781234). Budget estimates and scopes of work for fiscal year 1995 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 participated in a review meeting of the Terrestrial Ecosystem Studies by the Environment and Health Panel of the Nuclear Waste Technical Review Board (TRB). The TRB also toured Yucca Mountain. EG&G/EM scientists gave several briefings to tour participants on the terrestrial ecosystem program.

EG&G/EM participated in nine Public Outreach tours and one project orientation tour for Smithsonian Magazine. Throughout the year, EG&G/EM participated in meetings to provide input to the budgeting process and assist with project planning.

EG&G/EM staff scientists presented four papers and one poster session at the annual meeting of the Desert Tortoise Council.

Presentations:

"Hibernation Behavior of Desert Tortoises at Yucca Mountain, Nevada" by Audrey L. Hughes, Kurt R. Rautenstrauch, and Danny L. Rakestraw

"Selecting an Appropriate Method for Calculating Desert Tortoise Home Range Size and Location" by Kurt R. Rautenstrauch and Eric A. Holt

"Reproductive Characteristics of Desert Tortoises at Yucca Mountain, Nevada" by James M. Mueller, Kamila R. Naifeh, Danny L. Rakestraw, Kurt R. Rautenstrauch, and Katherine K. Zander

"Monitoring Raven Abundance at Yucca Mountain" by Eric A. Holt and James M. Mueller

Poster Session:

"The Desert Tortoise Program for the Yucca Mountain Site Characterization Project" by Danny L. Rakestraw, Kurt R. Rautenstrauch, and James M. Mueller

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.

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. M&O/SAIC conducted an environment, safety, and health review of EG&G/EM facilities and operations related to YMP.

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