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YUCCA MOUNTAIN

BIOLOGICAL RESOURCES MONITORING PROGRAM

ANNUAL REPORT FY91

JANUARY 1992

Santa Barbara Operations
130 Robin Hill Road, Goleta, California 93117

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ANNUAL REPORT FY91

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This is a continuing program, and interpretation of facts contained in this report may change as new data are acquired. Results should not be cited in scientific literature without consultation.

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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 Yucca Mountain as a possible site for a 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 repository. To ensure that site characterization activities (SCA) do not adversely affect the Yucca Mountain area, an environmental program has been implemented to monitor and mitigate potential impacts and to ensure that activities comply with applicable environmental regulations.

1.1 STUDY AREA DESCRIPTION

The Yucca Mountain Site Characterization Project (YMP) study area is located on the southwestern edge of the Nevada Test Site (NTS) in Nye County, Nevada, approximately 26 km north of the town Amargosa Valley (formerly Lathrop Wells) (Figure 1). The area is located exclusively on lands controlled by the federal government. Ownership and control of the proposed area is divided among the DOE, which controls the eastern portion of the area through land withdrawn for use as the NTS; the U. S. Air Force, which controls the northwestern portion of the site through land-use permits for the Nellis Air Force Range; and the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 characterized by rugged linear mountain ranges that dissect broad valleys. Yucca Mountain is a long north-south volcanic ridge with an elevation of 1494 m. It slopes steeply (15 to 30°) west to Crater Flat (ca. 1175 m) and gradually (5 to 10°) east, in a series of highly dissected ridges, to valleys of approximately 915 m elevation. The large basin, Jackass Flats (ca. 1100 m), and its associated drainage, Fortymile Canyon, lie to the east of Yucca Mountain.

The vegetation within the Project area is dominated by Mojave Desert plant communities below 1220 m and by transitional plant communities of Mojave Desert and Great Basin Desert flora at higher elevations. Four major plant associations occur within the study area: *Larrea-Ambrosia* (creosote bush-bursage), *Larrea-Lycium-Grayia* (creosote bush-boxthorn-hopsage), *Coleogyne* (blackbrush), and *Lycium-Grayia* (Beatley, 1976). Each association is a mosaic of sub-associations consisting of dominant shrubs and less dominant forbs and grasses.

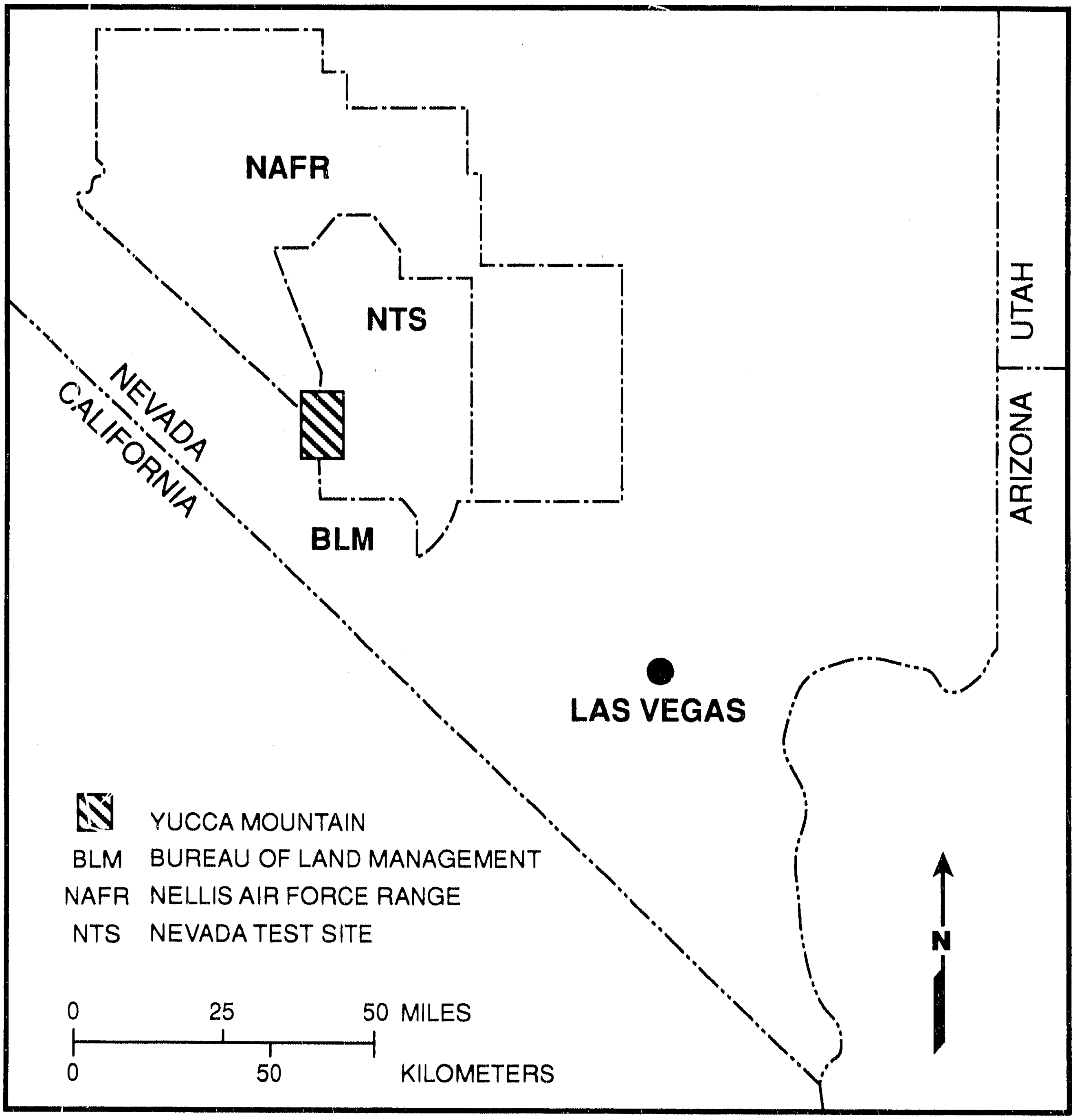

Figure 1. Location of the Yucca Mountain Study Area, Nye County, Nevada.

1.2 PROGRAM DESCRIPTION

This report describes the activities and accomplishments of EG&G Energy Measurements, Inc. (EG&G/EM) during fiscal year 1991 (FY91) for six program areas within the Terrestrial Ecosystem component of the YMP environmental program. The six program areas are Site Characterization Activities Effects, Desert Tortoises, Habitat Reclamation, Monitoring and Mitigation, Radiological Monitoring, and Biological Support.

2. SITE CHARACTERIZATION EFFECTS PROGRAM

The studies in the Site Characterization Effects Program were designed to assess the effects of SCA on the terrestrial ecosystem by monitoring attributes of various ecological components. The program includes studies of the vegetation, small mammals, reptiles, invertebrates, the spotted bat, disturbance levels, and climate.

2.1 STUDY DESIGN

SCA includes a wide variety of activities with different spatial and temporal scales. Therefore, studies were designed to assess the combined effects of the most common disturbances caused by SCA. The experimental approach is a split-plot design of paired treatment and control plots with repeated measures over time. Since the Yucca Mountain area is a single "site," true replications cannot be attained. Consequently, the field method for data collection can be regarded as analytical sampling involving subsamples (Eberhardt and Thomas, 1991). The sample units are 200- x 200-m ecological study plots (ESPs). Treatment plots are adjacent to existing or future SCA that are active on a weekly basis for at least 18 months. Control plots are at least 200 m from existing or future SCA. Details of the sampling design are provided in Green et al. (1991).

In FY91, one additional ESP (LLG7T) was established for a total of 48 ESPs in the Yucca Mountain study area (Figure 2). EG&G/EM (1991) describes criteria for selecting ESP locations.

2.2 VEGETATION STUDIES

Vegetation was selected as a parameter to help assess the effects of SCA because 1) vegetation is a key component of terrestrial ecosystems and represents the primary source of energy into the food webs; 2) vegetation provides cover and habitat for the fauna of Yucca Mountain; 3) vegetation is stationary and easier to sample compared to other biological components; and 4) vegetation is a biological component that experiences the full impact of SCAs.

Arid ecosystems may have substantial differences in vegetation cover, density, and production between years (Brown, 1974; Beatley, 1975). Variable precipitation, which is common at Yucca Mountain, is largely responsible for these year-to-year differences. Data from the NTS have shown one hundredfold changes in productivity between years (Beatley, 1969; 1975). Parameters with high variability require statistical designs with adequate control and monitoring of other associated environmental factors, such as site-specific precipitation to detect impact effects. Because the vegetation at Yucca Mountain is adapted to highly variable environmental factors and the dominant lifeform is perennial (i.e., shrubs), anticipated impacts should cause gradual and cumulative changes rather than dramatic changes.

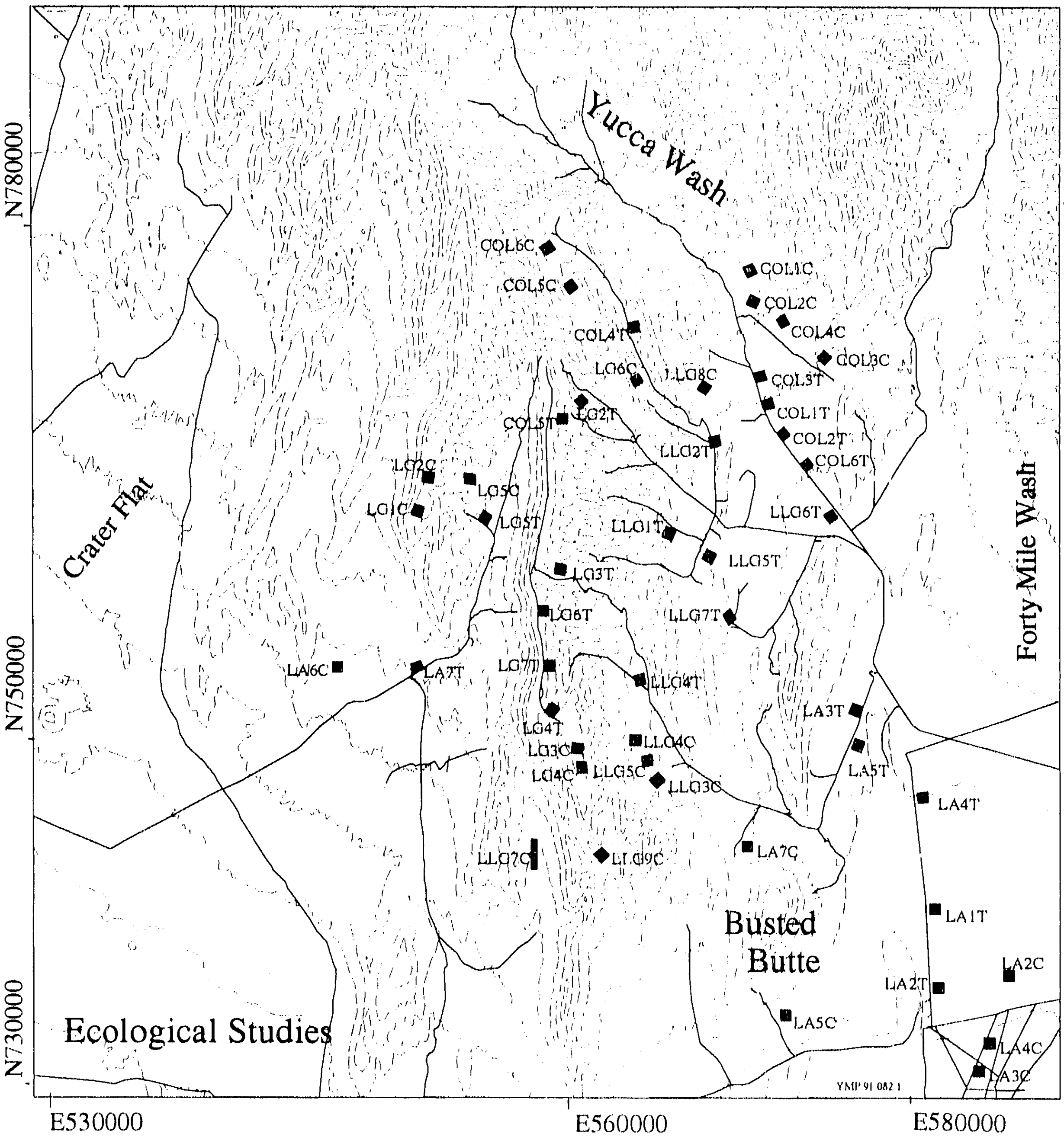

Figure 2. Location of permanent Ecological Study Plots (ESP) for the Yucca Mountain Site Characterization Project.

2.2.1 Vegetation Associations

Vegetation research has been conducted on the NTS for 30 years (Beatley, 1976; O'Farrell and Emery, 1976; Wallace, 1980). The major vegetation associations of the NTS and surrounding areas have been identified and described (Beatley, 1976; DOE, 1986). Four dominant vegetation associations occur on the Yucca Mountain Study area. The major perennial plant species present identify each vegetation association. *Larrea-Lycium-Grayia* (LLG) is the most common vegetation association at Yucca Mountain and covers approximately 35% of the surface area. The *Coleogyne* (COL) and *Lycium-Grayia* (LG) vegetation associations cover 30% and 26% of the area, respectively. *Larrea-Ambrosia* (LA) inhabits 9% of the area. Several very minor associations intergrade with the dominant plant associations but were not sampled because of their limited size.

The LLG association predominates on the eastern bajadas of central Yucca Mountain. LLG occurs at intermediate elevations (1000 to 1500 m) and on soils that are very gravelly to rocky, particularly near the steeper slopes that make up Yucca Mountain proper. Slopes are gentle, ranging from 1 to 5%. Impacts from SCAs will probably be greatest in the LLG association.

The COL association occurs across the northern one-third of the study area. Typically, soils are shallow and slopes 1 to 10%. *Coleogyne ramosissima* is the dominant plant and tends to exclude other species, making this the least diverse vegetation association. The COL association occurs on level to gently sloping valley floors and ridge tops between 1030 and 1710 m. *Coleogyne ramosissima* is generally absent from steep slopes that connect these two areas.

The LG association occurs on steep slopes throughout Yucca Mountain and dominates the Yucca Mountain ridgetop south of Antler Ridge. Soils in the LG association are very shallow and rocky. The LG association is the most complex vegetation association with respect to species and environmental diversity. Several plant species (e.g., *Ephedra* spp. and *Eriogonum* spp.) dominate local areas and form subassociations (Beatley, 1976). Subassociations, because of their small size and scattered distribution, were not recognized as distinct and separate units for study.

The LA association occurs in the south and southeastern sections of the Yucca Mountain study area. Deep, loose, and sandy soils without a well developed surface pavement characterize the LA association. Elevation ranges from 900 to 1,050 m, and slopes are gentle (0-5%). *Ambrosia dumosa* is the most common species, and accounts for almost one-half of the total cover.

2.2.2 Sampling Design, Methods, and Accomplishments

This section describes the sampling design and methods used to estimate vegetation cover, density, and biomass production. Methods used to obtain density data were modified to improve sampling efficiency and repeatability. Results from the sampling are provided where data has been summarized.

2.2.2.1 Cover

Vegetation cover was sampled on 48 ESPs. Sampling occurred on two 50-m line transects randomly located at each of five distances (10, 25, 75, 125, and 175 m) from the disturbance adjacent to each treatment ESP. Control ESPs do not have a distance effect; therefore, the 10-m distance was not sampled. Eight and ten transects were sampled in control and treatment ESPs, respectively. At 1-m intervals along each transect, two points were sampled using the ocular point cover technique (Buckner, 1985). The ocular point cover technique was used because it has greater accuracy, improved efficiency, repeatability, and reduced sampler error (Buckner, 1985). One hundred points were sampled on each transect which provided 1,000 and 800 points for each treatment and control ESP, respectively. When the ocular point intersected living plant tissue, the plant species was recorded. If the point intersected dead plant material (e.g., a dead branch on a living plant) litter was recorded. If ground cover was intersected, either bare ground, gravel, cobble, or rock was recorded. Electronic data recorders were used to record most cover data. Data recorders greatly reduced the time required for data entry.

Cover estimates showed that the effects of the drought were still evident despite near normal precipitation. The two lower elevation vegetation associations (LA and COL) showed a decline in cover of 4.1% and 2.4%, respectively (Table 1). The LA association has seen a drop in cover of 6.6% cover or nearly 40% of the original 1989 value of 17.0%. This decline is attributable to the continuing drought in this area and not Site Characterization activities, because the declines occurred in both the treated and control ESPs. The mid-elevation association, LLG, showed an increase in cover of 3.5%; however, this was caused by an increase in the cover of annual species, not perennials. The high-elevation association, LG, showed an increase of 1%; most of which was also attributable to cover contributed by annuals.

LLG association had the most cover averaging 17.1% for all ESPs (Table 1). The LG association was second with 16.7% cover followed by COL at 15.0% and LA at 10.4%. Many of the shrubs resprouted from old stems during 1991 in response to more favorable spring moisture. This allowed a clear distinction to be made between old dead stems and living plant material.

Table 1. Comparison of cover data for 1989-1991 for all ESPs sampled in each vegetation association. Data is reported as percent plant cover. n = 12 for all ESPs (Treatments = 6; Controls = 6) unless indicated otherwise.

	1989		1990		1991	
Vegetation Association	Mean	S.D.	Mean	S.D.	Mean	S.D.
Coleogyne (all ESP's)	22.0[1]	1.9	17.4	4.4	15.0	6.4
Treatment	21.9	2.5	16.7	1.7	15.2	6.8
Control	22.2	1.0	18.1	6.1	14.8	6.6
Larrea-Lycium-Grayia	17.8[2]	3.4	13.6[4]	2.4	17.1	1.9
Treatment	17.1	4.1	12.9	3.2	16.5	2.3
Control	19.0	1.6	14.1	1.6	17.7	1.2
Larrea-Ambrosia	17.0	3.1	14.5	2.1	10.4	2.6
Treatment	15.3	2.5	13.7	2.0	9.0	2.6
Control	18.7	2.7	15.4	2.0	11.7	2.0
Lycium-Grayia	20.4[3]	2.9	15.7	1.8	16.7	3.2
Treatment	20.5	1.8	15.8	2.3	16.9	4.1
Control	20.2	5.1	15.6	1.4	16.4	2.6

1. N for all 1989 *Coleogyne* ESPs = 8, Treatments = 4, Control = 4
2. N for all 1989 *Larrea-Lycium-Grayia* ESPs = 8, Treatments = 5, Control = 3
3. N for all 1989 *Larrea-Grayia* ESPs = 5, Treatments = 3, Control = 2
4. N for all 1990 *Larrea-Lycium-Grayia* = 11, Treatments = 5, Control = 6

2.2.2.2 Production

Vegetation production was sampled on 48 ESPs using the double sampling technique (Hutchings and Schmautz, 1969). Vegetation representing the current year's growth was clipped in eight 1- x 1-m randomly placed quadrats located along 200-m line transects parallel to, and 6 m from, the cover transects. Two additional quadrats were placed on each side of the clipped quadrat. Production from species rooted in these two quadrats was estimated, by lifeform (i.e., shrub, perennial grass, perennial forb, and annual), as a percentage of the production present in the clipped quadrat. Vegetation harvested from the clipped quadrat was sorted by lifeform and placed in paper bags. Samples were oven dried at 60° to 70° C and weighed to the nearest 0.01 g. Sample weights will be multiplied by the percentage estimates in the adjacent, nonclipped quadrats. This provides two production estimates for each clipped quadrat. Production data have not been summarized for 1991.

2.2.2.3 Density

Desert plant communities change slowly; therefore, plant density differences between years should be small. We tested the adequacy of the density sampling method used in FY89 and FY90 (EG&G/EM, 1991) by comparing density data from 1989 and 1990 data from the same replicates. The comparison suggested poor consistency between years. Primary causes for poor consistency were: 1) some plants were not counted because they grew in large clusters that made the identification of individual plants difficult, 2) inconsistent determination of whether plants were rooted in or out of a transect, and 3) incorrect species identification. The density sampling method was modified to minimize these problems.

Annual and perennial species density was previously estimated by recording the number of individuals of each species per 100 m^2. The new method also samples annual and perennial species, but at different intensity levels. Perennial seedlings also will be sampled. There were several reasons for these changes. First, annual species are short-lived and transitory. Long-lived, perennial species define a plant community and are used to determine the response to disturbance. Perennial species, therefore, should be the focus of the sampling method. Second, the density of annual species and perennial seedlings are largely the result of winter and spring precipitation, which is highly variable between years. Annual species and perennial seedlings frequently have high densities in good precipitation years, and it is impractical to sample an entire 100-m^2 belt transect. Third, understanding annual species and perennial seedling responses to known biotic and abiotic parameters will benefit the YMP reclamation program. Knowledge of conditions that promote and/or retard seedling germination, establishment, and survival is useful for developing effective reclamation techniques.

Perennial Plant Species. Data on perennial plant density was collected on 432 replicates. Sampling occurred in belt transects (2 x 50 m) adjacent to each 50-m cover transect. Each belt transect was divided into twenty-five 2- x 2-m quadrats. The "X" and "Y" coordinates (0 - 200 cm) of live and dead perennial plants were recorded in each quadrat. An "X - Y" coordinate map for each quadrat is created using a computer spreadsheet program. The location of each perennial plant recorded is plotted on the map. The mapping techniques' primary advantage is it allows a direct comparison of data collected between years. Also, misidentified species can be corrected. Species incorrectly identified one year, because of little or no vegetative development (due to drought), can be correctly identified during good growing years. Plants rooted on or near each belt transects' boundary also are indicated on each map so different data collectors can be consistent in recording these plants each year. It also is easier for data collectors to search twenty-five small quadrats instead of one large quadrat. Attention is focused on a smaller area; therefore, individual plants are less likely to be missed. The life history of individual plants and plant species in each replicate also can be monitored through time. This provides information on vegetation response to disturbance and normal fluctuations in environmental conditions.

Spring precipitation in 1991 was advantageous to plant growth. Many species which had been dormant for several years had excellent growth; therefore, species identification and determination of life status (i.e., alive or dead) was possible. This will provide an excellent baseline database for subsequent sampling sessions. Density data has not yet been summarized for 1991.

Annual Plant Species. The density of annual plants is estimated by recording the number of plants in five randomly placed 1- x 1-m quadrats located within each 2- x 50-m belt transect. Once established, each quadrat will be sampled every year. All annual plants rooted within each quadrat are totaled by species.

No data on annual species density were collected. Sampling quadrats were established on 14 ESPs. Sampling quadrats will be established on the remaining 34 ESPs in FY92.

Perennial Plant Seedlings. Perennial plant seedlings will be sampled using the "X - Y" coordinate system used to estimate density and survival. The same 1-m^2 quadrats used to sample annual species density will be used. Seedling survival will be tracked over time and correlated with disturbance levels and fluctuations in environmental conditions. Data collection on seedling survival will commence in FY92.

2.3 SMALL MAMMAL STUDIES

Small mammals are useful indicator species for monitoring changes to desert ecosystems because their home ranges are relatively small, their generation time is short, and they are sufficiently abundant to permit statistical comparisons. The objective of this study is to monitor potential effects of SCA on the small mammal community by estimating the demographic attributes of the most abundant small mammal species through time.

Small mammal populations at Yucca Mountain have been live-trapped on ESPs since FY89. Each sample plot consists of a 12 x 12 trap grid of 144 trap-stations (two live-traps/station). The plots are stratified by vegetation associations with one treatment and one control ESP in each association for a total of eight plots. Trapping is conducted in 4-day trap sessions five times during the year (EG&G/EM, 1991).

All eight plots were trapped in FY91. Six of the plots were trapped during six trap sessions (Table 2). The remaining two plots were trapped for only three trap sessions due to restrictions in the State of Nevada animal handling permit. The sampling effort for all the trap sessions in FY91 was 48,384 trap-nights.

Nine different small mammal species were captured (Table 2). The number of individuals captured per plot during June 1991 were generally greater than the number in June 1990. Numbers of individuals captured per plot in August and September 1991 were 2–4 times greater than numbers captured during the same months in 1989 (plots were not trapped during these months in 1990). The large increase in individuals during late-summer 1991 was caused by high reproduction, a probable response to increased precipitation and plant production in FY91. The long-tailed pocket mouse (*Perognathus formosus*) showed the greatest population response of all the species. The long-tailed pocket mouse was abundant in all vegetation associations except *Larrea-Ambrosia*, where the little pocket mouse (*Perognathus longimembris*) was more abundant. Merriam's kangaroo rat (*Dipodomys merriami*) was common in all vegetation associations.

Detailed interpretations of the data cannot be made until estimates of demographic attributes (i.e., population density, survival, and recruitment) are calculated, and additional data are collected.

Table 2. Number of individual small mammals captured on Ecological Study Plots, December 1990 - September 1991.

Species	Month	*Larrea-Ambrosia* LA5T	*Larrea-Ambrosia* LA2C	*Coleogyne* COL1T	*Coleogyne* COL2C	*Larrea-Lycium-Grayia* LLG5T	*Larrea-Lycium-Grayia* LLG8C	*Lycium-Grayia* LG6T	*Lycium-Grayia* LG4C
Perognathus formosus Long-tailed pocket mouse	December	0	0	0	2	-[a]	1	-	-
	March	0	1	16	16	-	41	-	-
	May	7	4	57	33	-	67	-	-
	June	3	0	137	52	75	188	64	55
	August	23	7	160	165	183	289	145	111
	September	18	0	156	177	132	286	136	119
Perognathus longimembris Little pocket mouse	December	0	0	0	0	-	0	-	-
	March	9	5	0	0	-	0	-	-
	May	46	68	0	0	-	0	-	-
	June	34	20	0	0	0	0	0	0
	August	49	49	0	0	0	0	0	0
	September	56	36	0	0	0	0	0	0
Dipodomys merriami Merriam's kangaroo rat	December	4	5	7	9	-	17	-	-
	March	2	2	8	11	-	25	-	-
	May	26	13	11	13	-	23	-	-
	June	22	7	10	14	47	23	7	10
	August	26	13	14	20	65	32	10	19
	September	37	36	16	31	86	41	19	22

[a] Hyphen indicates plot was not trapped during a particular month.

Table 2. Continued.

Species	Month	Vegetation Association and Plot Number							
		Larrea–Ambrosia		*Coleogyne*		*Larrea–Lycium–Grayia*		*Lycium–Grayia*	
		LA5T	LA2C	COL1T	COL2C	LLG5T	LLG8C	LG6T	LG4C
Dipodomys microps Great Basin kangaroo rat	December	0	0	4	2	–[a]	1	–	–
	March	0	0	2	3	–	0	–	–
	May	0	0	3	2	–	1	–	–
	June	0	0	6	4	2	0	2	5
	August	0	0	4	3	2	0	5	8
	September	0	0	4	7	4	0	4	9
Onychomys torridus Southern grasshopper mouse	December	1	0	0	2	–	0	–	–
	March	2	0	0	1	–	1	–	–
	May	1	0	0	0	–	1	–	–
	June	0	1	0	0	3	1	3	0
	August	1	1	0	1	4	1	2	0
	September	3	0	0	5	4	2	2	1
Peromyscus crinitus Canyon mouse	December	0	0	0	0	–	2	–	–
	March	0	0	0	0	–	0	–	–
	May	0	0	0	0	–	0	–	–
	June	0	0	0	0	0	2	11	23
	August	0	0	0	0	6	0	39	53
	September	1	0	2	4	11	11	55	63

[a] Hyphen indicates plot was not trapped during a particular month.

Table 2. Continued.

Species	Month	Vegetation Association and Plot Number							
		Larrea–Ambrosia		*Coleogyne*		*Larrea–Lycium–Grayia*		*Lycium–Grayia*	
		LA5T	LA2C	COL1T	COL2C	LLG5T	LLG8C	LG6T	LG4C
Peromyscus maniculatus Deer mouse	December	0	0	0	0	–[a]	0	–	–
	March	0	0	0	1	–	0	–	–
	May	0	0	0	1	–	0	–	–
	June	0	0	0	0	0	0	0	0
	August	0	0	0	0	0	0	0	0
	September	0	0	0	0	0	0	0	0
Ammospermophilus leucurus White-tailed antelope squirrel	December	1	0	0	0	–	0	–	–
	March	0	0	0	0	–	1	–	–
	May	0	3	1	0	–	0	–	–
	June	3	1	3	0	2	0	3	4
	August	7	3	4	6	4	0	2	5
	September	4	1	1	1	1	0	3	1
Neotoma lepida Desert woodrat	December	0	0	0	0	–	0	–	–
	March	0	0	0	0	–	0	–	–
	May	0	0	0	1	–	0	–	–
	June	0	0	0	0	0	0	1	2
	August	0	0	0	0	0	1	2	3
	September	0	0	0	0	0	2	1	3

[a] Hyphen indicates plot was not trapped during a particular month.

Table 2. Continued.

		Vegetation Association and Plot Number							
		Larrea-Ambrosia		*Coleogyne*		*Larrea-Lycium-Grayia*		*Lycium-Grayia*	
Species	Month	LA5T	LA2C	COL1T	COL2C	LLG5T	LLG8C	LG6T	LG4C
Totals for all species	December	6	5	11	15	-[a]	21	-	-
	March	13	8	26	32	-	68	-	-
	May	80	88	72	51	-	92	-	-
	June	62	29	156	70	129	214	91	99
	August	107	75	182	195	264	323	205	199
	September	119	73	179	225	238	342	220	218

[a] Hyphen indicates plot was not trapped during a particular month.

2.4 REPTILE STUDIES

Reptiles compose a significant portion of the vertebrate species in desert ecosystems. Many lizard species are habitat specific (Mayhew, 1968), making them good indicator species of change to habitat structure. The objectives of this study are to estimate species composition of the reptile community and monitor changes in abundance in relation to site characterization activities.

The primary attribute that will be estimated is the density of the most common lizard species. Also, changes in the species composition of the reptile community may be an indicator of subtle change to the local desert community.

2.4.1 Sampling Methods

One-hectare plots were established on three treatment ESP: one in each of the *Larrea-Ambrosia*, *Larrea-Lycium-Grayia*, and *Coleogyne* vegetation associations. Mark-recapture sampling will be used to estimate the density of lizards. The study is designed with multiple-capture methods of pitfall and funnel traps, drift fences, and noosing, because it is imperative that as many individuals in the population be marked as possible.

Each plot contains an array of 16 drift-fences aligned in four rows with fences in each row perpendicular to one another. Drift fences consist of galvanized flashing 15-m long and 51-cm high, buried 20 cm in the ground. The end of each drift fence overhangs into a 19-liter bucket (pitfall trap) buried flush with the soil surface. A funnel trap was placed at the middle of each fence on both sides. Funnel traps consist of hardware cloth covering a 20- x 20- x 56-cm wooden frame, with wire-mesh cones inserted into each end to permit lizards and snakes to enter but not to exit. In addition, nooses made of surgical thread and glued to the end of fishing poles were used to capture lizards.

Mark-recapture sampling was conducted on each plot during a two-week trap session in June and in August-September. Each day, lizards were captured with nooses during systematic searches of the plots. Searches and checking of funnel and pitfall traps commenced approximately one hour after sunrise and ended by early afternoon. Occasionally, traps were checked again during the afternoon to ensure animals were not heat stressed. Captured lizards were permanently marked by toe-clipping and temporarily marked by painting a unique number on their dorsum. The paint mark allowed individuals to be resighted within each trap session. Opportunistic sampling (i.e., night driving and searching specific habitats) was conducted for species that were not captured on the three established plots in order to document their presence or absence in the Yucca Mountain area.

2.4.2 Results

Eight lizard and 13 snake species were captured or observed during plot and opportunistic sampling (Table 3). The side-blotched lizard (*Uta stansburiana*) and western whiptail (*Cnemidophorus tigris*) species had the greatest number of individuals captured during mark-recapture sampling (Table 3). Density estimates for these two species have not been calculated.

All three capture methods were useful in capturing lizard and snake species. Of the 412 captures of side-blotched lizards, 72% were by noosing; 16% by funnel traps; and 12% by pitfall traps. Of the 273 captures of *Cnemidophorus*, 47% of the captures were by funnel traps with the remaining captures split evenly between pitfall traps and noosing. Sixty-seven percent of the snakes captured were by funnel traps (27 total captures).

Reptilian species thought to exist at Yucca Mountain but not captured or observed include desert iguana (*Dipsosaurus dorsalis*), desert night lizard (*Xantusia vigilis*), western blind snake (*Leptotyphlops humilis*), and lyre snake (*Trimorphodon lambda*). Zebra-tail lizards (*Callisaurus draconoides*) were frequently seen, but none was captured.

Table 3. Number of individual reptiles captured on three plots during two consecutive week trap sessions in June, August, and September, 1991; Species captured only during opportunistic sampling during the spring and summer months are noted with a ✓.

Species	LA3T June	LA3T Sept.	LLG2T June	LLG2T Sept.	COL2T Sept.	Opportunistic Sampling
Lizards						
Uta stansburiana Side-blotched lizard	10	19	31	106	94	
Cnemidophorus tigris Western whiptail	15	23	27	33	39	
Coleonyx variegatus Western banded gecko	4	4	3	6	12	
Gambelia wislizenii Longnose leopard lizard	4	8	0	0	3	
Sceloporus magister Desert spiny lizard	2	3	1	0	0	
Phrynosoma platyrhinos Desert horned lizard	0	5	0	0	7	
Crotaphytus insularis Desert collared lizard	0	0	0	1	0	
Sauromalus obesus Chuckwalla	0	0	0	0	0	✓

Table 3. Continued.

Species	LA3T June	LA3T Sept.	LLG2T June	LLG2T Sept.	COL2T Sept.	Opportunistic Sampling
Snakes						
Sonora semiannulata Ground snake	1	0	9	1	1	
Chionactis occipitalis Western shovelnose snake	2	0	0	0	0	
Rhinocheilus lecontei Longnose snake	0	0	2	2	1	
Tantilla hobartsmithi Southwestern blackhead snake	0	0	4	0	0	
Masticophis flagellum Coachwhip	0	0	1	1	0	
Salvadora hexalepis Western patchnose snake	0	0	0	0	0	✓
Hypsiglena torquata Night snake	0	0	0	0	1	
Phyllorhynchus decurtatus Spotted leafnose snake	0	0	0	0	0	✓
Pituophis melanoleucus Gopher snake	0	0	1	0	0	
Lampropeltis getula Common kingsnake	0	0	0	0	0	✓
Arizona elegans Glossy snake	0	0	0	0	0	✓
Crotalus mitchellii Speckled rattlesnake	0	0	0	0	0	✓
Crotalus cerastes Sidewinder	0	0	0	0	0	✓

2.5 SPOTTED BAT STUDY

The spotted bat (*Euderma maculatum*) is classified as a Category 2 species by the U. S. Fish and Wildlife Service and has been found in adjacent Clark and Lincoln counties (Best, 1988). A study was initiated in FY91 to determine if the spotted bat is present at Yucca Mountain. No previous field study has been conducted to determine the species' presence at Yucca Mountain. The spotted bat often occurs in desert scrub located within 16 km of coniferous forest (pers. comm., T. Best). *Juniperus* spp. and *Pinus* spp. communities are located 13 km north of Yucca Mountain.

2.5.1 Sampling Methods

Survey techniques used to detect the spotted bat were mist-netting and listening for vocalizations. Four man-made ponds along Forty-Mile Wash near Yucca Mountain were selected for mist-netting. Other sites used for mist-netting included several narrow passages in dry washes. Mist-netting was done on two consecutive nights in May (only two nights due to windy conditions) and three consecutive nights in July and August 1991. No location was mist netted twice during a month. Nets were erected over and around standing water or across narrow canyons about one hour before sunset and monitored until shortly after sunrise. Species, sex, reproductive condition, weight, and standard measurements were recorded for captured bats.

Spotted bats are unique in that their echolocation calls; their vocalizations are audible to the human ear (Fenton and Bell, 1981; Woodsworth et al., 1981). Spotted bat vocalizations can be heard as far away as 250 m (Fenton and Bell, 1981). Therefore, personnel listened for vocalizations while mist netting.

2.5.2 Results

Spotted bat surveys were conducted for 87 hours. No spotted bats were captured or heard. Five bat species were captured with mist nets. The western pipistrelle (*Pipistrellus hesperus*) was the most common (Table 4). A sixth species, the long-legged myotis (*Myotis volans*), was captured inside a building approximately 10 km east of Forty-Mile Wash. One specimen of each bat species was collected for a reference specimen. The Mexican free-tail bat (*Tadarida brasiliensis*), hoary bat (*Lasiurus cinereus*), and long-legged myotis are new species records for the Nevada Test Site.

Table 4. Total captures of each bat species during mist-net sessions near Yucca Mountain on May 6-7, July 8-10, and August 12-14, 1991.

Species	May	July	August
Pipistrellus hesperus Western pipistrelle	6	243	54
Myotis californicus California myotis	17	8	1
Antrozous pallidus Pallid bat	1	23	6
Lasiurus cinereus Hoary bat	1	0	2
Tadarida brasiliensis Mexican free-tail bat	0	1	5

2.6 INVERTEBRATE STUDIES

Invertebrates are important components of the desert ecosystem. Invertebrates affect the processes of primary production, decomposition, and nutrient cycling through consumption of plant tissues and detrital material. Also, invertebrates are the primary food source for many vertebrate species. Little information on invertebrates is available for the Yucca Mountain area. EG&G/EM conducted a pilot study to assess the invertebrate communities in the vicinity of Yucca Mountain. The primary objectives of the study were to identify some of the most common invertebrate taxonomic groups, develop a reference collection, and evaluate the efficacy of several trapping techniques for sampling different invertebrate groups (e.g., flying, soil surface and litter, or soil invertebrates).

2.6.1 Sampling Methods

Current literature was reviewed to identify sampling techniques with potential for use in this study. Three sampling methods were identified and evaluated; black-light traps, pitfall traps, and soil litter extraction. Sampling was conducted on ESPs established in FY90 (EG&G/EM, 1991). Sweep-netting and opportunistic sampling were used to collect specimens not captured with the other trapping methods. These specimens were used to supplement the reference collection of invertebrates.

2.6.1.1 Black-light Sampling

Sixteen ESPs, two control and two treatment plots in each vegetation associations, were selected for black-light sampling. One universal black-light trap was placed in the center of each ESP. The traps were operated for two consecutive nights from dusk to early morning. Chloroform, ethyl acetate, and acetone were each tested as killing agents in the traps. Chloroform was found to be the most effective chemical in reducing invertebrate activity. Captured invertebrates were placed in plastic bags, sealed, and held at 0°C for a minimum of 36 hours before sorting, identifying, and counting. The samples were returned to the freezer for long-term storage after processing.

2.6.1.2 Soil and Leaf Litter Extraction

Soil and leaf litter samples from the sixteen ESPs used for light trapping were collected for extraction of invertebrates. To avoid disturbing vegetation within the ESPs and potentially impacting other studies, a shrub located immediately outside each ESP was selected for sampling. Leaf litter, soil, and other debris found under the shrub was collected and placed into a plastic bag and sealed. The invertebrates were then extracted from the sample using a Berlese funnel. The Berlese funnel uses heat to force the invertebrates from the sample and into a jar filled with alcohol. Invertebrates extracted from samples were examined under a dissecting microscope, identified, and counted.

2.6.1.3 Pitfall Sampling

Pitfall sampling was used on two treatment ESPs, one in each of the *Larrea-Ambrosia* and *Larrea-Lycium-Grayia* vegetation associations. In each ESP four transects were established. Each transect consisted of two lines of eight traps, for a total of 32 traps per ESP. Each trap within a line was spaced ten meters apart. Sixteen-ounce plastic cups were used as traps and were placed in the ground with the lip of the cup level with the soil surface. Wooden covers were placed over the cup to protect any captured animals from the sun. The traps were open for two consecutive days and were checked at 24 hours, 32 hours, and 48 hours. Traps were sealed with plastic lids when trapping was completed. Samples were placed in plastic bags, sealed, and stored at 5°C for at least 24 hours before identification. The samples were placed into a petri dish filled with water and examined under a dissecting scope. Invertebrates were identified, counted, and removed.

2.6.1.4 Collection Preservation

During the sampling, representative specimens within each taxonomic group were preserved. Soft-bodied specimens were placed in a 70% alcohol solution. Other specimens were pinned and allowed to dry. Specimens were labeled and placed in museum trays for reference.

2.6.2 Results and Discussion

Captured invertebrates were sorted and counted by taxonomic group (mostly by Order). Data was summarized by vegetation association for each sampling method. Because pitfall traps were used only in the *Larrea-Ambrosia* and *Larrea-Lycium-Grayia* vegetation associations, comparison of the three sampling methods was made for only these two vegetation associations.

2.6.2.1 Black-light Sampling

Over 45 families representing eleven Orders of invertebrates were captured in the light traps (Table 5). Invertebrates were most numerous in the *Larrea-Lycium-Grayia* vegetation association. The *Larrea-Ambrosia* plots had the second highest number of captures, *Coleogyne* the third, and *Lycium-Grayia* had the fewest. The Orders Lepidoptera and Trichoptera (moths, butterflies, and caddisflies) were the most abundant, followed by Hymenoptera (ants, bees, and wasps), and Coleoptera (beetles).

Table 5. Average number of invertebrates by taxonomic group captured per study plot in black-light traps for each vegetation association.

	Vegetation Association							
	Larrea-Ambrosia n = 4		*Coleogyne* n = 4		*Lycium-Grayia* n = 4		*Larrea-Lycium-Grayia* n = 4	
	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Orthoptera	17	6.6	17	1.9	2	2.6	23	26.3
Hemiptera	6	0.8	95	62.9	9	8.8	450	474.6
Homoptera	41	7.3	31	15.1	11	10.6	201	198.8
Neuroptera	5	1.8	6	2.9	7	8.4	20	19.3
Coleoptera	35	2.1	168	42.9	23	24.4	1981	2065.8
Lepidoptera/Trichoptera	544	0.4	760	432.7	401	411.1	1242	1231.1
Diptera	23	3.7	7	6.9	3	2.6	48	50.3
Hymenoptera	966	233.1	189	47.6	83	80.7	1248	1404.5
Araneae	0	-	1	1.9	1	0.6	2	0.9
Scorpiones	0	-	0	-	0	-	<1	0.3
TOTAL	1637		1274		540		5216	

2.6.2.2 Berlese Funnel Sampling

Invertebrates from nine orders were identified from soil and soil litter samples (Table 6). The most common invertebrates were mites and ticks. Sixty-three percent of the organisms found in the samples were from the *Lycium-Grayia* plots. *Coleogyne* and *Larrea-Lycium-Grayia* had approximately the same abundance of invertebrates, while the fewest number were found in the *Larrea-Ambrosia* plots.

2.6.2.3 Pitfall Traps

The pitfall traps collected invertebrates from 15 Orders (Table 7). The majority of organisms captured were Hymenoptera (mostly ants). Spiders and minute soil insects in the Order Collembola (springtails) were also present in relatively large numbers. Approximately three times as many invertebrates were captured in pitfall traps on the *Larrea-Lycium-Grayia* plot than on the plot in *Larrea-Ambrosia*.

2.6.2.4 Comparison of Trapping Methods

Species from over 18 invertebrate Orders were collected in the Yucca Mountain area. Twelve of the Orders are in the Class Insecta indicating a major portion of the trap catches were insects. Other common arthropods trapped were spiders, scorpions, ticks, and mites.

The relative effectiveness of each sampling method was evaluated by comparing the rankings of the taxonomic groups captured with each method. The ranking was based on the average number of captures per study plot. Because pitfall trapping was conducted only in the *Larrea-Ambrosia* and *Larrea-Lycium-Grayia* vegetation associations, comparison of the three methods was based on data from only these two associations.

The ranking of taxonomic groups suggested that each method was effective for different types of invertebrates (Table 8). Both light-traps and pitfall traps were effective for Hymenoptera insects. Soil litter extractions produced few captures compared to either light-traps or pitfalls. However, they were effective in capturing ticks and mites (Order Acari) as were the pitfall traps. Pitfall traps caught fewer individuals than light-traps, but the pitfalls caught a higher diversity of taxonomic groups. Pitfalls were more effective in sampling spiders (Order Araneae) and springtails (Order Collembola). Members of the Orders Solufugae, Isopoda, Isoptera, and Thysanura were captured in pitfalls but not in black-light traps or soil litter extractions.

The most effective sampling method depends on the taxonomic group of interest or purpose of the study. Light traps are effective for capturing flying species. Pitfall trapping is directed towards invertebrates that crawl along the soil surface, while the Berlese funnel extraction method is effective for extracting the small, minute invertebrates living in soil or soil litter.

Table 6. Average number of invertebrates by taxonomic group extracted from litter samples per study plot with Berlese Funnel for each vegetation association.

	Vegetation Association							
	Larrea–Ambrosia n = 4		*Coleogyne* n = 4		*Lycium–Grayia* n = 4		*Larrea–Lycium–Grayia* n = 4	
Taxonomic Group	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE
Collembola	0	-	0	-	0	-	1	2
Hemiptera	0	-	1	1	<1	1	0	-
Thysanoptera	0	-	0	-	1	2	0	-
Coleoptera	<1	1	0	-	0	-	<1	1
Diptera	0	-	0	-	0	-	1	1
Hymenoptera	1	1	0	-	0	-	1	1
Acari (mites)	0	1	1	1	10	7	1	3
Acari (ticks)	1	2	4	5	9	6	1	1
Nematode	0	-	<1	1	0	-	0	-
Araneae	0	-	0	-	1	1	0	-
TOTAL	<3		<7		<22		<6	

Table 7. Total number of invertebrates by taxonomic group collected from pitfall traps per study plot in the *Larrea-Ambrosia* and *Larrea-Lycium-Grayia* vegetation associations during 1991.

	Vegetation Association	
Taxonomic Group	*Larrea-Ambrosia* n = 1	*Larrea-Lycium-Grayia* n = 1
Collembola	53	16
Orthoptera	2	12
Hemiptera	2	1
Homoptera	2	0
Isoptera	0	1
Thysanura	3	2
Neuroptera	1	0
Coleoptera	15	16
Diptera	4	3
Hymenoptera	56	450
Acari (mites)	21	11
Acari (ticks)	3	0
Araneae	11	69
Scorpiones	4	2
Isopoda	1	0
Solifugae	2	0
TOTAL	180	583

Table 8. Comparison of invertebrate sampling methods based on ranks of average number of captures per study plot of each taxonomic group. Groups are ranked in descending order of abundance from 1. Data are from the *Larrea-Ambrosia* and *Larrea-Lycium-Grayia* vegetation associations.

Taxonomic Group	Sampling Method		
	Light-traps	Berlese Funnels	Pitfall Traps
Hymenoptera	1	2	1
Coleoptera	2	4	5
Lepidoptera/Trichoptera	3	-	-
Hemiptera	4	-	10
Homoptera	5	-	11
Diptera	6	3	7
Orthoptera	7	-	6
Neuroptera	8	-	12
Araneae	9	-	2
Scorpiones	10	-	8
Solufugae	-	-	11
Isopoda	-	-	12
Collembola	-	2	3
Isoptera	-	-	12
Acari	-	1	4
Thysanura	-	-	9

2.6.2.5 Reference Collection

A reference collection of invertebrate species captured in vicinity of Yucca Mountain was developed. Specimens were preserved by pinning and drying or placing in vials with a 70% alcohol solution.

2.7 DISTURBANCE STUDIES

Disturbance studies quantify disturbance levels associated with SCA. Sampling of selected abiotic parameters provides indices of the mechanisms by which biotic resources may be impacted. Knowledge of how SCA frequency, intensity, and duration indirectly affects biotic resources allows development of predictions of community and population responses to future similar activities.

The objectives of this study are to: 1) quantify motor vehicle activity on Yucca Mountain; 2) determine fugitive dust deposition levels and the spatial distribution of fugitive dust on ESPs; 3) determine the number, frequency, and spatial distribution of animal-vehicle collisions; and 4) determine the influence of roads on soil moisture, soil temperature, soil compaction, and vegetation growth and structure in immediately adjacent habitat.

Traffic volume data were collected in FY91. Fugitive dust sampling stations were established on all 48 ESPs. Sampling for dust will commence in FY92. Study plot establishment and sampling to estimate animal-vehicle collisions; soil compaction, soil moisture, and temperature changes; and vegetation cover, density, and annual production near disturbances will occur in FY92.

2.7.1 Traffic Volume

Traffic volume data were collected with portable traffic counters (TC). TC use an airpulse system to count vehicle passes. A segment of road hose, plugged at one end and attached to the TC at the other end, was laid across the road surface. The TC records one vehicle pass every time two axles cross the road hose.

Eight TC were used to collect data at 22 treatment ESPs. Traffic counters were rotated between ESPs on a weekly basis. Data collection normally occurred every seven days (Friday to Friday). Traffic volume is reported as average vehicle passes per day.

Traffic volume sampling was initiated at 12 ESPs in early April, and expanded to 22 ESPs during the next 3 months. Traffic counts also will be recorded in Crater Flats in early FY92.

The road to the top of Yucca Mountain received the most traffic; averaging 17–24 vehicle passes per day (Figure 3). Another area of high traffic volume was near the 60-m meteorological tower (ESP LLG5T). Drilling operations were ongoing near this location. The road along the top of Yucca Mountain, and the road to Castle Point (ESP COL4T) had the least amount of vehicle traffic (2–5 vehicles per day). Traffic volume in Jackass Flats between wells J-12 and J-13 (ESP, LA1T, LA2T, and LA4T) ranged from 5-10 vehicles passes per day and 3-7 vehicle passes per day in Midway Valley (ESP, COL1T, COL2T, COL3T, and COL6T).

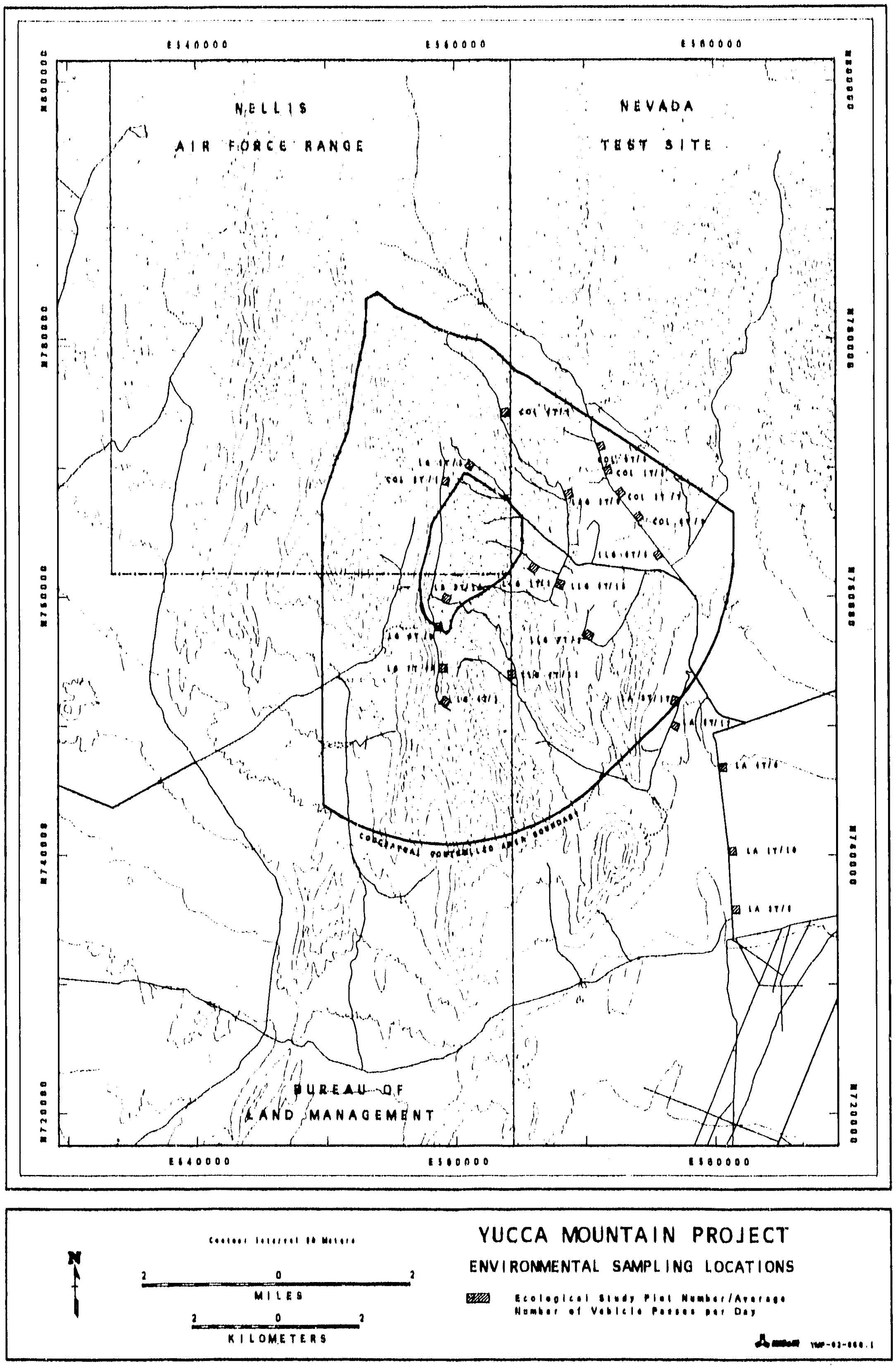

Figure 3. Distribution of vehicle traffic in the Yucca Mountain area in FY91. The average number of vehicle passes per day is listed after the / by each plot number (e.g., LA 4T/ 6).

2.7.2 Fugitive Dust

Disturbance may have an indirect effect on plant production via fugitive dust deposition (Ler an and Darby, 1975; Thompson et al., 1984; Borka, 1984). A study was initiated to determine the amount of fugitive dust deposition and its spatial distribution in the Yucca Mountain Site Characterization Project area. Dust deposition levels will be correlated with vehicle traffic counts and long-term changes, if any, in vegetation production and structure.

Fugitive dust will be sampled at each ESP. Fugitive dust sampling will occur biweekly during the growing season and monthly during the remainder of the year. Ten dust collection stations have been placed on each treatment ESP; one at each 2 X 50-m vegetation belt transect. Two dust collection stations have been placed on every control ESP.

Dust collection stations consist of a rebar stake with a clamp containing a petri dish and filter paper. The stake is anchored in the soil, and the collection dish is attached to the rebar 30–35 cm above the ground. Collection stations are placed so that existing vegetation does not interfere with dust collection. Fugitive dust sampling occurred on seven ESPs to determine the effectiveness of the sampling technique. Dust collection stations were established on all ESPs.

2.8 CLIMATE STUDY

One weather station was established in FY92. All 48 ESPs now have a weather station. Weather stations are located 100-m from the disturbance and along one edge of the ESP. Each weather station contains a maximum/minimum thermometer, a precipitation gauge, and lead wires of soil moisture/temperature probes placed at three depths (15, 30, and 45 cm).

Between March and early June soil moisture was adequate for plant growth; therefore, climate data was recorded each week. Climate parameters were monitored monthly during the remainder of FY91. Precipitation data collected at ESPs are summarized in Table 9.

Table 9. Maximum, minimum, and mean precipitation amounts at control and treatment ESPs for the four vegetation associations sampled between September 1990 to October 1991.

	PRECIPITATION (mm)[a]			
Vegetation Association	n	Mean	Standard Deviation	Range
Coleogyne Control	6	149	12.8	125-163
Coleogyne Treatment	6	151[b]	11.8	137-165[b]
Lycium-Grayia Control	6	126[b]	19.7	102-149[b]
Lycium-Grayia Treatment	6	143[b]	10.3	126-157[b]
Larrea-Lycium-Grayia Control	6	170	11.2	151-179
Larrea-Lycium-Grayia Treatment	6	174[b]	21.2	158-201[b]
Larrea-Ambrosia Control	6	131	18.4	103-158
Larrea-Ambrosia Treatment	6	137	14.8	121-158

[a] Values at Coleogyne and Lycium-Grayia ESPs are probably low. In March 1991 snow accumulated on top of precipitation gauges and was partially blown off and or lost to evaporation before melting into the collection container.

[b] Values may be low because one or more weather stations in this association had precipitation gauges established after September 1990.

3. DESERT TORTOISE PROGRAM

The goals of the desert tortoise program are to develop a better understanding of the biology and status of the desert tortoise population at Yucca Mountain, assess impacts of SCA on the population, and minimize those impacts. The objectives and program design developed to achieve these goals are described in EG&G/EM (1991) and Rautenstrauch et al. (1991).

3.1 INTRODUCTION

Nine interrelated studies were initiated or continued for this program. Four studies share a common design: population monitoring, movements and habitat use, health monitoring, and food habits. They were developed to monitor cumulative impacts of SCA. A fifth study was designed to evaluate and mitigate direct impacts of large-scale or long-term activities. The other studies were developed to evaluate mitigation techniques, monitor predator abundance, and analyze tortoise habitat quality at Yucca Mountain.

While conducting work on these nine studies during the 1991 tortoise activity period (March through October), and while working on other tasks during this period, EG&G/EM captured and marked 102 previously unmarked desert tortoises. Radio transmitters were attached to 90 of these tortoises. During 1989-1991, 128 tortoises have been marked; transmitters were attached to 102. Eighty-seven radiomarked tortoises still were being monitored at the end of the activity season in October 1991. The remainder of these tortoises had died (n = 4), were missing (n = 4), or their transmitters had fallen off (n = 7). Figure 4 shows the location of first capture of all tortoises found on or near Yucca Mountain during 1989-1991. Figure 5 shows the size and sex ratios of all tortoises captured and marked during this period.

3.2 POPULATION MONITORING STUDY

The objective of the Population Monitoring Study is to assess the effects of SCA on the dynamics of the tortoise population at Yucca Mountain. To achieve this objective, a study was designed in FY90 to census tortoises and tortoise sign annually in treatment and control sample plots. A pilot study to test the efficacy of this design was initiated in FY90 and completed in FY91. Only four tortoises were found, and the number of burrows/plot varied between plots and was inconsistent with the number of tortoises found on each plot (EG&G/EM, 1991:33). It was concluded that quadrat sampling is not an efficient method for monitoring impacts on the dynamics of low-density tortoise populations because so few animals are counted. Extremely large plots (>100 ha) must be searched to count enough tortoises to detect changes in population dynamics. It also was concluded that counts of tortoise sign are not reliable indices of tortoise abundance because of the low correlation between the amount of sign and tortoises found within plots.

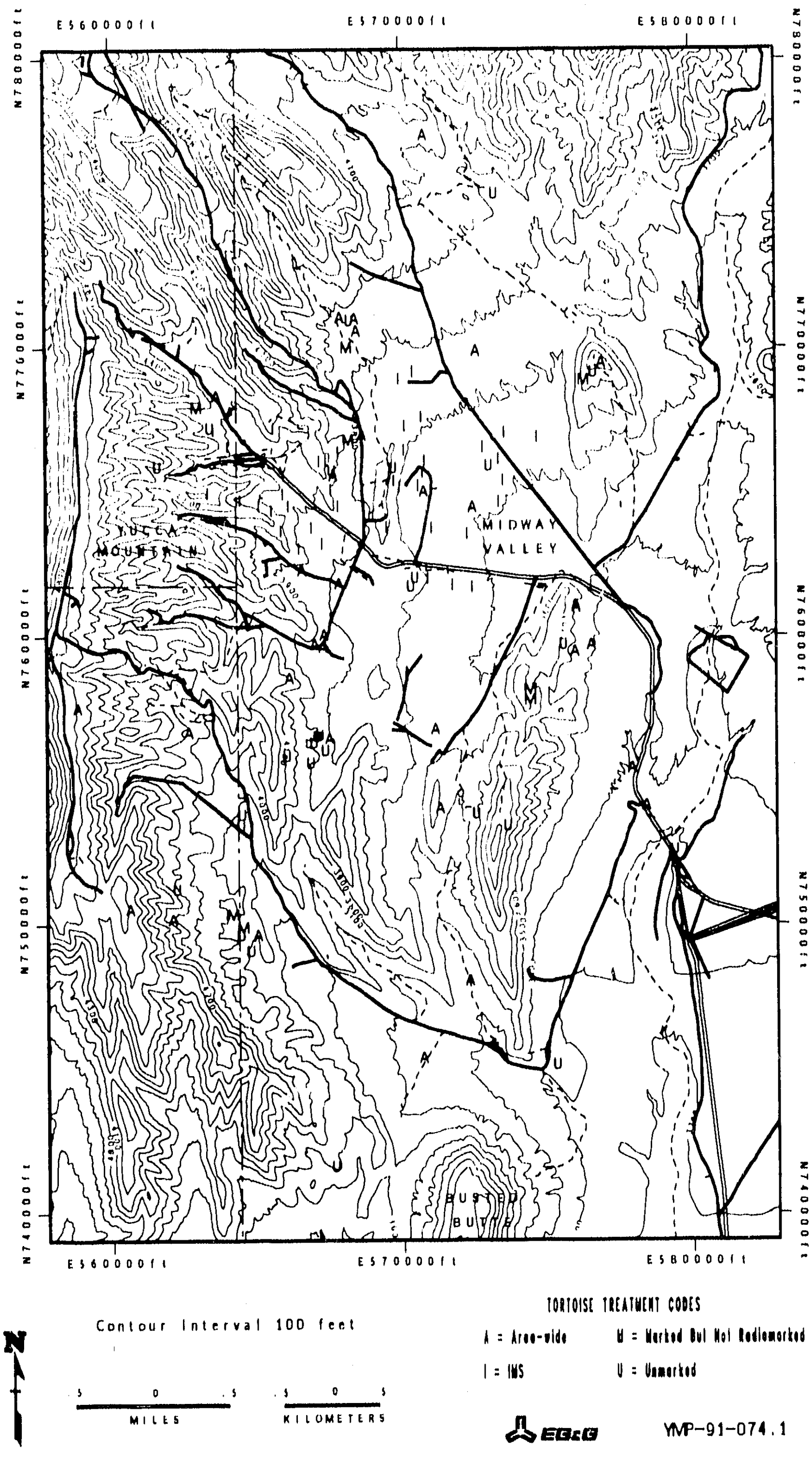

Figure 4. Location of first capture or sighting of desert tortoises found at Yucca Mountain during 1989-1991. The symbols represent whether the tortoise was marked, radiomarked, or left unmarked when found and the treatment sampling population assigned to radiomarked tortoises (U = unmarked; M = marked but not radiomarked; H = radiomarked, high-impact sample; A = radiomarked, area-wide sample) 33

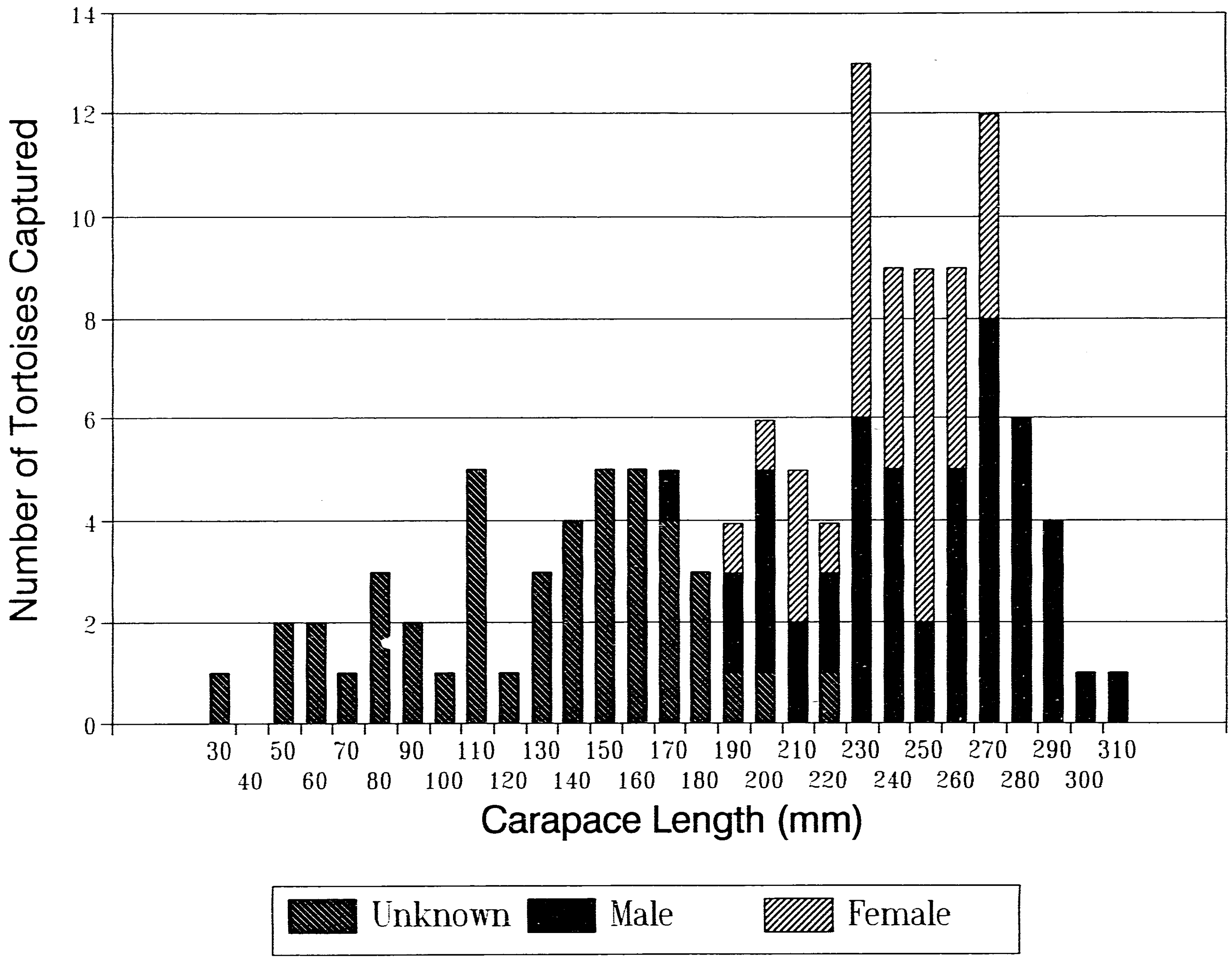

Figure 5. Number of desert tortoises captured at Yucca Mountain during 1989-1991 in 10-mm size classes.

Therefore, the design of the Population Monitoring Study was revised as were three other tortoise studies that share the same sampling design (Rautenstrauch et al., 1991). Effects of SCA on population dynamics will be evaluated by comparing survival and reproduction of ≥ 20 tortoises selected and radiomarked from each of three sampling populations representing different levels of impacts (i.e., statistical treatment levels) from SCA.

The first treatment is impacts of the few large-scale and long-term SCA such as the Exploratory Studies Facilities (ESF). It is hypothesized that these disturbances will have the greatest impact on tortoises. Tortoises radiomarked in Impact Mitigation Study (IMS) sites (see section 3.6) represent this high-impact treatment level. The second treatment is impacts from the many small (primarily <2 ha) disturbances that will be scattered throughout the area. Tortoises found throughout Yucca Mountain outside of the IMS sites represent this area-wide treatment level. The third treatment is a control (i.e., no effects from SCA) and is represented by tortoises found in a control area east of Yucca Mountain that will not be affected by SCA.

Figure 6 shows the boundaries of the areas searched to obtain these three samples. By the end of the 1991 tortoise activity period, 20 tortoises were being monitored for the control sample, 27 for the area-wide sample, and 35 for the high-impact sample. All control tortoises were radiomarked during searches conducted in the control area during June-October 1991. Two area-wide tortoises were radiomarked in 1989. The remainder were found during 1991. Eight of these were found during searches of ESPs, six were found along roads, six were found incidental to other work at Yucca Mountain, and six were found during searches conducted in areas not previously represented by this sample. Five of the high-impact sample of tortoises were radiomarked in 1989, six were radiomarked in 1990, and the remainder were found and radiomarked in 1991 during searches conducted for the Impact Mitigation Study. Additional hatchling and juvenile tortoises may be added to these samples in FY92.

3.2.1 Analysis of Survival

To measure survival rates of these three samples, tortoises were located twice weekly during the activity period and once weekly during hibernation. None of the five tortoises monitored since 1989 died. The carcass of a tortoise marked (but not radiomarked) in 1989 was found in 1991. One of seven tortoises radiomarked in 1990 died in 1991 and three of the 90 tortoises radiomarked in 1991 died. A hatchling was found dead three days after it was first located in its nest during October 1991. All tortoises died of natural causes. Survival rates will be calculated in FY92 and compared among the three treatment levels.

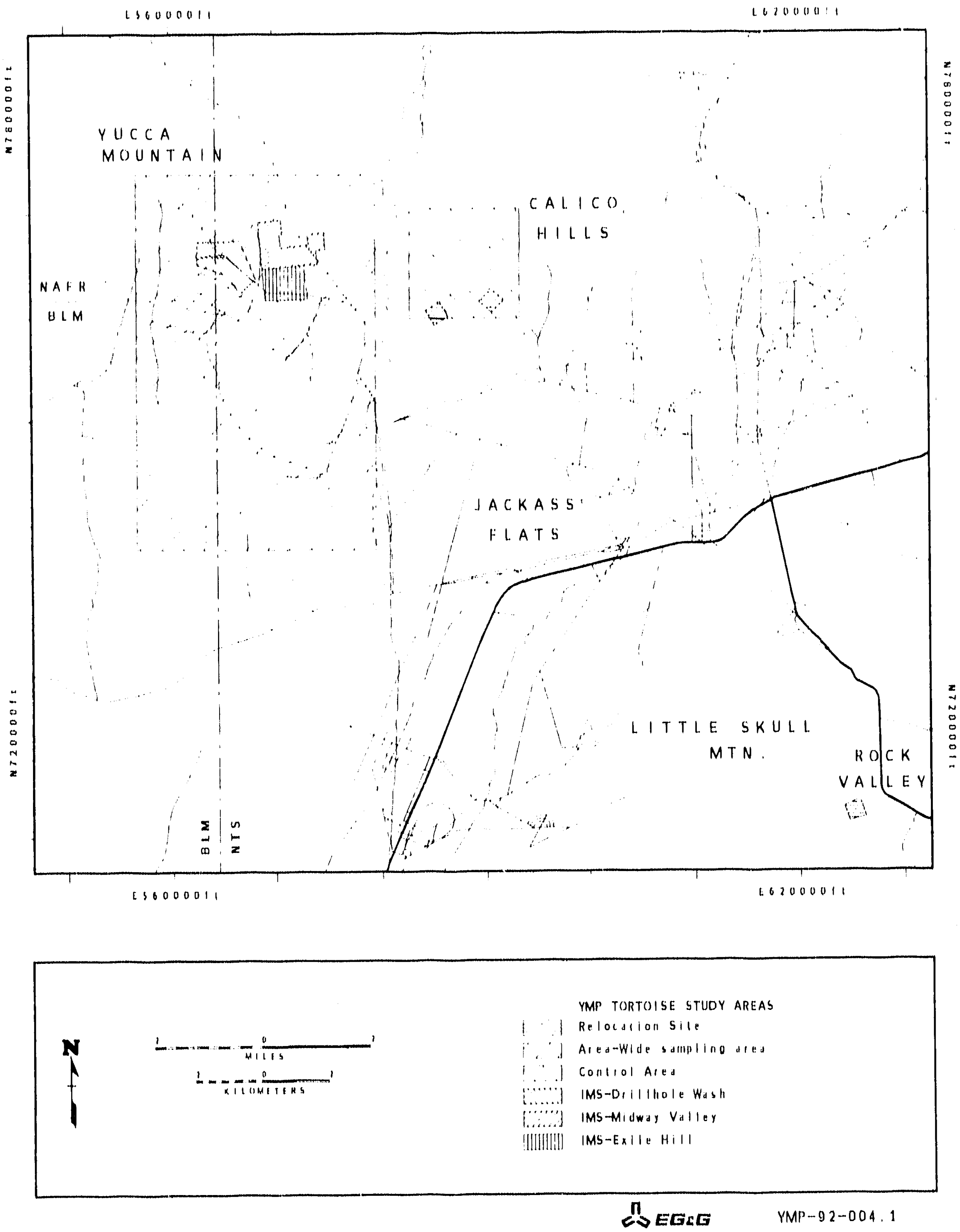

Figure 6. Location of Impact Monitoring Study sites, the Yucca Mountain area-wide sample search area, control area, and relocation plots for desert tortoise studies.

3.2.2 Analysis of Reproduction

A pilot study was conducted to evaluate field methods for monitoring reproduction. Eleven female tortoises thought to be of reproductive age were located four times weekly during their egg laying season (mid-May through mid-July) so their nests could be located and monitored. These females were weighed every 10 days to determine when they laid eggs. Original plans of this study were to search for tortoise eggs in all cover sites used by females as soon as a weight loss was detected. Because of Federal handling permit restrictions, searches for eggs could not be conducted.

During this 2-month period each female was located an average of 32 times and used an average of nine cover sites. The amount and timing of weight loss (Figure 7) was consistent with results of other studies (Turner et al., 1984; Roberson et al., 1985). A loss of ≥ 100 g indicates that a clutch of eggs was laid (Turner et al., 1984). Based on this criterion (a 90 g loss by one female also was considered to have met the criterion), 3 females laid one clutch, and 4 females laid two clutches. Only females with a carapace length >230 mm had a >100-g weight loss. The three largest females (Figure 7A) had the most consistent pattern of weight loss.

Areas used by females during the 10 days prior to weight loss were searched for hatchlings during September and October, after the incubation period (maximum of 99 days) had passed for each potential clutch of eggs. No hatchlings or egg shell fragments were found. It was concluded that searches for nests and hatchlings would have been more successful if timing of egg laying could have been predicted and movements more closely monitored during this period. This information will be incorporated into the design of the study.

3.3 MOVEMENTS AND HABITAT USE STUDY

The objectives of the Movements and Habitat Use Study are to: 1) evaluate the effects of SCA on the desert tortoise population by monitoring changes in selected behaviors of tortoises, 2) measure the behavioral responses of individual tortoises to SCA within or near their home ranges, and 3) gain a better understanding of selected aspects of the behavior of tortoises necessary for conserving this species at Yucca Mountain.

To achieve the first objective, the radiomarked tortoises described in the previous section were located twice weekly during the activity period and once each week during hibernation. Radiomarked tortoises were located 2,604 times. Each time a tortoise was located, weather conditions, tortoise behavior, cover site type, topography, microhabitat, elevation, aspect, slope, and distance to nearest shrub were recorded. Burrows used by radiomarked tortoises were assigned a unique number and depth, surface texture around the burrow, and composition of soil in the burrow apron were measured. Locations for each tortoise were determined using compass bearings or a Global Positioning System. Coordinates were verified by plotting locations on a map.

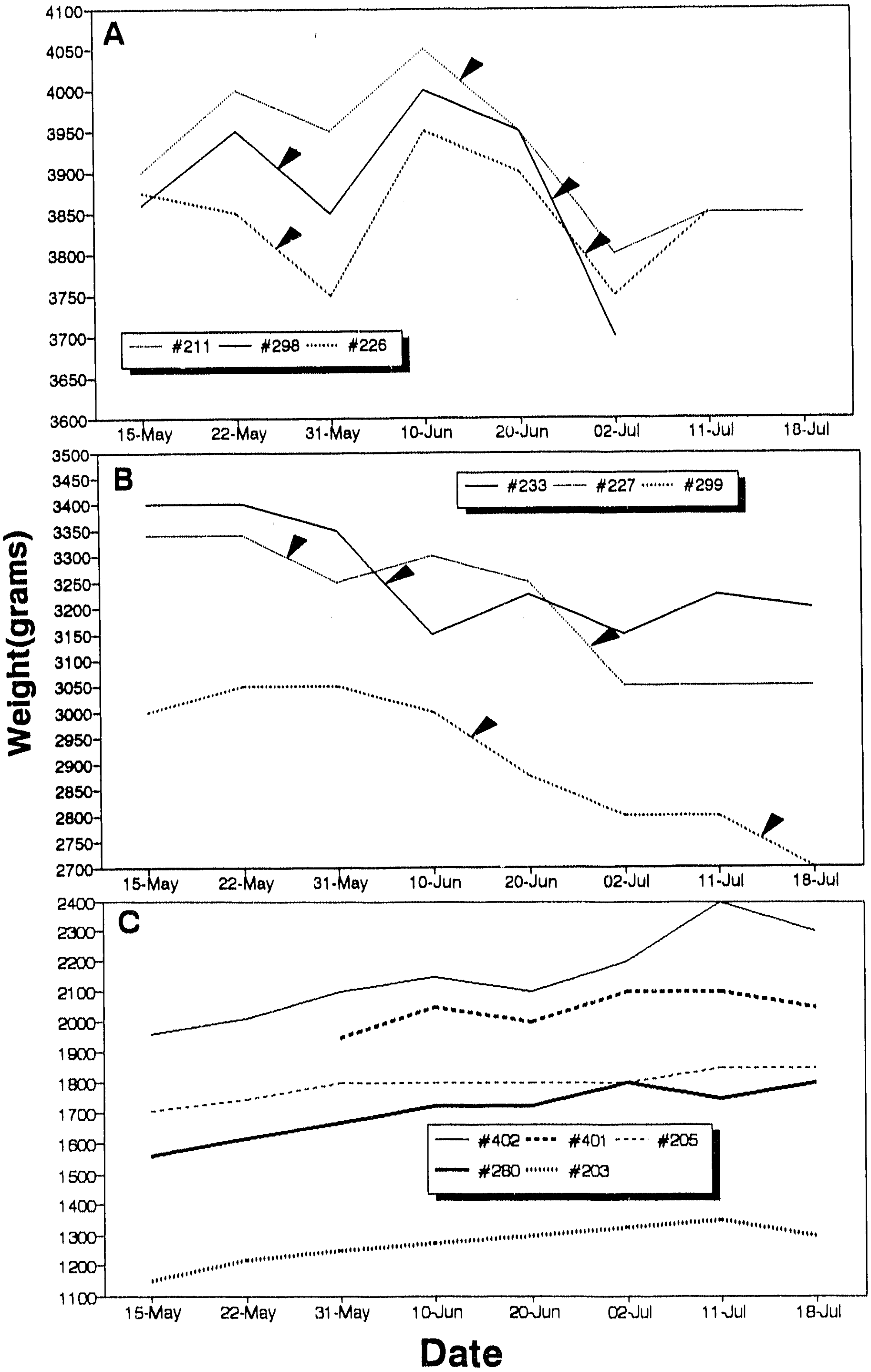

Figure 7. Weight changes in 11 female tortoises during the 1991 period of egg laying. The ▼ indicates time periods with at least a 100 g weight loss.

During the activity period, tortoises were located approximately equal number of times during three daily time periods: sunrise to four hours after sunrise, midday, and four hours before sunset to sunset. To evaluate effects of SCA, the following arameters will be estimated and compared among the three treatment levels: home range size, home range and core-use area overlap from the previous year, shift in center of activity, number of burrows used, number of new burrows used, timing and length of hibernation, and portion of time active.

No soil disturbances occurred within the home range of radiomarked desert tortoises; therefore, no evaluation was done for the second objective of this study. Behavioral response to disturbances will be measured and compared to behaviors of control tortoises when disturbances of >0.5 ha occur within the home range of radiomarked tortoises.

For the third objective, a study was started to evaluate measurements that may be useful for identifying potential hibernacula so they may be protected. The following measurements were taken at 12 hibernacula during the hibernation period (October 1990 through March 1991): slope and aspect at the burrow entrance, distance from entrance of burrow to tortoise, length of burrow, and vertical depth of tortoise below ground. It was also determined whether the burrow was dug by a tortoise or predator; if the burrow was below caliche, rock, or a shrub; if it was in a wash; if it forked or curved; and how many tortoises were using it. These measures will be taken again at FY92 hibernacula and compared with measures taken at a sample of burrows used during the activity period to determine if there are differences between burrows used during these periods.

3.4 HEALTH MONITORING STUDY

The objective of the health monitoring study is to evaluate the effects of SCA on the desert tortoise population at Yucca Mountain by monitoring changes in health profiles of tortoises. This study was not funded in FY91. The only work conducted (in conjunction with funded studies) was to measure weight-to-volume ratios of radiomarked tortoises immediately before hibernation, a potentially useful indicator of the relative health of tortoises. These ratios will be compared with post-hibernation measures. In FY92 a study will be developed and implemented to collect and analyze blood to compare health profiles among the three treatment levels.

3.5 FOOD HABITS STUDY

SCA may alter plant communities by removing plant cover or increasing the abundance of exotic plants. Tortoises depend on grasses and forbs for food and for maintaining water balance. Little is known about the diet of tortoises at Yucca Mountain. This study was implemented to determine tortoise diet, relative nutritional and quantitative importance of forage components, and effects of SCA on tortoise diet. Because this study was not funded in FY91, the only work done was to collect tortoise scat while working on other studies and summarize diet information collected and analyzed in FY90.

During the spring and summer of 1991, fresh tortoise scat was collected when radiomarked tortoises were located for the Movements and Habitat Use Study. These scat came from known individuals during specific time periods. Forage composition of scat collected from tortoises in the three treatment levels will be compared in FY92 to evaluate effects of SCA on the diet of tortoises at Yucca Mountain.

Twenty-seven fecal pellets collected during 1990 were analyzed using microhistological techniques to provide a list of food items eaten by tortoises at Yucca Mountain. Though fecal analysis is a cost-efficient technique for determining diet composition, it is not always accurate. Some plant taxa such as forbs can be under-represented in this analysis because they are more completely digested than others.

Twenty-five food items were identified in the scat samples. There was no indication that geophagy (i.e., eating of soil) occurred. The relative proportion of each forage species found in scat samples differed (Kruskal-Wallis test, $\chi^2 = 170.22$, $P < 0.0001$). Brome (*Bromus* spp.), a group of invading exotic grasses, was the largest component in the scat samples (Figure 8). The category of spines in Figure 8 could not be attributed to a specific cactus species.

A test was conducted to determine if tortoise diets were homogeneous throughout the Yucca Mountain area. Scat collected from different drainages were composed of significantly different food items. The diet of tortoises near Yucca Mountain, a relatively small geographic area compared to the range of the desert tortoise, is highly variable.

Tortoise diets in 1990 were composed primarily of cacti and two grasses, brome and fluffgrass (*Erioneuron* spp.) The diet composition from the 1990 scat sample may not be typical for the area because of drought conditions that year. Cheatgrass (*Bromus tectorum*), an exotic brome, has a competitive advantage over native plants when soil moisture is limited (Hironaka, 1961; Klemmedson and Smith, 1964), and may reduce abundance of native annuals on NTS (Hunter, 1991). The abundance of cactus in the diet of tortoises also may have been influenced by the drought conditions.

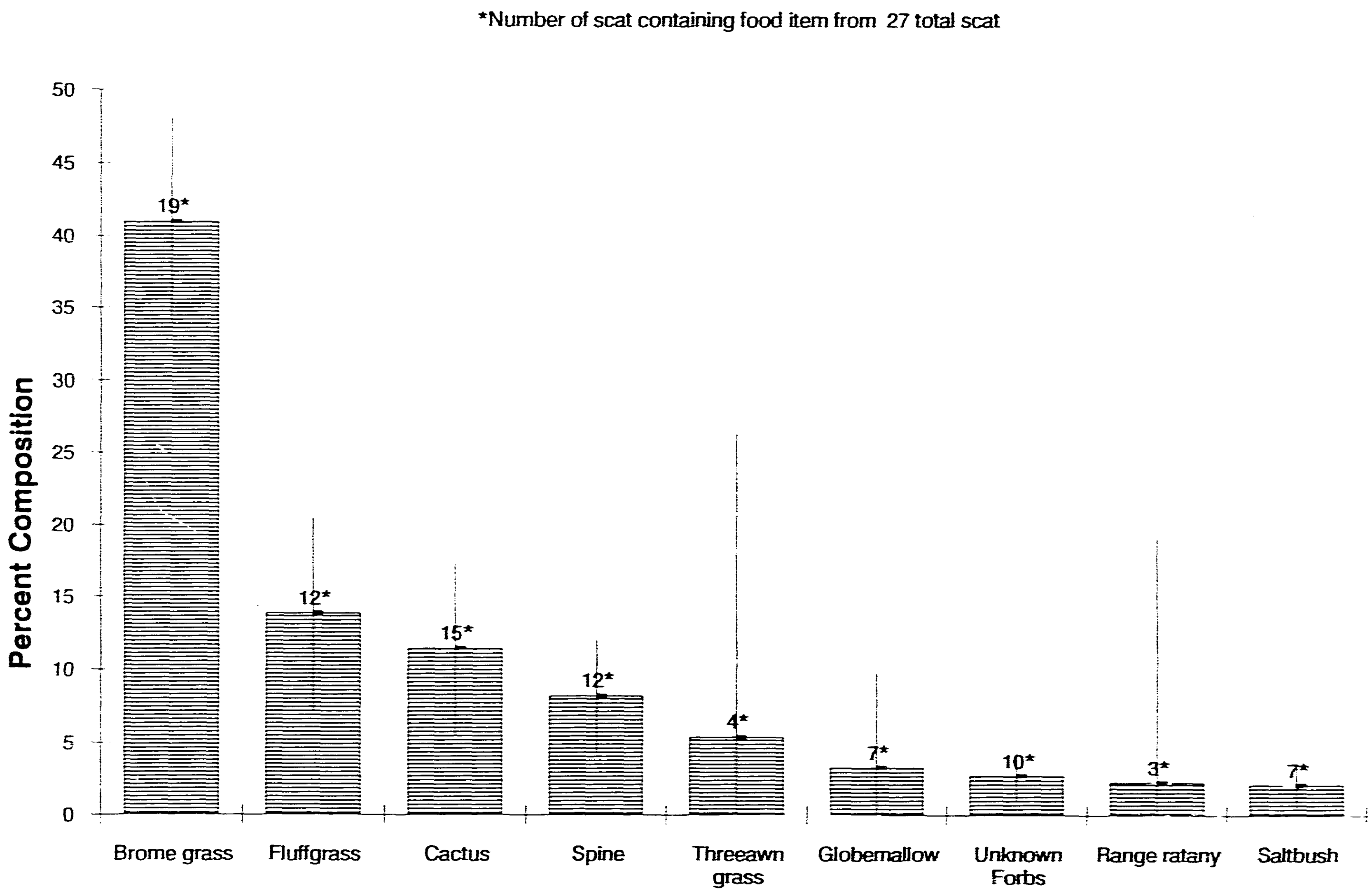

Figure 8. Percent composition of the nine most abundant food items in desert tortoise scat collected at Yucca Mountain, May–September 1990. Vertical bars represent standard error of the mean.

3.6 IMPACT MITIGATION STUDY

Most SCA will be small (<2 ha), short-term, and have relatively minor impacts on tortoises. Some activities, however, will disturb large areas and last throughout site characterization. Impacts of these disturbances may be greater. To effectively mitigate these disturbances, information is needed on the abundance, movements, and habitat use of tortoises in areas where large-scale and long-term SCA will occur. The Impact Mitigation Study (IMS) (formally called Impact Monitoring and Mitigation Study; EG&G/EM, 1991) was developed to collect this information.

For this study, areas where larger SCA will occur are searched up to one year before activities start. All tortoises found are radiomarked and monitored. Information collected on the movements and behavior of these tortoises is used to develop mitigation recommendations. This information also is used in the previously-described studies to evaluate impacts of SCA.

Two IMS efforts were started. One was an extension of the Midway Valley IMS site started in FY90. The second was in Drill Hole Wash (Figure 6). Monitoring continued in the Midway Valley IMS site.

Tortoise burrows found in the Midway Valley IMS area (Figure 6) during summer 1990 were searched during November-December 1990 to find previously unmarked tortoises hibernating there. Six new tortoises were found. Radios were immediately attached to two and later attached to two others after they emerged from hibernation. Eight more unmarked tortoises were found in this area and radiomarked in 1991. All radiomarked tortoises, including seven tortoises radiomarked before FY91, were monitored as described in the Movements and Habitat Use Study (Section 3.3). Two of these 19 tortoises died during the activity period, and two were missing at the end of this period.

The 105-ha southern extension of the Midway Valley IMS (Figure 6) was conducted to prepare for possible ESF construction near Exile Hill. The tortoise surveys for this area were conducted in April and May. Seven tortoises were found, and six were fitted with transmitters. One of these tortoises lost its transmitter, and another moved out of the area and is being monitored as part of the area-wide treatment sample.

The 160-ha Drill Hole Wash IMS (Figure 6) was started to evaluate impacts of the existing sub-dock and possible ESF in this area. The survey for tortoises and tortoise sign was conducted during August. Fourteen tortoises were found and fitted with transmitters; two later lost their transmitters. Four other tortoises were found and radiomarked in this area prior to the survey.

During FY92, an IMS will be conducted at the proposed locations for the ESF south portal and muck pile.

3.7 DISPLACEMENT AND RELOCATION STUDIES

More than 180 ha of desert tortoise habitat may be disturbed during SCA. Desert tortoises found in those areas may have to be moved to other areas within their home range or relocated to areas outside of their home range. The Displacement and Relocation Study was designed to develop, implement, and test methods for moving tortoises from areas to be disturbed while minimizing impacts on those tortoises and resident tortoises.

Habitat features potentially important to tortoises were measured on six proposed relocation sites searched in FY90 (EG&G/EM, 1991:34). Permission to use five of these sites was requested from the U. S. Fish and Wildlife Service (FWS), the Project Office, and DOE Nevada Field Office (DOE/NV). The sixth site was omitted because it did not appear to be suitable tortoise habitat. Permission was granted to use three of these sites (Figure 6). The other two sites could not be used because of nearby activities planned by DOE/NV.

The three approved sites were searched in July-August 1991, and four tortoises were radiomarked. These sites will be searched again during the winter of 1991-1992, and efforts will be made to radiomark resident tortoises after they leave their hibernacula. All tortoises radiomarked in these sites will be monitored before and during relocations to study the effects of relocations on resident tortoises.

At least five more potential relocation sites will be selected and submitted for approval during FY92 in anticipation of an increase in SCA.

3.8 ROADWAY MONITORING STUDY

FWS, under provisions of the Endangered Species Act, has issued YMP an incidental take provision of 15 desert tortoises (FWS, 1990). If more than 15 tortoises are killed as a result of SCA, YMP must request a revised incidental take provision and may be required to initiate additional, expensive measures to prevent mortalities. Roads are one of the more likely locations where tortoises may be killed during SCA. The objectives of the Roadway Monitoring Study are to monitor sightings and mortalities of tortoises along roads and, if necessary, develop and test methods for reducing the potential for mortalities along roads where tortoises are seen or killed.

All personnel working at Yucca Mountain were required to report sightings of desert tortoises to the YMP Field Operations Center. These reports were given to EG&G/EM and compiled. There were 26 observations of tortoises along roads in the Yucca Mountain area. Four of the tortoises had been previously radiomarked; one was previously marked but not radiomarked; 10 were captured, marked, and radiomarked; four were captured and marked only; and seven were left unmarked. Most of the sightings occurred on roads in and around Midway Valley and along the "H" Road extension leading from Jackass Flats to Midway Valley (Figure 9).

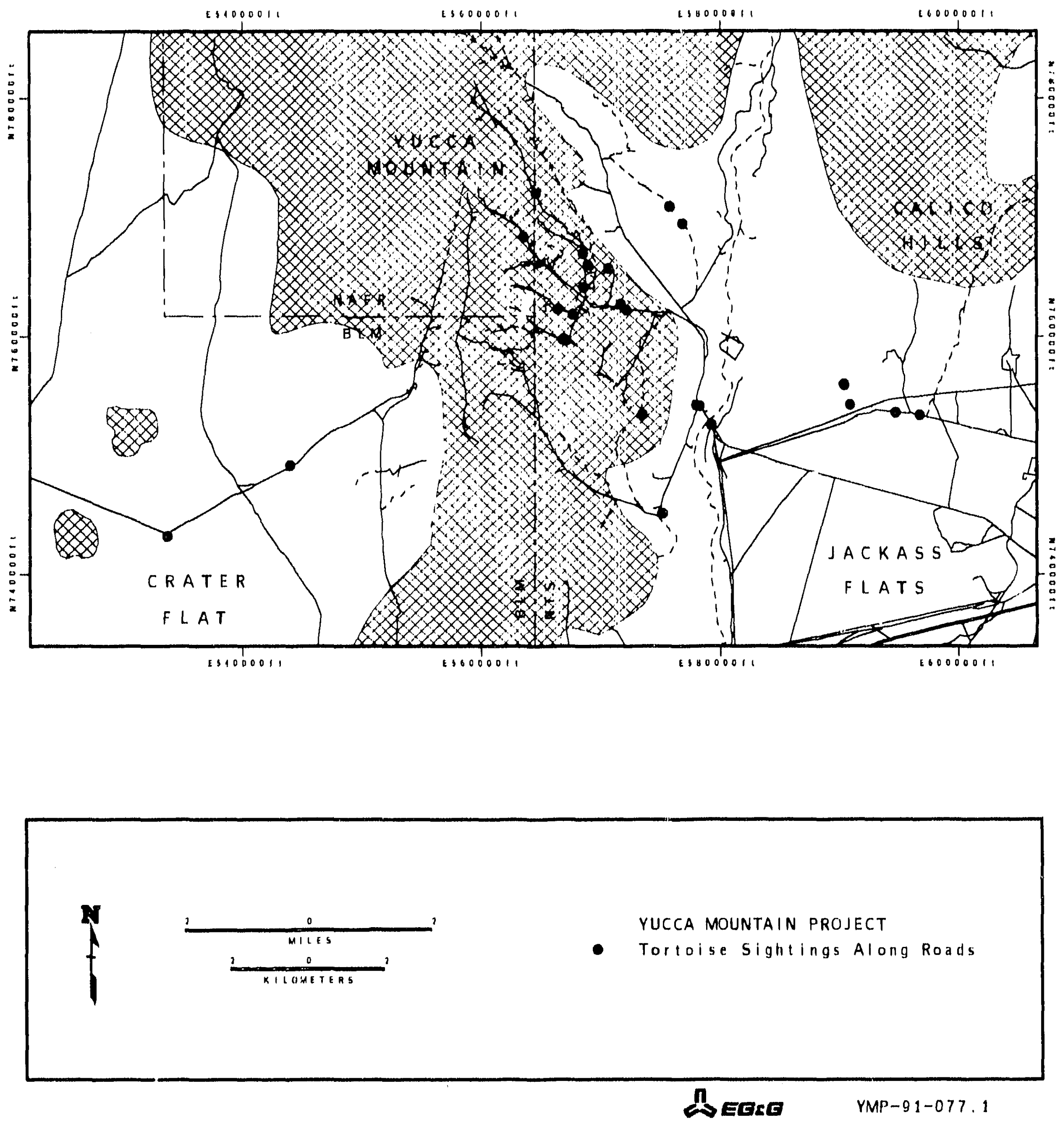

Figure 9. Locations of sightings of desert tortoises along roads at Yucca Mountain from October 1990 through September 1991.

3.9 RAVEN MONITORING STUDY

A Raven Monitoring Study was implemented to comply with requirements in the Biological Opinion on effects of SCA on desert tortoises (FWS, 1990). SCA may cause an increase in raven (*Corvus corax*) abundance by creating new nest or roost sites (e.g., buildings, power lines) and food sources (garbage and road-killed animals). Since ravens are known to prey on small tortoises (Campbell, 1983; Esque and Duncan, 1985), an increase in ravens may have a negative impact on the tortoise population at Yucca Mountain. For this reason, FWS has required YMP to construct all facilities using the best available technology for discouraging use by ravens and to monitor the abundance and distribution of ravens (FWS, 1990).

The objectives of this study are to determine if SCA cause an increase in raven abundance at Yucca Mountain, to monitor use of SCA facilities by ravens, and to identify facilities where ravens congregate. Raptor distribution, abundance, and species composition at Yucca Mountain also is monitored. Results of this study will be used to determine the effects of SCA on raven and raptor abundance and distribution at Yucca Mountain and the efficacy of raven deterrent equipment on YMP facilities.

3.9.1 Survey Methods

Road surveys were conducted simultaneously along a treatment (YMP area) and control route on five randomly selected weekdays every other month. The treatment route at Yucca Mountain was selected based on its proximity to proposed YMP facilities (Figure 10). A control route was selected in the Bare Mountains, approximately 16 km west of Yucca Mountain (Figure 11). The control area was selected to be similar to the treatment site in length and type of roads, vegetation, elevation, topography, and climate. Each route is 40 km long. Because ravens are more active mid-day (Kilham, 1989), surveys began four hours after sunrise. Every 0.8 km an observer stopped and stepped out of the vehicle to look for ravens and raptors for one minute. Data recorded for raven and raptor sightings were number of birds, behavior, and location.

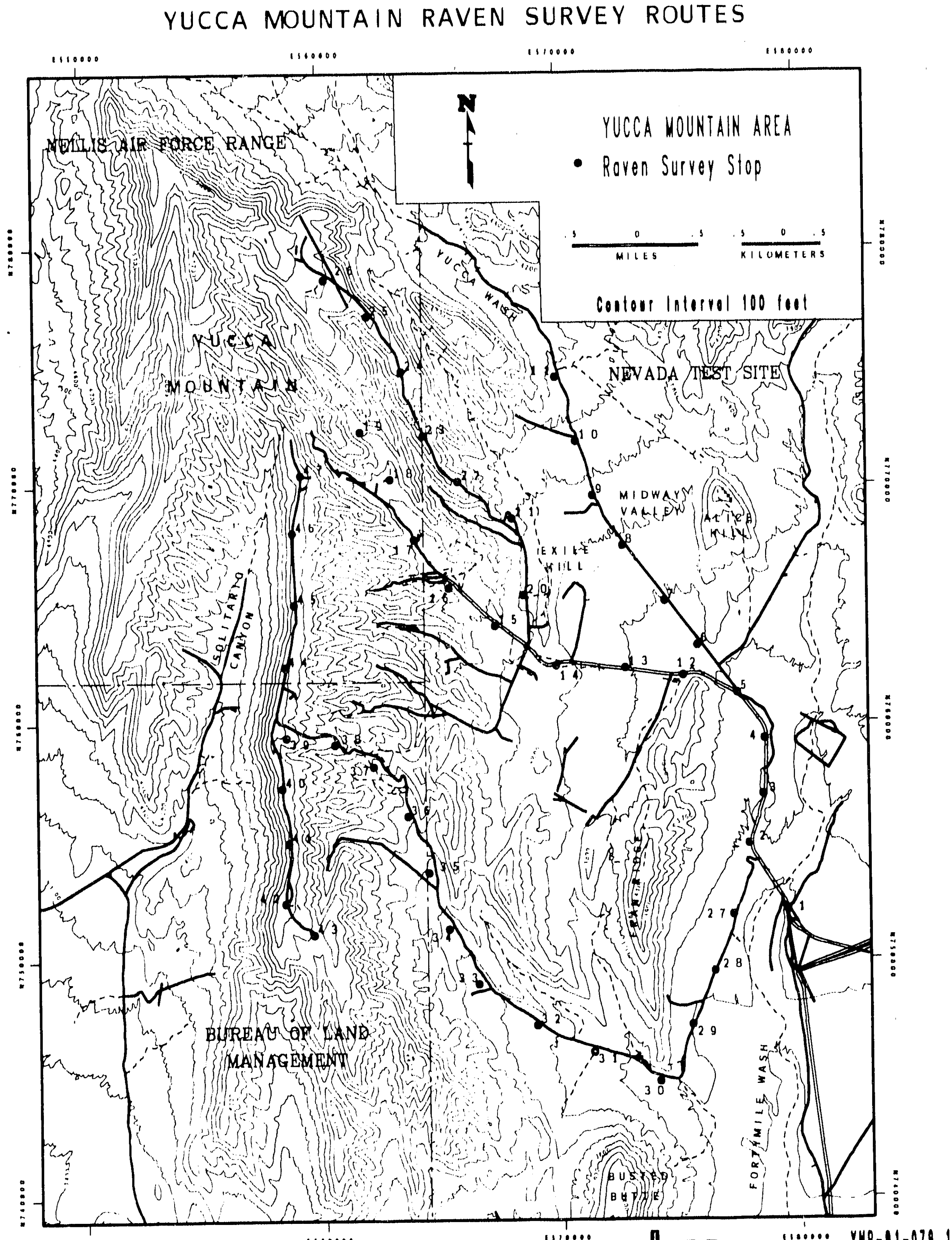

Figure 10. The 40-km treatment route for the Yucca Mountain Site Characterization Project Raven Monitoring study.

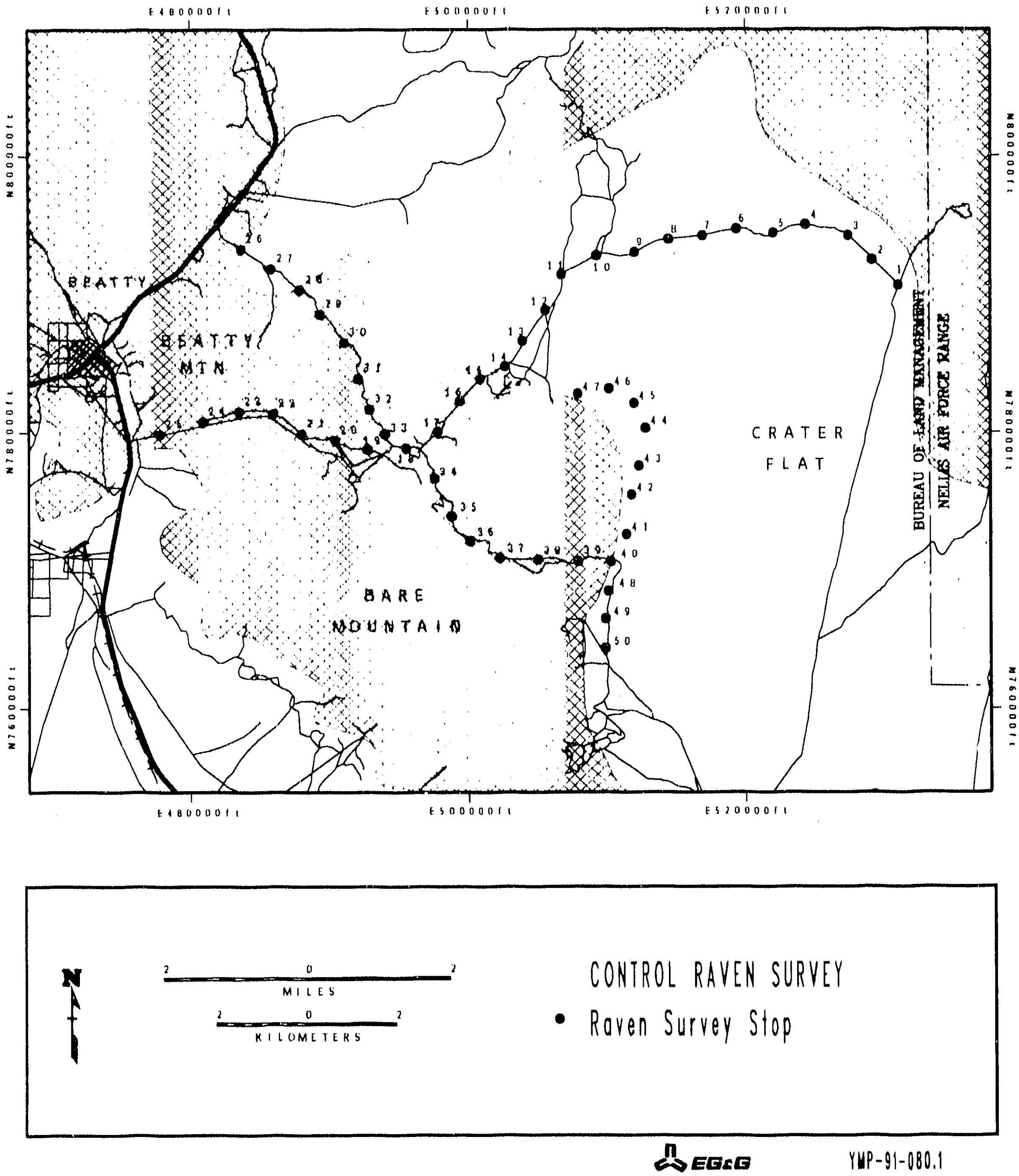

Figure 11. The 40-km control route for the Yucca Mountain Project Site Characterization Raven Monitoring study.

3.9.2 Survey Results

Field work commenced in August. Twenty-five ravens, three turkey vultures, and one red-tailed hawk were counted along the YMP route during the five surveys in August. On the control route, six ravens, three turkey vultures, and one red-tailed hawk were counted during the five August surveys. Distribution of ravens and use of SCA facilities will be summarized annually. This information will be used to determine the effectiveness of raven deterrents, and if necessary, to develop and test other raven deterrent techniques.

3.10 HABITAT EVALUATION STUDY

The objective of this study is to develop a model of tortoise habitat quality at Yucca Mountain that can be used in land-use planning. A pilot study was conducted to address questions regarding required sample size. Data were gathered on abundance of tortoise sign on the 48, 4-ha ESPs. An additional five sites that were no longer being used as ESPs also were searched. Four tortoises, 61 tortoise burrows, and 90 groups of tortoise sign were found. Twenty-eight plots had no tortoise sign, and 32 plots had no tortoise burrows. ESPs in the *Larrea-Ambrosia* vegetation association had the least amount of sign (Table 10).

Results of the pilot study will be used in developing and implementing a habitat evaluation study in FY92. Habitat features will be measured on these ESPs so a preliminary multiple regression model can be developed to describe the relationship between either tortoise or burrow density and habitat features. Additional plots will be searched for tortoise sign to test the model.

Table 10. Sum of tortoise sign found on 48, 4-ha ESPs.

Vegetation Association	Tortoise Sign					
	Burrows	Tortoises	Scat	Carcasses	Eggs	Total
Coleogyne						
Control	4	0	3	0	0	7
Treatment	9	1	6	2	0	18
Lycium-Grayia						
Control	6	0	26[a]	0	0	32[a]
Treatment	10	0	8	0	0	18
Larrea-Lycium-Grayia						
Control	14	1	0	1	1	17
Treatment	10	1	6	1	1	19
Larrea-Ambrosia						
Control	1	0	4	0	0	5
Treatment	1	0	1	1	0	3

[a] 20 scat were found in one plot.

4. HABITAT RECLAMATION PROGRAM

The Habitat Reclamation Program for the Yucca Mountain Site Characterization Project is described in the Reclamation Program Plan (RPP) issued by DOE (DOE, 1989). The RPP identifies two additional plans the Reclamation Implementation Plan and the Reclamation Feasibility Plan (RFP) that are necessary to accomplish reclamation objectives at Yucca Mountain. The RFP was released by DOE in March of 1990 (DOE, 1990). The RFP provides the framework for specific studies to determine effective reclamation techniques to reclaim areas disturbed by site characterization activities at Yucca Mountain. Since very little reclamation has occurred in extremely arid environments, site specific studies are needed to determine the types of practices that will most likely be successful. Two major areas of study, Disturbed Habitats and Reclamation Trials, are necessary to provide adequate information for the development of an effective reclamation program.

4.1 DISTURBED HABITAT STUDIES

The first step in reclamation feasibility studies is evaluating disturbed sites to assess the pattern and timing of natural revegetation or succession. Results from disturbed habitat studies can provide valuable insight into factors which control revegetation, and how these factors can be manipulated to improve reclamation success. Disturbed habitat studies have two components, a disturbed site inventory and plant succession studies.

4.1.1 Disturbed Habitat Inventory

The disturbed habitat site inventory was initiated. The Nevada Nuclear Waste Storage Investigations (NNWSI) Atlas of Field Activities (DOE, 1988) and NNWSI project maps generated by a Geographical Information System (GIS) were used to identify the location of past disturbances. Sites were then visited and inventoried. The inventory eventually will be computerized and updated annually.

The disturbed habitat inventory includes documenting each disturbance's location, the vegetation association in which the disturbance occurs, disturbance severity (i.e., high, moderate, low) and type (e.g., road, drill pad, trench, etc.), disturbance longevity (long-term or short-term), the presence of foreign materials (e.g., oils, cement, etc.), and the plant species invading onto the site. The suitability of each disturbed site for plant succession studies and reclamation trials was identified. Seventy-five disturbed sites were inventoried (Table 11).

Table 11. Distribution of disturbances inventoried by vegetation association.

Vegetation Association	Number of Disturbances
Larrea-Lycium-Grayia	30
Lycium-Grayia	22
Coleogyne	12
Lycium-Grayia/Larrea *Lycium-Grayia* Transition	6
Larrea-Ambrosia	4
Larrea-Ambrosia/ *Lycium-Grayia* Transition	1
Total	75

4.1.2 Plant Succession

The plant succession study was designed to characterize the vegetation that invades disturbed sites within the Yucca Mountain Site Characterization Project area. Knowledge of plant species' response to disturbance type and severity, and the time frame required for secondary succession will improve the Yucca Mountain reclamation program. Data collected will help determine which plant species are best suited for reclaiming areas disturbed by SCA.

Five of the disturbed sites inventoried in the Fall of 1990 (see Section 4.1.1) were approved for reclamation trials in FY92. Reclamation trials will destroy all existing vegetation; therefore, eight plant succession study plots (SSP) were established to obtain information on plant succession at these five disturbances. Eight study plots were established because several of the disturbed areas had two disturbance types (i.e., cut-slopes and drill pads), or two zones of disturbance intensity (compacted and non-compacted soils). One study plot was placed on each disturbance type or intensity level.

Study plot layout depended on disturbance size and shape. All study plots on drill pads had six line and six belt transects. Study plots on cut-slopes had three transects. Transects were established at random distances from a defined baseline edge for each SSP, and at one random distance from an edge perpendicular to the baseline edge. Line transects were 20-m long and tiered one under another (at least 3-m apart) along the fall-line of water runoff. Belt transects (2 x 20 m) were adjacent to each line transect.

No data were collected in FY91; however, cover and density were sampled on all eight study plots in October 1991. Cover and density data collection techniques are identical to those used on ESPs (see Section 2.2.2.1 and 2.2.2.3), except data is collected on shorter transects. Production data collection on SSP uses the "reference-unit" method (Etienne, 1989) instead of the "double-sampling" method (Hutchings and Schmautz, 1969) used on ESPs. The reference-unit method entails selecting a typical unit (i.e., the reference unit) of each species present and determining the average weight of the current year's growth within the reference-unit. Annual production is determined by multiplying the average dry weight of each species-specific reference-unit by the number of species-specific reference-units rooted in each belt transect. Production data was not collected on the eight SSPs sampled because the period of maximum plant growth had passed, and accurate production estimates were not possible.

Additional SSPs will be established in FY92. Most of these plots will be only sampled once, but 10 to 12 will be established as long-term study plots. There are several important purposes for long-term, permanent study plots. First, seedling germination, establishment, and survival can be correlated with abiotic parameters (e.g., precipitation, soil moisture, etc.). Information on abiotic conditions that enhance or inhibit plant establishment will help improve the Yucca Mountain reclamation program. Second, permanent succession study plots can be used to measure reclamation success. Results from various reclamation treatments and techniques can be compared to natural plant succession. Even if vegetation characteristics in reclaimed areas do not resemble vegetation characteristics in undisturbed areas, vegetation establishment on reclaimed areas should be substantially better than on the study plots and should occur during a shorter time interval.

4.2 RECLAMATION TRIALS

EG&G/EM requested approval for reclamation trials at five sites. These sites were approved in October 1991. Locating sites suitable for additional reclamation trials is an ongoing part of the disturbed habitat site inventory process. The initial design of a study that looks at variables influencing vegetation reclamation in arid ecosystems was completed. As new sites become available, the study design will be expanded to incorporate additional variables and modifications of revegetation techniques that may increase reclamation success.

Additional seed was obtained from commercial vendors in preparation for revegetation trials. Also, sources of native seed on the NTS were identified, and seed was collected in preparation of a study to compare differences in adaptability of plants grown from commercial and native NTS seeds. Both commercial and native seed sources will be used to establish a stock of nursery grown transplants for use in future reclamation studies.

Reclamation materials, such as erosion blankets and straw mulch, were procured in preparation for soil stabilization trials and actual stabilization of topsoil stockpiles and other disturbed sites. Reclamation equipment including a John Deere farm tractor, a seed drill, and a disk crimper were purchased. This equipment will be used to apply reclamation treatments to the study plots and to reclaim disturbed YMP sites.

5. MONITORING AND MITIGATION PROGRAM

One of the primary goals of the Environmental Monitoring and Mitigation Plan is to preserve important plant and animal species and their associated habitats that may be impacted by SCA. Important species include federally listed and candidate species and species of commercial and recreational value. A mitigation tool used by YMP is to conduct field surveys to detect the presence of important plant and animal species prior to any land-disturbing activities.

Land-disturbing activities include a variety of actions that may cause minimal or severe surface disturbance and have the potential of affecting important species. Examples of these activities include drill pad construction, excavation of soil test pits and trenches, construction of site facilities, driving vehicles on unapproved dirt roads, and repairing equipment or sampling water at existing wells.

5.1 SURVEY PROCESS

The preactivity survey process is initiated when the Project Office sends a written request to conduct a preactivity survey. The request includes the contractor's description of the proposed activity and time of when the activity will occur. After biologists evaluate what species may be present, 100% of the proposed activity site(s) and buffer zones are surveyed. Survey results and mitigation recommendations to preserve potentially impacted species, their habitat, or important biological resources are written in a report submitted to the Project Office. Site-specific recommendations often include monitoring important species prior to, during, and after land-disturbing activities. Standard desert tortoise mitigation recommendations also are provided for all activities conducted in tortoise habitat. These standard recommendations include contacting the Project Office when a desert tortoise is seen, avoiding all tortoises and their burrows, and receiving tortoise training specified by the FWS Biological Opinion.

If proposed activities will disturb topsoil, soil samples are collected for analysis during preactivity surveys. Recommendations for protecting topsoil by stockpiling and stabilizing it against erosion are written in site-specific reclamation stipulation reports submitted to the Project Office. Soil analyses and salvaging topsoil will aid final reclamation efforts when disturbed sites are decommissioned.

Post-activity surveys are conducted after an SCA has been completed and the site is ready for reclamation. A post-activity survey report is submitted to the Project Office which documents all interim topsoil salvaging actions and any mitigation and monitoring efforts to protect important species either prior to, during, or after the activity began. The post-activity survey process is initiated when the Project Office informs EG&G/EM that an activity site is no longer needed for site characterization.

5.2 SURVEY RESULTS

Twenty-nine preactivity survey requests were received from the Project Office which included 223 separate sites (Table 12). A single activity may disturb many separate sites. Sites vary greatly in size for different projects. For example, 137 sites, each 4 m^2, were surveyed for an aerial mapping project, while 14 sites, each a major wash greater than 20 km long, were surveyed for one hydrological study. Approximately 262.6 km of washes and 24.6 km of roads were surveyed for vehicular access or repairs. The remaining surveys covered 95.6 ha.

Surveys for two seismic stations (0.3 ha) and portions of nine wash systems (75.7 km) were conducted outside of desert tortoise habitat. No important species or resources were found at these 11 sites. All other surveys were conducted within tortoise habitat (Table 13). There were 0.25 tortoise sign/km of wash surveyed, and no sign was found along roads. For all other surveys conducted in tortoise habitat, there were 0.33 tortoise sign/ha. Only one tortoise was found. ESPs occurred within four survey sites and were considered important biological resources to be avoided. No important plant species were observed.

Alterations in activity location or design were recommended for seven activities (Table 14). Recommendations were made to use existing disturbed areas, construct trench openings of minimal slopes, avoid unnecessary erosion of a wash bank, and initiate informal consultation with U. S. Fish and Wildlife Service (FWS) for trenching activity in California. This trenching activity is not included in the Biological Assessment for SCA.

Specific tortoise mitigation measures to be conducted before, during, and/or after site activities begin were recommended for five sites (Table 14). Construction began at two of these sites: Well JF3 (hydrological studies) and Midway Valley Trench A'2 (seismic studies). Biologists collapsed empty burrows at both sites and continuously monitored tortoise movements via radio-telemetry during Trench A'2 excavation.

Topsoil salvaging was recommended for eight sites, and reclamation stipulation reports were prepared for each (Table 14). Construction was started only at two of these sites (Trench A'2 and Trench 14). Topsoil was salvaged at both trenches. Trench A'2 was completed and backfilled and is ready for reclamation. A post-activity survey report was prepared which documents all tortoise and topsoil salvaging mitigation actions taken at Trench A'2.

Table 12. FY91 preactivity surveys conducted for Yucca Mountain Site Characterization Project activities.

Project Type	No. of Requests	No. of Sites	Area (ha)	Distance (km)
Prototype Borehole	1	1	7.9	0
Hydrological Studies	5	25	15.4	262.6
Soil/Volcanism Studies	3	25	13.6	0
Seismic Studies/Stations	5	5	1.9	0
Radiological Monitoring Stations/Plots	3	13	10.4	0
Biological Research Plots	3	6	20.5	0
Facility Improvements, Road Access/Repair	8	11	8.8	24.6
Aerial Mapping Project	1	137	17.1	0
Total	29	223	95.6	287.2

Table 13. Results of the FY91 preactivity surveys for Yucca Mountain Site Characterization Project activities conducted in desert tortoise habitat.

Project Type	No. of Sites	Area or Distance	Tortoise Sign[A]	Important Plants	Important Biological Resource
Prototype Borehole	1	7.9 ha	1	0	0
Hydrological Studies	16	15.4 ha 186.9 km	4(1) 47	0 0	3 0
Soil/Volcanism Studies	25	13.6 ha	20	0	0
Seismic Studies/Stations	3	1.6 ha	0	0	0
Radiological Monitoring Stations/Plots	13	10.4 ha	0	0	1
Biological Research Plots	6	20.5 ha	6	0	0
Facility Improvements, Road Repair/Access	11	8.8 ha 24.6 km	0 0	0 0	0 0
Aerial Mapping Project	137	17.1 ha	0	0	0
Total	212	95.3 ha 211.5 km	31(1) 47	0	4

[A] Includes tortoises and tortoise burrows found; number of tortoises found is in parentheses.

Table 14. Mitigation recommendations and actions of FY91 preactivity surveys for Yucca Mountain Site Characterization Project activities .

Project Type	Recommended Altering Activity	Prepared Reclamation Stipulations	Recommended Tortoise Monitoring	Tortoise Monitoring Performed	Post-Activity Survey Done
Prototype Borehole	0	1	1	0	0
Hydrological Studies	4	3	2	1	0
Soil/Volcanism Studies	1	1	1	0	0
Seismic Studies/Stations	0	1	1	1	1
Radiological Monitoring	1	0	0	0	0
Facility Improvements, Road Repair/Access	1	2	0	0	0
Total	7	8	5	2	1

6. RADIOLOGICAL MONITORING PROGRAM

The objectives of the Radiological Monitoring Program are to collect plant and animal specimens for determination of radionuclide concentrations in tissues and to monitor populations of animals species being collected or that may be collected in the future. Collections were made for small mammals and deer forage. Monitoring programs were conducted for small mammal populations, predators, and lagomorphs.

6.1 SMALL MAMMAL COLLECTION AND MONITORING STUDY

Small mammals are being used as indicator species to characterize existing levels of radionuclides in the environment as well as to monitor unsuspected release pathways of radionuclides. Monitoring of small mammal populations and collection of selected species was conducted on eight plots (Figure 12). Six near-field (NF) plots are located at Yucca Mountain to monitor potential radionuclide sources from Site Characterization (plots NF2, NF5, NF14, NF37, NF59, and NF69), one near-field control plot east of Yucca Mountain (plot NF12), and one far-field control plot in Crater Flat (plot FF58). Each plot contains a trap grid of 240 live-traps. See EG&G/EM (1991) for details on plot location and methods of small mammal trapping and collection.

Due to restrictions in the State of Nevada animal handling permit, two of the eight plots for radiological monitoring were not trapped until July 1991, after a revised permit was issued. Five plots were trapped in December 1990, six plots in January and April 1991, and all eight plots in July 1991 (Table 15). The sampling effort for FY91 totalled 24,480 trap-nights. Based on the number of individuals captured (Table 15), spring 1991 populations of the Merriam's kangaroo rat (*Dipodomys merriami*) and long-tailed pocket mouse (*Perognathus formosus*) were similar to numbers in 1990. During the April 1991 trap session, either Merriam's kangaroo rats or long-tailed pocket mice were collected from five plots (Table 15). The last collection conducted on these plots was in April 1989 except for plot NF69 which had individuals collected in October 1989.

Precipitation during winter 1990 and spring 1991 provided some relief to the existing drought conditions. Total individual small mammals captured on some plots in July 1991 was 2-3 times greater than numbers recorded for the same plots in July 1989 (no plots were trapped July 1990). The control plot in Crater Flat (plot FF58) was the only plot that had a decrease in numbers over this same period.

Population size, survival, and recruitment estimates for each plot will be calculated in the future for Merriam's kangaroo rats and long-tailed pocket mice. These estimates will provide information on how collections, climatic conditions, and natural factors affect small mammal population dynamics. Results of the tissue analysis for radionuclide levels will be published by Science Application International Corporation, Inc (SAIC).

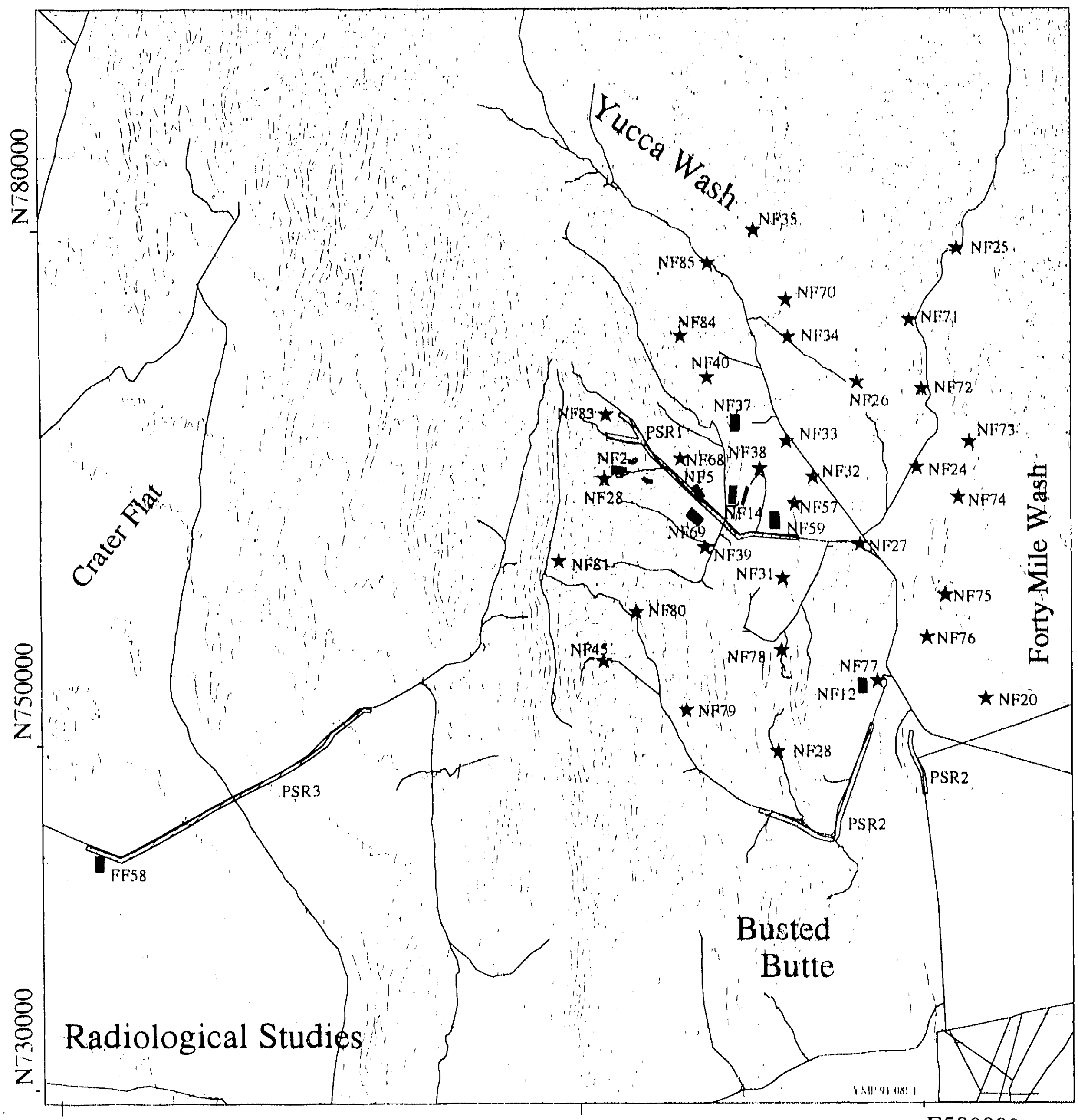

Figure 12. Location of Radiological Monitoring Program sampling locations for the Yucca Mountain Site Characterization Project. Polygons are small mammal trapping collection plots. Deer forage sample plots are indicated by stars. Predator survey routes are indicated by elongate and hashed belt transects along roads

Table 15. Number of individual Merriam's kangaroo rats (DIME) and long-tailed pocket mice (PEFO) captured on the radiological monitoring small mammal plots, December 1990 - July 1991. Number of individuals collected is in parentheses.

Plot	Species	December	January	April	July
NF2	DIME	-[a]	-	-	10
	PEFO	-	-	-	192
NF5	DIME	21	19	25	45
	PEFO	6	10	38(20)	213
NF12	DIME	-	-	-	38
	PEFO	-	-	-	110
NF14	DIME	43	33	53(12)	59
	PEFO	6	2	70	99
NF37	DIME	38	34	48	45
	PEFO	1	5	78(20)	230
FF58	DIME	-	11	10	23
	PEFO	-	0	1	0
NF59	DIME	70	64	69(12)	77
	PEFO	3	3	64	184
NF69	DIME	34	24	32	52
	PEFO	7	4	47(20)	227

[a] Hyphen indicates plot was not trapped during a particular month.

6.2 DEER FORAGE COLLECTION

Mule deer (*Odocoileus hemionus*) occur in low numbers in the vicinity of Yucca Mountain. Because mule deer are a game species and can be hunted on nearby public lands, deer represent a potential pathway for radionuclides to humans. Deer move over an area much larger than Yucca Mountain including portions of the NTS; therefore, it is impossible to attribute any detectable levels of radionuclides in deer tissue to the Yucca Mountain area. Instead, an indirect method using samples of potential deer forage species is being used to monitor radionuclide sources (Figure 12).

In FY90, low rainfall resulted in little production on deer forage plants, and only 17 forage samples were collected from 12 plots (EG&G/EM, 1991). In FY91, increased precipitation improved forage production, and 30 forage samples were collected from 24 sample plots (Table 16). In spite of the increased precipitation, some sample plots did not have sufficient production to permit sample collection.

Samples were transferred to the custody of SAIC in July 1991. Results of the radionuclide analysis of the forage samples will be published by SAIC when analyses are completed.

Table 16. Deer forage species collected in July 1991 for analysis of radionuclide levels.

Plot Number	Plant Species Collected	Wet Weight (g)
NF24	*Krameria parvifolia*	514
NF26	*Encelia virginensis*	639
	Purshia glandulosa	1090
NF32	*Krameria parvifolia*	807
	Encelia virginensis	1028
NF33	*Krameria parvifolia*	911
NF34	*Encelia virginensis*	1206
NF35	*Purshia glandulosa*	1076
	Atriplex canescens	449
NF38	*Atriplex confertifolia*	370
	Larrea tridentata	513
NF45	*Atriplex canescens*	462
NF57	*Krameria parvifolia*	627
NF68	*Atriplex polycarpa*	928
NF70	*Chrysothamnus nauseosus*	1394
NF71	*Krameria parvifolia*	476
NF73	*Atriplex polycarpa*	604
NF74	*Encelia virginensis*	860
NF75	*Krameria parvifolia*	536
NF77	*Krameria parvifolia*	544
NF78	*Atriplex confertifolia*	907
NF79	*Encelia virginensis*	401
NF80	*Krameria parvifolia*	762
NF81	*Atriplex canescens*	778
NF82	*Ceratoides lanata*	389
	Artemisia tridentata	392
NF83	*Artemisia tridentata*	760
NF84	*Encelia virginensis*	732
NF85	*Purshia glandulosa*	1043
	Chrysothamnus nauseosus	983

6.3 LAGOMORPH AND GAMEBIRD STUDIES

In FY90 a study was initiated to estimate lagomorph (hares and rabbits) and gamebird density to determine whether their populations could sustain a collection of individuals for radionuclide analysis. No lagomorphs or gamebirds were observed during the FY90 spring and fall field sampling of line transects (120 km). Because of low densities, clumped distribution of gamebirds, and difficulty in flushing lagomorphs, line transects were determined to be inappropriate for monitoring population abundance (Hayden, 1966). Based on further evaluation of field methods, separate sampling techniques were deemed necessary for monitoring lagomorphs and gamebirds.

6.3.1 Lagomorph Surveys

Because lagomorphs are primarily active at night (Smith, 1990), spotlight counts were chosen as an alternative to monitor population abundance. Spotlight surveys also will provide supplemental data on predator abundance (see Section 6.4). Although animal density cannot be estimated using spotlighting, an index of abundance can be calculated to compare lagomorph abundance through time.

6.3.1.1 Survey Methods

Spotlight routes were established in FY91 near the original line transects (EG&G/EM, 1991) to continue to sample the same areas. The spotlight routes consisted of 20 km of road on the east side of Yucca Mountain area (treatment area) and 20 km west of Yucca Mountain in Crater Flats (control area). The Yucca Mountain area was surveyed in October 1990, March 1991, and June 1991, and Crater Flat was surveyed in October 1990, March 1991, and May 1991. Spotlight surveys were conducted by driving the same route three consecutive nights (four nights in June) for a total of 19 spotlight nights. Sampling was conducted with two people operating spotlights on each side of the vehicle and a third person driving the vehicle at speeds of 5–10 mph.

6.3.1.2 Survey Results

An average of 1.26 (range 0-6) lagomorphs were observed each night. Coyotes (*Canis latrans*) were the most consistently observed carnivore while infrequent observations of other large mammals included: kit fox (*Vulpes macrotis*), mule deer, and burro (*Equus asinus*). The results indicate that lagomorphs were low in abundance. In FY92, spotlight surveys will be conducted during the winter 1991 and summer 1992.

6.3.2 Gamebird Surveys

No field monitoring of gamebird populations was conducted. Opportunistic observations of gamebirds were noted. A monitoring study will be initiated in FY92 to determine the distribution and abundance of Gambel's quail (*Callipepla gambelii*) and if there are sufficient numbers to allow collection for radionuclide analysis. The gamebird of primary concern as a potential pathway of radionuclides to humans is the mourning dove (*Zenaida macroura*). Because of their migratory nature, it would be difficult to attribute any detectable levels of radionuclides in mourning dove tissue to the Yucca Mountain area. Because Gambel's quail have similar foraging behaviors and are non-migratory, they may be a reliable model of potential radionuclide uptake in mourning doves.

6.4 PREDATOR STUDY

Because predators are relatively long-lived and high on the food chain, they could provide information on the bioaccummulation and concentration of radionuclides in the ecosystem. Several mammalian predators have been observed in the Yucca Mountain area. However, no site-specific information is available on abundance, distribution, or movements of these animals. This information must be obtained before specimens of mammalian predators could be collected for the Radiological Monitoring Program.

6.4.1 Survey Methods

This study was designed to provide basic information on the relative abundance of various mammalian predators throughout the Yucca Mountain area. Three predator survey routes (PSR), each with 12 scent-stations, were used to monitor abundance (Figure 12). The PSR locations represent three possible radionuclide contamination sources. PSR 1 is near the proposed ESF and represents potential radionuclide sources associated with SCA and NTS activities. PSR 2 is located north of Busted Butte on both sides of Forty-Mile Wash and represents potential contamination from NTS activities. PSR 3 is located in Crater Flat and represents a control for SCA and NTS activities.

Each scent-station was prepared on a smooth, level 1-m area. Fine dust was sifted onto the level area, and a synthetic Fatty Acid Scent (FAS) odor attractant was placed in the center of each station. Predator visits were determined by tracks left in the soil by animals attracted to the scent-station.

6.4.2 Survey Results

The survey lines were operated in September/October 1990, February 1991, and May 1991. PSR 3 was not operated in February 1991 due to high winds. All surveys were canceled in September 1991 due to high winds. During the September/October 1990 surveys, PSR2 had the highest visitation rate of the three routes (Table 17). The ringtail (*Bassariscus astutus*) and kit fox (*Vulpes macrotis*) had the greatest number of visits. The visitation rates for all survey routes are summarized in Table 17. High winds severely affected the use of the dust scent station technique. Other field methods will be reviewed in FY92 to develop a technique more resistant to high winds.

Table 17. Summary of operable stations, visits by predators, and visitations rates for Predator Survey Routes (PSR) 1, 2, and 3.

Month	Route	Operable Station-Nights[b]	Visitation Rates[a] (Number of Visits)				
			Kit Fox	Ringtail	Coyote	Spotted	Total
September/ October 1990	PSR1	34	0	0.12(4)	0.03(1)	0	0.15
	PSR2	36	0.33(12)	0.03(1)	0	0	0.36
	PSR3	24	0	0	0	0.04(1)	0.04
February 1991	PSR1	24	0	0	0	0	0
	PSR2	24	0.13(3)	0	0	0.04(1)	0.17
	PSR3[c]	-	-	-	-	-	-
May 1991	PSR1	33	0.03(1)	0	0	0	0.03
	PSR2	28	0	0	0	0	0
	PSR3[d]	0	-	-	-	-	-

[a] -Visitation rate is calculated as follows (number of stations visited during session)(number operable station-nights).
[b] -The total number of station-nights conducted per route. Stations were considered inoperable when greater 50% of the station was destroyed due to wind, rolling by an animal, or vehicle activity. Thirty-six station-nights are attempted each survey session.
[c] -Survey on PSR 3 was not attempted this session due to continuous high wind.
[d] -All stations were destroyed by wind, therefore visitation rates could not be calculated for PSR 3 during this survey session.

7. BIOLOGICAL SUPPORT

Biological support was provided to the Yucca Mountain Site Characterization Project by EG&G/EM through completion of special studies and reports, document reviews, presentations, tours, and permit acquisitions. Additional support was furnished in the areas of quality assurance, safety, and facility/equipment acquisition. These specific activities ensured compliance with the Nuclear Waste Policy Act of 1982 (as amended in 1987), Endangered Species Act of 1973, and DOE orders.

7.1 DOCUMENT REVIEW AND REVISION

Several documents were reviewed and commented on by EG&G/EM at Project Office request. EG&G/EM provided written response to review comments by the University Nevada, Las Vegas Environmental Research Center on the 1988 Terrestrial Ecosystems Environmental Field Activities Plan (EFAP). Written response also was provided on REECo's review comments on the desert tortoise relocation study. EG&G/EM reviewed the Safety and Operations Plan of Environmental Science Associates, the environmental consultants for the State of Nevada for the Yucca Mountain Site Characterization Project. EG&G/EM also reviewed the Exploratory Shaft Facility Title 1 Summary Report related to biological resources. The Terrestrial Ecosystems EFAP was revised and submitted to Project Office for review.

7.2 REPORTS AND SPECIAL REQUESTS

EG&G/EM provided Project Office with monthly and weekly reports of activities and accomplishments. An annual report of progress and accomplishments for FY89 and FY90 was written and published as a DOE report (EG&G/EM 1991). EG&G/EM prepared three manuscripts for presentation at the Second International High-Level Radioactive Waste Management Conference and publication in the conference proceedings. Reclamation expertise was provided to Project Office for the prototype drilling activities at Apache Leap, Arizona. EG&G/EM provided expertise in the areas of terrestrial ecology and endangered species during the application process for a State of Nevada water appropriations permit.

7.3 PRESENTATIONS, MEETINGS, AND PUBLIC TOURS

EG&G/EM participated in several presentations, Public Outreach tours, and meetings at Project Office request. Three presentations on the YMP biological resource monitoring program were given at the Second International High-Level Radioactive Waste Management Conference. The papers described the programs designed for monitoring desert tortoise populations, monitoring effects of SCA on biological resources, and reclaiming land disturbed by SCA. A presentation on the possible effects of thermal loading from the repository on biological resources was prepared for the Nuclear Waste Technical Review Board (TRB) meeting in early FY92. A mid-year review of the biological resources monitoring program was presented to the Project Office.

7.4 QUALITY ASSURANCE

Significant effort was expended to develop a quality assurance (QA) program for Yucca Mountain Site Characterization Project. EG&G/EM prepared a Quality Assurance Program Description (QAPD). The QAPD was approved by Project Office. A Quality Grading Report was submitted to the Quality Review Board for tasks assigned to EG&G/EM under WBS 1.2.5.4.7 (Terrestrial Ecosystems). EG&G/EM activities were removed from the Quality Assurance list and placed under the Project Requirements List. Instruction documents were prepared for new studies and to replace Technical and Administration Task Procedures for existing studies and activities.

7.5 PERMITS

In FY90 the State of Nevada renewed EG&G/EM's State Scientific Collecting Permit but activities were not authorized in a two square mile area (exclusion area) centered on Yucca Mountain. All activities authorized by the permit were terminated until November 1990 when the State agreed that permitted activities could continue in all but the exclusion area. In June 1991, the State agreed to remove the exclusion area and all permitted activities were resumed throughout the Yucca Mountain study area. The State Collecting Permit was renewed in July 1991 with no restrictions.

7.6 SAFETY

Safety and compliance with established environmental and health standards have been priorities for EG&G/EM. Staff meetings have included operational safety topics as part of the agenda. Monthly and quarterly YMP safety meetings were attended by EG&G/EM representatives. These meetings were to ensure compliance with the Environmental Safety Health Program Implementation Plan (ESHPIP). A Safety and Health Standard Operating Procedure was prepared for the YMP Safety Plan. An EG&G/EM Organizational Operating Procedure was written to establish procedures for scientific personnel to follow when working in remote locations.

Safety Analysis Evaluations were prepared for the spotted bat surveys and the reptile studies. YMP safety training and first aid/CPR training and certification was completed for most of the EG&G/EM staff.

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