MANAGEMENT AND RESEARCH OF DESERT TORTOISES

FOR THE YUCCA MOUNTAIN PROJECT

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ABSTRACT

A program has been developed for the Yucca Mountain Project (YMP) to manage and study the desert tortoise (*Gopherus agassizi*), a threatened species that occurs at low densities at Yucca Mountain. The goals of this program are to better understand the biology and status of the desert tortoise population at Yucca Mountain, assess impacts on tortoises of site characterization (SC) activities, and minimize those impacts. The first steps we took to develop this program were to compile the available information on tortoise biology at Yucca Mountain, ascertain what information was lacking, and identify the potential impacts on tortoises of SC. We then developed a technical design for identifying and mitigating direct and cumulative impacts and providing information on tortoise biology. Interrelated studies were developed to achieve these objectives. The primary sampling unit for the impact monitoring studies is radiomarked tortoises. Three populations of tortoises will be sampled: individuals isolated from disturbances (control), individuals near major SC activities (direct effects treatment and worst-case cumulative effects treatment), and individuals from throughout Yucca Mountain (cumulative effects treatment). Impacts will be studied by measuring and comparing survival, reproduction, movements, habitat use, health, and diet of these tortoises. A habitat quality model also will be developed and the efficacy of mitigation techniques, such as relocating tortoises, will be evaluated.

INTRODUCTION

The desert tortoise is the only species listed as threatened or endangered under the Endangered Species Act of 1973 (Public Law 93-205, as amended) that is common in areas where SC activities for the YMP will occur.[1] Because of the requirements of this Act and the emphasis YMP has placed on protecting desert tortoises, a program has been developed to study and conserve this species at Yucca Mountain. The goals of this program are to develop a better understanding of the biology and status of the desert tortoise population at Yucca Mountain, to assess impacts of SC on that population, and to minimize those impacts. We present here the development of this program and a review of the studies designed to achieve the program objectives.

Three types of information are required to achieve the goals of this program. The first is an understanding of the ecology of tortoises at Yucca Mountain, particularly those aspects of their ecology that may be affected by SC. Second, information is needed on the impacts of SC activities on the population. Third, the efficacy of management techniques for minimizing impacts must be determined. These information needs are interrelated. Causes of change in the population can be identified only if the ecology of that population is understood. Successful mitigation techniques cannot be developed without an understanding of the causes of those changes and their impacts on the species' ecology. Selection of ecological parameters to study is influenced by the types of impacts that may occur and the mitigation techniques needed.

Our first steps in developing this program were to evaluate information available on the ecology of tortoises, identify unavailable information needed to manage the Yucca Mountain population, and characterize the potential impacts of SC. The next three sections of this paper describes those steps. The program objectives, technical design, and studies developed to gain and use that information are then described.

SC ACTIVITIES

The SC Plan for YMP[2] describes the activities that will occur on or near Yucca Mountain. About 180 ha will be disturbed for this project, including 18 ha disturbed for construction of the Exploratory Shaft Facility (ESF). Other disturbances will be scattered throughout Yucca Mountain and surrounding areas.

Site Characterization studies and support facilities can be divided into two categories based on the distribution and amount of land each activity will disturb. The first type is the numerous activities scattered throughout Yucca Mountain that will disturb ≤3 ha. This includes most trenches; drilling operations; geophysical surveys; water infiltration and water table studies; and the roads, powerlines, wells, and other support facilities for these studies. The second type is the few activities that will require disturbing >3 ha. Most of these disturbances, such as muck piles, shafts, and support buildings, are for the ESF and are concentrated in one area.

Site Characterization activities may impact the tortoise population directly and immediately when tortoises are buried during land clearing, run over by vehicles, or their habitat is destroyed. The population also may experience subtle negative effects from the cumulative impacts of the many, scattered activities affecting each tortoise. Fragmentation of home

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ranges; loss of foraging sites, burrows, or other important habitat features; and increased exposure to human activities may cause tortoises to move to less suitable habitat and may cause a decrease in physiological condition and reproduction. We concluded that direct negative effects and cumulative effects both must be addressed to achieve the goals of the YMP tortoise management program.

Impacts of some human activities (e.g., livestock grazing, recreational off-road driving) on tortoises have been studied, although effects of these activities have not been clearly identified.[3] No studies have analyzed the impacts of activities similar to SC; therefore, we concluded that studies must be conducted to monitor how SC affects tortoises so mitigation procedures can be developed.

INFORMATION AVAILABLE ON TORTOISE BIOLOGY

Numerous descriptive and quantitative studies of desert tortoises have been done,[3,4] including those to identify and monitor changes in relative abundance of populations,[3,5] determine the effects of off-road driving and cattle grazing,[3] and understand adaptations for living in arid regions.[6,7] Most of this work has been conducted in the Mojave Desert of California where tortoises are abundant.

There is little site-specific information available on the ecology of desert tortoises along the northern edge of their range near Yucca Mountain. Tortoises at Yucca Mountain may differ morphologically and genetically from those in parts of the Mojave Desert where most studies have been conducted.[8,9,10] Because northern tortoises must cope with weather and vegetal conditions different from other parts of the species' range, tortoises at Yucca Mountain also may have behavioral adaptations different from other tortoises. Site-specific information on the ecology of tortoises therefore is important for understanding how SC activities will impact tortoises and for developing techniques to minimize those impacts.

Some studies of tortoises along or near the northern edge of their range may be applicable to the population at Yucca Mountain. Studies of the growth,[11,12,13] diet,[7] and physiology[7] of tortoises were done in Rock Valley, 20 km east of Yucca Mountain. A long-term study of the ecology of tortoises was conducted along the northern edge of the species' range in Utah.[14] Transect studies have been conducted in Nevada to determine relative abundance of tortoises.[15,16,17,18]

A transect study also was conducted at Yucca Mountain to determine the relative abundance of tortoises there. Over 400 km of transects were walked during 1981-1984. Nine tortoises were found and an average of 0.7 sign/km was counted. These results are similar to counts in areas categorized as having a low abundance of tortoises.[15,16] Sign was found throughout the range of elevations searched (1,000-1,700 m) and was more common on slopes and above 1,300 m than previously reported for Nevada.[19] Searches for tortoises in 1989 and 1990 at Yucca Mountain confirmed that the abundance of tortoises is low and that they are found throughout the area.

INFORMATION NEEDED ON TORTOISE BIOLOGY

Because of the paucity of site-specific information, we determined that studies must be conducted to develop a better understanding of desert tortoise biology at Yucca Mountain. Information needs for this program were dictated by the type of impacts that may occur, the parameters chosen to monitor those impacts, and the mitigation techniques that may be needed. The following six topics were identified as being the most important needs at the outset of this program.

A. Current Status

Current information on the abundance, structure, and health of the tortoise population at Yucca Mountain is needed as a baseline for detecting impacts and to ensure that a viable population is maintained. The site-specific information available is inadequate for these needs. Information will be collected during the initial phase of this program on the relative abundance of tortoises throughout the Yucca Mountain area, sex and size/age class ratios, and the incidence of disease.

B. Habitat Quality and Use

To minimize impacts of SC activities on tortoises, it will be necessary to classify the quality of tortoise habitat in areas proposed for disturbances so plans can be developed to preserve the best habitat. It is also important to identify habitat features required by tortoises that should be protected.

Models that predict tortoise habitat quality using easily measured features have been attempted.[5,20,21] These models were developed to predict habitat quality for large areas of the Mojave Desert in California. Because most SC activities will be ≤2 ha, a habitat model for this program must be site specific and have a scale useful for differentiating among small areas. Therefore, a model will be developed to predict quality of tortoise habitat at Yucca Mountain that is based on site-specific information from relatively small sample plots.

A number of habitat features have been identified as being important for tortoises: burrows and winter dens,[14] drinking depressions,[22] washes,[23,24] and large shrubs.[24] Because some of these features may be destroyed at Yucca Mountain, it will be important to know what habitat features are essential for tortoises and the consequences of destroying some of those features. This can be assessed by studying the behavior of tortoises to determine if they seek or frequently use habitat features that are rare.

C. Behavior

Tortoises may respond to a disturbance by moving away from it or restricting their movements to undisturbed portions of their home range. They may also be forced to spend more time above ground seeking needed resources or an unusual amount of time underground avoiding the disturbance. These functional and behavioral responses can be used to assess impacts. Information on movements, activity patterns, and interactions with other tortoises also is important for developing techniques to search for tortoises and to monitor the efficacy of relocating tortoises. Information on movements and behavior useful for evaluating relocation techniques has been reviewed.[25] Although this information is helpful, site-specific information is needed to evaluate whether behavioral patterns are similar at Yucca Mountain.

D. Diet

SC activities may affect the diet of tortoises by directly destroying important foraging sites or causing a change in the composition of vegetation. For example, accidental fires may cause an increase in annual grasses and a decrease in plant species more beneficial to tortoises. Composition of tortoise diets have been studied throughout most of their range and diets vary substantially among areas because of differences in the availability of forage species. Many of the plants commonly eaten in other parts of the range of tortoises are rare or not found at Yucca Mountain. It is therefore necessary to know what plants are important for tortoises at Yucca Mountain to adequately assess effects of changes in vegetative composition. This information also is needed to identify plant species to be used for reclaiming disturbed sites.

E. Disease

An outbreak of a virulent respiratory disease was one of the primary reasons the desert tortoise was classified as threatened.[26] Very little is known about the cause or transmission of URDS or its impacts on populations. It has been suggested that tortoises stressed by drought, loss of habitat, or human presence may be susceptible to URDS.[27] The incidence of this disease therefore must be monitored at Yucca Mountain so appropriate technology, if available, can be used to prevent the spread of the disease if it is found to be common.

F. Predators

An increase in raven populations was another reason why desert tortoises were listed as threatened.[3,26] Raven populations are believed to have increased in the Mojave Desert because of an increase in feeding, roosting, and nesting sites provided by human development.[3,28] This increase in raven abundance may have caused a decrease in survival of juvenile tortoises and decreases in some tortoise populations. Facilities to be developed at Yucca Mountain, such as powerlines, a sewage lagoon, and a landfill, are thought to be beneficial to ravens. Current status of the raven population at Yucca Mountain and changes in that population as facilities for SC activities are constructed must be assessed. If the abundance of ravens or other predators increase at Yucca Mountain, a study of predation rates on tortoises may be needed.

PROGRAM OBJECTIVES

After characterizing the potential impacts of SC, reviewing information available on the biology of tortoises at Yucca Mountain, and identifying information needed on tortoise biology, we identified the following six objectives to achieve the goals of this program.

1. Determine the current status (e.g., abundance, distribution, population structure, occurrence of disease) of the desert tortoise population at Yucca Mountain.

2. Monitor and assess the impacts of SC activities on tortoises.

3. Develop and test the efficacy of mitigation techniques.

4. Mitigate impacts of SC activities to the maximum extent possible.

5. Obtain site-specific information on the biology of the species needed to achieve these other objectives.

6. Ensure compliance with relevant federal and state regulations.

TECHNICAL DESIGN

The studies developed to achieve these objectives were designed to maximize efficiency of data collection and ensure that all parameters studied were temporally and spatially related so causal relationships could be evaluated. This will be achieved by using the same sampling unit for most studies and collecting as much information as possible from each sample.

The technical design evolved from the need to monitor and mitigate the direct, immediate impacts of each SC activity and the long-term, cumulative impacts of SC. It also was influenced by the need to determine current status and obtain information on tortoise biology. To monitor all impacts, each SC activity must be evaluated separately and in context with all other activities. There will be many types of SC activities, most of which will be small, scattered throughout Yucca Mountain, and probably have little direct or obvious impact. Cumulative impacts can be assessed more efficiently with a study design that monitors the combined impacts of all activities rather than sampling each type of activity separately. Because effects may be subtle, the sampling should be done over a long period at many levels of measurement, including the population, individual tortoises, and their habitat. To identify causal relationships, a sample of unaffected measures from control sites also is needed.

Two primary sampling units were selected initially for studies of impacts, population assessment locations and radiomarked tortoises. Population assessment locations were to be randomly and systematically located plots where the abundance of tortoises would be monitored and availability of habitat features measured.

As explained later in this paper, it was determined that measuring abundance annually is not an efficient method for monitoring impacts of SC because the density of tortoises at Yucca Mountain is too low. Radiomarked tortoises therefore will be used as the primary sampling unit for impact studies.

Radiomarked tortoises will be selected from three sampling populations. First, tortoises will be systematically selected from areas to be disturbed so direct impacts can be monitored and mitigated and the most severe cumulative impacts can be studied. Second, tortoises will be randomly selected from throughout the potentially affected area in Yucca Mountain to identify, monitor, and mitigate cumulative impacts affecting the entire population. Third, tortoises will be randomly selected from an unaffected, control area and will be used as a control population for impact studies and for studies of the ecology of tortoises in the region. Survival, behavior, diet, health, and other parameters will be measured and compared among these three groups to identify impacts. If differences are detected, additional studies will be conducted, if necessary, to find the causes of those changes.

Separate plans will be developed to mitigate the potential impacts of each SC activity. These plans will consider the direct impacts of the activity being evaluated and the impacts of surrounding activities. If cumulative impacts are detected, area-wide mitigation plans will be developed and studies will be conducted to determine if those plans are effective.

TORTOISE STUDIES

We developed the following studies to meet the objectives of this program. These studies are interrelated and most are designed to achieve more than one objective. The first two deal primarily with mitigating direct impacts. The next four are studies of cumulative impacts and the ecology of tortoises at Yucca Mountain. Two others are studies of habitat quality at Yucca Mountain and an evaluation of an important mitigation technique. Other studies of the environment at Yucca Mountain[29] will be used to evaluate current status and changes in predator populations and monitor levels of human activity and associated disturbances. Additional studies will be developed as factors affecting tortoises and mitigation needs are identified.

A. Preactivity Surveys

Preactivity surveys will be used to evaluate direct impacts and develop mitigation plans for each SC activity. Areas to be disturbed and a buffer around them will be searched shortly before any SC activity occurs that may disturb tortoises or other biological resources. Burrows and other important resources will be flagged and tortoises found will be radiomarked and monitored during the disturbance. Mitigation recommendations will be developed to protect tortoises and other important biological resources. These recommendations may include avoiding flagged resources, altering or moving the SC activity, or closely monitoring potentially endangered tortoises during the activity. Tortoises will be relocated to undisturbed areas only if all other mitigation options are not feasible.

B. Impact Monitoring and Mitigation

The preactivity survey process works well for identifying and preventing impacts of isolated, short-term, or small-scale disturbances. Preactivity surveys do not work as well for long-term and large-scale disturbances, or for many smaller disturbances concentrated in an area, because there usually is too little time to collect needed information on the movements and habitat use of tortoises that may be impacted. An Impact Monitoring and Mitigation Study (IMMS) therefore has been developed to assess and mitigate impacts of large-scale, long-term, or concentrated activities such as the ESF that are planned for areas where tortoises are believed to be abundant.

Areas to be disturbed by such activities and a large buffer around them will be searched six to twelve months before the activities begin. All tortoises found will be radiomarked and their movements, habitat use, and behavior will be measured. A plan then will be developed to protect the tortoises and their habitat and mitigate activity effects. All tortoises that may be harmed will be monitored closely during construction activities. Behavior, survival, and other parameters measured before, during, and after the activity will be compared to determine success of mitigation efforts. These parameters also will be compared to measures from the control population.

C. Population Monitoring

The initial objective of the population monitoring study was to detect area-wide, cumulative impacts of SC on the relative abundance and structure (i.e., sex and age ratios) of the tortoise population at Yucca Mountain. A split-plot design of treatment and control population assessment locations within four vegetation associations was to be used to compare relative abundance of tortoises. We selected counts of tortoises as an index of abundance because of the weak correlation and poor understanding of the relationship between abundance of tortoise sign and density of tortoises.

To determine if an annual count of tortoises in sample plots was a feasible method for monitoring relative abundance, we conducted a pilot study in fall 1990. Two 24-ha (400 X 600 m) population assessment locations were randomly located within each of the four vegetation associations. Plots were searched for tortoises by crews of 5-10 people walking contiguous belt transects. Four tortoises and 74 tortoise burrows were found. It took an average of six person-days to set up and 12 person-days to search each plot. Based on this data, we calculated that >100 tortoises must be counted annually to detect a 40% change in the population. This would require searching >3,200 ha and would take >1,600 person-days annually. Because of these high costs, we concluded that measuring relative abundance was not an efficient method for monitoring impacts on the population.

The alternative method we selected for evaluating impacts of SC on the tortoise population is to monitor and compare survival and reproduction of the three sampling populations of radiomarked tortoises. Survival and reproduction of tortoises radiomarked for the IMMS will be used as estimates of the greatest impacts on tortoises, i.e., as the worst-case estimate of impacts. The assumption that tortoises in the IMMS study sites experience the greatest impacts is valid because these sites are located where the largest and highest concentrations of SC activities will occur. A second sample of tortoises will be radiomarked in randomly selected areas located throughout Yucca Mountain to be searched for the Habitat Evaluation Study. Survival and reproduction of these tortoises will be used as measures of cumulative impacts affecting the entire population. Survival and reproduction of tortoises in an undisturbed area will be used as control measures.

These measures of population demographics also will be used to better understand the current status and ecology of the tortoise population at Yucca Mountain. Baseline information on distribution, abundance, and population structure already has been obtained from systematic searches of >500 ha and will be supplemented by other searches to be conducted before impacts of SC activities occur.

D. Movements and Habitat Use

The objectives of this study are to measure the normal movements and behavior (e.g., use of cover sites, activity patterns) of desert tortoises at Yucca Mountain, measure the behavioral responses of tortoises to disturbances, monitor impacts of SC on tortoises by measuring movements and behavior, and identify habitat features that may be important to tortoises. Measurements of movements and behavior of radiomarked tortoises taken before SC begins and of control tortoises taken during SC will be used to determine normal behavior. This information is needed as a baseline for measuring the response of tortoises to disturbances and for identifying impacts.

Behavior of radiomarked tortoises in IMMS sites during disturbances will be monitored to determine how tortoises react to human disturbances and loss of habitat. This information will be used to refine future mitigation recommendations and develop criteria for determining when tortoises should be relocated.

Use of habitat features such as burrows, wash banks, and rock outcrops will be measured and compared to the availability of those features to determine if there are any uncommon habitat resources at Yucca Mountain important to tortoises that should be preserved.

E. Food Habits

Other than fragmentation of home ranges and destruction of cover sites, changes in the availability and quality of forage may be the greatest indirect impact of site characterization on desert tortoises. This potential impact will be measured by comparing content and quality of foods eaten and their availability among the treatment and control study groups. Fecal samples will be collected seasonally from radiomarked tortoises and forage-species content will be analyzed. Availability and quality of forage will be measured as part of other studies of the environment at Yucca Mountain, if possible. If such measures are not applicable, forage availability and quality will be measured within home ranges of radiomarked tortoises.

F. Health Monitoring

Because adult desert tortoises are long-lived and have a low reproductive rate, subtle impacts of human activities may not cause immediate changes in population dynamics or behavior. These impacts may be more apparent by measuring physiological condition of tortoises. Techniques to evaluate the health of tortoises are currently being developed and tested by a number of researchers. When acceptable techniques are available, samples may be collected from radiomarked tortoises and compared among treatment and control groups. Presence of disease also will be monitored as part of this study.

G. Habitat Evaluation

The objective of this study is to develop a model of desert tortoise habitat quality at Yucca Mountain. To plan the location of activities so they have a minimum impact on desert tortoises, YMP must have information on the spatial distribution of desert tortoises at Yucca Mountain. This information can be used to identify areas that should be preserved because tortoises are abundant and areas where activities should be located because tortoises are absent or uncommon. This can be done best by developing a predictive model and map of habitat quality useful for land-use planning.

Measures of the relative abundance of tortoises will be taken on small (ca. 4 ha) plots randomly located throughout Yucca Mountain. Measures of habitat features that may be useful for predicting tortoise abundance will be measured from aerial photographs or other remote sensing techniques. Multivariate analyses will then be used to develop a model that best predicts relative abundance of tortoises. This model will be field tested and then extrapolated to all of Yucca Mountain so a map of relative abundance can be developed.

H. Relocation Efficacy

The last alternative for mitigating impacts of a SC activity is to relocate endangered tortoises away from areas to be disturbed. Relocating a tortoise may decrease its probability of survival and also may affect tortoises in the relocation area. Therefore, a study will be conducted to determine if tortoises can be relocated successfully to new areas, determine the effects of these relocations on tortoises residing in the relocation area, and identify ways to improve this technique.

Areas chosen for this relocation efficacy study will be searched and all tortoises found will be radiomarked and their movements and behavior monitored for at least six months prior to the relocation. Immediately after a relocation, the introduced tortoise will be intensively monitored and interactions with other tortoises will be recorded. Movements, survival, behavior, and health (if techniques are available) of resident tortoises before and after the relocation will be compared to identify impacts of introducing a new tortoise. Relocated tortoises will be monitored for a long period to determine if their survival is lower than other tortoises. Physical and biotic features of the areas a relocated tortoise settles into will be compared to features in their relocation site to identify habitat features that should be considered when selecting relocation sites.

I. Other Studies

Abundance of ravens and other potential predators of desert tortoises is being measured quarterly as part of other studies of the environment at Yucca Mountain. Information collected prior to initiation of SC activities will be used as a baseline to determine if predator populations are increasing. If increases are detected, studies will be initiated to evaluate the effects on the tortoise population.

Measures of human activity and habitat disturbances also are being taken as part of other environmental studies. Many of these measures are taken on the same areas searched for the sample of radiomarked tortoises representative of the Yucca Mountain region. Changes detected in the studies of cumulative impacts therefore can be related to levels of human activity to develop a better understanding of the causes of those changes.

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