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The Distribution and Relative Abundance of Desert Tortoises at Yucca Mountain

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Prepared by:
TRW Environmental Safety Systems Inc.

Prepared for:
U.S. Department of Energy
Office of Civilian Radioactive Waste Management
1000 Independence Avenue, S.W.
Washington, D.C. 20565

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Management and Operating Contractor

The Distribution and Relative Abundance of Desert Tortoises at Yucca Mountain

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Prepared for:

U.S. Department of Energy
Yucca Mountain Site Characterization Office
P.O. Box 98608
Las Vegas, NV 89193-8608

Prepared by:

TRW Environmental Safety Systems Inc.
1180 Town Center Drive
Las Vegas, Nevada 89134

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Civilian Radioactive Waste Management System
Management and Operating Contractor

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Prepared by:

Patrick E. Lederle — 2/5/97 Date
Science Applications International Corporation

Kurt R. Rautenstrauch — 2/5/97 Date
Science Applications International Corporation

Danny L. Rakestraw — 2/5/97 Date
Science Applications International Corporation

James M. Mueller — 2/5/97 Date
EG&G Energy Measurements, Inc.

Approved by:

Michael W. Harris — 2/5/97 Date
Science Applications International Corporation

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EXECUTIVE SUMMARY

The desert tortoise (*Gopherus agassizii*) is the only resident vertebrate species in the Yucca Mountain area that is protected under the Endangered Species Act. Following the listing of the desert tortoise as endangered (subsequently relisted as threatened), the U.S. Department of Energy entered formal consultation with the U.S. Fish and Wildlife Service. One of the terms and conditions resulting from consultation was that the Department of Energy continue the Desert Tortoise Monitoring Program. That program included as one of its goals the development of a better understanding of the ecology of the desert tortoise population at Yucca Mountain, including assessing the distribution and abundance of tortoises in the area. This report summarizes the information available on the distribution and abundance of desert tortoises in the Yucca Mountain area.

Numerous transect surveys conducted from 1981-1989 indicated that tortoises were distributed throughout the Yucca Mountain area. These surveys also indicated that the relative abundance of tortoises was low. Tortoise densities were reported to be from about 4 to 20/km^2. In addition, it was determined that the northern boundary of the distribution of desert tortoises was less than 10 km north of that part of Yucca Mountain being intensively studied as part of the Yucca Mountain Site Characterization Project.

A pilot study was conducted in 1990 to assess the use of quadrat sampling to monitor the abundance of tortoises at Yucca Mountain. It was concluded that, because of low tortoise abundance, the number of quadrats required to monitor the abundance of tortoises was prohibitively large. Therefore, the abundance of tortoises at Yucca Mountain was not directly measured or monitored as part of the Desert Tortoise Monitoring Program. However, a large number of tortoises were marked for this program during 1989-1995, and information collected while marking these individuals provides additional insight into the distribution and abundance of tortoises at Yucca Mountain.

The number of tortoises observed in a 117-km^2 area was tallied and the distribution of these sightings was mapped. Two smaller areas where intensive tortoise research was conducted from 1989-1995 were identified and the number of tortoises within these areas was tallied to determine the minimum population size. The minimum density of tortoises found in these areas was 10 and 12 tortoises/km^2, which is similar to results reported from earlier surveys. These density estimates are similar to most other areas in southern Nevada near Yucca Mountain, yet are lower than many estimates of tortoise density in the Mojave Desert in California, where densities of greater than 75/km^2 have been reported.

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1. INTRODUCTION

In response to the *Nuclear Waste Policy Act of 1982* and the *Nuclear Waste Policy Amendments Act of 1987*, the U.S. Department of Energy (DOE) developed and is implementing the Yucca Mountain Site Characterization Project. This project consists of a series of multidisciplinary scientific investigations designed to provide detailed information necessary to assess the suitability of Yucca Mountain, Nevada, for possible development of a geologic repository for high-level nuclear waste.

Surveys of the biological resources in the Yucca Mountain area determined that the desert tortoise (*Gopherus agassizii*) was the only vertebrate resident in the immediate vicinity of Yucca Mountain that was being considered for protection under the *Endangered Species Act of 1973*. Shortly after the listing of the Mojave population of the desert tortoise as endangered in 1989 (subsequently relisted as threatened in 1990), DOE entered into formal consultation with the U.S. Fish and Wildlife Service, as required by Section 7 of the Endangered Species Act. As a result of that consultation, the Fish and Wildlife Service issued a non-jeopardy Biological Opinion to the DOE Yucca Mountain Site Characterization Office (U.S. Fish and Wildlife Service 1990). One of the terms and conditions of the Biological Opinion was the continuation of the Desert Tortoise Monitoring Program that had been initiated in 1989. The goals of the Desert Tortoise Monitoring Program (Rautenstrauch et al. 1991) were to monitor and assess the potential effects of site characterization activities on desert tortoises; evaluate and develop mitigation methods for minimizing those impacts; and develop a better understanding of the status and ecology of the desert tortoise population at Yucca Mountain, including the distribution and relative abundance of desert tortoises in the area.

Knowledge of the distribution and abundance of desert tortoises in the Yucca Mountain area is important for several reasons. This information is important for land-use planning, because the impacts of site characterization activities are likely to be more severe, in terms of the number of individual tortoises affected, in areas of high tortoise density. Moreover, if reasonable estimates of tortoise abundance in the area could be determined, these values could be monitored over time to assess whether the abundance of desert tortoises at Yucca Mountain is increasing or decreasing. Of particular interest are declines in tortoise abundance, because declines have been noted in many regions of the Mojave Desert (Corn 1994; U.S. Fish and Wildlife Service 1994). Also, information on the abundance of tortoises and associated population age/sex structure in the Yucca Mountain area can be incorporated into the development of population models. These models may be useful for predicting impacts of future activities on tortoises, should the area become a nuclear waste repository.

The general distribution (which includes all known geographic locations where a species has been observed) and habitat associations of the desert tortoise throughout much of its range (i.e., the geographical boundaries of the distribution) are well documented (reviewed by Bury et al. 1994; Fritts and Jennings 1994; Germano et al. 1994). Generally, the desert tortoise is found throughout large portions of the Mojave and Sonoran deserts of California, Nevada, Arizona, Utah, and the Mexican states of Sonora and Sinaloa. In the Mojave Desert, the desert tortoise occupies a wide range of habitats; the most commonly noted are alluvial fans and gentle slopes at elevations less than 1,200 m dominated by the shrubs *Larrea tridentata* and *Ambrosia dumosa* (Luckenbach 1982; U.S. Fish and Wildlife Service 1994). Also important, although not adequately investigated, are

rocky slopes in the northern Mojave Desert up to elevations of 1,600 m, which provide numerous sites for burrows and deep hibernacula (Collins et al. 1986; Bury et al. 1994). In the Sonoran Desert, which receives more rainfall and is vegetationally more diverse than the Mojave Desert (Shreve 1942), tortoises are found associated with desert scrub and low woodland trees (Germano et al. 1994). At the extreme southern end of their range, desert tortoises inhabit both Sinaloan thornscrub and deciduous forest in northern Mexico (Fritts and Jennings 1994; Germano et al.1994).

A number of investigations have assessed the relative abundance (i.e., an index of the number of individuals in an area relative to other areas measured using the same technique) of desert tortoises at Yucca Mountain and in surrounding areas. Although workers in the Yucca Mountain area prior to site characterization undoubtedly encountered desert tortoises, and tortoises were included in the reptile list established for the adjacent Nevada Test Site (Tanner and Jorgensen 1963), the presence of tortoises specifically in the Yucca Mountain area was first officially reported in 1981 (Medica et al. 1981). That report was the first in a series of efforts by DOE to evaluate the distribution and relative abundance of desert tortoises in the Yucca Mountain area. During 1981-1984, surveys were conducted to record the amount of desert tortoise sign along transects (O'Farrell and Collins 1983 and 1984; Collins and O'Farrell 1985; Collins et al. 1986). In addition, the State of Nevada, Nuclear Waste Project Office, conducted tortoise surveys in the Yucca Mountain area during 1989 (Karl 1989).

To achieve the goals of the Desert Tortoise Monitoring Program, studies on movement patterns, reproduction, disease status, burrow use, and food habits were conducted on a large sample of marked tortoises from 1989 through September 1995. Most tortoises were found and marked as a result of extensive and thorough searches throughout the Yucca Mountain area early in the studies. Results of these initial searches and continuing field observations during the course of the studies yielded useful information that can further clarify the distribution and abundance of desert tortoises at Yucca Mountain.

The objectives of this report are to summarize the findings from tortoise surveys conducted in the Yucca Mountain area during the 1980s, and to present additional information on the distribution and abundance of tortoises collected during 1989-1995 as part of other research efforts at Yucca Mountain.

2. STUDY AREA

Yucca Mountain is located in Nye County, Nevada, approximately 150 km northwest of Las Vegas, and crosses the boundaries of lands managed by three federal agencies: DOE, the U.S. Air Force, and the U.S. Bureau of Land Management. The areas managed by DOE and the Air Force have been reserved for use by government agencies in support of national security needs, and have been restricted from public access and grazing since the early 1950s.

The Yucca Mountain area lies on the northern edge of the Mojave Desert along an ecotone between the Great Basin and Mojave deserts. The region is characterized by linear mountain ranges and broad valleys. The portion of Yucca Mountain being evaluated by DOE as a potential geologic repository is a ridge of volcanic origin oriented north to south, with a maximum elevation of about 1,510 m. Two major floristic zones occur in this area, a Mojave Desert zone and a transition zone between the Mojave and Great Basin deserts. Three vegetation associations commonly found in these zones cover most of the study area (Beatley 1976; O'Farrell and Collins 1984; CRWMS M&O 1996a). An association dominated by the shrubs *Larrea tridentata, Ambrosia dumosa, Grayia spinosa*, and *Ephedra nevadensis* is found in the Mojave Desert zone on alluvial slopes below about 1,300 m. *Ephedra nevadensis*, *Grayia spinosa*, and *Lycium andersonii* dominate the vegetation association in the transition zone on alluvial slopes above 1,300 m and on the upper slopes of Yucca Mountain. Another transition zone vegetation association is dominated by *Coleogyne ramosissima* and is found on upper alluvial slopes and relatively level ridges, between about 1,160 and 1,510 m.

The Yucca Mountain area experiences limited and erratic precipitation, low relative humidity, and large daily temperature fluctuations. Average annual precipitation from 1960-1995 at weather station 4JA, approximately 13 km southeast of Yucca Mountain, was 13.9 cm (DOE Nevada Operations Office, unpublished data). The average daily minimum and maximum temperatures during December, the coldest month at Yucca Mountain, were 2°C and 10°C, respectively (recorded at Yucca Mountain from 1986-1995; DOE Yucca Mountain Site Characterization Office, unpublished data). The average daily minimum and maximum temperatures for the hottest month, July, were 22°C and 34°C, respectively.

3. PREVIOUS TRANSECT SURVEYS AT YUCCA MOUNTAIN AND COMPARISONS TO OTHER SURVEYS IN SOUTHERN NEVADA

Following the confirmation that desert tortoises occurred in the Yucca Mountain area (Medica et al. 1981), a series of sign transect surveys were conducted (O'Farrell and Collins 1983 and 1984; Collins and O'Farrell 1985; Collins et al. 1986). The purpose of these surveys was to record the amount of tortoise sign (i.e., tortoises, burrows, carcasses, scat, eggs, or shell fragments) per kilometer of transect and infer from that information the relative abundance of tortoises in the areas surveyed (see Table 1). These techniques have been widely used by land management agencies in the Mojave Desert (e.g., U.S. Bureau of Land Management, Nevada Division of Wildlife) to obtain three types of information: presence/absence, relative abundance, and density.

Transect surveys accurately detect the presence of desert tortoises, therefore, these data are useful for determining the geographic range of the species and its distribution within that range (e.g., EG&G/EM 1991; Bury et al. 1994).

Transect data may also be of value to compare the relative abundance of tortoises among areas by comparing the amount of sign found along transects in those areas. To make such comparisons, it is assumed that the relationship between number of tortoises and amount of sign is constant among sites and through time. This assumption is likely not valid since the amount of sign counted can be influenced by the time of year transects were walked, the age structure of the populations (Turner et al. 1985), and environmental and geographic factors (Fritts 1985). In addition, this method is not sensitive enough to distinguish between small or moderate differences in abundance of tortoises among sites (Turner et al. 1985; Weinstein 1989). Therefore, use of this technique should be limited to comparisons of large-scale differences in abundance using categories such as those presented in Table 1.

Transect data also have been used to estimate the density of tortoises. To achieve this, the number of sign observed along a transect is converted to estimates of density by conducting multiple transects through plots of "known density." From these multiple transects, regression models are

Table 1. Relationship of sign detected per kilometer of transect walked to categories of abundance of tortoises (from Karl 1981). Values for sign detected were converted from sign detected along 2.4 km transects in Nevada (see Schneider et al. 1985, Table 1).

Sign Detected/km Transect	Abundance Class	Density	
		Tortoises/mi²	Tortoises/km²
0	Very Low or None	0-10	0-3.9
0.4-1.2	Low	10-45	3.9-17.4
1.6-2.8	Moderate	45-90	17.4-34.7
3.2-4.4	Moderately High	90-140	34.7-54.0
> 4.8	High	≥ 140	> 54.0

developed that predict density of tortoises from the amount of sign counted per kilometer of transect. "Known density" for calibration plots is determined using complete-coverage searches and mark-recapture techniques (Berry and Nicholson 1984). Table 1 presents the abundance categories and tortoise densities most often used in Nevada. These categories were developed by Karl (1981) based on four plots in Nevada and one in California. Converting transect data to density in this manner should be treated as suspect for a number of reasons. The first is the uncertain relationship between sign and tortoise densities, as discussed above. Second, estimates of density on the calibration plots were determined using complete-coverage surveys, which tend to be biased toward larger, easier to see individuals (Shields 1980). Also, the density estimates for these plots have very large confidence intervals, yet this lack of precision has not been incorporated into the regression models.

During 1981-1984, tortoise sign was recorded along 341 transects totaling approximately 520 km in the Yucca Mountain area. The small amount of sign detected (0.28 sign/km of transect walked) indicated that the overall relative abundance of tortoises was very low (EG&G/EM 1991) (Table 1). Sign of tortoises was found scattered throughout most of the area surveyed, but was more common on alluvial fans dominated by *Larrea tridentata* or on ridge tops than on alluvial fans dominated by *Coleogyne ramosissima* or steep slopes. Sign was found at elevations from 1,000 to 1,600 m. Based on these transect surveys, "densities were estimated to be low (less than 20 per square mile [8/km^2])" (DOE 1986).

An additional transect survey was conducted at Yucca Mountain in 1989. Twenty-three transects totaling approximately 55 km were walked, primarily in Midway Valley and the slopes and ridges west of that valley (Karl 1989). An average of 0.85 sign was counted per kilometer of transect walked, which is in the low relative-abundance category (Table 1). Sign was found throughout the area, except on steep middle slopes, leading to the conclusion that alluvial fans, inset fans, and gently sloping ridges provided better habitat for tortoises than steep ridge slopes. Karl (1989) concluded "that densities are probably between approximately 10 and 50 tortoises/mi^2 [3.9 to 19.3/km^2]."

Similar relative abundances of tortoises have been found in areas of southern Nevada near Yucca Mountain. Results from 150 transects in six areas in southern Nevada also showed generally low tortoise abundances, although the amount of sign in some areas, such as Piute Valley near the southern tip of Nevada, was higher (Schneider et al. 1985). The transects (Schneider et al. 1985) conducted in the Desert National Wildlife Range (60 transects totaling 114 km) located east of Yucca Mountain, indicated that relative abundance was generally very low to low (0 to 17 tortoises/km^2). No sign was detected on almost half of the transects on the Wildlife Range (28 of 60), indicating very low (0 to 4 tortoises/km^2) relative abundance in those areas. None of the areas surveyed on the Wildlife Range had relative abundances greater than moderate. Karl (1981) also reported low relative abundance for much of the area surveyed in Lincoln and Nye counties in southern Nevada. For example, 72% of the transects walked in Lincoln County and 74% of the transects in Nye County were in areas that had densities of fewer than 4 tortoises/km^2. Some of the transects surveyed in Nye County were located in Crater Flat immediately west of Yucca Mountain. In contrast, approximately 72% of transects walked in Clark County, Nevada, south of Yucca Mountain, were estimated to be in areas with more than 8 tortoises/km^2 (Karl 1980).

4. ADDITIONAL INFORMATION ON THE DISTRIBUTION AND ABUNDANCE OF TORTOISES AT YUCCA MOUNTAIN

Surveys conducted during 1981-1989 demonstrated that tortoises were distributed in low abundance (i.e., fewer than 20/km^2) throughout the Yucca Mountain area and that the northern boundary of that distribution was less than 10 km north of Yucca Mountain (Karl 1989; EG&G/EM 1991; Rautenstrauch et al. 1994). Because the distribution of tortoises at Yucca Mountain was well documented, no surveys were conducted during 1989-1995 in conjunction with the Desert Tortoise Monitoring Program specifically to gather additional information on tortoise distribution.

As part of the program to evaluate the effects of the Yucca Mountain Site Characterization Project on desert tortoises, a literature review and pilot study were conducted in 1990 to select an appropriate method for monitoring changes in the abundance of desert tortoises at Yucca Mountain. Because transect surveys cannot be used to precisely estimate abundance of tortoises (Fritts 1985; Weinstein 1989; Bury et al. 1994), quadrat sampling was evaluated in that pilot study. Eight randomly selected, 24-ha plots were established and complete-coverage searches were conducted on all plots. In the 192 ha surveyed, only four tortoises were found. Based on these results, it was concluded that the level of effort required to find all tortoises present, and then detect changes in the abundance of tortoises on quadrats, was prohibitive. Much larger, and many more quadrats would be required to monitor long-term trends in population size because the statistical power to detect changes in abundance is weak in low-density populations (Taylor and Gerrodette 1993). For these reasons, the abundance of tortoises at Yucca Mountain was not directly measured or monitored as part of the Desert Tortoise Monitoring Program.

Although the distribution and abundance of tortoises at Yucca Mountain were not directly studied as part of the Desert Tortoise Monitoring Program, many tortoises were marked and monitored for this program during 1989-1995, and this information provides additional insight into the distribution and abundance of tortoises at Yucca Mountain. Most of these tortoises were marked during extensive searches to find and radiomark tortoises for studies of the impacts of site characterization activities on tortoises. When possible, each unmarked tortoise found in the Yucca Mountain area was given a permanent, unique mark by scute notching, and a corresponding, easily seen, number was painted on its carapace. Many of these tortoises, depending upon the situation (see below), were also fitted with radio transmitters. When marked, the carapace length of each tortoise was measured using large aluminum calipers. Tortoises that were large enough (generally > 180 mm) were sexed based on external morphology (Woodbury and Hardy 1948). Some tortoises had blood drawn for disease monitoring, and some of the smaller individuals (generally < 180 mm) were sexed using blood testosterone levels (Rostal et al. 1994). Exact locations for all sightings were determined using Global Positioning System units with differential correction, or by directly measuring bearing and distance to a known point.

Radiomarking a large number of tortoises to study the effects of site characterization activities (CRWMS M&O 1996b) required extensive complete-coverage searches for tortoises. These searches were conducted from 1989-1993 in several areas in Midway Valley that were scheduled for major ground-clearing operations. The areas near disturbances were considered treatment areas for evaluating the effects of site characterization activities on several aspects of desert tortoise biology

(see CRWMS M&O 1996b). Systematic searches of tortoise habitat in an area to remain undisturbed (the control area for effect evaluation studies), located on the southern alluvial slopes of Calico Hills, were conducted in 1991. During all of these searches, and throughout the remainder of the Desert Tortoise Monitoring Program, all of the tortoises found in these areas were marked and most were radiomarked.

Most tortoises found during preactivity surveys, which were required prior to all ground-disturbing activities, were radiomarked to monitor and protect tortoises near construction areas. These surveys were conducted one to three months prior to each planned disturbance, and normally a second search was conducted immediately prior to the start of construction activities.

Since 1990 all Yucca Mountain Site Characterization Project personnel have been required to report sightings of tortoises to the Field Operations Center. Locations for these sightings were noted and biologists responded to many of these sightings. When biologists responded, tortoises were individually marked and some were fitted with radio transmitters in association with other Desert Tortoise Monitoring Program studies.

Many unmarked tortoises were also found and marked during the routine monitoring of radiomarked tortoises using telemetry equipment. Once a tortoise was radiomarked, it was located generally twice per week during the activity seasons (approximately April through October) of 1989 through 1994 and weekly during the activity season of 1995. Tortoises were located twice per month while in hibernation (approximately November through March).

4.1 DISTRIBUTION OF TORTOISES

All of these efforts to locate and mark tortoises between 1989-1995 resulted in 340 individual tortoises being marked in a 117-km^2 area surrounding Yucca Mountain (Figure 1). The distribution of tortoises in Figure 1 indicates that tortoises were observed throughout the Yucca Mountain area where field work was conducted to assess environmental effects of the project. The higher number of tortoises in the treatment and control areas is a reflection of the much greater amount of time spent searching for tortoises in these areas, compared to areas on the map where no tortoises are indicated. The areas devoid of tortoises could represent lack of searching in those areas, poor habitat, or both. The sex ratio of the 233 tortoises for which gender was determined was 0.86 female:1 male. The size/gender distribution of tortoises marked at Yucca Mountain is presented in Figure 2. Tortoises in all 10-mm size categories from 40 mm (hatchlings) through 300 mm (large adult males) were observed.

4.2 ABUNDANCE OF TORTOISES

A large majority of the field work conducted for assessing the effects of site characterization activities on desert tortoises took place in one 13-km^2 treatment area in Midway Valley, and most efforts in the control area were concentrated in a 5-km^2 area (see Figure 1). One-hundred and nineteen tortoises were radiomarked and monitored on a regular basis in the treatment area during 1989-1995. Generally, greater than five person-days per week were spent in this area locating this

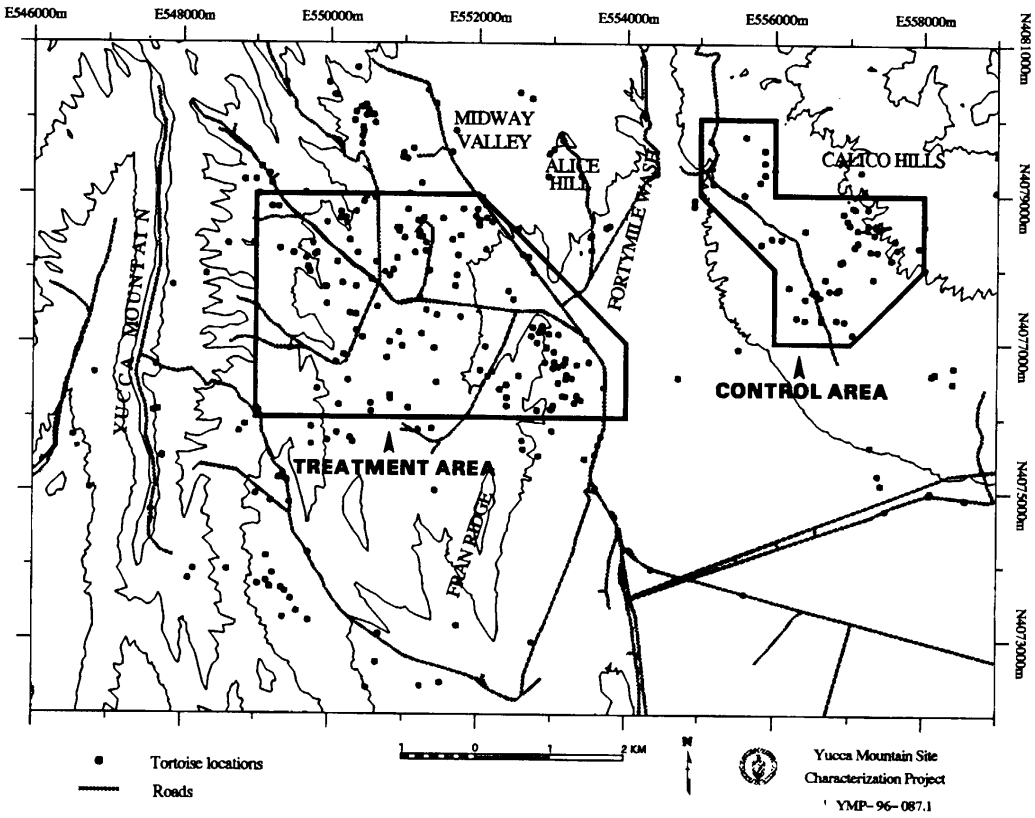

Figure 1. Location of Tortoises Marked at Yucca Mountain during 1989-1995

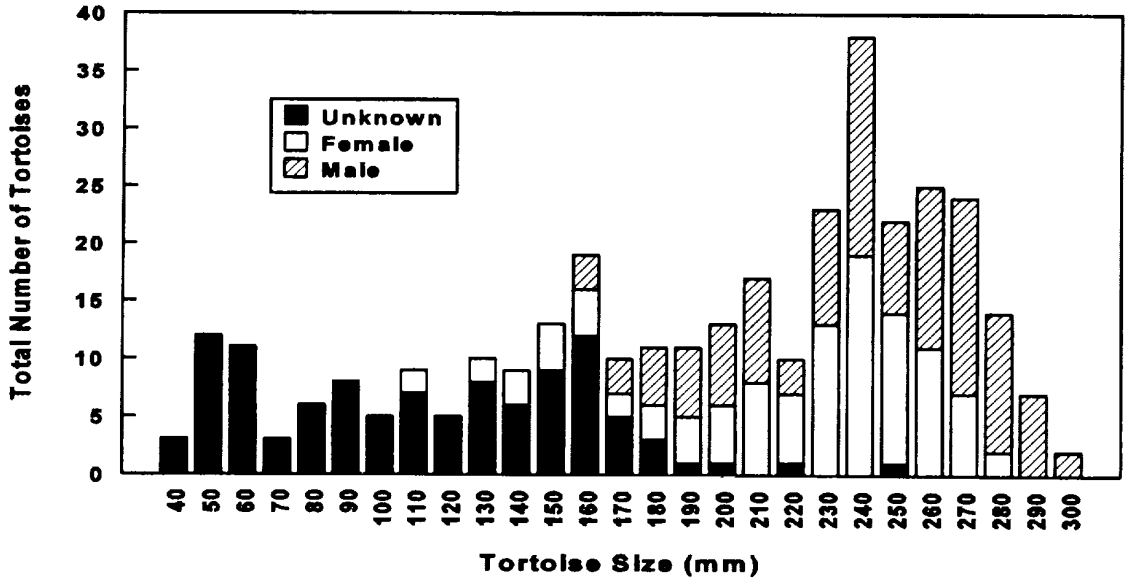

Figure 2. Total Number of Tortoises Marked at Yucca Mountain during 1989-1995, by Size and Gender Classes

sample of tortoises using radiotelemetry. In addition, biologists spent a great deal of time in this area conducting preactivity surveys and other environmental studies not associated directly with desert tortoises. In the control area, from 1991-1995, 50 tortoises were radiomarked and monitored and more than three person-days were spent locating these tortoises each week. Because of the high number of person-days spent in the field in these two areas, it is of interest to compute the minimum number of tortoises encountered in these areas and compare these numbers to previously computed estimates of abundance for the Yucca Mountain area. Because field efforts in these areas were relatively constant after the initial searches, the number of previously unmarked tortoises found each year was tallied to evaluate whether most tortoises in the areas had been marked. Also, because small tortoises are more difficult to detect (e.g., Shields 1980), it would be expected that most large tortoises would be found first and the size of new tortoises encountered would decline over time. Therefore, the average size of new tortoises found each year was calculated as an indication of whether most large tortoises had been found in these areas.

During 1989-1995, 161 tortoises were marked in the 13-km^2 treatment area (12.4 tortoises marked/km^2). The sex ratio of the 113 individuals whose gender could be determined was 1.13 female:1 male. The number of new individuals found decreased from 1991 through 1994 (Figure 3). However, 19 new tortoises were found in the treatment area during 1995, suggesting that a sizable portion of the population in that area was not being located and marked. The size of new tortoises encountered in the treatment area generally declined during 1989-1995 (Figure 4). The increase in mean size of new individuals in 1993 probably was due to searches conducted that year in areas not previously searched. For example, 17 unmarked tortoises, many of them adults, were found during

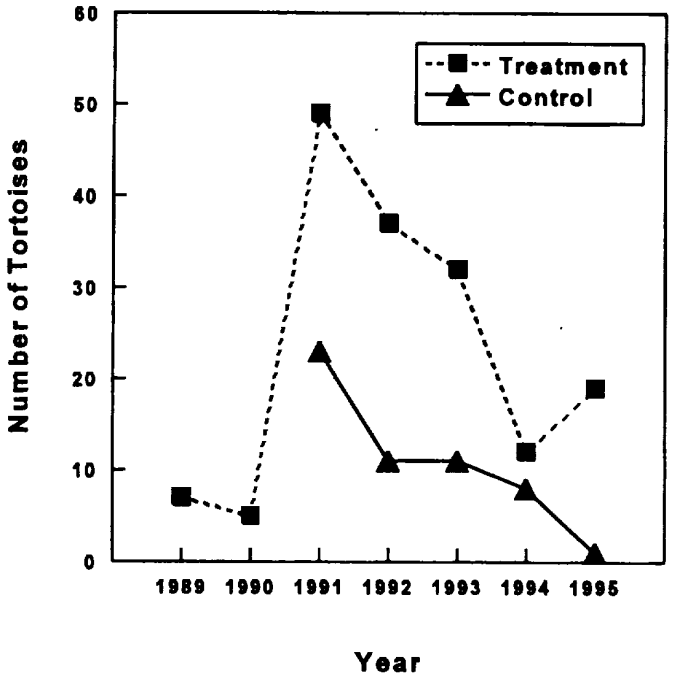

Figure 3. Number of New Tortoises Marked in Treatment (1989-1995) and Control (1991-1995) Areas at Yucca Mountain

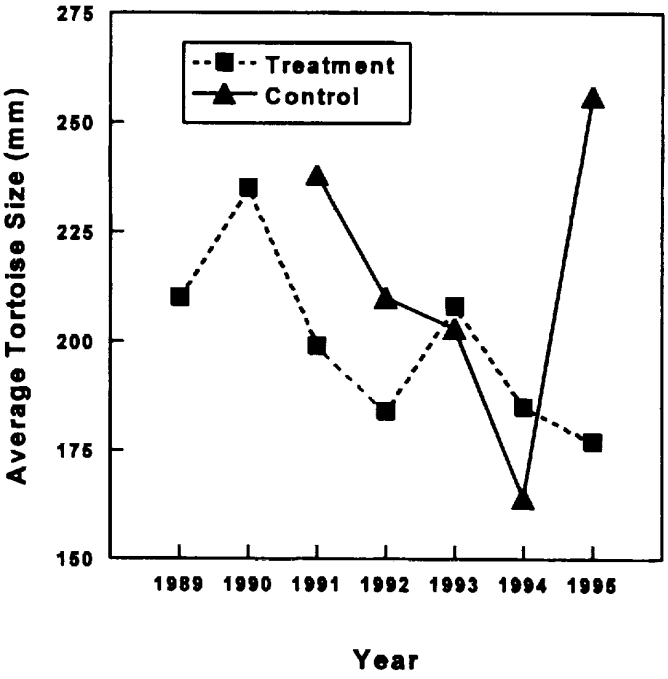

Figure 4. Average Size of New Tortoises Marked in Treatment (1989-1995) and Control (1991-1995) Areas at Yucca Mountain

searches of the Fran Ridge borrow pit. Many new individuals found during 1994 and 1995 were adults (> 180 mm), which suggests that not all tortoises in the treatment area were found, or that new individuals were moving into the area.

In the 5-km^2 control area 54 individuals were marked (10.8 tortoises marked/km^2). The sex ratio of 45 individuals of known gender was 0.66 female:1 male. This is lower than the sex ratio observed on the treatment area, where females were more numerous. The number of new individuals encountered decreased from 1991-1995 (Figure 3). The size of new tortoises found also decreased each year except 1995 (Figure 4). Only one new individual was found in the control area in 1995, an adult female on the northern edge of the site. Based on this information, it is likely that most tortoises, and especially most large tortoises, were counted in this 5-km^2 site.

Because these counts were conducted over a five-year period, the number of tortoises in these areas may be overestimated if new animals were hatched or entered the areas and were marked, or marked animals left the area or died. However, young tortoises hatched during the period make up <15% of the total number counted. In addition, survival rates of large tortoises were very high, and information on movements of tortoises in these areas suggests that approximately equal numbers would have left or entered the areas during this time (CRWMS 1996b). Observations of unmarked tortoises were not included in these estimates of minimum number of tortoises in each area because there was no way of assessing how often each unmarked tortoise was observed. Hatchling tortoises originally marked when they emerged from a nest as part of a survival study also were not included in these estimates. Those hatchlings would most likely not have been found had female tortoises not been monitored closely in order to locate nests. Therefore, although these counts should not be considered estimates of density, they should approximate the minimum number of animals in the areas during 1991-1995.

5. CONCLUSIONS

Based on approximately 575 km of transects walked during 1981-1989 and intensive efforts to find and mark tortoises during 1989-1995, it is concluded that desert tortoises are widespread throughout Yucca Mountain. During these studies, tortoises were found in all three of the common vegetation associations at Yucca Mountain and in a wide range of elevations. They appear to be least common on steep slopes. In addition, the northern boundary of the range of tortoises was found to be less than 10 km north of that part of Yucca Mountain being investigated by DOE.

In the Environmental Assessment for the Yucca Mountain Site Characterization Project produced by DOE in 1986 (DOE 1986), it was stated that the density of desert tortoises at Yucca Mountain "were estimated to be low (less than 20 per square mile)." This estimate (which translates to less than 8 tortoises/km^2) was based on data from 129 sign-survey transects covering 315 km (O'Farrell and Collins 1983), yet only one tortoise was actually observed. Observation data recorded in the Yucca Mountain area during field work conducted from 1989-1995 suggest that desert tortoise densities may be higher than that estimate, yet within the range of 4 to 20 tortoises/km^2 presented by Karl (1981). Although not a true density estimate, 161 tortoises observed in the 13-km^2 treatment area suggests that the minimum number was higher than 12 tortoises/km^2. Likewise, 54 tortoises observed in the 5-km^2 control area indicates that at least 10 tortoises/km^2 were present in that area.

The relative abundance of desert tortoises at Yucca Mountain is low compared to much of the rest of the range of this species. The relative abundance is similar to that found elsewhere in Nye and Lincoln counties, Nevada (Karl 1989), but is much lower than what has been reported for the southern portions of Clark County (Schneider et al. 1985) and, especially, parts of California where densities of greater than 75 tortoises/km^2 have been reported (U.S. Fish and Wildlife Service 1994).

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