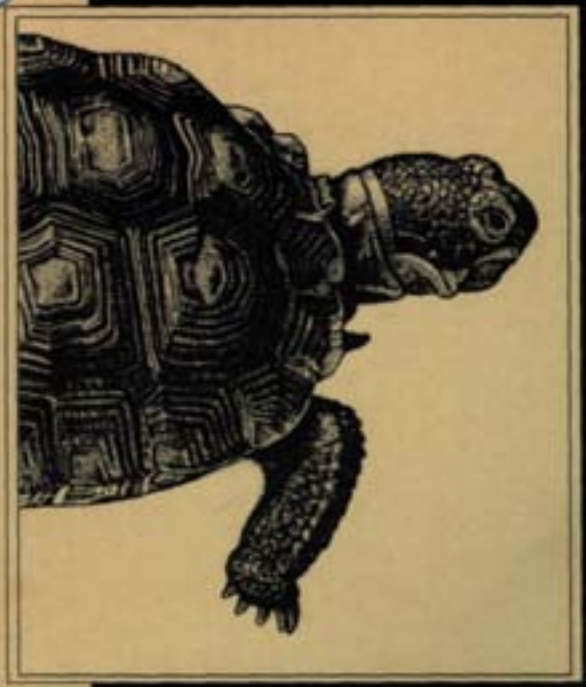
Desert Tortoise

(Mojave Population)



Recovery Plan

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Desert Tortoise

(Mojave Population)

Recovery Plan

June 1994

Prepared for Regions 1, 2, and 6 of the U.S. Fish and Wildlife Service
Region 1 - Lead Region, Portland, Oregon.

DESERT TORTOISE (MOJAVE POPULATION)

RECOVERY PLAN

Prepared by
the Desert Tortoise Recovery Team

For

Regions 1, 2, and 6
U.S. Fish and Wildlife Service
Region 1 - Lead Region, Portland, Oregon

Approved _____
Regional Director, U.S. Fish and Wildlife Service

Concurred _____
Chairman, Desert Tortoise Management Oversight Group

Date Approved June 28, 1994

DISCLAIMER PAGE

Recovery plans delineate reasonable actions which are believed to be required to recover and/or protect listed species. Plans are published by the Fish and Wildlife Service, sometimes prepared with the assistance of recovery teams, contractors, State agencies, and others. Objectives will be attained and any necessary funds made available subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery plans do not necessarily represent the views, official positions, or approval of any individuals or agencies involved in the plan formulation, other than the Fish and Wildlife Service, and only after they have been signed by the Regional Director or Director as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in special status, and the completion of recovery tasks.

LITERATURE CITATION SHOULD READ AS FOLLOWS:

Fish and Wildlife Service. 1994. Desert tortoise (Mojave population) Recovery Plan. U.S. Fish and Wildlife Service, Portland, Oregon. 73 pages plus appendices.

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EXECUTIVE SUMMARY

Current Status:

The range of the desert tortoise, *Gopherus agassizii*, includes the Mojave and Sonoran deserts in southern California, southern Nevada, Arizona, the southwestern tip of Utah, and Sonora and northern Sinaloa, Mexico. The Mojave population of the desert tortoise (an administrative designation for animals living north and west of the Colorado River) was listed as threatened on April 2, 1990. Critical habitat for the Mojave population was designated on February 8, 1994.

Habitat Requirements and Limiting Factors:

The Mojave population of the desert tortoise occurs primarily on flats and bajadas characterized by scattered shrubs and abundant inter-space for growth of herbaceous plants, with soils ranging from sand to sandy-gravel. Desert tortoises are also found on rocky terrain and slopes, and there is significant geographic variation in the way desert tortoises use available resources.

The Mojave population was listed because desert tortoise numbers are declining precipitously in many areas. These declines are mainly attributed to direct and indirect human-caused mortality coupled with the inadequacy of existing regulatory mechanisms to protect desert tortoises and their habitat. Impacts such as the destruction, degradation, and fragmentation of desert tortoise habitat result from urbanization, agricultural development, livestock grazing, mining, and roads. Human "predation" is also a major factor in the decline of desert tortoise populations. Predation is used here in its broadest sense, meaning the taking of desert tortoises out of their populations either by death (accidental or intentional) or removal from native habitat. An upper respiratory tract disease (URTD) is an additional major cause of desert tortoise mortality and population decline, particularly in the western Mojave Desert.

Recovery Objective:

Delisting through recovery.

Delisting Criteria:

Genetics, morphology, behavior, ecology, and habitat use define six distinct population segments or recovery units[1] within the range of the Mojave population: northern Colorado, eastern Colorado, upper Virgin River, eastern Mojave, northeastern Mojave, and western Mojave. The

[1] For the purpose of this document, the following definitions should be used:

Recovery unit - a geographic area harboring an evolutionarily distinct population of the desert tortoise (Mojave population);
Desert Wildlife Management Area (DWMA) - administrative area within the recovery unit which is managed such that reserve-level protection is afforded desert tortoise populations while maintaining and protecting other sensitive species and ecosystem functions (e.g., watersheds).

population within a recovery unit may be considered for delisting when the following criteria are met:

(1) As determined by a scientifically credible monitoring plan, the population within a recovery unit must exhibit a statistically significant upward trend or remain stationary for at least 25 years (one desert tortoise generation);

(2) enough habitat must be protected within a recovery unit, or the habitat and desert tortoise populations must be managed intensively enough to ensure long-term viability;

(3) provisions must be made for population management within each recovery unit so that discrete population growth rates (lambdas) are maintained at or above 1.0.

(4) regulatory mechanisms or land management commitments must be implemented that provide for long-term protection of desert tortoises and their habitat; and

(5) the population in the recovery unit is unlikely to need protection under the Endangered Species Act in the foreseeable future.

Actions Needed:

This Recovery Plan describes a strategy for recovery and delisting. Key to this strategy is

- the establishment of at least one Desert Wildlife Management Area

- implementation of reserve level protection within each DWMA

so as to maintain at least one viable population at a minimum density of 10 adult tortoises per square mile within each of the six recovery units. Based on genetic and demographic considerations outlined in the Plan it is recommended that each DWMA within a recovery unit be at least 1,000 square miles in extent so as to contain a viable population of desert tortoises that is relatively resistant to extinction processes. To insure population persistence the Plan proposes multiple DWMAs connected by protected functional habitat within recovery units wherever enough extant desert tortoise habitat exists. Multiple, smaller, and more intensively managed DWMAs with a combined area of 1,000 square miles may be necessary in recovery units where individual DWMAs of 1,000 square miles are not possible to contain a viable population. In all, 14 DWMAs are proposed.

The Recovery Plan recommends general areas where DWMAs should be established within recovery units. DWMA selection and boundary delineation, however, should be accomplished by land management agencies in close coordination with the Fish and Wildlife Service and State wildlife agencies, after soliciting input from other interested parties. The design of DWMAs should follow accepted concepts of reserve design. Action Need 1 is recommended to establish the DWMAs:

1. <u>Develop and implement recovery unit management plans.</u> This task includes (a) selection and delineation of DWMAs, (b) securing of habitat in DWMAs, (c) development of management within DWMAs necessary to reduce or eliminate factors which have caused declines in desert tortoise populations, (d) implementation of DWMA management, and (e) monitoring of the recovery effort.

Additional actions needed to accomplish recovery are:

2. Environmental education to inform the public about the status of the desert tortoise and regulations within DWMAs.

3. Research activities necessary to monitor and guide the recovery effort.

Costs:

(in $1,000s) Costs of specific management actions in DWMAs will be determined after recovery unit management plans are developed and are shown as "to be determined" (TBD).

Year	Need 1	Need 2	Need 3	Total
1994	860	950	1760	3570
1995	2055	0	1817	3872
1996	0	0	1750	1750
1997	0	0	1225	1225
1998	1135	0	1205	2340
1999	0	0	325	325
2000	0	0	305	305
2001	1135	0	285	1420
2002	0	0	285	285
2003	0	0	300	300
2004	1135	0	90	1225
2005	0	0	50	50
2006	0	0	70	70
Recovery Costs:	6,320	950	9,432	16,702

Date of Recovery: Delisting could be initiated in year 2019 if recovery criteria have been met.

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I. Introduction

Desert Tortoise
(Mojave Population)

Recovery
Plan

proposed Desert Wildlife Management Areas; Appendix G proposes a means to analyze the environmental determinants of population size; Appendix H contains designated desert tortoise critical habitat maps which were based upon DWMA boundaries proposed in the Draft Plan; and Appendix I provides a summary of the comments received on the Draft Plan.

A. Status of the Mojave Population of the Desert Tortoise.

1. Listing of the Mojave Population.

In the early 1970's, biologists began to recognize that desert tortoise populations were declining through much of their range in the United States. In 1980, the Fish and Wildlife Service listed the desert tortoise on the Beaver Dam Slope in Utah as a federally threatened species and designated critical habitat. In 1984, the Defenders of Wildlife, Natural Resources Defense Council, and Environmental Defense Fund petitioned the Fish and Wildlife Service to list the desert tortoise as endangered (Fish and Wildlife Service 1985). In 1985, the Fish and Wildlife Service made a determination that the listing was warranted, but action was precluded because of other pending higher priorities. New information on mortality rates resulted in the emergency listing of desert tortoises north and west of the Colorado River (excluding the Beaver Dam Slope population) as endangered, on August 4, 1989 (Fish and Wildlife Service 1989a). The entire Mojave population* was subsequently listed as threatened on April 2, 1990 (Fish and Wildlife Service 1990a). The primary reasons for listing this population included deterioration and loss of habitat, collection for pets or other purposes, elevated levels of predation, loss of desert tortoises from disease, and the inadequacy of existing regulatory mechanisms to protect desert tortoises and their habitat (Fish and Wildlife Service 1990a).

2. Critical habitat designation.

In 1993 several environmental groups sued the Department of the Interior to compel designation of critical habitat for the Mojave population of the desert tortoise, alleging that the Secretary had failed to meet the designation deadline under section 4(b)(6)(C)(ii) of the Endangered Species Act. Final critical habitat designation for the Mojave population was published in the Federal Register in February 1994 (59 FR 5820). Designated critical habitat for the desert tortoise encompasses portions of the Mojave and Colorado deserts that contain the primary constituent elements and focuses on areas that are essential to the species' recovery. The critical habitat

* "Mojave population" as used here is a regulatory designation for those desert tortoises occurring north and west of the Colorado River. Elsewhere in this document "population" adheres to the biological definition: a group of individuals in a given area at a given time (Ehrlich et al. 1974).

unit boundaries were based on proposed DWMAs in the Draft Recovery Plan for the Desert Tortoise (Mojave Population) (Fish and Wildlife Service 1993) (Appendix H). Further discussion of critical habitat and its relevance to recovery of the species can be found in Section II.E.

3. *Current population trends.*

It is estimated that many desert tortoise populations have declined at rates ranging between 3 and 59 % per year (Berry 1990, as amended). These declines have been attributed to direct take by humans (e.g., collection for pets or food, shooting, killing and injuring with motor vehicles); habitat loss, degradation, and fragmentation (e.g., due to roads, agriculture, residential development, military training); diseases; and recent drought (Sievers et al. 1988, Luckenbach 1982, Coombs 1977a and b, Appendix D). Populations in areas with a high incidence of known human-caused mortality exhibit the greatest declines (Figure 1).

B. *Reasons for Decline.*

The following account draws upon a large body of literature detailing the major causes of desert tortoise population decline (Table 1). This information is reviewed in Appendix D and in Jacobson (1994), except where otherwise cited.

The most serious problem facing the remaining desert tortoise populations in the Mojave region (the area occupied by the Mojave population of the desert tortoise) is the cumulative load of human and disease-related mortality accompanied by habitat destruction, degradation, and fragmentation. Virtually every extant desert tortoise population has been affected by one or more of these factors. While the recent drought undoubtedly exacerbated already difficult conditions for desert tortoises, current population declines are not simply the result of drought. Drought is a natural occurrence which desert tortoises have experienced and survived for thousands of years (VanDevender et al. 1987).

As a result of cumulative impacts, desert tortoise populations have been extirpated or almost extirpated from large portions of the western and northern parts of their geographic range in California (e.g., Antelope, Indian Wells, and Searles valleys) (Appendix D). Population declines or extirpations attributable to cumulative impacts have occurred in and near the California communities of Mojave, Boron, Kramer Junction, Barstow, Victorville, Apple Valley, Lucerne Valley, and Twentynine Palms. Similar patterns are evident near Las Vegas, Laughlin, and Mesquite, Nevada; and St. George, Utah. Future extirpations can be expected in the vicinity of all cities, towns, and settlements.

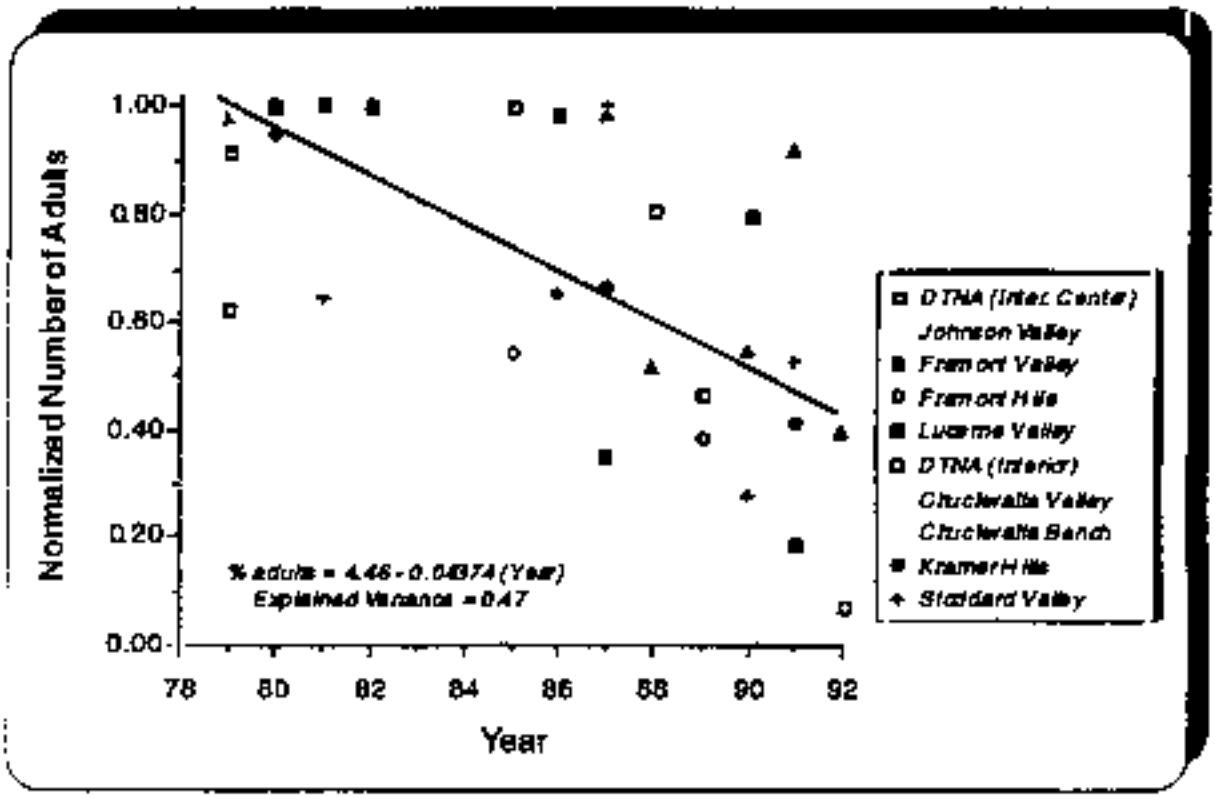


Figure 1. The number of adult desert tortoises found on desert tortoise trend plots located in California (Berry 1990, as amended). The study plots shown occur in areas with a high incidence of known human-caused mortality. All data are normalized to the highest population size recorded within the years populations were monitored. The downward trend in population density is highly significant ($F_{1,14} = 28.4$, $p < 0.0001$).

Table 1. Partial summary of references relating the effects (direct and indirect) of human activities, off highway vehicles (OHVs), and grazing of domestic cattle and sheep on desert tortoise habitat and on the desert tortoise (*Gopherus agassizii*).

HUMAN ACTIVITIES

Effects of Human Population Growth and Urbanization
- Biosystems 1992
- Berry 1984b
- Berry and Burge 1984
- Berry and Nicholson 1984b
- Klemens 1989
- Lamb 1991
- Swingland and Klemens 1989
- Tierra Madre 1991

Effects of Freeways, Highways, Paved and Dirt Roads, and Railroads
- Berry et al. 1986a
- Berry and Turner 1984
- Bourman et al. 1992
- Dames and Moore 1991
- Goodlett and Goodlett 1991, 1992
- Marlow and Hoff 1992
- Mount 1986
- Nicholson 1978a, 1978b
- U.S. Ecology 1989

Effects of Military Operations
- Berry and Nicholson 1984b
- Krzysik 1985
- Krzysik and Woodman 1991
- Prose 1985, 1986
- Prose and Metzger 1985
- Prose et al. 1987

Effects of Energy (transmission and pipelines), and Mineral Development
- Berry 1984b
- Berry and Nicholson 1984b
- Biosystems 1992
- Brum et al. 1983
- Riedy 1989
- Robinette 1973
- Woodman et al. 1983

Human Vandalism
- Berry 1984b, 1986a, 1990, as amended
- Berry and Nicholson 1984b
- Berry et al. 1986a
- Bury and Marlow 1973
- Campbell 1981
- Gotz 1990
- Jaeger 1950
- Jennings 1991

Human Predation for Food
- Dutzler 1991
- Swingland and Klemens 1989
- Schneider and Evenson 1989

Collection and Commercial Trade
- Berry 1990, as amended
- Berry and Burge 1984
- Berry and Nicholson 1984b
- Gotz 1990
- Howland 1989
- Jennings 1991
- St. Amant 1984
- Stewart 1991

USE OF OHVs

Immediate Effects

Loss of Soil
- Wilshire 1977a, 1977b, 1979
- Wilshire et al. 1977

Loss of Annual Plants, Grasses
- BLM 1975
- Wilshire et al. 1977

Loss of Perennial Plants
- Wilshire 1979
- Wilshire et al. 1977

Loss of Desert Tortoise Burrows
- Burge 1983
- Bury 1978
- Bury and Luckenbach 1986
- Bury and Marlow 1973

Crushing Desert Tortoises
- Bury and Luckenbach 1986
- Luckenbach 1975

Delayed and Cumulative Effects

Loss of Soil
- Baldwin and Stoddard 1973
- Gilette and Adams 1983
- Hildebley et al. 1983
- Nakata 1983
- Sheridan 1979
- Stull et al. 1979
- Wilshire 1980
- Wilshire et al. 1977

Soil Compaction
- Adams et al. 1982a
- Bodman and Constantin 1965
- Dickey et al. 1973
- Webb 1983
- Webb et al. 1978
- Wilshire 1977a, b
- Wilshire and Nakata 1976
- Wilshire et al. 1977

Effects on Annual Plants
- Adams et al. 1982a, 1982b
- Rowlands et al. 1980

Effects on Perennial Plants
- Biosystems 1992
- Bury and Luckenbach 1983, 1986
- Bury et al. 1977
- Davidson and Fox 1974
- Keefe and Berry 1973
- Ludrop 1983a, b
- Vollmer et al. 1976

Effects on Live Desert Tortoises
- Bury 1987
- Bury and Luckenbach 1986
- Bury et al. 1977

Effects on Other Vertebrates
- Berry 1973
- Bondello 1976
- Bunnstein and Bondello 1983
- Bury and Luckenbach 1983
- Bury et al. 1977
- Busack and Bury 1974
- U.S. BLM 1975

GRAZING OF DOMESTIC SHEEP AND CATTLE

Changes in Habitat

Soil
- Arndt 1966
- Avery et al. 1992
- Ellison 1960
- Gifford and Hawkins 1978
- Klemmedson 1956
- Sharp et al. 1964

Vegetation
- Beasley 1898
- Clements 1934
- Coombs 1977a, b
- Corbett 1952
- Ellison 1960
- Frenkel 1970
- Gardner 1951
- Hardy 1945
- Humphrey 1958, 1987
- Janzen 1986
- Kay et al. 1988
- Mack 1981
- Nicholson and Humphreys 1981
- Orians 1984
- Reynolds 1958
- Rowlands et al. 1980
- BLM 1980a
- Webb and Stielstra 1979
- Wester 1981

Competition Between Tortoises and Livestock
- Berry 1978
- Biosystems 1992
- Coombs 1979
- Medica et al. 1982
- Nicholson and Humphreys 1981
- Shepard 1981

Trampling
- Berry 1978
- Berry and Shields et al. 1986
- Knowles 1987
- Marlow 1974
- Nicholson and Humphreys 1981
- Rauzi and Smith 1973
- Webb and Wilshire 1980

Consequences of Altered Habitat
- Coe et al. 1976, 1979
- Congdon and Gibbons 1985
- Gibbons and Patterson 1982
- Gibbons et al. 1983
- Jarchow and May 1989
- Jones 1987
- Mitchell 1985
- Swingland and Coe 1979
- Tracy 1992
- Turner et al. 1984, 1987
- Wingfield 1983

Population Declines in the Tortoise and Other Native Herbivores
- Busack and Bury 1974
- Karl 1980, 1982
- Medin and Clancy 1989
- Phillips 1936
- Turner et al. 1981

1. *Human contact and direct mortality.*

Human "predation" is a major factor in the decline of the desert tortoise. Here predation is used in its broadest sense, meaning the taking of desert tortoises out of their natural populations either by death (accidental or intentional) or by removal. People illegally collect desert tortoises for pets, food, and commercial trade. Some new immigrants to the United States collect desert tortoises for medicinal or other cultural purposes (Section 4.1 of Appendix D). Stewart (1991) reported that from 12.5 to 43.7% of desert tortoises with radio transmitters were poached or suspected of being poached from his research site in the western Mojave Desert between 1987 and 1991. Berry (1990, as amended) presented similar evidence of illegal collections at a study plot near Stewart's site during the 1980's. Even in remote areas, desert tortoises on permanent study plots have been collected and later have appeared in cities or towns dozens of miles away from the plots.

Desert tortoises are often struck and killed by vehicles on roads and highways, and mortality of desert tortoises due to gunshot and off-highway vehicles is common in parts of the Mojave region, particularly near cities and towns where people and desert tortoises most frequently come in contact. For example, between 1981 and 1987, 40% of the desert tortoises found dead on a study plot in the Fremont Valley, California, were killed by gunshot or vehicles traveling cross-country or on trails (Berry 1990, as amended). Berry (1986a) reported that nearly 15% of 635 desert tortoise carcasses that were examined from several California study sites showed signs of gunshot.

2. *Predation.*

Desert tortoises, particularly hatchlings and juveniles, are preyed upon by several native species of mammals, reptiles, and birds. Domestic and feral dogs are a new, and probably significant, source of mortality (Causey and Cude 1978, Berry 1979). Predation by the common raven (*Corvus corax*) is intense on younger age classes of the desert tortoise, and the Fish and Wildlife Service's Breeding Bird Survey Program provided data to show a 15-fold increase in raven populations in the Mojave Desert and a 4.7-fold increase in raven populations in the Colorado and Sonoran deserts from 1968 and 1988 (Bureau of Land Management et al. 1989, Table 1). Raven population increases seem to be due to increased food supplies, (e.g., roadkills, landfills, trash, garbage dumps, agricultural developments), as well as new sites for perches and nests (e.g., fence posts, power poles and towers, signs, buildings, bridges, and freeway access-ramps).

The contribution of mammalian or avian predation to overall desert tortoise mortality is not well understood. The best-documented predator is the raven. Berry (1990, as amended) believes that

predation pressure from ravens probably has resulted in such high losses of juveniles in some portions of the Mojave region that recruitment of immature desert tortoises into the adult population has been halted. Increased mortality of young desert tortoises combined with drastically lowered survivorship of adults is likely responsible for observed catastrophic population declines (Berry 1990, as amended).

3. *Disease.*

Disease has contributed to high mortality rates in the western Mojave Desert in the last four years (Berry 1990, as amended, Avery and Berry 1990, Jacobson 1994). Disease is also suspected of contributing to declines in desert tortoise populations in the Chuckwalla Bench area of the eastern Colorado Desert and at some sites on the Beaver Dam Slope in the northeastern Mojave Desert (Berry 1992, Jacobson et al. 1994).

An upper respiratory tract disease (URTD) is prevalent in captive desert tortoises and has been identified in wild desert tortoises in many localities in the Mojave region. The disease is currently a major cause of mortality in the western Mojave Desert and perhaps elsewhere. Recent studies have demonstrated *Mycoplasma agassizii* sp. nov. as the causative agent of URTD. A serological test has been developed to determine exposure status of desert tortoises to URTD (Schumacher et al. 1993). Predisposing factors such as habitat degradation, poor nutrition, and drought are also likely involved (Jacobson et al. 1991). Drought and concomitant poor nutrition have the potential to compromise desert tortoises immunologically and, therefore, make them more susceptible to URTD. However, in recent experimental studies, URTD was induced in apparently healthy desert tortoises when challenged with an isolate of *M. agassizii* obtained from an ill desert tortoise (M.B. Brown, University of Florida, pers. comm. 1993). Under certain conditions, even healthy desert tortoises may become infected with the causative organism and develop signs of URTD. Controlling human-related spread of URTD (Jacobson 1994), improving habitat conditions, and monitoring health status of desert tortoise populations are some of the more important management tools which can be used in controlling URTD in wild populations of the desert tortoise.

URTD appears to be spreading, and may have been introduced to wild populations through illegal releases of captive desert tortoises that were ill (Jacobson 1994). Wild desert tortoises with signs of URTD are commonly found near cities and towns with concentrations of captive desert tortoises (Marlow and Brussard 1992).

A shell disease, characterized by lesions, is correlated with desert tortoise decline in the Chuckwalla Bench population in the eastern Colorado Desert (Jacobson et al. 1994, Berry 1992). Lesions

typically appear at seams between adjacent scutes and then spread toward the middle of each scute in an irregular pattern. A variety of mineral and metal deficiencies, as well as various toxicants, are known to cause integumentary pathology in mammals, suggesting a disease or toxicosis may be responsible for these observed shell abnormalities (Appendix D).

4. *Habitat destruction, degradation, and fragmentation.*

Changes in vegetation accumulating over almost a century and a half in the Mojave region have been substantial. In general, these changes are characterized by decreases in perennial grasses and native annuals and an increase in exotic ephemerals such as red brome (*Bromus rubens*). Continuous stands of exotic ephemerals provide fuel which can carry fire over large areas. Historically, fires were small or infrequent over vast areas of the Mojave region, and because native desert plants have not evolved with fire and are not adapted to it, they generally are killed by high-intensity fire. The increasing incidence and severity of fires in the Mojave region are already converting desert shrublands into ephemeral grasslands. The effects of invading exotic grasses on several ecosystems have recently been reviewed by D'Antonio and Vitousek (1992).

These vegetational changes can be detrimental to desert tortoises for a number of reasons. First, these animals require perennial shrubs for cover from the intense solar radiation in the desert. Second, perennial grasses are important secondary food sources for the desert tortoise in many areas. Third, recurrent fires and competition from exotic ephemerals may reduce the abundance and diversity of native forbs which are the major food source of the desert tortoise. Finally, major fires fragment desert tortoise habitat; fires can also kill desert tortoises (Appendix D).

Habitat fragmentation is a major contributor to population declines (Berry 1984b, Berry and Burge 1984, Berry and Nicholson 1984b, and Berry 1984c). Desert tortoises require a great deal of space to survive (Figure 2; see also Appendix C). Over its lifetime, each desert tortoise may require more than 1.5 square miles of habitat and may make forays of more than 7 miles at a time (Berry 1986b; Esque et al. in prep; K.H. Berry, pers. comm. 1993). In drought years, desert tortoises forage over larger areas (Figure 2) and thus have a greater probability of encountering potential sources of mortality. Roads and urban areas form barriers to movement and tend to create small, local populations which are much more susceptible to extinction than large, connected ones (Wilcox and Murphy 1985).

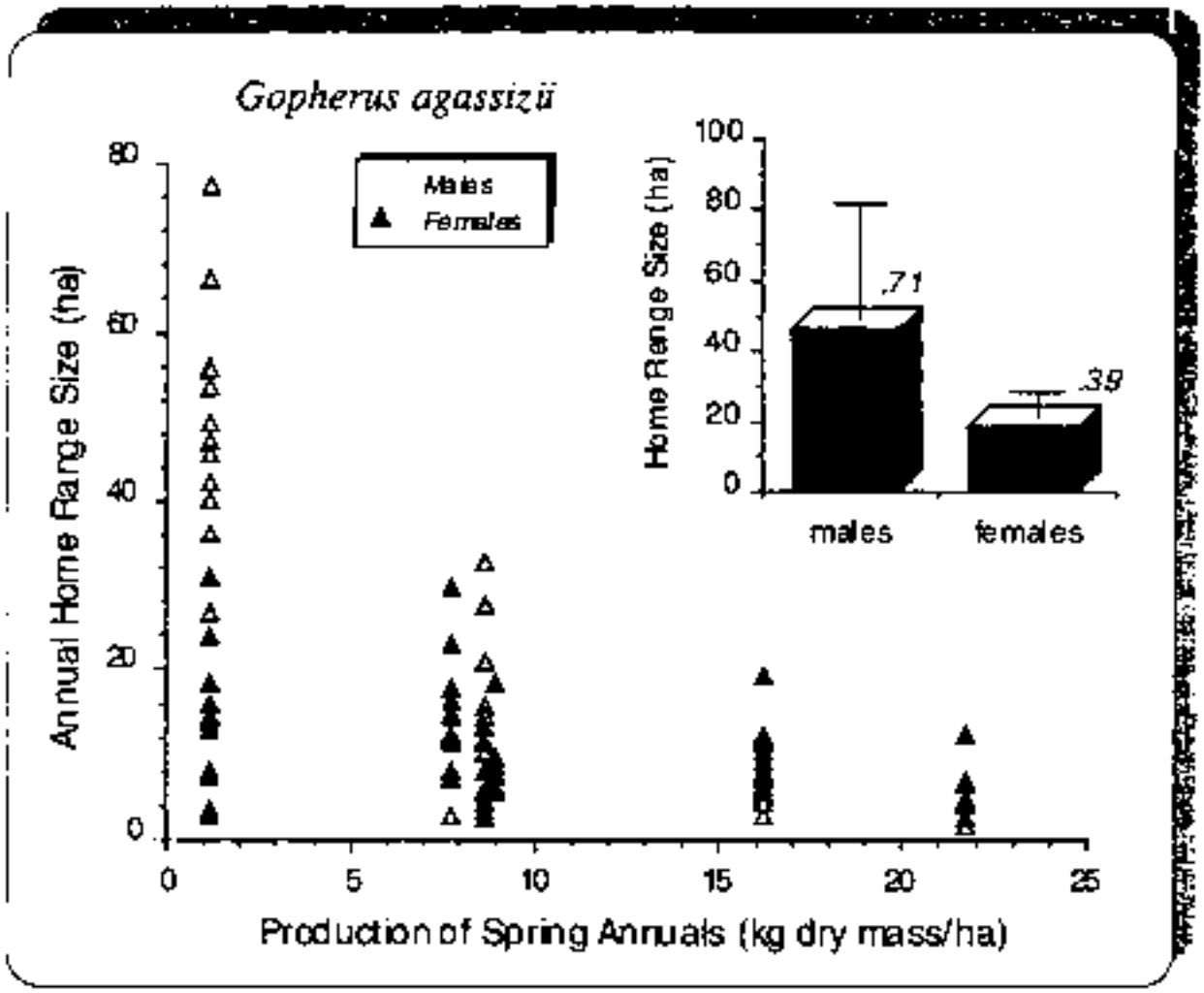


Figure 2. Annual home range sizes of desert tortoises as a function of the amount of food resources (spring annual plants) (from Esque et al., in prep.)

Grazing by cattle, domestic sheep, and feral equids can also affect desert tortoises and their habitats negatively. Livestock can kill desert tortoises and eggs directly by trampling. Grazing can also damage soil crusts, reduce water infiltration, promote erosion, inhibit nitrogen fixation in desert plants, and provide a favorable seed bed for exotic annual vegetation. Habitat destruction and degradation is especially evident in the vicinity of livestock water sources. Off-road vehicle (ORV) use also destroys, degrades, and fragments considerable areas of desert tortoise habitat; and disturbances from both grazing and ORVs facilitate the invasion of exotic plants and increased incidence of fire (Table 1, Appendix D).

A variety of other human uses have caused significant quantitative and qualitative losses of desert tortoise habitat. Urbanization; agricultural development; construction and use of transportation routes and corridors; development of utility corridors; exploration for and development of hard rock minerals, sand and gravel pits, oil and gas, and other mineral resources; and concentrated visitor use are all important causes of widespread habitat destruction. In some portions of the desert, military activities such as maneuvers, bombings, and explosions also contribute to the degradation and loss of desert tortoise habitat (Kryzik and Woodman 1991, Fish and Wildlife Service 1992). The combined effects of these various activities have resulted in extirpations and population declines of desert tortoises throughout the Mojave region. The relative contributions of these factors are well documented in some areas, but not in others (Table 1, Appendix D).

C. *Current Management*

1. *Endangered Species Act protection.*

Section 9 of the Endangered Species Act prohibits the take of any listed wildlife species, including the desert tortoise. The definition of "take" includes to harass, harm, hunt, shoot, wound, kill, trap, capture, collect, or attempt to engage in any such conduct. "Harm", in the definition of "take", includes significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering (50 CFR 17.3). Sections 7 and 10 of the Endangered Species Act provide regulatory mechanisms for actions affecting desert tortoises on public and private lands, respectively. Section 7(a)(1) directs Federal agencies to use their authorities to carry out programs for the conservation of endangered and threatened species. Through the section 7(a)(2) process, all Federal agencies are required to ensure that any action they authorize, fund, or carry out in the United States or upon the high seas is not likely to jeopardize the continued existence of any listed species [50 CFR 402.01(a)]. Section 10(a)(1)(B) of the Endangered Species Act gives the Fish and Wildlife Service the authority to issue permits to non-Federal and private entities for the

take of listed wildlife species, as long as such taking is incidental to, and not the purpose of, carrying out otherwise lawful activities (16 U.S.C. 1539). A section 10(a)(1)(B) permit is granted only if the applicant institutes appropriate conservation measures for habitat maintenance, enhancement, and protection, coincident with the action.

Since the emergency listing of the desert tortoise in August 1989, the Fish and Wildlife Service has reviewed hundreds of proposals for activities that could adversely affect the desert tortoise. Over this time, the Fish and Wildlife Service, other Federal agencies, and State wildlife agencies, have developed and implemented measures to minimize harm and mortality to desert tortoises resulting from human activities. These measures include the following provisions for avoiding impacts to desert tortoises found in project areas: moving animals from harm's way to adjacent undisturbed habitat where their probability of survival is increased; land acquisition and protection as compensation for destruction of desert tortoise habitat; increased law enforcement; improved management; public education; and research. The Fish and Wildlife Service has specified that all handling of desert tortoises would be in accordance with procedures approved by them.

The section 7 process can influence the planning activities of Federal agencies to reduce impacts to desert tortoises and, in some cases, benefit desert tortoises. For example, through informal consultation with the Fish and Wildlife Service, the Marine Corps developed an alternative location for a new airfield that avoided impacts to the largest concentration of desert tortoises at the Marine Corps Air Ground Combat Center at Twentynine Palms, California. In another example, through the section 7 consultation process the Fish and Wildlife Service and the Navy developed a programmatic approach for desert tortoise management and routine operations at the Naval Air Weapons Station at China Lake, California. This consultation specified standard mitigation measures for Navy staff to implement whenever desert tortoises are encountered during an action. The Navy has established an area of approximately 200,000 acres in which it will attempt to avoid siting any new facilities that would result in the disturbance of greater than 2.5 acres of desert tortoise habitat at any one time. The Navy also committed to continue its ongoing efforts to remove feral burros from desert tortoise habitat and to fence its boundary to prevent livestock grazing on its lands. In Nevada, programmatic consultations directed urban development and ORV use in the Las Vegas Valley to areas of degraded or poor habitat, thereby reducing conflicts in areas necessary for desert tortoise recovery.

Other important section 7 consultations have resulted in time and space restrictions on domestic sheep and cattle grazing and reduced impacts to desert tortoises and their habitat resulting from ORV activities, right-of-way development, mining operations, military

actions, and many other activities authorized, funded, or carried out by Federal agencies.

In 1991, the Fish and Wildlife Service issued a 3-year section 10(a)(1)(B) incidental take permit to Clark County and the cities of Las Vegas, North Las Vegas, Henderson, and Boulder City in Nevada. As a condition of the permit, the permittees are implementing a habitat conservation plan (HCP) which provides for conservation and management of at least 400,000 acres in Clark County for the benefit of the desert tortoise (RECON 1991). Three types of mitigation measures are required by the terms of the permit: (1) conservation and management of desert tortoise habitat, (2) initiation of a desert tortoise research and relocation program, and (3) imposition of a $550-per-acre mitigation fee on projects in the permit area. Key management actions to be implemented on the 400,000 or more acres of conservation lands include: acquisition and retirement of grazing privileges; designation of roads and trails and elimination of off-highway vehicle events over most of the conservation lands; no new landfills or intensive recreation sites; and adequate enforcement, biological monitoring, and maintenance actions needed to implement these actions. The $550-per-acre mitigation fees are to be used to fund the conservation and mitigation measures. The permittees are pursuing a long-term incidental take permit which will address all of Clark County for a period of 20 years or more.

The Fish and Wildlife Service is also involved in preparation of HCPs for Washington County, Utah, and Nye County, Nevada, and several other section 10(a)(1)(B) permits have been issued or are pending for smaller projects. Washington County, Utah is in the process of applying for a 20-year incidental take permit for desert tortoise. On May 4, 1994, the Fish and Wildlife Service received a proposed Washington County HCP (Washington County Commission 1994), as part of a permit for incidental take of desert tortoise and its habitat. The major mitigation proposed for take of desert tortoise is increased protection of the remainder of desert tortoise habitat in the area through establishment of a desert habitat reserve, or desert wildlife management area. Land ownership within the reserve will be Federal, and land exchanges and acquisition are required to consolidate habitat and management efforts. Management of the desert habitat reserve is proposed to be by BLM through eventual establishment of a National Conservation Area. The proposed reserve extends from the eastern boundary of the Paiute Indian Reservation on the west, to the City of Hurricane on the east. Within the reserve, land uses will be carefully controlled and all management actions will place the desert tortoise/habitat conservation as the highest priority. Acquisition of habitat, fencing, enforcement, education, and removal of competing uses comprise the majority of mitigation measures for proposed take. The Washington County HCP also includes proposed conservation measures for other listed and candidate species. Funding for administration, implementation, and monitoring of the

Washington County HCP includes collection of county-wide fees: 0.2% of all new construction costs, plus $250 per acre for plotted housing developments. The Fish and Wildlife Service is currently reviewing the Washington County HCP.

The Bureau of Land Management's (BLM) California Desert District, in cooperation with the Fish and Wildlife Service, California Department of Fish and Game, and local governments, is currently developing the West Mojave Coordinated Management Plan. This multi-species management strategy for 8.6 million acres will provide for long-term conservation of the desert tortoise and other rare or sensitive species, such as the Mohave ground squirrel. The plan will be the basis for a programmatic section 7 consultation for BLM activities in the planning area and serve as an HCP for local governments to obtain section 10(a)(1)(B) permits. This plan is expected to be the first of several regional conservation planning efforts in California, which would implement the guidance provided in this Recovery Plan.

2. *BLM management.*

The BLM manages most desert tortoise habitat in the Mojave region and initiated management actions to conserve this species. In 1988, the BLM issued a habitat management plan for conservation of the desert tortoise on public lands throughout its range in the United States (Spang et al. 1988). The plan groups desert tortoise habitat into three goal-oriented categories:

> Category I—Maintain stable, viable populations and protect existing tortoise habitat values; increase populations, where possible.
>
> Category II—Maintain stable, viable populations and halt further declines in tortoise values.
>
> Category III—Limit tortoise habitat and population declines to the extent possible by mitigating impacts.

Habitat areas are categorized according to four criteria: (1) importance of the habitat to maintaining viable populations, (2) resolvability of conflicts, (3) desert tortoise density, and (4) population status (stable, increasing, or decreasing). BLM's goal is to maintain viable desert tortoise populations in category 1 and 2 habitats and to limit population declines to the extent possible in category 3 habitats. The plan identifies management actions needed to implement these goals, which address environmental education, ORV use, energy and mineral development, livestock use, lands and realty actions, and other activities which may affect desert tortoises. Included is a provision to compensate for residual impacts to desert tortoises after other mitigation measures are incorporated into proposed actions. A compensation formula was

developed and adopted to implement this provision (Desert Tortoise Compensation Team 1991).

The Federal Land Policy Management Act of 1976 (public law 94-579) directed the BLM to manage public lands for multiple use and sustained yield. Wildlife is identified as one of the major uses of public lands. The Sikes Act (public laws 93-452 and 95-420) authorizes the BLM to develop and implement plans in cooperation with State wildlife agencies for the development and protection of wildlife habitat. In response to these authorizations, the BLM has developed numerous habitat management plans which address the management and conservation of the desert tortoise. The California Desert Conservation Area Plan, 1980 (BLM 1980a), a management strategy for 12.1 million acres of public land, identified five areas where habitat management plans were to be developed to conserve desert tortoise habitat. This plan also designated eight crucial desert tortoise habitat areas with specific management actions to protect desert tortoises. In addition, the BLM carries out land exchanges and uses Land and Water Conservation funds to acquire desert tortoise habitat. Special land use designations such as Areas of Critical Environmental Concern and Research Natural Areas have also been established by the BLM for the desert tortoise in the Mojave region.

3. Management by other agencies.

The BLM is the primary land manager, but a number of other Federal, State, and local entities also manage desert tortoise habitat in the Mojave region. The National Park Service provides protection for desert tortoise habitat at Joshua Tree National Monument and at Death Valley National Monument in California, and Lake Mead National Recreation Area in Nevada. The Department of Defense manages large parcels of land, particularly in California at the Fort Irwin National Training Center, the Naval Air Weapons Station at China Lake, Edwards Air Force Base, the Marine Corps Air Ground Combat Center at Twentynine Palms, and the Chocolate Mountains Gunnery Range, and in Nevada at the Nellis Air Force Base. Desert tortoise management plans have been or are being prepared for some of these military lands. The Fish and Wildlife Service's Desert National Wildlife Refuge provides protection for a portion of the desert tortoise habitat in the Coyote Spring area of Nevada. Other lands are managed by State parks and wildlife agencies, Bureau of Indian Affairs, Bureau of Reclamation, and other government agencies.

4. State laws protecting desert tortoises.

All four states in which the Mojave desert tortoise occurs have laws that provide some protection for this species; for instance, the collection of desert tortoises is prohibited in all four states. In Nevada, section 501.110.1 (d) of the Nevada Revised Statutes prohibits transportation of desert tortoises within Nevada or across

State lines. The desert tortoise is also listed as a threatened species under the California Endangered Species Act of 1984. Similar to the Federal Act, this legislation requires State agencies to consult with the California Department of Fish and Game on activities which may affect a listed species. Compensation is required by California Department of Fish and Game for projects which result in loss of desert tortoise habitat.

D. Desert Tortoise Habitat.

1. Desert regions and vegetational communities.

The Mojave region includes portions of both the Mojave and Sonoran deserts. Within the Mojave region, the Mojave Desert is represented in parts of Inyo, Kern, Los Angeles, San Bernardino, and Riverside Counties in California; the northwestern part of Mohave County in Arizona; Clark County, and the southern parts of Esmeralda, Nye, and Lincoln Counties in Nevada; and part of Washington County, Utah. The Colorado Desert, a division of the Sonoran Desert, is located south of the Mojave Desert, and includes Imperial County and parts of San Bernardino, and Riverside Counties, California. The climatic, geological, and ecological features of those portions of the Mojave and Colorado deserts inhabited by the desert tortoise are described in Appendix E.

2. Habitat requirements.

Within the varied vegetational communities of the Mojave region, desert tortoises can potentially survive and reproduce where their basic habitat requirements are met. These requirements include sufficient suitable plants for forage and cover, and suitable substrates for burrow and nest sites. Throughout most of the Mojave region, desert tortoises occur primarily on flats and bajadas with soils ranging from sand to sandy-gravel, characterized vegetationally by scattered shrubs and abundant inter-shrub space for growth of herbaceous plants. Desert tortoises are also found on rocky terrain and slopes in parts of the Mojave region, and there is significant geographic variation in the way desert tortoises use available resources (see Section I.F. for further details).

E. Natural History of the Desert Tortoise.

1. Nomenclature and description.

The generic assignment of the desert tortoise has gone through a series of changes since its original description by Cooper (1863) as *Xerobates agassizii*. Until the status of the genus is further clarified, this Recovery Plan will use the more familiar *Gopherus agassizii*. Morafka and Brussard (in prep.) detail the history of this nomenclature.

The genus *Gopherus* contains between 15 and 19 fossil, and four living, species (Auffenberg 1976, Crumly 1984). Generally, these species are divided into two groups based on morphological and genetic evidence (Auffenberg 1976, Crumly 1984, Lamb et al. 1989). One group includes the living *G. agassizii* and the Texas tortoise (*G. berlandieri*). The extant Mexican bolson tortoise (*G. flavomarginatus*) and gopher tortoise of the southeastern United States (*G. polyphemus*) are included in the second group. The recently described peninsular Baja Californian *Xerobates lepidocephalus* would have added a fifth extant species to the genus, but this taxon is most probably based on individuals of Sonoran Desert *G. agassizii* which were released into the Cape region of Baja California (Crumly 1994).

The desert tortoise is the only naturally occurring tortoise in the Mojave region. It is distinguished from the other three species of the genus *Gopherus* by a combination of characters, including a rounded front head, interhumeral seam longer than integular seam, single triangular axillary scale, and distance from base of first claw to fourth claw equal for forefoot and hindfoot (Brame and Peerson 1969). In comparison to the Mojave *G. agassizii*, *G. berlandieri* exhibits a wedge-shaped head, relatively small adult size, a bifurcate and upturned gular projection in males, and a high-domed carapace (Bogert and Oliver 1945, Behler and King 1979). *G. polyphemus* has a rounded head and is similar in maximum size to *G. agassizii*, but its carapace is more elongate and tends to be widest at midbody, whereas in *G. agassizii* the carapace is widest at about the fourth costal scute (Grant 1960, Behler and King 1979). *G. flavomarginatus* attains the largest size of any of the four species. It is distinguished from *G. agassizii* by a broad head and the presence of a pale yellow lateral border on its carapace laminae (Morafka 1982). Escaped or released captive tortoises other than *G. agassizii* (particularly *G. berlandieri*) are occasionally encountered in the Mojave region.

2. *Paleontology and distribution.*

The earliest fossils of *G. agassizii* come from Pleistocene deposits (Brattstrom 1961). During the Holocene, *G. agassizii* ranged as far west as California's San Joaquin Valley (Miller 1942, VanDevender and Moodie 1977). Prior to European settlement of the Mojave region, its range included the Mojave and Sonoran deserts in southern California, southern Nevada, western Arizona, the southwestern tip of Utah, and Sonora and Sinaloa, Mexico (Stebbins 1954, 1966). This species is also found on Tiburon Island in the Sea of Cortez (Linsdale 1940). The desert tortoise is now considerably reduced in numbers throughout much of this area and has been extirpated from parts of its historic range (Spang et al. 1988, Berry 1978).

3. *Genetics and morphology.*

Jennings (1985) used starch-gel electrophoresis of allozymes encoded by about 20 loci to explore genetic variation in *G. agassizii*. Although he found no fixed genetic differences among samples, phenograms generated from genetic distance values suggest two major population groupings that correspond roughly with the Mojave region and Sonoran Desert in Arizona. In addition, a plasma protein was polymorphic in samples from the Mojave Desert, but monomorphic in samples from the Sonoran Desert (Glenn et al. 1990).

Based on mitochondrial DNA (mtDNA) restriction-fragment polymorphisms, Lamb et al. (1989) described three major genetic units within *G. agassizii*. One unit is found in the Colorado and Mojave deserts and a second in the Sonoran Desert from west-central Arizona to central Sonora. The Colorado River appears to have been a sufficient barrier for these two assemblages to have evolved independently since the Pliocene. The third major unit is found in southern Sonora and Sinaloa, south of the Yaqui River.

Morphological variation coincides reasonably well with the mtDNA genotypes found north of Mexico. There are three distinct shell phenotypes in the United States: (1) the California phenotype from California and southwestern Nevada; (2) the Sonoran Desert phenotype from Arizona south and east of the Colorado River, and (3) the Beaver Dam Slope phenotype from extreme southwestern Utah and Arizona north of the Grand Canyon (Weinstein and Berry 1987). The California and Sonoran Desert phenotypes correspond to the Mojave region and Sonoran Desert mtDNA genotypes, respectively.

Thus, based on genetic and morphological criteria, *G. agassizii* is divided into at least two well-differentiated entities, one in the Sonoran Desert in Arizona and one in the Mojave region. A third may exist in Sonora and Sinaloa, Mexico.

4. *Ecology and natural history.*

The most complete account of the biology, ecology, and natural history of the desert tortoise is that of Woodbury and Hardy (1948). These authors studied a population of desert tortoises on the Beaver Dam Slope in extreme southwestern Utah for more than 10 years. Their study presented details of reproduction, growth and development, longevity, food habits, behavior, movement patterns, and general adaptations to desert conditions. Although no other single study of *G. agassizii* covers as many topics as Woodbury and Hardy's, a reasonably large body of literature exists on most aspects of desert tortoise biology. Berry (1986c) lists over 30 papers

published between 1976 and 1985 on topics such as distribution, abundance, habitat use, size-age class distributions, sex ratios, mortality rates, time and energy budgets, thermal relations, metabolism, and the effects of land use on population dynamics. The following general account is based upon information contained in these papers except where otherwise referenced.

Desert tortoises spend much of their lives in burrows, emerging to feed and mate during late winter and early spring. They typically remain active through the spring, and sometimes emerge again after summer storms. During these activity periods, desert tortoises eat a wide variety of herbaceous vegetation, particularly grasses and the flowers of annual plants (Berry 1974, Luckenbach 1982). Desert tortoises are essentially "K-strategists" (MacArthur and Wilson 1967), with delayed maturity and long life. Eggs and hatchlings are quite vulnerable, and pre-reproductive adult mortality averages 98% (Wilbur and Morin 1988, Turner et al. 1987, Morafka in press). Adults, however, are well protected against most predators (other than humans) and other environmental hazards and consequently are long-lived (Germano 1992, Turner et al. 1987). Their longevity helps compensate for their variable annual reproductive success, which is correlated with environmental conditions.

Desert tortoises are well adapted to living in a highly variable and often harsh environment. In adverse conditions they retreat to burrows or caves, at which time they reduce their metabolism and loss of water and consume very little food. Adult desert tortoises lose water at such a slow rate that they can survive for more than a year without access to free water of any kind. During a recent drought, desert tortoises at a study site in eastern California not only survived with very little food or water, but they produced an average of three eggs per female per year (B. Henen, UCLA, pers. comm.). Desert tortoises apparently tolerate large imbalances in their water and energy budgets (Nagy and Medica 1986). This ability enables them to survive lean years and exploit resources that are only periodically available. During years of average or better than average precipitation and forage production, desert tortoises can balance their water budgets and have a positive energy balance, providing opportunity for growth and reproduction (Nagy and Medica 1986). All the mechanisms by which desert tortoises maintain their energy and water balance in the face of stochastic availability of resources are still not clear, but desert tortoises seem to be flexible in their mechanisms of energy and water gain and in their expenditures of these resources (Wallis et al., 1992).

F. Distinct Population Segments of the Desert Tortoise

1. Background.

As a general rule, most widespread species show substantial geographic variation in genetic, morphological, ecological, physiological, and behavioral traits. This is largely attributed to natural selection favoring different character states in different climates and biotic communities (Darwin 1859), or genetic drift (Wright 1931). Such divergence, which may arise from past or present barriers to dispersal or from mere distance (Williams 1992), requires at least the partial isolation of gene pools within a species .

The desert tortoise is no exception to this generalization, because groups of populations within the Mojave region exhibit different habitat preferences, food habits, periods of activity, selection of sites for burrowing and egg-laying, and social behavior (see Section I.F.2. below). This is not surprising, since this region encompasses two major North American deserts, eight vegetational provinces, and numerous vegetation types (Appendix E).

Sections 2(b and c) and 3(15) of the Endangered Species Act provide protection to "any distinct population segment of any [listed] species of vertebrate fish or wildlife which interbreeds when mature." Waples (1991) states that, "[a] vertebrate population will be considered distinct . . . for purposes of protection under the Act if the population represents an evolutionarily significant unit (ESU) of the biological species." An ESU is a population, or group of populations, that represents significant adaptive variation within a species (Ryder 1986). Evidence of current or past reproductive isolation is not, by itself, sufficient evidence for ESU designation. Rather, the identification of ESUs requires evidence that population units have undergone significant evolutionary differentiation. Thus the identification of ESUs requires data on range and distribution, natural history, morphometrics, and genetics; concordance among two or more of these data sets strengthens the case for ESU designation (Ryder 1986). The following questions are relevant (Waples 1991):

(1) Is the population genetically distinct?

(2) Does the population occupy unusual or distinct habitat?

(3) Does the population show evidence of unusual or distinct adaptation to its environment?

2. *Evolutionarily significant units of the desert tortoise within the Mojave region.*

Data from a variety of sources indicate that there are at least six ESUs of the desert tortoise within the Mojave region. These ESUs consist of populations or groups of populations that show significant differentiation in genetics, morphology, ecology, or behavior (Tables 2, 3, 4, and 5) and thus are important components of the evolutionary legacy of *Gopherus agassizii*. The conservation of all these ESUs will help to ensure that "the dynamic process of evolution [in this species] will not be unduly constrained in the future" (Waples 1991). Hereafter these ESUs are referred to as "recovery units" (Figure 3).

In the following accounts, information on the ecology and distribution of desert tortoises comes primarily from unpublished data and field notes of the Recovery Team.

Northern Colorado Recovery Unit.

This recovery unit is located completely in California. Here desert tortoises are found in the valleys, on bajadas and desert pavements, and to a lesser extent in the broad, well-developed washes. They feed on both summer and winter annuals and den singly in burrows under shrubs, in intershrub spaces, and rarely in washes. The climate is somewhat warmer than in other recovery units, with only 2 to 12 freezing days per year. The tortoises have the California mtDNA haplotype and phenotype. Allozyme frequencies differ significantly between this recovery unit and the Western Mojave, indicating some degree of reproductive isolation between the two.

Eastern Colorado Recovery Unit.

Desert tortoises in the eastern Colorado recovery unit, also located completely in California, occupy well-developed washes, desert pavements, piedmonts, and rocky slopes characterized by relatively species-rich Succulent Scrub, Creosote Bush Scrub, and Blue Palo Verde-Ironwood-Smoke Tree communities. Winter burrows are generally shorter in length, and activity periods are longer than elsewhere due to mild winters and substantial summer precipitation. The tortoises feed on summer and winter annuals and some cacti; they den singly. They also have the California mtDNA haplotype and shell type.

Upper Virgin River Recovery Unit.

This recovery unit encompasses all desert tortoise habitat in Washington County, Utah, except the Beaver Dam Slope, Utah population. The desert tortoise population in the area of St. George, Utah, is at the extreme northeastern edge of the species' range and experiences long, cold winters (about 100 freezing days) and mild summers, during which the tortoises are continually active. Here

the animals live in a complex topography consisting of canyons, mesas, sand dunes, and sandstone outcrops where the vegetation is a transitional mixture of Sagebrush Scrub, Creosote Bush Scrub, Blackbush Scrub, and a psammophytic community. Desert tortoises use sandstone and lava caves instead of burrows, travel to sand dunes for egg laying, and use still other habitats for foraging. Two or more desert tortoises often use the same burrow. Shell morphology and mtDNA have not been studied in this recovery unit, but allozyme variation is similar to that found in the northeastern Mojave recovery unit.

Eastern Mojave Recovery Unit.

Primarily in California, this recovery unit also extends into Nevada in the Amargosa, Pahrump, and Piute valleys. In the eastern Mojave recovery unit, desert tortoises are often active in late summer and early autumn in addition to spring because this region receives both winter and summer rains and supports two distinct annual floras on which they can feed. These desert tortoises occupy a variety of vegetation types and feed on summer and winter annuals, cacti, perennial grasses, and herbaceous perennials. They den singly in caliche caves, bajadas, and washes. This recovery unit is isolated from the western Mojave by the Baker Sink, a low-elevation, extremely hot and arid strip that extends from Death Valley to Bristol Dry Lake. This area is generally not suitable for desert tortoises. Desert tortoises have both the California and the southern Nevada mtDNA haplotype and the California shell type. They are also differentiated from desert tortoises in the northeastern Mojave recovery unit at several allozyme loci.

Northeastern Mojave Recovery Unit.

This recovery unit is found primarily in Nevada, extending into California along the Ivanpah Valley and into extreme southwestern Utah and northwestern Arizona. Desert tortoises here are generally found in Creosote Bush Scrub communities of flats, valley bottoms, alluvial fans, and bajadas, but they occasionally use other habitats such as rocky slopes and Blackbush Scrub. Two or more desert tortoises often den together in caliche caves in bajadas and washes, and they typically eat summer and winter annuals, cacti, and perennial grasses. Three mtDNA haplotypes are found in this recovery unit, but they exhibit low allozyme variability with relatively little local differentiation. A distinct shell phenotype occurs in the Beaver Dam Slope region.

Western Mojave Recovery Unit.

The Western Mojave recovery unit is completely in California and is exceptionally heterogeneous and large. It is composed of the Western Mojave, Southern Mojave, and Central Mojave regions, each of which has distinct climatic and vegetational characteristics. The most pronounced difference between the Western Mojave and

other recovery units is in timing of rainfall and the resulting vegetation. Most rainfall occurs in fall and winter and produces winter annuals, which are the primary food source of tortoises. Above ground activity occurs primarily in spring, associated with winter annual production. Thus, tortoises are adapted to a regime of winter rains and rare summer storms. Here, desert tortoises occur primarily in valleys, on alluvial fans, bajadas, and rolling hills in saltbrush, creosote bush, and scrub steppe communities. Tortoises dig deep burrows (usually located under shrubs on bajadas) for winter hibernation and summer estivation. These desert tortoises generally den singly. They have a California mtDNA haplotype and a California shell type.

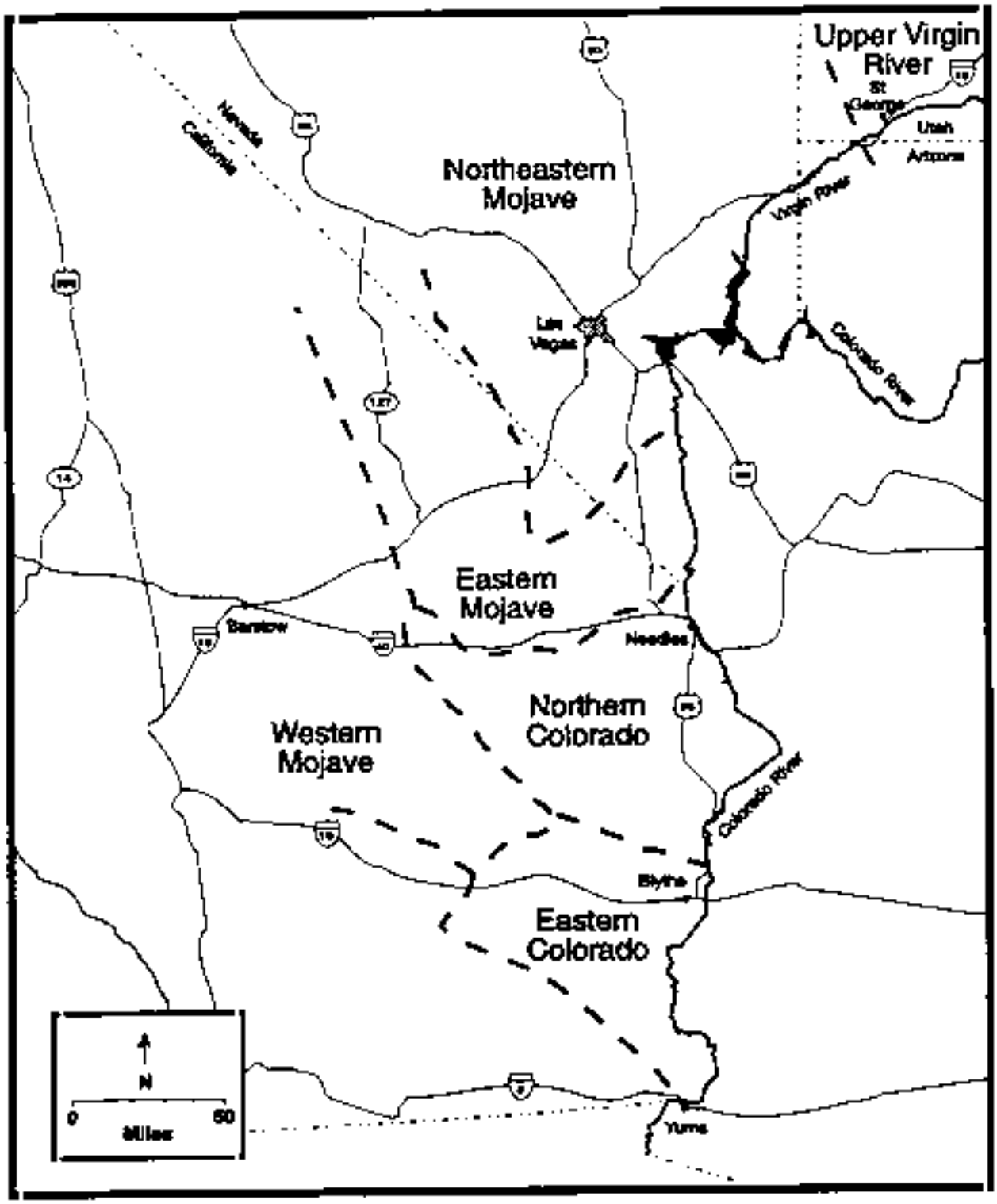


Figure 3. Approximate boundaries of recovery units of the desert tortoise in the Mojave region

Table 2. Vegetation communities and typical foods used by the desert tortoise (*Gopherus agassizii*) within recovery units.

Recovery Units	Vegetation Communities[1]	Plant Foods
Northern Colorado	(1) Succulent Scrub (*Fouquieria, Opuntia, Yucca*), (2) Blue Palo Verde-Smoke Tree Woodland, (3) Creosote Bush Scrub (lava flows)	Summer and winter annuals
Eastern Colorado	(1) Succulent Scrub (*Fouquieria, Opuntia, Yucca*), (2) Blue Palo Verde-Ironwood-Smoke Tree Woodland, (3) Creosote Bush Scrub (rocky slopes)	Summer and winter annuals, cacti
Upper Virgin River	Transitional Vegetation: (1) Sagebrush Scrub, (2) Psammophytes, Great Basin (sand sage), (3) Blackbush Scrub	Summer and winter annuals, perennial grasses, cacti (< 5%)
Northeastern Mojave	(1) Creosote Bush Scrub, (2) Big Galleta Scrub-Steppe, (3) Desert Needlegrass Scrub-Steppe, (4) Blackbush Scrub	Summer and winter annuals, cacti, perennial grasses
Eastern Mojave	(1) Big Galleta-Scrub Steppe, (2) Succulent Scrub (*Yucca, Opuntia* species), (3) Creosote Bush Scrub, (4) Cheesebush Scrub (east Mojave type), (5) Indian Rice Grass Scrub-Steppe	Summer and winter annuals, cacti, perennial grasses, herbaceous perennials
Western Mojave	(1) Creosote Bush Scrub, (2) Mojave Saltbush- Allscale Scrub (endemic), (3) Indian Rice Grass Scrub-Steppe, (4) Hopsage Scrub, (5) Big Galleta Scrub Steppe, (6) Cheesebush Scrub (west Mojave type), (7) Desert Psammophytes, (8) Blackbush Scrub	Winter annuals, few herbaceous perennials, cacti

[1]From Appendix E

Table 3. Topography, substrate, winter burrow site preference, and denning behavior of the desert tortoise (*Gopherus agassizii*) in each recovery unit.

Recovery Unit	Physical Attributes of Habitat	Burrow Sites	Denning Behavior
Northern Colorado	Flats, valleys, bajadas, rocky slopes, small washes	Under shrubs, in intershrub spaces, few in washes	Single
Eastern Colorado	Flats, valleys, fans, small washes, deeply dissected washes, rocky slopes	Shallow burrows, bajadas, more use of shrubs	Single
Upper Virgin River	Rock caves, sandstone crevices	Burrows in sand, and in sandstone crevices; (Do not use habitat like NE Mojave, even if available)	Multiple
Eastern Mojave	Flats, valleys, fans, bajadas, rocky slopes	Some caliche caves, bajadas, washes	Single
Northeastern Mojave	Flats, valleys, fans, bajadas, rocky slopes	Caliche caves, bajadas, washes	Multiple
Western Mojave	Flats, valleys, fans, rolling hills, mountainous slopes, rock outcrops, badlands, sand dunes, lava flows	Under shrubs, in bajadas, few in washes	Single

Table 4. Distribution of recovery units of the desert tortoise by genetic unit (mtDNA) and phenotype.

Recovery Unit	Genetic	Phenotype
Northern Colorado	California	California
Eastern Colorado	California	California
Upper Virgin River	Eastern Nevada/Utah	Unknown
Eastern Mojave	California, Southern Nevada	California
Northeastern Mojave	Western Nevada, Central Nevada, Eastern Nevada/ Utah	Beaver Dam Slope, Unknown
Western Mojave	California	California

Table 5. Numbers of freezing days and amounts and timing of precipitation within desert tortoise recovery units.

Recovery Unit	Mean number of freezing days annually	Precipitation	
		Mean annual precip. (mm)	% precip. July-Sept.
Northern Colorado	2-12	112-129	33-34
Eastern Colorado	12-16	96-100	32-37
Upper Virgin River	96	210	24-29
Eastern Mojave	24-46	112-208	28-38
Northeastern Mojave	46-127	100-210	24-31
Western Mojave (totals)	33-104	90-150	6-27
Fremont-Kramer DWMA	33-84	90-150	6-10
Ord-Rodman DWMA	57-104	108	18-27
Superior-Cronies DWMA	57+	109	27

G. Desert Tortoise Life History, Population Dynamics, and Other Factors Which Dictate a Slow and Uncertain Recovery.

The life history strategy of the desert tortoise depends on longevity and iteroparity (reproduction many times per lifetime). Under natural conditions, this strategy allows the species to persist in spite of the stresses of extremely harsh and variable environments. Because adults normally live long enough to have multiple opportunities to reproduce, populations can grow or at least remain stationary (neither growing or declining) if long periods with unsuccessful reproduction are punctuated occasionally with a few successful years. These factors also make recovery of the desert tortoise more difficult, and one or two good years of reproductive success do not signal a trend toward recovery any more than several poor ones signal inevitable extirpation.

This life history strategy is advantageous where availability of resources is unpredictable and juvenile survival rates are highly variable, but even moderate downward fluctuations in adult survival rates can result in rapid population declines (Stearns 1976). Thus, maintaining high survivorship of adult desert tortoises is the key factor in the recovery of this species.

Even when adult survivorship is "normal" (approximately 98% per year), desert tortoise populations are not capable of rapid growth. For example, the 7-year average egg production at a study site near Goffs, California, was 5.8 eggs per female per year (Turner et al. 1986, B. Henen, UCLA, pers. comm.). At this rate of egg production and assuming "normal" adult survivorship, population growth would be less than 0.5% per year (Figure 4). At this growth rate, more than 140 years would be required for the population to double in size.

Under reasonably favorable conditions, a desert tortoise population might be able to grow at an average rate of 1% per year. At that rate of growth, its doubling time would be 70 years. This means that a population that has decreased to 10 adults per square mile would require three doublings, or 210 years, to reach a density of 80 per square mile.

No population with rates of growth as low as these can stand loss rates of breeding adults as high as those reported in the populations shown in Figure 1 without serious threat of extinction. Desert tortoise populations can withstand high rates of natural juvenile mortality as long as the probability of adults surviving each year does not drop below approximately 98% (Figure 5; Appendix C). Thus, the desert tortoise is extremely vulnerable to extinction in

areas in which the probability of adult survival has been significantly reduced. Other species with similar life history strategies (e.g., California condor, black rhinoceros, blue whale) have been caught in altered environments in which the probability of adult survival has decreased dramatically. These species are all in danger of extinction.

Other factors also affect recoverability of this species. For example desert tortoises have complex social behaviors and intimate familiarity with their home ranges, which are quite large. This means that translocating desert tortoises is not likely to be very successful (Berry 1986b) until research projects determine if translocation can be a successful means of recovery (Appendix B).

Desert tortoise recovery is further complicated by the large area involved. The Mojave region spans four states (each with different laws and regulations), two different deserts (Mojave and Colorado), and several hundred thousand square miles. There is considerable genetic and ecological variability within the desert tortoise throughout the Mojave region. Maintaining this variability is necessary for desert tortoises to adapt to these varied environmental conditions and possible future changes in the environment. In addition, the threats facing the desert tortoise differ in degree, although not necessarily in kind, in different parts of the Mojave region. Consequently management actions needed to promote recovery will have to be tailored to the needs of specific areas. If recovery is to be achieved, the cooperative efforts of a myriad of State, Federal, and local agencies will be necessary to abate these threats and implement the recovery strategy outlined in this Recovery Plan.

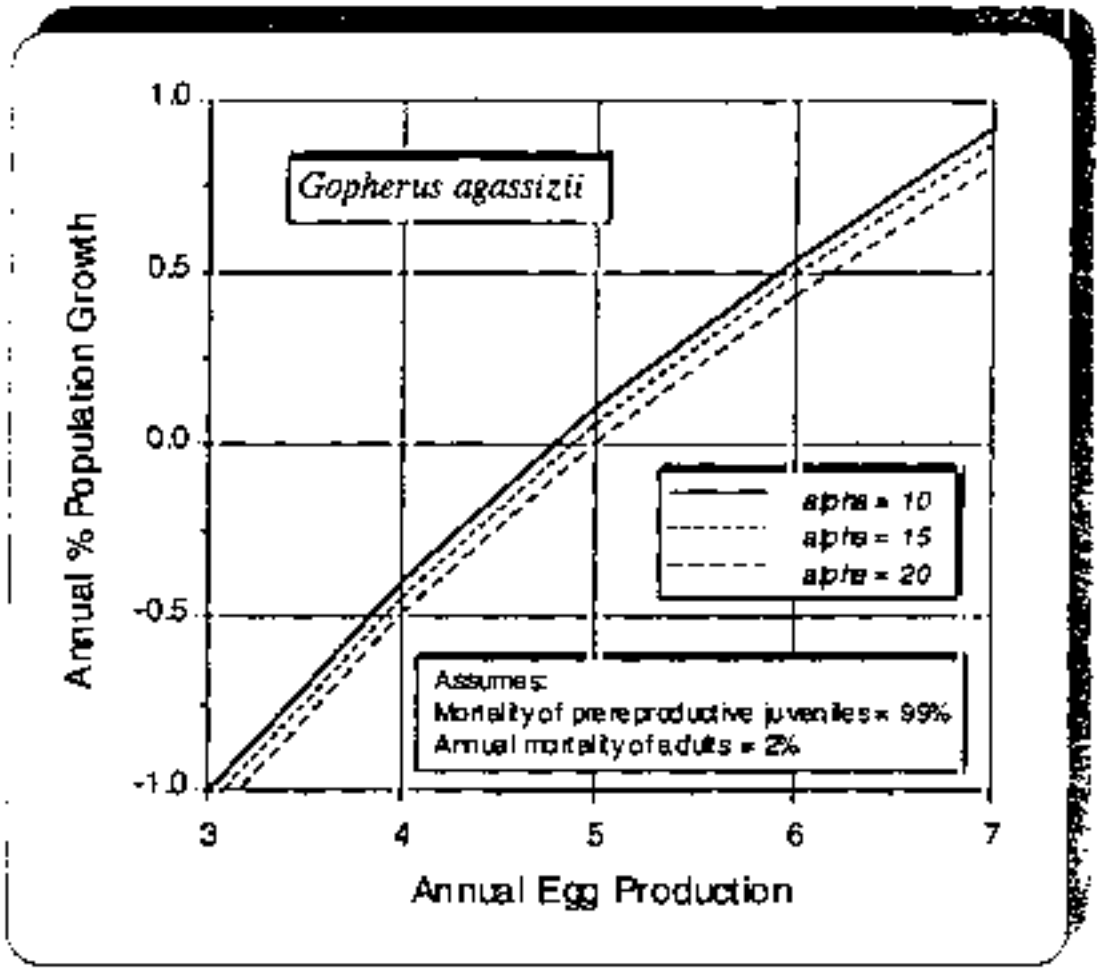


Figure 4. Simulated population growth rate of desert tortoises assuming various rates of mortality and maturation. Alpha is the age of first reproduction.

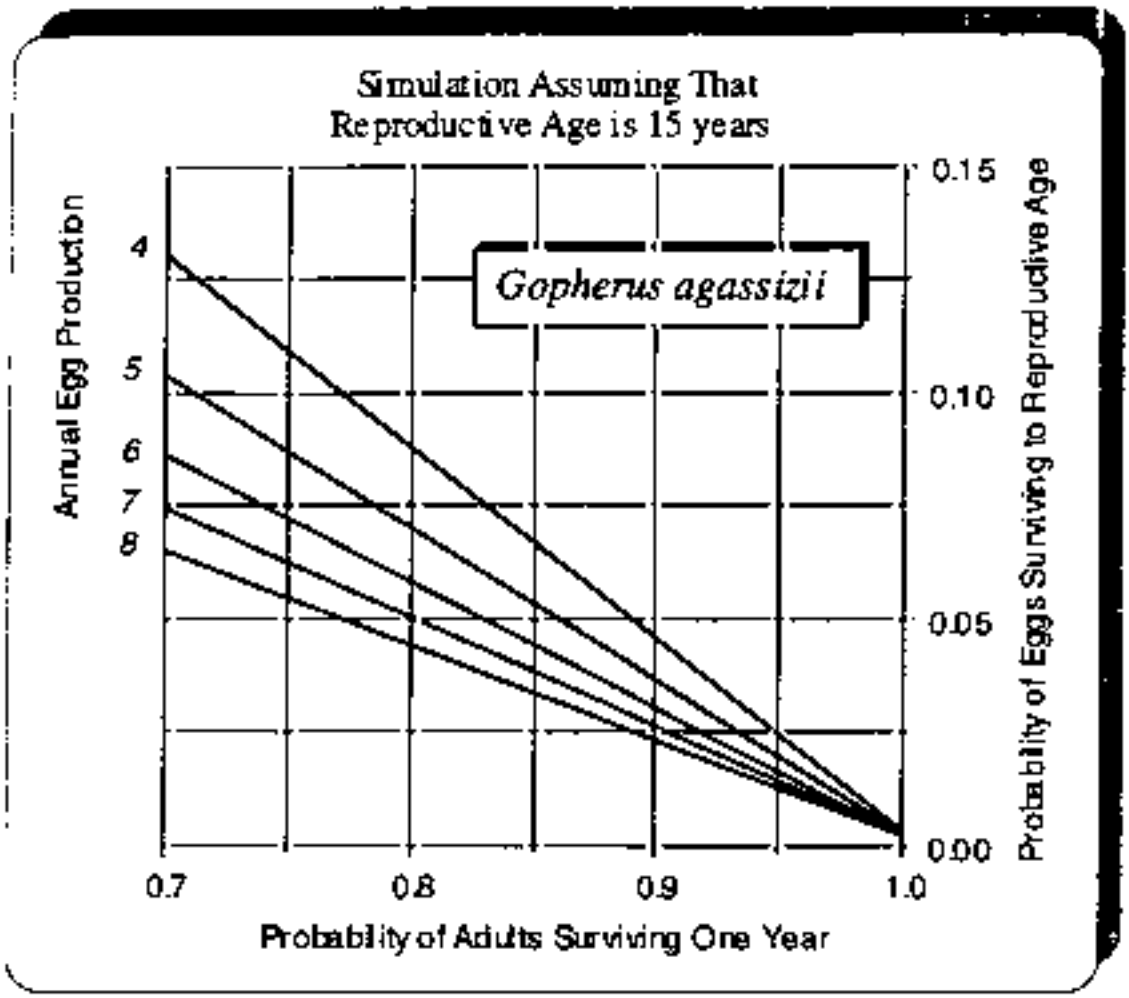


Figure 5. Adult and juvenile survivorship necessary to have a net reproductive rate of 1 (viz., a population neither growing nor declining) when females produce an average of 5 to 6 eggs per year.

Appendices

Desert Tortoise
(Mojave Population)

Recovery Plan

II. RECOVERY

A. Principles Followed in Developing Recovery Goals.

The following biological principles provide the framework for development of delisting criteria and the recovery strategy for the Mojave population of the desert tortoise.

1. Maintenance of distinct population segments.

Data on habitat use, general ecology, genetics, and behavior reviewed in section I.F. define six distinct population segments or recovery units of the desert tortoise within the Mojave region: the northern Colorado, the eastern Colorado, the Upper Virgin River, the eastern Mojave, the northeastern Mojave, and the western Mojave recovery units (Tables 2, 3, 4, and 5, Figure 3). Preserving viable populations of desert tortoises within each of these units is essential to the long-term recovery, viability, and genetic diversity of the species. Identification of these recovery units also facilitates the tailoring of recovery strategies to the varying biological requirements and management needs of each recovery unit. Within recovery units, Desert Wildlife Management Areas (DWMAs) need to be identified in which recovery actions will be implemented to provide for the long-term persistence of viable desert tortoise populations and the ecosystems upon which they depend.

2. Genetic considerations in population viability.

In small populations, short-term genetic deterioration occurs from inbreeding and loss of genetic heterozygosity (Frankel and Soulé 1981, Ralls and Ballou 1983). This genetic deterioration can cause problems in individual fitness and in the population's ability to increase. In the longer-term, inbreeding depression and loss of heterozygosity can limit the ability of the population to respond adaptively to changes in environment. Both of these problems can contribute to the probability of population extinction.

The extent to which genetic deterioration can affect populations is related to the genetically effective size (N_e) of the population (loosely defined as the number of individuals actually passing on their genes to the next generation). In vertebrates, N_e is usually between 0.1 and 0.5 of the total population size, N (Ryman et al. 1981, Shull and Tipton 1987). There are no data on N_e/N ratios in desert tortoises, but the age structure and mating strategies of this species indicate that its N_e/N ratio will be at the lower end of that range. The long-term evolutionary potential of populations requires an N_e of about 500 individuals, although this number is not very precise and might be off by an order of magnitude (Lande and Barrowclough 1987). Thus, if the N_e/N ratio for a desert tortoise

population is 0.1, and an N_e of about 500 to 5,000 individuals is required to maintain the long-term evolutionary potential of the species, then a population size (N) of 5,000 to 50,000 would be required for a genetically healthy population. Desert tortoise population age structures indicate that the percentage of adults in the population range between 4 and 40% (see Appendix C); thus, a population of 5,000 total individuals could have between 200 and 2,000 adult animals; a population of 50,000 total individuals could have between 2,000 and 20,000 adults. While estimates that vary over two orders of magnitude are not very satisfying, they indicate a need for caution in assessing the conditions under which a population will remain viable. Thus, a minimally viable population of desert tortoises from genetic considerations should probably contain at least 2,000 to 5,000 adult animals.

3. Demographic considerations in population viability.

In addition to genetic deterioration that can occur at very small population sizes, numerous negative demographic effects can occur when population sizes are small or when their densities are low. When population densities are very low, random variations in sex ratios, age distributions, and birth and death rates among individuals (called demographic stochasticity) can cause the population to fluctuate widely and potentially go extinct (Richter-Dyn and Goel 1972). In very sparse populations, males and females may have problems finding mates. This phenomenon is called the Allee effect, and it also can result in population declines or extinction (Ehrlich and Roughgarden 1987). In desert tortoises, the population densities below which demographic stochasticity and the Allee effect become a matter of concern are estimated to be approximately 10 adults per square mile (See Appendix C). Below this density extinction becomes increasingly possible.

Even at much larger sizes, populations can go extinct from a variety of random (stochastic) events, although large populations have a much lower probability of extinction than small ones. Recovery targets should be set at population levels that have comfortable extinction probabilities. To determine the likelihood of stochastic extinctions for desert tortoise populations of various sizes, three population viability analyses (PVAs) were performed (Appendix C). A PVA provides an estimate of how large a population has to be to have a given probability of persistence over a certain period of time.

The first PVA modeled population persistence as a function of the discrete population growth rate (lambda) and its variance. Using data from 13 study plots (see Appendix C), the average lambda was calculated to be 0.985 and its variance 0.08. Using these figures, the model predicted that 50% of the populations starting with 20,000 adult animals would go extinct within about 500 years, or 20 tortoise generations. This prediction was based upon observed variability in population growth rates during 1979-89, relatively equitable years for desert tortoises, at least with respect to food

production. Even so, the average lambda of 0.985 shows that populations declined during these years, although not drastically. However, during 1990 and 1991, population growth rates declined substantially because of the cumulative effects of drought and disease. Thus, an additional analysis was conducted which incorporated greater variability in population growth rates on the assumption that droughts and epizootics are likely to recur during the next few centuries. Increasing the variation in the 1979-89 growth rates by 50% resulted in the model predicting that a minimum population size of approximately 40,000 to 60,000 adult desert tortoises would be required in order for the population to persist for a 500-year median extinction time.

A second PVA was based on detailed demographic data from the Goffs study site in California and samples from 19 populations in California and Nevada which have been monitored for a number of years (Berry 1990, as amended). The mean lambda for this more extensive sample was determined to be 0.975 with a standard deviation of 0.019 (due entirely to random variation around population trends; the other sources of variation had been partitioned out). This model predicted that a population with this mean lambda (0.975) could never persist for more than about 390 years, or approximately 15 tortoise generations, regardless of initial population size. Running the model with lambdas of 1.0 and a standard deviation of 0.019 gave quite long times to extinction. A third PVA also emphasized the importance of lambdas near 1.0 for population persistence.

4. *Comprehensive considerations in population viability.*

These analyses of minimal viable populations and population persistence probabilities suggest several things. First, tortoise populations at minimum densities (10 adults per square miles) require at least 200 to 500 square miles to be genetically viable (see Sections II.A.2 and II.A3). Second, if lambdas are slightly below 1.0 but vary over a range of approximately 25%, extremely large reserves (5,000 square miles to support 50,000 adults at minimal density) are necessary to support populations that are relatively resistant to extinction within the next half century. Third, if lambdas are below 0.975 on average, no population size is large enough for persistence to 500 years.

These findings indicate that suitable DWMAs could be somewhere between 200 to 5,000 square miles, a fairly wide range of choices. In view of this uncertainty, at least 1,000 square miles is recommended as the target size. Reserves of this size will likely provide sufficient buffering from demographic stochasticity and genetic problems at low population densities, and they are large enough to support recovered populations that have reasonable probabilities of persistence into the future. The utility of large reserves in preventing extinction is one of the best established tenets

of conservation biology (e.g., Terborgh and Winter 1980; Soulé and Simberloff 1986). And, all else being equal, large reserves will conserve more species than small ones (Wilcox 1980; Simberloff and Abele 1982; Wilcove et al. 1986).

Large reserves will also facilitate managing desert tortoise populations within the DWMAs to maintain average lambdas of 1.0 or more during the recovery process. Large reserves are more likely to have sufficient internal environmental heterogeneity and enough isolated areas in their interiors to ensure that some subpopulations will be growing even if others are declining. In summary, genetic, demographic, and other considerations point to the inescapable conclusion that small reserves in a highly fragmented habitat are a recipe for extinction of the desert tortoise.

A preliminary analysis suggests that there may be a mechanistic link between mean annual production of grasses and forbs and maximum tortoise densities (see Appendix G). However, additional research is necessary to ascertain what properties of the environment determine the maximum number of tortoises that can be supported in particular regions of the desert. Information from this kind of research is critical to a proper evaluation process of the efficacy of management schemes.

5. *Reserve architecture.*

DWMA size is not the only important consideration in determining the probability of success in preserving desert tortoise populations. Principles of reserve design dictate that the shape of DWMAs is also very important (see Section II.D.1.d). Population persistence will be maximized in a recovery unit if the unit has several large DWMAs (each of which is at least 1,000 square miles; see Section II.A.3). Furthermore, these DWMAs should be designed to minimize perimeter relative to area. The optimal shape for such a DWMA is circular, but this configuration may not be feasible (see Figure 6A). Fewer large DWMAs per recovery units diminish persistence probabilities; a minimally acceptable condition is one large DWMA with a minimum perimeter/area ratio (Figure 6B). When no other choice is available, it may be necessary to create smaller DWMAs. These must be connected with very wide strips of suitable tortoise habitat (Figure 6C). In extreme cases, it may be necessary to create DWMAs that are smaller than the recommended size and unconnected to other DWMAs by functional habitat. Such DWMAs must be intensely managed to control extrinsic sources of mortality (Figure 6D). More details on reserve design are found in Section D.1.b.

RECOVERY UNITS

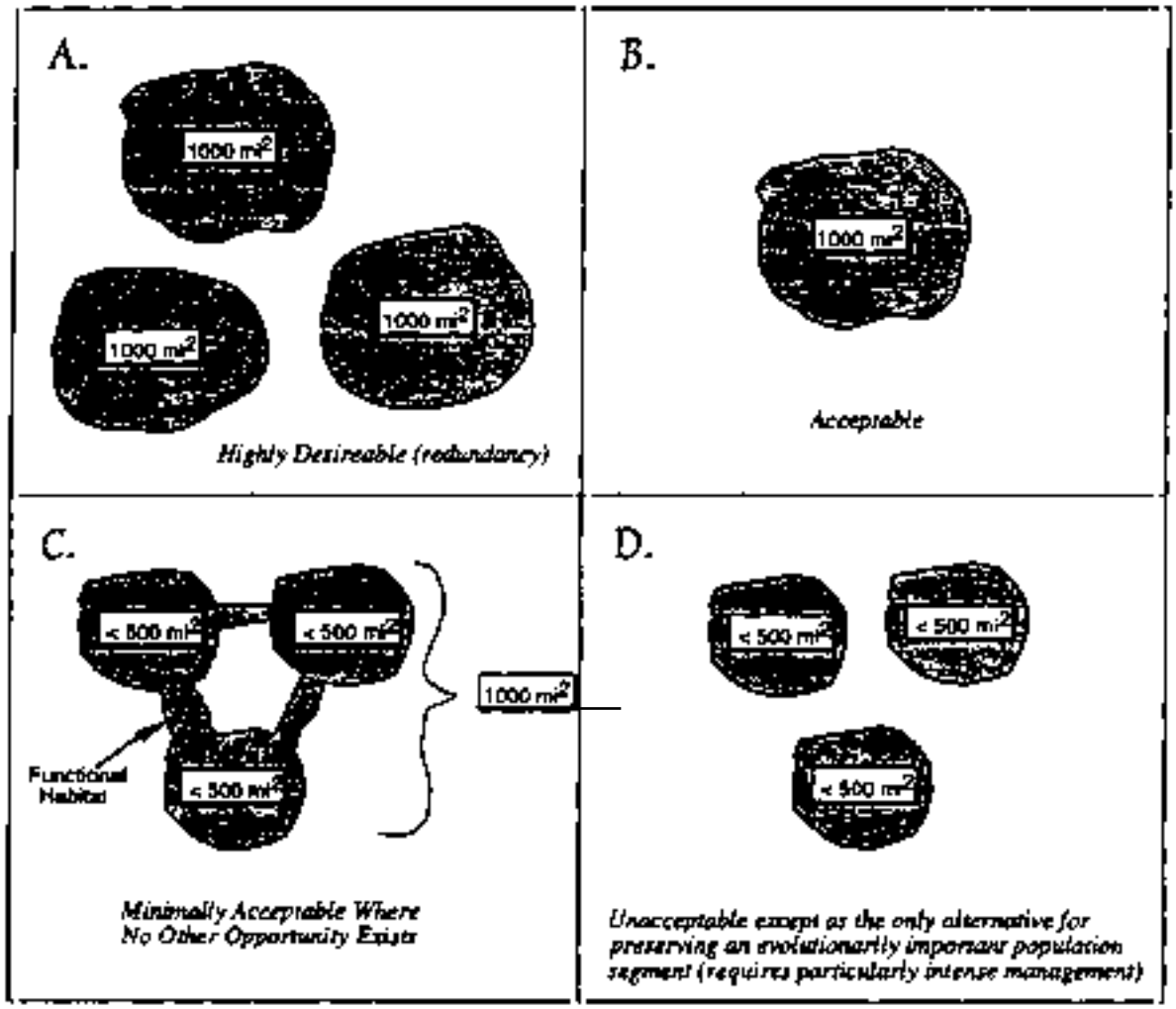


Figure 6. Schematic representation of possible wildlife reserves within recovery units; (A) The recommended arrangement in which several DWMAs will be located in each recovery unit; (B) The minimally acceptable arrangement in which there is no redundancy in DWMAs, (C) The minimally acceptable arrangement in situations in which it is not possible for a round DWMA - corridors of suitable habitat need to connect smaller units of a DWMA; (D) The generally unacceptable alternative of small, unconnected DWMAs. Such reserves must be intensely managed in perpetuity to ensure population persistence.

6. Ecosystem protection.

Section 2(b) of the Endangered Species Act provides for protection of the ecosystems on which threatened or endangered species depend. Thus, survival and recovery of the desert tortoise should occur in its natural habitat, not in zoological gardens or other artificial situations, and DWMAs should protect the environments in which the desert tortoise lives. In preserving these environments, other species will benefit, including many rare and/or sensitive species. Land managers are strongly encouraged to take a multi-species approach to reserve design and include habitat of other rare or declining species into DWMAs. Such an approach would reduce the need to list other species of plants and animals in the Mojave region.

B. Recovery Strategy

This Recovery Plan describes a strategy for the recovery and delisting of the Mojave population of the desert tortoise. This strategy includes: (1) identification of six recovery units within the Mojave region, (2) establishment of a system of DWMAs within recovery units, and (3) development and implementation of specific recovery actions within DWMAs. This recovery strategy will be revised as recovery actions are implemented and new information becomes available from research and monitoring.

1. Size and number of reserves.

The key to this recovery strategy is timely establishment of at least one DWMA in each recovery unit and prompt implementation of reserve-level protection within them. DWMAs must be located in areas with good desert tortoise habitat currently supporting a minimum of several hundred adult animals at a density of no fewer than 10 per square mile (See Section II.A). More than one DWMA within each recovery unit will increase the probability that a population within a recovery unit will recover. The Recovery Plan identifies 14 proposed DWMAs (Table 6, Figures 7, 8, 9, 10, Apendix F), some of which occur in more than one recovery unit. Summary descriptions of the 14 proposed DWMAs are presented in Appendix F and Brussard et al. (1994).

2. Experimental management zones.

All DWMAs should restrict human activities that negatively impact desert tortoises (Section II.E.1., Appendix F, Brussard et al. 1994). However, a maximum of 10% of tortoise habitat within a DWMA may be designated as an experimental management zone (EMZ) where certain prohibited activities (e.g., intrusive research on desert tortoises) may be permitted on an experimental basis during the recovery period. EMZs should be located toward a DWMA's periphery.

3. Modification of the Recovery Plan.

Conservation biology works with the best available knowledge for any given species in its current situation as the basis for hypotheses or models that will best effect the recovery of the species. These models originate, and are debated, on the scientific side of conservation biology. They evolve quite slowly, and are usually stable throughout the planning process. However, new data can become available at any time, and such new data should be able to influence management practices. Thus, this Recovery Plan should be reassessed every three to five years or at any time it becomes apparent that the plan is not fulfilling its function to guide recovery. Reassessment should be based on recent and ongoing research, on population and habitat trends, and on the results of any restoration efforts both inside and outside of the DWMAs. The reassessment team should consist of representatives from all affected Federal, state, and local wildlife and land management agencies, and experts in the field from other agencies, the private sector, and academia. The Desert Tortoise Management Oversight Group should facilitate this review process.

Table 6. List of Desert Wildlife Management Areas, their current estimated densities (adults per square mile), and degree of threat (1=low, 5=extremely high).

Recovery Unit	DWMA	Estimated Density (adults/mi^2)	Degree of Threat
Northern Colorado			
	Chemehuevi	10-275	1
Eastern Colorado			
	Chuckwalla	5-175	4
Upper Virgin River			
	Upper Virgin River	up to 250	5
Eastern Mojave			
	Fenner[1]	10-350	3
	Ivanpah[2]	5-250	3
	Piute-Eldorado[2]	40-90	2
Northeastern Mojave			
	Beaver Dam Slope	5-60	5
	Coyote Spring	up to 90	2
	Gold Butte-Pakoon	5-60	2
	Mormon Mesa	40-90	3
Western Mojave			
	Fremont-Kramer	5-100	5
	Ord-Rodman	5-150	4
	Superior-Cronese	20-250	5
	Joshua Tree[3]	up to 200	1

1 Located in both the eastern and northern Colorado recovery units.
2 Located in both the eastern and northeastern Mojave recovery units.
3 Southeastern corner of this DWMA is located in the eastern Colorado recovery unit.

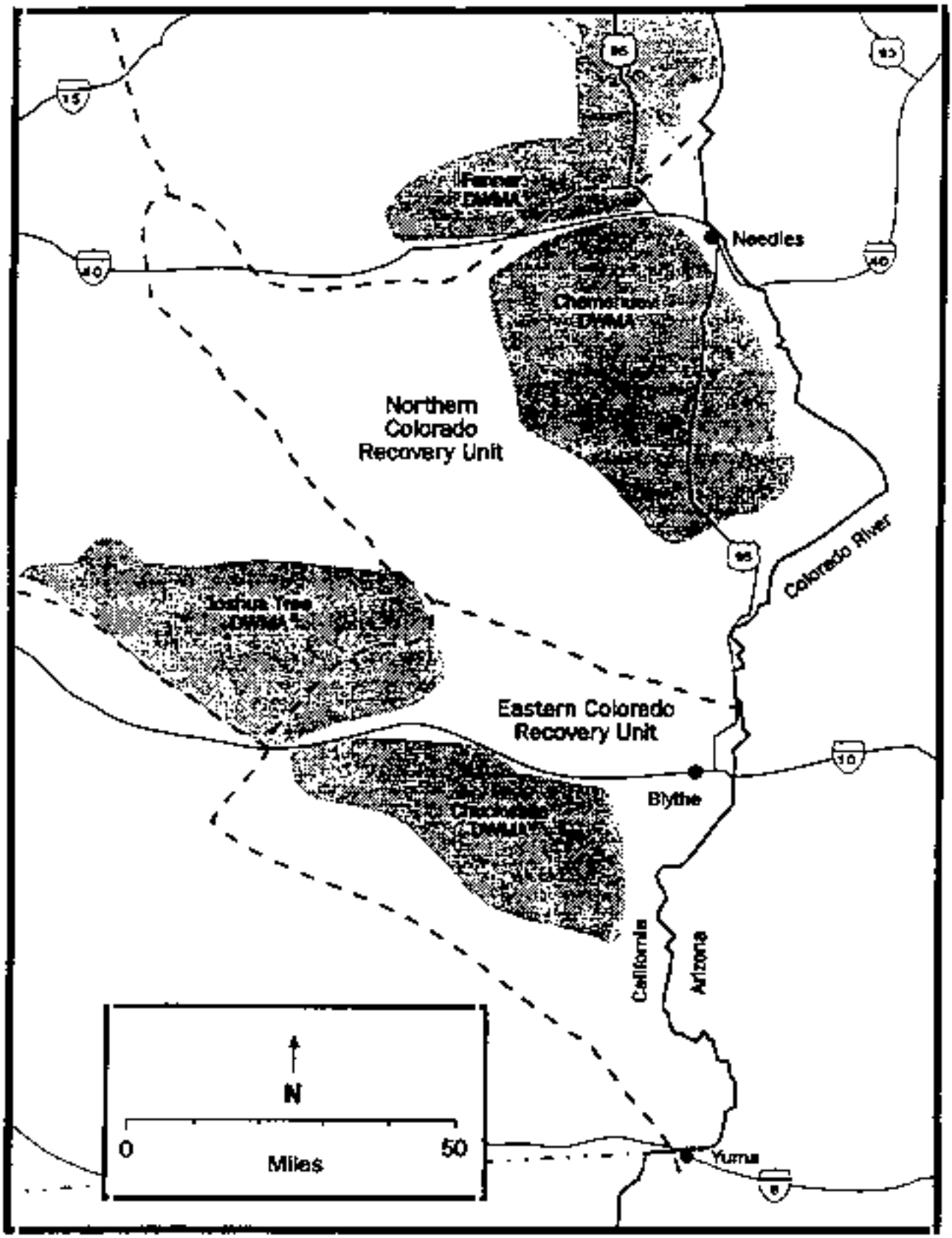


Figure 7. Proposed DWMAs in the northern Colorado and eastern Colorado recovery units.

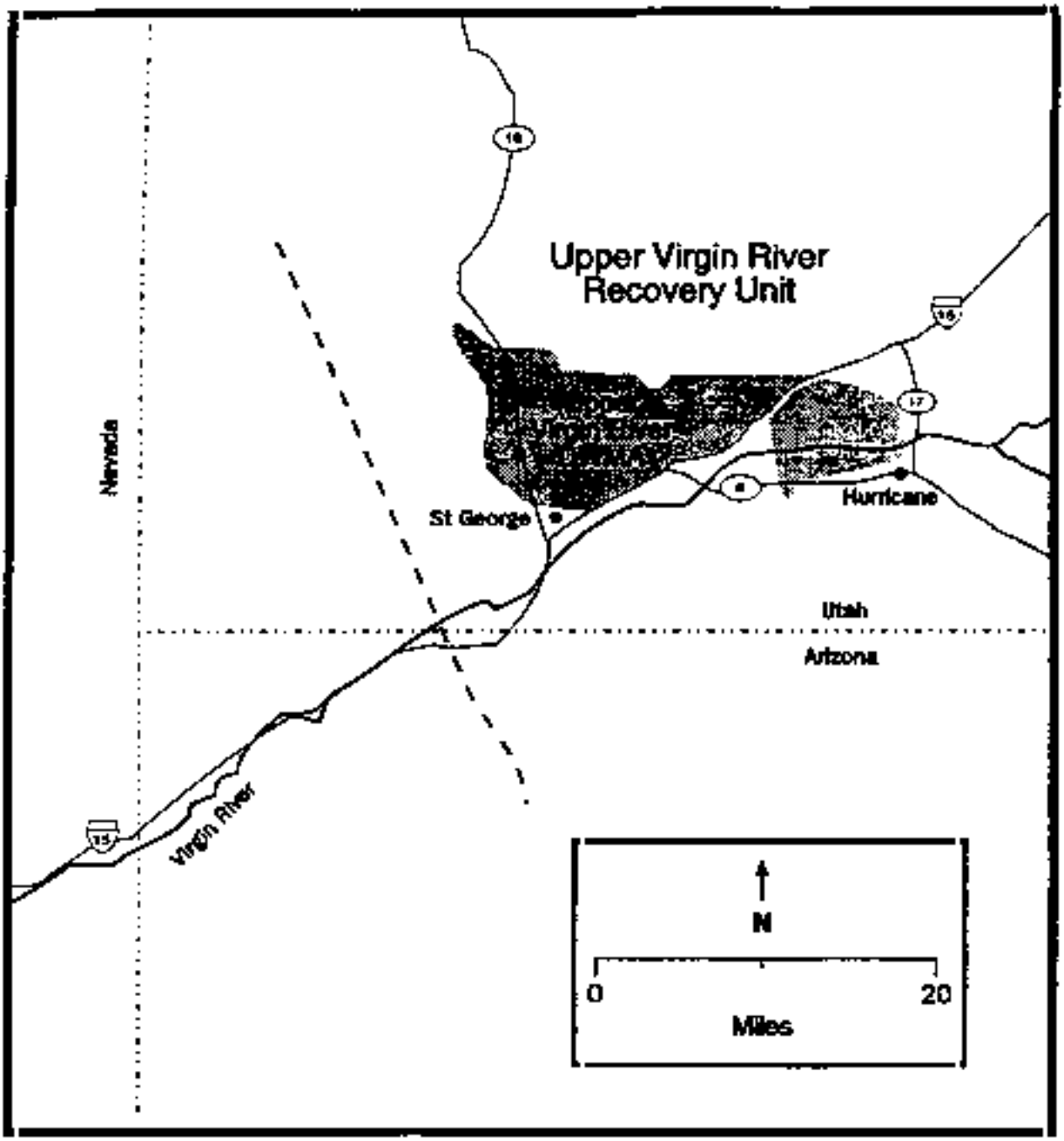


Figure 8. Proposed Upper Virgin River DWMA in the Upper Virgin River recovery unit.

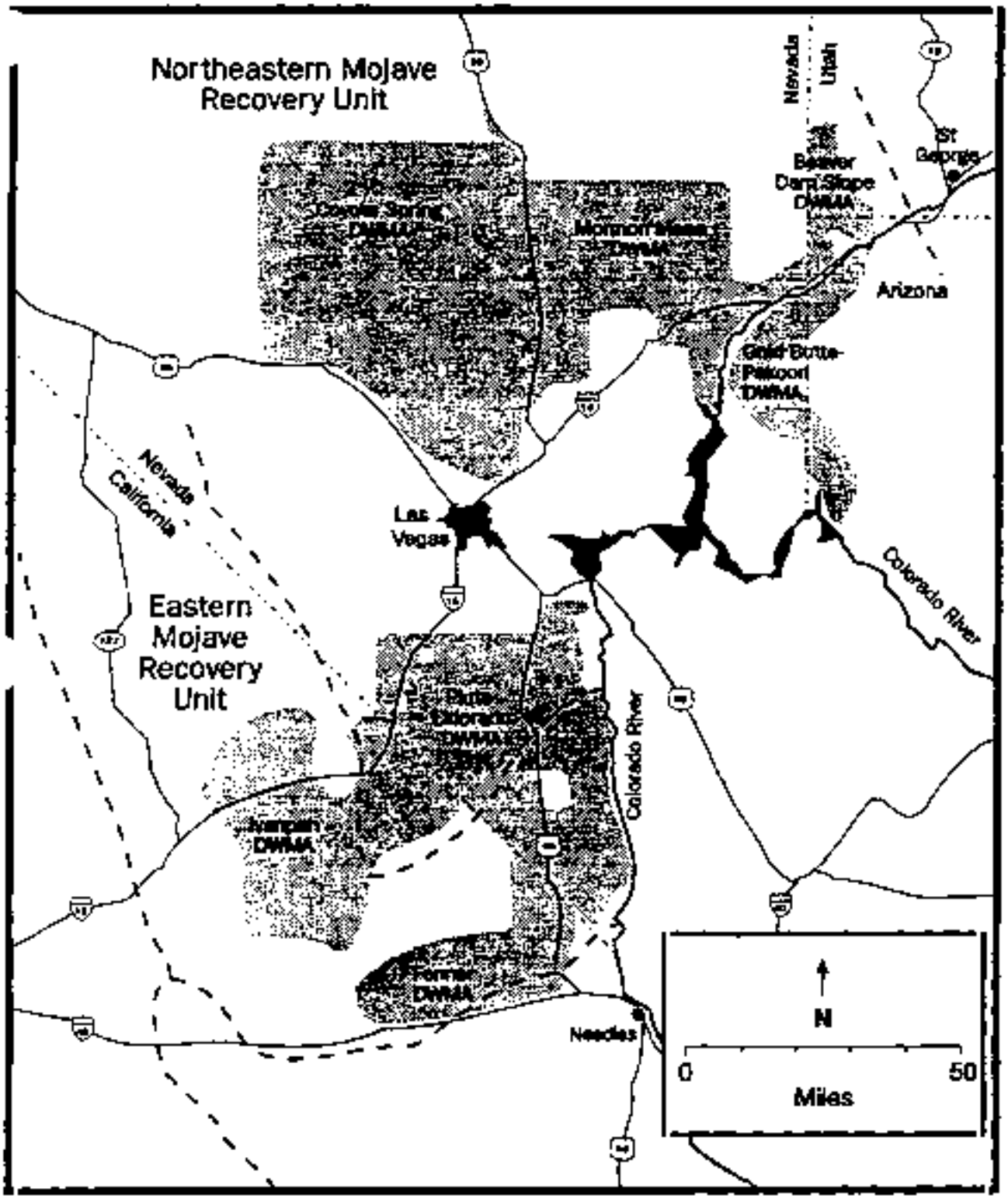


Figure 9. Proposed DWMAs in the eastern and northeastern Mojave recovery units.

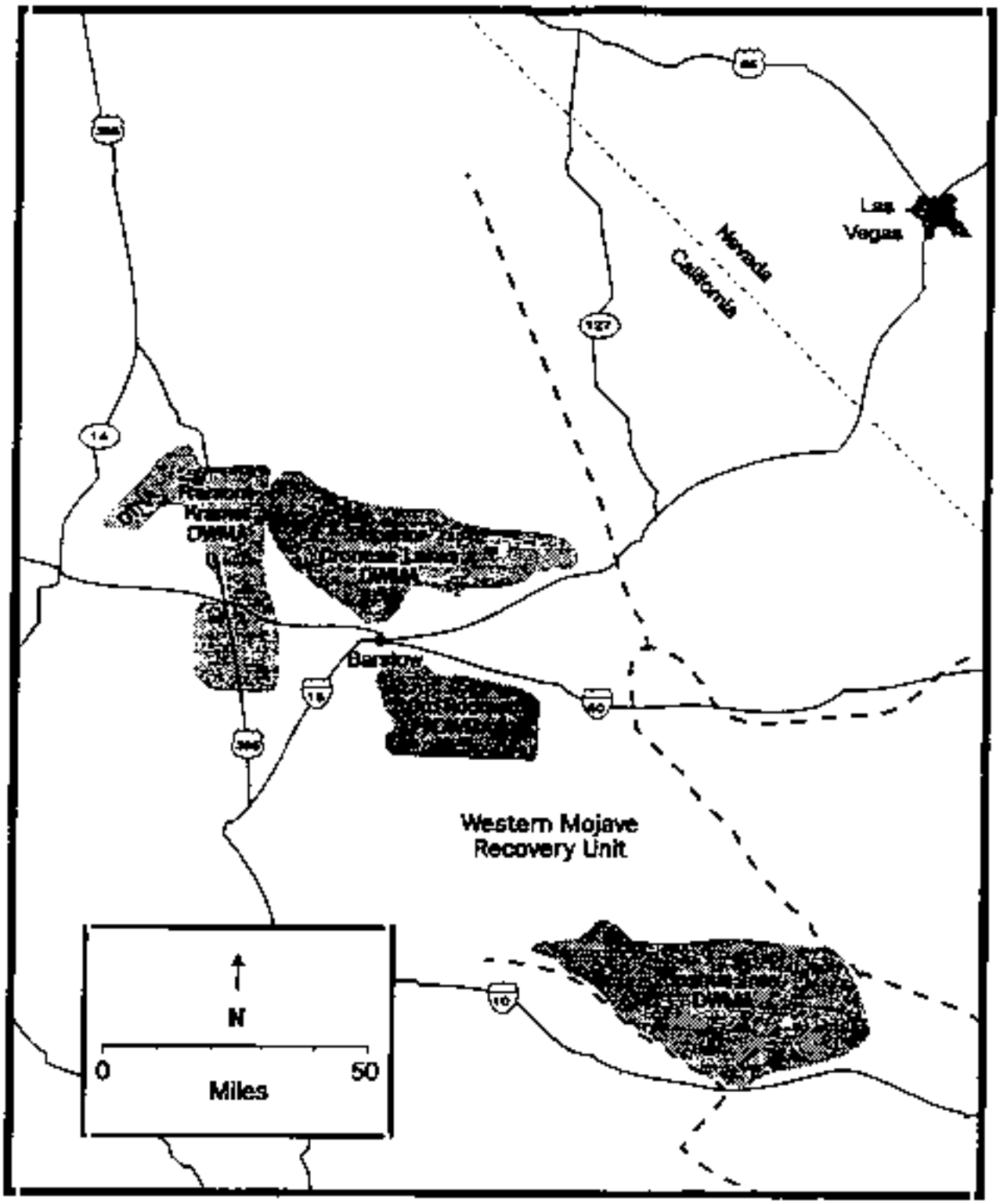


Figure 10. Proposed DWMAs in the western Mojave recovery unit.

C. Recovery Objective and Delisting Criteria.

1. Recovery objective.

The objective of this Recovery Plan is the recovery and delisting of the Mojave population of the desert tortoise. Management actions and research necessary to effect recovery are described, supported, and scheduled.

2. Recovery criteria.

Desert tortoise populations, which are only capable of very slow growth, have declined substantially throughout much of the Mojave region in the last two decades. Therefore, desired improvement in the status of these populations will necessarily be a very long process, measured in decades or centuries. Nevertheless, delisting may be considered if population size is stationary or increasing (long-term trends in lambda are equal to or less than 1.0), sufficient habitat is protected or managed for recovery and long-term persistence, regulatory mechanisms are in place, and the population is unlikely to become threatened again in the foreseeable future.

Recovery units are considered distinct population segments and may be individually delisted if they meet the recovery criteria. Specifically, the population within a recovery unit may be considered for delisting when **all** of the following criteria are met:

Delisting Criterion 1:

As determined by a scientifically credible monitoring plan, the population within a recovery unit must exhibit a statistically significant upward trend or remain stationary for at least 25 years (one desert tortoise generation). Consistent with Appendix A, a sampling plan should be instituted in each recovery unit to monitor the progress of recovery. Appendix A calls for a population estimation every 5 years; thus data from at least five estimates need to be considered in evaluating population trends. Monitoring should continue following delisting to ensure population stability.

Delisting Criterion 2:

Enough habitat must be protected within a recovery unit, or the habitat and the desert tortoise populations must be managed intensively enough, to ensure long-term population viability. Consistent with section II.A., at least one DWMA must be established in each recovery unit that is, except under unusual circumstances, at least 1,000 square miles in area.

Delisting Criterion 3:

Provisions must be made for population management at each DWMA so that populational lambdas are maintained at or above 1.0 into the future.

Delisting Criterion 4:

Regulatory mechanisms or land management commitments have been implemented that provide for adequate long-term protection of desert tortoises and their habitat, such as those described in Sections II.D. and E. Delisting would be followed by a loss of protection under the Endangered Species Act; therefore adequate protection through alternative means is essential before delisting can occur. For example, management plans for Federal lands should provide adequate assurances of habitat protection prior to consideration of delisting. The form of these regulations, commitments, and their implementation should be determined during future land management planning efforts and will likely vary throughout the Mojave region and by agency, reflecting the differing management needs of different areas. Reasonable assurance must exist, on a case by case basis, that conditions which brought about population stability will be maintained, or as necessary, improved during the foreseeable future.

Delisting Criterion 5:

The population in the recovery unit is unlikely to need protection under the Endangered Species Act in the foreseeable future. Detailed analyses of the likelihood that a population will remain stable or increase must be carried out before determining whether it is recovered. These analyses should include observed and anticipated effects of: (a) fluctuations in abundance, fecundity, and survivorship; (b) movements of desert tortoises within the area and to or from surrounding areas; (c) changes in habitat, including catastrophic events; (d) loss of genetic diversity; and (e) any other threats to the population which might be significant.

When the population within a recovery unit meets all of these five criteria it may be considered recovered and eligible for delisting. When all recovery units are considered recovered, the Mojave population of the desert tortoise could be considered for delisting. These recovery criteria were designed to provide a basis for consideration of delisting, but not for automatic delisting. Before delisting may occur, the Fish and Wildlife Service must determine that the following five listing factors are no longer present or continue to adversely affect the listed species: (1) the present or threatened destruction, modification, or curtailment of the species' habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease and predation; (4) inadequacy of existing regulatory mechanisms; and (5) other human-made or natural factors affecting the continued existence of

the species (50 CFR 424.11). The final decision regarding delisting would be made only after a thorough review of all relevant information by the Fish and Wildlife Service.

The five recovery criteria and the methods to determine densities will be revised as appropriate as new information pertinent to these topics becomes available. Revisions must be based on the best data available and must be approved by the Fish and Wildlife Service.

D. *Narrative Outline Plan for Recovery Actions Addressing Threats*

The desert tortoise was listed as threatened primarily because of a variety of human impacts which cumulatively have resulted in widespread and severe desert tortoise population decline and habitat loss. The destruction, degradation, and fragmentation of desert tortoise habitat and loss of individual desert tortoises from human contact, predation, and disease are all important factors in the decline of the Mojave population (section I.B.). If the desert tortoise is to be recovered within its native range, the causes of the decline must stop, at least within the DWMAs. Some factors are likely more important than others; for instance, urbanization has probably caused more habitat loss than light cattle grazing. However, eliminating all factors that are deleterious to desert tortoise populations will certainly result in faster recovery than will selective elimination of a few.

Because of the many political jurisdictions in the Mojave region, implementation of recovery actions will require unprecedented interagency cooperation. Delays in implementing this Recovery Plan caused by political constraints would increase the costs of recovery and decrease the likelihood that recovery efforts will successfully avert extinction of the desert tortoise. Interagency cooperation could be facilitated by the Desert Tortoise Management Oversight Group. All agencies with management responsibilities for the desert tortoise need to participate in the implementation of the recovery strategy.

Desert tortoises outside of DWMAs will still be protected by section 9 of the Endangered Species Act. Take of desert tortoises is prohibited unless specifically authorized by the Fish and Wildlife Service pursuant to sections 7 or 10 of the Endangered Species Act. These desert tortoises may be important in recovery of the Mojave population by providing a source of adult desert tortoises for repopulating extirpated populations in DWMAs once translocation techniques have been perfected. Habitat outside DWMAs may provide corridors for genetic exchange and dispersal of desert tortoises among DWMAs.

In addition, isolated populations of healthy desert tortoises found outside of DWMAs should be noted, but no active management is

recommended for these populations unless it is needed to ensure their viability. These isolated populations may have a better chance of surviving the potentially catastrophic effects of URTD or other diseases than large, contiguous populations.

Accomplishment of the recovery actions described in this section is needed to reduce or eliminate human-caused impacts in the recovery units and to implement the recovery strategy described in section II.C. Recovery actions are listed in a stepdown form in which broad categories of recovery actions are stepped down to specific tasks. Tasks listed here also appear in the Implementation Schedule (Section III), in which costs and scheduling are estimated and lead Federal agencies are identified for specific actions. DWMA-specific tasks and costs, which will be crucial to implementation of management plans, are not detailed here or in the Implementation Schedule because they will vary depending on the number, location, and size of DWMAs selected and the management needs of specific areas. The contributions of state agencies will come into play when specific management plans are written for each recovery unit.

Although DWMA-specific management actions cannot yet be precisely defined, the reduction and elimination of threats necessary to recover the desert tortoise broadly define the range of actions necessary within DWMAs. Actions which will likely be needed in all DWMAs to address these threats are listed in Section II.E. The summary descriptions for each DWMA in Appendix F include recommendations to address site-specific management needs of the 14 proposed DWMAs. These recommendations are presented to aid land managers in the development of management plans. These plans should implement the guidance provided in this Recovery Plan. The costs associated with the following recommended tasks are provided in the Implementation Schedule (Section III). The Implementation Schedule will be amended and expanded as management plans are developed and DWMA-specific management actions are identified. In addition, as new information becomes available and recovery actions are implemented, ongoing recovery actions may be modified to speed recovery.

1. Establish DWMAs and implement management plans for each of the six recovery units.

Management plans should be developed and implemented for each of the six recovery units. Such management plans should determine the number, size, location, and boundaries of DWMAs; determine how habitat within DWMAs will be secured and managed, and describe how monitoring of the recovery effort will be accomplished. Plans should be developed by land management agencies in close coordination with the Fish and Wildlife Service, State wildlife agencies, local governments, and the public. Splitting recovery units by political or other boundaries and developing more than one management plan to address a single recovery unit should be discouraged. Nevertheless, additional site-specific plans to address

management of individual DWMAs may be appropriate to implement guidance provided in the recovery unit management plans.

DWMAs have great potential to serve as multi-species reserves which could conserve habitat for a variety of species. Land managers should be strongly encouraged to consider this multi-species approach in development of recovery unit management plans, as it could preclude the need for Federal listing of other sensitive species of the Mojave region. The Western Mojave Coordinated Management Plan, currently being developed by the BLM, California Department of Fish and Game, Fish and Wildlife Service, and local governments, could be the first of these recovery unit management plans.

1.a. Select DWMAs.

General requisites for determining number and size of DWMAs in a recovery unit are described in the Recovery Strategy (Section II.B.). Generally, reserves should be established within each recovery unit which are at least 1,000 square miles in extent, or if this is not possible, particularly intensive habitat and desert tortoise population management should be implemented to ensure long-term viability of the population. In many areas of the Mojave Desert, it is possible to establish DWMAs large enough to provide a high probability of recovery. However, some population segments will have to be recovered in smaller DWMAs. These will have to be particularly well managed to prevent extinctions because of the higher probabilities of extinction ascribed to small populations (see Appendix C). Many population segments within most recovery units are currently declining, and human-caused mortality, habitat loss, and the possible catastrophic effects of URTD or other diseases further endanger these populations. Thus, simply setting aside the minimum land area necessary to support a viable population will not be adequate to effect recovery.

The task of selecting DWMAs is listed in the Implementation Schedule in a stepdown fashion by recovery unit. Table 6 lists the Recovery Team's recommendations for DWMAs in the six recovery units. Proposed DWMAs are described in Table 6, Figures 7, 8, 9, 10, Appendix F, and in Brussard et al. (1994).

1.a.1. Northern Colorado Recovery Unit

1.a.2. Eastern Colorado Recovery Unit

1.a.3. Upper Virgin River Recovery Unit

1.a.4. Eastern Mojave Recovery Unit

1.a.5. Northeastern Mojave Recovery Unit

1.a.6. Western Mojave Recovery Unit

1.b. Delineate DWMA boundaries.

Whenever possible, DWMA boundaries should be drawn to include the best examples of desert tortoise habitat in specific vegetation regions. In addition, heterogeneous terrain, soil types, and vegetation within DWMAs will best provide protection for the entire ecosystems upon which healthy desert tortoise populations depend.

Boundary delineations for DWMAs (and contained EMZs) should be consistent with current theory and practice of reserve design (Thomas et al. 1990, Noss 1991). Land-management agencies should follow these guidelines when establishing boundaries for DWMAs and EMZs. These guidelines should also be followed in prescribing management goals.

(a) Reserves that are well-distributed across a species' native range will be more successful in preventing extinction than reserves confined to small portions of a species' range. Preservation of one or more viable populations within each of the six recovery units will ensure that the full range of variation within the species is maintained, enhancing the desert tortoise's ability to adapt or adjust to future environmental changes.

(b) Large blocks of habitat, containing large populations of the target species, are superior to small blocks of habitat containing small populations. While the persistence of all desert tortoise populations is subject to the effects of environmental stochasticity and catastrophes, the persistence of small populations is additionally threatened by demographic and genetic stochasticity (see Section II.A. and Appendix C). This means that the largest possible blocks of good desert tortoise habitat in an area, containing the most dense desert tortoise populations, should be included within DWMA boundaries.

(c) Blocks of habitat that are close together are better than blocks far apart. This arrangement facilitates dispersal of desert tortoises among habitat patches. Connecting habitat segments should be of medium to high quality and be wide enough to accommodate several desert tortoise home-range widths (several miles), but narrow enough to discontinue contact between DWMAs by double fencing, if necessary to impede the spread of disease (Figure 6). Such linkages are necessary both for a demographic "rescue effect" (Brown and Kodrik-Brown 1977) and for continued genetic interchange.

(d) Habitat that occurs in less fragmented, contiguous blocks is preferable to habitat that is fragmented. The desert tortoise does best in undisturbed environments where the presence of edge species, such as ravens, is minimized. Highly fragmented habitat is mostly edge (because small patches maximize the ratio of edge to interior area) and should be avoided to the extent possible within DWMAs.

(e) Habitat patches that minimize edge to area ratios are superior to those that do not. This means that round or square patches of habitat are more likely to retain desert tortoise populations than elliptical or rectangular ones. Long, linear strips are the least desirable.

(f) Interconnected blocks of habitat are better than isolated blocks, and linkages function better when the habitat within them is represented by protected, preferred habitat for the target species. Interpopulation dispersal, as mentioned above, is important for population persistence. One possible negative effect of interpopulation dispersal on the desert tortoise is the potential for spreading disease from infected to non-infected populations. Inclusion of isolated but healthy populations into DWMAs could be valuable in avoiding the possible catastrophic effects of this disease. However, aside from the problems of disease transmission, the advantages of dispersal often outweigh the disadvantages. Thus, maintaining linkages among habitat patches within DWMAs and among the DWMAs themselves is considered here to be important. This will require maintaining connecting segments of habitat that are at least marginally acceptable to the desert tortoise.

(g) Blocks of habitat that are roadless or otherwise inaccessible to humans are better than blocks containing roads and habitat blocks easily accessible to humans. Because declines in desert tortoise populations are associated with high densities of access routes, vehicular traffic, and human access (Appendix D, Schoenwald-Cox and Buechner 1992), the access must be limited in the DWMAs. Populations within DWMAs that are inaccessible to motorized recreation or similar activities will have a much better chance of recovery than those in DWMAs where human access is prevalent.

Delineation of DWMA boundaries should be guided by the above concepts and will be integral to development of recovery unit management plans.

1.b.1. Northern Colorado Recovery Unit

1.b.2. Eastern Colorado Recovery Unit

1.b.3. Upper Virgin River Recovery Unit

1.b.4. Eastern Mojave Recovery Unit

1.b.5. Northeastern Mojave Recovery Unit

1.b.6. Western Mojave Recovery Unit

1.c. Secure habitat within DWMAs.

To ensure manageability, private and State lands in DWMAs (exclusive of State parks or other lands managed for the benefit of the desert tortoise) should be acquired or conservation agreements developed to protect desert tortoise habitat. Land acquisitions should include surface and subsurface mineral rights whenever possible. Habitat conservation plans, or similar efforts, should consider this as appropriate mitigation for the take of desert tortoises and/or habitat.

1.c.1. Northern Colorado recovery unit

1.c.2. Eastern Colorado recovery unit

1.c.3. Upper Virgin River recovery unit

1.c.4. Eastern Mojave recovery unit

1.c.5. Northeastern Mojave recovery unit

1.c.6. Western Mojave recovery unit

1.d. Develop reserve-level management within DWMAs.

Because the factors causing the decline of the desert tortoise are primarily human-related (see Section I.B.), many human activities within DWMAs will need to be strictly regulated or eliminated. Because the kinds and levels of human uses vary among recovery units and proposed DWMAs, defining specific management actions needed for recovery must be preceded by DWMA selection and boundary delineation. DWMA management needs could be identified in recovery unit management plans or in specific DWMA plans. Section II.E. describes recommended recovery actions in DWMAs which should become part of recovery unit management plans if DWMAs are selected and delineated as described here. Recommended management actions should be tailored to the needs of specific DWMAs and include activities such as eliminating burro, horse, and domestic livestock grazing; limiting vehicular access, including prohibiting new vehicular access and reducing existing access; and prohibiting new surface disturbances, except to improve the quality of wildlife habitat, watershed protection, or improve opportunities for non-motorized recreation; among others (see Section II.E.).

1.d.1. Northern Colorado recovery unit

1.d.2. Eastern Colorado recovery unit

1.d.3. Upper Virgin River recovery unit

1.d.4. Eastern Mojave recovery unit

1.d.5. Northeastern Mojave recovery unit

1.d.6. Western Mojave recovery unit

1.e. Implement reserve-level management within DWMAs.

Once habitat is secured, management necessary to remove threats to the desert tortoise and its habitat must be implemented. Specific actions are recommended in Section II.E. and include activities such as partial fencing of DWMA boundaries to control livestock, burros, and horses; increased law enforcement; closure of vehicle routes and designation of vehicle ways; and construction of barrier fencing and highway underpasses that can be used by desert tortoises, thus reducing mortality of animals on and near roads and railroad tracks.

DWMAs will serve as recovery sites for the desert tortoise, but they will also be important as ecosystem reserves and as habitat for other rare and/or sensitive species or communities. DWMAs also can play a secondary role in providing watershed protection and some forms of recreation which are compatible with desert tortoise recovery. Management actions should be tailored to meet these other needs whenever possible. These concepts helped shape the management recommendations in Section II.E., Appendix F, and Brussard et al. (1994).

Although specific tasks are difficult to define at this time, implementation of recovery unit plans will be a crucial step in recovering the desert tortoise. As a result, implementation is included in the Implementation Schedule. Most costs and scheduling are listed as "to be determined", as they are contingent upon size and location of DWMAs.

1.e.1. Northern Colorado recovery unit

1.e.2. Eastern Colorado recovery unit

1.e.3. Upper Virgin River recovery unit

1.e.4. Eastern Mojave recovery unit

1.e.5. Northeastern Mojave recovery unit

1.e.6. Western Mojave recovery unit

1.f. Monitor desert tortoise populations within recovery units.

Monitoring of desert tortoise populations will be crucial to determining if desert tortoise populations are stationary, declining, or increasing (recovery criterion 1). Currently, monitoring of trends in population densities, such as described in Appendix A, is the only defensible way to evaluate recovery of desert tortoise populations. The advantages of this method include: (1) it assesses population trends over large areas, not just in single plots; (2) sample areas are selected randomly, allowing comparisons with standard statistical techniques; and (3) it violates no known assumptions of the underlying model.

Population trend monitoring should be funded by the appropriate land management agency, conducted by qualified biologists, and reviewed by the Fish and Wildlife Service and other appropriate agencies. If monitoring indicates that the desert tortoise population within a DWMA or recovery unit is not progressing towards recovery, management within DWMAs will need to be modified to ensure positive population growth or stability.

In addition to the population trend monitoring described in Appendix A, intensive, long-term study plots should also be maintained throughout the Mojave region, because the data they produce are critical for a thorough understanding of desert tortoise population biology and are necessary for delisting criterion #4.

1.f.1. Develop monitoring plan

A monitoring plan has been completed (Appendix A) and a workshop will be held in 1994 to further refine the techniques to be used for the desert tortoise.

1.f.2. Implement monitoring plan

Apply the monitoring plan developed in task 1.f.1. to each of the six recovery units.

1.f.2.a. Northern Colorado recovery unit

1.f.2.b. Eastern Colorado recovery unit

1.f.2.c. Upper Virgin River recovery unit

1.f.2.d. Eastern Mojave recovery unit

1.f.2.e. Northeastern Mojave recovery unit

1.f.2.f. Western Mojave recovery unit

2. Establish environmental education programs.

Start an aggressive and widespread effort in schools, museums, hunting clubs, and in BLM and National Park Service visitor centers and interpretive sites, etc. to inform the public about the status of the desert tortoise and its recovery needs. Develop interpretive kiosks or visitor centers near DWMAs to disseminate information about the desert tortoise and the need for regulated access and use of habitat. Education programs should include such subjects as: husbandry and adoption programs for captive tortoises, the illegality of releasing captive tortoises to wild lands, the illegality of translocating wild tortoises from one site to another, and the role of euthanasia in managing captive and wild populations where disease is a serious threat to survival of the species. Education efforts should be focused

on groups that use the desert on a regular basis, such as rockhounders. A permit system would offer one way to do this.

2.a. Develop environmental education programs.

Recovery unit management plans should include an environmental education feature, but such programs could also be developed by land management or other entities to educate contracted or in-house construction crews and other personnel who might encounter desert tortoises, or for educating the public in urban centers outside of recovery units.

2.b. Implement environmental education programs.

Implement the environmental education program developed in task 2.a.

3. *Initiate research necessary to monitor and guide recovery efforts.*

Unlike the situation with many threatened or endangered species, considerable data exist on many aspects of the biology of the desert tortoise. Unfortunately, few of these data are useful in recovery planning. The magnitude and scope of new research data essential for recovery planning requires an unprecedented level of coordination and cooperation within and among agencies. Biologists and research scientists in the Department of the Interior (BLM, NPS, Bureau of Reclamation, and National Biological Survey), Department of Defense, and other Federal agencies must work closely with their colleagues in state agencies to achieve this goal. No one agency can handle all the essential research, and monitoring. Employing talents of academic researchers will be essential. During the next two decades, research priorities on the desert tortoise should focus on the following areas:

3.a. Obtain baseline data on desert tortoise densities both inside and outside of DWMAs.

In addition to the population monitoring within DWMAs described in task 1.e., population density and distribution data are needed in some areas. The methodology recommended to determine densities is described in Appendix A. This methodology should be tested for replicability and accuracy in a variety of habitats.

3.b. Develop a comprehensive model of desert tortoise demography throughout the Mojave region and within each DWMA.

Such a model should be based on at least 25 years of data. This time span represents one desert tortoise generation and is necessary to capture the effects of normal environmental variability on desert tortoise survival and reproduction. Research should be done in both high- and low-density areas.

Research to develop documents for this model should include the following actions:

3.b.1. Initiate epidemiological studies of URTD and other diseases.

3.b.2. Research sources of mortality, and their representation of the total mortality, including human, natural predation, diminishment of required resources, etc.

3.b.3. Research recruitment and survivorship of younger age classes.

3.b.4. Research population structure, including the spatial scale of both genetic and demographic processes and the extent to which DWMAs and recovery units conform to natural population subdivisions.

3.c. Conduct appropriately designed, long-term research on the impacts of grazing, road density, barriers, human-use levels, restoration, augmentation, and translocation on desert tortoise population dynamics.

3.d. Assess the effectiveness of protective measures (e.g., DWMAs) in reducing anthropogenic causes of adult desert tortoise mortality and increasing recruitment.

3.e. Collect data on spatial variability of climate and productivity of vegetation throughout the Mojave region and correlate this information with population parameters (e.g., maximum sustainable population size, see Appendix G).

3.f. Conduct long-term research on the nutritional and physiological ecology of various age-size classes of desert tortoises throughout the Mojave region.

3.g. Conduct research on reproductive behavior and physiology, focusing on requisites for successful reproduction.

E. Desert Wildlife Management Areas: Management Recommendations

General requisites for siting DWMAs are found in Section II.B.; concepts of reserve design needed to guide delineation of DWMA boundaries and needed management actions are listed in the narrative outline of recovery actions (Section II.D.). The narrative outline contains only those actions which at this time can be identified. After DWMAs are selected and their boundaries delineated, DWMA-specific management actions must be defined to address specific threats and management problems in each DWMA. This chapter provides recommendations for management in the 14 proposed DWMAs (see Table 7). Although in some recovery units proposed DWMAs may be larger than 1,000 square miles (Appendix F and Brussard et al. 1994), declining populations and continuing threats from human-caused mortality and disease suggest that protecting only the minimum area necessary to support a viable population probably will not be adequate to achieve recovery. If DWMAs are selected and established as described in this Recovery Plan, and if DWMA-specific management actions recommended herein are implemented to protect habitat and to reverse current declines in desert tortoise populations, recovery should be an achievable goal.

Appendix F provides a broad range of information on each proposed DWMA including: (1) summary description, (2) current densities and population size, (3) land ownership, and (4) threats specific to individual DWMAs. Brussard et al. (1994) details further site-specific information which will be needed by land managers to delineate boundaries and assemble management plans for DWMAs. General boundaries are described in Figures 7, 8, 9, 10 and in Appendix F for each DWMA; however, these boundaries can be somewhat flexible.

Only one DWMA is proposed for the Upper Virgin River recovery unit. With intensive and careful management this recovery unit can support a viable population. Similarly, apart from a small portion of the Fenner DWMA, the Chemehuevi DWMA is the only proposed DWMA identified in the northern Colorado recovery unit and thus is a key area. The Chuckwalla DWMA is also very important because it is the only DWMA entirely contained within the eastern Colorado recovery unit. The Joshua Tree DWMA is partially in the eastern Colorado recovery unit, but most of the desert tortoises and most of the land area in this DWMA are in the western Mojave recovery unit.

The 1994 designation of critical habitat for the desert tortoise (59 FR 5823) was based on recommendations of the Draft Plan (Fish and Wildlife Service 1993), and is consistent with the recommendations of this final Plan (Appendix H). Areas not included in critical habitat, but recommended as DWMAs in the Draft Plan, were

considered to have current management policies which provided adequate protection against potential habitat-altering activities because they are primarily managed as natural ecosystems. The regulation of activities within critical habitat through section 7 (of the Endangered Species Act) consultation will be based on recommendations in this Plan (Section II C.1.). Critical habitat does not accomplish the same goals or have as dramatic an effect upon tortoise conservation as does a recovery plan because critical habitat does not apply a management prescription to designated areas. However, designation of critical habitat does provide protection of desert tortoise habitat until such time as the Desert Tortoise Recovery Plan is implemented and DWMA management is employed.

The management needs of DWMAs will likely be influenced by some important regulatory decisions in the near future. For instance, the California Desert Protection Bill (S.21, H.R. 518), currently before Congress, may affect proposed DWMA management needs. If passed into law, proposed DWMAs in the California portion of the eastern Mojave recovery unit could be managed wholly or in part by the National Park Service, and they may contain significant land area designated as wilderness.

The following actions are recommended for each DWMA. However, until DWMA boundaries are established, cost estimates cannot be derived. The Implementation Schedule (Section III) will be updated as these costs become available.

I. Recommended regulations in DWMAs.

For reasons given in Section I.B., if DWMAs are to function well as desert tortoise reserves, some human activities must be restricted. Extensive, rigorously obtained data which unambiguously define activities that are incompatible with desert tortoise recovery are largely unavailable. However, extensive anecdotal as well as other data do exist and they suggest strongly that the following activities should be prohibited throughout all DWMAs if population trends are to be reversed and recovery is to occur within a reasonable period of time. Implementation of these regulations will require intensive enforcement and willing cooperation.

The following activities should be prohibited throughout all DWMAs because they are generally incompatible with desert tortoise recovery and other purposes of DWMAs:

- all vehicle activity off of designated roads; all competitive and organized events on designated roads;

- habitat-destructive military maneuvers, clearing for agriculture, landfills, and any other surface disturbance that diminishes the capacity of the land to support desert tortoises, other wildlife, and native vegetation;

- domestic livestock grazing;
- grazing by feral ("wild") burros and horses;
- vegetation harvest, except by permit;
- collection of biological specimens, except by permit;
- dumping and littering;
- deposition of captive or displaced desert tortoises or other animals, except under authorized translocation research projects (see Appendix B.);
- uncontrolled dogs out of vehicles;
- discharge of firearms, except for hunting of big game or upland game birds from September through February; and

The following activities are compatible with tortoise recovery and may be allowed in DWMAs:

- non-intrusive monitoring of desert tortoise population dynamics and habitat;
- limited speed travel on designated, signed roads and maintenance of these roads;
- non-consumptive recreation (e.g., hiking, birdwatching, casual horseback riding, and photography);
- parking and camping in designated areas;
- fire suppression that minimizes surface disturbance;
- permitted or otherwise controlled maintenance of existing utilities;
- surface disturbances that enhance the quality of habitat for wildlife, enhance watershed protection, or improve opportunities for non-motorized recreation. This includes the construction of visitor centers, wildlife guzzlers, camping facilities, etc. where appropriate;
- population enhancement of native wildlife species such as desert bighorn, Gambel's quail, etc;
- mining on a case-by-case basis, provided that the cumulative impacts of these activities do not significantly impact desert tortoise habitats or populations, that any potential effects on desert tortoise populations are carefully mitigated during the operation, and that the land is restored to its pre-disturbance condition; and
- non-manipulative and non-intrusive biological or geological research, by permit.

DWMAs are intended to provide suitable habitat for the desert tortoise and effect recovery. They will also serve as ecosystem reserves, refuges for other plants and animals, and play secondary roles in watershed protection and in furnishing non-motorized recreational opportunities. Permit requirements (on some activities listed above) provide an opportunity for the land-management agency to instruct users on these goals. Manipulative or intrusive biological or geological research should generally be discouraged in DWMAs except under unusual circumstances, and none should be allowed except by permit.

Whether or not livestock grazing should be allowed in DWMAs is extremely controversial. At this time, there are no data showing that continued livestock grazing is compatible with recovery of the desert tortoise, although it appears that cattle grazing under certain circumstances can be compatible with desert tortoise survival (Tracy et al., in prep.). Because tortoise recovery is the goal of management within DWMAs, until such data are forthcoming, no grazing should be permitted within the DWMAs. Data required to show that cattle grazing can be compatible with recovery include a demonstration that adult tortoise densities are stationary or increasing and that regular recruitment is occurring into the adult age classes in areas where cattle are grazed. Such studies must be adequately controlled, replicated, and statistically robust.

2. *Recommended management actions.*

Actions recommended for immediate implementation inside DWMA boundaries to effect recovery of the desert tortoise are shown in Table 6. These and other necessary actions are discussed below:

2a. Control vehicular access in DWMAs.

Paved highways, unpaved and paved roads, trails, and tracks have profound impacts on desert tortoise populations and habitat. In addition to providing many opportunities for accidental mortality, they also provide access to remote areas for collectors, vandals, poachers, and people who do not follow vehicle-use regulations. Substantial numbers of desert tortoises are killed on roads. Thus, desert tortoises thrive best where the density of access routes is low, traffic on them is low, and human access is limited. The following actions should be implemented in all DWMAs to control vehicular access:

1. Restrict establishment of new roads in DWMAs.

2. Implement closure to vehicular access with the exception of designated routes, including Federal, State, and County maintained vehicle routes.

3. Implement emergency closures of dirt roads and routes as needed to reduce human access and disturbance in areas where human-caused mortality of desert tortoises is a problem.

4. Fence or otherwise establish effective barriers to tortoises along heavily-traveled roads; install culverts that allow underpass of tortoises to alleviate habitat fragmentation.

2b. Enforce regulations.

Several DWMAs have serious problems with vandalism, collecting of desert tortoises, release of captives, and unauthorized vehicle use, all of which contribute to abnormally high desert tortoise mortality rates. Therefore, regular and frequent patrols of such DWMAs by law enforcement personnel will be essential.

2c. Restore disturbed areas.

Surface disturbance in DWMAs should be restored to pre-disturbance conditions (defined as the topography, soils, and native vegetation that exist in adjacent undisturbed or relatively undisturbed areas). This includes such actions as closing access to non-designated roads and restoring non-designated roadbeds to their pre-disturbance state.

2d. Sign and fence DWMAs as needed.

The periphery of some DWMAs (on a case-by-case basis) should be fenced with material such as raised hog wire in areas where conflicts with adjacent land uses exist and where access cannot otherwise be controlled. In any event, it is essential that the boundaries of the DWMAs be clearly marked to regulate authorized use and to discourage unauthorized use. Boundaries of EMZs also should be clearly marked.

2e. Implement appropriate administration.

For the DWMAs to function effectively as reserves, local residents should understand and support them, as some traditional uses will be eliminated. Each DWMA may require a reserve manager, additional staff, and law enforcement personnel. In some cases, adjacent DWMAs could be managed by the same staff. DWMA personnel should be hired locally whenever possible. The relevant agencies and the DWMA employees should meet with various user groups to discuss implementation of land use restrictions in the DWMAs. The formation of local advisory committees to assist with this task is strongly recommended. Certain incentives may be necessary to encourage local people to respect DWMA boundaries; these might be paid for from funds collected through regional habitat conservation plans. As funds become available, each DWMA or group of DWMAs managed as a unit should have an associated visitor center or set of interpretive sites and panels and perhaps other amenities such as campgrounds or provisions for guided tours. These amenities would attract tourists and needed revenue to the local area. However, increased tourist traffic will need to be prevented from coming into conflict with the biological needs of the desert tortoise.

Table 7. Actions recommended for immediate implementation in proposed Desert Wildlife Management Areas to effect recovery of the desert tortoise.

Desert Wildlife Management Areas (DWMAs)	UV RV	BDS	FK	SC	CHU	OR	MM	IV	FE	PE	CS	GBP	CHE	JT
Level of Threats to DWMAs (1 = low; 5 = high)	5	5	5	5	4	4	3	3	3	2	2	2	1	1
ISSUES														
Modify Planned and Ongoing actions			X	X		X		X	X		X			X
Withdraw Grazing		X	X	X	X	X	X	X	X					
Withdraw Mining			X		X			X						
Develop DWMA Management Plans	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Develop Education Program	X	X	X	X			X			X		X		
Secure Habitat	X		X	X	X						X			
Modify/Control Landfills			X	X	X	X		X						
Sign and Fence Boundaries	X		X	X		X	X			X				
Halt Unauthorized ORV Use			X	X		X								
Halt Vandalism of Desert Tortoises		X	X	X	X	X	X			X				
Halt Collecting of Desert Tortoises			X	X	X	X	X	X	X	X				
Halt Releases of Captive Tortoises			X	X		X	X	X	X	X				
Control Vehicle Access			X	X	X	X		X	X					

UVRV = Upper Virgin River Valley; BDS = Beaver Dam Slope; FK = Fremont-Kramer; Superior-Cronese; CHU = Chuckwalla; OR = Ord-Rodman; MM = Mormon Mesa; IV = Ivanpah; FE = Fenner; PE = Piute-Eldorado; CS = Coyote Spring; GBP = Gold Butte-Pakoon; CHE = Chemehuevi; JT = Joshua Tree

2f. Modify ongoing and planned activities.

Ongoing and planned activities should be modified so they are consistent with the recovery objective and recommendations of this Recovery Plan.

2g. Control use of landfills and sewage ponds by desert tortoise predators.

Identify and clean up unauthorized dumps in DWMAs. Reduce or eliminate use of authorized landfills and sewage ponds in and near DWMAs by predators of desert tortoise (e.g., ravens & coyotes). Allow no new landfills or sewage ponds within DWMAs.

2h. Establish environmental education programs and facilities.

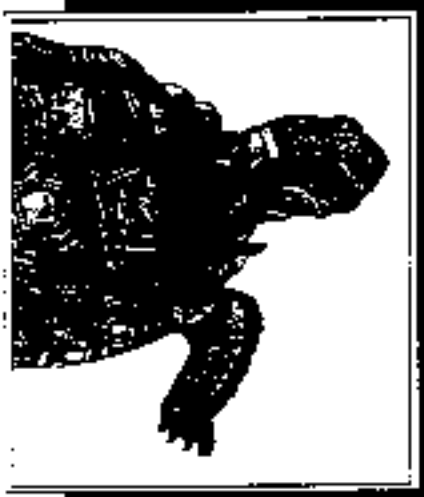
As described in Task 6, visitor centers, interpretive sites, guided tours, and campgrounds are all appropriate in towns near DWMAs to educate the public about the status and management needs of the desert tortoise and its habitat. In addition, desert tortoise programs should be developed for use in schools, museums, clubs, the media, etc. Education efforts should be focused on groups using the desert regularly, such as rockhounders.

These actions are recommended to increase manageability, establish an enforcement presence, effect an immediate reduction in the threats to extant desert tortoise populations in DWMAs, and build local support for the reserve concept. In addition to these actions, emergency closures of cattle and domestic sheep allotments, or placement of allotments and licenses into nonuse categories will be needed in many DWMAs. Mineral withdrawals will likely be needed in some DWMAs to prevent impacts to desert tortoises and their habitat. Other actions critical to recovery in DWMAs have been defined in Section II.D. and the Implementation Schedule (Section III), including research necessary to guide recovery efforts, and monitoring. In addition, land managers are encouraged to implement management actions which promote the conservation of other species and biotic communities.

If extinction occurs in any DWMA, efforts to recolonize the DWMA with wild desert tortoises from the same recovery unit should be undertaken. Long-term research and monitoring would be necessary to ensure the success of any such recolonization effort. All translocations should be done in accordance with the guidelines in Appendix B.

III. Implementation Schedule

Desert Tortoise
(Mojave Population)



Recovery Plan

III. IMPLEMENTATION SCHEDULE

The table that follows is a summary of scheduled actions and costs for this recovery program. It is a guide to meet the recovery objective. This table indicates the scheduling priority for each task, which agencies are responsible for performing these tasks, and the estimated costs to perform them. Implementation of all tasks listed in the Implementation Schedule will lead to recovery. Initiation of these actions is subject to availability of funds.

Priorities in column two of the implementation schedule are assigned as follows:

1. **Priority 1:** An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

2. **Priority 2:** An action that must be taken to prevent a significant decline in population or habitat quality, or some other significant negative impact short of extinction.

3. **Priority 3:** All other actions necessary to meet the recovery objective.

ACRONYMS USED IN THE IMPLEMENTATION SCHEDULE

*	= Lead Agency
AGFD	= Arizona Game and Fish Department
BLM	= Bureau of Land Management
CC	= Clark County
CDSP	= California Department of State Parks
CDFG	= California Department of Fish and Game
CEC	= California Energy Commission
DOD	= Department of Defense
DOE	= Department of Energy
DWMA	= Desert Wildlife Management Area
ECRU	= Eastern Colorado recovery unit
EMRU	= Eastern Mojave recovery unit
FWS	= Fish and Wildlife Service
FHWA	= Federal Highway Administration
NCRU	= Northern Colorado recovery unit
NDOW	= Nevada Division of Wildlife
NEMRU	= Northeastern Mojave recovery unit
NPS	= National Park Service
TBD	= To be determined
UDWR	= Utah Division of Wildlife Resources
UNR	= University of Nevada, Reno
USP	= Utah State Parks
UVRRU	= Upper Virgin River recovery unit
URTD	= Upper respiratory tract disease

Clearly, managers must be able to alleviate detrimental impacts on a population so that the expected growth is at least zero. At zero the population will stay constant in total size. However, even with such management, there will still be random forces that impel a population both up and down. These are the stochastic factors discussed in Section 3 of this appendix. There is often a threshold in total population size, density, or spatial arrangement below which these stochastic factors can result in a high probability of extinction within a given time period. A PVA may be able to predict this threshold--the minimum viable population.

Catastrophes. - A catastrophe is an extreme event which, by itself, can result in population extinction. Fires, floods, and epizootics are commonly cited catastrophes. In general, catastrophes are rare events whose probabilities are hard to estimate, and because of the difficulty they are typically handled in ad hoc fashion outside of a formal PVA. The Upper Respiratory Tract Disease (URTD) is a possible catastrophe threatening desert tortoises. However, its rate of spread and potential ultimate impact have not yet been estimated by epidemiological models.

The only protection against catastrophes is to have redundancy built into the management system--several widely-spaced populations would not likely be struck by the same catastrophic event at the same time. For threats such as drought or flooding, local populations would have to be distributed over a region that is large compared to the total spatial scale of catastrophes. Since the epidemiology of URTD is not yet understood, managing this epizootic is extremely problematic.

Desert Tortoise Genetics.

A comprehensive PVA requires considering population genetics--including loss of heterozygosity, inbreeding depression, outbreeding depression, long-term loss of adaptability, pedigrees, paternities, population structure, etc. However, most PVAs involve much smaller total populations (Table C1) than currently exist for the desert tortoise (although population density must be considered vis-a-vis short-term genetic deterioration as well).

Table C1. The number of individuals modeled in PVAs for endangered species.

Species	Number of Individuals
Blackfooted Ferrets	6
California Condors	28
Whooping Cranes	50
Yellowstone Grizzlies	200
Northern Spotted Owls	2000

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
1	1.a.5	Select DWMAs in Western Mojave Recovery Unit	1	FWS*	20		20			
				BLM	20		20			
				NPS	10		10			
				DOD	10		10			
				CDFG	10		10			
1	1.b.1	Delineate DWMA boundaries in Northern Colorado Recovery Unit	1	FWS*	20		20			
				BLM	20		20			
				CDFG	10		10			
1	1.b.2	Delineate DWMA boundaries in Eastern Colorado Recovery Unit	1	FWS*	20		20			
				BLM	20		20			
				CDFG	10		10			
				DOD	10		10			
1	1.b.3	Delineate DWMA boundaries in Upper Virgin River Recovery Unit	1	FWS*	20	20				
				BLM	20	20				
				UDWR	20	20				
				USP	10	10				
1	1.b.4	Delineate DWMA boundaries in Eastern Mojave Recovery Unit	1	FWS*	20	10	10			
				BLM	20	10	10			
				NPS	10	5	5			
				NDOW	10	5	5			
				CDFG	10		10			
				CDSP	10		10			

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
1	1.b.5	Delineate DWMA Boundaries in Northeastern Mojave Recovery Unit	1	FWS*	20		20			
				BLM	20		20			
				DOD	10		10			
				NPS	10		10			
				AGFD	10		10			
				NDOW	10		10			
				UDWR	10		10			
1	1.b.6	Delineate DWMA boundaries in Western Mojave Recovery Unit	1	FWS*	50		50			
				BLM	100		100			
				NPS	20		20			
				DOD	20		20			
				CDFG	20		20			
1	1.c.1	Secure DWMAs in Northern Colorado Recovery Unit	5	FWS*	TBD					
				BLM	TBD					
				CDFG	TBD					
1	1.c.2	Secure DWMAs in Eastern Colorado Recovery Unit	5	FWS*	TBD					
				BLM	TBD					
				CDFG	TBD					
				DOD	TBD					
1	1.c.3	Secure DWMAs in Upper Virgin River Recovery Unit	5	FWS*	TBD					
				BLM	TBD					
				UDWR	TBD					
				USP	TBD					

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
1	1.c.4	Secure DWMAs in Eastern Mojave Recovery Unit	5	FWS*	TBD					
				BLM	TBD					
				NPS	TBD					
				NDOW	TBD					
				CDFG	TBD					
				CDSP	TBD					
1	1.c.5	Secure DWMAs in Northeastern Mojave Recovery Unit	5	FWS*	TBD					
				BLM	TBD					
				DOD	TBD					
				NPS	TBD					
				AGFD	TBD					
				NDOW	TBD					
				UDWR	TBD					
1	1.c.6	Secure DWMAs in Western Mojave Recovery Unit	5	FWS*	TBD					
				BLM	TBD					
				NPS	TBD					
				DOD	TBD					
				CDFG	TBD					
1	1.d.1	Develop DWMA Management Plan in Northern Colorado Recovery Unit	1	FWS*	20		20			
				BLM	40		40			
				CDFG	10		10			
1	1.d.2	Develop DWMA Management Plan in Eastern Colorado Recovery Unit	1	FWS*	20		20			
				BLM	40		40			
				CDFG	10		10			
				DOD	10		10			

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
1	1.d.3	Develop DWMA Management Plan in Upper Virgin River Recovery Unit	1	FWS*	20		20			
				BLM	40		40			
				UDWR	20		20			
				USP	10		10			
1	1.d.4	Develop DWMA Management Plan in Eastern Mojave Recovery Unit	1	FWS*	40		40			
				BLM	40		40			
				NPS	20		20			
				NDOW	10		10			
				CDFG	10		10			
				CDSP	10		10			
1	1.d.5	Develop DWMA Management Plan in Northeastern Mojave Recovery Unit	1	FWS*	50		50			
				BLM	40		40			
				DOD	10		10			
				NPS	10		10			
				AGFD	10		10			
				NDOW	10		10			
				UDWR	10		10			
1	1.d.6	Develop DWMA Management Plan in Western Mojave Recovery Unit	1	FWS*	50		50			
				BLM	250		250			
				NPS	50		50			
				DOD	50		50			
				CDFG	10		10			

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
1	1.e.1	Implement DWMA Management Plans in Northern Colorado Recovery Unit	Cont.	BLM*	TBD					
1	1.e.2	Implement DWMA Management Plans in Eastern Colorado Recovery Unit	Cont.	BLM* DOD	TBD TBD					
1	1.e.3	Implement DWMA Management Plans in Upper Virgin River Recovery Unit	Cont.	BLM* USP	TBD TBD					
1	1.e.4	Implement DWMA Management Plans in Eastern Mojave Recovery Unit	Cont.	BLM* NPS	TBD TBD					
1	1.e.5	Implement DWMA Management Plans in Northeastern Mojave Recovery Unit	Cont.	BLM* DOD NPS FWS	TBD TBD TBD TBD					
1	1.e.6	Implement DWMA Management Plans in Western Mojave Recovery Unit	Cont.	BLM* DOD NPS	TBD TBD TBD					
2	1.f.1	Develop Monitoring Plan	1	FWS* UNR CC	10 10 30	10 10 30				

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
2	1.f.2.a	Implement Monitoring Plan in Northern Colorado Recovery Unit	Cont.	BLM*	400		100			100
2	1.f.2.b	Implement Monitoring Plan in Eastern Colorado Recovery Unit	Cont.	BLM*	300		75			75
				DOD	100		25			25
				NPS	100		25			25
2	1.f.2.c	Implement Monitoring Plan in Upper Virgin River Recovery Unit	Cont.	BLM*	140		35			35
				USP	60		15			15
2	1.f.2.d	Implement Monitoring Plan in Eastern Mojave Recovery Unit	Cont.	BLM*	960		240			240
				NPS	200		50			50
				CDSP	40		10			10
2	1.f.2.e	Implement Monitoring Plan in Northeastern Mojave Recovery Unit	Cont.	BLM*	800		200			200
				NPS	80		20			20
				FWS	160		40			40
2	1.f.2.f	Implement Monitoring Plan in Western Mojave Recovery Unit	Cont.	BLM*	600		150			150
				DOD	200		50			50
				NPS	400		100			100
		Subtotal costs needs 1			6320	200	2715	0	0	1135

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
		Needs 2: Establish Environmental Education Program								
2	2.a	Develop Environmental Education Programs	1	FWS*	200	200				
				BLM	200	200				
				DOD	50	50				
				NPS	200	200				
				CDGF	50	50				
				AGFD	50	50				
				NDOW	50	50				
				UDWR	50	50				
				CDSP	50	50				
				USP	50	50				
2	2.b	Implement Environmental Education Programs	Cont.	FWS*	TBD					
				BLM	TBD					
				DOD	TBD					
				NPS	TBD					
				CDGF	TBD					
				AGFD	TBD					
				NDOW	TBD					
				UDWR	TBD					
				CDSP	TBD					
				USP	TBD					
		Subtotal costs needs 2				950	950	0	0	0	0

Desert Tortoise (Mojave Population) Implementation Schedule

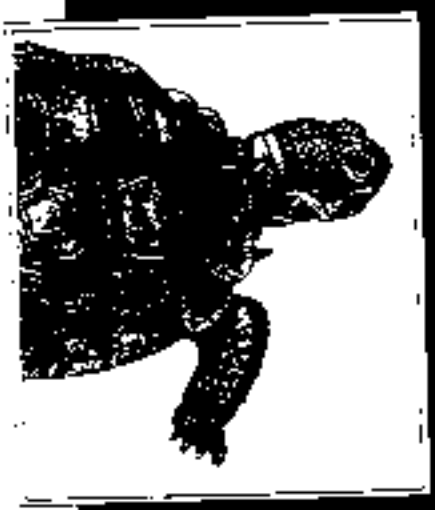
Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
		Needs 3: Conduct Tortoise Research								
2	3.a	Research on Tortoise Densities	5	FWS*	25	5	5	5	5	5
				BLM	250	50	50	50	50	50
				DOD	100	20	20	20	20	20
				NPS	100	20	20	20	20	20
				CDSP	25	5	5	5	5	5
				USP	25	5	5	5	5	5
				UDWR	25	5	5	5	5	5
2	3.b.1	Research on Upper Respiratory Tract Disease and other Diseases	3	BLM*	1000	350	350	300		
				AGFD	3	3				
				UDWR	10	10				
				FWS	25	25				
2	3.b.2	Research on Mortality	10	BLM*	400	40	40	40	40	40
				CC	200	100	100			
2	3.b.3	Research on Recruitment and Survival	10	BLM*	440	20	20	50	50	50
				DOE	100	50	50			
				DOD	20	10	10			
				UDWR	45	5	5	5	5	5
2	3.b.4	Research on Population Structure	10	BLM*	1000	100	100	100	100	100
				NPS	400	40	40	40	40	40
				DOE	60	20				
				FWS	60	20				

Desert Tortoise (Mojave Population) Implementation Schedule

Priority Number	Task Number	Task Description	Task Duration (YRS)	Responsible Party	Total Cost	Cost Estimates ($1,000) FY 1994	FY 1995	FY 1996	FY 1997	FY 1998
2	3.c	Research on Human-use Impacts	5	BLM*	2940	420	420	700	700	700
				DOD	80		20	20	20	20
				NPS	80		20	20	20	20
				CC	225	105	120			
				CEC	40	20	20			
				FHWA	250	40	140	70		
				CDFG	4	2	2			
3	3.d	Research on Effectiveness of Protection	cont.	FWS*	550			50	50	50
3	3.e	Research on Climate and Vegetation	cont.	NPS	100	20			20	
3	3.f	Research on Nutrition and Physiology	5	BLM*	260	100	100	60		
				NPS	100	20	20	20	20	20
				UDWR	100	20	20	20	20	20
				CC	240	80	80	80		
3	3.g	Research on Reproductive Behavior	5	BLM*	150	30	30	30	30	30
				UDWR	45	5	5	5	5	5
		Subtotal costs needs 3			9432	1760	1817	1715	1225	1205
		Total costs			16702	2910	4532	1715	1225	2340

Appendices

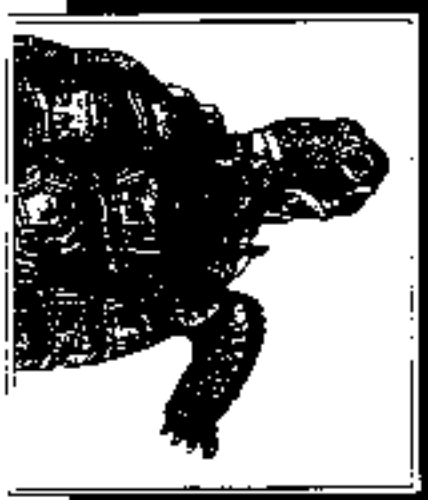
Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix A

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix A: Estimation of Regional Densities

I. Introduction

Accurate determination of desert tortoise densities is a critical component of this recovery plan. Densities should be monitored both inside and outside of Desert Wildlife Management Areas (DWMAs) to determine whether or not protection from human activities within DWMAs is effective in reversing current population declines. Comparisons of population growth rates between experimental management zones (EMZs) and other reserve areas will be necessary to assess the impact of activities permitted in the former and not in the latter and to adjust management actions accordingly.

The method described herein is to be used for estimating desert tortoise densities throughout a recovery unit. It should not be confused with the widely-used strip transect and study plot techniques (Berry 1984a; Berry and Nicholson 1984a, 1984b; Karl 1983). Strip transects provide data to map desert tortoise distribution and may allow estimation of relative densities if properly calibrated on nearby study plots in similar habitats. Intensive surveys of study plots produce detailed data on habitat condition, human uses, and such population attributes as densities, size-age class structure, sex ratios, recruitment, causes of death, and mortality rates in localized areas. However, neither of these techniques is suitable for economical and reliable estimates of desert tortoise densities on a regional scale.

II. Hypothesis to be tested

Most desert tortoise populations in the Mojave region have experienced rapid declines, and recovery depends on reversing these trends. Because most population declines appear to be directly or indirectly caused by various human activities, the establishment of a network of DWMAs where such activities are curtailed or carefully managed should result in positive population growth rates and the eventual achievement of recovery goals. Thus, monitoring of desert tortoise density should be performed to test the following hypothesis:

H_1. If protection afforded by DWMAs has no effect on desert tortoise population dynamics, there will be no significant differences between the densities of populations inside and outside of the DWMAs.

III. Methods

A. Number and Location of Sample Plots Within Each DWMA.

Each sample plot should be 1 square kilometer in area. The number of sample plots per DWMA will depend upon its size, but at least 5% of the total area of the DWMA must be sampled in each sampling cycle (e.g., 10 square miles [25.9 square kilometers]), or 26 sample plots, would be the minimum acceptable area to sample within a DWMA of 200 square miles). No fewer than three control plots must be sampled outside of each DWMA. These plots must be located no closer than 2 miles and no farther than 10 miles from the DWMA boundary. Adjacent DWMAs may share one or more control plots that fit these criteria.

The DWMAs should be divided into plots 1 square kilometer in area using Universal Transverse Mercator coordinates, and each plot should receive a unique number. Plots to be sampled should be chosen from a random number table. If a randomly chosen plot is in an area that is very unlikely to contain desert tortoises, it should be excluded and another plot chosen. Such exclusions include (1) plots with average elevations over 4000 feet, (2) plots transected by paved highways, (3) plots largely consisting of playas or other areas with no natural vegetation, and (4) plots with large areas of human-caused surface disturbance (e.g., agricultural field, gravel pit). Control plots should be chosen using the same criteria as plots within the DWMAs. New plots should be chosen each time the DWMA and the control areas are sampled.

B. Data Collection - Scheduling.

Initial population estimates to establish baseline densities must be accomplished as soon as DWMA boundaries are established. Resampling must occur every 3 years. Because population estimations must coincide with periods of high desert tortoise activity, all surveys must be completed during the months of February through May. This 16-18 week period is sufficient for a team of properly trained biologists to survey at least 10 sample plots, allowing for periods of inclement weather and other complications.

Each square kilometer plot may require up to 7 days of complete sampling by a team of four experienced desert tortoise biologists. If ten DWMAs required 26 plots plus three outside controls each, this would mean a total of 290 plots to sample. However, it is unlikely that all DWMAs will be established simultaneously, and with a 3-year resampling schedule, approximately one-third of this number, or 97, would have to be sampled every year. Thus, nine teams, starting in areas with early greenup and moving into regions with later phenologies, could accomplish these sampling goals.

C. *Data Collection - Methods.*

The removal method (Southwood 1978; Zippin 1956, 1958) should be used to estimate densities of large immature and adult desert tortoises (carapace length > 140 mm) in the square-kilometer plots. The principle behind this method is that if a known number of animals is "removed" (in this case, marked and released in situ) on each sampling occasion, the rate at which new captures fall off will be directly related to the size of the total population and the total number "removed." Thus, the removal method, unlike capture-mark-release methods, requires that animals be handled only once during a survey. The assumptions of this method are that (1) the catching procedure does not lower the probability of other animals being caught, (2) the population remains stationary during the sample period, (3) the population is not so large that the capture of one individual interferes with the capture of another, and (4) the chance of capture is equal for all animals. By restricting the sample to adult and large immature animals and by analyzing males and females separately, none of these assumptions is violated.

All samples should be made by a four-person team of experienced desert tortoise biologists. The biologists should proceed to a previously selected, randomly chosen plot and use a global positioning device to locate its four corners. Temporary flags, to be removed after the sample period, should be used to mark plot boundaries. The plot should be searched thoroughly for desert tortoises each day of the sample by all four biologists, concentrating on times of high activity. Each biologist should search one quarter of the plot to achieve complete coverage each day. Desert tortoises are to be sampled only on the surface, except when they can be coaxed out of their burrows by thumping. No desert tortoises will be pulled from their burrows with hooks or other devices.

Upon capture, adult desert tortoises should be sexed and measured, in millimeters, along the midline of the carapace. Those with midline carapace length of 140 mm or greater will be included in the sample. These animals should be marked with a small dot of acrylic paint placed on the dorsal surface of both the anterior and posterior marginals; the paint marks will enable the survey team to recognize previously handled ("removed") desert tortoises.

Even if no desert tortoises are encountered, each plot should be sampled for a minimum of 3 days in weather suitable for the animals to be above ground. If desert tortoises are found, sampling should continue for 7 days or until no unmarked desert tortoises have been encountered for 2 consecutive days.

D. *Data analysis.*

Zippin's (1956, 1958) maximum likelihood method, as described in Southwood (1978, pp. 232-236), should be used to estimate desert tortoise densities and their standard errors in each square-kilometer

plot. Because plots were randomly selected, these estimates will provide an accurate picture of desert tortoise densities and spatial variation within the DWMA and surrounding areas.

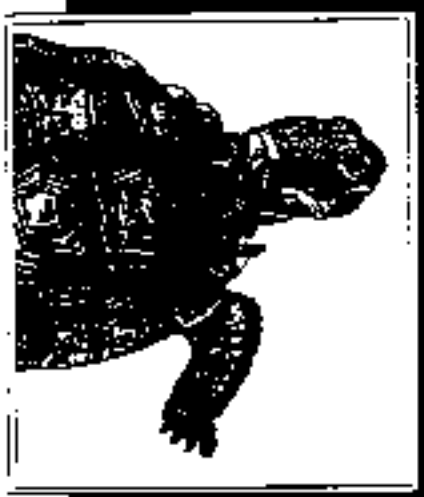
IV. Interpretation of results.

The immediate goal of these samples is to obtain reliable estimates of desert tortoise densities in the DWMAs and adjacent, non-protected areas. The long-term goals are to assess the success of the recovery strategy developed in this plan, adjust management goals as appropriate, and determine when recovery has been achieved. Sufficient data to accomplish the long-term goals will require many sampling periods. Estimated densities and their standard errors accumulated over at least 12 years, or five samples, will be necessary to adequately falsify the hypotheses posed above and to consider delisting a recovery unit.

If it appears that desert tortoise densities are still declining after the second sample, these data should trigger a reassessment of management practices and suggest additional research. For example, examining the effectiveness of management efforts directed at curtailing human activities within the DWMA would be appropriate under these circumstances. On the other hand, research may show that desert tortoise habitat has been so degraded by previous management practices that it will take several more years of freedom from disturbance before conditions for desert tortoises will improve within the DWMA.

Appendix B

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix B: Guidelines for Translocation of Desert Tortoises

(1) Experimental translocations should be done outside experimental management zones. No desert tortoises should be introduced into DWMAs—at least until relocation is much better understood.

(2) All translocations should occur in good habitat where the desert tortoise population is known to be substantially depleted from its former level of abundance. Translocation of reproductively competent adults into depopulated areas can have beneficial effects on population growth. Before population growth can occur, however, individuals must establish home ranges and enter into any existing social structure. Desert tortoises should be periodically evaluated against a defined health profile (proportional weight/size, fecal scans, and blood panels).

(3) Areas into which desert tortoises are to be relocated should be surrounded by a desert tortoise-proof fence or similar barrier. The fence will contain the desert tortoises while they are establishing home ranges and a social structure. If the area is not fenced, past experience suggests that most animals will simply wander away from the introduction site and eventually die. (Fencing is not cheap: estimates range from $2.50 to $5.00 per linear foot). Once animals are established some or all of the fencing can be removed and probably reused.

(4) The best translocations into empty habitat involve desert tortoises in all age classes, in the proportions in which they occur in a stable population. Such translocations may not always be possible, since young desert tortoises are chronically underrepresented in samples, often due to observer sampling error, and may now actually be underrepresented in most populations due to poor recruitment and juvenile survivorship during the last several years. Desert tortoises smaller than the 7-year age-size class are particularly vulnerable to predation and may be a poor investment for translocation, unless predator exclusion (fencing, for example) is incorporated into such endeavors. Mature females would probably be the best sex/age class to introduce into below carrying capacity extant populations because of their high reproductive value (low potential mortality, high potential fecundity for many years).

(5) The number of desert tortoises introduced should not exceed the pre-decline density (if known). If the pre-decline density is not known, introductions should not exceed 100 adults or 200 animals of all age classes per square mile in category 1 habitat (Bureau of Land Management designation for management of desert tortoise habitat) unless there is good reason to believe that the habitat is capable of supporting higher densities. Post-introduction mortalities

might be compensated by subsequent introductions if ecological circumstances warrant this action.

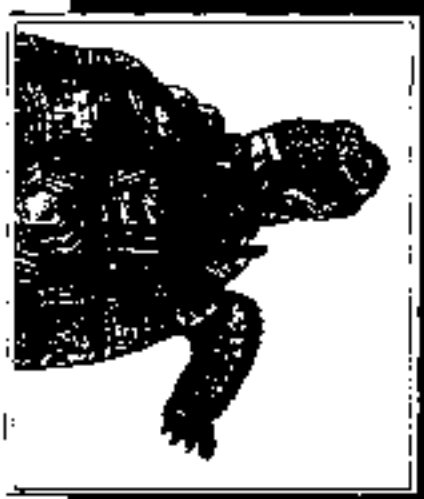
(6) All potential translocatees should be medically evaluated in terms of general health and indications of disease, using the latest available technology, before they are moved. All translocatees should be genotyped unless the desert tortoises are to be moved only very short distances or between populations that are clearly genetically homogeneous. All translocated animals should be permanently marked, and most should be fitted with radio transmitters so that their subsequent movements can be closely tracked.

(7) If desert tortoises are to be moved into an area that already supports a population—even one that is well below carrying capacity—the recipient population should be monitored for at least 2 years prior to the introduction. Necessary data include the density and age structure of the recipient population, home ranges of resident desert tortoises, and general ecological conditions of the habitat.

Areas along paved highways can serve as good translocation sites, if properly fenced. Many such areas support good habitats, but vehicle-caused mortalities and/or collecting have substantially reduced or totally extirpated adjacent desert tortoise populations. Any translocation sites should be isolated by a desert tortoise barrier fence or similar barrier next to the highway or road. The purpose of fencing the highway is obvious—to keep translocated animals from being crushed by vehicles on the road. However, fencing the other sides of the translocation area is critical for establishment. If a fenced area or strip of habitat approximately 0.125 to 0.25 mile wide is established along highways, some translocatees should establish home ranges and a social structure within this strip. When the inside fence is removed, the translocated desert tortoises and those from the extant population farther away from the road will eventually expand their home ranges into the remaining low-density areas. A second reason for inside fencing is to prevent any diseased, but asymptomatic, desert tortoises from infecting nearby, healthy populations. In the event that disease is an issue and a resident population is present nearby, double inside fencing should be considered.

Appendix C

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix C: Desert Tortoise Population Viability

I. Introduction

Because desert tortoises live to such great age, are found in very sparse populations, and are very difficult to study, we know very little about the tortoise population dynamics. Thus, computer modeling has been used as a means of supplementing our knowledge in this area. We present here a life history analysis of the consequences of demographic characteristics in tortoise populations, an analysis of trends in these populations, and, finally, an analysis of the population viability of desert tortoises in the Mojave. These exercises have all supported the necessity for large reserves (DWMAs) for the recovery of the species.

II. Life history analysis

Understanding the life-history consequences of modifications to mortality and/or fecundity to population persistence is crucial to management decisions on desert tortoise populations. Nevertheless, the quality of data for such an analysis are understandably poor for this extremely long-lived species that may undergo huge natural temporal and spatial swings in population density in response to a stochastically varying environment. Mertz (1971) developed an approach to investigate life-history consequences to changing environments of a long-lived species. We have used this approach to estimate the relative contributions of juvenile and adult mortality, as well as fecundity, to the ability of desert tortoise populations to maintain themselves at stable population densities. The basis of the analysis is a model of the demography of the desert tortoise. This model purposely does not contain great demographic detail, since the questions asked do not require great detail. Mertz used a similar low-resolution model to ask "broad-brush" questions about California Condors.

The basis of the model comes from the work of Leslie (1966). The model is based upon transition matrices containing age-specific mortality and fecundity. The following simplifying assumptions were made:

1. Mortality for eggs and juveniles were lumped into a probability of surviving to reproductive age, β.

2. Mortality of reproductive adults was taken to be the same regardless of age and was represented as the probability of surviving one year, ρ.

The model predicting net reproductive rate is:

$$R_0 = (\beta * f * C * (1 - F) * (1 - \rho^{(\omega - \alpha)}) / (1 - \rho^{T})$$

where:

R_0 = The net reproductive rate or the proportional change in population size per generation.

β = The probability of surviving to reproductive age.

ρ = The probability of an adult surviving one year.

f = The proportion of females in the population.

C = The clutch size.

F = The proportion of females failing to breed.

ω = The age at which reproduction ends.

α = The age at which reproduction begins.

T = The time interval at which reproduction occurs.

Simulations illustrated the conditions that produced a net reproductive rate, R_0, of zero (or stable population size). These simulations included the following additional assumptions for the purpose of the analysis:

1. Sex ratio was assumed to be 0.5.

2. All reproductive-aged females were assumed to reproduce.

3. Reproduction was assumed to continue to age 100 (this assumption was checked separately and found not to affect the results greatly).

4. The age of first reproduction was taken to be 15 years (this assumption has no effect on simulations confined to $R_0 = 1.0$).

5. Egg laying, multiple clutching, and years without reproduction were all condensed to an average number of eggs produced per year (thus, separate mortality probabilities for different clutches, and clutches in bad years were not considered).

Three variables were considered:

1. ρ, differences in which can be taken as reflecting elevated adult mortality.

2. β, differences in which can be taken as elevated mortality of eggs or juveniles.

3. C, differences in which can be taken as reflecting conditions more or less optimal for reproduction.

Figures C1 and C2 present simulations showing the combinations of r, b, and C necessary to have $R_0 = 1.0$. Clearly, if a population is healthy, and relatively free from sources of adult mortality, and thus having a r of > 0.95 and a fecundity > 9 eggs/year, then very few juveniles need survive to adulthood. Indeed, somewhere in the order of only 1% of all eggs need survive to reproductive age. On the other hand, a 10% increase in adult mortality can require a 300% increase in juvenile survivorship. Furthermore, any reduction in fecundity of adults exacerbates this still further. These results illustrate the requirements of desert tortoises in their natural environments, particularly the premium placed upon adult survival. The life-history strategy of desert tortoises may have evolved in an environment in which 99% of all juveniles die before reaching reproductive age. However, this life-history strategy may not work for desert tortoises faced with increased mortality on adults. Desert tortoises may very well have been able to handle high juvenile mortality in the past, but in populations suffering high mortality from URTD, off-road vehicles, and pet collection, juvenile survivorship becomes increasingly important.

The simulations also point to the necessity of considering all sources of age-specific mortality in management plans, not just mortality in a particular age group. Finally, the simulations point to the extremely potent effect that climate change could have if new conditions resulted in abandoning reproduction altogether in numerous bad years interspersed among somewhat better years for production of food resources.

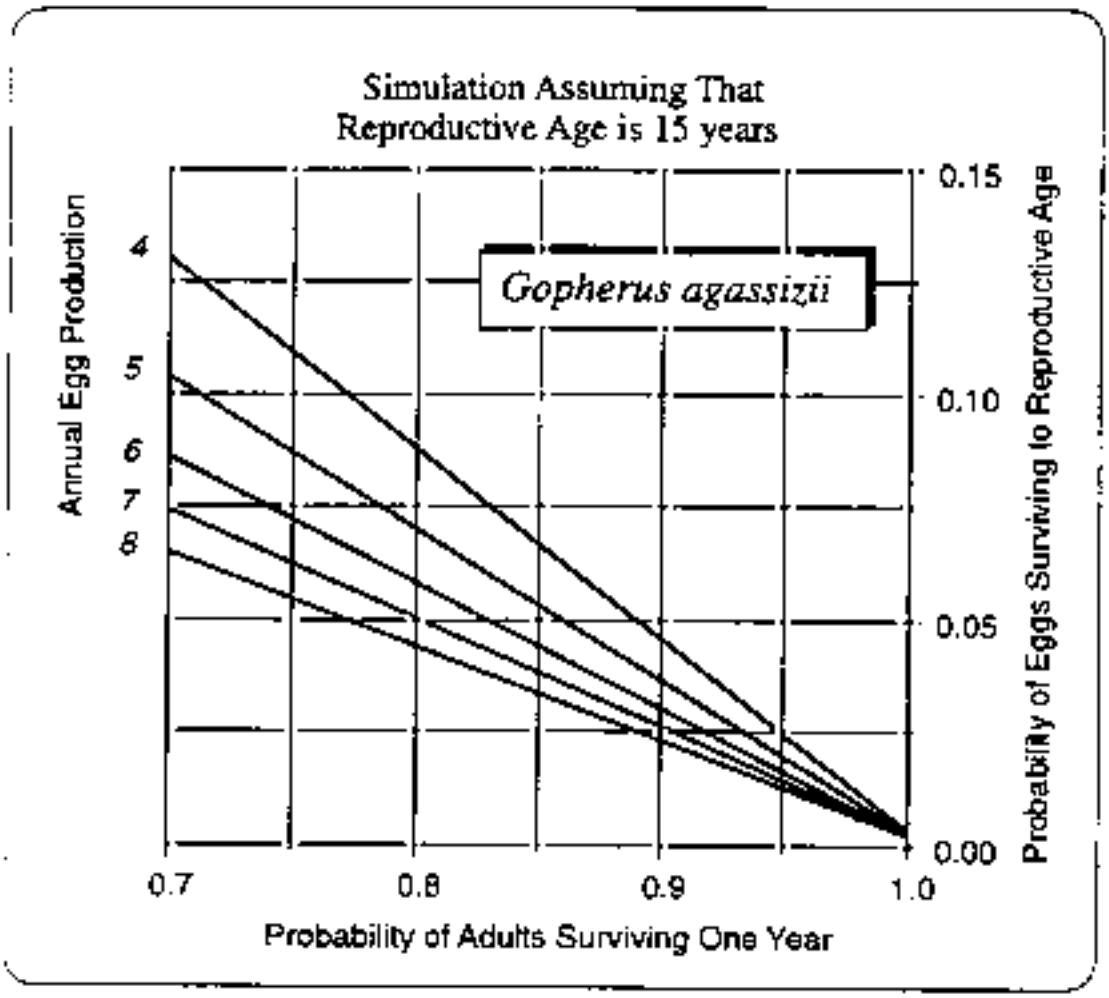


Figure C1. Calculated requirements for adult and juvenile survivorship in order to have a net reproductive rate of 1 (viz., a population neither growing nor declining) as a function of the average number of eggs produced per year.

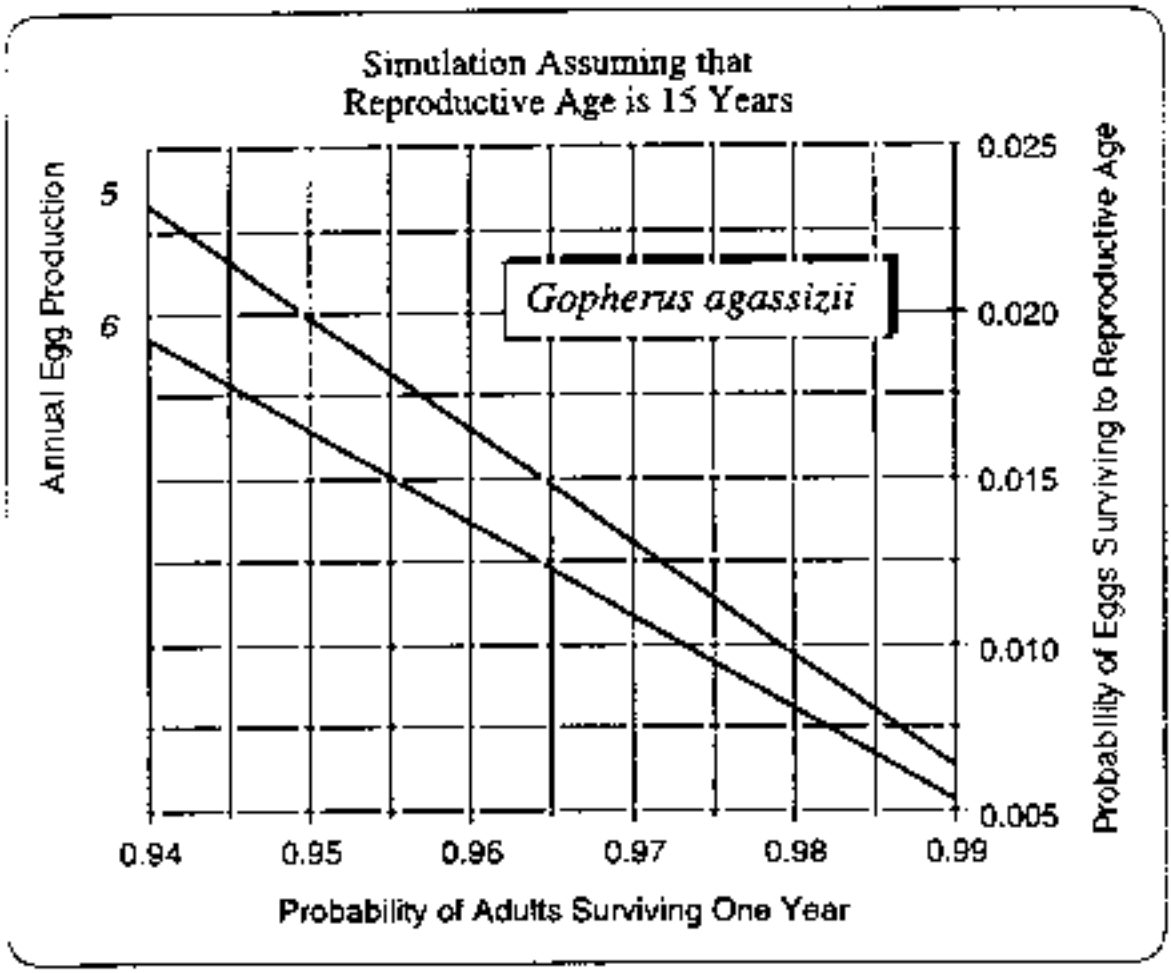


Figure C2. Calculated requirements for adult and juvenile survivorship in order to have a net reproductive rate of 1 (viz., a population neither growing nor declining) when females produce an average of 5 to 6 eggs per female per year.

III. Population Trends in the Mojave Desert Tortoise in Different Parts of the Mojave Desert

The desert tortoise has been listed as a threatened species because of disturbing downward trends in population sizes in many portions of the species range. Some desert tortoise populations have reached such low numbers that extirpation is highly probable. Furthermore, the population dynamics of this species are so ponderous that recovery from major reductions in population size is problematic. Nevertheless, desert tortoises have persisted in the Mojave Desert for thousands of years even though there have almost certainly been random local extinctions and subsequent reinvasions (Hanski 1991). Today, many desert tortoise populations are so fragmented that they have little ability to recover from major population declines. Thus, it is very important to distinguish between the forces causing "normal" fluctuations in population sizes and those that threaten population persistence.

There are two kinds of population change: stochastic fluctuations and trends. Population trends are monotonic changes in population size caused by some persistent demographic change in the population (Figure C3). For example, persistently reduced fecundity or increased rates of mortality will cause changes in the "equilibrium" population size as well as changes in the ability of populations to grow. In the desert tortoise, such changes could be caused by increased predation by animals or humans, reduction in the forage base due to changes in climate or competition with domestic grazers, etc. Clearly, downward population trends must be halted in order for a population to persist.

Stochastic fluctuations (Figure C3) occur when some random event causes a downturn from which the population begins immediate recovery. These events can be caused by such things as drought, fire, and disease. Recovery from stochastic fluctuations will depend upon their frequency and severity. Thus, a large population which is infrequently influenced by random events will have a high probability of persistence; alternatively, small populations repeatedly assaulted by stochastic increases in mortality or decreases in fecundity will have a lower probability of persistence.

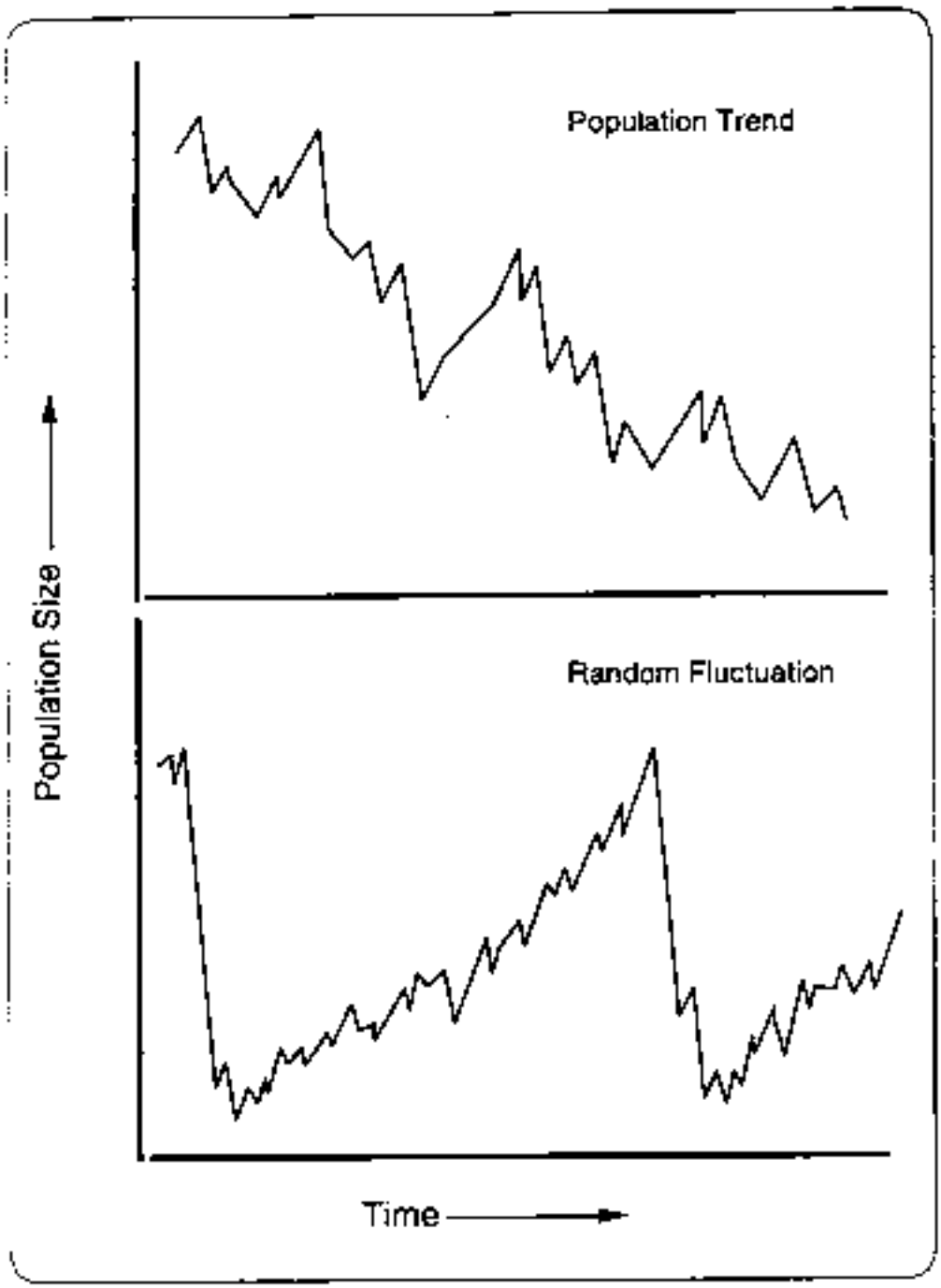


Figure C3. Hypothetical population dynamics over time for a population undergoing a trend in numbers and a population undergoing stochastic declines followed by recovery in numbers.

Populations undergoing steady downward trends will go extinct. The likely time to extinction is easily calculated. However, extinctions can also occur in populations that, on average, are stochastically fluctuating around some long-term mean. Thus, it is critical that existing data on the population dynamics of desert tortoises can be classified as trends or as stochastic fluctuations. Clearly, the severe droughts in 1989 and 1990 contributed to severe crashes in population sizes for many tortoise populations (Berry 1990, as amended). Droughts are stochastic events that will, of course, occur in the desert, and desert tortoise populations have a long history of recovering from the effects droughts. However, populations that have been fragmented into smaller units or with densities reduced by the effects of increased predation, human vandalism, or competition with grazers will have a lower probability of persistence in the face of these stochastic events.

Because of the difficulty of obtaining accurate population size estimates on these cryptic, semi-fossorial, and sparse animals, most data collected over the last 15 years on the dynamics of desert tortoise populations are insufficient to determine whether a population is stationary, fluctuating stochastically, or undergoing a population trend. However, the data from many samples may be statistically "blocked" according to similarities among sites in order to sort out possible trends and their causes.

Data collected by the Bureau of Land Management (Berry 1990, as amended) has been sorted into two categories: the Western Mojave, which includes areas that both do not normally receive summer rains and also have heavy human-induced mortality of tortoises, and the Eastern and Northeastern Mojave and Eastern and Northern Colorado areas which receive summer as well as winter rains and where relatively little mortality is directly attributable to humans. Our analysis indicates that areas receiving summer rains and are relatively free from human-induced mortality show no statistically significant population trend (Figure C4), whereas areas in the Western Mojave clearly show a downward trend in population size during the same time period (Figure C5).

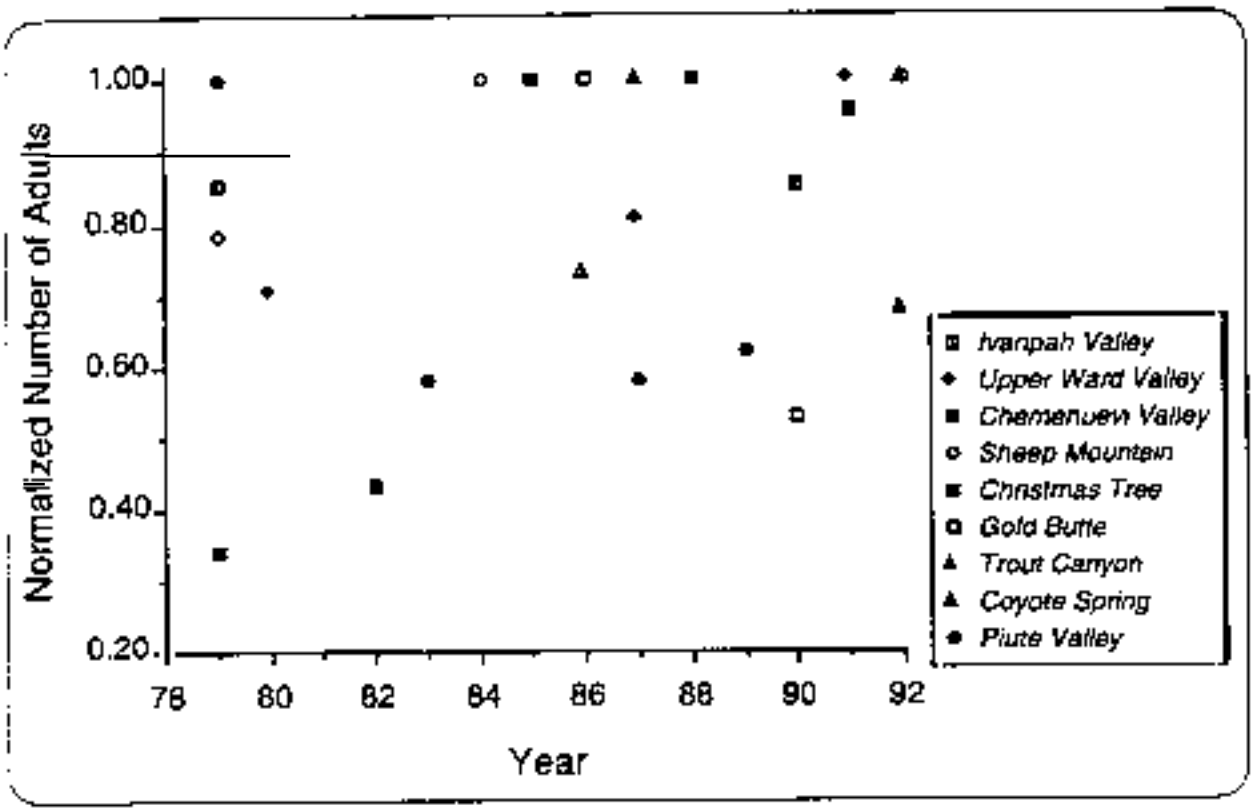


Figure C4. The number of adult desert tortoises found on BLM trend plots located in areas receiving summer rains and relative freedom from human-induced tortoise mortality. Only those trend plots sampled at least twice are included in the analysis. All data are normalized to the highest population size recorded within the years populations were monitored.

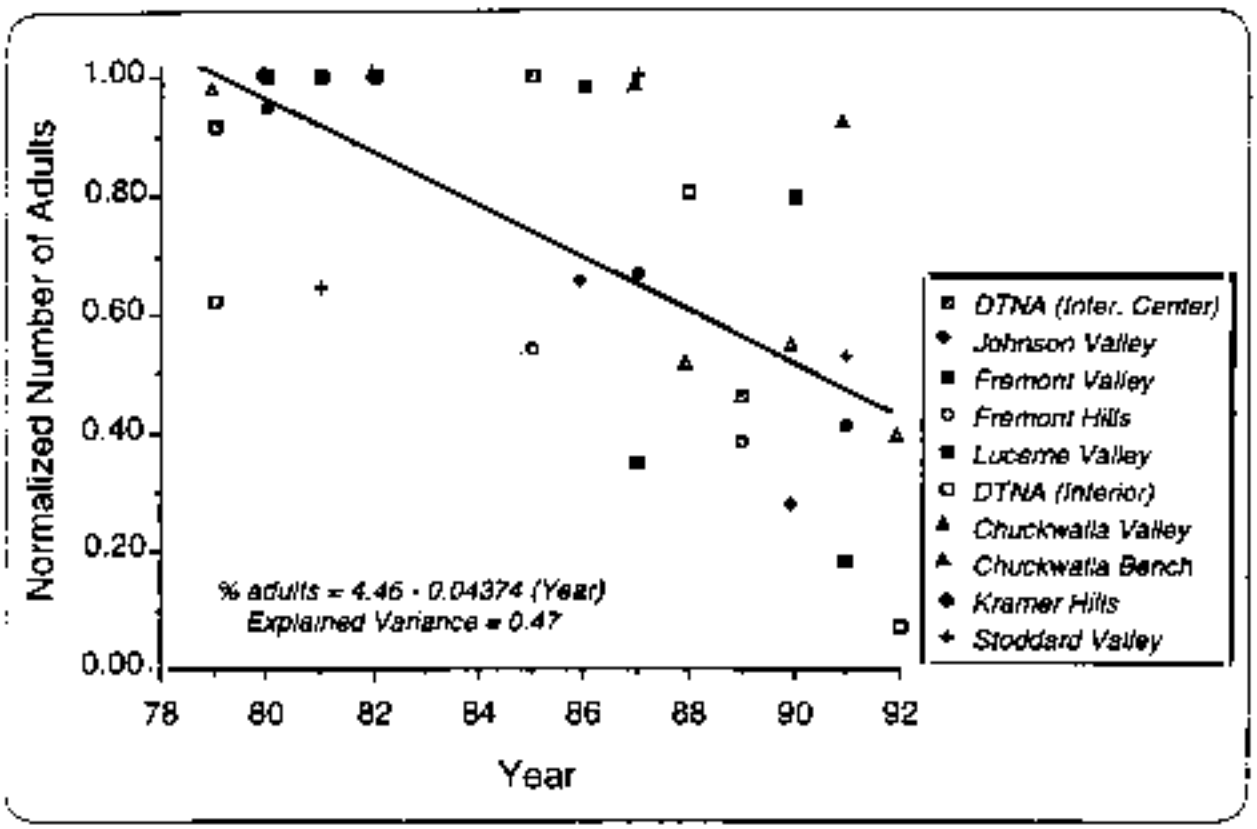


Figure C5. The number of adult desert tortoises found on BLM trend plots located in the Western Mojave. All data are normalized to the highest population size recorded within the years populations were monitored. The downward trend in population density is highly significant ($F_{1,14} = 28.4$, $p < 0.0001$).

This analysis emphasizes that management of tortoise populations requires recognition of two separate types of population change: population trends and stochastic fluctuations. Uncorrected downward trends are disastrous and must be corrected or else the population will go extinct. Stochastic fluctuations can be disastrous for small populations or populations that are frequently victims of stochastic increases in mortality. However, large, "healthy" desert tortoise populations should be able to withstand normal stochastic fluctuations with a reasonable probability of persistence.

This analysis also shows that several areas within the Mojave region are seriously impacted by human-induced mortality. Specifically, all of the sampled sites located close to BLM designated Off-Highway Vehicle Areas and/or towns have high levels of known direct human-induced tortoise mortality. These areas have significant downward trends in population sizes; thus, these trends can only result in extinction of desert tortoises unless their causes are mitigated. The actual mechanisms of these downward trends cannot be determined from this analysis, but in all the sampled areas there is evidence of high mortality caused by off-highway vehicles and guns. Additionally, it is likely that tortoises from these areas are taken as pets, and it is also likely that diseased tortoise pets are released into these areas. Thus, the ultimate cause of downward trends in desert tortoise populations is uncontrolled human disturbance.

Finally, this analysis leads to the conclusion that the Desert Wildlife Management Area concept is the logical means by which human activity can be controlled in desert tortoise habitat, and it is perhaps the only way to reverse downward population trends in desert tortoise populations.

IV. Population Viability Analysis

Background

Earlier reviews have discussed the reasons why populations become extinct (Shaffer 1981, Soulé 1980, Simberloff 1986, Gilpin and Soulé 1986). Four explanations are generally implicated in **conditions for extinction** (CFE). Three of the CFEs are can act very quickly within a generation or two, and the fourth can take many generations.

One of the proximate conditions of extinction is **Demographic Stochasticity**, problems caused by random demographic imbalances which can occur in small populations (Richter-Dyn and Goel 1972). These events include imbalances in sex ratios, birth or death rates, or age distributions. In very small populations males or females may have difficulty finding mates, most of the population

may be post- or pre-reproductive, etc. These "accidental" demographic imbalances can occur when a population becomes very small or very sparsely distributed, and all of them can result in extinction. Demographic stochasticity certainly could be a force in highly fragmented and diminished desert tortoise populations such as can be found in the Western Mojave and Beaver Dam Slope.

A second condition of extinction is **Social Dysfunction**. This can occur by many mechanisms, and it also occurs in very small populations. In some populations, mating only occurs when it is socially facilitated. This is especially true in some birds and mammals that form leks, colonies, or herds. The selective forces leading to vulnerability through social dysfunction has been discussed by Simberloff (1986). This CFE is not likely to be important for desert tortoises because this species is widely distributed and mating does not occur in groups. However, no data exist on the extent to which breeding behavior is socially facilitated in this species.

A third CFE comes from any of several possible **Extrinsic Forces**. Extrinsic forces generally occur when there exists temporal variation in abiotic, habitat, or biotic conditions with which the population cannot contend. These can include random abiotic catastrophes such as floods, droughts, and fires. They could include epizootics (such as URTD), or shifts in prey base of predators (such as ravens switching from road-killed jackrabbits to hatchling or yearling tortoises). Other forces could include anthropogenic changes in habitat such as urbanization, mining, road development, or livestock grazing. This CFE can affect populations that are large or dense, particularly when the frequency of "damaging" extrinsic forces increase to levels never encountered by a species during its evolutionary history. This CFE is probably the most important one with which desert tortoises must contend today.

The fourth CFE is **Genetic Deterioration**. Short-term genetic deterioration results from inbreeding depression and loss of genetic heterozygosity (Frankel and Soulé 1981, Rall and Ballou 1983). These factors can cause problems in individual fitness and in a population's ability to increase. A longer-term problem resulting from loss of genetic heterogeneity is that a population may be unable to adapt to a changing environment. Generally, genetic problems occur only in very small populations. Thus, they may be a problem for the highly diminished populations of desert tortoise in the Western Mojave and Beaver Dam Slope areas.

Prescriptions for abating loss of genetic diversity has led to the "50/500 rule" (Franklin 1980) which suggests that a **genetically effective population size** of at least 50 is needed to avoid the problems of inbreeding depression in the short term and that a **genetically effective population size** of at least 500 is needed to retain enough genetic heterogeneity for long-term evolution. However, the 50/500 rule has been criticized for a variety of reasons, and Dawson et al. (1986) have speculated that a genetic

population size of at least 1500 is needed for long-term persistence of vertebrate populations such as the northern spotted owl.

Characteristics Important in Defining Minimum Population Sizes

To ensure persistence of the desert tortoise in the Mojave region it is necessary to determine the conditions under which a population will remain viable. This is called a Population Viability Analysis (PVA). Population viability is very difficult to determine (Dawson et al. 1986) largely because a PVA requires data that are often not collected for rare and difficult-to-study species. Determining population viability for the desert tortoise is especially difficult since the species has a long generation time, a complex demography, and it is being assaulted by ecological factors to which it may not have been previously exposed during its evolutionary history.

Conservation biologists and managers must understand a number of terms, definitions, and standards before the implications of a PVA can be clearly understood (Gilpin and Soulé 1986). These are:

Time Frame .- Population viability must be defined for a specific time horizon; i.e., the probability of being extant T years from now. Time spans, T, of 100 or 200 years are commonly used. However, desert tortoises may live 80 years or more, and generation time is around 25 years. Thus, for this species, a time horizon of 500 years (or approximately 20 generations) into the future is a reasonable time frame for evaluating population persistence probabilities.

Population Size .- Early work on Population Viability (Franklin 1980, Shaffer 1981) postulated that extinction probabilities were a function of population size alone. Shaffer (1981), working with data from the Yellowstone National Park grizzly bear population, looked solely to demographic and environmental factors that influenced population fluctuations. On the other hand, Franklin (1980) focused on loss of genetic variation through genetic drift, a process whose rate is inversely proportional to population size. Even though both of these early efforts at population viability determination were monofactorial, both processes can be important and should be considered in a PVA.

Population Density .- Under some circumstances, population dynamics may depend upon density of individuals per unit area rather than the total population number remaining in the region. For example, finding a mate becomes problematical in very sparse populations because few animals of the right sex are encountered.

Spatial Fragmentation .- In situations where a population is divided into a set of loosely-coupled spatial units exchanging a few animals per year, the configuration of these units in two-dimensional space may be more important than total population size. Thus, a system of small local populations, each of which is nonviable by itself, can nonetheless form a viable system if connectivity is

sufficient so that local populations that go extinct can be recolonized from other local populations in the system.

Deterministic vs. Stochastic Factors. - A population that has, on average, negative population growth is doomed to extinction. The time to extinction is straightforwardly calculated from the exponential growth equation, $dN/dt = rN$. If r is the negative per-year population change, then the time to extinction, T_{ext}, is

$$T_{ext} = \log(N/2)/r,$$

where N is the current (i.e., initial) population size. Suppose, for example, that a population of 25,000 is decreasing at 10% per year, as is the case for several local populations of the desert tortoise. The expected time to extinction is easily calculated--95 years. A doubling of N produces only a small increase in time to extinction. If N were 50,000, then the time to extinction is only increased to 102 years, hardly any gain at all. The following graph shows T_{ext} for some other negative growth rates:

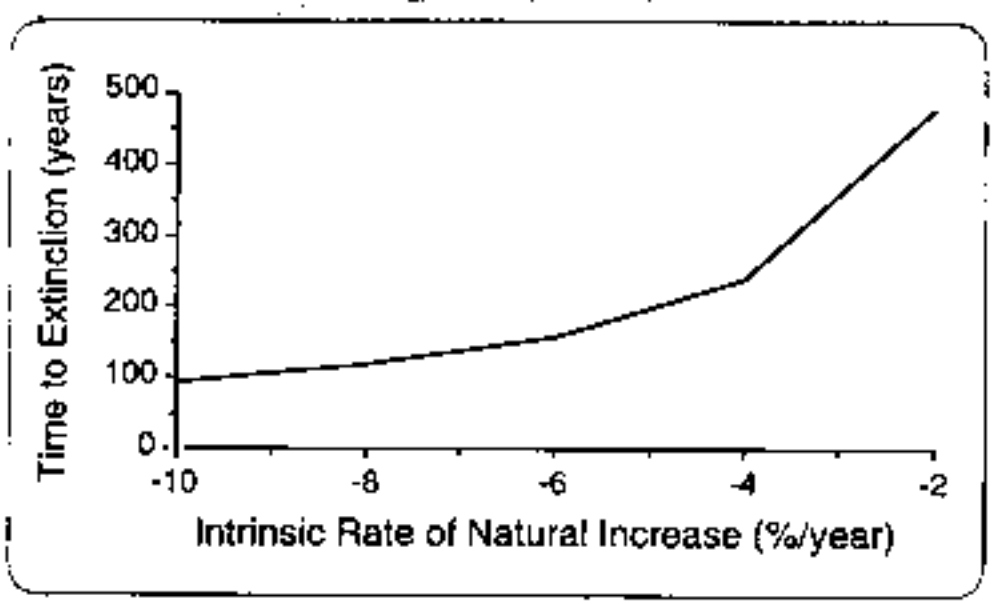


Figure C6. Time to extinctions for a population of 25,000 animals as a function of the intrinsic rate of natural increase expressed as percent decline per year.

Clearly, managers must be able to alleviate detrimental impacts on a population so that the expected growth is at least zero. At zero the population will stay constant in total size. However, even with such management, there will still be random forces that impel a population both up and down. These are the stochastic factors discussed in Section 3 of this appendix. There is often a threshold in total population size, density, or spatial arrangement below which these stochastic factors can result in a high probability of extinction within a given time period. A PVA may be able to predict this threshold--the minimum viable population.

Catastrophes. - A catastrophe is an extreme event which, by itself, can result in population extinction. Fires, floods, and epizootics are commonly cited catastrophes. In general, catastrophes are rare events whose probabilities are hard to estimate, and because of the difficulty they are typically handled in ad hoc fashion outside of a formal PVA. The Upper Respiratory Tract Disease (URTD) is a possible catastrophe threatening desert tortoises. However, its rate of spread and potential ultimate impact have not yet been estimated by epidemiological models.

The only protection against catastrophes is to have redundancy built into the management system--several widely-spaced populations would not likely be struck by the same catastrophic event at the same time. For threats such as drought or flooding, local populations would have to be distributed over a region that is large compared to the total spatial scale of catastrophes. Since the epidemiology of URTD is not yet understood, managing this epizootic is extremely problematic.

Desert Tortoise Genetics.

A comprehensive PVA requires considering population genetics--including loss of heterozygosity, inbreeding depression, outbreeding depression, long-term loss of adaptability, pedigrees, paternities, population structure, etc. However, most PVAs involve much smaller total populations (Table C1) than currently exist for the desert tortoise (although population density must be considered vis-a-vis short-term genetic deterioration as well).

Table C1. The number of individuals modeled in PVAs for endangered species.

Species	Number of Individuals
Blackfooted Ferrets	6
California Condors	28
Whooping Cranes	50
Yellowstone Grizzlies	200
Northern Spotted Owls	2000

Most desert tortoise populations are probably still larger than even the largest of these above-cited cases (although some populations may have become this small by the time the recovery plan is implemented). Furthermore, the generation time of the desert tortoise is long, at least 25 years, which slows genetic deterioration in calendar time. Beyond this, the current information about the genetics of the desert tortoise is extremely scant. All of these facts suggest that genetic considerations will be secondary to other problems threatening the desert tortoise with extinction—at least for the time being.

Nevertheless, genetical considerations are important in reserve design. DWMAs must support a tortoise population with a large enough genetically effective population size to maintain sufficient genetic diversity for long-term persistence. Genetically effective population, N_e, is usually between 0.1 and 0.5 of the total adult population size, N, in vertebrates (Ryman et al. 1981, Shull and Tipton 1987). Details of desert tortoise life history suggests that the N_e/N ratio will be at the low end of this range—certainly no larger than 0.1, particularly in populations of low densities. If we assume that a genetic population size of at least 500 is necessary to maintain the genetic diversity required for long-term evolutionary potential, DWMAs should contain no fewer than 5,000 adult tortoises.

V. *Home Range and Movements*

If we know the amount of area that a tortoise occupies, we can determine the probability that individuals will encounter one another for mating. If there is a diminished probability of encounter between males and females, then population growth will be impeded by stochastic demographic forces discussed in Section IV of this appendix. Thus, knowledge of home range size is critical for determining a minimum viable population *density* for desert tortoises.

Estimates of the home range sizes of desert tortoises are necessarily constrained by inadequate data. In particular, desert tortoises may live in excess of 50 years, and thus, data on the normal lifetime movements of desert tortoises simply do not exist for logistic reasons. Indeed, the difficulty of working with desert tortoises has resulted in estimates of home range size that are seriously in error. Although estimated home range sizes of desert tortoises have been summarized recently (Berry 1986b), most of these estimates are based upon very small sample sizes or questionable methods (Table C2). Small sample sizes tend to produce estimates that underestimate actual habitat use. On the other hand, many of the statistical estimates of home range size assume that tortoises use their habitat as "central-place foragers" resulting in a distribution of habitat use that is spatially Gaussian (see Turner et al. 1981). This

assumption of spatial normality tends to inflate estimates of home range size.

In spite of these problems, these data can produce insights into home range size in desert tortoises. First, some of these estimates can be used as an index of habitat use without claiming that these estimates are seasonal, annual, or lifetime home ranges of tortoises. If this is done, females seem to have habitat-use indices that are approximately 58 % (ranging from 40 to 73 %) of the indices of males. Thus, it would appear that habitat requirements of male tortoises are different from those of females. Data on habitat use by two populations of desert tortoises have been collected by Esque et al. (in prep.) who have monitored populations from sites in Utah and Arizona for three years. Their preliminary data show that estimates of home range size increase continually with the number of relocations of tortoises over time (Figure C7).

Table C2. Home range estimates (ha) for desert tortoises from six sites (after Berry 1986)

Location	Males	Females	All	Source
Argus, California	53 (39 -77)	21 (4 - 46)		Berry 1974
Ivanpah Valley, California			22 (3 -89)	Turner et al 1981
			19 (2 - 73)	Medica et al 1982
Arden, Nevada	26 (20 - 38)	19 (11 - 27)		Burge 1977
Peacho, Arizona			– (0.3 - 268)	J. Schwartzmann unpublished data
	26 (4 - 331	15 (2 - 34)		Vaughan 1984
Beaver Dam Slope, Arizona	23 (5 - 59)	15 (2 - 34)		Hohman and Ohmart 1980
Beaver Dam Slope, Utah			-- (4 - 40)	Woodbury and Hardy 1948

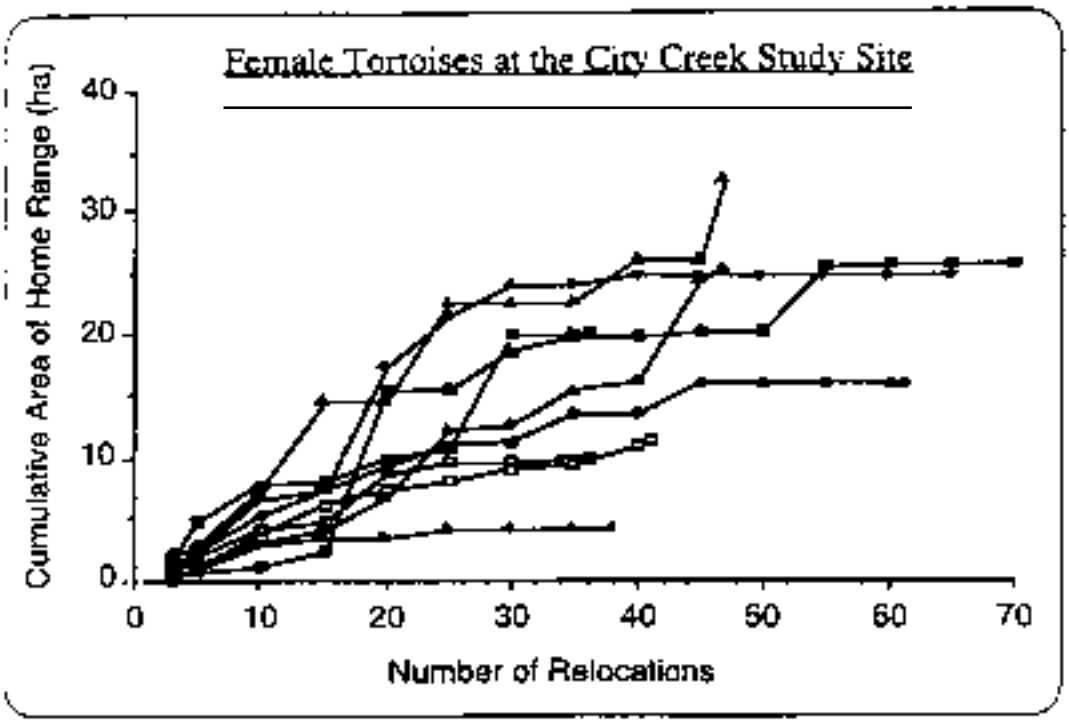


Figure C7. Cumulative estimate of home range size of adult female desert tortoises as a function of the number of relocations of each tortoise (Esque et al. in prep.). Relocations were separated in time by at least two days, and most relocations were spaced evenly over the activity season of the tortoises over a period of three years. Home range sizes were determined by the minimum convex polygon method.

This occurs for two reasons. First, the estimate depends upon the amount of data comprising the estimate. Too few data points will lead to an underestimation of the actual use of the habitat. Second, tortoises never occupy the same exact area of habitat from year to year, so that as more and more data are collected, the resulting estimate of home range size becomes larger and larger (Figure C8). It follows that to determine the lifetime home range size of desert tortoises, data would be needed on movements of tortoises over a period of at least 50 years. Clearly, this is not yet feasible, but the preliminary data may allow a reasonable estimate. Home range sizes appear to vary with site and among different years. However, in a data set covering four sites across most of the Mojave, and covering three years, the effect of site on home range size disappears ($F_{1,68}$ = 0.005, p = .94) when the effect of food availability (measured as production of spring annual plants, $F_{1,68}$ = 15.3, p = .0002) is entered into a statistical model (Figure C8). Furthermore, when both sexes of tortoises are considered at all sites, it is clear that home

range size is strongly predicted by food availability (Figure C9). When food becomes scarce, home range sizes become larger. However, when annual plant production exceeds approximately 30 kg dry mass/ha, home range sizes for both sexes appear to remain constant at a relatively small size. When each gender of tortoise is considered separately, it appears that female tortoises maintain approximately the same size home range regardless of site or food production at that site (Figure C10). However, male tortoises greatly increase their home range sizes in response to low food availability (Figure C10).

Many tortoises appear "to anchor" their annual movements to an overwintering site that may be used repeatedly in many seasons (Figure C11). This fidelity to an overwintering cave or burrow has also been seen by C. C. Peterson (unpublished data) at The Desert Tortoise Natural Area in the eastern Mojave and at Ivanpah Valley in the western Mojave of California. This does not mean that all tortoises invariably return to the same winter cave or burrow, but rather that fidelity to a well-developed cave or burrow appears to be fairly common. If a tortoise does indeed anchor its use of the habitat to an overwintering cave or burrow to which it remains faithful for many years, then it can be assumed that over its lifetime a tortoise would range in all directions from the overwintering site at distances similar to those seen in any one year. Thus, a circle can be drawn with the overwintering burrow as the center and the radius being the furthest point from the overwintering burrow. The resulting area is the estimated lifetime home range of the tortoise (Figure C12). From this analysis, the estimated lifetime home range for the City Creek tortoise ranging furthest in the three year study (female # 11.0 in Figure C11) is 180 hectares or about 0.7 square mile. The average estimate for all tortoises at City Creek is 97 ha (ranging from 38 to 180 ha).

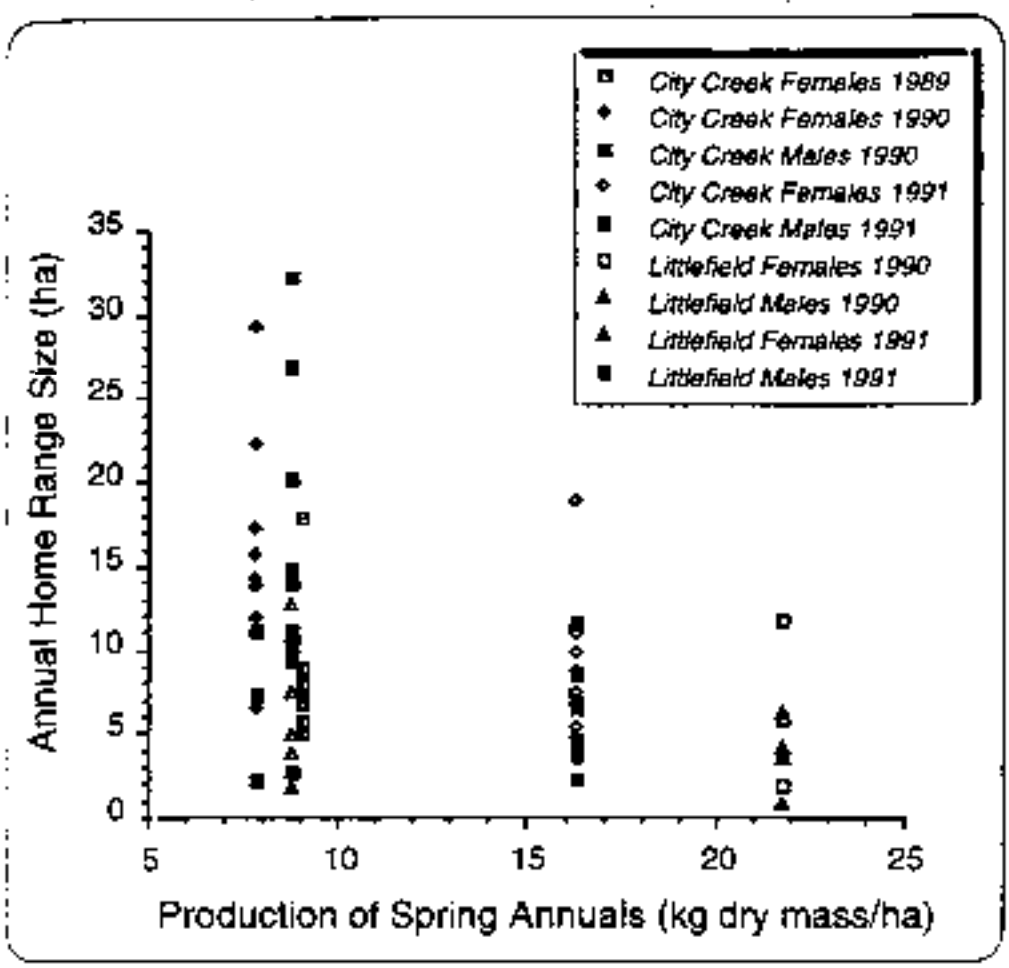


Figure C8. Annual home range sizes of tortoises at the City Creek and Littlefield Study Sites.

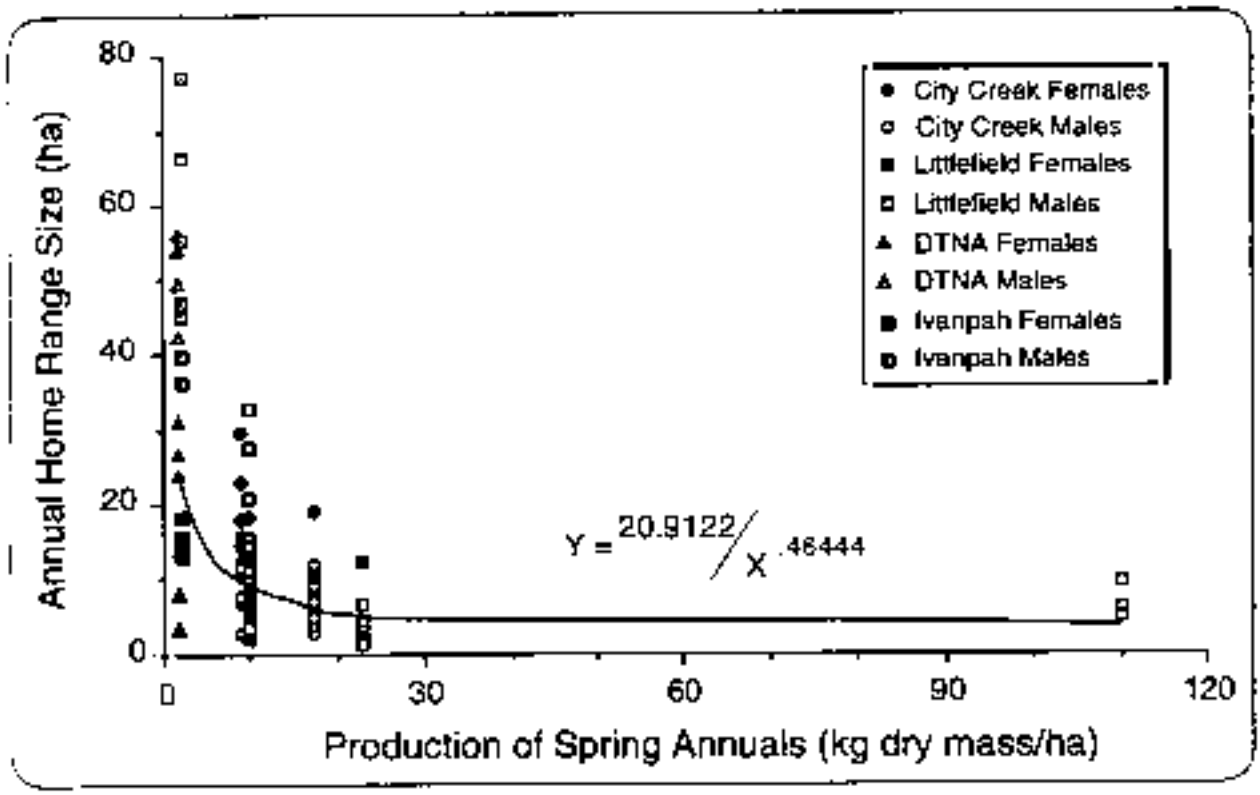


Figure C9. Annual home range sizes of desert tortoises at four sites in the Mojave Desert during the period of 1988 to 1991.

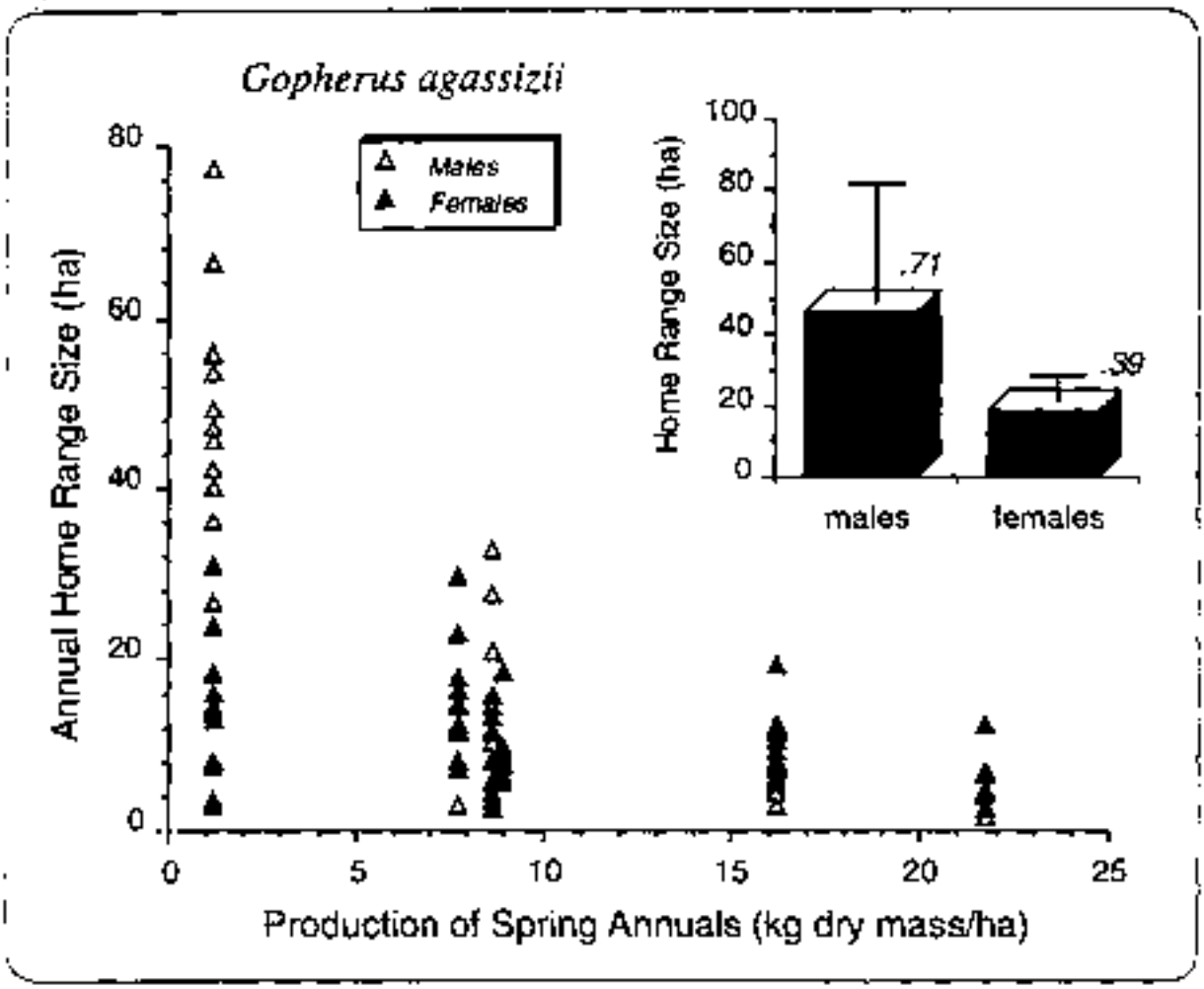


Figure C10. Annual home range sizes of desert tortoises at four sites in the Mojave Desert.

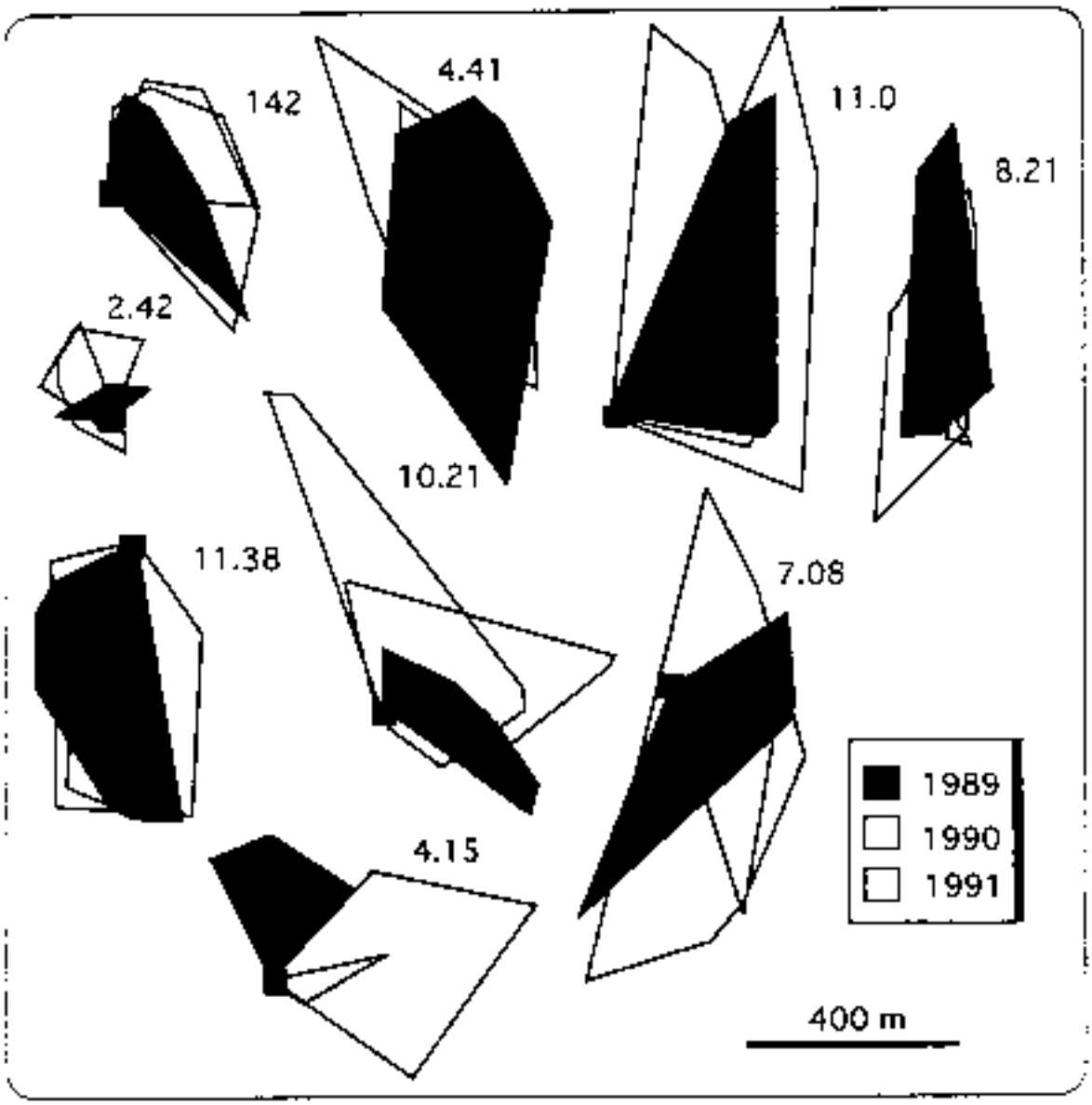


Figure C11. Home ranges estimated from the minimum convex polygons of relocations of nine adult female tortoises from the City Creek Study Site, St. George, Utah. Polygons were generated from 38-70 relocations (see Fig. 7) over a three-year period from 1989 to 1991. Relocations were evenly spaced over the activity seasons of each year. In most cases an overwintering cave was identified (black square), and in all of these cases, the overwintering cave was used repeatedly over the three-year period.

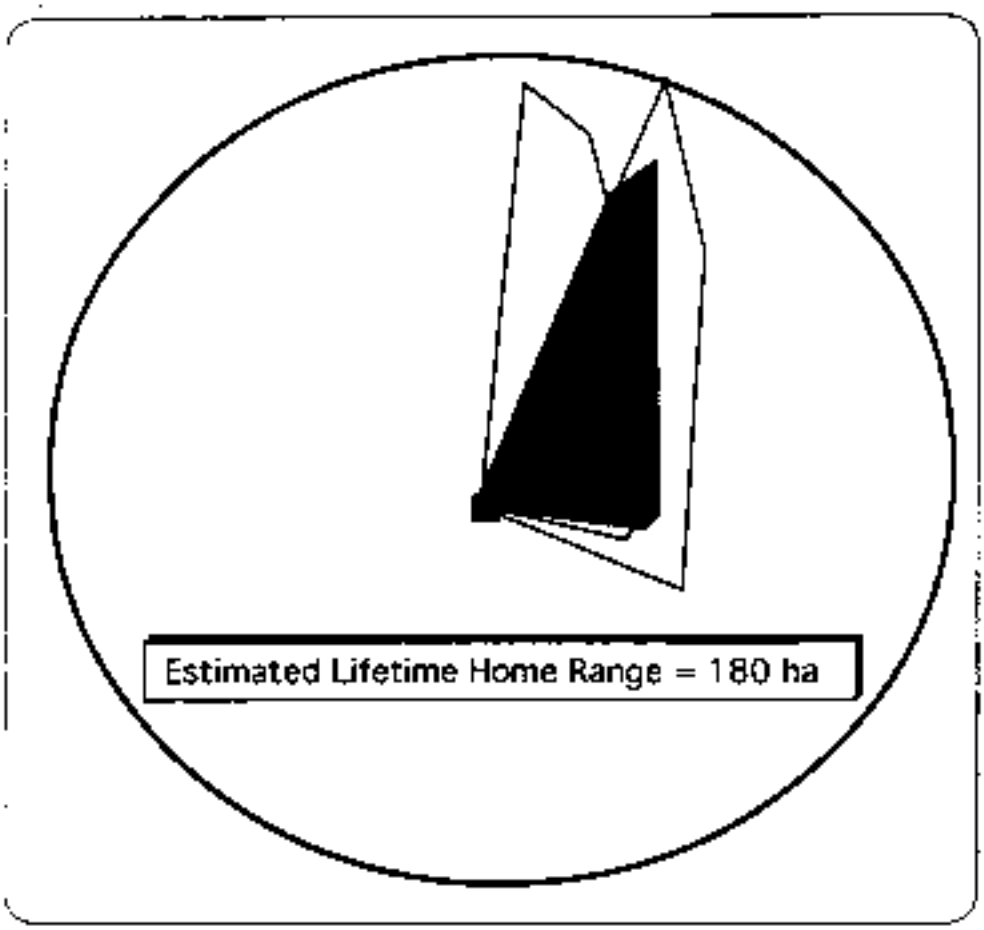


Figure C12. Estimated maximum lifetime home range of adult female tortoises at the City Creek Study Site, St. George, Utah.

Because these estimates are for females, and because females have home ranges that are about half that of males, it can be assumed that the lifetime home range of adult males may be twice these sizes, or about 194 ha (ranging up to 360 ha or about 1.5 square miles).

Even these estimates of lifetime home range size could substantially underestimate the habitat use of a tortoise that lives to a very old age. For example, tortoises are known to take lengthy forays from their home ranges and then return. Both male and female tortoises have been observed to make very long-distance forays (Figure C13). For example, at the DTNA Site, one female tortoise moved more than 8 km from its hibernation burrow over a period of between 11 and 58 days (the telemetry signal from the tortoise could not be found

during a sample 11 days after a previous sample, and the tortoise was not relocated until 58 days after its previous relocation). Two of four tortoises known to make long forays were found dead within three months of the initiation of the foray. One of those two tortoises was the first desert tortoise in nature to be observed with Upper Respiratory Tract Disease. Of the two tortoises that lived after having made a long-distance foray, one moved from a small area of activity (less than 10 ha) to another similar-sized area more than 2 km distant. This tortoise never returned to the area in which it was originally observed. The other tortoise was repeatedly relocated in an area totaling 38 ha before it made a foray of approximately 4km.

From these estimates of home range sizes of adult tortoises, we can estimate the minimum viable density of tortoise populations. Because we have very few data on mate-finding strategies in this species, this estimate is necessarily crude. Refinements, however, require considerable additional data.

Male and female tortoises have home ranges that are dynamic from year to year and from place to place. During years in which food resources are sparse, male tortoises expand their home ranges considerably, and female tortoises somewhat less (Figure C10). Averaging across several studies, male home ranges have been shown to expand to approximately 50 hectares, with considerable variability around the average, when food resources are scarce. Thus, in years when average home ranges are very large, approximately 5 male tortoises can "fit" into a square mile with no overlap of their annual home ranges. (This assumes that tortoises are "overdispersed," which may or may not be true.) At this density, males moving about as they have been seen to do in years when home ranges are very large, would theoretically patrol all of their habitat. Fewer than five males would result in some parts of this theoretical square mile not being patrolled, and females in the unpatrolled parts would not come into contact with males every year. Assuming that the population is 50% females, then the "minimum contact density" which would guarantee that all females would be mated every year is 10 adult animals per square mile, or higher if the population had more females than males.

This reasoning suggests that the minimum viable density of tortoise populations—the density below which the potential for population growth is diminished due to stochastic demographic forces--is about 10 adults per square mile. Thus, a DWMA has to be large enough to hold some predetermined number of tortoises at a density of no less than this.

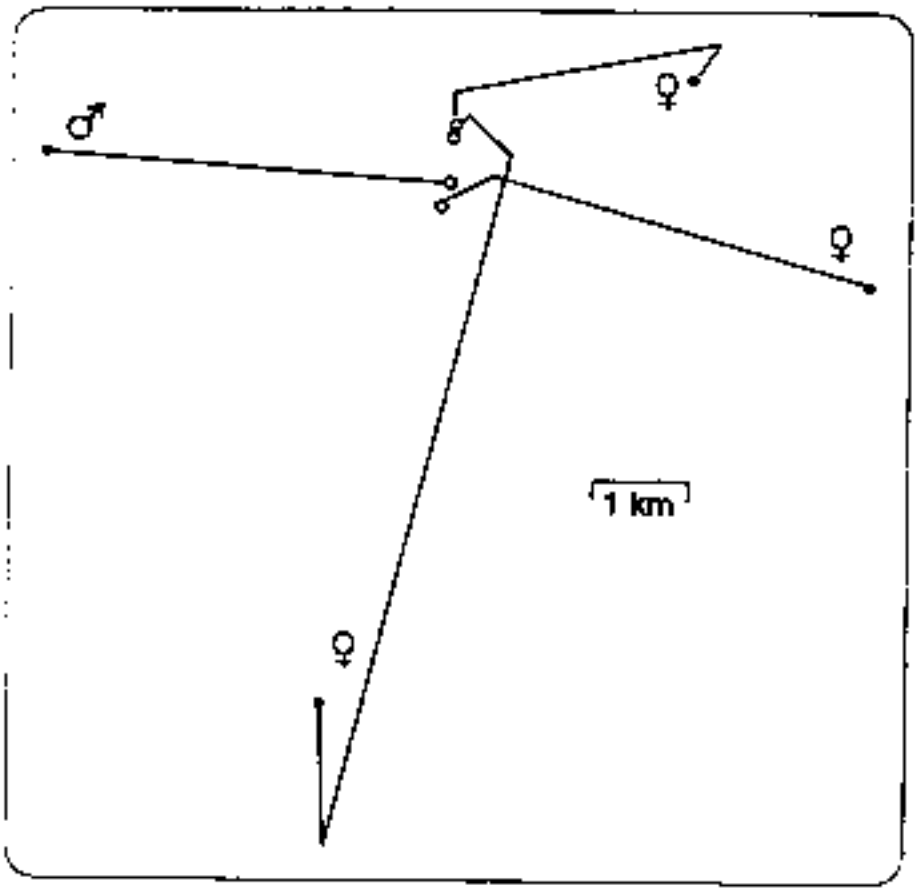


Figure C13. Long-range movements of tortoises at the DTNA site.

VI. Desert Tortoise Demography

Tortoise demography is complex but the overall features are well known. There is a long prereproductive period and females first reproduce at ages between 12 and 25 years (Turner et al. 1984) with animal size bing more important than age in determining vital rates. As a general rule-of-thumb, 185 mm is the carapace length for first reproduction. There seems to be no senescence; adults die off at a slow rate and may live for more than 80 years. Adults continue to reproduce throughout their lives. In general, females reproduce in most years and may have two clutches per year. The survival of juveniles is very low and probably varies from year to year.

Because of limited data on the demographic processes and parameters for desert tortoise, modeling of desert tortoise population dynamics is difficult and not independent of modeling assumptions. Thus, three separate modeling exercises were conducted to assess extinction probabilities in desert tortoises. These three exercises were conducted at different times during the production of the Recovery Plan. Thus, some had the benefit of more recent data. The first of the analyses, the Gilpin analysis, is the richest with respect to the diversity of questions asked of the models. The second, the Tracy analysis, partitioned the variance in the empirical data upon which the modeling is based into its different components. The third, the Peacock model, was done as a check on both of the previous modeling exercises by using a commercially available demographic program.

A. The Gilpin Model

A Projection Model. The data for this analysis come from the work of Turner et al. (1987) on a population near Goffs, California. From these data, it is straightforward to construct an age or stage projection matrix (Biehl and Gilpin 1990). A stage-structured matrix was constructed by collapsing Turner et al.'s (1987) more finely resolved data:

Stage 1 = hatchlings
Stage 2 = 1-5 years old
Stage 3 = 6-10 years old
Stage 4 = Subadults
Stage 5 = Adults

These correspond to a five element column vector. The output from one run of the program is:

Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
.000	.000	.000	.000	6 200
.620	.706	.000	.000	.000
000	.093	.802	.000	.000
000	.000	.031	.719	.000
.000	.000	.000	.111	.937

Stage 1 had 23.4485% of the individuals.
Stage 2 had 48.3691% of the individuals.
Stage 3 had 21.9897% of the individuals.
Stage 4 had 2.38581% of the individuals.
Stage 5 had 3.80685% of the individuals.

Stage 1 Reproductive value = 1
Stage 2 Reproductive value = 1.62349
Stage 3 Reproductive value = 5.24694
Stage 4 Reproductive value = 34.402
Stage 5 Reproductive value = 89.1427

This output is for a single run of the model. Each of the parameters in the transition matrix has some uncertainties associated with it; thus, a sensitivity analysis was done on the matrix before any conclusions were drawn from the model. These conclusions are given in the following sections.

The per year growth rate of desert tortoises is low. The Turner et al. (1987) study found only 2% per year. If this rate is a maximum that is generally true for all populations, desert tortoises have low resistance to negative deterministic impacts (harvesting by humans, predation, disease, kills by motor vehicles, competitive interactions from livestock, etc.) to the population. Figure C14 illustrates this schematically.

Because of the extremely long prereproductive period (to an age as great as 25 years), the reproductive values of desert tortoises vary greatly. Figure C15 shows the reproductive values versus age for the Turner et al. (1987) desert tortoise data.

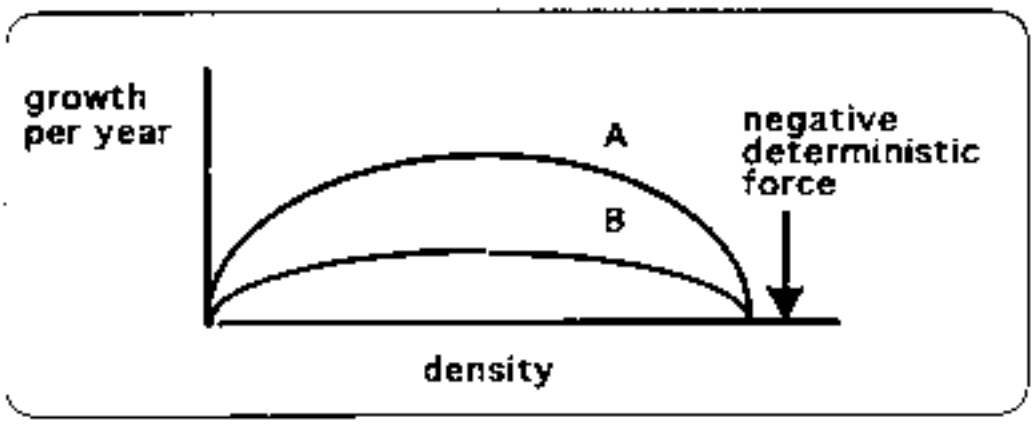


Figure C14. Two population growth curves. Both A and B have the same carrying capacity (the rightmost point on the abscissa where the growth curves intersect). Curve A has a higher intrinsic rate of increase. If a deterministic force indicated by the downward arrow at the right of the figure impacts the population, the population following curve A could adjust to a lower equilibrium density and could persist. Curve B, however, has too low a rate of increase and would be overwhelmed by the negative deterministic force and the population would go extinct.

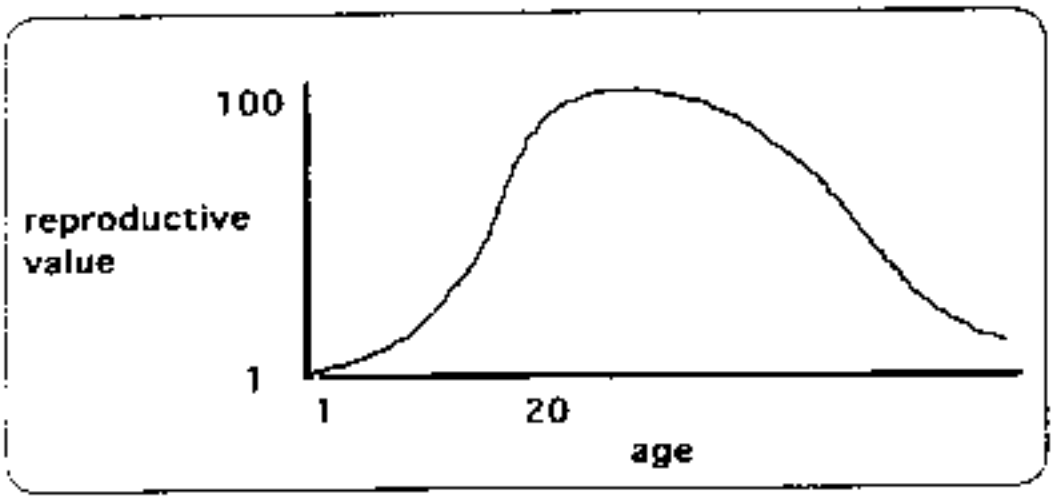


Figure C15. Reproductive values.

One consequence of this is that introductions of desert tortoises to empty habitat should best be accomplished with the addition of high reproductive value individuals; i.e., young adults. Of course, this mathematical result is consistent with common sense.

The age and size structure of a population of desert tortoises is very slow to return to the stable distribution following a perturbation. This is much like the human population, where, for example, in the United States the consequences of the baby boom will be felt for a century. An out-of-equilibrium age/size distribution could have implications for desert tortoise social structure. Figure C16 shows one simulation of age-structured growth that begins from a disturbed (non-steady) state. Note that the initial oscillations have a period of about 14 years. This implies that any trend analysis for less than 14 years could give very misleading projections.

Density dependence.- Nothing is known about the mechanism of density dependent population regulation in the desert tortoise. That is, what sets a carrying capacity, K? Is K ever reached? If so, what determines K - food resources, soil available for burrows? There is some suggestion that maximum densities of desert tortoises are set by levels of primary productivity (See Appendix G). Other relevant questions include: Are tortoise densities held down by predation? Is there social regulation of population density?

Demography and deterministic population regulation is an area that needs further research and study. These processes may vary over the range of the desert tortoise, and applications of details from the Goffs study to desert tortoise populations in the far western Mojave or to northern populations in

Nevada and Utah, may be inappropriate. However, the general character of desert tortoise demography as revealed by the Goffs study is probably valid throughout the range.

Variable Growth Rates of Desert Tortoises (Environmental Stochasticity). Growth rates for desert tortoise populations are variable from time period to time period and from one local population to the next local population. With variable growth rates comes the possibility of stochastic extinction: the population will have a run of bad luck and its density will drop below the threshold of extinction. This is environmental stochasticity.

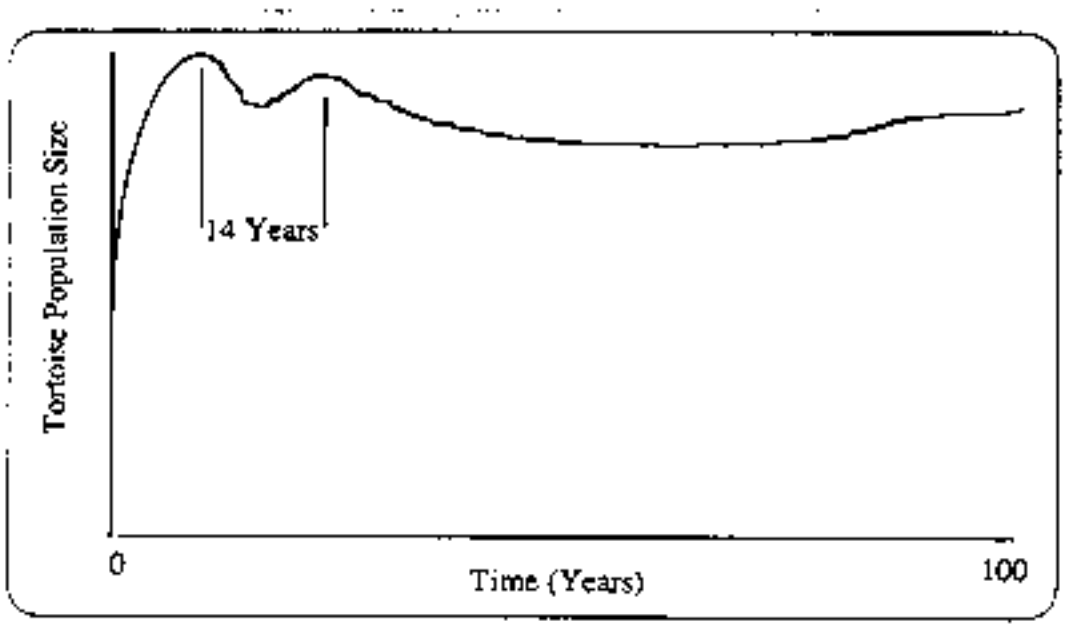


Figure C16. A projection of age structured growth for a desert tortoise population.

A simple discrete equation for stochastic growth is:

$$N_{t+1} = \{lambda\}\ N_t \qquad \text{if} \qquad N <= K$$
$$N_{t+1} = K \qquad \text{if} \qquad N > K$$

where N_t is the current population size and where N_{t+1} is the size of the next time period, and where {lambda} represents a random variable for discrete growth described below. If the current population is above K, the carrying capacity, the population size drops to K the next year. But if the population is below K, the new population size is determined by drawing a discrete growth rate, lambda, from a probability distribution with a known mean and variance. In most explorations of this model, it is assumed that the mean lambda is greater than 1, which corresponds to an r of greater than 0. The relationship between r and lambda is:

$$\rho = \log_e(\text{lambda}).$$

In more sophisticated models (e. g., Goodman 1987), the mean and variance of the distribution of lambda values may change with the size of the population; that is they may be functions of N. For populations in natural environments, it is almost impossible to determine the relationship of mean and variance of lambda to N, if for no other reason than the problem of obtaining a sufficiently large sample size. Thus, it will not always be the case that the variation of population growth will be modeled as independent of N.

Data for this model came from desert tortoise populations that had been sampled at 13 locations throughout the Mojave desert (Berry 1990, as amended, Nevada Department of Wildlife 1990; SWCA, Inc. 1990):

California:	Chemehuevi
	Chuckwalla Bench
	Goffs
	Ivanpah valley
	Upper Ward Valley
	Desert Tortoise Natural Area
	Fremont Valley
	Johnson Valley
	Kramer Hills
	Lucerne Valley
	Stoddard Valley
Nevada:	Piute Valley
Arizona:	Littlefield

Samples of adult desert tortoises were taken at these study locations at various years. From these samples, the discrete growth rate

lambdas can be computed. These lambdas are based on per year growth intervals. For samples on two successive years, the lambda is given by:

lambda = final_sample/initial_sample.

If the period is more than 1 year, the relationship is

lambda=(final_sample/initial_sample)^(1/no_of_years).

where the "^" sign indicates exponentiation. From these study locations, some of which had more than two samples, 27 different values of lambda can be determined, which define a probability distribution. The mean lambda is .985, with a standard deviation of 0.08. The probability distribution of lambdas is shown in Figure C17.

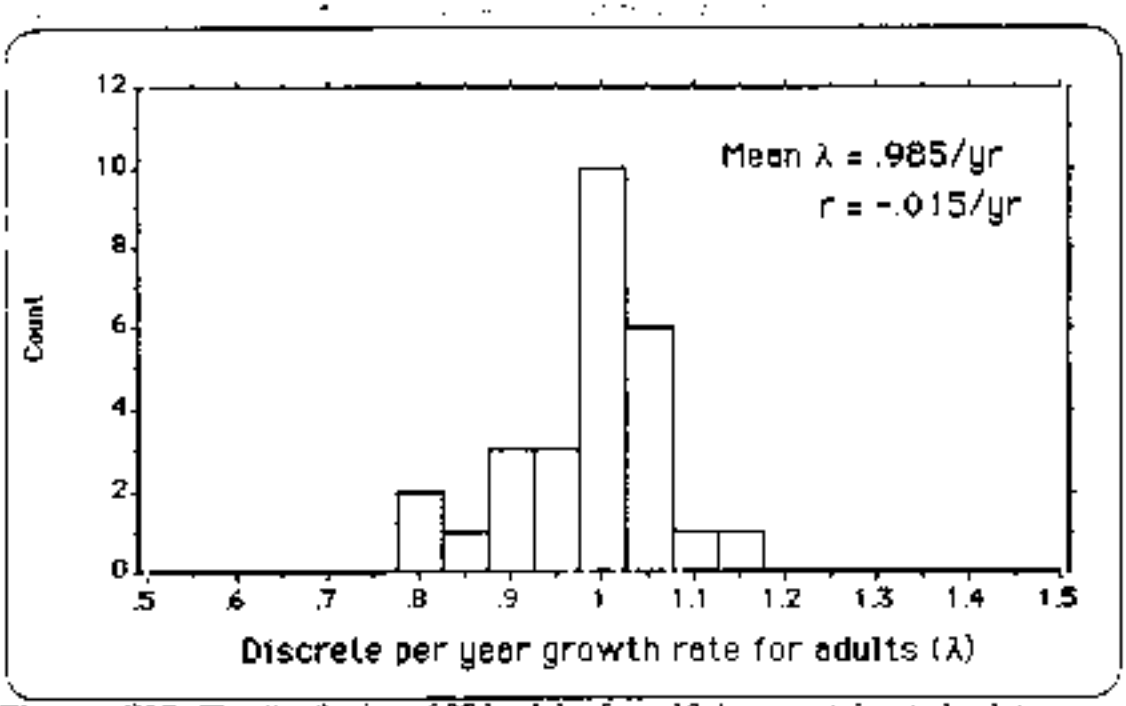


Figure C17. The distribution of 27 lambdas from 13 desert tortoise study plots.

The lowest lambda is 0.8 and the highest is 1.15. These correspond to per year changes of roughly -20% and +15%, with a mean of -1.5%/year. That the average growth rate from these sites is -1.5% does not mean that the entire desert tortoise population is only shrinking at this rate, for these study populations represent for the most part local populations in the centers of good habitat. The entire species population of desert tortoises could simultaneously be shrinking in its spatial extent, and this would not be represented in these figures. Furthermore, these are pre-URTD studies. Adult dieoff accelerates by as much as an order of magnitude not long after URTD is first identified in these populations. Also, the extreme growth rates of -20% and +15% probably correspond to cases where the age structure of the population is badly out of stable age distribution (see below), or where there is some form of animal movement into or out of the local population.

Nonetheless, the variance in lambda values possibly represents the variance that would be present in reserve systems with protected boundaries and which were free of URTD. Thus, these are good numbers to use in a first-pass simulation study of local extinction of desert tortoise populations on reserves. They may set one kind of lower limit to the scale of reserve units, suggesting that anything smaller is certain to be inadequate. They may also be a best-case scenario insofar as the consequences of disease are not reflected in the data.

To model time to extinction, N_{t+1} is calculated using the empirical distribution of lambdas in Figure C18. The first simulation assumed an initial N of 20,000 adult desert tortoises at equilibrium (i.e., K is the same value). An extinction threshold is taken as 2 individuals. The distribution of times (in years) to extinction is given in Figure C18.

From Table C3 it can be seen that, among other things, 90% of the populations will survive at least 350 years, and that the mean time to extinction is 505 years, with a standard deviation of 115 years.

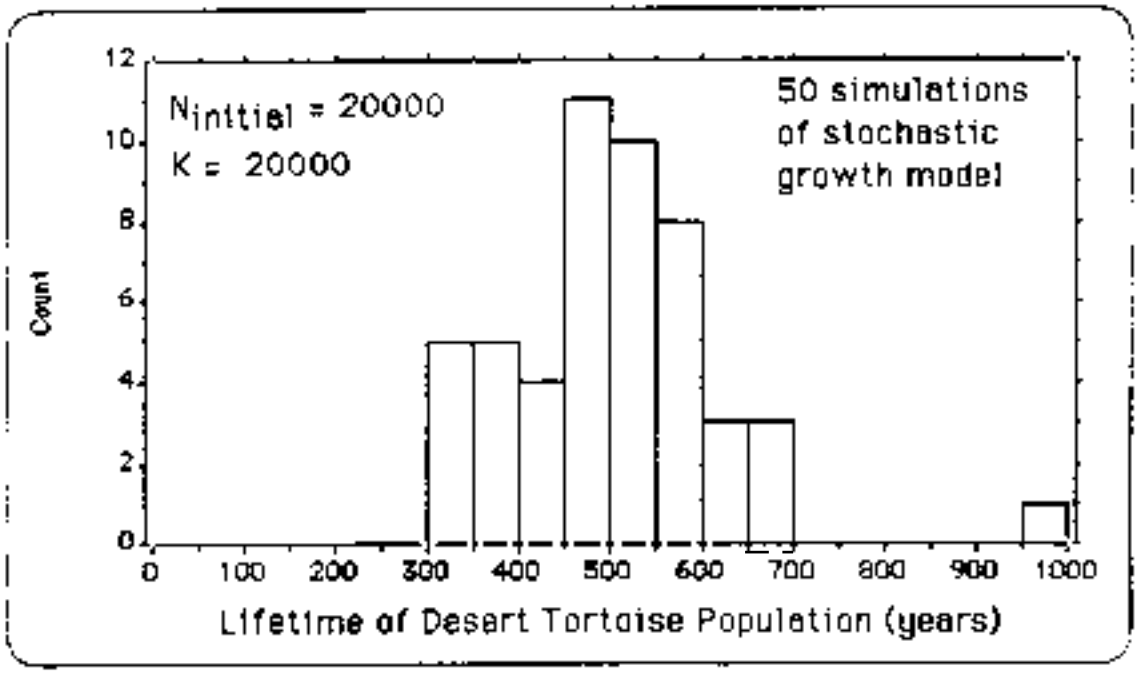


Figure C18. Time to extinction based on current best estimates of stochastic growth.

Table C3. Descriptive statistics for the distribution of times to extinction (Fig. C18).

Mean:	Std. Dev.:	Std. Error:	Variance:	Coef. Var.:	Count:
504.8	115.427	16.324	13323.429	22.866	50
Minimum:	Maximum:	Range:	Sum:	Sum Squared:	# Missing:
332	987	655	25240	13394000	0
# < 10th %:	10th %:	25th %:	50th %:	75th %:	90th %:
5	350	423	499.5	562	633.5
# > 90th %:					
5					

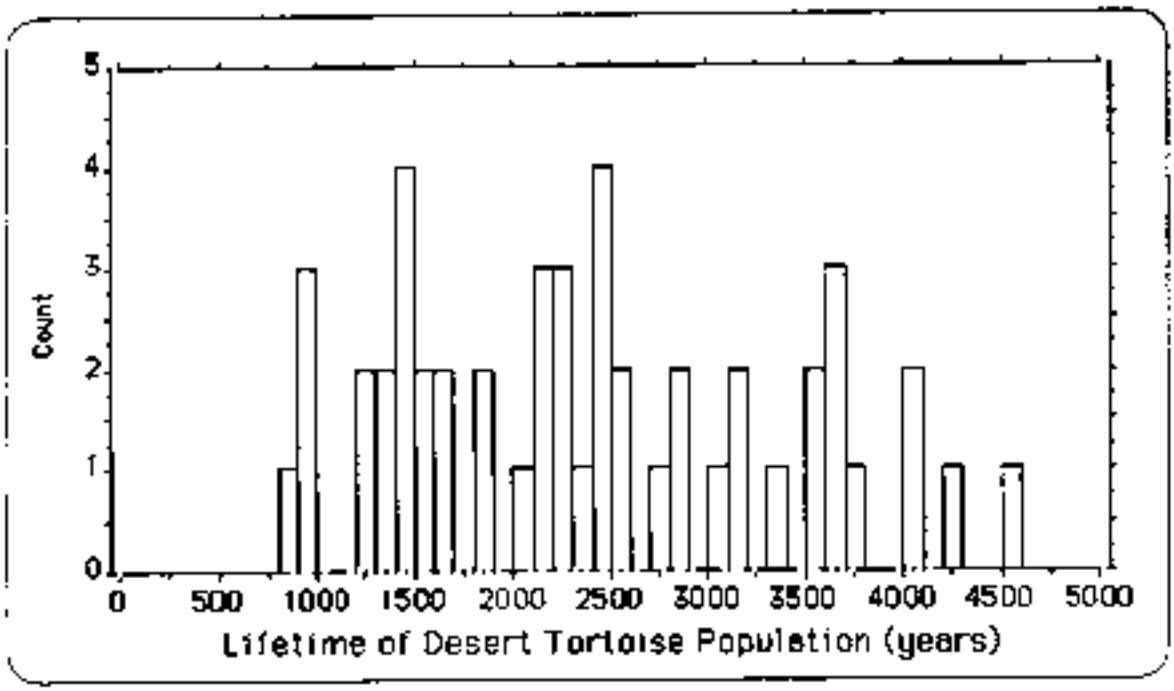


Figure C19. Extinction time under hypothesized management (see text).

These projections are based on a relatively simple model and on relatively limited data. One way to get a feeling for the reasonableness of "stability" of such projections is to change the model slightly. If the mean lambda is raised from 0.985 to 1.000 (a growth rate for maintaining stable population size), but the variance in growth remains the same; that is, that the histogram in Figure C18 is shifted rightwards by an amount 0.015, the mean tendency is for the population to remain stationary in size. However, it cannot increase above its K, while at the same time it has no lower bound other than extinction. If the model is now run with the slight increase in mean lambda, the growth distributions are as shown in Figure C19.

The mean time to extinction has now increased five fold to 2,474 years, with a standard deviation of 1,150 years. That is, given the hypothetical situation for growth now assumed for a desert tortoise population, a 1.5% elevation of the growth rate leads to a 500% increase in time to extinction. This suggests that a little management of tortoise habitat may go a long way to help local populations.

A second manipulation is also instructive. If the mean lambda is kept at 1.000, but the local population is made ten times smaller (i.e., $N_{initial} = 2000$ and $K = 200$), the mean time to extinction is

361 years(Figure C20). Thus, the size of the population (and hence the reserve) matters greatly given the observed fluctuation in growth rates. Thus, even with improved management, a reserve with a maximum population of 2,000 desert tortoises is too small to achieve a reasonable predicted time to extinction.

Even though tortoise populations declined (mean lambda = 0.985), the years 1979-1989 were relatively good ones for the desert tortoise compared to the next two. During 1990 and 1991 marked declines in numbers occurred. If the data from 1990-91 are added to the 1979-89 data, the mean lambda (i. e., the per year discrete growth rate) is so reduced that the model populations promptly go extinct. However, recovered populations, or populations on their way to recovery, should have the ability to rebound from bad years, once most of the extrinsic sources of mortality have been removed. Clearly, these years are not the first drought or disease episode experienced by desert tortoises over their long history of occupation of this region. In addition to bad years, there will also be some years of extraordinarily high lambdas associated with very good conditions. This implies that the average lambda from the 1979-89 data set will still be obtained--only its variance (or standard deviation) will be increased. The amount of the increase in the standard deviation will depend on the frequency of very good years and very bad years, whatever that may be.

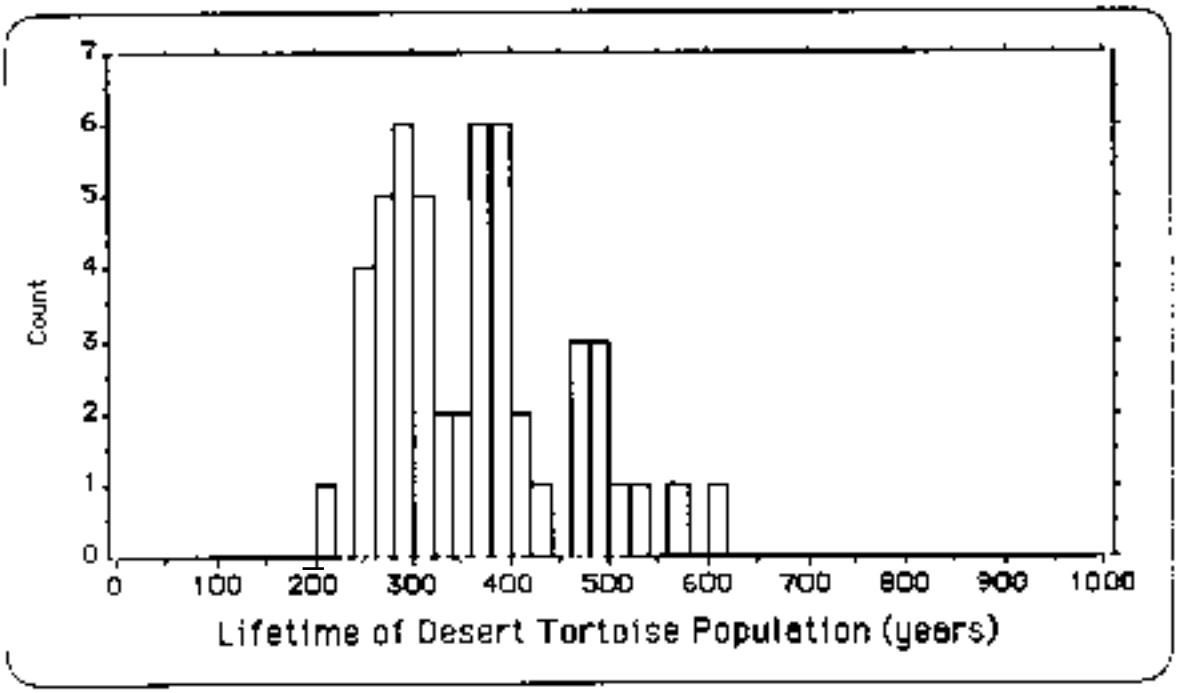


Figure C20. Extinction times in a small managed reserve.

This model can also be used to examine the time to extinction for various modifications to variation in lambdas. Population ceilings of 200, 2000 and 20,000 adult desert tortoise were used, and the variation in lambdas is increased by certain percentage amount while all else was kept constant. Fifty trials were performed for each case, and the median number of years of persistence is used as the estimator of time to extinction. The results are shown in Figure C21. Time to extinction increases linearly with the logarithm of population size, as is expected from standard theory. The highest line is for the 1979-1989 data. The 500 year time to extinction is reached with a population ceiling (K) of 20,000 adult desert tortoises. The three lower lines on the figure, based upon simulations using ceilings of 200, 2000 and 20,000 adult animals, show the effect of increasing the variance in lambda to 120%, 150% and 200% of its value in the 1979-1989 data set.

This experiment shows that the higher the variability of population growth, the larger the population size required for viability. For example, about 50,000 adult tortoises would be required for a median time to extinction of 500 years if the actual variance in lambda is 120% of the 1979-89 value. Since population size is a function of reserve size, a reserve large enough to support this number of adult tortoises would be necessary. That is, this model suggests that reserves large enough to support 50,000 adult desert tortoises would be advisable building blocks to achieve a median time to extinction of 500 years for recovered populations.

This model does not incorporate three important features. First, it ignores catastrophes. Second, it extrapolates from the last decade of desert tortoise history hundreds of years into the future. Many things, such as climate change, could invalidate these data considerably. Third, it does not account for spatial structure and the possible interactions of local populations. Nonetheless, this analysis does show that a reasonable reserve size for long-term protection of desert tortoises should be large enough to accommodate roughly 50,000 adult animals.

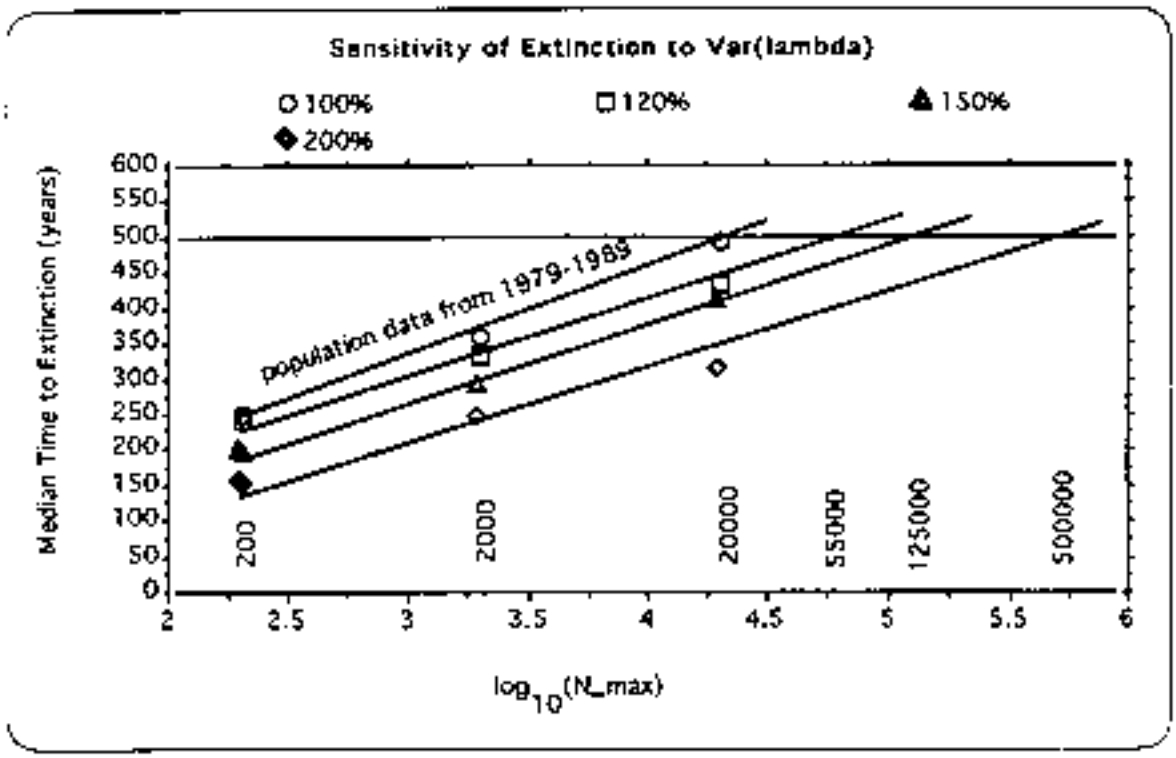


Figure C21. Median time to extinction as a function of population carrying capacity (denoted N_max) and of the variance of the discrete growth rate, lambda. The standard deviation of lambda is increased by 20%, 50% and 100% above the value used in the original report. The horizontal line is at 500 years, which is taken as the minimally acceptable time for a single reserve.

B. The Tracy Analysis

Matrix Population Model. - The only compilation of detailed demographic data for the desert tortoise comes from studies at the Goffs Site in California (Turner et al. 1987, Burnham et al. 1987). From these data it is straightforward to construct a stage-transition matrix (Caswell 1989). All tortoises were placed into five stage categories (Table C4), and these stages were incorporated into a five-stage demographic model (Figure C22).

The demographic flows modeled in Figure C22 are placed into a transition matrix:

$$\mathbf{A} = \begin{pmatrix} P_1 & F_2 & F_3 & F_4 & F_5 \\ G_1 & P_2 & 0 & 0 & 0 \\ 0 & G_2 & P_3 & 0 & 0 \\ 0 & 0 & G_3 & P_4 & 0 \\ 0 & 0 & 0 & G_4 & P_5 \end{pmatrix}$$

The G and P elements of this matrix model were estimated from the simulated survivorship curve (Figure C23) for the Goffs Site (Turner et al. 1987, Burnham et al. 1987). The F element (only "adults" produce eggs) was taken as a variable based upon population growth rates to be modeled.

Table C4. Description of the ages of desert tortoises included in the five stages for the stage-based demographic model of desert tortoise population growth.

Stage	Ages
1	hatchlings
2	1 to 5 years old
3	6 to 10 years old
4	subadults
5	adults

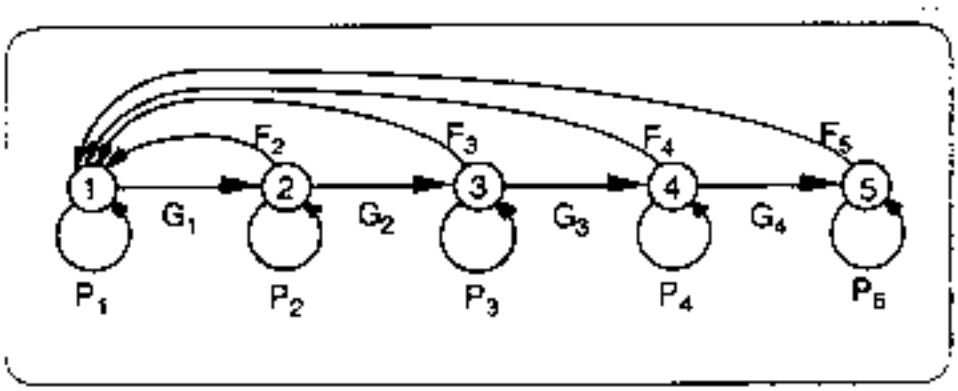


Figure C22. Conceptual model of the life cycle of desert tortoises in which individuals move among the five stages within the life cycle according to two probabilities of movement: P_x is the probability of an individual remaining in a particular stage x, G_x is the probability of an individual moving to the next older stage x, and F_x is the number of hatchlings produced by individuals surviving to the adult stage.

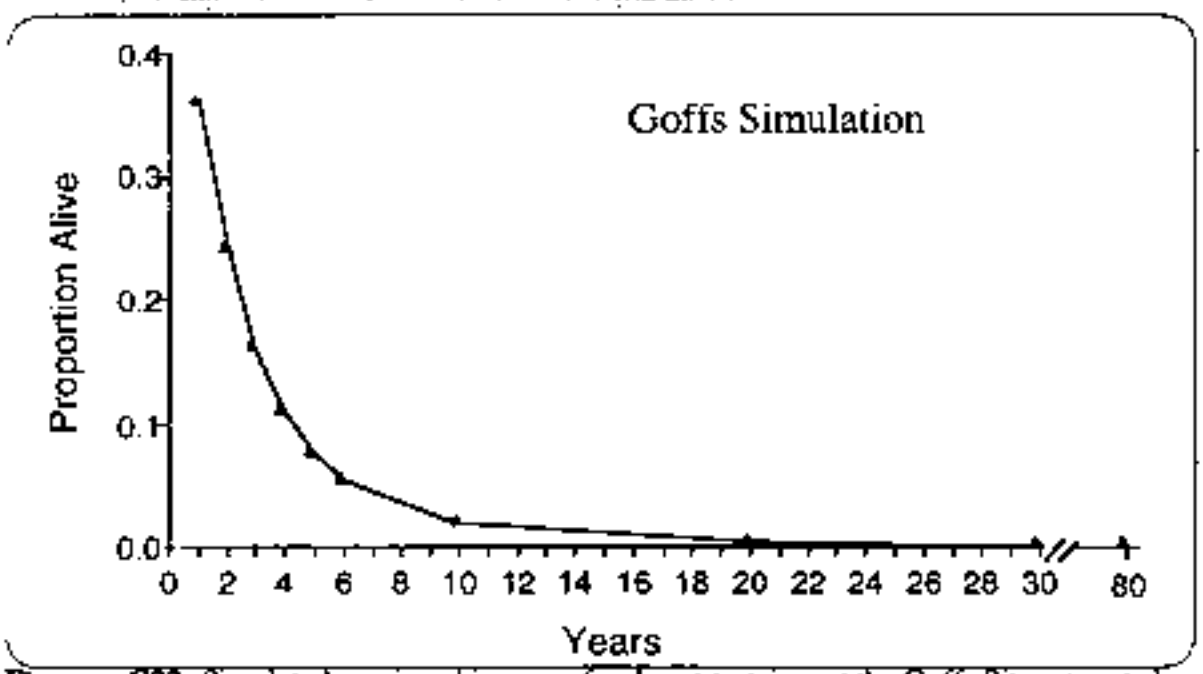


Figure C23. Simulated survivorship curve for desert tortoises at the Goffs Site estimated from data presented in Turner et al. (1984) and Burnham et al. (1987). Survivors are presented as proportion of the population still alive as a function of tortoise age.

Growth of Mojave Populations

Nineteen sites in California and Nevada have been monitored for desert tortoise population sizes since 1979 (Table C5). At all of these sites populations have been sampled more than once over a period of 13 years yielding a total of 39 estimates of the discrete growth rate (lambda, l) calculated as,

$$l = (N^*/N)^{(1/(t^*-t))}$$

where:

N^* = Population size at time = t^*

N = Population size at time = t

t^* = time of the initial sample

t = time of the second sample

The mean lambda for all monitoring sites was 0.975 (Figure C24A) with a standard deviation of 0.091. However, this standard deviation for the mean lambda includes variation attributable to several sources: (1) differences in lambda among sites, (2) differences in lambda due to temporal trends in population size, (3) year-to-year variation around the temporal trends, and (4) errors in the estimation of population sizes. An analysis of covariance was performed to partition these sources of variation around the mean lambda (Figure C25). The standard deviation for the mean lambda due only to year-to-year variation around the temporal trends, plus the estimation errors, was only 0.019 (Figure C24B). Until an analysis is performed to determine the errors in population estimation, it is not possible to sort out the year-to-year variation around the mean lambda completely.

Using the transition matrix from Goffs and the mean Lambda for the 39 sites in California and Nevada, the unknown F_x in the model can be solved for. This results in the transition matrix for the "average" population in the Mojave to be,

$$\mathbf{A} = \begin{pmatrix} .000 & .000 & .000 & .000 & .500 \\ .360 & .614 & .000 & .000 & .000 \\ .000 & .076 & .715 & .000 & .000 \\ .000 & .000 & .171 & .840 & .000 \\ .000 & .000 & .000 & .174 & .940 \end{pmatrix}$$

Table C5. Long-term monitoring sites at which population sizes of desert tortoises have been estimated between 1979 and 1992.

Sites Receiving Winter and Summer Rains

Chemehuevi Valley, California
Chuckwalla Bench, California
Chuckwalla Valley, California
Ivanpah Valley, California
Upper Ward Valley, California
Christmas Tree, Nevada
Coyote Springs, Nevada
Gold Butte, Nevada
Piute Valley, Nevada
Sheep Mountain, Nevada
Trout Mountain, Nevada

Sites Receiving Winter Rains Only

Desert Tortoise Natural Area (Interior), California
Desert Tortoise Natural Area (Visitors Center), California
Fremont Valley, California
Fremont Peak, California
Johnson Valley, California
Kramer Mountains, California
Lucerne Valley, California
Stoddard Valley, California

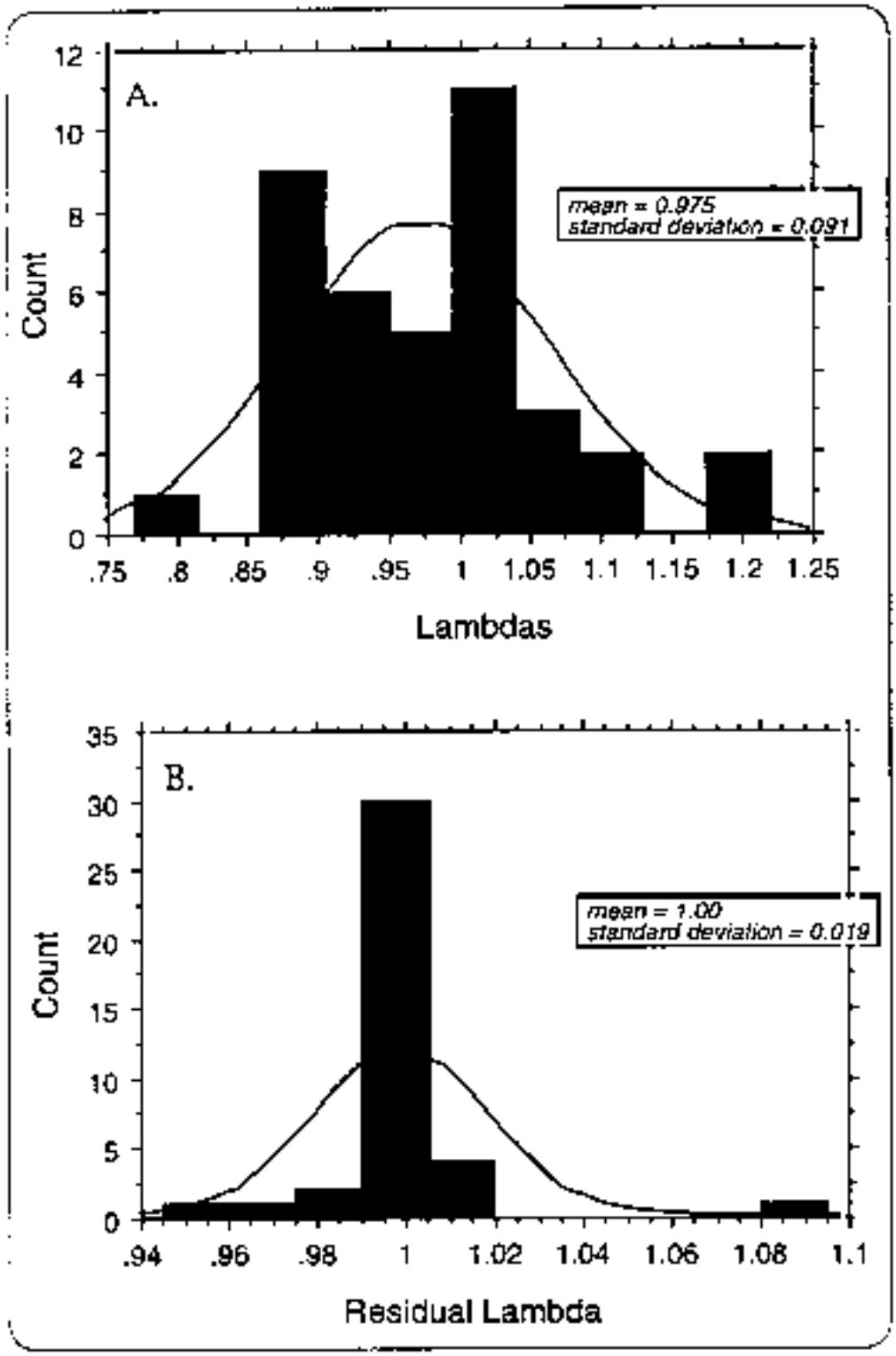


Figure C24. Frequency distribution of Lambdas for (A) all 39 Lambda estimations, and (B) for the residuals after variation due to site, time, and site * time interaction are removed.

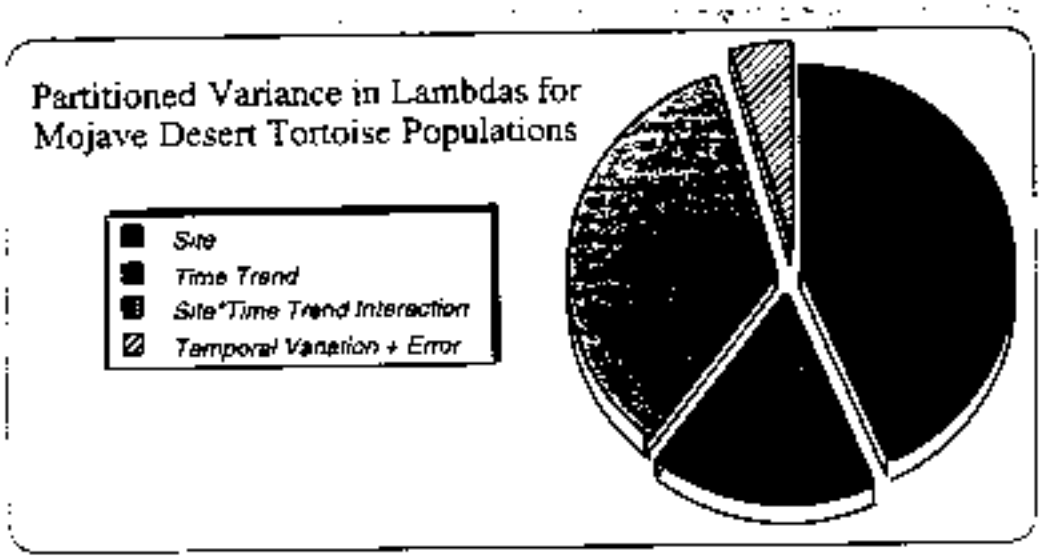


Figure C25. Proportions of variance around the mean lambda for 39 sites in California and Nevada.

When the "A" matrix (the transition matrix) is multiplied times a vector containing the number of tortoises in each of the five stages, the result is a new vector containing the numbers of tortoises in each stage one time step (one year) into the future. After many repeated time steps, the relative proportions of tortoises in each stage remains a constant, and the population is said to have reached a stable-age distribution. The stable-age distribution for an idealized population with the growth and survival characteristics of the Goffs population and the Lambda of the average population from the monitored sites is given in Figure C26. This stable-age distribution is similar to a collective size distribution assembled from data at several study sites in the Mojave and Sonoran desert tortoise populations (Figure C27). Moreover, when the data in Figure C27 are collapsed to a stage distribution and compared to the stage-based distribution assembled for the Goffs population (Turner et al. 1987, Burnham et al. 1987), it would appear that the Goffs population is typical of other desert tortoise populations (Figure C28).

The principal difference between the stage distributions in Figure C26 (simulated) and Figure C28 (observed in the field) is that the modeled distribution has a greater proportion of individuals in the hatchling and 1-5 year age classes than do the distributions from Goffs and the multi-site aggregate. While it is true that there are high levels of mortality at the younger ages (with only approximately 7% of all hatchlings surviving to the age of six years), the low proportions of young tortoises in the empirical distributions (Figure C28) more likely reflect the difficulties with locating very small tortoises in the field. Regardless, the proportion of individuals that are adults is very high: 42% in the simulated population and 60% in the empirical data sets.

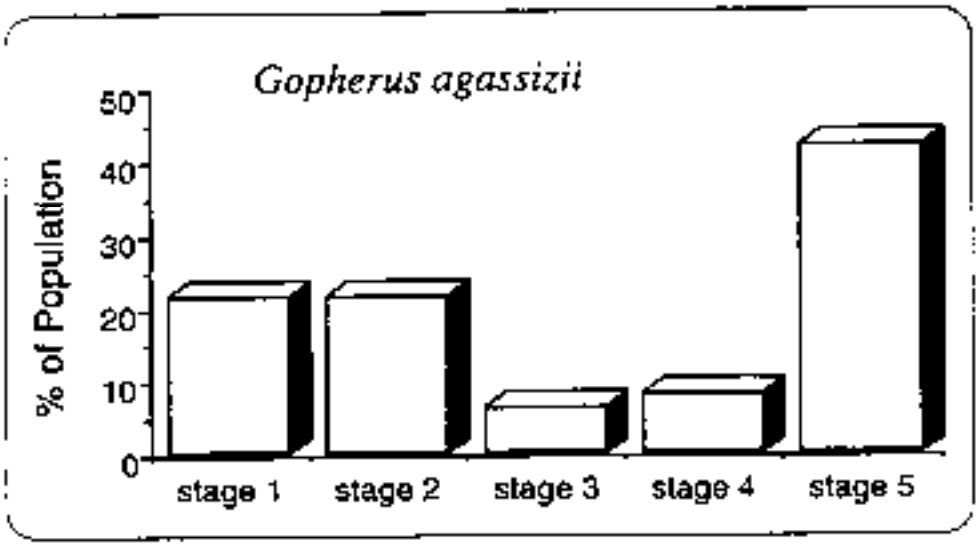


Figure C26. The proportion of individuals in each age stage of the modeled population when the population is in stable-age distribution.

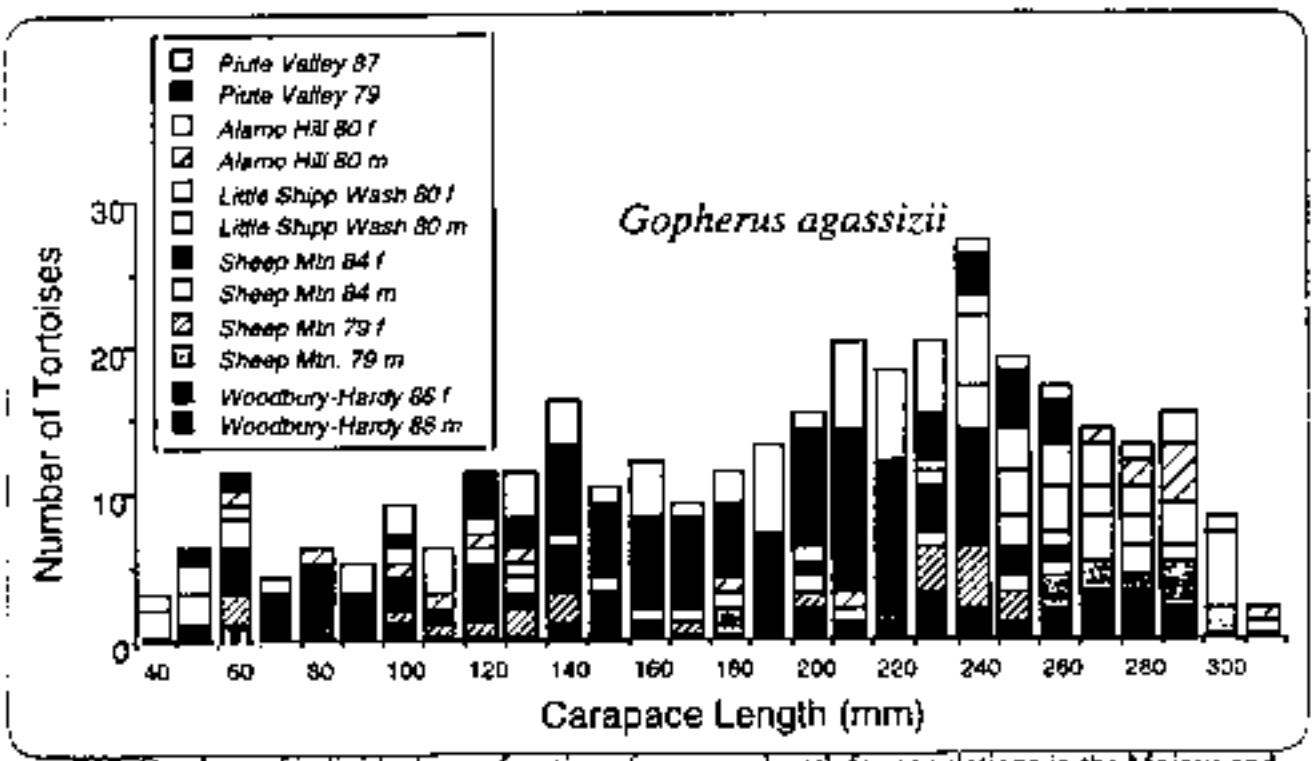


Figure C27. Numbers of individuals as a function of carapace length for populations in the Mojave and Sonoran deserts.

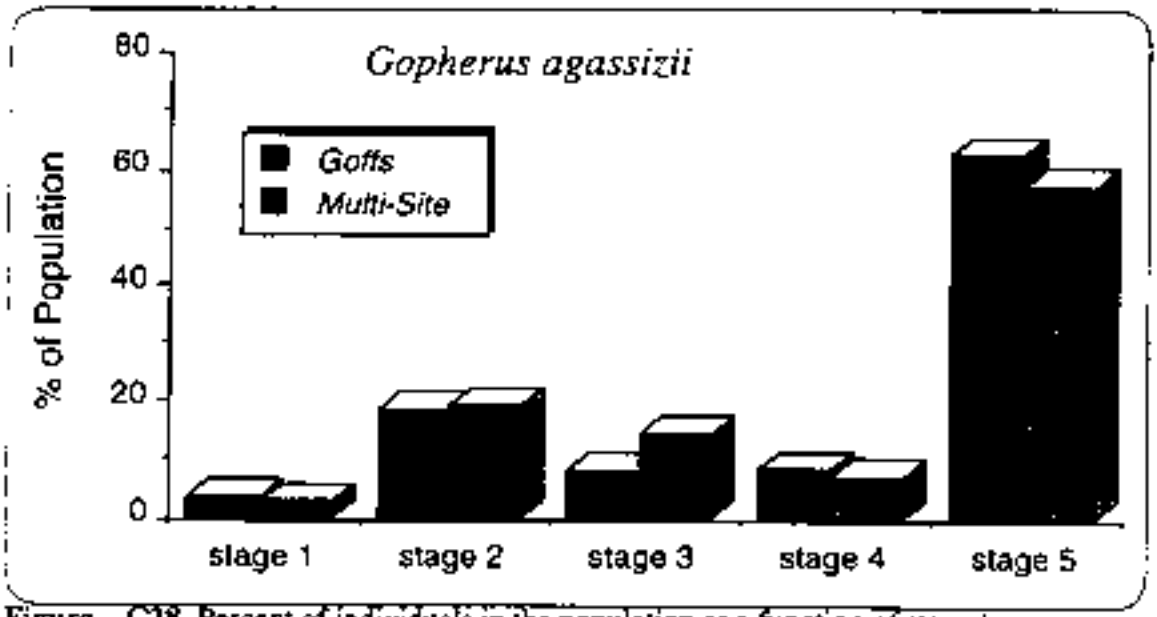


Figure C28. Percent of individuals in the population as a function of stage (age categories) for (a) the Goffs population (Turner et al. 1987, Burnham 1987), and (b) an aggregate of populations in the Mojave and Sonoran deserts.

Effects of Environmental Stochasticity. - Environmental stochasticity can cause population growth rates to vary from time to time and from locality to locality, and variable population growth rates can increase the probability of extinction. For example, a population could have a run of years with stochastic drops in population size until its density drops below a recovery threshold and it subsequently goes extinct.

Stochastic population growth was simulated with a "Monte Carlo" simulation, with lambda being drawn from a probability distribution with different means (all below 1.0 and including the observed mean of 0.975), and a standard deviation of 0.19 (the standard deviation due to random variation around population trends calculated from sampled populations; see Figure C24). An additional simulation was performed holding the mean lambda at 0.975 and using two different standard deviations around lambda (0.019 and 0.038). All simulated populations were started with different numbers of tortoises to assess the effect of mean lambda, standard deviation of lambda, and starting population size on the computed time to extinction (extinction was assumed to occur when the population reached two individuals).

Of course, all simulations with lambdas below 1.0 eventually go extinct. The time required to reach extinction theoretically is affected by both lambda and the stochastic variation around lambda (Figure

C29). However, the effect of the mean lambda was considerably greater than was the standard deviation around those means. The model's prediction that a population with a mean lambda of 0.975 (the observed mean of sampled populations in California and Nevada) could never persist for more than approximately 390 years (approximately 15 tortoise generations), regardless of the initial population size, was particularly disturbing.

Partitioning the variance in lambdas into its components was also instructive. The importance of within-population environmental stochasticity is trivial unless lambdas are close to 1.0. Even then, such populations are predicted to persist for a long time.

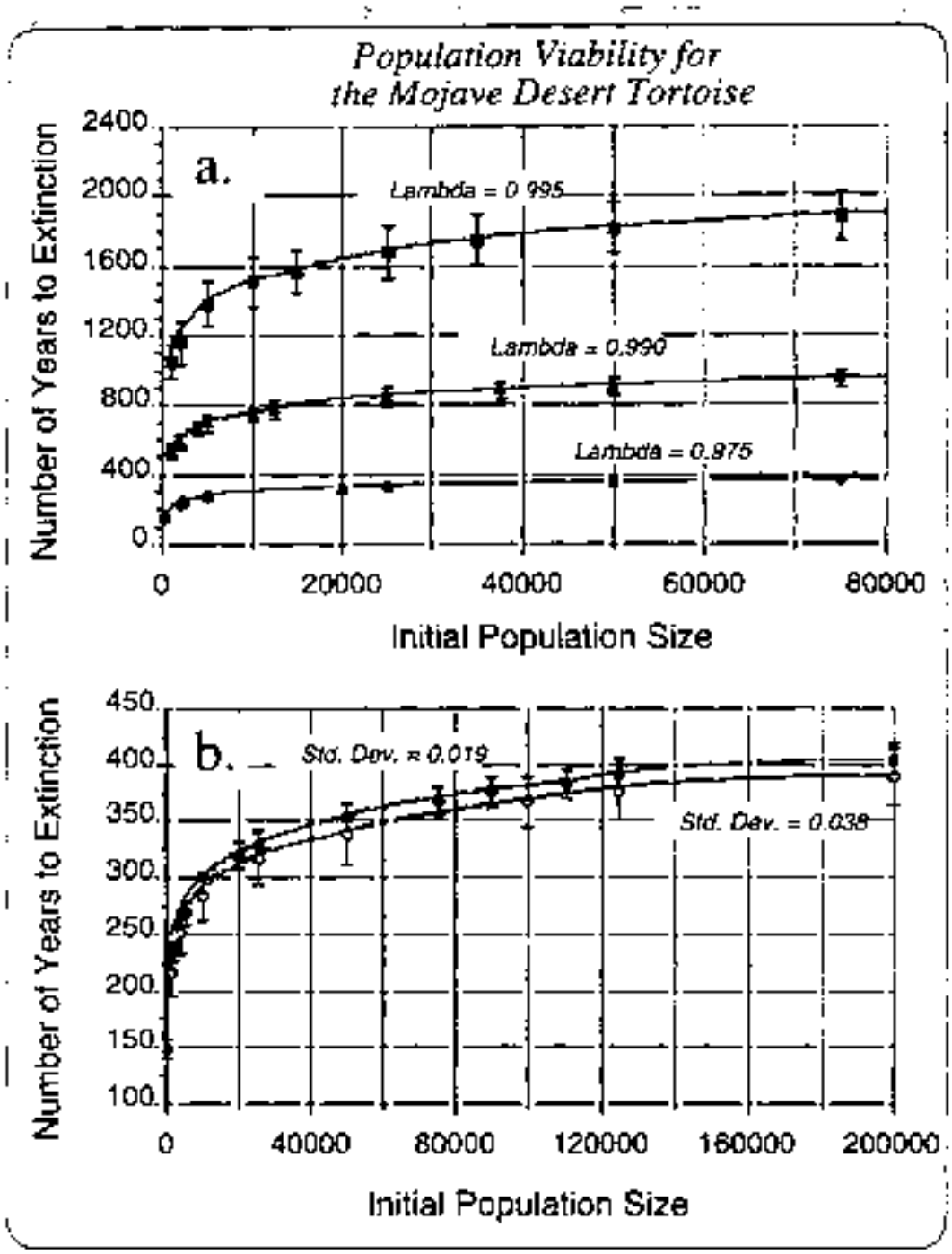


Figure C29. Results of a Monte Carlo simulation of the mean time to extinction for desert tortoise populations (a) as a function of lambda all with a standard deviation of 0.019, and (b) as a function of two different standard deviations at a lambda of 0.975 for populations starting at different initial sizes.

C. *The Peacock Model*

Projection Model. - Demographic data for the desert tortoise was entered into RAMAS/Stage, a single-species, stage-based model developed by Applied Biomathematics (Ferson, 1990). RAMAS simulates discrete-time stage-structured population dynamics. This model is used to predict the behavior of population trajectories (probability of extinction or population explosion) as influenced by demographic parameters and stochastic environmental variables. RAMAS is a modeling environment which allows the user to build a species-specific model using mathematical expressions based upon stage modeling theory (Lefkovitch 1965).

The effect of environmental variability on demographic processes was not measured independently for the desert tortoise; thus, the effect of stochastic environmental variation on population dynamics could not be modeled separately from demographic variation. Five life history stages were defined as in the Gilpin Analysis (see above) and the Tracy Analysis (see above): 1) hatchlings, 2) 1-5 year olds, 3) 6-10 year olds, 4) subadults, 5) adults or 17-100 year olds. Transition matrix variables: P_X (probability of remaining in a stage), G_X (probability of moving to the next older stage) and F_X (number of hatchlings produced by individuals surviving to the adult stage) were then used to simulate population growth over a 600-year period.

$$\mathbf{A} = \begin{pmatrix} P_1 & F_2 & F_3 & F_4 & F_5 \\ G_1 & P_2 & 0 & 0 & 0 \\ 0 & G_2 & P_3 & 0 & 0 \\ 0 & 0 & G_3 & P_4 & 0 \\ 0 & 0 & 0 & G_4 & P_5 \end{pmatrix}$$

Survival probabilities estimated from demographic data (Turner et al. 1987) were used to construct a transition matrix (Table C6). Because data on survivorship from the egg to hatchling stage are unavailable, F5 was defined as the average number of eggs produced per adult female per year. (More properly, F5 should be the number of hatchlings--which will always be lower than the number of eggs because not all eggs live to become hatchlings--but reliable data were not available.) Initial population size was modeled as 20,000 individuals; additional simulations were also conducted using starting populations of 40,000, 60,000, and 100,000 individuals. The initial stage distribution used for all simulations was based upon stable-age distribution generation by The Tracy Analysis (Figure C26).

Simulation Results. - The simulation of population dynamics over a 600-year period predicts a steady decline in the population

(Figure C30). With a starting population of 20,000, the total declines to 100 individuals by 327 years, 24 individuals by 400 years, and goes extinct (at one individual) at 553 years. Lambda averaged over the first 400 years of the simulation was 0.979. Abundances in each stage at 200, 400, and 600 years show a preponderance of individuals in stages 1 and 2 (Figure C31) with very low recruitment from stage 2 to 3 (although this result is likely due to the overestimation of recruitment of hatchlings into the population). A stable-stage distribution generated at the end of 200 years indicates that the adult breeding population would be reduced to 100 individuals. Although the total population was still relatively high (N=1400) after 200 years, a small breeding population (based upon the number of adults present) due to primarily to the low recruitment of individuals from stage 2 to 3, results in a potentially unstable population.

Population projections using starting populations of 40,000, 60,000, and 100,000 individuals show that after 200 years populations would be 200, 300, and 400 individuals respectively. By 400 years, all simulations, regardless of starting population size, produced populations of less than 100 total individuals and breeding adult populations of less than 10 individuals (Table C7). Given the current survival probabilities, desert tortoises would be extinct (fewer than one individual) in less than 600 years (Figure C32).

Table C6. The transition matrix used in population simulations, calculated using survival probabilities from Turner et al. 1987.

	Hatchlings	1-5	6-10	11-16	Adults
Hatchlings	0	0	0	0	5.8
1-5-year olds	0.36	0.619	0	0	0
6-10-year olds	0	0.057	0.6	0	0
11-16-year olds	0	0	0.085	0.806	0
Adults	0	0	0	0.126	0.925

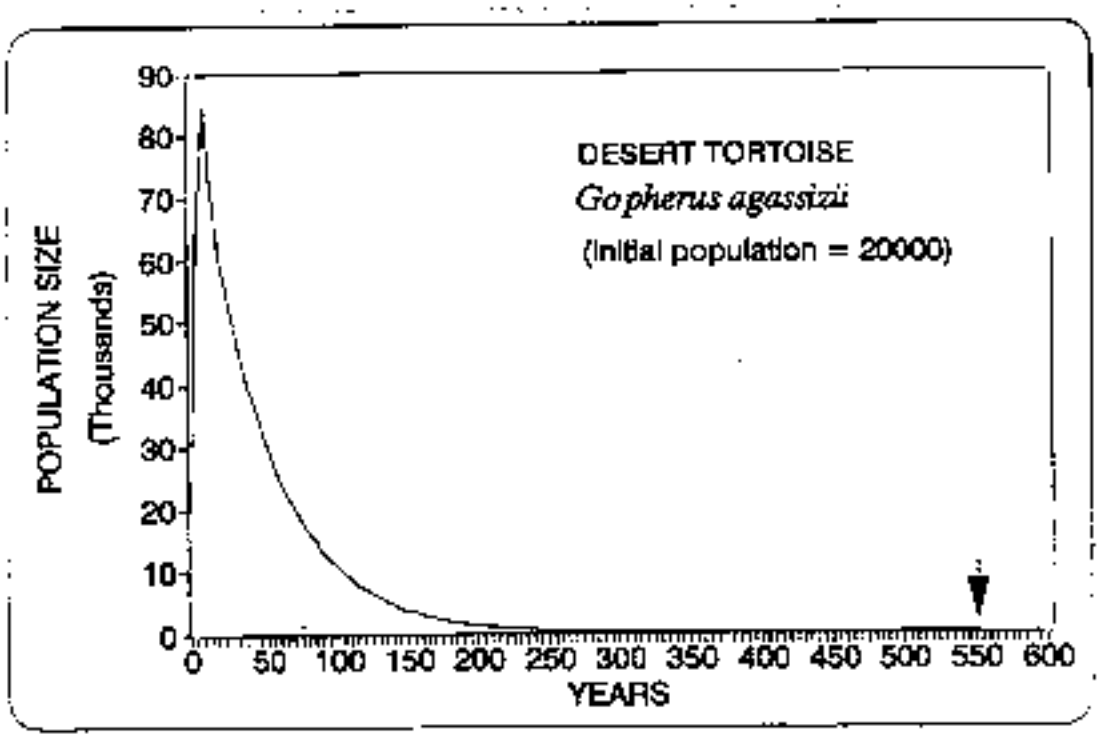


Figure C30. Population projection based upon survival probabilities for each stage (Turner et al. 1987). The starting population size was 20,000 individuals. The population goes extinct (at 1 individual) at 553 years.

Table C7. The total number of individuals remaining in the population given current survival probabilities after 200, 400, and 600 years of simulation. Simulations were conducted for populations with initial sizes of 20,000, 40,000, and 60,000, and 100,000 individuals.

Initial Size	200 y	400 y	600 y
20,000	1,400	24	0
40,000	2,900	48	0
60,000	4,300	72	1
100,000	5,700	96	1

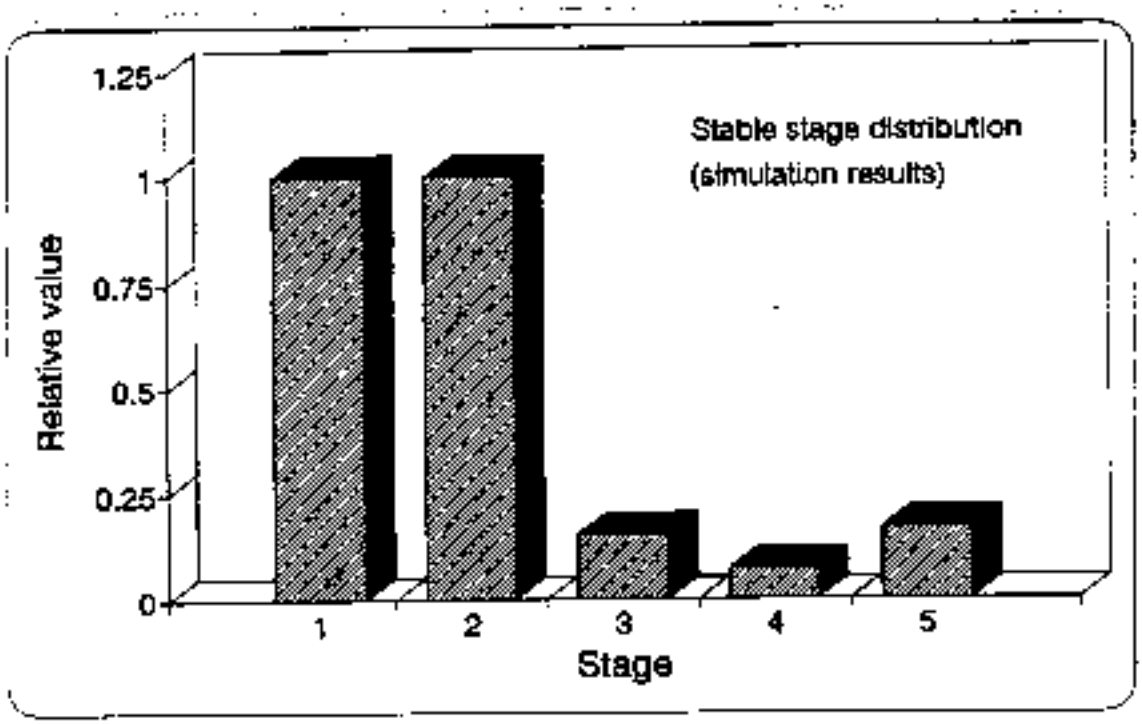


Figure C31. The stable stage distribution generated by the simulations.

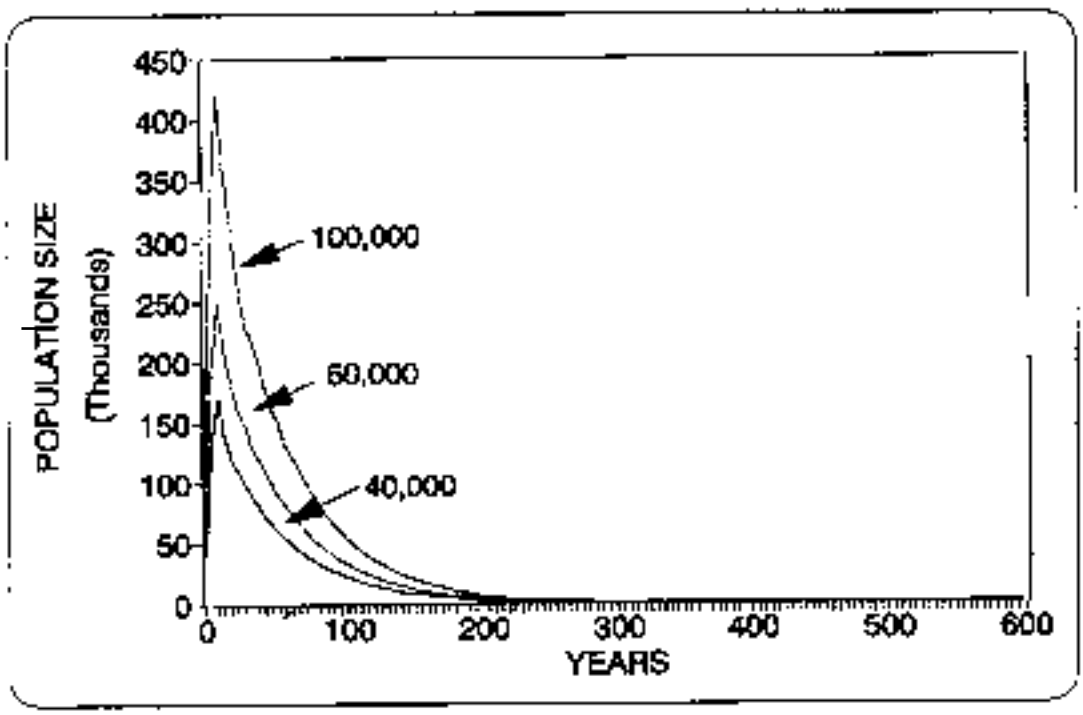


Figure C32. Population projections with starting populations of 40,000, 60,000, and 100,000 individuals. Regardless of starting size, all populations go extinct at the same time.

VII. Viability of the Mojave Desert Tortoise Population

Several criteria important to recovery and long-term persistence for the desert tortoise have been reviewed in this appendix. These include avoiding conditions for extinction (CFE) which are (1) demographic stochasticity, (2) social dysfunction, and (3) genetic deterioration. These CFEs are closely related to population density and population size. Therefore, the vulnerability of a population to these CFEs can be directly affected by two conditions: (1) extrinsic sources of mortality, and (2) the area occupied by the population. Any plan to recover the desert tortoise through the establishment of reserves must consider both the sizes of the reserves and controlling levels of mortality on the reserves.

Population Density and Size of Reserves

In Section 5 of this appendix it was shown that a minimum population density for desert tortoises is approximately 10 adults per square mile. Below this density there will be a high probability of demographic stochasticity, social dysfunction, and genetic deterioration. Section 4 of this appendix shows that a population of at least 5,000 tortoises (all age classes) is necessary to maintain sufficient genetic diversity for long-term evolutionary potential. Taken together, these two analyses indicate that an area of at least 500 square miles is necessary to maintain evolutionary potential at minimum density (Figure C32). In practice, reserves should be larger than this because acceptable tortoise habitat is patchy and not all areas are occupied. Thus, 1,000 square miles should be taken as the minimum size for a viable reserve based on these criteria.

Population Numbers and Size of Reserves

In Section VI. of this appendix it was shown that desert tortoise populations are extremely vulnerable when lambda decreases to low levels. For example, a population with a lambda of 0.975 will decrease to half its starting size in only 25 years. However, the time it takes a population with a lambda of 0.975 to decline to extinction depends most upon the size of the population before it begins its decline. For all populations with lambdas less than 1.0 there is a curvilinear relationship between mean time to extinction and initial population size (Figure C29). At population sizes exceeding 10,000 to 20,000 individuals, any further increases in population size do not greatly increase the time to extinction. That is, if variances in lambda due to year-to-year variation in population trends are small, very large populations do not have a much lower risk of extinction than do populations of approximately 10,000 to 20,000 individuals. However, the time to extinction for very small populations is strongly related to population size. If desert tortoise populations become smaller than 10,000 to 20,000 individuals, strict

management of extrinsic sources of mortality is required to prevent the populational lambda from falling much below 1.0. If this management is ineffective, the population will rapidly progress to extinction.

Taken together, these characteristics of desert tortoise population dynamics indicate two themes of major importance for recovery: (1) Reserves should be large enough to contain at least 20,000 individuals to buffer the population adequately from extinction vulnerability due to small size. (2) Populations must be managed to prevent lambdas from falling below 1.0 on average; otherwise the populations become extremely vulnerable to extinction. These themes translate directly to two management prescriptions: (1) Assuming that most current population declines will not be reversed until minimal viable density is reached (10 adults per square mile, Figure C33), reserves should be no smaller than 1000 square miles. (2) Sources of extrinsic mortality, i.e., the threats listed in Appendix D, should be reduced to the point that lambdas can reach at least 1.0. The precise means by which this can be achieved are given in the Recovery Plan section called, "Desert Wildlife Management Areas: Descriptions and Specific Management Recommendations."

Reserve Sizes in Relation to both Population Density and Size

Considerations of both minimum population densities and minimum population numbers indicate that reserves, or DWMAs, should be at least 1,000 square miles. When populations are well above minimum viable density (e.g., 30 or more adult tortoises per square mile) and lambdas can be maintained, on average, at 1.0 or greater through elimination of extrinsic sources of mortality, smaller reserves that provide high-quality, secure habitat for 10,000 to 20,000 tortoises should provide comfortable persistence probabilities for the species well into the future.

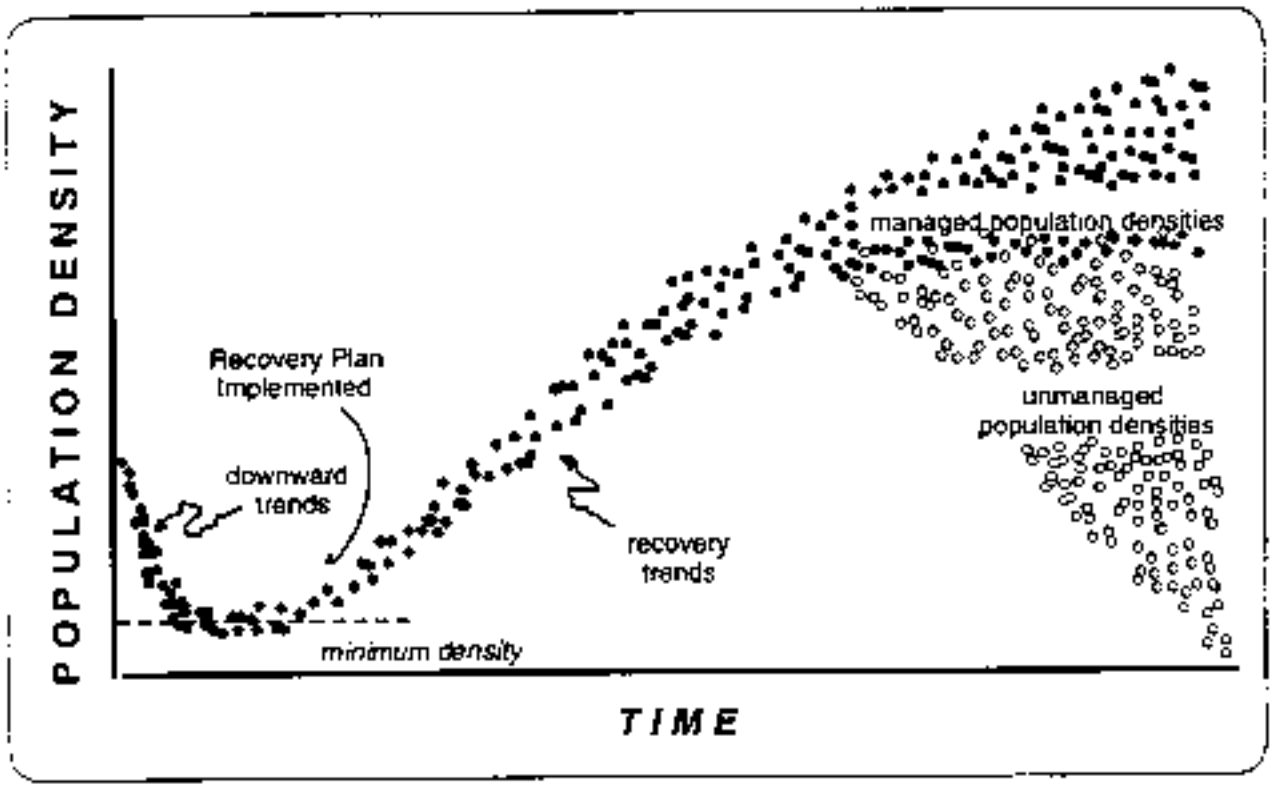
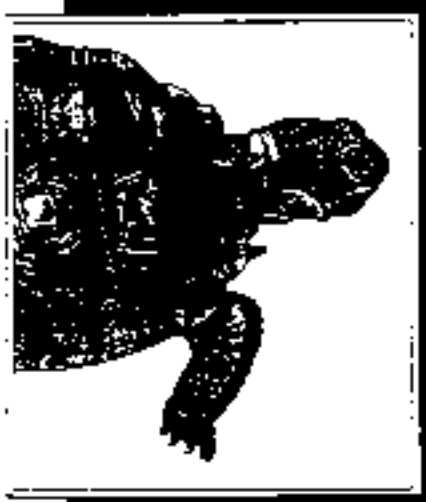


Figure C33. Idealized population densities as a function of time shown before, during, and after recovery. Downward trends are reversed at or near minimum viable density. Subsequently, the population "recovers" by growing significantly for 25 years. At that time, the population could continue to grow in response to good conditions created by proper management until (or if) the population reaches a "carrying capacity". After the population has become dense, the population might continue to grow, fluctuate around a high density, or, if management is relaxed, it may again decrease slowly.

Appendix D

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix D: Human Activities Which Directly or Indirectly Threaten Naturally-Occurring Populations of Desert Tortoises and Their Habitats in the 1990's

I. Introduction

The purpose of this appendix is to review, update, document, and summarize human-induced pressures operating on naturally occurring populations of desert tortoises in the Mojave and Colorado deserts. The appendix begins with a brief overview of prehistoric and historic trends in human-desert tortoise interactions both globally—relative to the entire tortoise family (Testudinidae), and regionally—relative to desert tortoises. This document focuses on demonstrated and probable threats to desert tortoise recovery areas. Where appropriate, records of specific threats to other chelonians are incorporated to establish their potential impact to desert tortoises. The collective, synergistic, and cumulative nature of threats is illustrated with a case study of progressive extirpation of desert tortoises in the Antelope Valley, California of the western Mojave recovery unit.

II. Methods and Sources of Data

The following resources were used, in descending order of confidence: (1) peer-reviewed journal articles; (2) published symposia and professional texts; (3) government agency reports and data; (4) environmental impact statements and related documents; (5) reports and commentaries of private consultants; and (6) properly attributed personal communications of qualified professionals and lay people.

We have drawn particularly on the following published or released surveys of human threats to desert tortoises: (1) California Statewide Desert Tortoise Management Policy (BLM and California Department of Fish and Game 1990); (2) Chapters 3, 4, 6, 8, and 10 of Berry (1984); (3) (Final) Cumulative Impacts Study on the Desert Tortoise in the Western Mojave Desert (Chambers Group, Inc. 1990b); and (4) "Assessment of Biological Information for Listing the Desert Tortoise as an Endangered Species in the Mojave Desert, A Predecision Document" (Fish and Wildlife Service

1990b). Also of interest were locally focused supplemental reports, e.g., Desert Tortoise Impacts Analysis (Lamb 1991) and the Short-Term Habitat Conservation Plan for the Desert Tortoise in Las Vegas, Clark County, Nevada (RECON 1991).

III. History of Human-Desert Tortoise Interactions

A. Prehistoric Accounts.

Prehistoric human predation on desert tortoises in California and Nevada was vigorous and widespread (Schneider and Everson 1989). Aboriginal groups that used desert tortoises included the Chemehuevi, California; Owens Valley Paiute and Mono, Tubatulabal, and Panamint Shoshoni, California; the Cahuilla in California; and Southern Paiute of Ash Meadows and Shoshoni of Beatty, Nevada. However, some aboriginal groups such as the Mohave had a "great aversion to eating desert tortoise and spoke in a derogatory manner about groups that did eat the animal" (Schneider and Everson 1989).

Human predation often involved well-developed techniques for hunting (Schneider and Everson 1989). For example, in Mexico, Seri Indians used dogs to locate desert tortoises, water to induce them to emerge from their burrows, and hooked probes for extracting them from their burrows. Papago Indians even developed protocols for roasting desert tortoise flesh (removing the plastron and inserting hot rocks). Hunting practices varied with both the location and chronology of the site.

Morafka (1988) reviewed the Late Quaternary prehistory of human-desert tortoise interactions globally, emphasizing data on the progressive extirpation of the bolson tortoise, *Gopherus flavomarginatus*. Human predation, which is still ongoing, appears to have had a pivotal role in reducing bolson tortoise distribution over the last 20,000 years.

B. Human-Tortoise Interactions and Human Cultures.

Globally, tortoises are preyed upon for a variety of reasons (Swingland and Klemens 1989). Swingland (1989) stated:

> In economic terms, the tortoise is an important part of rural dynamics, being used for food in most parts of the world, as a musical instrument (maracas and banjo), as a scoop or water bail in boats, and canned as meat in parts of the Mediterranean. The adults are often kept in village pens for food and as a source of hatchlings, which are becoming a new economic product of this traditional habit.

The traditions of developing countries may seem tangential to a review of threats to desert tortoises posed by human actions in the southwestern United States, but in fact many former residents of these areas are bringing their traditional practices with them as they immigrate to the pluralistic societies of Los Angeles, Las Vegas, and elsewhere in the West.

Highway mortalities and habitat modification and fragmentation have critical negative impacts on terrestrial turtles in the more industrial societies (Swingland and Klemens 1989). Most authors of species accounts in Swingland and Klemens' book described similar threats. For example, Klemens (1989) described problems faced by emydid turtles in New England, a region subject to the kinds of development which now increasingly characterize Mojave Desert landscapes.

Nowhere are the correlations with human influences more pronounced than in the history of the insular tortoises of Madagascar and the adjacent western Indian Ocean. More than a dozen putative taxa of giant tortoises once occurred in this region (Arnold 1979). Of these, all but a single population of the species *Geochelone gigantea* were apparently driven to extinction by the direct or indirect impact of abrupt human colonization. The chronology of these human colonizations and resulting tortoise extinctions were strikingly correlated. Interestingly, similar extinctions were not observed on the adjacent African mainland where more than half a dozen tortoise taxa of varying sizes have occurred sympatrically with hominoids for tens of millions of years. Perhaps the continued existence of the mainland tortoise species can be explained by long-term associations with hunter-gatherers in complex and relatively stable relationships. In contrast, the sudden appearance of humans, especially in the simplified and isolated ecosystems of oceanic islands, had a much more catastrophic impact on tortoises and their habitats.

IV. Human-Induced Threats to Desert Tortoises

A. Deliberate Removal of Desert Tortoises by Humans.

1. Predation for food. The use of tortoises for food was historically the primary motive for collections on a global scale (Swingland and Klemens 1989) and regionally for desert tortoises in the Great Basin and southwestern deserts (Schneider and Everson 1989). Many cultures have engaged in both individual and commercial exploitation of desert tortoises as food items (Berry and Nicholson 1984b). Commercial exploitation has included export of desert tortoises from the Mojave Desert to restaurants in Los Angeles, the Central Valley, and elsewhere in the West. Such practices continue today. Meat markets which offer live aquatic turtles still exist in some areas of metropolitan Los Angeles--Monterey Park for example. Asian nationals were arrested in two separate incidents for taking over one dozen desert tortoises from the Western Mojave Desert for food and ceremonial purposes in 1991 and 1993 (Ditzler 1991, BLM files).

2. Collection and commercial trade for pets. This threat is similar to, and may not be clearly separable from, collecting desert tortoises for food or other purposes. Collections for pets and the commercial trade were undoubtedly of importance in the past (Berry and Nicholson 1984b). Commercial collecting of desert tortoises continued to be significant into the 1970's, even though full legal protection was extended to the species in California by 1961 (St. Amant 1984). Intense collecting of desert tortoises occurred well into the 1960's in the Jawbone Canyon region of Kern County, California (David J. Morafka, pers. comm.). Dr. A. D. Stock (University of Nevada, pers. comm. to D.J. Morafka) similarly recalled fairly intense commercial collecting of desert tortoises and Gila monsters (*Heloderma suspectum*) in the Beaver Dam Slope region of southwestern Utah. Two instances of commercial collecting in Nevada were documented in 1982 and 1983 (Berry and Burge 1984). In one case, more than 30 wild desert tortoises were taken to Alabama.

In spite of Federal and State listings, commercial collecting still occurs. Felicia Probert, a BLM District Ranger in Riverside, California, described an ongoing case involving the attempted sale of desert tortoises in 1990, at a Barstow gas station. An arrest warrant was issued, but the suspect apparently fled the country to avoid prosecution. Other cases provide circumstantial evidence of large-scale take. For example, a substantial decline in subadult and adult desert tortoises occurred between 1982 and 1987 at the Kramer Hills study site in California, without any evidence of mortality (Berry 1990, as amended). Within the same time frame, signs of human excavation of desert tortoises burrows were observed near the study site (A.P. Woodman pers. comm.), and a sheepherder reported to a BLM employee that he saw a truck containing over a

dozen desert tortoises at nearby Kramer Junction (Berry 1990, as amended).

Families and individuals still collect desert tortoises for personal pets, especially when they are found on roads. This threat is serious in areas with high visitor use and is, surprisingly, even operative in remote desert areas. Three examples of desert tortoises taken from research sites (and, in some cases later recovered) provide an indication of the extent of the threat. During studies conducted from 1987 to 1991 near Kramer Junction in the western Mojave Desert, two of 16 desert tortoises with radio transmitters were lost to poaching; five others may have also been poached (Stewart 1991). This area experiences human traffic of more than 500 visitors/mi^2 per year. In another example, one of a few dozen desert tortoises with transmitters was removed from a study site in the Ward Valley, California in summer of 1990 (A. Karl pers. comm.). The site is in an area with fewer than 100 visitor-use days/mi^2 per year. The transmittered desert tortoise was recovered at a motel parking lot in Bullhead City, Arizona. In Nevada, one of 78 desert tortoises (1.3%) marked in 1986 at the BLM's Coyote Spring Valley study site was found as a captive in the Las Vegas Valley a few years later (Betty L. Burge, per. comm.). This site is in a relatively remote part of Nevada and has few human visitors.

Naturalists at the Desert Tortoise Natural Area in eastern Kern County, California described probable illegal take during spring (Howland 1989, Ginn 1990, Jennings 1991). Additional information is also available from personal discussions between agency biologists and the public by phone, at meetings, or in government offices. Each year, Berry (pers. comm.) receives several accounts from individuals who describe "saving" desert tortoises from traffic on highways. Most such desert tortoises are either inappropriately released or retained in captivity.

The threat of collections should not be underestimated and will continue to remain high for three reasons. First, most new arrivals to the Southwest are unaware that desert tortoises are protected. Second, the presence of law enforcement officers in open desert lands is inadequate. And third, commercial poaching of rare, threatened, and endangered species is well documented, and in some cases, a lucrative business (Reisner 1991, Poten 1991). Reisner (1991), who presented a powerful documentary of the effects of poaching on alligators, pointed out that many wildlife biologists tend to attribute population declines to habitat loss, when illegal collections are a major factor.

B. Vandalism.

Shooting and vandalism play a major role in losses of desert tortoises in many areas, particularly where human visitation is high (measured in visitor-use days/unit area per year). Deliberate

shooting of desert tortoises or crushing them with vehicles has been documented (Berry 1986a, Berry and Nicholson 1984b; Michael Coffeen, BLM, Glenallen, Alaska, pers. comm.). Acts of vandalism have also included beheading, severing of body parts, and overturning. At the BLM's western Mojave Desert study plots, 14.6% to 28.9% of all desert tortoise carcasses bore evidence of gunshots, whereas carcasses from the less-visited eastern Mojave Desert yielded gunshot frequencies of 0% to 3.1% (Berry 1986a). Fencing the Desert Tortoise Natural Area did not effectively reduce the frequency with which carcasses bearing gunshot holes were encountered, at least in the vicinity of the interpretive center (Berry and Shields et al. 1986). The highest rate of vandalism was recorded in the Fremont Valley, where 40.7% of desert tortoises found dead between 1981 and 1987 showed signs of gunshots and other vandalism (Berry 1990, as amended).

In 1991, local residents of Mesquite, Nevada, and St. George, Utah, threatened to undertake "reprisal" killings of desert tortoises in response to the recent Federal listing, economic hardships, and perceived loss of local self-government (Tim Duck, BLM, St. George, Utah; pers. comm. to David J. Morafka). Residents threatened to shoot desert tortoises or flip them over to immobilize them.

Desert visitors also harass desert tortoises. Three incidents of harassment occurred at the Desert Tortoise Natural Area in the spring of 1990 when visitors handled wild desert tortoises (Ginn 1990). In one case, a group of adults from France poked a desert tortoise with a stick. Jennings (1991) described the trampling of a burrow by a visitor.

People who vandalize desert tortoises are difficult to identify and classify, thus increasing the problem of apprehending and educating them. Some who are suspected of shooting desert tortoises claim to be hunting rabbits, but such "hunters" are regarded as "plinkers" by legitimate hunters. In general, "...illegal hunters face little threat of arrest from the thinly spread force of ... federal and state wildlife enforcement officers" (Satchell 1990). While no law enforcement officer has caught a person in an act of vandalism to desert tortoises since the species was federally listed in August of 1989, the threats and actual mortalities from such acts remain high in many areas.

C. Deliberate Manipulation of Desert Tortoises by Humans.

1. Relocation and translocation. Relocation can be defined as "... moving an animal or population of animals away from an area where they are immediately threatened...to an area where they would be less prone to habitat loss..." (Dodd and Siegel 1991). Past relocations of desert tortoises were frequently motivated by sincere attempts at conservation, but their results have been both

varied and disappointing, so much so that poorly planned and executed relocations should be treated as a threat.

Several factors are likely to contribute to low success rates of relocations: (1) the tendency of the released desert tortoises to travel or wander from the site or attempt to return home; (2) increased vulnerability to predators; and (3) the potential for agonistic responses from resident or host desert tortoises (Berry 1986b, Stewart 1991). Significantly higher mortality rates were recorded for relocated desert tortoises than in the host or control population in a 1990-1991 relocation project (Weinstein 1992). The higher mortality rates did not appear to be associated with higher rates of predation or availability of food and water.

The potential for introducing or spreading diseases must not be overlooked. Diseases such as URTD pose a grave threat to wild populations, especially because such a significant proportion of ill desert tortoises are asymptomatic (Brown et al. 1992, Jacobson 1994). Diseases such as URTD may be passed from mother to offspring through the eggs and from male to female through seminal fluid.

Illegal relocations by local desert residents and visitors occur frequently and must be treated as an ongoing threat. Such activities have been best documented at the Desert Tortoise Natural Area in eastern Kern County, California (Howland 1989, Ginn 1990, and Jennings 1991), but are by no means limited to that site. For example, illegal releases or attempted releases of six wild desert tortoises were recorded in 1990 elsewhere in California (Ginn 1990, Gilbert Goodlett, BLM files).

2. Release of captive desert tortoises. Captive releases pose numerous problems to their wild host populations, not to mention the inhumanity of placing animals which have been provided with water, food, and shelter on a regular basis into a hostile environment. Examples of areas of concern include genetic pollution, the potential for introducing or spreading disease, and disturbance to the social structure of the host population. In terms of genetics, the most potentially disruptive releases into the Mojave region would be the introduction of Sonoran Desert tortoises or Texas tortoises (Gopherus berlandieri), which are reported to hybridize with desert tortoises in captivity.

Release of captives has been, and continues to be, a problem (Jacobson 1993). The California Department of Fish and Game released thousands of captives and has formal records for over 800 releases undertaken in the 1960's and 1970's (Berry and Nicholson 1984a). In the 1970's, California Department of Fish and Game also set up a program to rehabilitate captive desert tortoises and prepare them for return to the wild through quarter-way and half-way house projects. Of more than 200 individuals exposed to the desert transitional pens, only 15% survived more than a few years. About 30 of the survivors, some of which were apparently ill with

URTD, were subsequently released in Antelope Valley (Cook 1983).

Information on the prevalence of released or former captive desert tortoises in wild populations can be derived from several sources. For example, a single captive release was found among 45 wild desert tortoises registered during a formal survey in the Black Mountains, Mojave County, Arizona (Hall 1991). In the Las Vegas Valley in 1990, 13 (1.5%) captive desert tortoises were found among a sample of 842 wild desert tortoises collected from private parcels of land (Hardenbrook and Tomlinson 1991). Ten of the 13 captives were found in close proximity to urban development. Naturalists at the Desert Tortoise Natural Area in California intercepted people in the process of releasing captives and discovered recently released captives (Howland 1989, Ginn 1990, and Jennings 1991). Howland (1989) reported illegal releases and an attempted release of five desert tortoises, three of which showed signs of URTD. Jennings (1991) recorded two such instances. Released captives may introduce infectious diseases, including URTD, to wild populations (e.g., see Berry and Slone 1989, Jacobson 1993). In the Mojave population, the outbreak and incidence of URTD appears to be closely correlated with known and suspected release sites for captives, as well as with the proximity to urban development and degree of human access (e.g., Hardenbrook and Tomlinson 1991, Jacobson 1993, and Tomlinson and Hardenbrook 1992).

V. *Human-Induced Habitat Alterations Coupled with Losses of Desert Tortoises*

A. *Urbanization.*

Many terrestrial chelonians are affected by habitat destruction and fragmentation resulting from urbanization (Swingland and Klemens 1989, Klemens 1989). In addition, populations of chelonians are often depressed in the vicinity of roads as a result of animals killed by vehicles or collected by visitors.

The portions of the desert Southwest occupied by desert tortoises have experienced episodic human settlements since the mid to late 1800's. A checkerboard or braided pattern of public and private lands has encouraged patchy development. Current areas of rapid development include, but are not limited to, the Antelope, Peerless, Fremont, Indian Wells, Lucerne, Yucca and Victor valleys of the western Mojave Desert; the Mojave River Valley of the western and central Mojave; Las Vegas and Virgin River valleys, and the towns of Mesquite, St. George, and Searchlight in the eastern Mojave Desert; Laughlin, Bullhead City, Lake Havasu City, Parker, and

Blythe along the Colorado River; and parts of the Chuckwalla Valley (Berry 1984a).

Tierra Madre (1991) provided careful documentation for the current status of desert tortoises for about 225 square miles in the City of Lancaster and surrounding areas. Surveyors walked transects and recorded desert tortoise sign on 90 square miles of undeveloped, nonagricultural lands. Three desert tortoise carcasses and a single live desert tortoise (observed in 1983) were the only remaining records of the presence of this once common species. Within the City limits and the general planning area, evidence of sheep grazing, shotgun shells and rifle cartridges, trash, litter, ORV tracks, domestic canines, unimproved roads, and ravens were recorded in over 50% of the transects. The lack of desert tortoise sign was attributed in part to these disturbances. Roughly a third of the area was found to be no longer suitable for desert tortoises (Tierra Madre 1991).

Desert tortoise populations have virtually been extirpated to the south of the City of Lancaster (Judy Hohman, Fish and Wildlife Service, Ventura, California, pers. comm.). Occasional desert tortoise sign is still observed east of Palmdale, but not in Palmdale west of Hwy 14 (Palmdale Freeway) or south of Hwy 138 (Pearblossom Highway). No signs of desert tortoises were found in a survey of 68 square miles of northeastern Palmdale and at Saddleback Butte State Park (Feldmuth and Clements 1990).

Las Vegas illustrates regional trends for future growth in the eastern Mojave Desert. The City is projected to increase in population by more than 100%, from 674,000 in 1988 to 1,400,000 in 2030 (Clement Associates, Inc. 1990). Numbers of visitors are expected to similarly increase. The City of St. George, Utah, may increase in population by as much as 1000% in the next 35 years. In addition, the Southern California megalopolis is spreading north and east from metropolitan Los Angeles into the deserts of Kern, Los Angeles, San Bernardino, and Riverside counties. The desert portion of San Bernardino County, with a 1984 population of 192,100, is projected to reach 441,800 (a 230% increase) by the year 2010.

In the Colorado Desert, the Coachella and Imperial valleys are centers for continuing urban and agricultural growth, a process which dates back to the turn of the century (Berry and Nicholson 1984b). Here, most development does not impinge directly on important desert tortoise habitats. However, the proposed transfer of urban-generated wastes to desert landfills via rail through the Chuckwalla Bench Area of Critical Environmental Concern (RECON 1991) and the new prison in the Chuckwalla Valley bring urban threats to portions of the Colorado Desert.

Urban environments have indirect impacts on desert tortoise populations and habitat at their interface with the desert (Berry and Nicholson 1984b, Berry and Burge 1984, Lamb 1991). Dogs range

into the desert, often for several miles (see Predators: Non-natives). Unauthorized collecting of desert tortoises, dumping of trash, and removal of vegetation are common near urban development. Children and adults shoot firearms and use ORVs indiscriminately adjacent to towns. For example, Lamb (1991), in discussing ORV/off-highway-vehicle use in the eastern Mojave, reported that the "...greatest amount of unauthorized off-highway vehicle use occurs around urbanized areas such as Beaver Dam, Windy Acres, and Mesquite, Nevada."

B. Agriculture.

Agricultural development yields disturbance patterns similar in distribution and extent to urban development. However, no future projections for agricultural growth can rival the rates for urban centers. As of 1980, about 3,000 square miles of desert tortoise habitat had been developed for agricultural use in California, especially in the Antelope, Victor, Lucerne, Coachella and Imperial valleys, and around the Cantil-Koehn Dry Lake region (Berry and Nicholson 1984b). Other areas that have experienced additional development since 1980 include the Cadiz and Chuckwalla valleys and parts of the Colorado River Valley near Blythe in California (Berry and Nicholson 1984b); and Mesquite and the Virgin River Valley in Nevada, Arizona, and Utah (Lamb 1991).

Most agricultural developments, such as alfalfa farming, draw water from local or regional ground water aquifers and require clearing of native vegetation, plowing of previously undisturbed soils, and applications of pesticides and/or fertilizers. All such activities either kill desert tortoises directly, obliterate their habitats, lower primary productivity, or otherwise negatively impact wildlands. Even fields long fallow contain pesticides and fertilizers, along with compacted and disturbed soils. Old fields are often invaded by Mediterranean and Asian weeds and become sources of seeds. For example, Russian thistles blow from adjacent agricultural fields at Cantil into the Desert Tortoise Natural Area in eastern Kern County, California, where they are becoming established (BLM and California Department of Fish and Game 1988).

Desert tortoise deaths occurred as a result of jackrabbit poisoning in the Cantil, California, farming area in 1952 and 1953 (Berry and Nicholson 1984b). Populations of the marginate tortoise (*Testudo marginata*) are adversely affected in agricultural areas in Greece, where they are killed by machinery and herbicides (Stubbs 1989a). The Egyptian tortoise (*T. kleinmanni*) is also threatened by agriculture, related human settlements, dogs, and corvids (Mendelssohn 1990).

Pumping of ground water for agricultural and urban developments has caused local and widespread depression of the water table in numerous valleys and basins within desert tortoise habitat (see Berry

and Nicholson 1984b). For example, in the western Mojave Desert, depressions in the water table at Koehn Dry Lake and adjacent Fremont Valley were evident from the 1950's to the 1970's due to pumping of ground water from deep-water wells for cotton and alfalfa farming (Koehler 1977). Depression of the water table resulted in the death of mesquite trees along the edge of Koehn dry lake. By 1983, large fissures, which can function as giant pit-fall traps, formed in the earth. One such fissure was a mile-long, 15- to 20-feet deep, and varied from 6 inches to 50 feet in width. Similar fissures occurred at Rogers Dry Lake on Edwards Air Force Base in 1990-1991.

C. *Garbage, Trash, and Balloons.*

Turtles and tortoises are known to eat foreign objects, such as rocks, balloons, plastic, and other garbage (John Behler, Chairman of the Freshwater Turtle and Tortoise Group, Species Survival Commission, International Union for the Conservation of Nature, and New York Zoological Society, pers. comm; Karen Bjorndahl, pers. comm.). Such objects can become lodged in the gastrointestinal tract or entangle heads and legs, causing death. A desert tortoise was observed consuming trash from an abandoned campsite and fire ring adjacent to the Desert Tortoise Natural Area in 1991 (BLM files for Site 4, Desert Tortoise Natural Area Interpretive Center). Burge (1989) has found metal foil and glass chips in scat of wild desert tortoises. She also discovered a desert tortoise entangled by a rubber band caught in the mouth and around the forelegs. In still another case, string, which was caught around a desert tortoise's leg, resulted in the eventual amputation of the limb.

Unauthorized deposition of refuse occurs close to towns, cities, and settlements in remote, inaccessible areas. Remnants of 130 balloons were found on a square-mile study plot in the Lucerne Valley in 1990 (southern Mojave Desert, California), which is about 9 miles from the nearest town. Only one of the 130 balloons was a weather balloon; four were message balloons; and the remaining 125 were individual balloons, possibly released by children at schools during fairs or other celebrations. Balloons are found on study plots in remote parts of the eastern Mojave and Sonoran deserts also. Burge (1989) described how she answered letters and notes attached to balloons and learned that some balloons were released 100 to 200 miles from landing sites. Refuse such as bicycle tires, chains, lawn clippings, sheet rock, and more recently, plastic bottles with toxic wastes are not unusual sights. On the Ward Valley study plot in the northern Colorado Desert, California, bags of garbage apparently dropped from an airplane were found (Burge - BLM field notes).

D. *Mortality and Collections Associated with Freeways, Highways, Paved and Dirt Roads, and Railroads.*

Impacts of roads on desert tortoise populations are well documented in California and can be assumed to similarly affect desert tortoises elsewhere. Desert tortoises are frequently killed or collected on freeways, paved highways and roads, and dirt roads, resulting in depletion of adjacent populations (e.g., Boarman et al. 1992). A significant and parallel pattern of loss in terrestrial wood turtles (*Clemmys insculpta*) and box turtles (*Terrepene carolina*) was noted in southwest New England where a growing number of roads and highways have fragmented wood turtle habitat (Klemens 1989).

Desert tortoise populations are depleted up to a mile or more on either side of roads when average daily traffic is greater than 180 vehicles (Nicholson 1978a, 1978b). Numbers of juvenile desert tortoises on permanent study plots in California were significantly lower adjacent to well-used dirt and paved roads (Berry and Turner 1984). Significant differences in desert tortoise densities were also documented adjacent to Highway 58 in San Bernardino County, California (Boarman et al. 1992). Based on desert tortoise sign, a similar situation occurs along Highway 395 (LaRue 1992). The breeding cohort of desert tortoises was severely depressed on a U.S. Ecology study plot about 2 miles from Interstate 40 in eastern San Bernardino County, California (Karl 1989, and in Dames and Moore 1991). Even dirt roads with relatively low vehicle use can contribute to depressions in local desert tortoise densities (Berry et al. 1986a).

Railroads are similar sources of mortality for desert tortoises and other chelonians (U.S. Ecology 1989, Dames and Moore 1991, Mount 1986). Desert tortoises can get caught between the tracks, overheat, and die or be crushed on the tracks by trains. Railroad workers have reported finding dead desert tortoises between the tracks (U.S. Ecology 1989). Desert tortoise populations adjacent to railroads are probably depleted in the same way that desert tortoise populations are diminished adjacent to well-used dirt or paved roads. The effects of railroads on desert tortoises was examined at the U.S. Ecology study plot; however, the effects of the railroad could not be separated from the effects of the adjacent Goffs Road (Dames and Moore 1991).

E. *Mining, Minerals, and Energy Development.*

Exploration and extraction of locatable minerals, fossil fuels, geothermal resources, and other types of mineral resources occur in most desert tortoise habitats. The potential for fragmenting DWMAs with small and large disturbances from mining and mineral exploration and extraction is high for some areas and moderate to low for others. The types of impacts are numerous, including: (1)

cross-country travel by vehicles during the exploration phase; (2) construction of roads; (3) disturbance of the soil surface and vegetation for access to the mineral resources (shafts, mill sites, open pits, placer diggings, tailings, leach pits, etc.); (4) production of toxic products or byproducts; (5) development of small towns and settlements to support large mines; and (6) temporary (short- or long-term oil and gas leases) or permanent transfer of title of public lands to the private sector, and (7) refuse of stakes and wire from seismic testing.

Examples of the above-listed problems, including large-scale destruction of desert tortoise habitat, are obvious in the western Mojave Desert with the mining of gold, tungsten, and borax in the Rand Mountains, Atolia, and Boron, respectively. The new cyanide heap-leach process for obtaining gold has initiated a new era in surface disturbance throughout the Mojave region.

As of 1991, leasing for oil and natural gas exploration and development was less common in the Mojave region than development of hard-rock minerals. However, it is nonetheless a substantial threat. Major exploration in the 1970's in the Ivanpah Valley left behind an uncapped well, peripheral unmitigated damage to the habitat, and an unauthorized road (Berry and Nicholson 1984b). During the 1980's, several areas of 0.5 to a few acres were cleared and/or damaged by exploratory oil and gas wells in the proposed Fremont-Kramer DWMA. At one site, an ORV trail was established, mud was dumped from the well over several hundred square feet, and additional surface area was cleared and compacted to construct temporary living quarters (BLM files).

F. Utility and Energy Facilities and Corridors.

Most proposed DWMAs have one or more pole or power lines, natural gas pipelines, fiberoptic cables, and/or communication sites. In some States, the localities for utility and energy corridors are specified in land-use plans (e.g., BLM 1980). Construction, operation, and maintenance of facilities usually involves clearing of land, creation of access routes, and generally large-scale disturbances. Vegetation is removed or degraded, soils are disturbed, and trenches are dug. Disturbances are usually linear in nature and are similar to those described above for urbanization, agricultural uses, and roads.

The zone of disturbance in utility corridors can gradually increase from 50 to 100 feet to several hundred yards as the number of transmission lines increases. Natural gas pipelines are similar: the area of disturbed soils devoid of vegetation can be 125 feet or more in width.

The potential for utility lines and energy corridors to fragment habitat is obvious; less obvious are impacts that occur during

construction and from long-term maintenance. For example, the temporary opening of deep trenches for pipelines can form significant "pit traps" into which desert tortoises may fall (Olson et al. 1992, S. Hale, pers. comm.). Towers supporting transmission lines also provide predatory birds with new perching and nesting sites which are otherwise scarce in the generally treeless habitat of the Mojave region (see Predators: Native, below).

G. *Military Operations.*

Impacts to desert tortoises and their habitats caused by military activities fall into at least four categories: (1) construction, operation, and maintenance of bases and support facilities (air strips, roads, etc.); (2) development of local support communities, including urban, industrial, and commercial facilities; (3) field maneuvers; including tank traffic, air to ground bombing, static testing of explosives, littering with unexploded ordnance, shell casings, and ration cans; and (4) distribution of chemicals. The several military bases and test ranges in the Mojave Desert include Edwards, and George Air Force bases, Twentynine Palms Marine Air-Ground Combat Center, Fort Irwin National Training Center, China Lake Naval Air Weapons Station, the Mojave B and Randsburg Wash Test Ranges, and Cuddeback Aerial Gunnery Range. The Chocolate Mountains Aerial Gunnery Range is the primary base affecting desert tortoise habitat in the Colorado Desert.

Some military activities occurred outside the above designated bases during World War II and later. General Patton conducted extensive maneuvers using tanks in Nevada, California, and Arizona to prepare troops for the North African campaigns in the 1940's (e.g., see Berry and Nicholson 1984b, Prose 1986). Additional maneuvers occurred in 1964 in California as part of Desert Strike (Berry and Nicholson 1984b). Even today some military activities overflow base boundaries, damaging or destroying adjacent habitats.

Hundreds of square miles of the Ivanpah, Fenner, Chemehuevi, and Chuckwalla DWMAs were affected by tank maneuvers during the early 1940's. Desert tortoise populations and habitat are still recovering from these impacts that occurred almost 50 years ago. The effects of tank maneuvers on soil compaction are significant, as are changes in composition, abundance, and distribution of perennial plants (Prose 1985, Prose and Metzger 1985, Prose et al. 1987). In general, areas with intense disturbance (camps, roads, and parking lots) probably will require additional decades or centuries for recovery.

The construction of military bases, test facilities, and supporting civilian communities have substantially affected desert tortoise populations and habitat in entire valleys since about 1940. For example, with development of the Naval Ordnance Test Station

(presently the Naval Air Weapons Station) at China Lake in the 1940's and 1950's, human populations rapidly grew to about 20,000 people in Indian Wells Valley. Desert tortoise populations correspondingly declined to low levels by the late 1970's (Berry and Nicholson 1984a). Similar patterns were observed at Edwards Air Force Base and Twentynine Palms. At Edwards Air Force Base, the civilian population of about 13,000 people affected desert tortoise populations for more than 30 miles in any direction. Large numbers of desert tortoises were collected on the base, especially on runways, and relocated north of base boundaries (Berry and Nicholson 1984b).

Detailed reports on impacts to tortoises from military maneuvers are available primarily for the National Training Center at Fort Irwin (Krzysik 1985, Krzysik and Woodman 1991, Woodman et al. 1986) and to a lesser extent the Naval Air Warfare Center at China Lake (Kiva Biological Consulting and McClenahan and Hopkins Assoc. 1991).

Dramatic reductions in shrubs (especially cover of creosote), pulverization of soils, and high frequencies of weedy annuals were observed at Fort Irwin in areas heavily used by tanks (Krzysik 1985, Krzysik and Woodman 1991, Woodman et al. 1986). The most recent assessment of tank traffic and the impact of ordnance directly on desert tortoises was summarized by Krzysik and Woodman (1991):

> In 1983, desert tortoise density was low in the two main valleys used for training exercises, but by 1989 tortoise density decreased by an additional 62%. Training scenarios have increased dramatically in the northwest portion of the fort since 1985, and in this area tortoises have declined by 81%.

Military ORV use results in some habitat damage. However, little habitat damage from ORVs was reported on the Naval Air Weapons Station except during retrieval of ordnance with ORVs (Kiva Biological Consulting and McClenahan and Hopkins Associates 1991).

Military maneuvers, installations, and camps can encourage congregations of desert tortoise predators such as the common raven (see Predator: Natives, below). Stubbs (1989b), in describing threats to Egyptian tortoise populations in Israel and North Africa, stated that the brown-necked raven (*Corvus ruficollis*) was a predator of concern and that: "Army camps in the desert also serve to increase the raven population."

Explosions of ordnance, static tests, and air-to-ground bombing on or adjacent to military installations may affect desert tortoise habitat and populations. For example, a new bomb crater, phosphorus flares, and parachutes were discovered on the Chuckwalla Bench study plot in California during 1988 (Berry 1990, as amended).

Military activities associated with the Chocolate Mountains Aerial Gunnery Range were probably responsible. Nearby, two student pilots released twelve 500-pound bombs near a campsite with 10 civilians (Bernstein 1989, Coleman 1989, Hurst and Healy 1989, Katoaka 1989). The bombs left foot-deep craters 10- to 12-feet wide and set fire to yuccas, palo verdes, and creosotebushes.

Damage is also incurred by collectors of scrap metal from military operations and utility lines. On the Chuckwalla Bench, Milpitas Wash drainage, and on the Chocolate Mountains Aerial Gunnery Range, California, scrap collectors illegally travel off-road in search of metal to sell. In 1989, unauthorized travel caused so much habitat damage that the BLM closed some areas of the Chuckwalla Bench (BLM 1989b).

H. Off-Highway (OHV) or ORV - Recreation.

ORV use takes many forms: organized events such as the Fast Camel Cruise in the southeastern Colorado Desert, California; large- or small-scale competitive races involving up to thousands of motorcycles (e.g., the Barstow to Las Vegas motorcycle competition); and casual family activities. ORV activities are among the most destructive, widespread, and best documented of threats to the survival of desert tortoises and other vertebrates, and to the integrity of their habitats (Adams et al. 1982ga and b, 1984; Berry and Nicholson 1984b; Brattstrom and Bondello 1983; Bury 1987, Bury and Luckenbach 1983, 1986; Bury et al. 1977; Busack and Bury 1974; Luckenbach 1975; Sheridan 1979; Stebbins 1974, 1975; Webb and Wilshire 1983).

The list of impacts from ORV use is extensive, including: mortality of desert tortoises on the surface and below ground; collapsing of desert tortoise burrows; damage or destruction of plants used for food, water, and thermoregulation; damage or destruction of the mosaic of cover provided by vegetation; adverse effects to the general well-being of desert tortoises through water balance, thermoregulation, and energy requirements; noise pollution; impact, damage or destruction of soil crusts; soil erosion; proliferation of weeds; and increases in numbers and locations of wild fires.

ORV use in the desert has increased and proliferated since the 1960's (Adams et al. 1982a, Stebbins 1974). As of 1980, ORV activities affected approximately 25% of all desert tortoise habitat in California and 67% of habitat which supported densities estimated at more than 100 individuals/mi^2 (Berry and Nicholson 1984b). Substantial portions of desert tortoise habitat in southern Nevada are also affected (Berry and Burge 1984, Burge 1986).

Government documents provide ample evidence of severe declines in biomass of plants and vertebrates as well as desert tortoise densities in the western and southern Mojave deserts due to

OHV/ORV-related activities (Busack and Bury 1974, Bury et al. 1977, Berry and Nicholson 1984b, Berry 1990, as amended). Bury (1987) demonstrated that desert tortoise densities and health (measured by length-scaled body weight) also deteriorated as a result of ORV activities when contrasted to values from appropriate control areas.

In the Southwest, the BLM and some other governmental agencies have been (and continue to be) ineffective in preventing ORV competitive events and casual use from causing more habitat damage and loss in important desert tortoise habitats (Burge 1983, 1986, Woodman 1983, BLM 1989a, 1990a, Fish and Wildlife Service 1989a, 1989b, 1989c). For example, when competitive events are held, old routes are widened, new routes are formed, race participants and observers camp and park in unauthorized areas, race monitors are unable to prevent unauthorized activities, and garbage is not appropriately handled. In general, more habitat is damaged or destroyed with each new event. In 1989, the BLM and Fish and Wildlife Service monitored the annual Barstow-to-Vegas race and reported that motorcycles and other vehicles strayed beyond the designated course by an average of 30 feet, causing damage or loss of hundreds of acres of desert tortoise habitat in the eastern Mojave Desert (BLM 1989a, 1990a).

The BLM has been unable to protect important habitats in the Rand Mountains and Fremont Valley of eastern Kern County, California from damage by casual recreational vehicle users (Goodlett and Goodlett 1991, 1992). This area, which is part of the proposed Fremont-Kramer DWMA and adjacent to the Desert Tortoise Natural Area, has experienced intensive ORV-oriented recreation since 1973, and has the highest rate (40.7%) of vandalism to desert tortoises (Berry 1990, as amended). Between 1989 and 1990, BLM closed much of the area to recreational use on an emergency basis to protect desert tortoises, but then reopened a network of "designated routes" in November of 1990. After route designation, vehicle-oriented recreationists traveled on closed routes and vandalized signs marking closed routes. Motorcyclists illegally traveled parallel to designated routes, creating new tracks and trails and widening existing routes. Just prior to, during, and after the Thanksgiving holiday in 1991, the level of unauthorized use was extremely high (Goodlett and Goodlett 1992). For example, of 65 vehicles observed in a 4-hour period, only 38% were following regulations and traveling on authorized routes, whereas 62% traveled cross-county or were on closed routes. In a second experiment, 39 transects (each of which was 500 feet long) were established perpendicular to designated, open routes, and data were recorded on numbers of trails and tracks crossing the transects. Eighty-five trails and 553 recent, unauthorized tracks were recorded. An average of 16 unauthorized trails or tracks crossed each transect, or one track every 31 feet. In a third experiment, 17 trails signed as "closed" were raked to remove tracks before Thanksgiving and then re-visited a week later. There were 195 new tracks or 11.5 unauthorized tracks per closed route.

I. Livestock Grazing.

Negative interactions between grazing and desert tortoises are not restricted to the American Southwest. In the habitat of *Testudo kleinmanni* in North Africa and Israel, livestock grazing changes the composition of desert vegetation and the altered vegetation is less favorable to rodents (Stubbs 1989b). Rodent burrows are vital to the survival of the species during summer. Livestock grazing has also contributed to declines in *Chelonoidis chilensis* (Waller et al. 1989, pers. comm.). In reference to a proposed nature preserve in Israel, Mendelssohn (1990) stated that "...areas were badly affected or even destroyed by overgrazing." Mendelssohn (1983) adds:

> The...Egyptian tortoise...is endangered by much of its habitats being turned into agricultural land, and, in the remaining areas, by overgrazing by Bedouin herds which destroys the protective vegetation and exposes the turtles to predation by ravens.

Sheep, cattle, burros, and horses can affect desert tortoises and their habitats directly and indirectly. The degree of impact depends on a number of factors including, but not limited to: resiliency of soil and vegetation types, type of stock, stocking rates, season of use, and years of use with and without rest. Other factors which interact with livestock grazing and can affect the degree and extent of impacts include: introduction and spread of weeds, previous grazing-induced changes in vegetation, fire, drought, and other land uses.

Livestock can trample, injure, or kill desert tortoises either above ground or while in burrows. Trampling of live desert tortoises by cattle has been observed in the eastern Mojave Desert (M. Coffeen pers. comm., T. Duck pers. comm) and juvenile desert tortoises have been trampled in the western Mojave Desert (Berry 1978a, Berry and Shields et al. 1986, Nicholson and Humphreys 1981; Craig Knowles, BLM field notes for Stoddard Valley). Livestock can also trample desert tortoise nests. Feral burros damaged nests of giant tortoises in the Galapagos, thereby reducing nesting success (Fowler de Neira and Roe 1984).

Livestock can also trample burrows and other cover sites. BLM study plot files (journal notes, 35-mm slides) for desert tortoises contain numerous examples of burrows trampled by cattle and sheep. For example, sheep damaged 10% and destroyed 4% of 164 freshly-used desert tortoise burrows on a study plot in the western Mojave Desert during less than 2 weeks of grazing (Nicholson and Humphreys 1981). Juvenile desert tortoise burrows are particularly vulnerable to trampling because of their locations and the shallow soil covering protecting the tunnels.

Livestock also trample shrubs (e.g., creosote) used as sites for desert tortoise burrows and pallets, and which provide protection from predators and temperature extremes. Cattle and sheep have been observed breaking apart large creosote bushes while feeding on annual plants in coppice mounds and when seeking shade and bedding sites (Berry 1978, Jeff Aardahl, pers. comm.). Cattle have also been observed swinging their heads/horns back and forth in creosote bushes, breaking apart the branches (Harold Avery, BLM, Riverside, pers. comm.). Once the branches were broken, the cattle then ate the annual plants in coppice mounds at the base of the creosote. The overall result was a loss of shrub biomass and canopy cover and reduction in shade-giving properties, etc. Burge (1977) and Berry and Turner (1984, 1986) described the importance of shrubs in providing cover for burrows and shade for desert tortoises. For example, most juvenile burrows (80%) were sheltered by shrubs, particularly creosote and burro bush, (*Ambrosia dumosa*).

Grazing can cause soil erosion and soil compaction similar to vehicle-induced compaction (Arndt 1966, Ellison 1960, Klemmedson 1956). Data from 25 grazing studies showed that filtration rates decrease by about 25% in areas of light to moderate grazing, and about 50% in areas of heavy grazing (Gifford and Hawkins 1978). Runoff of precipitation in heavily grazed areas was 150% greater than in areas of moderate grazing and 1000% greater than in areas of light grazing (Sharp et al. 1964). When grasses were continually grazed, their root systems shrink, and their capacity to hold soil from erosion was reduced (Johnson 1983). Livestock grazing also has negative impacts on soil crusts and cryptogams (e.g., Avery et al. 1992).

Livestock grazing can and has altered perennial vegetation in a number of ways. Livestock grazing has caused, or contributed substantially to, the reduction and loss of native perennial grasses (e.g., members of the genera *Bouteloua*, *Hilaria*, *Stipa*, *Oryzopsis*, *Poa*, *Muhlenbergia*, *Sporobolus*) in the desert as well as in other parts of the western United States (e.g., Bentley 1898; Frenkel 1970; Humphrey 1958, 1987; Rowlands, unpubl.; BLM 1980). Perennial grasses in many areas have been replaced by woody shrubs, often with an understory of non-native annual grasses introduced from Europe and Asia. Livestock play an important role in proliferation of non-native weeds such as *Erodium cicutarium*, *Schismus barbatus*, *S. arabicus*, *Bromus*, and *Salsola iberica* (Kay, Meyers, and Webb 1988). This profound change in structure of vegetation has contributed to invasion of weeds and an increase in fire (see below).

Livestock grazing has affected composition of shrubs used for cover by desert tortoises. For example, sheep reduced some perennial shrubs by 65 to 68% in volume and by 16 to 29% in cover (Webb and Stielstra 1979). In areas consistently and heavily grazed by sheep, cover of many species of shrubs was substantially reduced and creosote and weeds were often the predominant vegetation

(Webb and Stielstra 1979). The following shrubs can be reduced in numbers and vigor in such grazed sites: burro bush, goldenhead (*Acamptopappus sphaerocephalus*), Anderson thornbush (*Lycium andersoni*), spiny hop sage (*Grayia spinosa*), winter fat (*Ceratoides lanata*), and Mojave aster (*Machaeranthera tortifolia*).

Livestock grazing can affect quality and quantity of plant foods available to desert tortoises, and thereby affect nutritional intake. Data gathered through spring of 1992 indicate that desert tortoises are generally quite selective in their choices of foods (Burge 1977, Nagy and Medica 1986, Turner et al. 1987, Avery 1992, Esque 1992, 1994, Henen 1992, Jennings 1992, 1993). Desert tortoises may have individual preferences and seek out particular species to eat. In some areas, the preferences are clearly for native plants over the weedy non-natives. Food preferences may vary by age, sex, and locality.

The relation between food availability and growth, reproduction, and general well-being of desert tortoises has been the discussion of many published papers (e.g., Tracy 1992). For example, juvenile desert tortoises exhibit increased growth in years when rainfall and forage are abundant (Medica et al. 1975). Desert tortoises also produce more eggs when more food and water are available than when these resources are scarce (due to drought or grazing pressure) (Turner et al. 1986, 1987, Henen 1992).

Juvenile desert tortoises may be at greatest risk in grazed areas, because they are likely to be too small to reach remaining food items concealed within shrubs after livestock have used an area. Juveniles are less likely to travel the distances necessary to locate remaining patches of forage. If soils have been churned by trampling, juveniles may not be able to travel easily across the landscape. In addition, juveniles may require diets with more protein than adults (see Adest et al. 1989 for the bolson tortoise, also Troyer 1984).

The most substantial impacts to vegetation, soils, and desert tortoises likely occur at and in the vicinity of heavy-use sites where livestock are watered, bedded down, or trailed. The loss of cover and changes in vegetation are often evident for many acres around each cattle watering trough or tank. Biologists have observed trails leading to stock-watering sites miles from the actual waters. Sheep bedding and watering areas also receive substantial impacts (Nicholson and Humphreys 1981). Loss of cover can increase vulnerability of desert tortoises to predation (see below).

J. Invasion and Establishment of Weedy and Non-Native Plants.

The relationships among livestock grazing, invasion of non-native plants, and fire are complex. From a global perspective, invasions by non-native grasses are most severe in the arid and semi-arid western United States (D'Antonio and Vitousek 1992). Cheatgrass

(*Bromus tectorum*) for example, spread throughout the Great Basin in conjunction with the introduction of sheep and cattle.

Many species of non-native plants from Europe and Asia have invaded desert tortoise habitats in the Mojave and Colorado deserts and have become common to abundant in some areas, particularly where disturbance has occurred and is ongoing. Some of the more common non-native or native weedy species found within the Mojave region include: bassia (*Bassia hyssopifolia*), sand bur (*Ambrosia acanthicarpa*), western ragweed (*Ambrosia psilostachya var. californica*), common spikeweed (*Hemizonia pungens*), pineapple weed (*Matricaria matricarioides*), fiddleneck (*Amsinckia intermedia, A. tessellata*), flixweed (*Descurania sophia*), tumble mustard (*Sisymbrium altissimum*), London rocket (*Sisymbrium irio*), Russian thistle (*Salsola iberica*), redstem filaree (*Erodium cicutarium*), turkey mullein (*Eremocarpus setigerus*), and horehound (*Marrabium vulgare*) (in part from Tierra Madre 1991, and BLM files). Several species of annual grasses are also important, including: foxtail chess or red brome (*Bromus rubens*), cheat grass or downy brome (*Bromus tectorum*), barley (*Hordeum glaucum, H. jubatum, H. leporinum*), Mediterranean or split grass (*Schismus barbatus*), and Arab grass (*S. arabicus*).

The above weeds—particularly filaree, foxtail chess, and cheat grass--thrive in many open deserts which have been or are (1) grazed by livestock, particularly sheep; (2) disturbed by OHV/ORVs and cross-country travel; (3) used for military maneuvers; and (4) used for settlements, townsites, or air-strips. Weedy species, which lack adaptations for germinating in thickly crusted desert soils, gain entry when crusts are broken. Certain soil types, such as aeolian sands, are particularly vulnerable to such invasions.

As non-native plant species become established in some areas, some native perennial and annual plant species decrease, diminish, or die out (D'Antonio and Vitousek 1992). For example, under pressure from livestock grazing, many native perennial bunch grasses have declined, died out, and been replaced with such species as foxtail chess (Robbins et al. 1951). The native bunch grasses include, but are not limited to: desert needle grass (*Stipa speciosa*), Indian rice grass (*Oryzopsis hymenoides*), bush muhly (*Muhlenbergia porteri*), the grama grasses (*Bouteloua sp.*), fluffgrass (*Erioneuron pulchellum*), and members of the genera Poa and Sporobolus. Many areas formerly occupied by the native grasses have been filled by annual grasses and weeds from Europe and Asia.

Some botanists view non-native species as aggressive competitors capable of replacing native species (Frank Vasek, pers. comm., Webb and Stielstra 1979, D'Antonio and Vitousek 1992). Loss of native plants and replacement by weedy, non-native plants has resulted in what some call disclimax vegetation (Vasek, pers. comm.). Native plant populations in disturbed habitats have been in a weakened condition for decades, and are more vulnerable to competition than at any other time in the historic past (Vasek, pers.

comm.). Drought conditions in the last few years have placed additional pressures on native plant populations.

Few quantitative data are available to document patterns of successful invasion of non-native plants in the northern Mojave; however, vegetation samples from Rock Valley, Nevada, clearly show a remarkable increase in abundance of foxtail chess (Figure D1). Furthermore, expansion of foxtail chess does not correlate with population sizes of native plants (Figure D2), suggesting that foxtail chess is successfully invading the Mojave, but may not be competitively displacing native plants. In some areas, the bromes have become so abundant that they are capable of fueling fires that threaten the very structure of the desert as a shrubland (see Section 5.K. below). A prime example is the Pakoon Basin in northern Arizona (Laroh 1991).

K. Fire.

Fire has the potential to be an important force governing habitat quality and persistence of desert tortoises. Impacts of fire on desert tortoises have not been well documented; however, a few accounts provide some evidence that animals are injured or killed by fire (e.g., Woodbury and Hardy 1948, Richard Franklin pers. comm.). Remains of 14 desert tortoises thought to have been killed by a fire 2 years earlier were found near Bunkerville, Nevada, in December 1942 (Woodbury and Hardy 1948). Stubbs (1981a, 1981b, 1984) provided substantial evidence of the serious impacts of fire on a population of *Testudo hermanni* in Greece in alyki heaths, which is similar in appearance to the saltbush or alkali sink communities in California deserts. Fires maim or kill tortoises in Greece as surely as they do in the United States if the tortoises are above ground or exposed in shallow burrows.

With the help of Richard Franklin (BLM, Riverside, California), data were assembled from BLM files in areas where desert tortoises occur in Utah, Arizona, Nevada, and California. In excess of 5,000 fires occurred in the four-state region, burning more than 1 million acres (Table D1).

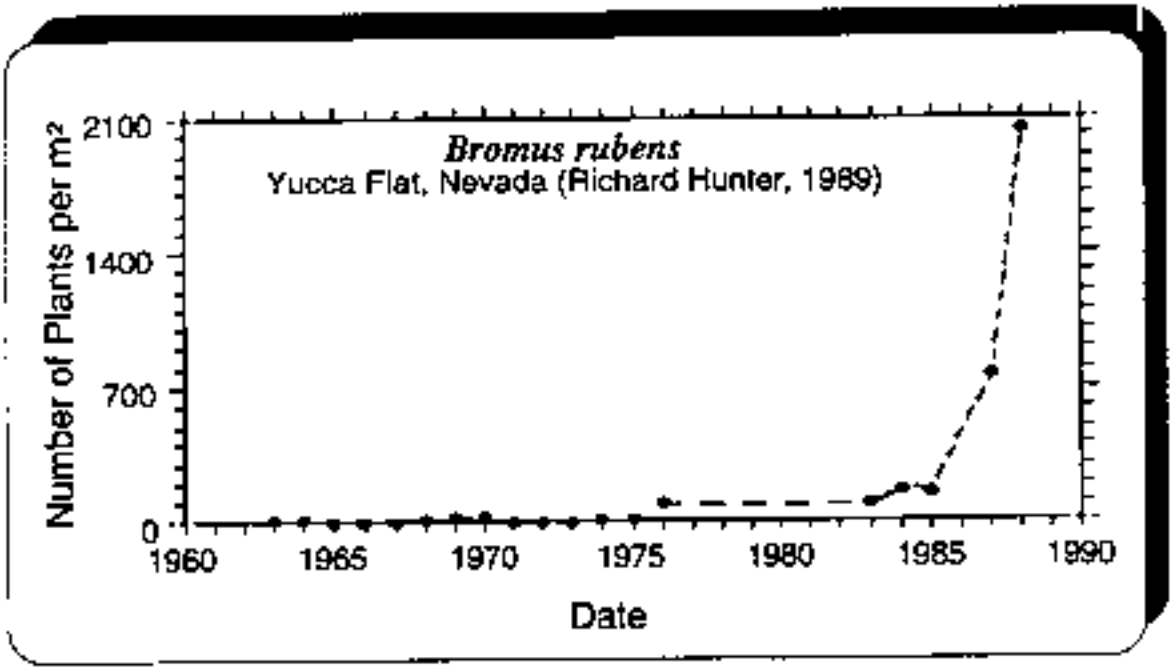


Figure D1. Historical increase in Bromus rubens in Yucca Flat, Nevada as a function of time (Hunter 1989).

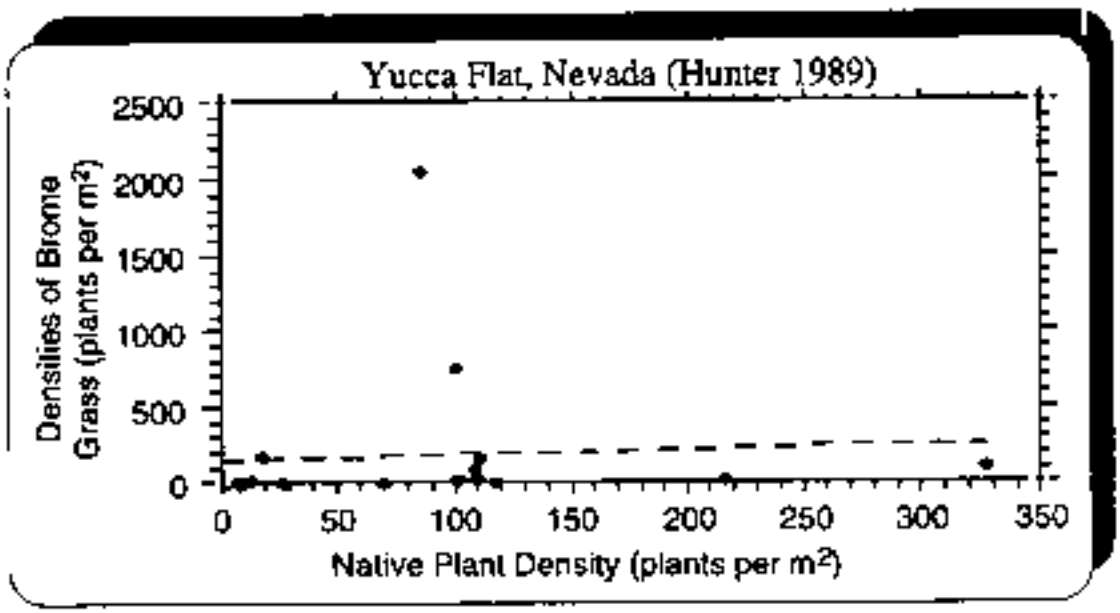


Figure D2. Relationship of densities of brome grass to native plant densities at Yucca Flat, Nevada.

Table D1. Number of fires and areas burned from 1980 to 1990 in the Mojave Desert.

State	No. of fires	No. of acres
Utah	830	49,944.6
Arizona	745	102,031.8
Nevada	2,114	159,275.8
California	1,437	243,316.9
Total	5,126	554,569.1

Most fires during the 1980's occurred in Nevada, but more habitat was burned in California (Figure D3). During the 1980's, the trend was towards an increasing number of fires in California, compared with a downward trend in the number of fires in Nevada (Figure D3, Tables D2 and D3). These trends were not due to lightning, and there was no significant trend in the number of fires caused by lightning in California or Nevada (Figures D3 and D4). Thus, fires directly caused by humans explain trends in both California and Nevada. The frequency of fires in California is significantly related to winter rainfall (Table D3). In years when winter rainfall exceeded eight centimeters, more fires occurred in the subsequent spring and summer seasons (Figure D5, Table D4). Rainfall is responsible for increased plant production, which in turn can produce more fuel for fire (Figure D5, see section on invasion of non-native weeds, above). Fires are more prevalent in areas where European and Asian weeds are successfully established. Ironically, in years with high rainfall that could produce greater amounts of potential food for desert tortoises, more fires occur which directly endanger desert tortoises and destroy shrub cover necessary for suitable desert tortoise habitat. Fires are associated with changes in annual and perennial desert vegetation not necessarily associated with changes in climate (Brown and Minnich 1986; Humphrey 1963, 1974; O'Leary and Minnich 1981, Reynolds and Bohning 1956). The relations among fire, disturbance, and changes in annual plant composition are complex. Biomass of weedy species has increased remarkably in deserts and desert tortoise habitat due to disturbance from vehicles, grazing, agriculture, and urbanization, etc. (Figure 5, see transect data in Berry 1990 as amended). Weedy, non-native grasses such as red brome, cheat grass, and split grass; and forbs increasingly blanket the desert floor, resist decomposition, and provide flammable fuel for fires. Once fires occur, they may improve opportunities for invasion and increases in the weeds. For example, Brown and Minnich (1986) reported that "...postfire herb cover was 23% greater in burned than unburned stands ...[and]...most cover was of exotic European annuals..."

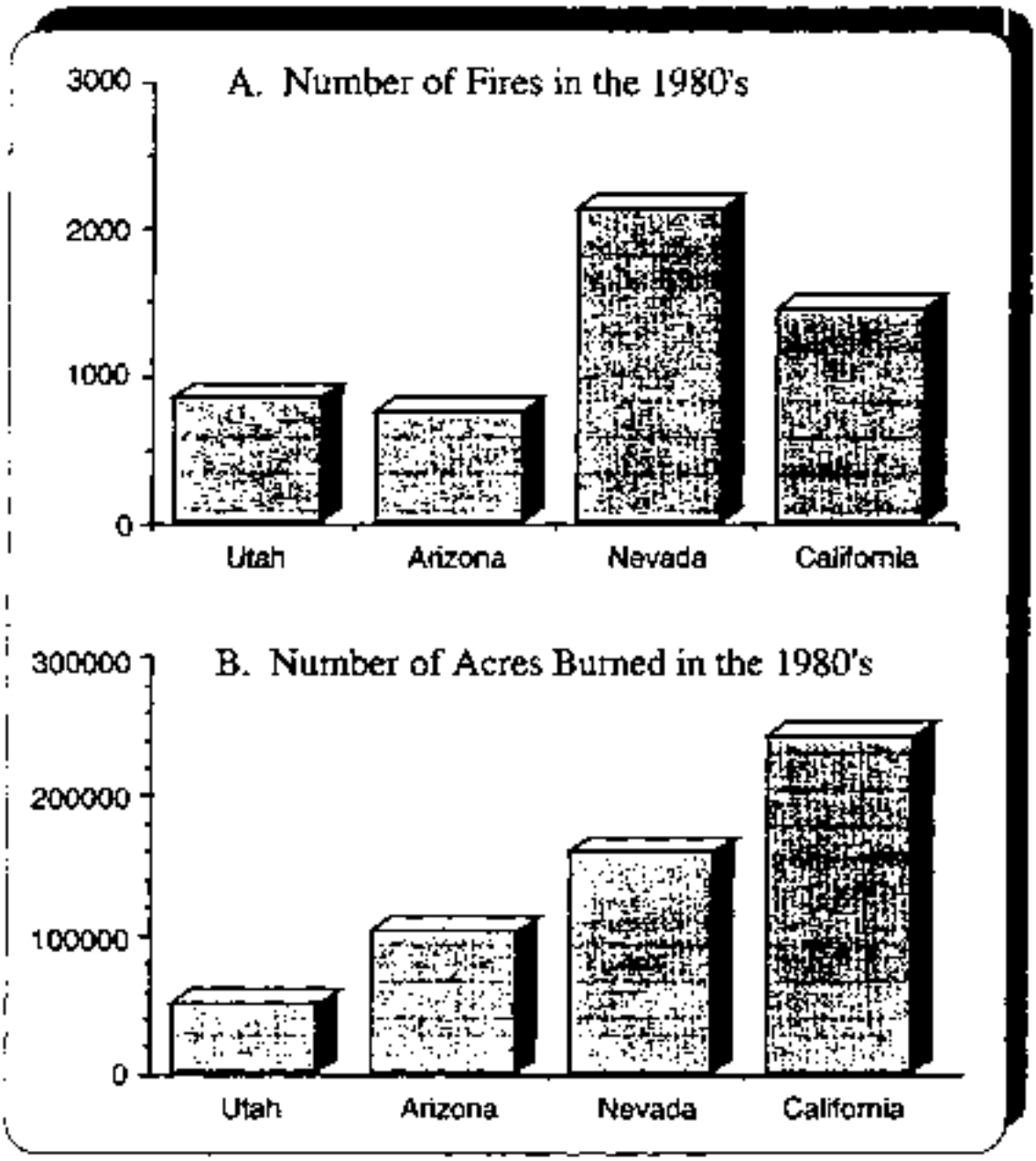


Figure D3. Number of fires and acres burned in the Mojave Desert between 1980 and 1990.

Table D2. Results of a regression analysis of the number of fires occurring in the Las Vegas District as a function of time (year in which the fire occurred).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
Intercept	1	34285.461	34285.461		
year	1	23476.809	23476.809	9.356	.0136
Residual	9	22584.100	2509.344		

Dependent: no. of fires

Model Summary
Dependent: no. of fires

R-Squared	.510	Adj. R-Squared	.455	RMS Residual	50.093

	df	Sum of Squares	Mean Square	F-Value	P-Value
Model	1	23476.809	23476.809	9.356	.0136
Error	9	22584.100	2509.344		
Total	10	46060.909			

Model Coefficient Table
Dependent: fires

	Beta	Std. Error	t-Test	P-Value
Intercept	1501.682	406.259	3.696	.0049
year	-14.609	4.776	-3.059	.0136

Table D3. Results of a regression analysis of the number of fires occurring in the California Desert District as a function of time (year in which the fire occurred) and whether or not winter rainfall was above or below eight centimeters (rainfall category).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
year	1	20384.861	20384.861	14.561	.0051
rain category	1	8055.276	8055.276	5.754	.0433
Residual	8	11199.606	1399.976		

Dependent: No. of Fires

Model Summary
Dependent: No. of Fires

R-Squared	.649	Adj. R-Squared	.562	RMS Residual	37.416

	df	Sum of Squares	Mean Square	F-Value	P-Value
Model	2	20734.921	10367.461	7.405	.0151
Error	8	11199.606	1399.976		
Total	10	31934.727			

Model Coefficient Table
Dependent: No. of Fires

		Beta	Std. Error	t-Test	P-Value
Intercept		-1201.322	350.189	-3.430	.0089
year		15.897	4.166	3.816	.0051
rain category	below 8	-70.955	29.580	-2.399	.0433
	above 8	0.000	*	*	*

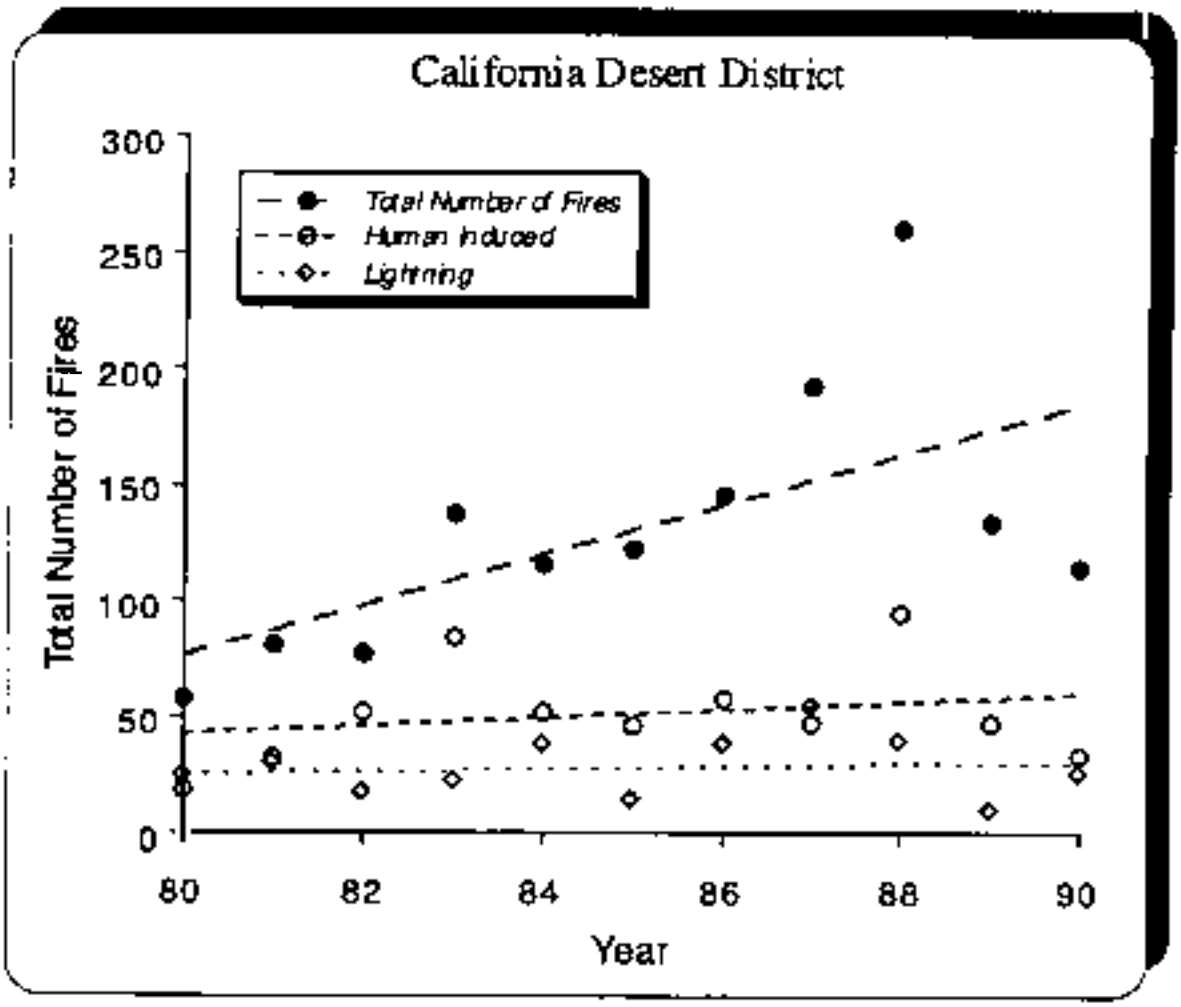


Figure D4. Number of fires occurring between 1980 and 1990 in the California Desert District of the BLM. Fires are presented as those produced by lightning, humans, and the total of lightning and human-induced fires.

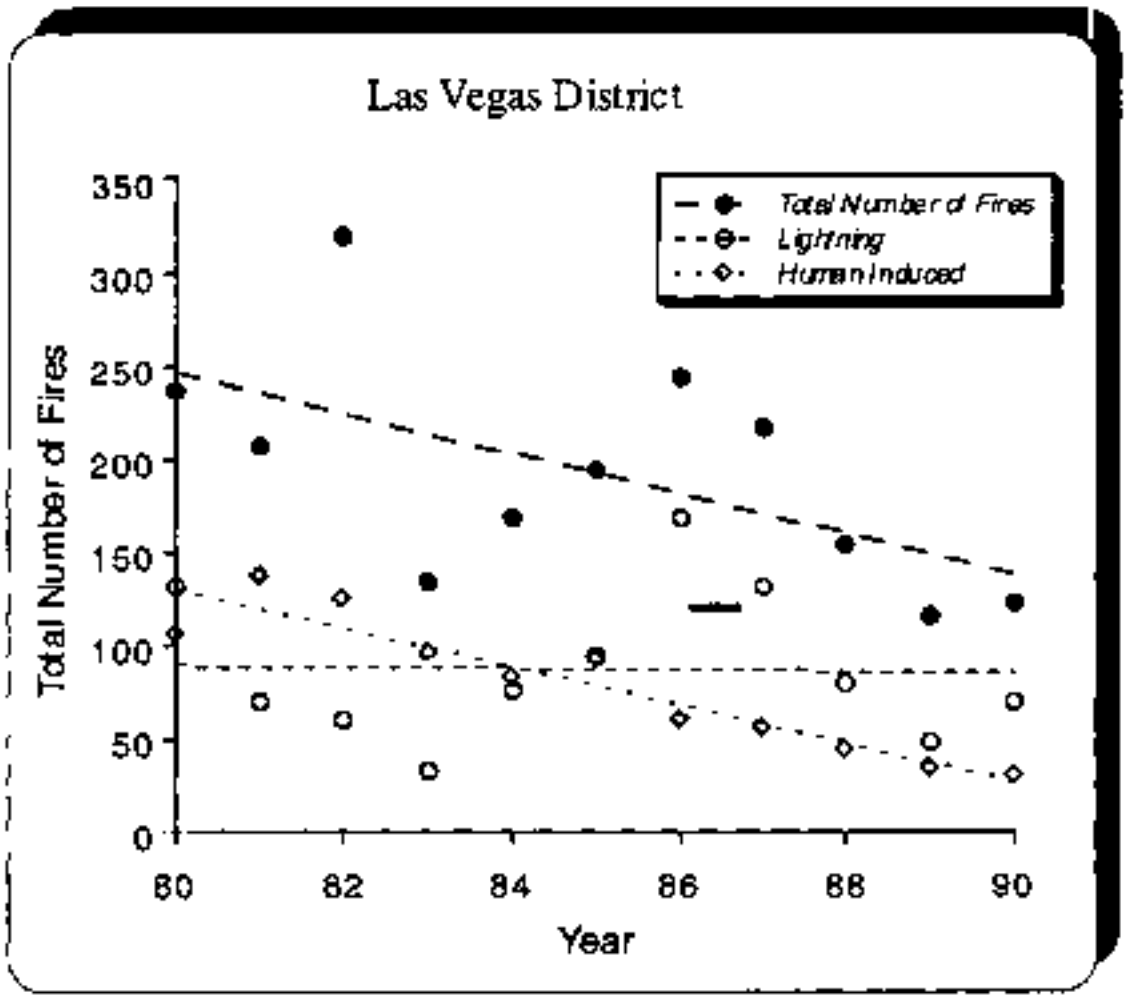


Figure D5. Number of fires occurring between 1980 and 1990 in the Las Vegas District of the BLM. Fires are presented as those produced by lightning, humans, and the total of lightning and human-induced fires.

Table D4. Results of a regression analysis of the number of fires occurring in the Las Vegas District as a function of time (year in which the fire occurred).

Type III Sums of Squares

Source	df	Sum of Squares	Mean Square	F-Value	P-Value
year	1	20384.861	20384.861	14.561	.0051
rain category	1	8055.276	8055.276	5.754	.0433
Residual	8	11199.806	1399.976		

Dependent: No. of Fires

Model Summary
Dependent: No. of Fires

R-Squared	.649	Adj. R-Squared	.562	RMS Residual	37.416

	df	Sum of Squares	Mean Square	F-Value	P-Value
Model	2	20734.921	10367.461	7.405	.0151
Error	8	11199.806	1399.976		
Total	10	31934.727			

Model Coefficient Table
Dependent: No. of Fires

		Beta	Std. Error	t-Test	P-Value
Intercept		-1201.322	350.189	-3.430	.0089
year		15.897	4.166	3.816	.0051
rain category	below 8	-70.955	29.580	-2.399	.0433
	above 8	0.000	*	*	*

Desert perennials are poorly adapted to burning and are poor colonizers (Tratz and Vogl 1977, Tratz 1978). Creosote, for example, can require hundreds of years to recolonize and recover (Vasek 1980, 1983). Fuel loads provided by canopies of split grass and brome make it more likely for fire to become hot enough to damage shrubs. Ultimately, fire can change the character of desert shrublands into Mediterranean grass and weedlands. Some shrublands have already been converted to annual grasslands in parts of the Apple, Stoddard, and Victor valleys in the southern Mojave Desert (R. Franklin, pers. comm.) and in the Pakoon Basin of northwestern Arizona (Lamb 1991). In the latter area, 88,152 acres of habitat burned from 1980 to 1990. Conversion of shrublands to annual grasslands can be devastating for desert tortoises, which depend upon shrubs for cover.

Relations among fire, rain, domestic grazing, proliferation of weeds, and destruction of desert tortoise habitats are complex; but understanding these relations is essential to promoting long-term habitat recovery. Grazing can promote invasion of weeds, which can enhance the destructive forces of fires. For example, grazing of sheep in California deserts is authorized by the BLM when winter rains produce sufficient poundage of winter annuals. Thus, rainfall simultaneously provides opportunities for sheep grazing, which in turn encourages proliferation of weeds and provides fuel for fires. Rainfall, especially when above the norm, virtually always encourages fires in disturbed habitats. Many desert fires are ignited by humans, thereby turning a "bounty" of potential desert tortoise foods into a season with higher potential for fires and habitat destruction.

L. *Harvest and Vandalism of Vegetation.*

Cacti and tree yuccas (*Yucca brevifolia, Y. schidigera*) are the primary targets of both legal and illegal harvesters. Harvesting operations impose much the same negative impacts as ORV activities: crushing of desert tortoises and their burrows, removal of vegetative cover, compaction of soils, and inhibition of annual and grass germination (Berry and Nicholson 1984b). Harvesting of yuccas can be viewed as a form of desertification because of the loss of cover and structure in the plant communities and the long period required for recovery.

Berry and Nicholson (1984b) summarized the data on yucca harvesting in California through the early 1980's. In recent years, San Bernardino County has modified the permitting process to enhance protection of the environment, but has continued to issue permits for yucca harvests on private lands in the eastern Mojave and northern Colorado deserts; notably in the Fenner, northern Ward, and Chemehuevi valleys. Several dozen square miles of private lands have recently been harvested both legally and illegally, and some illegal harvests occurred on public lands (U.S. Ecology 1989).

Vandalism of vegetation is common in some parts of the desert. Tree yuccas and cacti are frequent targets and are shot or set on fire, sometimes setting off wild fires (R. Franklin, pers. comm.). For example, use of semi-automatic and automatic weapons to vandalize vegetation is increasingly frequent in the southern parts of the Needles Resource Area (Chemehuevi DWMA) and "a...pipe bombing was associated with more shooting of structures and cactus in the Turtle Mountain area" (BLM 1991b).

M. Predation.

1. Native predators. Many species of predators prey on desert tortoises at different stages of their life cycle, including predation on eggs by Gila monsters (Beck 1990), destruction (and probably consumption of eggs) by kit foxes and coyotes (Turner et al. 1987), predation of juvenile and immature desert tortoise by ravens (Berry 1985, Woodman and Juarez 1988, Farrell 1989), and predation of immature and adult desert tortoises by golden eagles (Berry 1985). Many authors have reported predation by ophidians, felids, canids, and mustelids.

Natural predation in undisturbed, healthy ecosystems is generally not an issue of concern. Under certain situations, however, the level and type of predation becomes a management issue, and action must be taken to control the predator(s). The most obvious example is when numbers of desert tortoises become precariously low in local areas or regions, and any loss of individuals is likely to threaten that population. Predation rates may be altered when natural habitats are disturbed or modified. For example, densities of predators may increase, food habits of predators may be altered so that desert tortoises become more frequent components in the diets, and predators may be able to prey upon desert tortoises more easily when cover has been reduced.

The most important predators of desert tortoises at this time are the common raven (*Corvus corax*) and the coyote (*Canis latrans*). Based on data from over 1,000 remains, ravens generally kill juvenile desert tortoises with a carapace length of less than 110 mm (Campbell 1983, Berry 1985, Woodman and Juarez 1988). The evidence that ravens are preying upon and not scavenging juvenile desert tortoises is three-fold. First, ravens have been observed killing juvenile desert tortoises (Tom Campbell, Jim Farrell, Ted Rado, and others, pers. comm.). In contrast, scavenging of juveniles has not been observed (although scavenging of larger road-killed desert tortoises has been documented).

Second, large numbers of young desert tortoise remains show signs consistent with raven predation. Many remains show puncture wounds made by ravens' beaks or have entry wounds on the carapaces or plastrons where ravens pecked through the shells and

withdrew the organs (Berry 1985). The patterns of damage to the shell and removal of heads, legs, and girdles are consistent from one geographic region to another and from one species of tortoise to another (see Geffen 1990, for *Testudo kleinmanni*). The puncture wounds and openings in the shell must have been made when the tortoise was alive or within minutes of death, when the shell was soft and pliable and could be opened without fracturing it. Third, large numbers of young desert tortoise remains are found in and at the base of raven nests, as well as near perches. Concentrations of shells have been discovered along fence posts (Campbell 1983), at the bases of known raven perches and nests (Woodman and Juarez 1988), and along transmission line towers (Farrell 1989). For example, between 1987 and 1990, 564 shells of carapace length less than 110 mm were collected in California from 1987 to 1990 on study plots, along powerlines, and at raven nests and perch sites. Of this total, 215 (38%) were found on study plots and 349 (62%) were found associated with raven perch or nest sites, most of which were along powerlines.

In spring 1991, a case of probable raven predation occurred at a research site on the National Training Center, Ft. Irwin, California (D. Morafka, pers. comm.). In early 1990, two contiguous predator-proof enclosures were established for neonate desert tortoises. One enclosure had a roof of chicken-wire screen to prevent avian predation, and the other did not. In late summer and autumn 1990, approximately 30 juveniles hatched inside the roofed enclosure, 18 in the outside enclosure, and another 12 were free ranging. During a 2-week period in spring 1991 (29 April to 9 May), an avian predator, presumably a raven, preyed upon and killed the 18 desert tortoises in the open enclosure. Of the 12 free-roaming desert tortoises (each with a radio transmitter) outside the enclosures, 8 were found dead. All shells had punctures either through the carapace or plastron or both in patterns consistent with raven predation (Campbell 1983, Berry 1985, and others). The shells were within a few hundred feet of the sites where desert tortoises were last seen alive.

Raven predation on juveniles can be a threat to the long-term persistence of desert tortoise populations. In California, desert tortoise study sites that show high percentages of raven-killed juveniles also show significant changes in size-age class structure of populations from the 1970's to the 1980's (Berry et al. 1986a and b). The data show significant declines in percentages of live juveniles desert tortoises as well as declines in recruitment of juvenile and immature desert tortoises into the young adult size-age classes. Ray et al. (1992) developed a simple model to evaluate spatially structured raven predation on juvenile tortoises. This model predicts that ravens must increase mortality of juveniles 5 years old by 25% before a discrete reduction in population growth from 1.02 to 1.00 can occur.

The extent of raven predation varies regionally and appears to be correlated with densities of raven populations. Berry (1985)

demonstrated that the proportion of juvenile shells showing evidence of raven predation was significantly higher in the western Mojave than the eastern Mojave and southern Colorado deserts. This pattern is consistent with raven surveys in which large numbers of raven sightings were recorded in the western Mojave, intermediate numbers in the eastern Mojave, and relatively few in the southern Colorado deserts (Knowles et al. 1989a, 1989b). Considerable predation also occurs in the eastern Mojave Desert. For instance, most of the 248 desert tortoise remains collected in 1988 at or near three active raven nests and one foraging site in the eastern Mojave were estimated to have died that year (Farrell 1989).

Populations of common ravens apparently have been increasing for many decades. Numbers of ravens observed during Fish and Wildlife Service breeding bird surveys in the Mojave Desert increased by 1528% between 1968 (the year the surveys were initiated) and 1988 (Fish and Wildlife Service, Laurel, MD; cited in BLM 1989). Increases of 474% were also documented for the Colorado Desert during the same time period. Probable causes for population increases are increased availability of foods (e.g., landfills, sewage ponds, dumpsters, highways, cities) and water (e.g., sewage ponds, agricultural fields, golf courses). Artificial sources of food and water help sustain more individuals during times of low natural resource availability, such as winter and summer. Such artificial food sources also probably facilitate larger clutch sizes or increased frequencies of clutches and greater fledgling success for the common raven. In addition, human-made structures have increased numbers and distribution of perches and nest sites (power and telephone poles, bridges, bill boards, freeway overpasses, etc.). The presence of human refuse in almost a quarter of 226 raven pellets collected from the eastern Mojave Desert in May 1991 demonstrates the close relationship between humans and ravens (Camp et al. 1992). In another example, ravens spent 51% of non-flight time along transmission towers, railroads, telephone poles, and non-native tamarisk shrubs in the eastern Mojave (Sherman and Knight 1992).

A parallel issue involves Egyptian tortoises, which are preyed upon by the hooded crow (*Corvus corone sardonius*) and the brown-necked raven (*C. corax ruficollis*) in Israel, Egypt, and elsewhere in North Africa (Geffen and Mendelssohn 1989, Mendelssohn 1990, Stubbs 1989b):

> When I came to Palestine in 1933 the brown-necked raven was not a rare, but neither was it a common, desert bird. Each pair has a territory of about 100 kilometers^2 and there were small nomadic flocks of immatures and non-breeding adults. After the foundation of the State of Israel, when large scale immigration, agricultural, and settlement development began, the brown-necked raven became synanthropic and started a population explosion.

> Formerly a cliff-nesting species, it now began to nest on trees, on power line pylons, and on and in large buildings (hangars, etc.). ...The hooded crow has recently been removed from the list of protected species because of its population explosion and damage to agriculture. Brown-necked ravens are still on the list of protected species but in case of damage are controlled by rangers of the Nature Reserves Authority.
>
> [The hooded crow] was formerly distributed only in areas close to the Mediterranean, where human settlements were quite dense and high trees for nesting were available. Predation on young *Testudo graeca floweri* (a semi-desert subspecies) has been observed several times. Following human settlements they advanced eastwards penetrating into the area of *T. kleinmanni* and recently reaching Beer Sheva, 50 kilometers from their former distribution area. This synanthropic species can reach very high densities, notwithstanding that breeding pairs are territorial, but feed also outside their territory, as do the flocks of immatures and non-breeding adults. Recent research carried out not far from Tel Aviv, has shown that there can be up to 17 breeding pairs in 1 kilometer^2!
>
> [The brown-necked raven]...became also synanthropic and invaded the areas of *T. kleinmanni* from the east, so that now both species are sympatric there. Lack of trees so far prevents these corvids from exploiting much of the area, but I have seen even the hooded crow, not such a good flyer as the brown-necked raven, flying several kilometers from the next settlement over the *T. kleinmanni* habitat, apparently foraging (Mendelssohn 1990).
>
> Shells of young tortoises of both species, some still bloody from predation, are often reported. The disappearance of *T. graeca floweri* from some areas is likely due to crow predation, and there is increased concern about the impact of brown-necked ravens on Egyptian tortoises (Mendelssohn 1990).

The above documentation is sufficient to demonstrate that corvids in general are extremely efficient and demanding predators on young or small tortoises throughout the world. Their impact, relative to other predators and to tortoise population growth and general survivorship, is likely to vary from site to site.

Coyotes have been implicated in heavy levels of predation on desert tortoises at the Desert Tortoise Natural Area, Rand Mountains, and

Fremont Valley since 1988. Coyotes dug up and ate several adult desert tortoises which were fitted with radio transmitters (Charles Peterson, UCLA, pers. comm.). However, desert tortoises may have been ill (with URTD) or dead and then scavenged by coyotes, or coyotes may have been attracted to the area by large numbers of dying and dead desert tortoises. Feral dogs may have also been responsible for some of the predation.

2. **Domestic and feral predators.** Domestic and feral dogs are documented threats to captive and wild tortoises alike, not only for desert tortoises but for other species as well (Swingland and Klemens 1989). With the growing number and sizes of cities, towns, and settlements in the desert, this type of threat is increasing and will be difficult to control. Dogs singly, and in packs, often roam miles from home, dig up desert tortoises and injure them beyond recovery. For example, in 1971 and 1972, many burrows destroyed or damaged by dogs and two severely injured desert tortoises were found near scattered homes along Highway 58 in Kern County, California (K. Berry pers. comm.). Dog tracks and scats were unambiguously identified (size and shape of print; size and composition of scat).

Dogs have also attacked desert tortoises on BLM's permanent study plots in California. Judging from gnawed and chewed scutes and bones, a large proportion of desert tortoises observed at the Lucerne Valley study plot in 1986 and 1990 appeared to have been attacked by dogs. Numerous dog packs were observed at the same time (BLM files, Riverside, California).

At the Desert Tortoise Natural Area in California, two dogs were observed harassing a desert tortoise (Jennings 1991). Also at the Desert Tortoise Natural Area, George Moncsko of the Desert Tortoise Preserve Committee (pers. comm. to Kristin Berry) chased a pack of dogs from a desert tortoise. In the adjacent Fremont Valley permanent study plot, dog packs were observed on three occasions in spring of 1991, and dogs had apparently excavated desert tortoise burrows and probably killed desert tortoises there (Craig Knowles and Paul Frank, pers. comm.). On one occasion, the dogs charged a fieldworker. In each case, the nearest human habitation was 2- to 3-miles away.

N. Diseases and Toxicosis.

In this section, diseases related to toxicosis are discussed. Information on other diseases may be found in Jacobson (1994).

Evidence is mounting that desert tortoises are experiencing toxic effects and higher rates of mortality from one or more elements or compounds, such as selenium, heavy metals, chlorinated hydrocarbons, organophosphates, as well as nitro compounds and alkaloids in plants. In some cases, such chemicals occur naturally

or result from distribution or concentration through human-induced activities. While research on the aforementioned subjects in desert tortoises is in preliminary stages, existing data are sufficient to suggest that these sources of mortality may be important, especially when coupled with drought.

Levels of mercury in the livers of desert tortoises ill with URTD at the Desert Tortoise Natural Area were significantly higher than in desert tortoises from the Ivanpah Valley (eastern Mojave Desert) (Jacobson et al. 1991). The mercury levels in livers of Desert Tortoise Natural Area desert tortoises could be higher for natural reasons, e.g., naturally higher levels in soils and plants, or perhaps higher levels as a result of mining:

Many attribute mercury levels to emissions from industrial activity in the area. However, most of the area is within an epithermal alteration area due to, and within acid volcanic rocks. These rocks, and the saprolites and soils mantling these rocks, contain anomalous levels of mercury. Many of the deposits currently being mined...were defined in part by using mercury geochemical tracing. There may be naturally high levels of mercury in plants, and those animals that graze these plants. In addition, considerable smelting of ores has occurred in the early part of this century that could have resulted in emissions and deposition of elemental mercury in the surrounding soils (e.g., Tropico Mill) (Robert Waiwood, BLM geologist, pers. comm.).

Jacobson et al. (1991), in summarizing the potential effects of mercury on desert tortoises, stated:

> ...several investigators have reported altered host resistance to pathogens...depressed antibody responses to mitogen stimulation..., and thymic cortex and splenic follicular atrophy with concomitant depression of ... antibody response to mitigen stimulation...

Between 1982 and 1988, desert tortoise populations on the Chuckwalla Bench permanent study plot (Riverside County, California) sustained about a 70% decline in numbers (Berry 1990, as amended). Dead desert tortoises and a high proportion of the remaining live animals showed signs of shell disease (Berry 1990 as amended). These animals had experienced dyskeratosis and metabolic disorders typical of toxicosis from such elements or compounds as selenium; mercury, lead, and other heavy metals; chlorinated hydrocarbons; and/or organophosphate (Jacobson et al. 1991). The exact cause(s) of the shell disease has not been determined, but it is widespread in the California deserts, and most common in the eastern Mojave, northern Colorado, and southern Colorado deserts (K. Berry, pers. comm.).

During spring 1991, two partially paralyzed, dying desert tortoises were discovered in the eastern Mojave Desert of California and

southern Nevada. A necropsy of one of these animals showed it had been suffering from lymphangiectasia of the gastrointestinal tract; focal ulceration and heterophilic inflammation of the nasal sinuses; marked denervation atrophy and edema of skeletal muscle; and myelomalacia, liquefaction necrosis, and degeneration of the spinal cord (etiology unknown) (James Klaassen, APL Veterinary Labs, Las Vegas, NV, pers. comm.). The paralysis and some other symptoms were typical of selenium toxicosis in swine (E.R. Jacobson pers. comm., Casteel et al. 1985). Sheep and cattle also experience similar symptoms, not only from selenium, but from poisoning by some species of locoweed (*Astragalus sp.*). Poisoning from locoweed can occur in four ways: as selenium converter plants; through poisoning by aliphatic nitro compounds; by locoine (the toxic principle is not yet known); and with congenital defects and abortion. Some locoweeds may also reduce cell-mediated immune responses. Selenium toxicosis can occur in ranges where the nonselenium accumulating forage is depleted by livestock and selenium-accumulating plants remain (Blood et al. 1989, Fuller and McClintock 1986). Desert tortoises in some parts of the Mojave region consume locoweed, including species known to have properties toxic to livestock (e.g., *A. layneae*; see Fuller and McClintock 1986).

Many other species of desert plants besides locoweed are toxic to livestock (Keeler et al. 1978) and could affect desert tortoises. The levels of lead in plants and soils should also be explored, especially along roadways and adjacent to mines (Robert Waiwood, pers. comm.).

O. Noise and Vibration.

Anthropogenic noise has several potential impacts on desert tortoises, including disruption of communication and damage to the auditory system. Background noise has been shown to mask vocal signals essential for individual survival and reproductive success in other animals (e.g., bushcrickets, Conocephalus brevipennis, Bailey and Morris 1986; green treefrogs, Hyla cinerea, Ehret and Gerhardt 1980). Desert tortoises are known to have hierarchical social interactions (Brattstrom 1974), are capable of hearing (Adrian et al. 1938; Patterson, 1971, 1976), and communicate vocally (Campbell and Evans 1967; Patterson, 1971, 1976). Desert tortoises use eleven different classes of vocalizations in a variety of social encounters (Patterson 1971, 1976). The signals are relatively low in amplitude, have fundamental frequencies as low as 0.2 kHz or lower, and harmonics as high as 4.5 kHz (Patterson 1976).

Many human-induced sources of noises, such as automobiles, jets, and trains, cover a wide frequency bandwidth. When such sounds propagate through the environment, the high frequencies rapidly attenuate, but the low frequencies may travel great distances (Lyon, 1973). The dominant frequencies that remain after propagation

correspond closely to the frequency bandwidth characteristic of desert tortoise vocalizations. The masking effect of these sounds may significantly alter an individual's ability to effectively communicate or respond in appropriate ways. The same holds true for incidental sounds made by approaching predators; masking of these sounds may reduce a desert tortoise's ability to avoid capture by a predator. The degree to which masking affects desert tortoise survival and reproduction probably depends on the physical characteristics (i.e., frequency, amplitude, and short- and long-term timing) of the noise and the animal signal, the propagation characteristics of the sounds in the particular environment, the auditory acuities of desert tortoises, and importance of the signal in mediating social or predator interactions.

Loud noises (and associated vibrations) may damage the hearing apparatus of desert tortoises. Sources of noise and vibration include, but are not limited to: cars, trucks, and other vehicles on paved highways, dirt roads, and test tracks; trains; recreation vehicles traveling on or off road; terrestrial military vehicles; commercial and military aircraft; equipment associated with exploration for and development of hard-rock minerals and saleable and leasable minerals; explosions from military ordnance; air to ground bombing or release of missiles; mining; road construction; and nuclear tests. Little research has been performed on desert tortoise ears, but it is clear that they are able to hear, and the relatively complex vocal repertoires demonstrated by desert tortoises suggests that their hearing acuity is similarly complex. Brattstrom and Bondello (1983) experimentally demonstrated that ORV noise can reduce hearing thresholds of Mojave fringe-toed lizards (Uma scoparia). Relatively short bursts (500 sec) of loud sounds (95 decibels at 5 meters) caused hearing damage to seven test lizards. Comparable results were obtained when desert iguanas (Dipsosaurus dorsalis) were exposed to 1 to 10 hours of motorcycle noise (Brattstrom and Bondello 1983). Repeated or continuous exposure to damaging noises is likely to cause an even greater reduction in auditory response of these lizards. It is not unreasonable to expect loud noises to similarly impact the auditory performance of desert tortoises.

Ground vibrations can cause desert tortoises to emerge from their burrows; slapping the ground several times within a few feet of a desert tortoise burrow entrance will often cause a desert tortoise to emerge (C. Peterson, pers. comm., and others). Research is needed to determine what kinds of vibrations and noise cause a desert tortoise to emerge from its burrow.

P. Other Potential Impacts.

Impacts to desert tortoise populations and their habitats described above are well documented or established. While chelonian experts and conservation biologists may not agree on the importance of each

particular impact or the degree of effect, they generally have concluded that such impacts should be substantially reduced or eliminated.

Another group of impacts which can be categorized as "potential impacts" includes air pollution, acid rain, acid precipitation, electromagnetic fields, electromagnetism, global warming, and greenhouse effects. The role of these factors in the status and recovery of desert tortoise populations should become apparent as more information becomes available.

VI. Cumulative and Synergistic Effects of Human Uses on Desert Tortoise Populations and Habitats

A. Interface between the Desert and Developed Areas.

Overall, desert tortoise habitats most susceptible to negative impacts are those at the interfaces between developed lands and open desert. At this interface, many, if not all, threats described above may be present. For example, deserts adjacent to urban and agricultural areas are exposed to deliberate take or removal of desert tortoises, vandalism, release of captives, translocation of wild desert tortoises, unauthorized or authorized deposition of trash, dumping of toxic or hazardous waste, vehicle kills on and off road, proliferation of trails and roads, clearing of land for utility lines and corridors, casual ORV use and general recreation, invasions of weedy and non-native plants, human-caused fires, harvest and vandalism of vegetation, predation by domestic animals, and noise. Even near small settlements, isolated tracts, and ranches, the same factors are present, and the cumulative impacts can spread in a radius of several miles from such areas. Dog packs, for example, can be found digging up and killing desert tortoises miles from home. Ravens can use resources available at human settlement, such as perches, nest sites, water, and food, as a springboard for preying on wild animals nearby. Examples of existing problem areas include but are not limited to the Antelope, Indian Wells, Fremont, Apple, Victor, Lucerne, Johnson, Chuckwalla, and northern Ivanpah valleys in California; Las Vegas, Laughlin, Piute and Mesquite in Nevada; and the Virgin River Valley and St. George in northern Arizona and Utah.

B. Human Access.

The density of paved and dirt roads, routes, trails, and ways in desert tortoise habitat has a direct effect on mortality rates and losses of desert tortoises. The status of desert tortoise populations is directly linked to access, because access allows people to penetrate

into remote parts of the desert, and people cause or contribute to mortality of desert tortoises and habitat loss (Nicholson 1978, Berry 1986, 1992, see discussion above). As mileage of roads, trails, and tracks increased on BLM study plots in California, desert tortoise population declines occurred at greater rates (Berry 1990, as amended, 1992).

The types of human activities recorded on or near access routes in remote parts of the desert include, but are not limited to: take or removal of desert tortoises (predation for food, collections for pets, and commercial trade), vandalism, translocation and release of captive desert tortoises, dumping of trash and other wastes, vehicle kills on and off roads, proliferation of roads and trails, invasion of weedy, non-native plants, fire, harvest of and vandalism to vegetation, and predation by dogs and ravens. Remote areas of the desert are also disturbed by mining, grazing, military use (past and current), and the access routes that permit such activities. The long list of threats to desert tortoises becomes a greater burden when each individual, vehicle, family, or event (e.g., vehicle race or tour) enters desert tortoise habitat. As numbers of visitor days increase, the potential for losses of desert tortoises and their habitats increases (e.g., Berry 1986a).

To ensure recovery of desert tortoises, mortality from human-related sources must be eliminated or reduced to very low levels. Because of the natural history characteristics of the species, losses of even a few adults can delay or prevent recovery (see Appendix C). Currently, acts of vandalism, collecting, release of captives, vehicle kills, etc. occur on all or nearly all desert tortoise study sites. Low rates of desert tortoise mortality from human causes have been documented for only a few relatively remote areas with low levels of human access, such as parts of Ivanpah, Ward, Fenner, Chemehuevi, and Piute valleys. Vandalism and vehicle kills occur at these sites but at relatively low rates. The level of human access in DWMAs, as measured in linear miles of access routes per square mile or township, should mirror road/route densities in areas where: (1) human-caused death rates are very low, and (2) stable or increasing desert tortoise populations exist. Route densities in DWMAs should be reduced where human-caused mortality of desert tortoises is a problem.

C. *Recovery Rates of Habitat.*

Natural recovery rates of soils and perennial vegetation in desert habitats from development of utility-line corridors, military activities, and human settlements may require decades, centuries, or even millennia (Lathrop 1983b, Lathrop and Archbold 1980, Vasek 1989, Vasek et al. 1975a, 1975b, Webb and Newman 1982, Webb et al. 1983). Recovery rates of native annual plants, a critical source of food for desert tortoises, has not been examined in depth and cannot be estimated. Potentially, recovery of native plant

communities could be hastened by revegetation. However, the science of restoration and revegetation of native ecosystems is in its infancy. In general, because of the uncertainties and costs associated with revegetation and the long periods required for natural recovery, the first priority in mitigation should be to minimize land disturbance (Kay et al. 1988).

VII. A Case Study in Extirpation of Desert Tortoise Populations: Antelope Valley in Los Angeles and Kern Counties, California

The Antelope Valley is currently the most broadly urbanized landscape within the Mojave region. Portions of this valley supported high densities of desert tortoises from 1920's to the 1950's (Berry 1984b), but a series of human activities gradually reduced desert tortoise populations and destroyed or damaged the habitat. Examples of causative factors include, but are not limited to: collection of desert tortoises for food, pets, and commercial purposes; agricultural and urban development; construction of roads, railroads, and utility corridors; mining and energy development; high native predator densities (ravens); and uncontrolled predation by domestic and feral pets (Berry 1984b, Luckenbach 1982). The Antelope Valley is now characterized by numerous cities and small towns, several major State highways, Edwards Air Force Base, several airports and airfields, light and heavy industry, and a burgeoning human population. Parts of the Valley have become suburbs of the greater Los Angeles area. The town of Rosamond was recently a toxic-waste disposal site and is now identified has having high rates of cancer in the human population. Alfalfa and other crops are supported with crop dusting, fertilizers, plowing, and irrigation. Skip development has left hundreds of acres of scattered lots covered by Asian and Mediterranean weeds (Tierra Madre Consultants, Inc. 1991), which fuel increasing numbers of wildfires.

The vast network of paved and dirt roads render most areas accessible to ORV-oriented recreationists and general recreationists. Power, communication, water, gas lines, and fiber-optic cables border many of these roads, creating broad corridors of disturbed and destroyed habitat. Telephone and power poles further contribute to pressures on desert tortoises because they have become perch sites for increasingly abundant raven populations.

As of 1991, extirpation of desert tortoises from the Antelope Valley was nearly complete. Desert tortoise sign is occasionally observed east of Palmdale but not in Palmdale west of Highway 14 (Palmdale Freeway) or south of Highway 138 (Pearblossom Highway) (J. Hohman, pers. comm.). For instance, desert tortoise sign was observed recently in the vicinity of Lake Los Angeles (G.M. Groenendaal, Tehachapi, California, pers. comm. 1991). Desert

tortoise sign has also been reported in northeastern Palmdale (Feldmuth and Clements 1990), and desert tortoises have been observed recently at Saddleback Butte State Park by park naturalists.

Surveys for tortoises and habitat condition were conducted in a 225 square mile area, including the City of Lancaster and surrounding lands (Tierra Madre). Only 90 square miles of land were undeveloped, nonagricultural lands. The only remaining records of the presence of the once common desert tortoise were three desert tortoise carcasses and a single live desert tortoise (observed in 1983). An analysis of disturbance, which included types of impacts observed on each desert tortoise transect and from aerial photographs, was conducted in the same area (Tierra Madre 1991). Very high levels of disturbance were recorded in the city and surrounding lands, and lack of desert tortoise sign was attributed in part to this disturbance. Roughly a third of the area had been rendered unsuitable for desert tortoises.

Although we lack the data base and chronological history to resolve specific contributions to extirpation of desert tortoises, the Antelope Valley provides unambiguous evidence of the cumulative and synergistic effects of human activities on desert tortoises and how such trends have led to the demise of desert tortoise populations from a substantial portion of the historical range in the western Mojave Desert. Furthermore, these same patterns are operative nearby in the Indian Wells, Fremont, Victor, Mojave River, Apple, Lucerne, and Johnson valleys. Human activities are likely having the same impact in the Las Vegas, Colorado River, and Virgin River valleys.

Appendix E

Desert Tortoise
(Mojave Population)

Recovery Plan

Appendix E: Vegetation and Climate of the Mojave Region

I. Regional Setting

North America includes five desert regions (Jaeger, 1957): The Chihuahuan Desert of North Central Mexico and adjacent parts of Texas and New Mexico; the Sonoran Desert of northwest Mexico and parts of southern California and Arizona; the Mojave Desert in part of southeastern California, southern Nevada and adjacent parts of Utah and Arizona; the Great Basin Desert in the Great Basin region of Nevada, Utah, Oregon, Idaho, Wyoming and Colorado; and the Navahoan Desert of the four corners region of Utah, Colorado, Arizona and New Mexico.

The Desert Tortoise does not occur in the Great Basin or the Navahoan Deserts. It does occur in the other three deserts but our present interest is concerned with its range in the Mojave Desert and in that portion of the Sonoran Desert located west of the Colorado River, namely the Colorado Desert of California.

Mojave Desert

The Mojave Desert is located in southern California, southern Nevada, the northwest corner of Arizona, and the southwest corner of Utah. The Mojave Desert is bordered on the north by the Great Basin Desert, on the west by the Sierra Nevada, on the south by the San Gabriel and San Bernardino Mountains and by the Sonoran Desert, and on the east by the Hurricane Cliffs in Utah, and by Grand Wash Cliffs and the Peacock and Hualapai Mountains in Arizona.

The boundary between the Mojave Desert and the Great Basin Desert is basically defined, at low elevations, by a vegetational component, namely the creosote bush (*Larrea tridentata*) which occurs in the Mojave, but not in the Great Basin (Cronquist, et al., 1972). The boundary is thus an irregular line across southern Nevada extending roughly from Olancha (south of Bishop), in Inyo County, California to St. George, in the southwest corner of Washington County, Utah. The Mojave Desert includes all of Clark County as well as the southern parts of Esmeralda, Nye, and Lincoln Counties, Nevada.

Sonoran Desert

The greater Sonoran Desert includes seven geographical divisions (Shreve and Wiggins 1951). The lower Colorado Valley division of the Sonoran Desert occurs in western Arizona, in southeastern California, in northwestern Sonora, and in Baja California east of the Peninsular Ranges as far south as Bahia de Los Angeles. The other six divisions of the Sonoran Desert occur elsewhere in Arizona and in Mexico and do not concern us at present.

The Lower Colorado Valley Division was considered by Jaeger (1957) to consist of two parts: the Yuman desert in Arizona and Sonora; and the Colorado Desert in California, Baja California and a small part of Arizona near Needles, California. The Lower Colorado Valley Division in retained as a unit by Crosswhite and Crosswhite (1982) as the Lower Colorado-Gila Division, since it includes much of Arizona's Gila River drainage. Nevertheless, use of Colorado Desert for the California portion has gained widespread and consistent currency. We follow that custom and consider the Colorado Desert to be that part of the Colorado-Gila Division of the Sonoran Desert located west of the Colorado River.

The boundary between the Mojave Desert and the Colorado Desert has been subject to controversy. Toward the west, the Little San Bernardino and Cottonwood Mountains provide excellent boundary definition. Farther east, mountains seem less prominent and more widely spaced, and provide little definition. To the contrary, broad lowland areas provide north to south continuity, with Sonoran elements extending far to the north, and Mojavean elements extending far to the south. As a result, the boundary between the two deserts has variously been interpreted to be farther north or farther south (References in Vasek and Barbour, 1977) than the arbitrary line running from Indio to Needles as indicated by Crosswhite and Crosswhite (1982). Most interpretations extend the Colorado Desert northward along the Colorado River Valley to the vicinity of Needles, California.

A more northerly distribution of the Colorado Desert along the Colorado River Valley and also as far west as the Bristol Mountains, was proposed by Rowlands et al. (1982) after analysis of vegetation and climate. We basically adopt the definition of the Colorado Desert proposed by Rowlands with only minor modification. According, the boundary between the Mojave and Sonoran (Colorado) Deserts extends eastward along the Little San Bernardino and Cottonwood Mountains, then goes north from Cottonwood Pass along the eastern edge of the Hexie, Pinto, Sheephole and Bullion Mountains to Ludlow. It continues northward through Broadwell Lake and then loops around the northern end of the Bristol Mountains. The boundary returns southeast between the Granite and Old Dad Mountains, and then heads eastward along the northern edge of the Marble, Clipper, Piute and Dead Mountains before crossing the Colorado River about 20 miles north of Needles.

The boundary between the Mojave Desert and the Sonoran (Yuman) Desert extends eastward into Arizona, skirts around the southern end of the Black Mountains and proceeds eastward to the base of the Hualapai Mountains, approximately at the latitude of Yucca, Arizona.

The triangular portion of Mohave County, Arizona between Needles, Yucca and Parker Dam is included in the Colorado Desert on two maps by Jaeger (1957), but his discussion of the Yuman Desert clearly indicates its extension along the Colorado River to the north of Needles. We adopt the strict interpretation that the Colorado Desert occurs west of the Colorado River (and Gulf of California) in California and Baja California, and the Yuman Desert occurs east of the Colorado River and Gulf of California) in Arizona and Sonora.

The Mojave Desert includes most of San Bernardino County and parts of Inyo, Kern, Los Angeles and Riverside Counties, California, and the western part of Mohave County, Arizona. The Colorado Desert occurs west of the Colorado River in Imperial and parts of San Bernardino, Riverside, and San Diego Counties, California.

Subdivisions of the Mojave Desert

The Mojave Desert has been divided into five regions for the convenience of description (Rowland et al., 1982); namely the Northern, Eastern, Central, Southwestern and South Central regions. We agree that the five regions are defined on the basis of significant, large scale differences in soils and land forms, in climate, in plant ecology and vegetation, and in animal ecology. Accordingly, we accept the five Mojavean regions, but propose a slightly simpler nomenclature by shortening the last two regional names to the Western region and the Southern region respectively. We also propose some rather mind changes in the boundaries. Those boundaries are somewhat arbitrary and do not follow straight lines. Hence, the following descriptions of the five Mojavean regions must be considered approximate:

I - A Northern Mojave region has two sections: a California section roughly corresponding to the desert areas of Inyo County; and a Nevada section roughly corresponding to the desert portions of Esmeralda and Nye Counties.

II - An Eastern Mojave region has three sections: a Southern Nevada section in Clark County and the desert portion of Lincoln County; an Arizona section in western Mohave County, Arizona, and extending to St. George, Utah; and a California section from the Soda Lake Basin to the Nevada State Line.

III - A Southern Mojave region (the Southcentral region of the Rowlands, et al., 1982) occurs roughly from Victorville to Ludlow in San Bernardino County, California, and then southward to the Little San Bernardino and Cottonwood Mountains in Riverside County, California.

IV - A Central Mojave region includes the area around Barstow, and extends northward nearly to the Panamint Range, and eastward toward Baker and Ludlow, all in San Bernardino County, California.

V - A Western Mojave region (the Southwestern region of the Rowlands, et al., 1982) occurs in San Bernardino, Kern and Los Angeles Counties, California, roughly in the area from Trona to Victorville and west to the bordering mountains.

Subdivisions of the Colorado Desert

Subdivisions of the Colorado Desert. The Colorado Desert has informally been subdivided into eastern and western regions by Rowlands (unpubl.). Such subdivision is useful. However, we suggest three subdivisions of the Colorado Desert, based largely on general considerations of topography and vegetation.

I - The Northern Colorado Desert region includes the area from the Bristol Mountains to the Colorado River north of Needles, and southward to the Coxcomb Mountains and Vidal Wash.

II - An Eastern Colorado Desert region includes the area south from Pinto Basin and Vidal Wash between the Salton Trough and the Colorado River.

III - The Southwestern Colorado Desert region includes the Salton Trough and the desert to the south and west from the Little San Bernardino Mountains south into Baja California, Mexico (The peninsular strip of Colorado Desert along the Gulf of California coast may comprise a fourth subdivision.)

Boundaries between desert subdivisions

The boundary between Northern and Eastern Mojave regions comes southward from Emigrant Valley in Nye and Lincoln Counties, Nevada, to Indian Springs Valley and then around the western edge of the Spring Mountains where it crosses into California just east of the Resting Spring and Nopah Ranges. It skirts the west edge of Pahrump Valley and turns westward around the south edge of the Kingston Range. It then follows the north edge of Kingston wash to the north end of Silurian Valley, at the junction of Salt Creek with the Amargos River.

The boundary between the Northern and Central Mojave regions proceeds westward from Salt Creek through a low channel to Leach Lake and Pilot Knob Valley to the south end of the Slate Range. This boundary is south of the Owlshead and Quail Mountains, and north of the Avawatz and Granite Mountains.

The boundary between the Northern and Western Mojave regions goes north along the west edge of the Slate Range and turns westward at the north end of Searles Valley, passing just north of the Southern Argus Mountains and the Coso Basin, joining the Sierra Nevada just south of Little Lake.

The boundary between the Western and Central Mojave regions goes south from the south end of the Slate Range, skirting the west edge of Black Hills, to Fremont Peak, loops around Fremont Peak and cuts back to the south east, passing along the north edge of Harper Lake and then goes due south to Hinkley, joining the Mojave River near Hodge.

The boundary between the Western and Southern Mojave regions is the Mojave River, from Hodge southward through Victorville to the San Bernardino Mountains.

The boundary between the Central and Southern Mojave regions goes easterly from Hodge, passing south of Lenwood, to Daggett. It then follows Interstate Highway 40 to Ludlow.

The boundary between the Central Mojave and the Northern Colorado regions proceeds north from Ludlow through Broadwell Lake, and passes along the northwest edge of the Bristol Mountains to the northern tip of the Bristol Mountains.

The boundary between the Central and Eastern Mojave regions proceeds from the northern tip of the Bristol Mountains northward through Soda, Silver and Silurian Lakes to the junction of Salt Creek and the Amargosa River.

The boundary between the Eastern Mojave and the Northern Colorado regions proceeds southeast from the northern tip of the Bristol Mountains between the Old Dad Mountains and the Granite Mountains to the northern tip of the Marble Mountains. It proceeds eastward along the northern edge of the Clipper Mountains toward Goff and the northern end of the Dead Mountains. It crosses the southernmost couple of miles of Nevada before ending at the Colorado River.

The boundary between the Eastern Mojave region and the Yuman Desert of the Colorado-Gila Division of the Sonoran Desert goes from the Colorado River to the Black Mountains in Arizona and then around the southern end of the Black Mountains and proceeds eastward to the base of the Hualapai Mountains, approximately at the latitude of Yucca, Arizona.

The boundary between the Southern Mojave and the Northern Colorado regions goes south from Ludlow along the eastern edge of the Bullion Mountains and the eastern edge of the Sheephole Mountains to Clark's Pass.

The boundary between the Southern Mojave and the Eastern Colorado regions goes south from Clark's Pass in a sinuous path at the base of the Pinto and Hexie Mountains around Pinto Basin and Smoketree Wash to Cottonwood Pass at the eastern end of the Cottonwood Mountains. It continues westward to the southeast end of the Little San Bernardino Mountains near Cactus City.

The boundary between the Southern Mojave and the Southwest Colorado regions follows the scarp of the Little San Bernadino Mountains westward to Morongo Valley.

The boundary between the Eastern Colorado and the Southwest Colorado regions goes southwest from Cactus City around the Mecca Hills and then southeast along the edge of the Salton Trough to the Colorado River.

II. Major Topographic Features

The desert region under consideration varies extensively with regard to number, size and stature of mountains. Topographic diversity is greatest in the Northern Mojave Desert region with numerous high mountain ranges and large basins at low elevations. For example, the sink of the Amargosa River in Death Valley reaches 280 feet below sea level whereas Telescope Peak in the Panamint Range a few miles to the west reaches an altitude of 11,049 feet above sea level. Topographic diversity and the stature of mountains generally decreases southward. Concomitantly, the proportion of open desert consisting of broad plains and gentle alluvial fans also increases southward. Hence, each subdivision of the desert has its own characteristic array of landforms.

The Northern Mojave Desert region includes the Amargosa (8,738), Coso (8,160), Kingston (7,323), Last Chance (674), Nelson (7,701), Nopah (6,394), Panamint (11,049), Resting Springs (5,264), Saline (6,548), and northern Argus Ranges (8,839) as well as California, Chicago, Death, Eureka, Greenwater, Long, Panamint, and Saline Valleys in the California section. Features of the Nevada section include the Bare Mountains (6,316), Gold Mountain (7,565), the Sportted Range (6,254), and part of the Amargoas Range (8,738) as well as Sarcobatus Flat, the Amargosa Desert (Valley) and Ash Meadows.

The Eastern Mojave Desert region also has impressive mountains and Valleys. The Nevada section, including Arizona, includes the Black (5,456), Cerbat (6,900), Eldorado (5,060), Newberry

(5,639), Spring (11,919), and Virgin (8,056) Mountains and the Desert (6,540), Las Vegas (6,943), McCullough (7,026) and Pintwater (7,040) and Sheep (9,120) Ranges. It also includes Desert, Dry Lake, Eldorado, Hidden, Hualapai, Indian Spring, Las Vegas and parts of Ivanpah, Pahrump and Piute Valleys. The California section includes Table Mountain (6,176), and the Castle (5,120), Clark (7,929), Granite (6,786), Ivanpah (6,163), Mescal (6,493), Mesquite (5,160), New York (7,530, Old Dad (4,250), Pinto (6,144), Providence (7,040) Mountains or Ranges, as well as Clipper, Ivanpah, Lanfair, Mesquite, Pahrump, Piute, Silurian, and Valjean Valleys and the Soda Lake Basin and the Devil's Playground.

The Southern Mojave Desert region includes the Bullion (4,187), Cottonwood (4,375), Hexie (3,820), Little San Bernardino (5,814), Newberry (4,882), Ord (6,270), Pinto (3,963), Rodman (6,010), Sheephold (4,685), and Sidewinder (5,168) Mountains. It also includes Antelope, Apple, Johnson, Lucerne, Sidewinder, Stoddard, and Yucca Valleys as well as Dale, Emerson, Melville, Soggy, Rabbit and Lucerne Dry Lakes.

The Central Mojave Desert region includes the Avawatz Mountains (6,154), Calico Mountains (4,542), Eagle Crags (5,512), Granite Mountains (4,862), Pilot Knob (5,428), Slocum Mountains (5,124), Soda Mountains (3,617) and Tiefort Mountains (5,090). Important Basins are Goldstone, Harper, Coyote, Troy, Cronese, Soda and Superior Dry Lakes and the lower half of the Mojave River.

The Western Mojave Desert region includes the southern Argus Mountains (6,562), El Paso Mountains (5,244), Fremont Peak (4,584), Rand Mountains (4,755), Red Mountain (5,270), and numerous smaller mountains. Important Basins include Antelope, Fremont, Indian Wells, Searles and Victor (part) Valleys, as well as China, Cuddeback, Koehn, El Mirage, Rogers and Rosamond Dry Lakes.

The Northern Colorado Desert region includes the Bristol (3,422), Calumet (3,723), Chemehuevi (3,697), Clipper (4,604), Iron (3,296), Marble (3,842), Old Woman (6,326), Piute (4,165), Sacramento (3,308), Turtle (4,231), and Whipple Mountains (4,131). Important valleys are Cadiz, Chemuevi, Fenner, Vidal and Ward, together with Bristol and Cadiz Dry Lakes.

The Eastern Colorado Desert region includes the Arica (2,163), Big Maria (3,100), Cargo Muchacho (2,130), Chuckawalla (4,504), Chocolate (2,967), Coxcomb (4,416), Eagle (5,350), Granite (4,353), Little Chuckawalla (1,261), Little Maria (3,043), Little Mule (1,465), McCoy (2,835), Mule (1,801, Orocopia (3,815), Palen (2,443), Palo Verde (1,795), Riverside (2,252), and West Riverside (2,667) Mountains, and the Mecca Hills (1,642). It also includes Chuckawalla Valley, Ford Dry Lake, Hayfield Lake,

McCoy Wash, Milpitas Wash, Palen alley, Palo Verde Mesa, Palo Verde Valley, Pinto Basin and Rice Valley.

The Southwestern Colorado Desert includes the Algodones Dunes, Fish Creek Mountains (2,334), Indio Hills (1,739), and Superstition Mountains (759). Its main features are the Borrego, Coachella and Imperial Valleys and the Salton Sea.

Climate of the Mojave and Colorado Deserts

Weather recording stations are relatively few, especially in the mountainous Northern and Central Mojave regions and the remote lowland areas that experienced early agricultural development. The climatic data (Table E1) and the accompanying description are drawn largely from Rowlands (unpubl.), Hunting (1978), and Rowlands et al. (1982). Temperatures are given in degrees Celsius; precipitation is given in mm rainfall.

The two major climatic factors, temperature and precipitation, are both extremely variable in both space and time. Temperature decreases with latitude and elevation, thus permitting a calculation of lapse rate. Temperature also shows extensive, but predictable seasonal variation and extreme, unpredictable yearly variation. Precipitation increases with elevation and also has marked seasonal variation and even more extreme yearly variation.

Temperature

The hottest places are in low elevation basins. Mean July maxima are nearly 47°C in Death Valley, 43 at Baker, 41 at Trona, 32 to 40 at other Mojave Desert stations and from 32 to 36 at neighboring Great Basin stations. Mean July maxima range from 41 to 43 over much of the Colorado Desert and from 39 to 43 in the Yuman Desert of Arizona, reflecting the slightly higher elevations of the latter.

The coldest places are at the higher elevations of the Northern and Eastern Mojave Desert. Mean January minima range from -6 to -10 C at Great Basin Stations, but -1 to +5 in the Northern Mojave, -6 to +3 in the Eastern Mojave, and -3 to +2 in the Western, Central and Southern Mojave. Mean January minima range from +2 to +5 in the Colorado Desert and from -1 to +5 in the Yuman Desert of Arizona, again reflecting slightly higher elevations of the latter.

The number of freezing days ranges above 144 at Great Basin stations, 3 to 127 in the Mojave Desert (plus 157 at Alamo on the Great Basin margin), 1 to 19 in the Colorado Desert, and 0 to 65 in the Yuman Desert.

Mean annual temperatures range roughly from 11 to 14 at neighboring Great Basin stations and 14 to 19 at Mojave Desert stations, except for two hotter stations in Death Valley at 22 and 25. Mean annual temperatures range from 21 to 23 in the Colorado Desert and 18 to 23 in the Yuman Desert.

Precipitation

Precipitation is delivered by storms which follow one of the three principal patterns: winter cyclonic storms; summer thunder storms; and erratic hurricanes (locally called "chubascos"). Winter storms bring moisture from the north Pacific. They are usually widespread, mostly of low intensity, and frequently deliver snow at the higher elevations. Their effects diminish toward the south and toward low elevations.

Summer thunder storms are usually intense, of fairly short duration and somewhat local. Chubascos are very large, violent, and may deliver very large amounts of rain, but they are quite sporadic. Both summer thunder storms and chubascos bring moist tropical air northward from the Gulf of California and up the Cotorado River Valley into the Eastern Mojave Desert. These storms may diverge northwestward through the Salton Trough, or westward through Rice Valley, but their effects usually diminish award from the Colorado River Valley.

Total precipitation ranges from 90 to 203 mm at nearby Great Basin stations, 50 to 260 at stations in the Northern and Eastern Mojave Desert regions, and 80 to 170 mm in the Western, Central and Southern Mojave regions (plus recordings of 263 and 377 near mountains at the southern margin of the Western Mojave Desert). Total precipitation ranges from 49 to 139 mm in the Colorado Desert and from 77 to 281 in the Yuman Desert.

The percentage of summer precipitation ranges from 5 to 40 at Great Basin stations, 15 to 20 in the Northern Mojave, 20 to 40 in the Eastern Mojave, only 3 to 10 in the Western Majoave, but 6 to 36 in the Central and Southern Mojave. The percentage of summer precipitation ranges from 11 to 36 in the Colorado Desert and 35 to 59 in the Yuman Desert.

Precipitation during the spring is usually recorded on more than three days a year at stations in the Great Basin, the Eastern Mojave Desert, and Southern Mojave Desert, the Northern Colorado Desert, and the Yuman Desert, but on fewer than three days at Eastern Colorado and Southwest Colorado Deserts.

Vegetation of the Mojave and Colorado Deserts

Vegetation in the desert areas strongly reflects availability of water and evaporative demand for water. Consequently, vegetational biomass is very low at low elevations with their characteristic low precipitation and high temperatures. Vegetational biomass generally increases with elevation as precipitation increases and temperatures decrease. Vegetation structure follows a similar pattern with the predominant growth form being low shrubs at low elevations and in valley bottoms, larger shrubs at intermediate elevations, small trees at higher elevations and larger trees at high mountain elevations.

Vegetational species composition follows a similar elevational pattern and is further modified by regional climatic and other environmental factors.

Classification

The California desert vegetation has been described in detail and classified by Rowlands (unpubl.). We basically follow his classification with slight augmentation from included references (e.g. Thorne, 1982,1986, Vasek and Thorne, 1988). The entire desert area supports seven major vegetational complexes (Table E2). Each complex includes one to several subcomplexes, and each subcomplex includes one to several vegetation types. A vegetation type typically includes all the numerous, similar communities dominated by a given group of perennial plants.

Vegetation across the Mojave Desert is quite complicated,with much variation in species composition and much interdigitation between vegetation units. A range of variation in space and in time exists for each environmental parameter, and a range of variation in tolerance to each parameter exists in each species. Although exact correspondence between variation in species composition and variation in physical environmental factors does not exist, vegetational units must reflect good generalizations on species composition, biomass productivity, soils, climatic conditions and the water table.

Many of the common species may live in more than one vegetation type. Hence, Complex is an appropriate term for major vegetational units (Rowlands unpubl.). Furthermore, the occurrence of common species outside their primary vegetation unit leads to difficulty in delimitation and classification, and hence to differences of opinion regarding the correct classification of vegetation. In all probability, there is no such thing as a "correct classification" (Rowlands unpubl.). Any system of classification is only as good as its utilitarian value. We follow the system out lined by Rowlands based on the judgement that the vegetational units described are reasonable in terms of repetitive observation and useful in terms of management units.

Vegetation Types

I. Desert Scrub Complex

The Desert Scrub Complex includes three subcomplexes. This vegetation occurs on slopes, plains, and alluvial fans and in basins and valleys at low elevations over most of the desert area.

1. The Mojave-Colorado Desert Subcomplex is most common and widespread, occurring over more than 70% of the area of the Mojave and Colorado Deserts. Its three component vegetation types experience similar climatic conditions. This vegetation is limited by cold temperatures at

northern or upper elevational margins, and by high salt or extreme aridity at low elevations.

Creosote Bush Scrub is by far the most important and widespread desert vegetation type. It occurs on most terrain below about 1,500 meters, being common on alluvial fans and gentle slopes, becoming less common on steep, rocky slopes. It is dominated in various proportions by *Larrea tridentata* and *Ambrosia dumosa*, but a great many other species (see Table E3) also occur in various proportions at various places, and may even assume co-dominance.

The ratio of Potential Evaporation to Precipitation varies from 4 at upper elevations to 32 in Death Valley. Precipitation ranges from 40 to about 270 mm. Mean January minimum temperatures range from -6 to 6 degrees C, and mean July maxima range from 34 to 47 (Table E4).

Cheesebush Scrub occurs within the Creosote Bush Scrub zone on sandy, mobile substrate, usually in washes and drainage channels of the Mojave Desert which do not have an overstory microphyll woodland. Some components evidently play a role in secondary succession (Vasek 1975a, b). Plants in this vegetation seem to tolerate slightly lower winter temperatures than those in the Creosote Bush Scrub (Table E4).

Succulent Scrub occurs on upper slopes and bajadas within the Creosote Bush Scrub zone, thus experiencing the most favorableclimatic conditions of that zone. It is dominated by stem succulent species: mostly *Cactaceae*, but also *Yucca*, in the Mojave Desert; and mostly Agavaceae, but also Cactaceae and *Fouquieria*, in the Colorado Desert. Other species of the Creosote Bush Scrub also occur here, but the strong dominance of stem succulent plants, which undergo CAM metabolism, warrants recognition as a functional vegetation type.

2. The Saline-Alkali Scrub Subcomplex occupies mostly sinks and valley bottoms, and also some upland slopes with or without pronounced saline or alkaline conditions. The five vegetation types are dominated by chenopodiaceous shrubs and constitute what others have called `salt bush scrub'. The first three vegetation types are primarily xerophytic in nature and the last two types are halophytic.

Shadscale Scrub occurs on alkaline soils at low elevations in the Great Basin and the northern and eastern Mojave Desert. It also occurs on heavy soils on steep slopes in mountains of the Death Valley region. It tolerates both high salt levels and very arid conditions. Shadscale Scrub often occupies a position between Creosote bush Scrub and Sagebrush Scrub, similar to the position of Blackbush Scrub, and the climate is similar to that for Black bush Scrub (Table E4). Shadscale Scrub is dominated by *Atriplex confertifolia*, although several other species usually are also present (Table E3).

Desert Holly Scrub occupies extremely arid sites mostly in the northern and eastern Mojave Desert. In Death Valley, stands of Desert Holly occur at the foot of alluvial fans which contain a high percentage of carbonate rocks and a very salty substrate. Precipitation is very low but summer temperatures and the potential evaporation are very high (Table E4). *Atriplex hymenelytra* often occurs in pure, albeit sparse, stands, but sometimes *Atriplex polycarpa* or *Tidestromia oblongifolia* are also present.

Mojave Saltbush - Allscale Scrub occurs only in the southwest Mojave Desert near Kramer Junction and Fremont Peak. It occupies some upland areas and is rather similar to Shadscale Scrub. The dominant species are *Atriplex spinifera* and *A. polycarpa* but other components may also occur (Table E3).

Allscale - Alkali Scrub occurs in and around sinks and dry lakes where available ground water may contain up to 2.5% salts. This vegetation includes succulent or semi-succulent halophytes such as *Atriplex polycarpa* and several other species of *Atriplex*, *Kochia* spp., *Suaeda torreyana* and *Haplopappus acradenius*. The climate is hot and dry (Table E4), but the vegetation is mediated primarily by the salty water table.

Iodinebush - Alkali Scrub is similar to the preceding in habitat, climate and physiognomy, but occurs in sinks where available ground water may contain up to 6% salts. This vegetation is dominated by succulent halophytes, primarily *Allenrolfea occidentalis*. It may also include *Sarcobatus vermiculatus*, *Nitrophila occidentalis* and several others (Table E3).

3. The Great Basin Scrub Subcomplex occurs primarily in the Great Basin but is represented by significant occurrences of three vegetation types at upper elevations of the Desert Scrub Zone, in the eastern and northern Mojave Desert and to a lesser extent southward. It generally occurs at elevations below the Xeric Conifer Woodland (see below) and above the Creosote Bush Scrub and Succulent Scrub.

Sagebrush Scrub is the dominant scrub vegetation of the Great Basin region, but may be found at upland Mojave Desert sites, such as Round Valley north of the Providence Mountains. The climate is generally colder in winter and cooler in summer than for the two preceding subcomplexes, and the precipitation is a little higher (Table E4). Usually *Artemisia tridentata* dominates over extensive areas, but sometimes is replaced by *Artemisia nova*, especially on heavy, rocky soils. Many other species (Table E3) also occur in various combinations at different places. Sagebrush Scrub often forms an under story to Pinyon and Juniper Woodland types.

Blackbush Scrub occurs widely in the Mojave Desert on rocky, heavy soils at elevations of 1,000 to 2,000 meters. It occurs sparingly in the Colorado Desert. This vegetation is dominated by *Coleogyne ramosissima*. In addition, *Grayia spinosa*, *Ceratoides lanata*, *Thamnosma montana*, and species of *Ephedra*, *Yucca*, *Lycium*, *Haplopappus*, etc. (Table E3), may also occur but species diversity is usually low at any one locality. The climate is similar to that of Succulent Scrub, but a little cooler in summer (Table E4).

Hopsage Scrub is common in the eastern Mojave Desert, usually on sandy-loamy soils with only moderate rock content. Otherwise the habitat and climatic conditions are very similar to those of Blackbush scrub. *Grayia spinosa* is the usual dominant, often with any of several species of *Lycium* as a co-dominant. *Haplopappus cooperi* and several components of Creosote Bush Scrub may also be present.

Sometimes Joshua Trees (*Yucca brevifolia*) may occur in Hopsage Scrub, Blackbush Scrub, Shadscale Scrub, Creosote Bush Scrub, Succulent Scrub, and the Juniper - One-leaf Pinyon Woodlands. In these cases, Joshua Trees may appear as visual dominants, but they provide very minor fractions of ground cover or biomass. Hence, Joshua Trees are not dominant anywhere, despite

their conspicuity around the Mojave Desert, and do not provide consistent basis for recognizing a separate vegetation type (Rowlands 1978).

II. Desert Woodland Forest-Conifer Complex

A Conifer Woodland-Forest Complex, with two subcomplex components, occurs in mountains and high elevation desert areas.

1. The Xeric Conifer Woodland Subcomplex covers large areas between about 1,200 to 2,800 meters in elevation. It includes three vegetation types dominated by shrubs and small trees. This subcomplex is a highly productive and floristically diverse desert vegetation.

Utah Juniper - One-Leaf Pinyon Woodland is common in the Great Basin region and in the Northern and Eastern Mojave Desert. It occurs in the Providence Mountains and then has a major disjunction in the San Bernardino Mountains. The overstory trees are *Juniperus osteosperma* and *Pinus monophylla*, and sometimes a few Joshua Trees. Some arborescent shrubs are *Quercus turbinella* and *Cercocarpus ledifolius*. A rich assortment of other associated shrubs is partly listed in Table 3. The climate is similar to that of Sagebrush Scrub but is a little wetter and colder (Table E4).

California Juniper - One-Leaf Pinyon Woodland occurs on mountains bordering the Mojave Desert from just north of Walker Pass in Kern County, California southward to the mountains bordering the Colorado Desert in San Diego County, California. It also occurs on mountains of sufficient stature within the desert area such as the Granite Mountains and Granite Pass*, the Old Woman, Coxcomb, Eagle, Cottonwood and Little San Bernardino Mountains. This vegetation type is dominated by small trees (*Pinus monophylla*) and arborescent shrubs (*Juniperus californica*). Some of the other associated species are listed in Table E3. The more southern distribution makes for a warmer climate than for the preceding type (Table E4).

California Juniper - Four-Leaf Pinyon Woodland occurs in the peninsular ranges of California and Baja California at the western margin of the Colorado Desert. The dominant species are *Juniperus*

* The sudden change from a Utah Juniper Woodland in the Providence Mountains to a California Juniper Woodland in the Granite Mountains and Granite Pass may be strong biogeographical evidence in favor of including the Granite Mountains in the Colorado Desert rather than the Mojave Desert.

californica, *Pinus quadrifolia*, and *P. monophylla*. Some of the associated understory species (Table E3) include several found in Desert Chaparral and Redshanks Chaparral (Hanes, 1977). The climate is similar to that of the preceding (Table E4).

2. A Desert Mountain Forest Subcomplex occurs in the limited area at higher mountain elevations, and essentially represent sub-humid islands in an arid environment. Three vegetation types are included.

White Fir Forest elements occur in small pockets in the New York, Clark and Kingston Ranges. These small pockets of forest are essentially imbedded in the upper parts of Utah Juniper-Oneleaf Pinyon Woodland where local site characteristics mediate an evapotranspiration rate well below that expected for the region. Some of the associated species (Table E3) are found with White Fir in the Charleston (Spring) Mountains. These pockets represent the western most attenuation of the White fir-Douglas fir-Blue spruce zone of the Wasatch Series of the Great Basin vegetation (Vasek and Thorne, 1988). The dominant tree is *Abies concolor* .

Subalpine Woodland is found on upper slopes of high desert margin mountains from the Sweetwater Mountains to the Transverse and Peninsular Ranges of Southern California, and on the highest desert mountains, namely the Inyo, Panamint and White Mountains, at elevations of about 2,900 to 3,500 meters. The main trees are *Pinus flexilis* and sometimes *Acer glabrum* or *Juniperus occidentalis*. This woodland may overlap the upper Pinyon Woodland at its lower margin and may overlap the Bristlecone Pine Forest at the higher elevations. The trees are usually small and sparsely distributed. A few associated shrubs are listed in Table E3. The climate is characterized by low precipitation and cold winters.

Bristlecone Pine Forest is found on the highest mountains in the Mojave Desert and Great Basin From the Inyo, Panamint and White Mountains of California to Nevada and Utah. A few trees also occur in the Last Chance Mountains. The trees, primarily *Pinus longaeva*, are usually small and scattered. They sometimes form small forest-like stands in the Inyo and White Mountains, but more commonly are scattered in a `woodland'.

III. Desert Microphyll Woodland Complex

A Desert Microphyll Woodland Complex with two subcomplexes occurs in low desert areas with favorable, but often intermittent,soil moisture conditions.

1. A Paloverde Microphyll Woodland occurring in washes and on slopes with substantial regular summer rain (e.g. Whipple Mountains), includes two vegetation types.

Foothill Paloverde - Saguaro Woodland occurs in Sonoran Desert areas with substantial summer rain. It is sparsely represented in California, being found only near the Colorado River, primarily in the Whipple Mountains, but is far more important southward in Arizona. Similarly, the two most conspicuous components, *Cercidium microphyllum* and *Carnegiea gigantea*, are also rare in California.

Blue Paloverde - Ironwood - Smoketree Woodland is rather common in the Colorado Desert. It occurs throughout the Creosote Bush climatic zone, usually being concentrated in washes. The main components are *Cercidium floridum*, *Olneya tesota*, *Psorathamnus spinosa*, *Chilopsis linearis*, *Acacia greggii*, and a few others (Table E3). The understory is drawn from species also found in Creosote Bush Scrub and Cheesebush Scrub.

2. A Mesquite Microphyll Woodland with only one vegetation type is found in basins near and around seeps and sinks, or on sand sheets over a shallow, salty water table.

Mesquite Thicket is dominated by *Prosopis glandulosa* and *Prosopis pubescens*. The understory associates are commonly halophytic species found in the Allscale - Alkali Scrub and the Iodinebush - Alkali Scrub. The climate is hot and arid (Table E4). This vegetation type is controlled mostly by the occurrence of water near the surface.

IV. Streamside (Riparian) and Woodland Complex

A Riparian and Oasis Woodland Complex, with two subcomplexes, is found in areas near running water.

1. Streamside Woodland Subcomplex, with two vegetation types, is found along rivers and streams. This vegetation reflects azonal humid conditions within an arid zone, being dependent on water flow in or under a stream channel and therefore essentially independent of the general climate.

Cottonwood - Willow - Mesquite Bottomland vegetation occurs intermittently in narrow strips on either side of major streams, such as the Colorado, Mojave and Virgin Rivers (near Parker, Victorville and Beaver Dam, respectively). It is dominated by *Populus macdougallii*, *P. fremontii*, *Salix exigua* and other willows, and *Prosopis glandulosa*. This vegetation has been suffering extensive degradation from the after-effects of dam construction, exhaustive recreational development and invasion of tamarisk trees.

Cottonwood - Willow Streamside Woodland occurs along small streams that flow into the desert. Some examples are the Amargosa Gorge near China Ranch, Andreas and Palm Canyons near Palm Springs, the Whitewater River and many canyons draining the Panamint Mountains and the eastern side of the Sierra Nevada. The dominant trees are *Populus Fremontii*, *Salix* spp., occasionally *Platanus racemosa*, and, in the Colorado Desert, *Washingtonia filifera*.

2. Desert Oasis Woodland Subcomplex has one vegetation type occurring primarily in the Colorado Desert, but also at Sonoran localities in Mexico and Arizona, and sparingly in the Mojave Desert as far north as southern Nevada and Death Valley National Monument.

Palm Oases occur around springs and seeps, being especially common along the San Andreas fault. *Washingtonia filifera* is the only species consistently found in all palm oases. The soil surface is often salt encrusted. Plants of the Saltgrass Meadow and Allscale- Alkali Scrub are frequent in the understory. The climate is similar to that of the Paloverde-Ironwood-Smoketree Woodland (Table E4).

V. Desert and Semidesert Grassland Complex

A Desert and Semidesert Grassland Complex, occurs in rather scattered locations, usually near the ecotone between scrub vegetation and woodland vegetation.

1. A Desert-Semidesert Scrub Steppe Subcomplex, in which perennial bunch grasses are at least co-dominant with shrubs, is widespread but scattered in the Mojave Desert. It includes four vegetation types (Table E2).

Indian Ricegrass Scrub-Steppe occurs in the Western and Southern Mojave where winter rainfall is the primary moisture source, or in mountains above 1,500 meters where winters are cold. The dominant grasses, *Oryzopsis hymenoides* and *Stipa speciosa*, have C3 metabolism. Shrub components within the grass matrix are usually *Larrea tridentata* and *Ambrosia dumosa*. A scattered overstory of *Yucca brevifolia* or *Juniperus californica* frequently occurs at higher elevations. The climate is somewhat like that of Blackbush Scrub, but a little hotter in summer (Table E4) and perhaps a little wetter.

Desert Needlegrass Scrub-Steppe also occurs in the Western and Southern Mojave, frequently at localities with significant summer rain. Extensive stands of *Stipa speciosa* often have a scattered overstory of *Yucca brevifolia* or *Juniperus californica*. Shrub associates are mostly those of the Blackbush Scrub (Table E3). The climate is slightly cooler than that of the Ricegrass Scrub Steppe (Table E4).

Big Galleta Scrub-Steppe is widely distributed through the Mojave Desert in areas where at least 20% of the precipitation falls in summer. It is dominated by *Hilaria rigida*, *Bouteloua eriopoda* and *Muhlenbergia porteri*, which are summer-active C4 grasses. The scattered overstory consists of *Juniperus osteosperma* and *Yucca brevifolia jaegeriana* in the Eastern Mojave and *Juniperus californica* and *Yucca brevifolia brevifolia* in the Western and Southern Mojave Desert. Associated scrub species are mostly those of the Hopsage Scrub and Blackbush Scrub (Table E3). Below 1,000 meters, where an overstory is not present, conditions approach those of Creosote Bush Scrub. Above 1,000 meters, an overstory is usually present and conditions are more like those of Hopsage Scrub or Blackbush Scrub (Table E4).

Galleta - Blue Grama Scrub-Steppe occurs mostly in the Eastern Mojave Desert at elevations above 1,400 meters where it replaces the preceding type. It is dominated by the summer active C4 grasses, *Hilaria jamesii* and *Bouteloua gracilis*. Shrub associates are usually those of Sagebrush Scrub and the overstory, when present, is usually *Juniperus osteosperma*. The climate is similar to that of Sagebrush Scrub (Table E4.)

2. A Desert Alkali Grassland Subcomplex with one vegetation type, occurs on highly saliferous substrates around springs and alkali seeps at low elevations.

Saltgrass Meadow occurs locally at Saratoga Springs, Tecopa Springs, and various places along the Amargosa River. It is dominated by *Distichlis spicata* and may also include *Sporobolus airoides*, *Anemopsis californica*, *Juncus cooperi* and several others (Table E4). Shrub cover and biomass are rather low. The few shrubs are mostly halophytes like *Allenrolfea*. The climate is very harsh with little precipitation and very high summer temperatures.

VI. Desert Saxicole Shrub Complex

A Desert Saxicole Scrub Complex, with two subcomplexes occurs on steep cliffs and rock faces, and therefore consists of highly localized and edaphically specialized azonal plant assemblages.

1. The Calciphyte Saxicole Subshrub Subcomplex has one vegetation type which grows on rock outcrops widely distributed in the Northern and Eastern Mojave Desert.

Calciphyte Saxicole Subscrub occurs in crevices and on rock faces of dolomite, dolomitic limestone and similar calciferous outcroppings. It includes two series: a dolomitic series on rocks high in calcium-magnesium carbonate; and, a gypsicolus series on rocks rich in calcium sulfate. The species composition is highly variable from one locality to another. Many are rare endemics. A partial list of such species for each series is given in Table E3.

2. The Non - Calciphyte Saxicole Subshrub Subcomplex also has one vegetation type which occurs on rock outcrops which are not or only slightly, calciferous.

Non - Calciphyte Saxicole Subscrub also occurs in the Northern and Eastern Mojave Desert but is more common to the south. The rock substrates are rather heterogeneous, and the species assemblages vary extensively from one locality to another. A partial list of species is given in Table E3.

VII. Desert Psammophyte Complex

A Desert Psammophyte Complex with only one subcomplex, the Desert Psammophyte Subcomplex, occurs on sand dunes.

1. The Desert Psammophyte Subcomplex occurs on sand dunes in both deserts. The largest dunes have the richest flora, and the most constant species, *Larrea tridentata* and *Coldenia plicata*, are not restricted to dunes and certainly are not obligate psammophytes. Many species are restricted to sand dunes or sandy substrates. Some of these obligate psammophytes apparently do not occur in northern dune systems and others do. Some rare endemics occur only on the Eureka Valley dune system (*Swallenia alexandre*, *Oenothera avita eurekensis*). Some rare species occur only in the Algodones Dunes (*Astragalus magdalenae peirsonii*, *Croton wigginsii*, *Helianthus niveus tephrodes*, *Pholisma sonorae*). The species composition varies from one locality to another. The vegetation is quite complex, consisting of local azonal assemblages. They are probably mediated largely by the fact of sand substrate, perhaps with associated water availability characteristics, rather than by climate *per se*.

Table E1. Climatic Summary for stations in several desert regions. (% J-S = percent of precipitation falling in summer; W and S = number of winter and spring days with 2.5 mm precipitation.)

Station	Elev	Temperature (°C) Mean Ann Min	Mean Jan	Mean July Max	No. Days Freeze	Precipitation (mm) Mean Ann	% J-S	No. of days w/ 2.5 mm ppt W	S
Great Basin									
Sarcobatus	1225	13.5	-6.5	36.8	144	89.9	40.0	6	3
Bishop	1252	13.4	-6.2	34.9	147	157.5	4.7	9	0
Caliente	1342	11.7	-8.7	35.2	165	202.7	27.4	18	5
Deep Spr.	1593	11.3	-10.1	33.4	155	131.3	12.8	9	3
Goldfield	1733	----	-6.8	32.0	150	127.8	23.3	---	---
Northern Mojave									
Cow Creek	-38	25.1	4.9	46.7	3	49.5	17.4	4	0
Greenland	-51	22.4	3.1	46.6	8	41.4	18.4	4	0
Beatty	1010	15.3	-2.4	37.5	88	118.0	14.9	11	2
Wildrose RS	1250	----	-1.6	35.1	---	185.2	19.8	---	---
Eastern Mojave									
Baker	319	----	0.9	42.9	---	75.2	20.7	8	1
Littlefield	567	18.2	-1.1	40.3	74	157.5	23.8	15	3
Las Vegas WPAP	659	18.9	-0.1	40.1	46	99.1	40.0	8	3
Boulder City	770	19.4	3.3	38.4	13	137.2	33.4	11	3
St. George	823	15.6	-5.3	38.4	96	209.6	29.2	16	4
Desert Game R	890	16.8	-1.5	38.2	127	103.9	27.1	6	3
Kingman	1016	16.4	-0.7	36.6	59	276.9	33.1	15	7
Alamo	1049	13.7	-5.9	37.7	157	164.9	30.7	12	2
Searchlight	1070	17.5	1.7	36.1	34	208.7	37.3	11	5
Pierce Ferry	1177	----	-2.2	35.6	---	256.5	35.9	---	---
Yucca Grove	1204	----	-2.5	35.3	---	185.4	21.0	---	---
Mitchell's Cav	1320	----	-3.1	34.2	---	171.5	27.5	---	---
Mountain Pass	1442	----	-2.0	34.8	---	173.0	31.2	---	---

Table E1. Climatic Summary for stations in several desert regions. (Continued.)

Station	Elev	Temperature (°C) Mean Ann Min	Mean Jan	Mean July Max	No. Days Freeze	Precipitation (mm) Mean Ann	% J-S	No. of days w /2.5 mm ppt W	S
Western Mojave									
Trona	517	18.9	-0.6	41.3	47	82.0	8.4	8	0
Lancaster	717	16.1	-1.9	37.4	80	124.2	2.9	11	0
Inyokern	744	17.6	-1.1	39.4	65	90.7	5.6	8	0
Palmdale AP	767	15.8	-1.6	36.7	81	139.2	3.2	12	0
Buckus Ranch	806	16.6	-1.2	37.0	67	162.9	5.5	12	1
Palmdale	809	16.5	-2.7	36.6	60	130.8	3.7	12	0
Mojave	846	----	-0.7	37.4	---	128.5	8.1	---	---
Victorville	871	15.3	-2.7	35.4	84	135.7	5.6	9	0
Fairmont	933	15.7	2.2	32.6	29	376.7	2.3	20	0
Randsberg	1076	17.2	1.6	36.7	33	149.6	9.9	11	1
Valyermo	1129	13.9	-2.5	40.3	103	263.3	7.6	13	1
Llano	1164	16.1	0.9	34.5	44	174.8	7.9	13	2
Haiwee	1166	15.5	-1.3	37.0	73	150.6	9.6	8	2
Central Mojave									
Barstow	653	17.7	-0.4	39.1	57	108.5	27.2	10	2
Southern Mojave									
Twentynine Palms	602	19.7	1.6	37.2	29	104.4	36.3	5	4
Joshua Tree	838	----	----	----	---	123.7	23.4	---	---
Lucerne Valley	919	15.8	-2.4	38.9	104	108.2	18.1	10	3
Hesperia	974	----	----	----	---	157.7	6.3	--	---
Kee Ranch	1318	----	----	----	----	167.6	9.2	7	2
Northern Colorado									
Parker Res	225	23.3	5.3	42.3	1	129.3	32.8	8	3
Needles	278	22.5	4.7	42.3	6	111.8	33.9	7	3
Iron Mtn	281	23.0	5.6	42.1	2	79.5	20.1	5	2

Table E1. Climatic Summary for stations in several desert regions. (Continued.)

Station	Elev	Temperature (°C) Mean Ann Min	Mean Jan	Mean July Max	No. Days Freeze	Precipitation (mm) Mean Ann	% J-S	No. of days w/ 2.5 mm ppt W	S
Eastern Colorado									
Blythe	81	22.2	2.0	42.2	12	100.3	32.7	5	1
Eagle Mtn	297	23.0	5.6	41.0	1	82.8	36.5	5	1
Hayfield	418	21.1	3.4	40.5	16	95.6	31.9	6	1
Southwestern Colorado									
El Centro	-11	22.6	3.4	42.8	15	65.3	28.0	5	1
Imperial	-20	22.4	3.9	41.6	5	49.0	25.0	5	0
Brawley	-36	22.9	3.2	42.1	7	59.4	21.4	2	0
Thermal	-37	22.8	3.9	41.8	12	70.1	21.4	4	1
Mecca	-53	22.1	2.9	41.2	12	75.9	24.1	3	0
Indio	3	22.9	3.4	41.6	15	79.8	19.7	4	0
Palm Springs	128	22.3	4.4	42.2	12	138.9	11.2	9	2
Borrego Spr.	191	21.1	2.6	41.4	19	89.2	26.8	7	1
Yuman Desert									
Yuma	42	22.2	3.7	41.3	11	82.3	38.0	3	3
Wellton	79	21.4	1.1	41.6	38	105.7	41.6	4	4
Dateland	138	22.9	3.4	43.1	15	76.7	35.1	4	4
Gila Bend	225	22.3	3.0	42.7	13	142.5	39.9	7	5
Phoenix PO	330	21.5	4.0	39.8	6	194.1	39.0	8	10
Organ Pipe NM	507	20.7	2.8	39.2	19	207.8	47.6	8	10
Ajo	537	21.8	4.8	39.4	6	231.9	48.6	9	9
Kofa Mtns	541	23.1	8.0	39.9	0	140.7	58.8	8	6
Yucca	594	----	----	----	--	167.1	36.3	---	---
Wickenburg	631	18.2	-1.1	39.3	65	272.0	40.3	13	8
Wickieup	648	18.8	0.6	40.3	55	264.6	38.8	12	7
Aguila	665	18.8	0.2	39.7	58	236.1	37.0	12	7
Signal	762	----	----	----	----	281.2	40.7	---	---

Table E2. Classification of Desert Vegetation.

- ***Complex***
  - ***Subcomplex***
    - Vegetation Type

- ***Desert Scrub***
  - ***Great Basin Scrub***
    - Sagebrush Scrub
    - Blackbush Scrub
    - Hopsage Scrub
  - ***Saline Alkali Scrub***
    - Shadscale Scrub
    - Desert Holly Scrub
    - MOjave Saltbush-Allscale Scrub
    - Allscale-Alkali Scrub
    - Iodinebush-Alkali Scrub
  - ***Mojave Colorado Desert Scrub***
    - Creosote Bush Scrub
    - Cheesebush Scrub
    - Succulent Scrub

- ***Desert Conifer Woodland-Forest***
  - ***Xeric Conifer Woodland***
    - Utah Juniper-Oneleaf Pinyon Woodland
    - California Juniper-Oneleaf Pinyon Woodland
    - California Juniper-Fourleaf Pinyon Woodland
  - ***Desert Montane Forest***
    - White Fir Forest
    - Subalpine Woodland
    - Bristlecone Pine Forest

Table E2. Classification of Desert Vegetation. (Continued.)

Desert Microphyll Woodland

Paloverde Microphyll Woodland

Foothill Paloverde-Saguaro Woodland

Blue Paloverde-Ironwood-Smoketree Woodland

Mesquite Microphyll Woodland

Mesquite Thicket

Riparian and Oasis Woodlands

Riparian Woodland

Cottonwood-Willow Riparian Woodland

Cottonwood-Willow-Mesquite Bottomland

Oasis Woodland

Palm Oasis

Desert and Semidesert Grassland

Desert and Semidesert Scrub Steppe

Indian Ricegrass Scrub Steppe

Desert Needlegrass Scrub Steppe

Big Galleta Scrub Steppe

Galletta - Blue Grama Scrub Steppe

Desert Alkali Grassland

Saltgrass Meadow

Desert Saxicole Subscrub

Calciphyte Saxicole Subscrub

Calciphyte Saxicole Subscrub

Non-Calciphyte Saxicole Subscrub

Non-Calciphyte Saxicole Subscrub

Desert Sand Dune

Desert Psammophyte

Desert Psammophyte

Table E3. Some characteristic plants of desert vegetation.

Great Basin Scrub Subcomplex

Sagebrush Scrub	
Artemisia tridentata	*Artemisia nova*
Purshia glandulosa	*Chrysothamnus nauseosus*
Chrysothamnus viscidiflorus	*Coleogyne ramosissima*
Cowania mexicana	*Ceratoides lanata*
Tetradymia sp.	*Oryzopsis hymenoides*
Gutierrezia sarothrae	*Poa secunda*
Sitanion hystrix	*Ephedra viridis*
Blackbush Scrub	
Coleogyne ramosissima	*Yucca baccata*
Yucca brevifolia	*Thamnosma montana*
Grayia spinosa	*Ceratoides lanata*
Artemisia spinescens	*Agave utahensis*
Ephedra nevadensis	*Ephedra viridis*
Atriplex confertifolia	*Atriplex canescens*
Tetradymia spp.	*Eriogonum* spp.
Lycium spp.	*Haplopappus* spp.
Hopsage Scrub	
Grayia spinosa	*Lycium pallidum*
Lycium andersonii	*Lycium shockleyi*
Haplopappus cooperi	*Larrea tridentata*
Ambrosia dumosa	*Yucca brevifolia*

Saline - Alkali Scrub Subcomplex

Shadscale Scrub	
Atriplex confertifolia	*Atriplex canescens*
Ceratoides lanata	*Artemisia spinescens*
Grayia spinosa	*Menodora spinescens*
Gutierrezia spp.	*Coleogyne ramosissima*
Yucca brevifolia	
Desert Holly Scrub	
Atriplex hymenelytra	*Atriplex polycarpa*
Tidestromia oblongifolia	
Mojave saltbush - Allscale Scrub	
Atriplex spinifera	*Atriplex polycarpa*
Ceratoides lanata	*Larrea tridentata*
Tetradymia glabrata	*Yucca brevifolia*
Tetradymia stenolepis	
Allscale-alkali Scrub	
Atriplex polycarpa	*Atriplex confertifolia*
Atriplex torreyi	*Atriplex lentiformis*
Atriplex canescens	*Kochia* spp.
Suaeda torreyana	*Haplopappus acradenius*
Allenrolfea occidentalis	*Prosopis* spp.
Sarcobatus vermiculatus	*Nitrophila occidentalis*
Suaeda spp.	*Atriplex* spp.

Table E3. Some characteristic plants of desert vegetation. (Continued.)

Saline - Alkali Scrub Subcomplex

Allscale-alkali Scrub (Continued.)

Salicornia utahensis	*Sporobolus airoides*
Phragmites australis	*Juncus cooperi*
Pluchea sericea	

Mojave-Colorado Desert Scrub Subcomplex

Creosote Bush Scrub

Larrea tridentata	*Ambrosia dumosa*
Hymenoclea salsola	*Atriplex* spp.
Encelia farinosa	*Acamptopappus sphaerocephalus*
Opuntia spp.	*Yucca* spp.
Lycium spp.	*Dalea* spp.
Hilaria rigida	*Stipa speciosa*
Oryzopsis hymenoides	

Cheesebush Scrub

Hymenoclea salsola	*Encelia farinosa*
Brickellia incana	*Brickellia oblongifolia*
Chrysothamnus paniculatus	*Baccharis* spp.
Ambrosia eriocentra	*Larrea tridentata*
Cassia armata	*Acacia greggii*
Chilopsis linearis	

Succulent Scrub

Agave spp.	*Nolina* spp.
Yucca spp.	*Opuntia* spp.
Ferocactus acanthodes	*Echinocereus* spp
Mammilaria spp.	*Coryphantha* spp.
Fouquieria splendens	*Larrea tridentata*
Ambrosia dumosa	*Encelia farinosa*

Xeric Conifer Woodland Subcomplex

Utah Juniper - Oneleaf Pinyon Woodland

Juniperus osteosperma	*Pinus monophylla*
Yucca brevifolia	*Artemisia tridentata*
Artemisia nova	*Ephedra viridis*
Coleogyne ramosissima	*Eriogonum wrightii*
Ceanothus greggii	*Cercocarpus ledifolius*
Fallugia paradoxa	*Chrysothamnus teretifolius*
Chrysothamnus viscidiflorus	*Rhus trilobata*
Quercus turbinella	*Cowania mexicana*
Purshia glandulosa	*Ribes velutinum*
Hilaria jamesii	*Stipa* spp.
Gutierrezia spp.	*Thamnosma montana*

Table E3. Some characteristic plants of desert vegetation. (Continued.)

Xeric Conifer Woodland Subcomplex (Continued.)

California Juniper - Oneleaf Pinyon Woodland

Juniperus californica	*Pinus monophylla*
Yucca brevifolia	*Quercus turbinella*
Quercus dumii	*Arctostaphylos glauca*
Eriogonum spp.	*Ephedra* spp.
Crossosoma bibelovii	*Haplopappus* spp.
Purshia glandulosa	*Prunus fasciculata*
Nolina parryi	*Salvia dorii*
Opuntia basillaris	*Hilaria rigida*
Stipa speciosa	*Bouteloua gracilis*

California Juniper - Fourleaf Pinyon Woodland

Juniperus californica	*Pinus quadrifolia*
Arctostaphylos glauca	*Pinus monophylla*
Nolina parryi	*Yucca whipplei*
Yucca schidigera	*Rhus ovata*
Ceanothus greggii	*Opuntia* spp.
Adenostoma fasciculatum	*Adenostoma sparsifolium*

Desert Montane Forest Subcomplex

White Fir Forest

Abies concolor	*Pinus monophylla*
Juniperus osteosperma	*Acer glabrum diffusum*
Amelanchier utahensis	*Fraxinus anomala*
Holodiscus microphyllus	*Petrophytum caespitosum*
Philadelphus microphyllus	*Quercus chrysolepis*
Quercus turbinella	*Ribes cereum*
Ribes velutinum	

Subalpine Woodland

Pinus flexilis	*Pinus longaeva*
Acer glabrum diffusum	*Juniperus occidentalis*
Artemisia tridentata	*Ribes cereum*
Chamaebatiaria millefolium	*Chrysothamnus viscidiflorus*
Ribes montigenum	*Symphoricarpus longiflorus*

Bristlecone Pine F.

Pinus longaeva	*Pinus flexilis*
Antennaria rosea	*Arenaria kingii*
Astragalus kentrophyta	*Chrysothamnus viscidiflorus*
Cymopterus cinerarius	*Erigeron pygmaeus*
Haplopappus acaulis	*Muhlenbergia richardsonis*
Phlox covillei	

Table E3. Some characteristic plants of desert vegetation. (Continued.)

Paloverde Microphyll Woodland Subcomplex

Foothill Paloverde -Saguaro Woodland

Cercidium microphyllum	*Carnegiea gigantea*
Larrea tridentata	*Encelia farinosa*
Opuntia bigelovii	

Blue Paloverde-Ironwood-Smokeetree Woodland

Cercidium floridum	*Bebbia juncea*
Olneya tesota	*Prosopis spp.*
Psorathamnus spinosa	*Hymenoclea salsola*
Chilopsis linearis	*Ambrosia dumosa*
Castela emoryi	*Larrea tridentata*
Acacia greggii	*Chrysothamnus paniculatus*
Hyptis emoryi	*Hoffmannseggia microphylla*
Cassia armata	*Brickellia* spp.

Mesquite Microphyll Woodland Subcomplex

Mesquite Thicket

Prosopis glandulosa	*Prosopis pubescens*
Atriplex polycarpa	*Atriplex confertifolia*
Atriplex torreyi	*Atriplex lentiformis*
Atriplex canescens	*Kochia* spp.
Nitrophila occidentalis	*Suaeda torreyana*
Sarcobatus vermiculatus	*Salicornia utahensis*

Streamside Woodland Subcomplex

Cottonwood - Willow - Mesquite Bottomland

Populus fremontii	*Salix exigua*
Salix spp.	*Prosopis glandulosa*
Tamarix spp.	

Cottonwood - Willow - Streamside Woodland

Populus fremontii	*Salix* spp.
Platanus racemosa	*Prosopis* spp.
Washingtonia filifera	*Typha* spp.
Pluchea sericea	*Phragmites australis*
Baccharis spp.	

Desert Oasis Woodland Subcomplex

Palm Oasis

Washingtonia filifera	*Pluchea sericea*
Sporobolus airoides	*Distichlis spicata*

Table E3. Some characteristic plants of desert vegetation. (Continued.)

Desert-Semidesert Scrub Steppe Subcomplex

Indian Ricegrass Scrub Steppe

Oryzopsis hymenoides	*Stipa speciosa*
Larrea tridentata	*Ambrosia dumosa*

Desert Needlegrass Scrub Steppe

Stipa speciosa	*Juniperus californica*
Yucca brevifolia	*Coleogyne ramosissima*
Ephedra nevadensis	*Haplopappus linearifolius*
Purshia glandulosa	*Lycium andersonii*
Tetradymia spinosa	
Eriogonum fasciculatum var. polifolium	

Big Galleta Scrub Steppe

Hilaria rigida	*Bouteloua eriopoda*
Muhlenbergia porteri	*Stipa speciosa*
Oryzopsis hymenoides	*Yucca brevifolia*
Juniperus spp.	*Larrea tridentata*
Ambrosia dumosa	*Ephedra nevadensis*
Hymenoclea salsola	*Yucca schidigera*
Haplopappus spp.	*Salazaria mexicana*
Thamnosma montana	*Menodora spinescens*
Yucca baccata	*Opuntia* spp.

Galleta-Blue Grama Scrub Steppe

Hilaria jamesii	*Bouteloua gracilis*
Sitanion hystrix	*Oryzopsis hymenoides*
Juniperus osteosperma	*Artemisia tridentata*

Desert Alkali Grassland Subcomplex

Salt Grass Meadow

Distichlis spicata	*Sporobolus airoides*
Phragmites australis	*Allenrolfea occidentalis*
Anemopsis californica	*Juncus cooperi*
Pluchea sericea	

Saxicole Subscrub Subcomplexes

Calciphyte Saxicole Subscrub
-dolomitic-

Arctomecon merriami	*Arenaria kingii*
Astragalus funereus	*Astragalus panamintensis*
Buddleia utahensis	*Cymopterus gilmani*
Cowania mexicana	*Dedeckera utahensis*
Dudleya saxosa	*Eriogonum gilmani*
Eriogonum intrafactum	*Eriogonum heermannii floccosum*
Fendlerella utahensis	*Forsellesia pungens*
Forsellesia nevadensis	*Gilia ripleyi*

Table E3. Some characteristic plants of desert vegetation. (Continued.)

Saxicole Subscrub Subcomplexes

Calciphyte Saxicole Subscrub
-dolomitic- (Continued.)

Hecastocleis shockleyi	*Holmgrenanthe petrophile*
Hedeoma nana	*Mimulus rupicola*
Mortonia utahensis	*Phacelia mustelina*
Penstemon calcareus	*Penstemon stephensii*
Salvia funerea	*Scopulophila rixfordii*
Viola charlestonensis	*Cheilanthes feei*
Notholaena jonesii	*Notholaena sinuata*
Mentzelia pterosperma	*Phacelia pulchella*
Enceliopsis argophylla	*Enceliopsis nudicaulis*
Eriogonum insigne	*Petalonyx parryi*
Phacelia palmeri	*Psathyrotes pilifera*
Arctomecon californica	*Camissonia multijuga*

Non-Calciphyte - Saxicole Subscrub

Peucephyllum schottii	*Haplopappus cuneatus*
Perityle emoryi	*Brickellia desertorum*
Pleurocoronis pluriseta	*Heuchera rubescens*
Arabis spp.	*Mimulus* spp.
Dudleya spp.	*Cheilanthes* spp.
Notholaena spp.	
Pellaea spp.	

Desert Psammophyte Subcomplex

Desert Psammophyte

Larrea tridentata	*Hesperocallis undulata*
Coldenia plicata	*Ammobroma sonorae*
Psorothamnus emoryi	*Hilaria rigida*
Ephedra trifurca	*Prosopis glandulosa*
Palafoxia arida	*Atriplex polycarpa*
Atriplex canescens	*Helianthus niveus*
Petalonyx thurberi	*Swallenia alexandre*
Oryzopsis hymenoides	*Oenothera avita eurekensis*
Croton wigginsii	*Astragalus lentiginosus micans*
Haplopappus acradenius	*Astragalus magdalenae peirsonii*
Abronia villosa	

Table E4. Vegetation types within the California desert together with a summary of the ranges of climatological variable associated with each (LL = Lower limit, UL = Upper Limit).

Vegetational Category	Mean Annual Precip (mm)		Temperature (°C) Mean Jan. Minima		Mean July Maxima		PotE/Ppt Range		Approx. Elev. (x100m)	
	LL	UL	LL	UL	LL	UL	LL	UL	LL	UL
I. Desert Scrub Complex										
A. Great Basin Scrub Subcomplex										
1. Sagebrush Scrub	175	325	-12	-4	25	36	2	5	12	26 (30)
2. Blackbush Scrub	150	240	-8	-4	29	37	3	7	10	20
3. Hopsage Scrub	150	240	-8	-4	29	37	3	7	10	20
B. Saline-Alkali Scrub Subcomplex										
1. Shadscale Scrub	130	225	-8	-4	31	37	3	7	10	18
2. Desert Holly Scrub	42	90	-8	-4	37	47	10	32	-0.8	8 (15)
3. Mojave Saltbush - Allscale Scrub	110	150	-1	1	37	40	6	8	6	10
4. Allscale - Alkali Scrub	82	170	-5	5	36	43	8	20	-0.8	12 (18)
5. Iodinebush - Alkali Scrub	42	275	-10	6	39	47	10	32	-0.8	7
C. Mojave - Colorado Desert Scrub Subcomplex										
1. Creosote bush Scrub	42	275	-6	6	30	47	4	32	-0.7	13
2. Cheesebush Scrub	42	275	-10	6	30	47	3	32	0.7	20
3. Succulent Scrub	150	275	-8	-2	29	47	2	7	10	20
II. Xeric Conifer Woodland - Desert Montaine Forest Complex										
A. Xeric Conifer Woodland Complex										
1. Utah Juniper - One-leaf Pinyon Woodland	175	375	-13	-4	23	36	1	4	15	30
2. California Juniper - One-leaf Pinyon Woodland	175	400	-9	-2	34	38	1	4	12	18
3. California Juniper - Four-leaf Pinyon Woodland	225	400	-9	-1	35	39	1	4	11	17

Table E4. Vegetation types within the California desert together with a summary of the ranges of climatological variable associated with each (LL = Lower limit, UL = Upper Limit). (Continued.)

Vegetational Category	Mean Annual Precip (mm) LL	Mean Annual Precip (mm) UL	Temperature (°C) Mean Jan. Minima LL	Temperature (°C) Mean Jan. Minima UL	Temperature (°C) Mean July Maxima LL	Temperature (°C) Mean July Maxima UL	PotE/Ppt Range LL	PotE/Ppt Range UL	Approx. Elev. (x100m) LL	Approx. Elev. (x100m) UL
II. Xeric Conifer Woodland - Desert Montaine Forest Complex (Continued.)										
B. Desert Montanie Forest Subcomplex										
1. White Fir Forest Enclaves	250	325	-10	-7	26	30	1.5	3	19	24
III. Desert Microphyll Woodland Complex										
A. Paloverde Microphyll Woodland Subcomplex										
1. Foothill Paloverde - Saguaro Woodland	115	160	1	6	40	44	10	12	3	4
2. Blue Paloverde - Ironwood Smoketree Woodland	80	160	1	6	40	44	10	20	0	8
B. Mesquite Microphyll Woodland Subcomplex										
1. Mesquite Thicket	42	160	-2	6	40	47	8	32	-0.8	8
IV. A. Streamside and Oasis Woodland Complex										
1. Cottonwood - Willow - Mesquite Bottomland	80	160	-4	6	35	42	5	17	0	10
2. Cottonwood - Willow - Streamside Woodland	125	250	-7	1	30	38	3	9	8	20
B. Desert Oasis Woodland Subcomplex										
1. Palm Oases	80	150	1	6	40	44	10	15	0	10

Table 4. Vegetation types within the California desert together with a summary of the ranges of climatological variable associated with each (LL = Lower limit, UL = Upper Limit). (Continued.)

Vegetational Category	Mean Annual Precip (mm) LL	Mean Annual Precip (mm) UL	Temperature (°C) Mean Jan. Minima LL	Mean Jan. Minima UL	Mean July Maxima LL	Mean July Maxima UL	PotE/Ppt Range LL	PotE/Ppt Range UL	Approx. Elev. (x100m) LL	Approx. Elev. (x100m) UL
V. Desert and Semidesert Grassland Complex										
A. Desert - Semidesert Scrub-Steppe Subcomplex										
1. Indian Ricegrass Scrub-Steppe	120	300	-9	0	28	40	2	8	6	23
2. Desert Needlegrass Scrub-Steppe	120	250	-9	-2	30	38	2	5	10	20
3. Big Galleta Scrub-Steppe	110(80)	250	-4	3	35	44	3	8(15)	3(0)	23
4. Galleta - Blue Grama Scrub-Steppe	175	300	-9	-3	28	36	2	4	12	23
B. Desert Alkali Grassland Subcomplex										
1. Saltgrass Meadow	42	120	-5	5	38	47	8	32	-0.8	10
VI. Desert Saxicole Subscrub Complex										
A. Calciphyte Saxicole Subscrub Subcomplex										
1. Calciphyte Saxicole Subscrub[1]	100	300	-9	0	26	38	2	10	6	24
B. Non-Calciphyte Saxicole Subscrub Subcomplex										
1. Non-Calciphyte Saxicole Subscrub[1]	100	300	-9	0	26	38	2	10	6	24
VII. Desert Psammophyte (Sand Dune) Complex										
A. Desert Psammophyte Subcomplex										
1. Desert Psammophyte[1]	42	150	-4	6	37	47	7	32	0	10

[1] An adequate synecologoical analysis should result in substantial subdivision of these types.

Appendix F

Desert Tortoise
(Mojave Population)

Recovery Plan

Appendix F: Summary Descriptions of Proposed Desert Wildlife Management Areas

I. Northern Colorado Recovery Unit

1. Chemehuevi DWMA

Current densities: 10 to 275 adult desert tortoises per square mile.

Location and Description:

The proposed Chemehuevi DWMA in San Bernardino County, California, lies approximately south of Interstate 40; north of Highway 62; west of Havasu National Wildlife Refuge and the Chemehuevi Indian Reservation; and east of the Old Woman Mountains and Essex (Figure 7). The Chemehuevi DWMA is varied, both vegetationally and topographically. It includes elements of both Colorado Desert and Mojave Desert floras, and elevations range from about 600 to 4,700 feet. A number of basins and ranges are represented. The BLM manages 67% of the lands in the proposed DWMA; remaining lands are in private (25%) or State (6%) ownership.

The desert tortoise population in this DWMA is relatively large, unfragmented, and little affected by human impacts. If this DWMA is made large, as proposed here, it could provide a relatively secure refuge for the species as populations in other areas are recovering.

Desert Tortoise Densities and Trends:

Currently the largest and most robust population of desert tortoises remaining within the geographic range is found in portions of the Ward and Chemehuevi valleys (Berry and Nicholson 1984a, Berry 1990, as amended). Between 1979 and 1988, densities in the Chemehuevi Valley increased from 145 to 224 tortoises per square mile, but had declined by 1992, at least among adults and subadults by 1992. The changes were not statistically significant. At the northern Ward Valley plot, total numbers of tortoises captured increased substantially between 1980 and 1991, and densities of the tortoises in the larger size classes increased markedly from 107 to 190 tortoises per square mile, but the changes were not statistically significant. Regional densities are probably depressed from military activities in the 1940s, livestock grazing, and other human uses (Berry and Nicholson 1984b). Densities along major highways,

such as Interstate 40 and Highways 62 and 95, are also depressed (Berry and Turner 1984, Karl 1989).

Threats:

In terms of current and planned human uses which may adversely affect desert tortoises, the Chemehuevi DWMA is one of the least threatened DWMAs. Major current human uses which impact desert tortoises include cattle grazing on the Lazy Daisy and Chemehuevi allotments; and fragmentation and mortality caused by highways, roads, and the Colorado River Aqueduct. Wild burros are also present in the DWMA and degrade desert tortoise habitat. Harvest of Mojave yucca is a problem in some areas.

As of 1991, no documented cases of URTD were known from the Chemehuevi DWMA, however, about 25% of desert tortoises are symptomatic for a shell disease, which appears different from that described for the Chuckwalla DWMA (K.H. Berry, pers. comm. 1993).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.2.), the following specific actions should be implemented in the Chemehuevi DWMA:

(1) Remove livestock grazing.

(2) Maintain feral burros within herd management areas at zero population levels, or as experimental populations. Remove feral burros outside of herd management areas.

(3) Construct desert tortoise barriers and underpasses along Interstate 40; Highways 95 and 62; the Atchison, Topeka, and Santa Fe Railroad; and frequently used roads. Evaluate the need for barrier fencing along the Colorado River Aqueduct and around communities such as Essex and Vidal, California.

(4) Establish a center, at or near Needles, where unwanted captive desert tortoises could be deposited. Develop programs to make unwanted desert tortoises available for research and educational purposes.

(5) Monitor health of desert tortoises, particularly URTD and shell disease.

Recommended Research:

The following research topic is especially suited to the management needs and opportunities presented in the Chemehuevi DWMA.

(1) The effects of feral burros, utility corridors, and barrier fencing on desert tortoises.

II. EASTERN COLORADO RECOVERY UNIT

1. Chuckwalla DWMA

Current densities:

5 to 175 desert tortoises per square mile.

Location and Description:

The proposed Chuckwalla DWMA is located in Riverside and Imperial Counties, California. Starting with the northwest corner, the proposed boundary would extend along the north facing slopes of the Orocopia Mountains, then run eastward along the southern edge of Interstate 10 to Wiley Well Road, then south to near Midway Well, and then north and west along the eastern portion of the Chocolate Mountains Aerial Gunnery Range to the south slopes of the Orocopia Mountains and the Southern Pacific Railroad (Figure 7). The DWMA contains several mountain ranges and valleys, ranging in elevation from 400 to 4,500 feet. Included is the Chuckwalla Bench, a bajada which has in the recent past supported the highest known densities of desert tortoises. Plant communities are typical of the Colorado Desert (Appendix E). Land ownership is a checkerboard of BLM, military, and private lands.

This DWMA is not large enough to support 50,000 adult desert tortoises at target density. Although the Joshua Tree DWMA is primarily in the western Mojave recovery unit, its southeast corner is in the eastern Colorado recovery unit. Protection of habitat there, as well as in the Chuckwalla DWMA, should be implemented to protect sufficient habitat for recovery.

Desert Tortoise Densities and Trends:

The Chuckwalla Bench DWMA has two study plots that provide density estimates and trend data: Chuckwalla Bench and Chuckwalla Valley (Berry 1990, as amended, Berry and Nicholson 1984a). In 1979-1982, estimated densities were 578 tortoises per square mile on the Chuckwalla Bench; by 1990 densities had declined to 160 tortoises per square mile. On the second plot, Chuckwalla Valley, densities were 163 tortoises per square mile in 1980 and subsequently declined to 73 tortoises per square mile in 1992. The density figures reflect the higher density portions of the DWMA (Berry and Nicholson 1984a). Declines are attributable to vandalism, vehicle kills, raven predation, and a shell disease (Berry 1990, as amended, BLM et al. 1989, Rosskopf 1989, Jacobson et al. 1994).

Threats:

Habitat in the Chuckwalla DWMA has been degraded or destroyed due to military activities in the 1940s, domestic sheep grazing, agricultural development, diversion dikes along Interstate 10, bombing associated with the Chocolate Mountains Aerial Gunnery Range, unauthorized ORV activity, and mining (Berry 1984b, Berry and Nicholson 1984b, Bernstein 1989, Hurst and Healy 1989, Kataoka 1989, Marquis 1989). A proposed landfill site in the Eagle Mountains is of concern because refuse would be transported via the old Southern Pacific railroad, which would contribute to fragmentation of desert tortoise habitat in the Chuckwalla Bench area.

The presence of URTD has not been confirmed in the proposed Chuckwalla DWMA; however, a substantial portion of desert tortoises on the Chuckwalla Bench experienced a shell disease that was associated with high mortality rates between 1982 and 1991 (Berry 1990, as amended, Jacobson et al. 1994).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.D.2), the following specific actions should be implemented in the Chuckwalla DWMA:

(1) Restrict train traffic to 1991 levels or construct barrier fencing and desert tortoise underpasses along the railroad tracks to reduce or eliminate mortality and population fragmentation.

(2) Construct barrier fences and underpasses for desert tortoises along well-used roads in the DWMA, including the south side of Interstate 10.

(3) Determine actual and potential raven use of palm trees and other roost and perch sites at the Chuckwalla Prison and the adjacent new prison site. Eliminate raven perch and nest sites.

(4) Work cooperatively with the Chocolate Mountains Aerial Gunnery Range to eliminate unauthorized bombing of public lands and mitigate habitat damage which has resulted from these activities.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in the Chuckwalla DWMA:

(1) The effects of dirt roads and mining on desert tortoise populations and habitat. Research habitat restoration, particularly of old agricultural fields and areas adversely affected by diversion dikes.

(2) Continue research on shell and other diseases to isolate causes of high mortality.

III. UPPER VIRGIN RIVER RECOVERY UNIT

1. Upper Virgin River DWMA

Current densities:

Small areas of the DWMA contain up to at least 250 adult desert tortoises per square mile; desert tortoises in this DWMA occur in a mosaic of high to low densities.

Location and Description:

The proposed Upper Virgin River DWMA in Washington County, Utah, lies approximately north of St. George and Hurricane, Utah, west of Highway 18, east of Snow Canyon, and south of Yant Flat and Cedar Bench (Figure 8). Desert tortoises of this proposed DWMA are notable among populations in the Mojave Region because they represent the northern-most population of the species and densities are currently very high in some areas. Desert tortoise habitat in this DWMA is characterized by rugged terrain of rocky outcrops and hills interspersed with sandy areas. Vegetation is diverse and includes creosote scrub, blackbush scrub, big galleta scrub steppe, desert psammophyte, and Utah juniper - one-leaf pinyon woodland (Appendix E). Land ownership is a patchwork of BLM, State, and private lands.

Because this recommended DWMA will not contain 1,000 square miles of contiguous desert tortoise habitat intensive management, even after recovery, will be necessary to ensure a reasonable probability of long-term population persistence (Figure 6D).

Desert Tortoise Densities and Trends:

On the City Creek study plot (1-mile square), 243 desert tortoises were marked in 1988, of which 163 were adults or subadults (Rick Fridell, Utah Division of Wildlife Resources, pers. comm. 1993). However, densities are much lower and patchy throughout most of the proposed Upper Virgin River DWMA. Data are insufficient to evaluate population trends; but, populations could decrease in the future as cities in Washington County grow and human use of this area increases.

Threats:

Quantitative, rather than qualitative, loss of habitat is the primary threat to the desert tortoise population in this proposed DWMA. Although a variety of human uses occur, the condition of the habitat is generally good. ORV use occurs in Snow Canyon but is limited by topography. Cattle grazing occurs, but is limited by topography

and access to water. A popular shooting area is located in the western portion of the DWMA on BLM land. A turkey farm occupies a large tract of private land, and dumps and landfills occur in the DWMA and nearby. Desert tortoise populations are also affected by human activities in and around St. George, a growing community with a population of 35,600 in 1993, up from 28,500 in 1990. Interstate 15 and Highway 18 are the major transportation corridors in the area. No mining occurs in this DWMA.

URTD is not currently known to be a threat to desert tortoises in this DWMA.

Specific Management Actions:

This is the only DWMA proposed for the Upper Virgin River recovery unit. Because of the small size of this proposed DWMA, management will need to be intensive and promptly implemented if this desert tortoise population is to be given a reasonable chance of long-term persistence. Acquisition of private inholdings (or development of conservation easements *in perpetuity*)is imperative for recovery, particularly for non-Federal and private lands north and northeast of St. George, Paradise and Padre canyons, and north of Hurricane. In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Upper Virgin River DWMA:

(1) Remove livestock grazing from the DWMA.

(2) Construct and maintain desert tortoise barrier fencing along Interstate 15, Highway 18, and the road to the turkey farm.

(3) Install underpasses for desert tortoises along Highway 18 between Paradise Canyon and Twist Hollow, and the road to the turkey farm.

(4) Close the debris dam road north of St. George or restrict access through installation of a locked gate.

(5) Establish a visitor center outside the DWMA which would educate the public about the desert tortoise and serve as a drop-off site for unwanted captive tortoises. Develop a program to make these animals available for educational and research purposes.

(6) Consolidate ownership and management of the entire DWMA, primarily for desert tortoise, under Federal management as a National Conservation Aea.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in the Upper Virgin River DWMA:

(1) Desert tortoise reproduction and growth rates.

(2) Desert tortoise nutritional ecology and physiology.

(3) Factors governing desert tortoise distribution in this DWMA.

IV. EASTERN MOJAVE RECOVERY UNIT

1. Fenner DWMA

Current densities:

10 to 350 desert tortoises per square mile.

Location and Description:

The proposed Fenner DWMA in San Bernardino County, California, would include the northeastern part of the Clipper Valley, north-central part of the Fenner Valley, and the southern Piute Valley. The DWMA would be bounded by the Providence Mountains on the west, Hackberry and Piute Mountains and the Nevada border on the north, the Dead Mountains on the east, and Interstate 40 and the Clipper Mountains on the south (Figure 9). This proposed DWMA is primarily in the eastern Mojave recovery unit, but as described here, the southeastern edge is in the northern Colorado recovery unit. The area is heterogeneous topographically with elevations from about 1,600 to 3,454 feet. Several plant communities are present, including Big Galleta Scrub Steppe, Succulent Scrub, a rich Creosotebush Scrub, Hop Sage Scrub and Blackbush Scrub (Appendix E). This proposed DWMA includes portions of the East Mojave National Scenic Area. Land ownership is about 67% public, 28% private, and 5% State.

Desert Tortoise Densities and Trends:

The highest densities of desert tortoises occur in only a few patches of a few square miles each (Berry et al. 1994), with the Goffs study plot supporting the highest levels. In the Goffs area, densities west of Lanfair Road range from 50 to 100 desert tortoises per square mile. To the east of the Lanfair Road, densities probably average about 50 per square mile. The desert tortoise population on the Goffs plot declined from 440 tortoises per square mile in 1980 to 362 in 1990 (Berry 1990, as amended). In less than 2 years of work on a health profile study in this DWMA, 7 of 20 desert tortoises either died or were presumed dead (Berry 1991, Nagy et al. 1990). Densities are probably depressed throughout the proposed DWMA as a result of a variety of human impacts (Berry 1984a).

Threats:

The Fenner, Clipper, and Piute valleys have experienced harvest of Mojave yuccas on Southern Pacific lands, with some unauthorized

harvest on BLM lands, and long-term cattle grazing. The valleys are the sites of major transportation and utility corridors, which undoubtedly have contributed to declines of adjacent desert tortoise populations. Settlements at Goffs, Essex, and the Providence Mountains State Park add to the cumulative impact load. As general recreation pressures increase in the East Mojave National Scenic Area, desert tortoise mortality rates from collecting, vandalism, and roadkills are likely to increase. Raven populations appear to be growing in the valley and nearby areas (Knowles et al. 1989a, 1989b).

Four ill desert tortoises were found on the Goffs study plot in 1990. The poor condition of these animals was attributed to below optimum water and nutrient uptake (Jacobson and Gaskin 1990), probably due to drought. *Mycoplasma sp.* and *Pasteurella testudinis* were found in a Goffs' desert tortoise in the summer of 1991. Both these organisms often appear together in desert tortoises with URTD (Jacobson et al. 1991).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Fenner DWMA:

(1) Remove livestock grazing.

(2) Implement a program to control raven predation on juvenile desert tortoises.

(3) Construct and maintain desert tortoise-proof fencing and underpasses along the Atchison, Topeka, and Santa Fe Railroad; Interstate 40; and well-used roads, such as the Goffs Road.

(4) Sign the DWMA boundary near the Goffs settlement.

(5) Establish a drop-off site for unwanted captive desert tortoises. Develop a program to make these animals available for research and educational purposes.

(6) Implement emergency action to halt harvest of yuccas and other vegetation.

(7) Closely monitor predation by ravens on desert tortoise populations. Where appropriate, ensure that excessive predation is controlled and that sufficient recruitment of juveniles into the subadult and adult cohorts occurs.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities of the Fenner DWMA:

(1) Health profiles, disease, and reproduction in desert tortoises at established sites (continue ongoing studies until complete).

(2) Population demography, movements, and food preferences and availability.

(3) The effects of small settlements, road densities, and railroads on adjacent desert tortoise populations and habitat, and effectiveness of barriers and underpasses.

(4) Methods to protect desert tortoises from high density forms of general recreation.

2. *Ivanpah DWMA*

Current densities:

5 to 250 desert tortoises per square mile.

Location and Description:

The proposed Ivanpah DWMA in San Bernardino County, California, is horseshoe in shape and is composed of the Ivanpah, Kelso, and Shadow valleys and interconnecting corridors (Figure 9). Although most of this proposed DWMA lies in the eastern Mojave recovery unit, Ivanpah Valley is in the northeastern Mojave recovery unit. Elevations range from 2,500 to 4,764 feet and topography includes bajadas, rolling hills, lava flows, one playa lake, and a few major drainages. Vegetation is diverse and includes seven distinct communities (Appendix E). This proposed DWMA includes portions of the East Mojave National Scenic Area. This area is managed almost entirely by BLM.

Desert Tortoise Densities and Trends:

The highest known densities of desert tortoise occurred in southern Ivanpah Valley, where about 20 square miles support densities of 200 to 250 per square mile. Throughout much of the northern Ivanpah, Kelso, and Shadow valleys, densities were generally less than 50 per square mile. About half of these were adult or subadult animals (Berry 1990, as amended, Berry 1991). On the Ivanpah Valley plot, densities declined from 368 tortoises per square mile in 1970 to 249 in 1990, but this trend was not statistically significant (Berry 1990, as amended). Nine of 18 desert tortoises monitored in Ivanpah Valley from 1989 to 1991 succumbed to drought-related stress (Nagy et al. 1990, Berry 1992, Jacobson and Gaskin 1990). In addition, the proportion of juvenile desert tortoises declined from the 1970's to the 1990's at the Ivanpah Valley plot, apparently as a result of high predation rates by ravens (Berry et al. 1986b, Berry 1990, as amended, 1991, BLM et al. 1989).

Threats:

A variety of human uses have contributed to habitat loss and degradation in this DWMA. Military maneuvers during the mid 1960's impacted areas in the southern Ivanpah Valley, while motorcycle races, including the Barstow to Vegas race, affected habitat in the Shadow Valley and northern Ivanpah Valley. Cattle grazing occurs on portions of five allotments in this DWMA, and perennial grasses are heavily grazed in some areas. Other major human uses include recreation that contributes to habitat degradation, mining, powerline corridors. Urban development at

Stateline, Nevada; OHV use in northern Ivanpah Valley and around Roach Lake; and landfills, garbage dumps, and sewage ponds which attract ravens all contribute to desert tortoise mortality and habitat destruction.

A few desert tortoises in a health profile research program tested positive for URTD (*Mycoplasma*) during 1991 (Brown et al. 1993). Some animals also have shell disease (Berry pers. comm. 1993). An adult desert tortoise was found paralyzed in Shadow Valley in 1991. Possible causes of the paralysis included poisoning resulting from ingestion of locoweed (*Astragalus sp.*) or some other toxin (Klaasan 1991, Blood et al. 1989, Casteel et al. 1985, Fuller and McClintock 1986).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Ivanpah DWMA:

(1) Remove livestock grazing from the Crescent Peak, Clark Mountain, Kessler Springs, Valley Wells, and Valley View allotments.

(2) Construct and maintain desert tortoise-proof barriers and underpasses to protect tortoises and habitat from Interstate 15 and well-used roads, such as Nipton and Ivanpah Roads. Also, construct fencing to protect desert tortoises from recreational vehicle use on the Ivanpah Dry Lake and near Whiskey Pete's casino.

(3) Conduct intensive new surveys (using strip transects) in northern Ivanpah, Shadow, and Kelso valleys and Cima Dome to gather information on distribution and densities of desert tortoises.

(4) Implement a raven-control program to reduce predation on juvenile tortoises. Monitor desert tortoise populations to ensure that juveniles are recruited into subadult and adult cohorts in sufficient numbers to promote population recovery.

(5) Sign DWMA boundaries in the vicinity of Nipton, Kelso, and other similar settlements and areas with conflicting land uses.

(6) Promote return of perennial grasses and increases in cover values of native grasses and decreaser species.

(7) Construct desert tortoise barriers and underpasses along the Union Pacific Railroad.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in this DWMA:

(1) Disease, health, nutritional requirements and physiology, as well as effects of grazing on vegetation, soils, and desert tortoise behavior (continue ongoing intrusive research).

(2) The extent and potential causes of toxicosis (possibly selenium poisoning, locoweed poisoning, or some other form of toxicosis) in desert tortoises in the Shadow Valley and elsewhere in this DWMA. Identify sources of poison and distribution of potentially poisonous plants.

(3) Genotypes of desert tortoises in areas of potential linkages between this DWMA, and the Fenner and Piute-El Dorado DWMAs.

(4) The effects of utility towers on the desert tortoise and its habitat. Towers and similar structures may encourage an increase in avian predators.

3. *Piute-Eldorado DWMA*

Current densities:

40 to 90 adult desert tortoises per square mile

Location and Description:

The proposed Piute-Eldorado DWMA in Clark County, Nevada, lies approximately west of the Colorado River, north and east of the California State line, south of Boulder City, and southeast of Goodsprings and the north end of the McCullough Mountains (Figure 9). As described here, this proposed DWMA would include portions of both the eastern and northeastern Mojave recovery units. This DWMA is heterogeneous vegetationally and topographically, and includes several parallel mountain ranges divided by valleys, dry lakes, and bajadas. Several plant communities are represented, including Shadscale Scrub, Creosote Bush Scrub, Blackbush Scrub, and Utah Juniper - One-Leaf Pinyon Woodland (Appendix E). The proposed Piute-Eldorado DWMA has a common border with the Fenner and Ivanpah DWMAs in California. Land ownership is a mix of National Park Service, BLM, and private lands.

Desert Tortoise Densities and Trends:

The Piute Valley represents the largest area of high density desert tortoise habitat known in Nevada. The population is contiguous with a larger high-density area in California and represents a zone of contact between two genetic types (Brussard 1992). Data are insufficient to assess population trends; however, densities are likely declining due to human-related disturbances which adversely affect desert tortoises, such as recreation, mines, residential development, and livestock grazing (Appendix D, Nevada Department of Wildlife 1990).

Threats:

Desert tortoises have been adversely affected by a variety of human uses in the proposed DWMA. ORV activity, including organized races, is the principle recreational activity affecting desert tortoises. Transmission lines and associated access roads run southwest from Hoover Dam through the DWMA. Six cattle grazing allotments are also present. Interstate 15 and Highway 95 pass through the DWMA and act as formidable barriers to east-west movement. Road density in the area was estimated at 0.9 miles per section in 1984, but has probably increased since that time. Historic as well as current mining is evident in many portions of the proposed DWMA.

A habitat management plan for this area, prepared by the BLM in cooperation with the National Park Service, Nevada Department of Wildlife, and the Nature Conservancy, is currently in draft form. This plan will implement mitigation actions required in a 10(a)(1)(B) incidental take permit issued to Clark County and the cities of Las Vegas, North Las Vegas, Henderson, and Boulder City. The habitat management plan proposes management plans and policies for about 430,000 acres in the Eldorado, Cottonwood, and Piute Valleys. It provides for land use controls including removal of livestock grazing, restriction of landfills and intensive recreation, elimination of most competitive off-highway vehicle events, and increased law enforcement (BLM 1983). To date four of the six grazing allotments have been purchased and are currently being held in non-use by The Nature Conservancy.

URTD has been observed in desert tortoises in this area. The occurrence of this disease is correlated with locations of releases of captive desert tortoises, particularly in and around urban areas and degraded habitats (Marlow and Brussard 1992).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the proposed Piute-Eldorado DWMA:

(1) Maintain feral equids within herd management areas at zero population levels. Remove feral equids outside herd management areas.

(2) Construct and maintain desert tortoise barrier fencing to protect desert tortoises and their habitat from vehicles and access provided by Highway 95, State Route 163, and the Nipton Highway. Install underpasses to allow for movements and gene flow within this DWMA.

(3) Establish a visitor center which would educate the public about the desert tortoise and its habitat and include a drop-off site for unwanted captive desert tortoises. Develop a program to make unwanted captives available for research and educational purposes.

(4) Sign DWMA boundaries around Searchlight, Laughlin and other settlements.

(5) Acquire Colorado River Commission lands or secure conservation easements for surface and subsurface management.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in the Piute-Eldorado DWMA:

(1) The effects of ORV use in the Eldorado Valley on the desert tortoise and its habitat.

(2) The impacts of various linear features, particularly Highway 95, which divides the proposed DWMA.

(3) Movements of desert tortoises through narrow passes (i.e., between Eldorado Valley and Jean Lake) compared with movement patterns in unstructured, unbounded areas (i.e., Piute Valley).

(4) Genetic relationships between desert tortoises in the northern and southern ends of the DWMA.

V. NORTHEASTERN MOJAVE RECOVERY UNIT

1. Beaver Dam Slope DWMA

Current densities:

5 to 56 desert tortoises per square mile.

Location and Description:

The proposed Beaver Dam Slope DWMA in extreme southwestern Washington County, Utah, and northwestern Mohave County, Arizona, lies approximately north of Interstate 15 and Littlefield, Arizona; west of the western slope of the Beaver Dam Mountains; south of Motoqua, Utah; and east of the Nevada State border (Figure 9). This proposed DWMA would include critical habitat designated for the desert tortoise in 1980 (Fish and Wildlife Service 1980). Desert tortoise habitat in this DWMA is typically eastern Mojave Desert Scrub, characterized primarily by Creosote Bush Scrub. Joshua trees (*Yucca brevifolia*) are well developed in this vegetation type, especially in the more northerly parts of the Beaver Dam Slope. Topography varies from the steep, lower slopes of the Beaver Dam Mountains to gently sloping creosote bush flats intersected by small to major washes, which often provide deep caliche-cave hibernacula for desert tortoises. Most lands within this proposed DWMA are in private ownership or managed by the BLM. About 22.4 square miles of this proposed DWMA were designated critical habitat for the desert tortoise in 1980 (Fish and Wildlife Service 1980).

The desert tortoise population in this DWMA is currently linked to the Mormon Mesa population across about 15 miles of fair to poor habitat north of the Virgin River. Because of its small target population, the probability of long-term persistence of desert tortoises on the Beaver Dam Slope DWMA would be enhanced if this corridor remains viable.

Desert Tortoise Densities and Trends:

Monitoring of desert tortoise numbers in this DWMA began with the Woodbury-Hardy study plot in the 1930s (Woodbury and Hardy 1948). Currently, desert tortoise numbers are monitored at 2 plots; one on the Beaver Dam Slope and one near Littlefield. Since the late 1970's, desert tortoise densities on the Beaver Dam Slope plot have declined; these declines have been drastic in some areas (Fridell and Coffeen 1993). Densities on the Littlefield plot have remained approximately constant at about 50 desert tortoises per square mile (Duck and Snider 1988), but more carcasses than expected have

been found over the last several years, suggesting increased mortality.

Threats:

The proposed Beaver Dam Slope DWMA is one of the most threatened DWMAs. Cattle grazing occurs over most of the area. Non-native annual plants comprise significant portions of the ephemeral cover, and perennial grasses are reduced or eliminated in some areas due, in part, to grazing, (Appendix D). Mining and agricultural development have eliminated desert tortoise habitat in Beaver Dam Wash. Access through the area is provided by Highway 91 and a network of ranch, mine, and graded dirt roads. ORV use is increasing in some areas.

Desert tortoises with signs of URTD have been found on the Beaver Dam Slope in Utah and extreme northern Arizona. A study of higher than expected mortality on the Beaver Dam Slope concluded that thinning of shell bone (osteopenia) had occurred in 16% of more than 200 desert tortoise carcasses examined and that the osteopenia may be related to poor nutrition (Jarchow and May 1989).

Specific Management Actions:

Current densities in this DWMA are at the minimum necessary to avoid demographic and stochastic effects that accelerate population declines (Section II.A.2). Immediate implementation of proposed management actions will be necessary to avoid extirpation of this population. In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific management actions should be implemented in the Beaver Dam Slope DWMA:

(1) Remove livestock grazing or, if desired, establish terms for experimental livestock grazing in EMZs.

(2) Initiate a semi-wild breeding program (Appendix B) to rebuild and restore the population of desert tortoises in this DWMA.

(3) Sign DWMA boundaries adjacent to communities and settlements to reduce conflicting land uses.

(4) Construct desert tortoise barrier fencing along Interstate 15 and Highway 91 to protect desert tortoises from vehicle kills, collection, and vandalism.

(5) Construct underpasses along Highway 91 to allow movement of desert tortoises and exchange of genetic material within this DWMA.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in this DWMA:

(1) The impacts of ORV use on the desert tortoise and its habitat.

(2) The effects of small settlements on the desert tortoise and its habitat.

(3) Translocation of desert tortoises.

2. Coyote Spring DWMA

Current densities:

0 to 90 adult desert tortoises per square mile.

Location and Description:

The proposed Coyote Spring DWMA in Lincoln and Clark Counties, Nevada, would consist mostly of Fish and Wildlife Service refuge lands on the Desert National Wildlife Refuge (DNWR). This DWMA would be bounded approximately by the Nye County line on the west, the DNWR boundary on the north and south, and Highway 93 on the east (Figure 9). The flats and lower slopes within this DWMA are characterized by well-drained alluvial sands and gravels dominated floristically by creosote and bursage. Mojave yucca and Joshua trees are common at higher elevations, and a shadscale scrub community is present west of the Sheep Range (Schneider et al. 1982).

Desert Tortoise Densities and Trends:

1986 transect data estimated adult desert tortoise densities at 36 to 62 per square mile in the Coyote Spring Valley and Hidden Valley (Nevada Department of Wildlife 1990, BLM, Las Vegas District, Las Vegas files). In 1982, transects were conducted on the DNWR east of Alamo Road, including areas around Desert Dry Lake which revealed low to moderate densities (0 to 90 desert tortoises per square mile). The area east of Alamo Road remains unsurveyed, but desert tortoises there are thought to be patchily distributed in low densities. Data are insufficient to evaluate trends.

Threats:

Due to resource management by DNWR, human impacts have left a minimal imprint throughout much of this DWMA. Near Highway 93, habitat has been degraded by ORV use, dumping, utility construction, sand and gravel mining, and other impacts. Large herds of feral horses are currently present, and the recent drought has caused heavy use of the range by these animals. Grazing by livestock is absent or minimal as all allotments are currently inactive. Military activities on the Nellis Bombing Range have resulted in some localized habitat destruction.

Several cases of desert tortoises with URTD have been reported in this area (Nevada Department of Wildlife 1990, RECON 1991).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following actions should be implemented in the Coyote Spring DWMA:

(1) Maintain feral equid within herd management areas at zero populations. Remove feral equids outside herd management areas.

(2) Remove livestock grazing of, if desired, establish terms for experimental cattle grazing in EMZs.

(3) Construct and maintain desert tortoise barrier fencing to protect desert tortoises and habitat along Highways 93 and 95. Install desert tortoise underpasses along Highway 93 to allow for movements and gene flow between the Coyote Springs DWMA and the Mormon Mesa DWMA.

(4) Establish a visitor center which would include a drop-off site for unwanted captive desert tortoises. Develop a program to make these animals available for educational and research purposes.

(5) Modify existing management plans and policies at DNWR to be consistent with this Recovery Plan.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in the Coyote Spring DWMA:

(1) The effects of bombing activities on the desert tortoise and its habitat. This research should include a comparison of survivorship of desert tortoises both inside and outside bombing ranges. Withdraw areas from bombing in which research shows adverse effects on desert tortoises or their habitat.

(2) The impacts of all road types (e.g., highways, roads, tracks, ways, etc.) on the desert tortoise and its habitat, particularly in the Indian Springs Valley and Three Lakes Valley area of Nellis Air Force Base.

(3) Movement patterns of desert tortoises through managed corridors (i.e., underpasses) and along fences (i.e., railroads and highways). This research should examine desert tortoise behavior, establishment, gene flow, reproduction, etc.).

(4) Distribution and abundance of desert tortoises east of Alamo Road.

3. *Gold Butte-Pakoon DWMA*

Current densities:

5 to 56 desert tortoises per square mile.

Location and Description:

The proposed Gold Butte-Pakoon DWMA in Mohave County, Arizona, and Clark County, Nevada, would be approximately bounded on the north by the Virgin River, on the east by the Virgin Mountains and Grand Wash, on the west by the Virgin River and Gold Butte, and on the south by Lake Mead (Figure 9). A habitat corridor to promote genetic exchange between this Gold Butte-Pakoon area and the proposed Mormon Mesa DWMA is included on the southwestern corner of the this DWMA. Desert tortoises in this area inhabit rolling hills and sloping bajadas, but are also found in volcanic boulder fields of the Pakoon Basin. The vegetation is mostly creosote bush scrub with occasional stands of Joshua trees or Mojave yucca. Land ownership is a mix of BLM, National Park Service, and private lands.

Desert Tortoise Densities and Trends:

Density estimates are available from transect data and at the Gold Butte study plot (RECON 1991, SWCA 1990). Most of the DWMA has densities of about 20 adult desert tortoises per square mile. Data are insufficient to derive trends.

Threats:

The entire Gold Butte-Pakoon DWMA has been grazed by livestock over the past century. Native perennial grasses have been reduced or eliminated in some areas, and non-native annual weeds such as filaree and red brome are common. Fires, carried by stands of introduced annuals, have contributed to the loss of perennial grasses and shrubs in some areas. Historic and current mining activity is evident in parts of the DWMA, but the most intensive mining has historically occurred in less important desert tortoise habitat areas, such as Gold Butte. The ruggedness of the terrain and relatively few roads, especially in the Gold Butte and Pakoon Basin areas, tend to limit human impacts to desert tortoise habitat. Recently, however, there have been noticeable increases in ORV vehicle activity, especially both north and south of the Virgin River in Arizona and Nevada.

One desert tortoise with signs of URTD was found in 1991 in the Pakoon Basin, Arizona (T.A. Duck, pers. comm.). URTD has not been reported in the Gold Butte area in Nevada.

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Gold Butte-Pakoon DWMA:

(1) Remove livestock grazing or, if desired, establish terms for experimental cattle grazing in EMZs.

(2) Construct desert tortoise barrier fencing along Interstate 15 and Highway 91 to protect desert tortoises from vehicle kills, collection, and vandalism.

(3) Sign DWMA boundaries adjacent to communities and settlements (e.g. Littlefield, Arizona, Mesquite, Nevada, etc.) and other areas with conflicting land uses.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities of this DWMA:

(1) The direct and indirect impacts (including, soils and vegetation) of grazing to the desert tortoise and its habitat.

(2) The impacts of ORV use on the desert tortoise and its habitat.

(3) Restoration of desert tortoise habitat converted to annual grasslands.

4. *Mormon Mesa DWMA*

Current density:

41 to 87 subadult and adult desert tortoises at the Mormon Mesa study plot.

Location and Description:

The Mormon Mesa DWMA in Clark and Lincoln Counties, Nevada, would lie east of Highway 93; south of the northern end of the Mormon Mountains; west of the east Mormon Mountains, Flat Top Mesa, and the Virgin River; north of the Moapa Valley; and northeast of Hidden Valley (Figure 9). The vegetation is predominantly creosote bush scrub. Mohave yucca, Joshua tree, and juniper increase in dominance with elevation (Appendix E). Major landowners include the BLM, Union Pacific Railroad, and other private parties.

Desert Tortoise Densities and Trends:

Estimated 1989 desert tortoise densities from the BLM permanent study plot at Mormon Mesa were 41-87 subadults and adults per square mile. Desert tortoise densities are patchy with the best habitat occurring in the northern portions of the DWMA. Data are insufficient to assess population trends.

Threats:

A variety of human, or human-associated, uses and impacts affect desert tortoises in the Mormon Mesa DWMA (Nevada Department of Wildlife 1990). A network of roads averaging about 1.3 linear miles per section crisscrosses the DWMA, including Interstate 15 which separates South Mormon Mesa from North Mormon Mesa. ORV use occurs in some BLM-designated "open" areas, as well. Domestic sheep grazing occurs on the eastern half of Mormon Mesa and cattle grazing occurs on the western side of the DWMA. Parts of 17 grazing allotments are contained within the Mormon Mesa DWMA. Mining and utility corridors have also adversely affected desert tortoises in this area.

Two cases of URTD were reported in 1989 in this proposed DWMA. Several animals with symptoms of nutritional deficiency were also noted at the same time (Nevada Department of Wildlife 1990).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Mormon Mesa DWMA.

(1) Remove livestock grazing or, if desired, establish terms for experimental cattle grazing in EMZs.

(2) Maintain feral equids within herd management areas at zero population levels. Remove feral equids outside herd management areas.

(3) Construct desert tortoise barrier fencing and underpasses along Highway 93 and Interstate 15 to allow movement of desert tortoises between the Mormon Mesa DWMA and Coyote Spring DWMA, and to connect the northern and southern parts of the Mormon Mesa DWMA.

(4) Construct desert tortoise barrier fencing and underpasses along the Union Pacific Railroad.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in the Mormon Mesa DWMA:

(1) Movement patterns of desert tortoises through natural corridors to determine what constitutes a corridor or boundary edge (see Beaver Dam Slope DWMA description). Research should include the movement patterns of desert tortoises through managed corridors (i.e., underpasses) and along fences (i.e., railroads and highways), and examine desert tortoise behavior, establishment, gene flow, reproduction, etc.

(2) The impacts of all road types (highways, roads, tracks, ways, trails, etc.) on the desert tortoise and its habitat.

(3) Distribution and abundance of desert tortoises throughout the DWMA.

VI. WESTERN MOJAVE RECOVERY UNIT*

1. Fremont-Kramer DWMA

Current densities:

5 to 100 desert tortoises per square mile.

Location and Description:

The proposed Fremont-Kramer DWMA in Kern and San Bernardino Counties, California, includes the Desert Tortoise Natural Area on its northwestern boundary as well as other lands south and east of Koehn Lake to the Randsburg Wash test range of the China Lake Naval Air Weapons Station in the northeast, almost to Helendale in the southeast, and to Edwards Air Force Base in the southwest (Figure 10). Six plant communities are represented (Appendix E); and the terrain is characterized by rolling hills and mountains up to 5,270 feet and valleys as low as 1,900 feet. Land ownership is a mix of private, BLM, military, and State lands.

Desert Tortoise Densities and Trends:

Data on population densities and trends are available from five plots: two at the Desert Tortoise Natural Area, as well as in Fremont Valley, near Fremont Peak and at Kramer Hills (Berry 1990, as amended). For example, in 1979 densities at the Desert Tortoise Natural Area ranged from 339 to 387 tortoises per square mile; in 1981, the Fremont Valley plot had 278 tortoises per square mile, and Fremont Peak had 99 tortoises per square mile. By the early 1990's, densities had declined precipitously, e.g. 88% at the Desert Tortoise Natural Area, due to a number of human impacts, URTD, and raven predation.

* The Western Mojave recovery unit is the largest and most heterogeneous of the recovery units in terms of climate, vegetation and topography. It includes three major vegetation types—the Western Mojave, Central Mojave, and Southern Mojave—each of which has significant and distinctive elements (Tables 4 and 5). Four DWMAs within the Western Mojave recovery unit represent this diversity. The Fremont-Kramer DWMA represents the Western Mojave region; the Superior-Cronese DWMA represents the Central Mojave region, and the Ord-Rodman DWMA represents the Southern Mojave region. The Joshua Tree DWMA, the fourth within this recovery unit, contains Southern Mojave and Eastern Colorado elements. The tortoises have responded to this habitat heterogeneity with different food habits and behavior in each of these areas. Thus, three DWMAs are essential in this recovery unit to preserve the heterogeneity. Secure, large reserves are especially critical because of the severe population declines and heavy human use in these areas.

Threats:

The Fremont-Kramer DWMA is one of the most threatened DWMAs. Collecting, vandalism, road kills, disease, raven predation, ORV activity, and other human-related impacts have contributed to significant population declines. Since the mid-1980's, numbers of adult desert tortoises have dropped 90% over large areas. The area has been grazed by cattle and domestic sheep, explored for hard-rock and leasable minerals, and has experienced human settlements since the 1860's. Since the 1960's, ORV recreationists have traveled cross-country over much of the region. Major transportation routes exist, including paved Highways 58 and 395, the Garlock Road, and Red-Rock Randsburg Road. The Fremont-Kramer DWMA has little, if any, habitat in pristine or climax condition (Berry and Nicholson 1984b, Chambers Group Inc. 1990 a and b). The Desert Tortoise Natural Area, which is fenced and intensively managed for desert tortoises, has some of the least disturbed habitat in the region.

URTD was first detected on the Fremont Valley plot in 1979 and is now present throughout the DWMA (Avery and Berry 1990, Berry 1990, as amended, Berry and Slone 1989). Recent high mortality rates are due in part to this disease (Berry 1990, as amended).

Specific Management Actions:

Current densities in this proposed DWMA are at the minimum necessary to avoid demographic and stochastic effects that accelerate population declines (Section II.A.2.). Immediate implementation of proposed management actions will be necessary to avoid extirpation of this population. In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Fremont-Kramer DWMA.

(1) Remove livestock grazing or, if desired, establish terms for experimental cattle grazing in EMZs.

(2) Implement emergency measures to control unleashed dogs and dog packs.

(3) Initiate a semi-wild breeding program to rebuild and restore the population. The Desert Tortoise Research Natural Area is an ideal place to begin such a program.

(4) Construct a visitor education center at the Desert Tortoise Natural Area which would include facilities for research as well as a drop-off site for unwanted captive desert tortoises. Develop programs to promote use of unwanted captives for research and educational purposes.

(5) Construct desert tortoise barrier fencing and underpasses along Highway 395; parts of Highway 58; the Randsburg-Mojave Road; the Red Rock-Randsburg Road; the Red Rock-Garlock Road; and the Atchison, Topeka, and Santa Fe Railroad north and adjacent to Highway 58 to protect desert tortoises from vehicle kills, collection, and vandalism; and to promote movement of desert tortoises within this DWMA.

(6) Sign or fence DWMA boundaries adjacent to communities and settlements such as Kramer Junction, California City, Cantil, Galileo Hill, Randsburg, Johannesburg, Atolia, and Helendale.

(7) Reduce populations of the common raven in the Fremont-Kramer DWMA to reduce predation on small desert tortoises to a point where recruitment of young into the adult cohort can occur at as rapid a rate as possible.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities of the Fremont-Kramer DWMA:

(1) Desert tortoise diseases, including URTD; toxicosis; shell lesions; general health; nutritional status; food preferences and requirements; water balance and energy flow; predation by feral dogs and other mammalian predators; raven predation; habitat restoration; the effectiveness of desert tortoise-proof fencing and culverts in eliminating road kills; interactions of desert tortoises with urban barrier fencing; protective barriers between urban development and open desert; and effects of mining, domestic sheep and cattle grazing, noise/vibrations, and cumulative impacts on mortality and survivorship (ongoing research should be continued).

(2) Translocation. Desert tortoises from adjacent lands, such as the El Mirage Open Area, should be experimentally translocated into this DWMA to increase the density of desert tortoises and salvage breeding stock.

2. *Ord-Rodman DWMA*

Current densities:

5 to 150 desert tortoises per square mile.

Location and Description:

The proposed Ord-Rodman DWMA southeast of Barstow in San Bernardino County, California, would lie approximately south of Interstate 40, east of Highway 247, west of Argus Mountain, and north of the central portion of the Fry Mountains (Figure 10). Elevations range from about 2,500 feet in Stoddard Valley to over 6,000 feet in the Ord Mountains. Several plant communities are present: Creosotebush Scrub, Indian Rice Grass Scrub-Steppe, Blackbush Scrub, and Cheesebush Scrub (west Mojave type) (Appendix E). Land ownership is a checkerboard comprised of about 65% public and 35% private lands.

Desert Tortoise Densities and Trends:

Data on population densities and trends are available from three study plots in the DWMA: Stoddard Valley, Lucerne Valley, and Johnson Valley (Berry 1990, as amended). In 1991, the densities at the Stoddard Valley plot were 125 tortoises per square mile (Berry 1990, as amended). In 1990, density at the Lucerne Valley was estimated at 82, a decline of 53% from 1980. At Johnson Valley, the 1990 density estimate was 18 tortoises per square mile, a decline of 84% from 1980. Densities over most of the DWMA are generally much lower than at these plots. Densities were probably considerably higher between the 1930's and 1950's (Berry 1984a). Declines appear to be due to human-related activities, URTD, and raven predation (Berry 1984b, Berry 1992).

Threats:

Collecting, vandalism, road kills, disease, ORV activities, livestock grazing, mining, excessive raven predation and other human-related impacts have contributed to significant population declines. The Ord-Rodman DWMA has a long history of domestic grazing by cattle and domestic sheep. Vegetation has largely been altered by grazing, but pockets of substantially unaltered vegetation remain in northern Lucerne Valley, and perhaps elsewhere. Major transportation routes for recreationists occur along power line corridors and Camp Rock, Troy, and Ft. Cady Roads.

Desert tortoises with signs of URTD have consistently been observed in eastern Stoddard Valley and Lucerne Valley since 1988 (Berry and Slone 1989). This disease is now thought to be present

throughout the DWMA and contributing to the observed high levels of mortality (Berry 1990, as amended).

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Ord-Rodman DWMA.

(1) Remove livestock grazing or, if desired, establish terms and conditions for experimental cattle grazing in EMZs.

(2) Implement emergency measures to control off-leash dogs.

(3) Construct and maintain desert tortoise barrier fencing and underpasses to protect desert tortoises and their habitat from traffic on well-used highways and roads such as Highway 247.

(4) Construct and maintain special fencing to protect desert tortoises from recreational-vehicle use in the Johnson Valley Open Area and surrounding lands.

(5) Sign DWMA boundaries in the vicinity of Barstow, Newberry Springs, Lucerne, Landers, Lucerne Valley, etc.

(6) Establish a drop-off site for unwanted captive desert tortoises at the BLM's Barstow Way Station. Develop programs to promote use of unwanted desert tortoises for research and educational purposes.

(7) Reduce populations of the common raven to lessen predation on juvenile desert tortoises and ensure recruitment of juveniles into the subadult and adult populations, thus allowing a rapid recovery of the desert tortoise.

(8) Designate the Ord-Rodman DWMA as an Ecological Reserve and Research Natural Area.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities of the Ord-Rodman DWMA:

(1) Translocation of desert tortoises from adjacent lands, such as the Johnson and Stoddard Valley Open Areas, into the DWMA to augment low densities of desert tortoises and to salvage breeding stock.

(2) Disease epidemiology; the effects of ravens and other predators on desert tortoise populations; and the effects of hunting of upland birds, big game, and fur bearers on desert tortoises and their habitat.

3. *Superior-Cronese DWMA*

Current densities:

20 to 250 desert tortoises per square mile.

Location and Description:

The proposed Superior-Cronese DWMA in San Bernardino County, California, would be bordered on the west by the Fremont-Kramer DWMA and Cuddeback Dry Lake, on the north by the northern end of Superior Valley and NASA Road on the National Training Center, on the east by West Cronese Dry Lake, on the southeast by Interstate 15, and on the south and southwest by Rainbow Basin National Natural Landmark and the southern end of the Gravel Hills (Figure 10). This DWMA is diverse topographically and vegetationally. It includes numerous dry lakes and springs and parts of several mountain ranges. Land ownership is about 63% BLM, 22% private, and 15% Department of Defense.

Desert Tortoise Densities and Trends:

Part of the Superior-Cronese DWMA has been surveyed for desert tortoises with triangular transects (Berry and Nicholson 1984a; Chambers Group 1990; Kiva Biological Consulting and McClenahan and Hopkins Associates 1991; Woodman and Goodlett 1990; Woodman et al. 1984). These data indicate patchy concentrations of desert tortoises throughout the DWMA. D. Morafka and M. Joyner-Griffith (California State University, Northridge, pers. comm.) found a wide range of younger age-size classes represented throughout the eastern portion of the DWMA, indicating a high probability of successful reproduction and possible recruitment there. Densities are thought to be depressed as a result of a number of human impacts and disease.

Threats:

The Superior-Cronese DWMA is one of the more threatened DWMAs. Current activities include livestock grazing (mostly cattle, but some sheep), small local mining operations, power and other utility lines, civilian and military ORV activity, aerial ordnance testing on the northern periphery, construction and operation of space communications and experimental stations, small-scale horticulture and agriculture in the vicinity of Coyote Lake, and hunting. The Kern River natural gas pipeline was constructed through the DWMA in 1991. One herd management area for feral equids occurs in this area (BLM 1980a).

An adult desert tortoise symptomatic for URTD was discovered near Barstow on the Ft. Irwin Road in spring 1991; however, the proposed Superior-Cronese DWMA contains at least some areas where desert tortoises are apparently free of URTD, shell disease, and other diseases. The observed health of desert tortoises within the DWMA appeared to be excellent as of spring 1992.

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Superior-Cronese DWMA.

(1) Remove livestock grazing or, if desired, establish terms and conditions for experimental grazing in EMZs.

(2) Establish a drop-off site for unwanted captive desert tortoises at BLM's Barstow Way Station (see Ord-Rodman DWMA summary). Develop programs to make unwanted captives available for research and educational purposes.

(3) Construct barrier fencing along Interstate 15, Ft. Irwin Road, Manix Trail, Superior Lake Road, and the northern border of the DWMA to protect desert tortoises from vehicles, collection, and habitat degradation.

(4) Sign DWMA boundaries adjacent to communities and settlements including Barstow, small settlements north of Barstow, and other areas with conflicting uses.

(5) Construct highway underpasses along the Ft. Irwin Road to allow desert tortoise movement and to facilitate genetic exchange throughout this DWMA.

(6) Reduce raven populations in the DWMA to lessen mortality of small desert tortoises to a point where recruitment into the adult cohort can occur at as rapid a rate as possible.

(7) Initiate cleanup of surface toxic chemicals and unexploded ordnance.

(8) Fence the periphery of the DWMA as needed to enforce regulations and protect desert tortoises from human impacts. Along the boundary with the Fremont-Kramer DWMA, a double row of desert tortoise barrier fencing may be necessary to prevent the spread of URTD into the Superior-Cronese DWMA.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented by the Superior-Cronese DWMA:

(1) The effects of domestic sheep grazing, wave/radiant energy, visitor use, military traffic, ORVs, and highways on the desert tortoise and its habitat.

(2) Epidemiology of URTD and other diseases; physiological, ecological, nutritional, and behavioral requirements of hatchling and juvenile desert tortoises; nutritional qualities of preferred food plants; habitat restoration; and characteristics of undisturbed desert tortoise habitat. Continue using the latest medical techniques to assess the health of desert tortoises. Conduct epidemiological surveys to determine the distribution and frequency of desert tortoises with URTD and other diseases. These surveys are critical to determine if fencing is necessary within the DWMA or between the Fremont-Kramer DWMA and the Superior-Cronese DWMA.

4. Joshua Tree DWMA

Current densities:

Up to 200 desert tortoises per square mile.

Location and Description:

The proposed Joshua Tree DWMA in Riverside and San Bernardino Counties, California, includes Joshua Tree National Monument (Monument) and adjacent lands in the Pinto Mountains, Eagle Mountains, and elsewhere on the perimeter of the Monument (Figure 10). It includes elements of both the Colorado and Mojave deserts, and it occurs partly in the eastern Colorado recovery unit and primarily in the western Mojave recovery unit. Elevations range from below 1,500 feet in Pinto Basin to 5,814 feet at Quail Mountain. Most of the proposed DWMA is managed by the National Park Service.

Desert Tortoise Densities and Trends:

Density data are available from two study plots in the Monument: the Panorama and Pinto Basin plots. In 1991, densities were estimated at 200 and 226 desert tortoises per square mile at the Pinto Basin and Panorama plots, respectively (Freilich and Moon 1991). Triangular transects have also been conducted in the Monument. These data show that distribution and densities of desert tortoises in the Monument are patchy, and densities are typically much lower than at the two study plots. Desert tortoises are frequently reported from between Smoke Tree Wash and Cottonwood Pass near the southern end of the Monument, and relatively high densities are thought to occur near the Coxcomb Mountains (Karl 1988, Dr. Jerry Freilich, Monument, pers. comm., 1992). Recent surveys in the Monument indicate few tortoises occur near the main road which dissects the Monument (J. Freilich, pers. comm., 1992).

Because of differing techniques used to calculate densities at different times, existing data are not appropriate to derive trends. Based on a large number of remains, Barrow (1979) believed densities were declining at the Pinto Basin plot; however higher densities were registered (using different techniques) in 1991 (Freilich and Moon 1991).

Threats:

Because of protective management by the National Park Service, this DWMA is one of the least threatened DWMAs. Within the Monument, vehicle access is restricted to 130 miles of roads, and no mining, ORV use, or grazing is permitted. Prior to establishment of

the Monument in the 1930's, the western half of the DWMA was intensively grazed, hard-rock mining occurred, and numerous settlements were present. Limited grazing continued into the 1950's (Hickman 1977). Areas of the proposed Joshua Tree DWMA which lie outside the Monument are primarily managed by BLM for multiple use. Evidence of mining can be seen in the Eagle and Pinto Mountains, east and north of the Monument, respectively. The proposed Eagle Mountain Landfill is located at the eastern end of the DWMA.

In 1991, two desert tortoises were found with signs of URTD at the western end of the Monument where releases of desert tortoises have occurred in the past. No other diseased animals have been reported.

Specific Management Actions:

In addition to the management actions recommended for all DWMAs (Section II.E.2.), the following specific actions should be implemented in the Joshua Tree DWMA:

(1) Establish a portion of the visitor center for the purpose of educating visitors to the Monument on the status and plight of the desert tortoise and its recovery needs, and to serve as a drop-off site for unwanted captive desert tortoises. Develop programs to make these animals available for educational or research purposes.

(2) Construct desert tortoise barrier fencing to protect desert tortoises and their habitat from human activities along roads and in urban settings. This should include desert tortoise barrier fencing along the north side of the DWMA boundary and along the road from Cottonwood Pass through the Monument from Desert Center to the Eagle Mountain Mine. Desert tortoise underpasses should accompany fence construction along the Cottonwood Pass Road, as well. Chain-link fence may be needed in some areas as barbed wire does not prevent urban encroachment. If fencing is not permitted within the Monument, expand the boundary of the DWMA to the boundary of the Monument.

Recommended Research:

The following research topics are especially suited to the management needs and opportunities presented in the Joshua Tree DWMA:

(1) The genetic origin of existing desert tortoises in the Monument, focusing at the northwestern end of the Monument near the release locations.

(2) Habitat restoration.

(3) Desert tortoise predation, including level of raven predation at the Monument and adjacent urban areas, and raven predation as a reflection of certain types of human uses.

(4) The effects of non-vehicular oriented recreation on desert tortoises and their habitat.

Appendix G

Desert Tortoise
(Mojave Population)

Recovery Plan

Appendix G: Environmental Determinants of Population Size

Census data and anecdotal accounts indicate that desert tortoise populations existed at quite different densities in various parts of the Mojave region prior to their recent decline. Thus, it is reasonable to expect that different DWMAs will support different tortoise densities after recovery, depending upon each reserve's particular ecological conditions and geographic location. Site-specific density might be equivalent to "carrying capacity," the density at which population growth is reduced as a result of competition among individual animals, although no data demonstrate such density-dependent feedback in desert tortoise populations. Another of the many possible factors that might determine site-specific density is the average amount of food available to tortoises during their active season. Food availability has the potential to control individual growth rates and, consequently, the age at which a tortoise reaches the size of reproductive competence. Food availability also influences fecundity. Both of these factors influence population growth rates and, hence, densities.

Some data do suggest that food availability is related to site-specific desert tortoise densities. Figure G1 shows the relationship between the highest recorded population density of adult and subadult tortoises at a study site and the mean production of annual forbs and grasses at the site, the latter being an index of long-term average food availability. Although highly significant, this correlation does not necessarily indicate causation. Many other factors, including those that might covary with food availability (e.g., variance in food availability), could actually be more important in determining population density. Nevertheless, this relationship might be used as a starting point to estimate a "target density" for each DWMA.

Before the concept of target density can be utilized effectively, research must be initiated to determine the strength and generality of the relationship indicated in Figure G1 and to identify the mechanisms underlying this relationship. Figure G1 represents only one hypothesis about factors which might determine desert tortoise population densities.

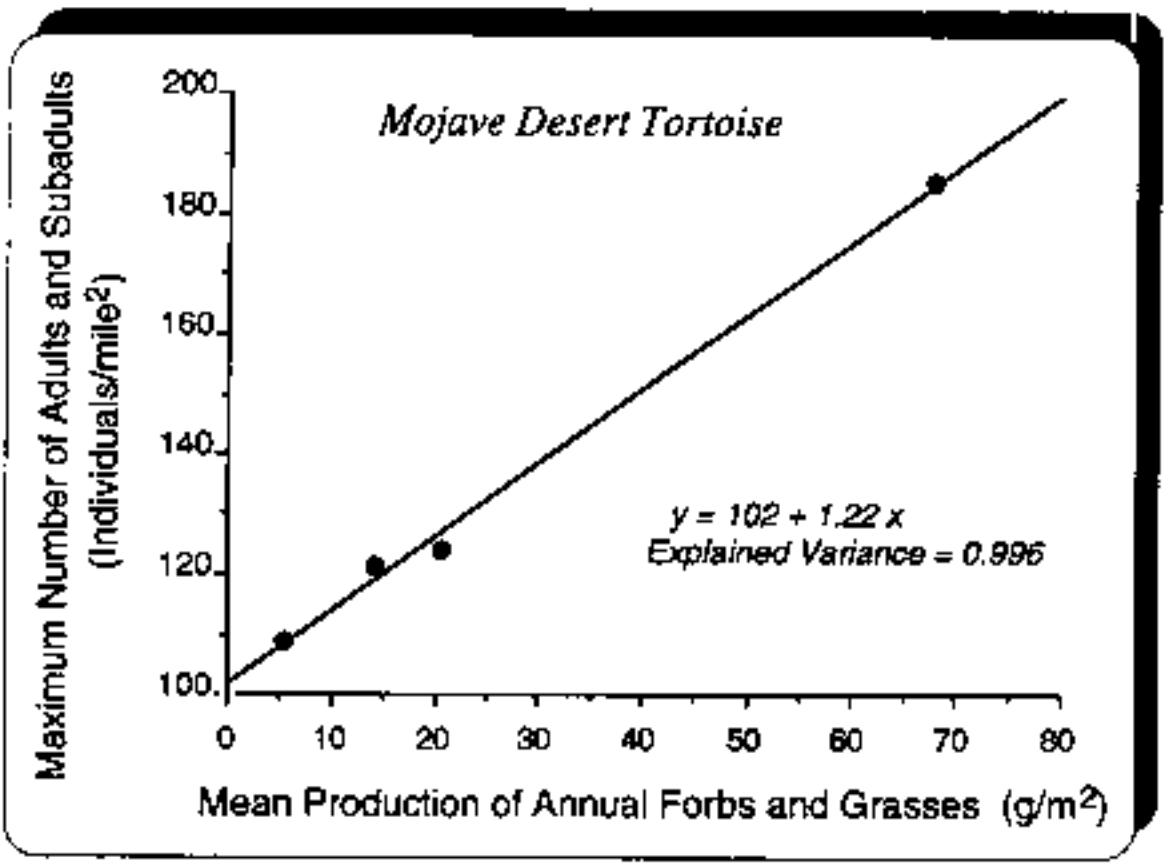
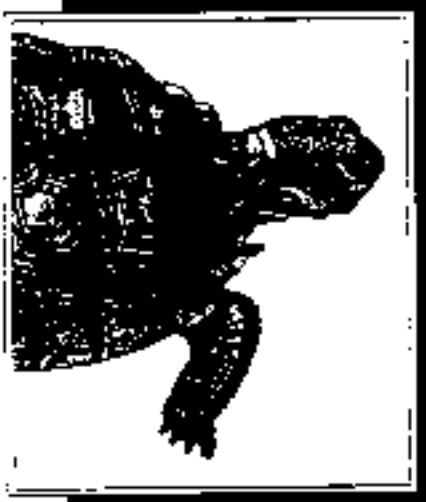


Figure G1. The highest estimated number of adult and subadult desert tortoises in a study site as a function of the long-term average production of spring annuals available in the same area. The sites represented are the Desert Tortoise Natural Area (Interior) Study Site, California; the Stoddard Valley Study Site, California; the Goffs Study Site, California; and the Woodbury/Hardy Study Site, Utah.

Appendix H

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix H: Critical Habitat for the Desert Tortoise (Mojave Population)

On February 8, 1994, the U.S. Fish and Wildlife Service published a final rule in the *Federal Register* (59 FR 5820) designating 6.4 million acres of critical habitat for the Mojave population of the desert tortoise (*G. agassizii*). This designation includes primarily Federal lands in southwestern Utah, northwestern Arizona, southern Nevada, and southern California.

In California, critical habitat designation totals 4,754,000 acres in Imperial, Kern, Los Angeles, Riverside, and San Bernardino counties. Of this, 3,327,400 acres are Bureau of Land Management land, and 242,200 acres are military land. The remainder includes 132,900 acres of state land and 1,051,500 acres that are privately owned.

In Nevada, four units totalling 1,224,400 acres are designated in Clark and Lincoln counties. Of this, 1,085,000 acres are Bureau of Land Management land, 103,600 acres are National Park Service land, and 35,800 acres are private.

In Utah, two units totalling 129,100 acres are designated in Washington County. This consists of 89,400 acres of Bureau of Land Management land, 27,600 acres of state land, 1,600 acres of Indian Tribal land, and 10,500 acres of private land.

In Arizona, two units totalling 338,700 acres are designated in Mohave County. This includes 288,800 acres of Bureau of Land Management land, 43,600 acres of National Park Service land, 5,700 acres of state land, and 600 acres of private land.

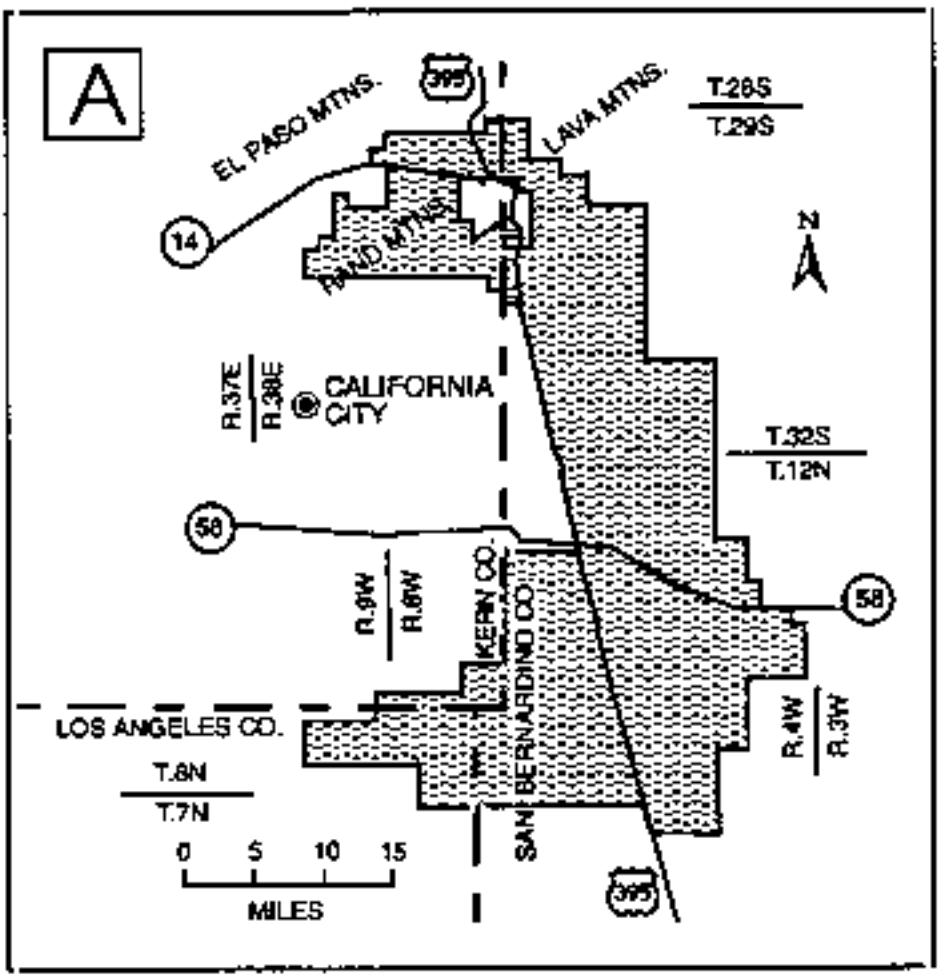
California. Areas of land as follows:

1. **Fremont-Kramer Unit.** Kern, Los Angeles, and San Bernardino Counties. From Bureau of Land Management Maps: Victorville 1978 and Cuddeback Lake 1978. (Index map location A).

Mt. Diablo Meridian: T. 29 S., R. 39 E., secs. 13, 14, 22-26, 35, and 36; T. 29 S., R. 40 E., secs. 12-33; T. 29 S., R. 41 E., secs. 7, 8, 17-20, 27-30, and 32-36; T. 30 S., R. 38 E., secs. 24-26, 35, and 36; T. 30 S., R. 39 E., secs. 1-36 except secs. 3-5; T. 30 S., R. 40 E., secs. 4-9, and 13-36, except that portion of secs. 13, 14, and 23 lying northwesterly of the Randsburg-Mojave Road; T. 30 S., R. 41 E., secs. 1-36, except secs. 5-8, and 20 and that portion of secs. 17 and 18 lying easterly of U.S. Highway 395; T. 30 S., R. 42 E., secs. 7-10, 15-22, and 27-34; T. 31 S., R. 40 E., secs. 1 and 6, except that portion of sec. 6 lying southeasterly of the Randsburg-Mojave Road; T. 31 S., R. 41 E., secs. 1-17, 20-29, and 32-36, except that portion of secs. 20, 29 and 32 lying westerly of U.S. Highway 395; T. 31 S., R. 42 E., secs. 3-10, 15-22, and 27-34; T. 32 S., R. 41 E., secs. 1-4, 9-16, 21-28, and 34-36, except that portion of secs. 4, 9, 16, 21, 27, 28, and 34 lying westerly of U.S. Highway 395; T. 32 S., R. 42 E., secs. 1-36; T. 32 S., R. 43 E., secs. 4-9, 16-21, and 28-33.

San Bernardino Meridian: T. 7 N., R. 5 W., secs. 2-11, and 14-18, except that portion of sec. 18, lying west of U.S. Highway 395; T. 7 N., R. 6 W., secs. 1-6, 12, and 13, except that portion of secs. 1, 12, and 13 lying westerly of U.S. Highway 395; T. 7 N., R. 7 W., secs. 1-6; T. 7 N., R. 8 W., secs. 1-4; T. 8 N., R. 4 W., secs. 6, 7, and 18; T. 8 N., R. 5 W., secs. 1-35 except secs. 24 and 25; T. 8 N., R. 6 W., secs. 1-36; T. 8 N., R. 7 W., secs. 1-36; T. 8 N., R. 8 W., secs. 1-28, and 33-36; T. 8 N., R. 9 W., secs. 1 and 7-24; T. 9 N., R. 4 W., secs. 2-11, 14-23, 30, and 31; T. 9 N., R. 5 W., secs. 1-36; T. 9 N., R. 6 W., secs. 1-36; T. 9 N., R. 7 W., secs. 1-4, 9-16, and 19-36; T. 9 N., R. 8 W., secs. 24, 25, and 31-36; T. 9 N., R. 9 W., sec. 36; T. 10 N., R. 4 W., secs. 6, 7, 18-20, and 29-34; T. 10 N., R. 5 W., secs. 1-36; T. 10 N., R. 6 W., secs. 1-36 except sec. 6; T. 10 N., R. 7 W., secs. 9-16, 21-28, and 33-36; T. 11 N., R. 5 W., secs. 2-11, 14-23, and 26-35; T. 11 N., R. 6 W., secs. 1-36, except that portion of secs. 6, 7, 18, 19, 30, and 31 lying westerly of U.S. Highway 395; T. 11 N., R. 7 W., that portion of sec. 1, lying easterly U.S. Highway 395; T. 12 N., R. 5 W., secs. 31-35; T. 12 N., R. 6 W., secs. 31-36; T. 12 N., R. 7 W., that portion of sec. 36 lying easterly of U.S. Highway 395.

FREMONT-KRAMER

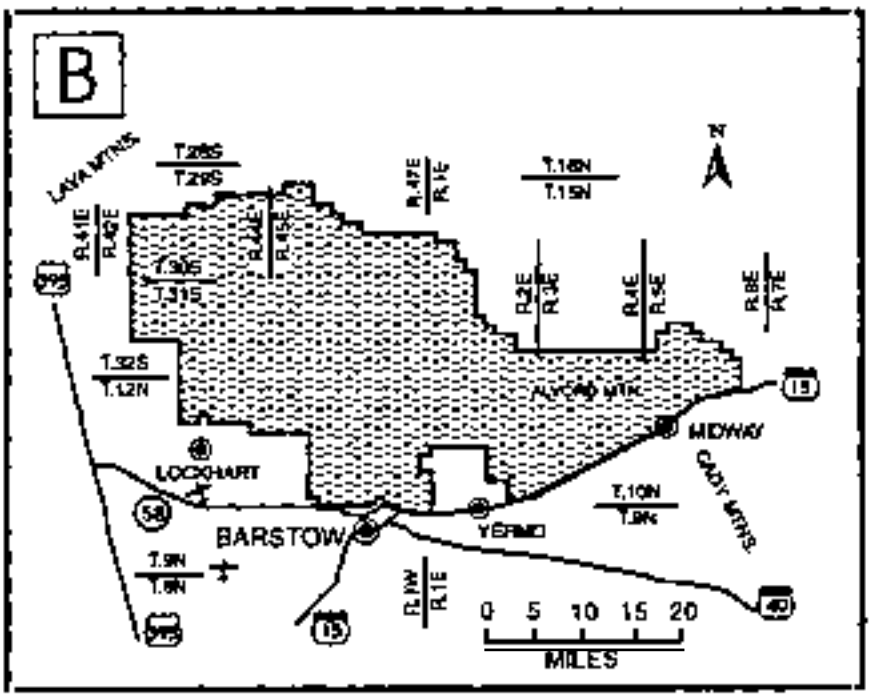


2. **Superior-Cropese Unit.** San Bernardino County. From Bureau of Land Management Maps: Cuddeback Lake 1978, Soda Mts. 1978, Victorville 1978, and Newberry Springs 1978. (Index map location B).

Mt. Diablo Meridian: T. 29 S., R. 42 E., secs. 35 and 36; T. 29 S., R. 43 E., secs. 25, 26, and 31-36; T. 29 S., R. 44 E., secs. 20-36; T. 29 S., R. 45 E., secs. 14-16, 19-23, and 25-36; T. 29 S., R. 46 E., secs. 30-32; T. 30 S., R. 42 E., secs. 1, 2, 11-14, 23-26, 35, and 36; T. 30 S., R. 43 E., secs. 1-36; T. 30 S., R. 44 E., secs. 1-36; T. 30 S., R. 45 E., secs. 1-36; T. 30 S., R. 46 E., secs. 3-36; T. 30 S., R. 47 E., secs. 7-10, 15-22, and 27-34; T. 31 S., R. 42 E., secs. 1, 2, 11-14, 23-26, 35, and 36; T. 31 S., R. 43 E., secs. 1-36; T. 31 S., R. 44 E., secs. 1-36; T. 31 S., R. 45 E., secs. 1-36; T. 31 S., R. 46 E., secs. 1-36; T. 31 S., R. 47 E., secs. 3-10, 15-22, and 27-34; T. 32 S., R. 43 E., secs. 1-3, 10-15, 22-27, and 34-36; T. 32 S., R. 44 E., secs. 1-36; T. 32 S., R. 45 E., secs. 1-36; T. 32 S., R. 46 E., secs. 1-36; T. 32 S., R. 47 E., secs. 3-10, 15-22, and 27-34.

San Bernardino Meridian: T. 9 N., R. 1 W., that portion of secs. 1 and 2 lying northerly of Interstate Highway 15; T. 9 N., R. 1 E., that portion of sec. 6 lying northerly of Interstate Highway 15; T. 10 N., R. 2 W., secs. 1-29; T. 10 N., R. 1 W., secs. 1-28, 30, and 33-36, except that portion of secs. 33-35 lying southwesterly of Interstate Highway 15; T. 10 N., R. 1 E., secs. 18, 19, 30, and 31; T. 10 N., R. 2 E., secs. 1-5, 8-17, and 22-34, except that portion of secs. 25, 26, and 34 lying southeasterly of Interstate Highway 15; T. 10 N., R. 3 E., secs. 1-12, 14-21, and 30, except that portion of secs. 11, 12, 14-16, 19-21, and 30 lying southeasterly of Interstate Highway 15; T. 10 N., R. 4 E., that portion of secs. 5-7 lying northwesterly of Interstate Highway 15; T. 11 N., R. 5 W., secs. 1 and 12; T. 11 N., R. 4 W., secs. 1-7, 9, 11, and 12; T. 11 N., R. 3 W., secs. 1-18; T. 11 N., R. 2 W., secs. 1-36; T. 11 N., R. 1 W., secs. 1-36; T. 11 N., R. 1 E., secs. 1-31; T. 11 N., R. 2 E., secs. 1-36 except sec. 31; T. 11 N., R. 3 E., secs. 1-36; T. 11 N., R. 4 E., secs. 1-34, except that portion of secs. 25, 26, 33, and 34 lying southeasterly of Interstate Highway 15; T. 11 N., R. 5 E., secs. 1-11 and 15-20, except that portion of secs. 1, 2, 10, 11, 15-17, 19, and 20 lying southeasterly of Interstate Highway 15; T. 12 N., R. 5 W., sec. 36; T. 12 N., R. 4 W., secs. 31-36; T. 12 N., R. 3 W., secs. 31-36; T. 12 N., R. 2 W., secs. 31-36; T. 12 N., R. 1 W., secs. 31-36; T. 12 N., R. 1 E., secs. 1-36; T. 12 N., R. 2 E., secs. 3-36; T. 12 N., R. 3 E., secs. 7-36; T. 12 N., R. 4 E., secs. 7-36; T. 12 N., R. 5 E., secs. 1-5 and 7-36; T. 12 N., R. 6 E., secs. 5-9, 15-22, and 27-34, except that portion of secs. 31-34 lying southerly of Interstate Highway 15; T. 13 N., R. 1 E., secs. 1-36; T. 13 N., R. 2 E., secs. 19 and 29-34; T. 13 N., R. 5 E., secs. 26-28 and 32-36; T. 14 N., R. 1 E., secs. 5-10, 15-23, and 24-36.

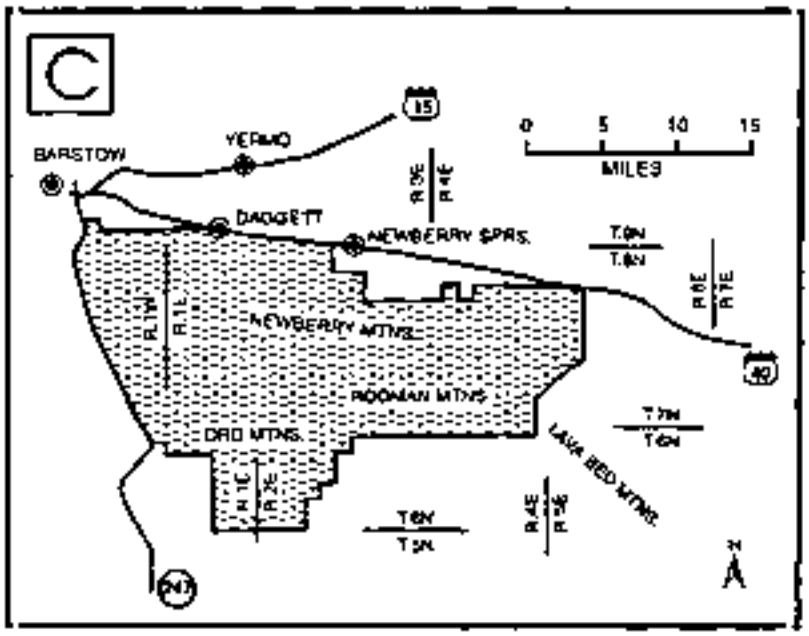
SUPERIOR-CRONESE



3. **Ord-Rodman Unit.** San Bernardino County. From Bureau of Land Management Maps: Newberry Springs 1978 and Victorville 1978. (Index map location C).

San Bernardino Meridian: T. 6 N., R. 1 E., secs. 1-6, 10-15, 22-27, and 34-36; T. 6 N., R. 2 E., secs. 1-11, 14-22, and 28-33; T. 7 N., R. 1 W., secs. 1-4, 9-15, 22-26, 35, and 36, except that portion of secs. 4, 9, 10, 15, 22, 23, 26, and 35 lying southwesterly of State Highway 247; T. 7 N., R. 1 E., secs. 1-36; T. 7 N., R. 2 E., secs. 1-36; T. 7 N., R. 3 E., secs. 1-36; T. 7 N., R. 4 E., secs. 1-36; T. 7 N., R. 5 E., secs. 4-9 and 17-19, except that portion of secs. 4, 8, 9, and 17-19 lying southerly of the northern boundary of Twentynine Palms Marine Corps Base; T. 8 N., R. 1 W., secs. 1-18, 20-29, and 32-36, except that portion of secs. 6, 7, 17, 18, 20, 29, 32, and 33 lying southwesterly of State Highway 247; T. 8 N., R. 1 E., secs. 1-36; T. 8 N., R. 2 E., secs. 2-36; T. 8 N., R. 3 E., secs. 7 and 18-36; T. 8 N., R. 4 E., secs. 13-16 and 18-36; T. 8 N., R. 5 E., secs. 16-18, 19-21, 28-30, and 31-33, except that portion of secs. 16 and 17 lying northerly of Interstate Highway 40; T. 9 N., R. 1 W., secs. 19, 20, and 25-36, except that portion of secs. 19, 20, and 29-31 lying westerly of State Highway 247; T. 9 N., R. 1 E., secs. 25-36, except that portion of secs. 25-27 lying northerly of Interstate Highway 40; T. 9 N., R. 2 E., secs. 27-35, except that portion of secs. 27-30 lying northerly of Interstate Highway 40.

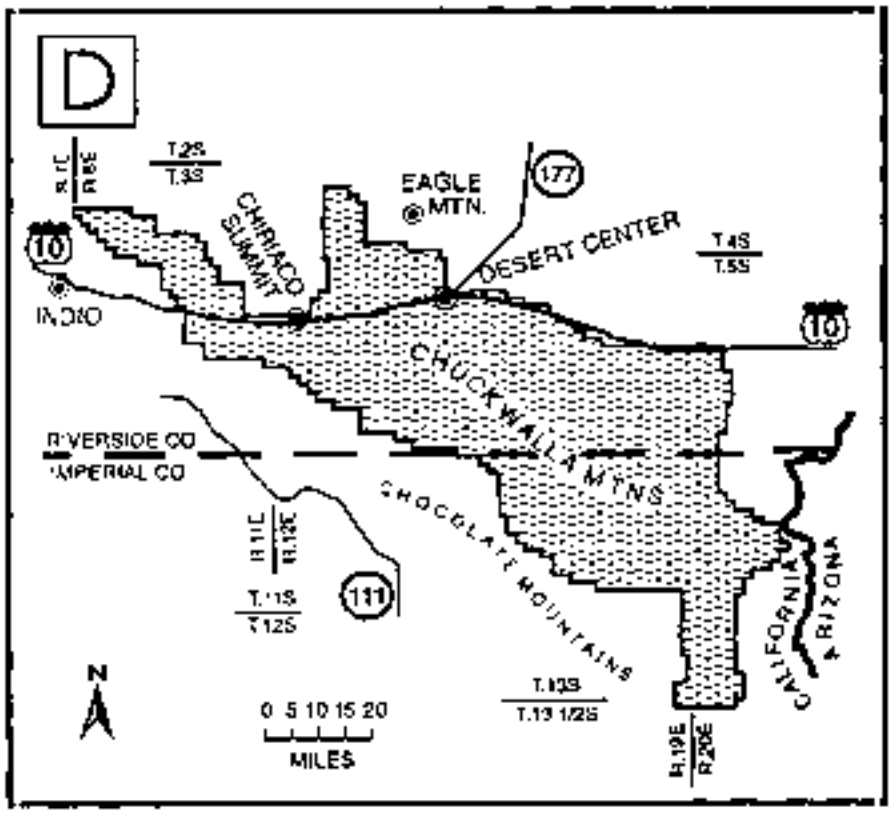
ORD-RODMAN


C
BARSTOW
YERMO
DAGGETT
NEWBERRY SPRS.
NEWBERRY MTNS.
RODMAN MTNS.
ORD MTNS.
LAVA BED MTNS.
0 5 10 15
MILES
15
40
247

4. Chuckwalla Unit. Imperial and Riverside Counties. From Bureau of Land Management Maps: Chuckwalla #18 1978, Parker-Blythe #16 1978, Salton Sea #20 1978, and Midway Well #21 1979. (Index map location D).

San Bernardino Meridian: T. 3 S., R. 13 E., secs. 19-21 and 27-35; T. 4 S., R. 8 E., secs. 1-6, 8-16, 22-26, and 36; T. 4 S., R. 9 E., secs. 6-10, and 15-36; T. 4 S., R. 10 E., secs. 19-21, and 27-34; T. 4 S., R. 13 E., secs. 2-36 except secs. 12 and 13; T. 4 S., R. 14 E., secs. 27-36; T. 4 S., R. 15 E., secs. 31 and 32; T. 5 S., R. 9 E., secs. 1-4, 12, 13, and 24; T. 5 S., R. 10 E., secs. 2-36 except sec. 31; T. 5 S., R. 11 E., secs. 19-21 and 28-33; T. 5 S., R. 12 E., sec. 36; T. 5 S., R. 13 E., secs. 1-36 except secs. 6 and 7; T. 5 S., R. 14 E., secs. 1-36; T. 5 S., R. 15 E., secs. 4-9, 16-21, 25, S 1/2 sec. 26, S 1/2 sec. 27, and secs. 28-36; T. 5 S., R. 16 E., secs. 28-35; T. 6 S., R. 10 E., secs. 1-4, 9-16, 21-26, 35 and 36; T. 6 S., R. 11 E., secs. 4-36; T. 6 S., R. 12 E., secs. 1-36; T. 6 S., R. 13 E., secs. 1-36; T. 6 S., R. 14 E., secs. 1-36; T. 6 S., R. 15 E., secs. 1-36; T. 6 S., R. 16 E., secs. 1-36; T. 6 S., R. 17 E., secs. 5-9, and 14-36; T. 6 S., R. 18 E., secs. 29-36; T. 6 S., R. 19 E., secs. 31-36; T. 6 S., R. 20 E., secs. 31-34; T. 7 S., R. 11 E., sec. 1; T. 7 S., R. 12 E., secs. 1-6, 9-15, and 23-25; T. 7 S., R. 13 E., secs. 1-30 and 31-36; T. 7 S., R. 14 E., secs. 1-36; T. 7 S., R. 15 E., secs. 1-36; T. 7 S., R. 16 E., secs. 1-36; T. 7 S., R. 17 E., secs. 1-36; T. 7 S., R. 18 E., secs. 1-36; T. 7 S., R. 19 E., secs. 1-36; T. 7 S., R. 20 E., secs. 3-10, 14-23, and 26-35; T. 8 S., R. 13 E., secs. 1, 2, and 11-14; T. 8 S., R. 14 E., secs. 1-18, and secs. 21-26; T. 8 S., R. 15 E., secs. 1-30 and 34-36; T. 8 S., R. 16 E., secs. 1-36; T. 8 S., R. 17 E., secs. 1-36; T. 8 S., R. 18 E., secs. 1-36; T. 8 S., R. 19 E., secs. 1-36; T. 8 S., R. 20 E., secs. 3-10, 15-22, and 28-33; T. 9 S., R. 15 E., sec. 1; T. 9 S., R. 16 E., secs. 1-17, 20-29, and 32-36; T. 9 S., R. 17 E., secs. 1-36; T. 9 S., R. 18 E., secs. 1-36; T. 9 S., R. 19 E., secs. 1-36; T. 9 S., R. 20 E., secs. 5-8, 17-20, and 29-33; T. 10 S., R. 16 E., secs. 1-5, 9-16, and 22-26; T. 10 S., R. 17 E., secs. 1-36; T. 10 S., R. 18 E., secs. 1-36; T. 10 S., R. 19 E., secs. 1-36; T. 10 S., R. 20 E., secs. 3-36; T. 10 S., R. 21 E., secs. 18-21 and 28-34; T. 10 1/2 S., R. 21 E., secs. 31-33; T. 11 S., R. 17 E., secs. 1-5 and 8-15; T. 11 S., R. 18 E., secs. 1-24; T. 11 S., R. 19 E., secs. 1-26, 35, and 36; T. 11 S., R. 20 E., secs. 1-23 and 26-34; T. 11 S., R. 21 E., secs. 4-8; T. 12 S., R. 19 E., secs. 1, 2, 11-14, 23-26, 35, and 36; T. 12 S., R. 20 E., secs. 3-10, 15-22, and 27-34; T. 13 S., R. 19 E., secs. 1, 2, 11, 12, 22-27, and 34-36; T. 13 S., R. 20 E., secs. 3-10, 14-23, and 26-34.

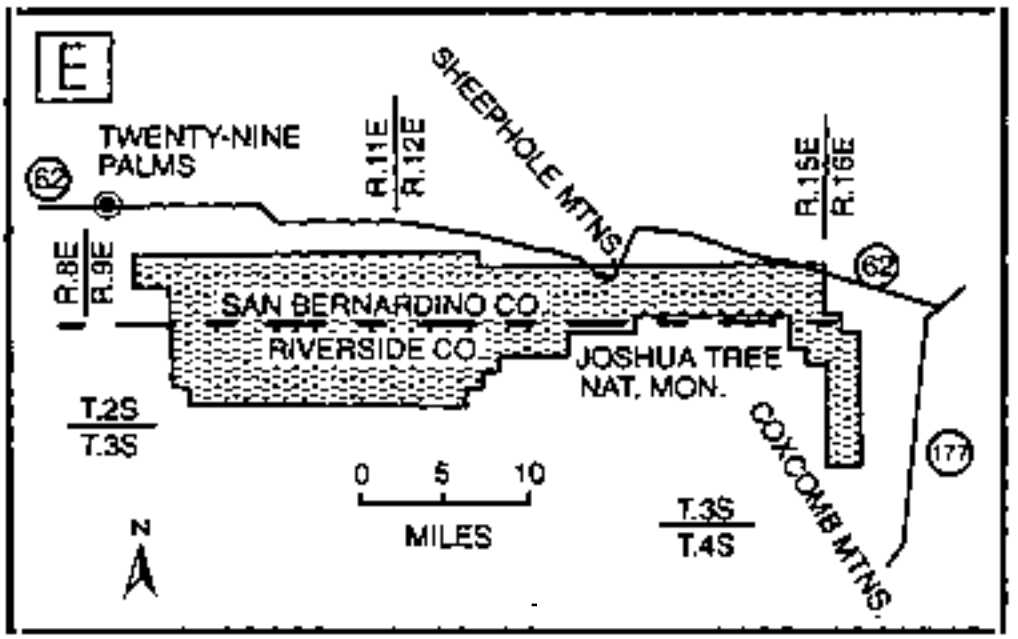
CHUCKWALLA


D
EAGLE MTN.
177
DESERT CENTER
CHIRIACO SUMMIT
10
INDIO
CHUCKWALLA MTNS
RIVERSIDE CO
IMPERIAL CO
CHOCOLATE MOUNTAINS
111
CALIFORNIA
ARIZONA
N
0 5 10 15 20
MILES

5. <u>Pinto Mountain Unit.</u> Riverside and San Bernardino Counties. From Bureau of Land Management Maps: Yucca Valley 1982, Sheep Hole Mountains 1978, Chuckwalla 1978, and Palm Springs #17 1978. (Index map location E).

San Bernardino Meridian: T. 1 S., R. 9 E., secs. 10-15, 24, 25, and 36; T. 1 S., R. 10 E., secs. 7-36; T. 1 S., R. 11 E., secs. 7-36; T. 1 S., R. 12 E., secs. 7-36 except sec. 12; T. 1 S., R. 13 E., secs. 13-36; T. 1 S., R. 14 E., secs. 13-32; T. 1 S., R. 15 E., secs. 13-30 and 36; T. 1 S., R. 16 E., secs. 18, 19, and 30-32; T. 2 S., R. 9 E., secs. 1, 12, and 13; T. 2 S., R. 10 E., secs. 1-24; T. 2 S., R. 11 E., secs. 1-24; T. 2 S., R. 12 E., secs. 1-22 except sec. 13; T. 2 S., R. 13 E., secs. 3-6; T. 2 S., R. 15 E., sec. 1; T. 2 S., R. 16 E., secs. 4-9, 16, 17, 20, 21, 28, 29, 32, and 33; T. 3 S., R. 16 E., secs. 4, 5, 8, and 9.

PINTO MOUNTAIN

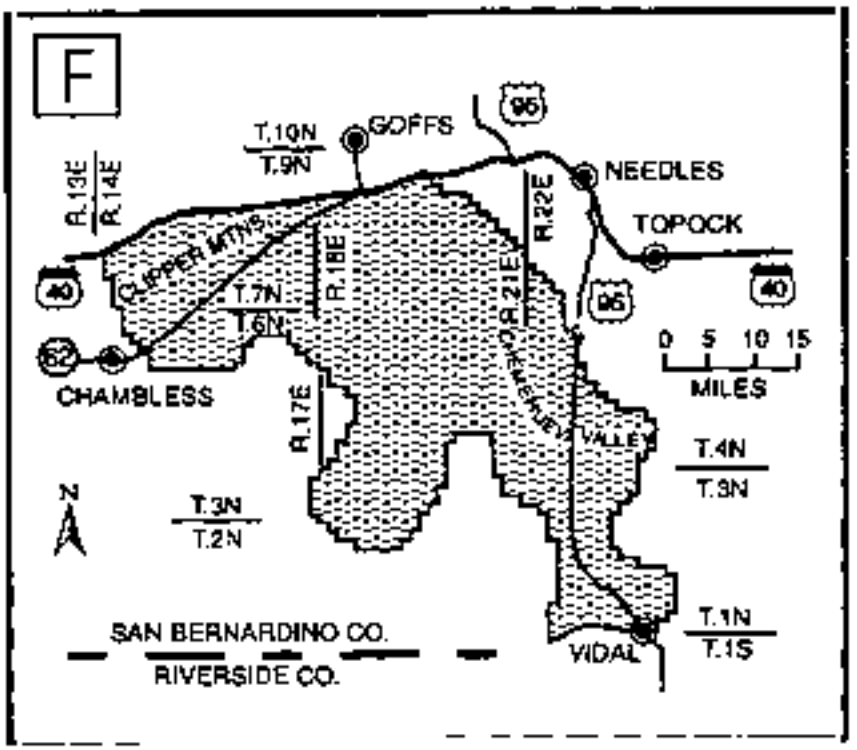


6. **Chemehuevi Unit.** San Bernardino County. From Bureau of Land Management Maps: Sheep Hole Mts. 1978, Parker 1979, Needles 1978, and Amboy 1991. (Index map location F).

San Bernardino Meridian: T. 1 S., R. 22 E., that portion of secs. 3-5, lying northwesterly of the Atchison Topeka and Santa Fe Railroad; T. 1 S., R. 23 E., that portion of secs. 1-3 lying northerly of the Atchison Topeka and Santa Fe Railroad, except that portion of sec. 1, lying easterly of U.S. Highway 95; T. 1 N., R. 22 E., secs. 1-4, 9-16, 20-29, and 32-36, except that portion of secs. 34-36 lying southerly of the Atchison Topeka and Santa Fe Railroad; T. 1 N., R. 23 E., secs. 1-36, except that portion of secs. 31-34 lying southerly of Atchison Topeka and Santa Fe Railroad; T. 1 N., R. 24 E., secs. 4-9, 16-21, and 29-31; T. 2 N., R. 18 E., secs. 1-5, and 9-14; T. 2 N., R. 19 E., secs. 2-10, and 16-18; T. 2 N., R. 22 E., secs. 1-5, 8-16, 21-28, and 33-36; T. 2 N., R. 23 E., secs. 5-8, 17-21, and 26-36; T. 2 N., R. 24 E., secs. 31 and 32; T. 3 N., R. 17 E., secs. 12, 13, 24, and 25; T. 3 N., R. 18 E., secs. 1-36; T. 3 N., R. 19 E., secs. 1-35; T. 3 N., R. 20 E., secs. 5-8, 18, and 19; T. 3 N., R. 21 E., secs. 1-5, 9-16, 23, and 24; T. 3 N., R. 22 E., secs. 1-36 except sec. 31; T. 3 N., R. 23 E., secs. 2-11, 14-22, and 28-32; T. 4 N., R. 18 E., secs. 1, 2, 10-15, 21-28, and 32-36; T. 4 N., R. 19 E., secs. 1-36; T. 4 N., R. 20 E., secs. 1-12, 16-20, and 29-32; T. 4 N., R. 21 E., secs. 1-17, 20-29, and 32-36; T. 4 N., R. 22 E., secs. 1-36; T. 4 N., R. 23 E., secs. 1-35; T. 4 N. R. 24 E., Secs 6, 7, 18, and 19; T. 5 N., R. 15 E., secs. 1-6; T. 5 N., R. 16 E., secs. 4-6; T. 5 N., R. 18 E., secs. 1-6, 8-17, 22-26, 35, and 36; T. 5 N., R. 19 E., secs. 1-36; T. 5 N., R. 20 E., secs. 1-36; T. 5 N., R. 21 E., secs. 1-36; T. 5 N., R. 22 E., secs. 2-36; (Unsurveyed) T. 5 N., R. 23 E., protracted secs. 19, and 29-33; T. 6 N., R. 14 E., secs. 1-3, 10-15, and 23-25; T. 6 N., R. 15 E., secs. 1-36; T. 6 N., R. 16 E., secs. 1-23, and 27-34; T. 6 N., R. 17 E., secs. 1-18, 22-26, and 36; T. 6 N., R. 18 E., secs. 1-36; T. 6 N., R. 19 E., secs. 1-36; T. 6 N., R. 20 E., secs. 1-36; T. 6 N., R. 21 E., secs. 1-36; T. 6 N., R. 22 E., secs. 3-10, 15-23, and 26-35; T. 7 N., R. 14 E., secs. 1-5, 8-17, 21-28, and 33-36; T. 7 N., R. 15 E., secs. 1-36; T. 7 N., R. 16 E., secs. 1-36; T. 7 N., R. 17 E., secs. 1-36; T. 7 N., R. 18 E., secs. 1-36; T. 7 N., R. 19 E., secs. 1-36; T. 7 N., R. 20 E., secs. 1-36; T. 7 N., R. 21 E., secs. 1-36; T. 7 N., R. 22 E., secs. 18-20, and 28-34; T. 8 N., R. 14 E., secs. 13, 23-28, and 31-36, except that portion of secs. 13, 23, 24, 26, 27, 28, 31, 32, and 33 lying northwesterly of Interstate Highway 40; T. 8 N., R. 15 E., secs. 9-36, except that portion of secs. 9-12, 17, and 18 lying northwesterly of Interstate Highway 40; T. 8 N., R. 16 E., secs. 1, 2, and 7-36, except that portion of secs. 1, 2, and 7-10 and 11 lying northerly of Interstate Highway 40; T. 8 N., R. 17 E., secs. 1-36, except that portion of secs. 1-6 lying northerly of Interstate Highway 40; T. 8 N., R. 18 E., secs. 1-36, except that portion of sec. 6 lying northerly of Interstate Highway 40; T. 8 N., R. 19 E., secs. 1-36; T. 8 N., R. 20 E., secs. 1-36; T. 8 N., R. 21 E., secs. 7, 17-21, and 27-35; T. 9 N., R. 18 E., that portion of secs. 31-36 lying southerly of Interstate

Highway 40; T. 9 N., R. 19 E., secs. 23-29, 31-36, except that portion of secs. 23, 24, 26-29, 31, and 32 lying northerly of Interstate Highway 40; T. 9 N., R. 20 E., secs. 19, 20, and 29-33, except that portion of secs. 19 and 20 lying northerly of Interstate Highway 40 and S 1/2 S 1/2 sec. 27, SW 1/4 SW 1/4 sec. 26, and W 1/2 W 1/2 sec. 35..

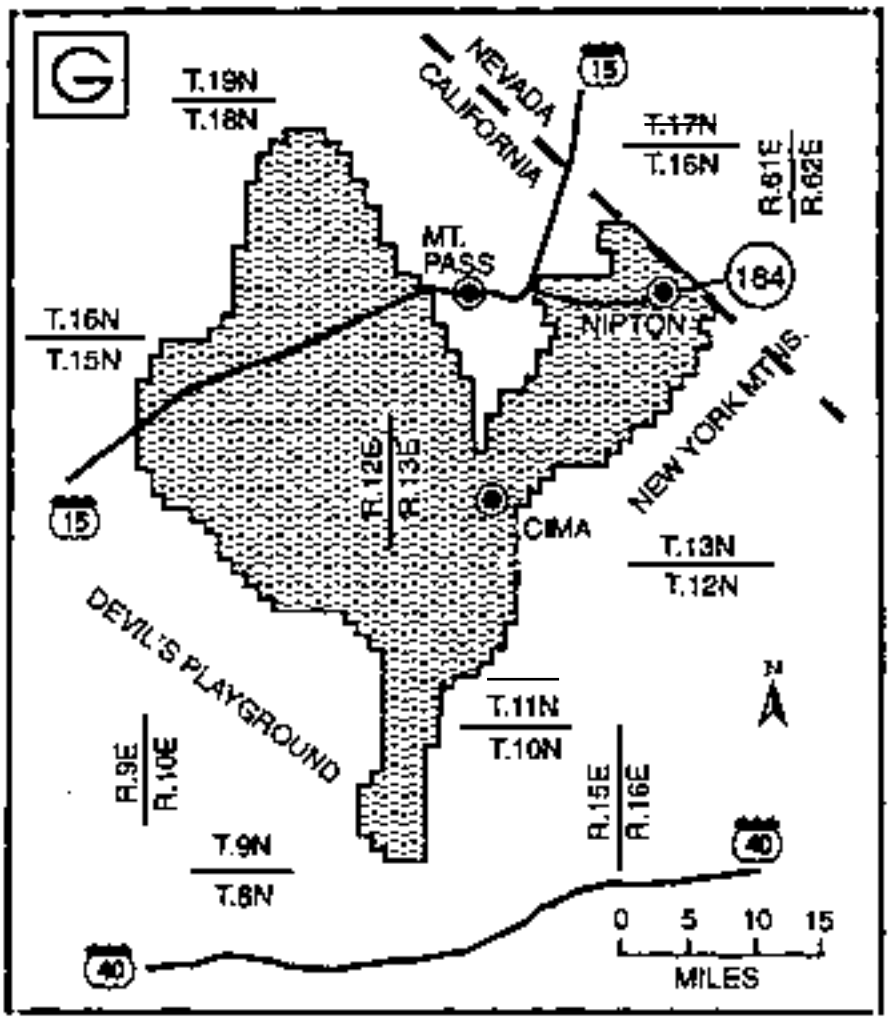
CHEMEHUEVI


F
T.10N
T.9N
GOFFS
95
NEEDLES
TOPOCK
R.13E
R.14E
R.22E
UPPER MTNS
R.18E
T.7N
T.6N
R.21E
40
95
40
62
CHAMBLESS
0 5 10 15
MILES
R.17E
VALLEY
T.4N
T.3N
N
T.3N
T.2N
SAN BERNARDINO CO.
RIVERSIDE CO.
VIDAL
T.1N
T.1S

7. **Ivanpah Unit.** San Bernardino County. From Bureau of Land Management Maps: Amboy 1991, Ivanpah 1979, and Mesquite Lake 1990. (Index map location G).

San Bernardino Meridian: T. 9 N., R. 12 E., secs. 1, 2, 11-14, and 24; T. 9 N., R. 13 E., secs. 4-9, 16-21, and 28-30; T. 10 N., R. 12 E., secs. 25, 35, and 36; T. 10 N., R. 13 E., secs. 3-10, 16-21, and 28-33; T. 11 N., R. 12 E., secs. 1, 12, 13, 24, 25, and 36; T. 11 N., R. 13 E., secs. 1-12, 15-21, and 28-33; T. 11 N., R. 14 E., sec. 6; T. 12 N., R. 11 E., secs. 1-5 and 9-15; T. 12 N., R. 12 E., secs. 1-18, 21-27, 35, and 36; T. 12 N., R. 13 E., secs. 1-36; T. 12 N., R. 14 E., secs. 4-9, 16-21, and 29-32; T. 13 N., R. 10 E., secs. 1-5, 10-14, 24, and 25; T. 13 N., R. 11 E., secs. 1-36; T. 13 N., R. 12 E., secs. 1-36; T. 13 N., R. 13 E., secs. 1-36; T. 13 N., R. 14 E., secs. 3-9, 16-21, and 28-33; T. 14 N., R. 9 E., secs. 1, 12, 13, and 24; T. 14 N., R. 10 E., secs. 1-36; (Unsurveyed) T. 14 N., R. 11 E., Protracted secs. 1-35; T. 14 N., R. 11 E., sec. 36; T. 14 N., R. 12 E., secs. 1-36; T. 14 N., R. 13 E., secs. 1-36; T. 14 N., R. 14 E., secs. 1-5, 8-17, and 19-35; T. 14 N., R. 15 E., secs. 1-12, and 14-22; T. 14 N., R. 16 E., sec. 6; T. 15 N., R. 9 E., secs. 24, 25, and 36; T. 15 N., R. 10 E., secs. 1-36 except sec. 6; T. 15 N., R. 11 E., secs. 1-36; T. 15 N., R. 12 E., secs. 1-36; T. 15 N., R. 13 E., secs. 3-11 and 14-36; T. 15 N., R. 14 E., secs. 12, 13, 23-28, and 33-36; T. 15 N., R. 15 E., secs. 1-36; T. 15 N., R. 16 E., secs. 1-11, 14-22, and 28-33; T. 15 1/2 N., R. 14 E., secs. 24 and 25; T. 15 1/2 N., R. 15 E., secs. 19-36; T. 15 1/2 N., R. 16 E., secs. 19-35; T. 16 N., R. 10 E., secs. 25, 35, and 36; T. 16 N., R. 11 E., secs. 1-36; T. 16 N., R. 12 E., secs. 1-36; T. 16 N., R. 12 1/2 E., secs. 12, 13, 24, 25, and 36; T. 16 N., R. 13 E., secs. 7, 17-20, and 29-33; T. 16 N., R. 14 E., secs. 24, 25, 35 and 36, except that portion of secs. 24 and 35 lying northwesterly of Interstate Hwy. 15; T. 16 N., R. 15 E., secs. 1-3, 10-14, and 23-36; T. 16 N., R. 16 E., secs. 6-8, 16-22, and 26-36; T. 17 N., R. 11 E., secs. 1-5, 8-17, 20-29, an 31-36; T. 17 N., R. 12 E., secs. 3-10, 14-23, and 26-36; T. 18 N., R. 11 E., secs. 13, 14, 22-28, and 33-36; T. 18 N., R. 12 E., secs. 18-20, and 28-33.

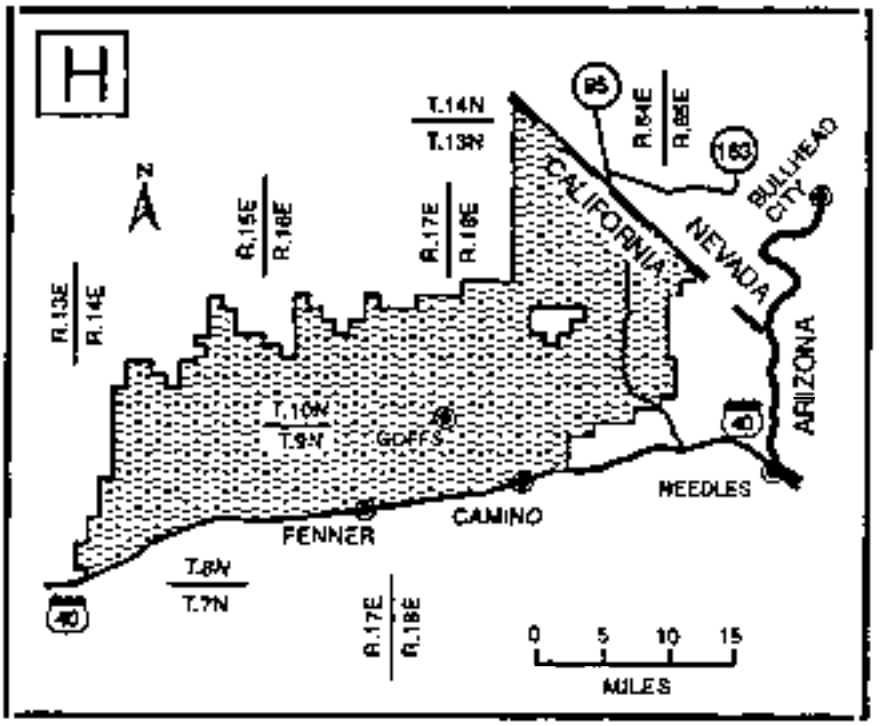
IVANPAH


G
T.19N
T.18N
NEVADA
CALIFORNIA
15
T.17N
T.16N
R.61E
R.62E
MT.
PASS
184
NIPTON
T.16N
T.15N
NEW YORK MTNS.
R.12E
R.13E
CIMA
15
T.13N
T.12N
DEVIL'S PLAYGROUND
N
T.11N
T.10N
R.9E
R.10E
R.15E
R.16E
T.9N
T.8N
40
40
0 5 10 15
MILES

8. **Pinto-Eldorado Unit.** San Bernardino County. From Bureau of Land Management Maps: Amboy 1991, Needles 1978, and Ivanpah 1979. (Index map location H).

San Bernardino Meridian: T. 8 N., R. 14 E., secs. 1-4, 8-17, 19-24, 26-30, 32, and 33, except that portion of secs. 13, 23, 24, 26-28, 32 and 33 lying southeasterly of Interstate Highway 40; T. 8 N., R. 15 E., secs. 1-12, 17, and 18, except that portion of secs. 1, 8-12, 17, and 18 lying southeasterly of Interstate Highway 40; T. 8 N., R. 16 E., secs. 1-10, except that portion of sections 1-3 and 6-10 lying southerly of Interstate Highway 40; T. 8 N., R. 17 E., that portion of secs. 1-6, lying northerly of Interstate Highway 40; T. 9 N., R. 14 E., secs. 1-3, 10-15, 22-28, and 33-36; T. 9 N., R. 15 E., secs. 1-36; T. 9 N., R. 16 E., secs. 1-36; T. 9 N., R. 17 E., secs. 1-36, except that portion of sec. 36 lying southerly of Interstate Highway 40; T. 9 N., R. 18 E., secs. 1-36, except that portion of secs. 31-36 lying southerly of Interstate Highway 40; T. 9 N., R. 19 E., secs. 1-24 and 26-32, except that portion of secs. 26-29, 31, and 32 lying southerly of Interstate Highway 40; T. 9 N., R. 20 E., secs. 3-8 and 17-20, except that portion of secs. 19 and 20 lying southerly of Interstate Highway 40; T. 10 N., R. 14 E., secs. 11-14, 22-27, and 34-36; T. 10 N., R. 15 E., secs. 1-3, 9-16, and 18-36; T. 10 N., R. 16 E., secs. 1-36; T. 10 N., R. 17 E., secs. 1-36; T. 10 N., R. 18 E., secs. 1-36; T. 10 N., R. 19 E., secs. 1-36; T. 10 N., R. 20 E., secs. 1-36; T. 10 N., R. 21 E., secs. 3-10, 15-22, and 28-31; T. 11 N., R. 15 E., secs. 9, 15, 16, 21, 22, 25-29, and 33-36; T. 11 N., R. 16 E., secs. 9, 15, 16, 21-23, 25-28, 31, and 33-36; T. 11 N., R. 17 E., secs. 8, 12-17, and 19-36; T. 11 N., R. 18 E., secs. 1-4 and 7-36; T. 11 N., R. 19 E., secs. 1-13, 18, 19, 23-27, and 29-36; T. 11 N., R. 20 E., secs. 1-11, 14-23, and 26-35; T. 12 N., R. 19 E., secs. 1-36; T. 12 N., R. 20 E., secs. 3-11 and 13-36; T. 12 N., R. 21 E., secs. 19, 30, and 31; T. 13 N., R. 19 E., secs. 3-11 and 13-36; T. 13 N., R. 20 E., secs. 19 and 29-33; T. 14 N., R. 19 E., secs. 19 and 29-33.

PIUTE-ELDORADO, CALIFORNIA

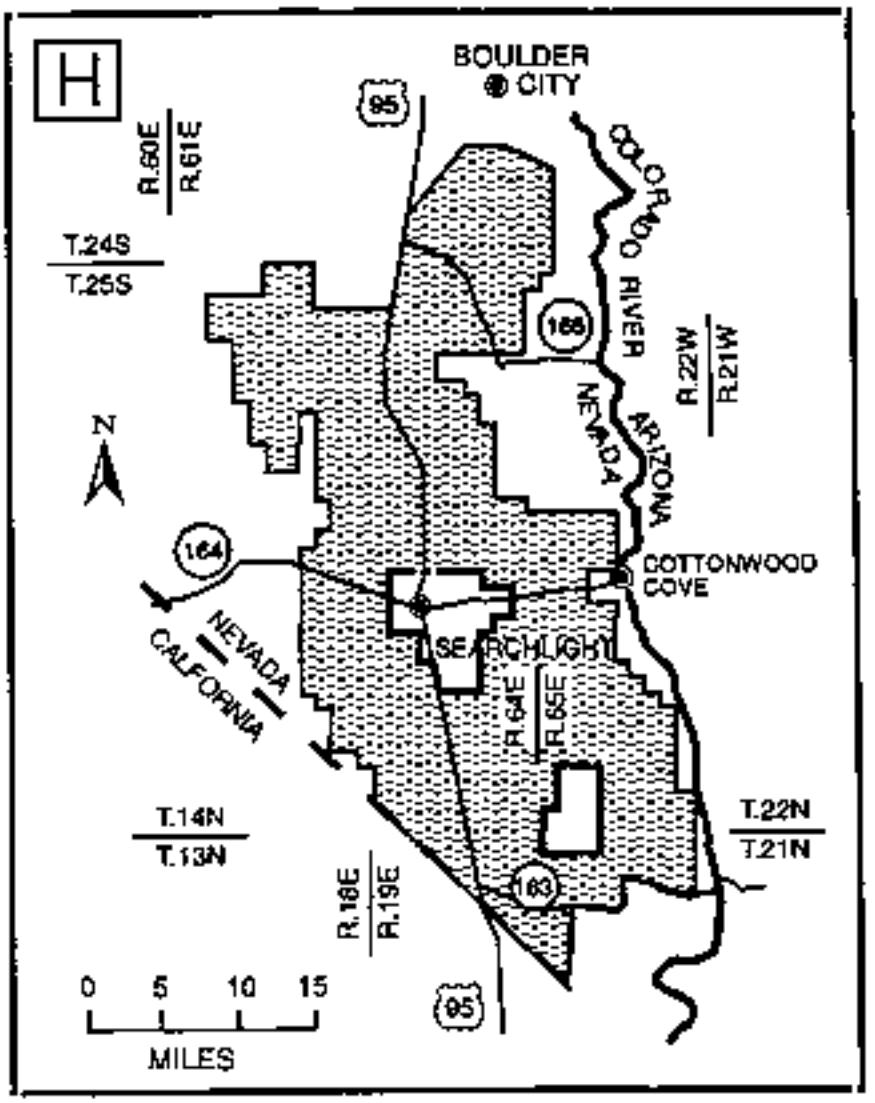


Nevada. Areas of land as follows:

9. **Pinte-Eldorado Unit.** Clark County. From Bureau of Land Management Maps: Mesquite Lake 1990, Boulder City 1978, Ivanpah 1979, and Davis Dam 1979. (Index map location H).

Mt. Diablo Meridian: T. 23 S., R. 64 E., secs. 31-36, except that portion of sec. 31 lying northwesterly of the powerline and also except that portion of secs. 34-36 lying northeasterly of the powerline; T. 23 1/2 S., R. 64 E., secs. 31-36, except that portion of sec. 31 lying northwesterly of the powerline; T. 23 1/2 S., R. 65 E., that portion of sec. 31, lying southwesterly of the powerline; T. 24 S., R. 63 E., secs. 1, 2, 11-15, 22-28, and 33-36, except that portion of secs. 1, 2, 11, 14, and 15 lying northwesterly of the powerline and also except that portion of secs. 22, 27, 28, and 33 lying northwesterly of U.S. Highway 95; T. 24 S., R. 64 E., secs. 1-36; T. 24 S., R. 65 E., secs. 6, 7, 18, 19, 30, and 31; T. 25 S., R. 61 E., secs. 13-15, E 1/2 sec. 16, E 1/2 sec. 21, secs. 22-27, E 1/2 sec. 28, secs. 35 and 36; T. 25 S., R. 62 E., secs. 4-9, and secs. 16-36; T. 25 S., R. 63 E., secs. 1-4, 9-16, and 19-36, except that portion of secs. 4, 9, and 16 lying northwesterly of U.S. Highway 95; T. 25 S., R. 64 E., secs. 1-35 except secs. 13, 24, and 25,; T. 25 S. R. 65 E., sec. 6; T. 26 S., R. 61 E., secs. 1, 2, 11-14, 24, 25, and 36; T. 26 S., R. 62 E., secs. 1-36 except secs. 28 and 33; T. 26 S., R. 63 E., secs. 2-36 except sec. 12; T. 26 S., R. 64 E., secs. 18-20, and 29-33; T. 27 S., R. 62 E., secs. 1-3, 5-8, 10-15, 22-26, 35, and 36; T. 27 S., R. 62 1/2 E., secs. 1, 12, 13, 24, 25, and 36; T. 27 S., R. 63 E., secs. 1-36; T. 27 S., R. 64 E., secs. 4-9, 16-21, and 26-36; T. 27 S., R. 65 E., secs. 31-35; T. 28 S., R. 62 E., secs. 1-3, 9-16, 21-28, and 33-36; T. 28 S., R. 63 E., secs. 1-20, and 29-32; T. 28 S., R. 64 E., secs. 1-18, 21-26, 35, and 36; T. 28 S., R. 65 E., secs. 2-11, 14-21, and 28-35; T. 29 S., R. 62 E., secs. 1-4, 9-16, 21-28, 34, 35 and 36; T. 29 S., R. 63 E., secs. 5-10, 15-23, and 26-36; T. 29 S., R. 64 E., secs. 1-3, 9-16, 21-28, and 31-36; T. 29 S., R. 65 E., secs. 2-36 except secs. 12 and 13; T. 29 S., R. 66 E., secs. 30-32; T. 30 S., R. 62 E., secs. 1, 2, and 11-14; T. 30 S., R. 63 E., secs. 1-36 except secs. 30 and 31; T. 30 S., R. 64 E., secs. 1-36; T. 30 S., R. 65 E., secs. 1-26, 30, 31, 35, and 36; T. 30 S., R. 66 E., secs. 4-9, 16-21, and 28-33; T. 31 S., R. 63 E., secs. 1-5, 8-16, 22-26, and 36; T. 31 S., R. 64 E., secs. 1-36; T. 31 S., R. 65 E., secs. 1, 2, 6, 11-14, 23-36, except that portion of sec. 36 lying southwesterly of State Highway 163; T. 31 S., R. 66 E., secs. 3-10, 15-22, and 27-34, except that portion of sec. 31 lying southwesterly of State Highway 163; T. 32 S., R. 64 E., secs. 1-6, 8-16, 22-26, and 36; T. 32 S., R. 65 E., secs. 1-12, 17-20, and 29-32, except that portion of secs. 1, and 9-12 lying southeasterly or easterly of State Highway 163; T. 32 S., R. 66 E., that portion of secs. 3-6 lying northerly of State Highway 163; T. 33 S., R. 65 E., sec. 5.

PIUTE-ELDORADO, NEVADA



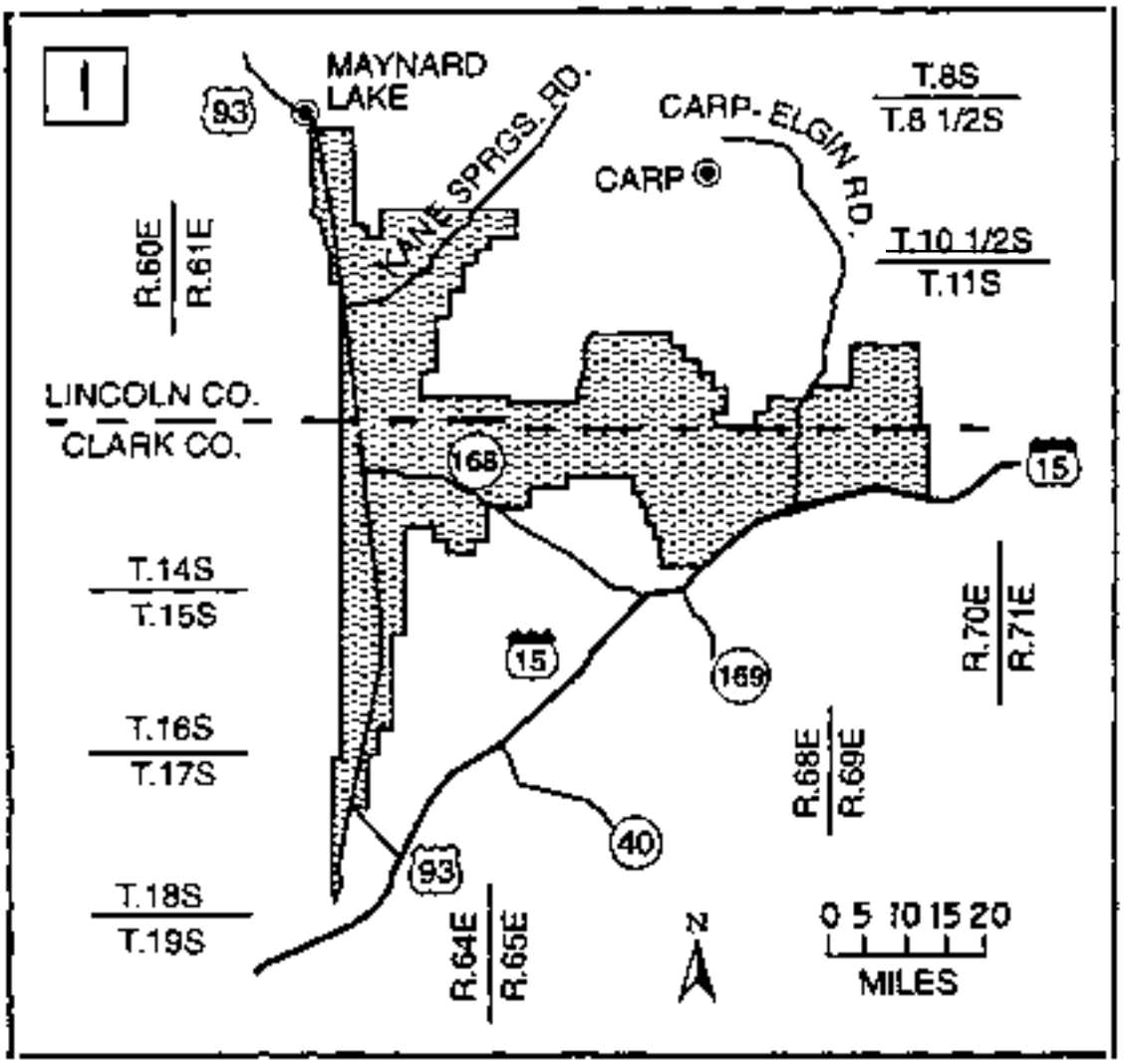
10. <u>Mormon Mesa Unit</u>. Clark and Lincoln Counties. From Bureau of Land Management Maps: Pahranagat 1978, Clover Mts. 1978, Overton 1978, Indian Springs 1979, Lake Mead 1979, and Las Vegas 1986. (Index map location I).

Mt. Diablo Meridian: T. 9 S., R. 62 E., secs. 13-15, 22-27, and 34-36, except that portion of secs. 15, 22, 27, and 34 lying westerly of the easterly boundary line of the Desert National Wildlife Range;

T. 9 S., R. 63 E., secs. 18, 19, 30, and 31; T. 10 S., R. 62 E., secs. 1, 2, 11-14, 23-25, and 36 except that portion of secs. 14, 23, 35, and 36 lying westerly of the easterly boundary line of the Desert National Wildlife Range:
T. 10 S., R. 63 E., secs. 6, 7, 13-15, 18-20, and 22-36; T. 10 S., R. 64 E., secs. 13-24 and 26-34; T. 10 S., R. 65 E., secs. 18, and 19; T. 11 S., R. 62 E., that portion of sec. 1 lying easterly of the easterly boundary line of the Desert National Wildlife Range; T. 11 S., R. 63 E., secs. 1-36; T. 11 S., R. 64 E., secs. 4-9, 17-20, 30, and 31; T. 11 S., R. 66 E., secs. 31-36; T. 12 S., R. 63 E., secs. 1-36; T. 12 S., R. 64 E., secs. 6, 7, and 25-36; T. 12 S., R. 65 E., secs. 1, 12, 13, and 24-36, except that portion of secs. 1, 2, 13, and 24 lying westerly of Union Pacific Railroad; T. 12 S., R. 66 E., secs. 1-36; T. 12 S., R. 67 E., secs. 6-8, 16-22, and 27-33; T. 12 S., R. 68 E., secs. 23-29 and 31-36; T. 12 S., R. 69 E., secs. 1-5, 8-17, and 19-36; T. 12 1/2 S., R. 62 E., that portion of sec. 36, lying easterly of the easterly boundary line of the Desert National Wildlife Range; T. 13 S., R. 62 E., that portion of secs. 1, 12, 13, 24, and 25 lying easterly of the easterly line of the Desert National Wildlife Range; T. 13 S., R. 63 E., secs. 1-36; T. 13 S., R. 64 E., secs. 1-36; T. 13 S., R. 65 E., secs. 1-24, N 1/2 26, N 1/2 27, N 1/2 and SW 1/4 sec. 28, 29-32, and W 1/2 33; T. 13 S., R. 66 E., secs. 1-26, W 1/2 sec. 27, 35, and 36; T. 13 S., R. 67 E., secs. 1-36; T. 13 S., R. 68 E., secs. 1-36, except that portion of secs. 25 and 33-36 lying southeasterly of Interstate Highway 15; T. 13 S., R. 69 E., secs. 1-30, except that portion of secs. 25-30 lying southerly of Interstate Highway 15; T. 13 S., R. 70 E., secs. 6, 7, 18, 19, 30, and 31, except that portion of secs. 30 and 31 lying southerly of Interstate Highway 15; T. 13 1/2 S., R. 63 E., secs. 31-36; T. 13 1/2 S., R. 64 E., secs. 31-36, except that portion of sec. 36 lying southwesterly of State Highway 168; T. 14 S., R. 63 E., secs. 1-23, and 26-35; T. 14 S., R. 64 E., secs. 2-6, 8-11, 15, and 16; T. 14 S., R. 66 E., secs. 1, E 1/2 sec. 2, 12, E 1/2 sec. 13, and E 1/2 sec. 24; T. 14 S., R. 67 E., secs. 1-12 and 14-22, except that portion of secs. 12, 14, 15, 21, and 22 lying southerly of Interstate Highway 15; T. 14 S., R. 68 E., that portion of secs. 4-7 lying northwesterly of Interstate Highway 15; T. 15 S., R. 63 E., secs. 2-11, 14-22, and 27-34; T. 16 S., R. 63 E., secs. 3-10, 15-22, and 28-33; T. 17 S., R. 63 E., secs. 7-9, 16-21, and 28-32, except that portion of secs. 29 and 32 lying easterly of the westerly boundary line of the Apex Disposal Road; T. 18 S., R. 63 E., secs. 5-8, 17-19, and 29-31, except that portion of secs. 5, 8, 17-19, and 29-31 lying easterly of the westerly boundary line of the Apex

Disposal Road, and that portion of sec. 31 lying westerly of the easterly boundary line of Desert National Wildlife Range.

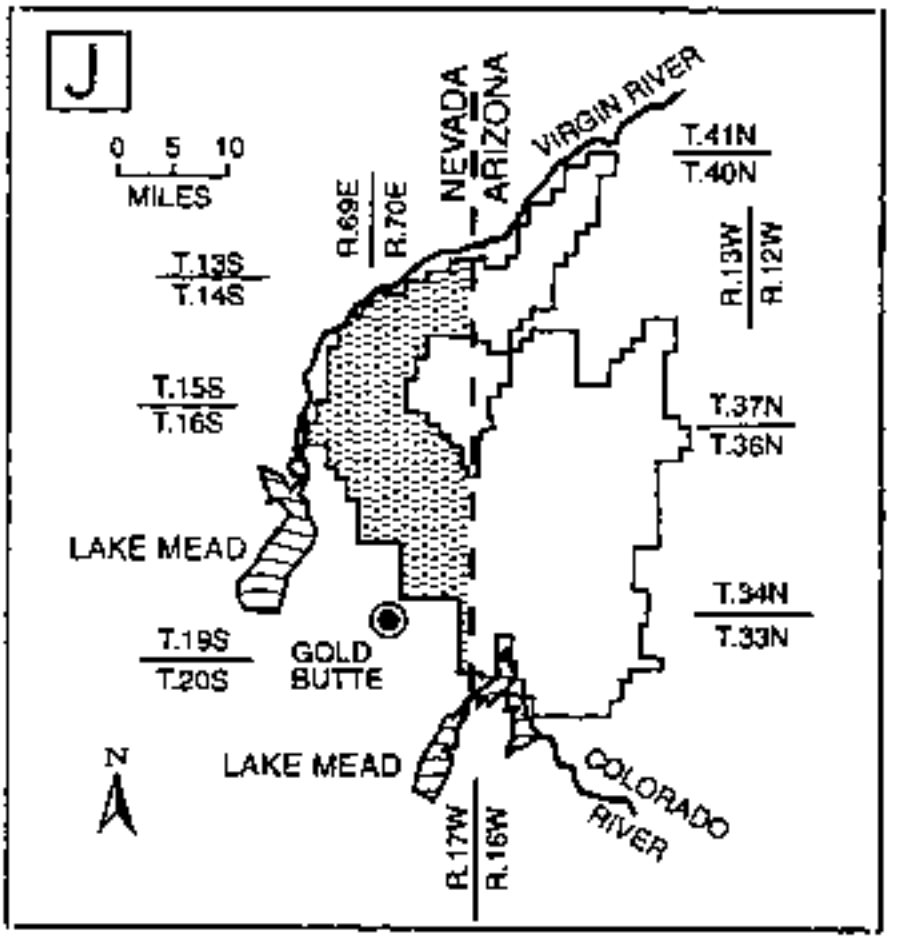
MORMON MESA


1
MAYNARD LAKE
93
LAKE SPRGS. RD.
CARP-ELGIN RD.
CARP
T.8S
T.8 1/2S
T.10 1/2S
T.11S
R.60E
R.61E
LINCOLN CO.
CLARK CO.
168
15
T.14S
T.15S
T.16S
T.17S
T.18S
T.19S
169
40
R.70E
R.71E
R.68E
R.69E
R.64E
R.65E
N
0 5 10 15 20
MILES

11. <u>Gold Butte-Pakoon Unit</u>. Clark County. From Bureau of Land Management Maps: Overton 1978 and Lake Mead 1979. (Index map location 3).

Mt. Diablo Meridian: T. 13 S., R. 71 E., secs. 32-34; T. 14 S., R. 69 E., secs. 24-26, and 34-36; T. 14 S., R. 70 E., secs. 1, and 10-36; T. 14 S., R. 71 E., secs. 3-10, 15-22, and 27-34; T. 15 S., R. 69 E., secs. 1-3, 9-16, 21-28, and 33-36; T. 15 S., R. 70 E., secs. 2-11, 15-22, and 28-33; T. 16 S., R. 69 E., secs. 1-36 except secs. 6, 7, and 29-32; T. 16 S., R. 70 E., secs. 4-36 except sec. 12; T. 16 S., R. 71 E., secs. 19, and 29-32; T. 17 S., R. 69 E., secs. 1-3, 11-14, 24, 25, and 36; T. 17 S., R. 70 E., secs. 1-36; T. 17 S., R. 71 E., secs. 4-10, 15-22, and 27-34; T. 18 S., R. 69 E., sec. 1; T. 18 S., R. 70 E., secs. 1-6, 10-15, 22-27, and 34-36; T. 18 S., R. 71 E., secs. 3-10, 15-22, and 27-34; T. 19 S., R. 71 E., secs. 3, 4, 9, 10, 15, 16, 21, 22, 27, 28, 33 and 34; T. 20 S., R. 71 E., secs. 3 and 4.

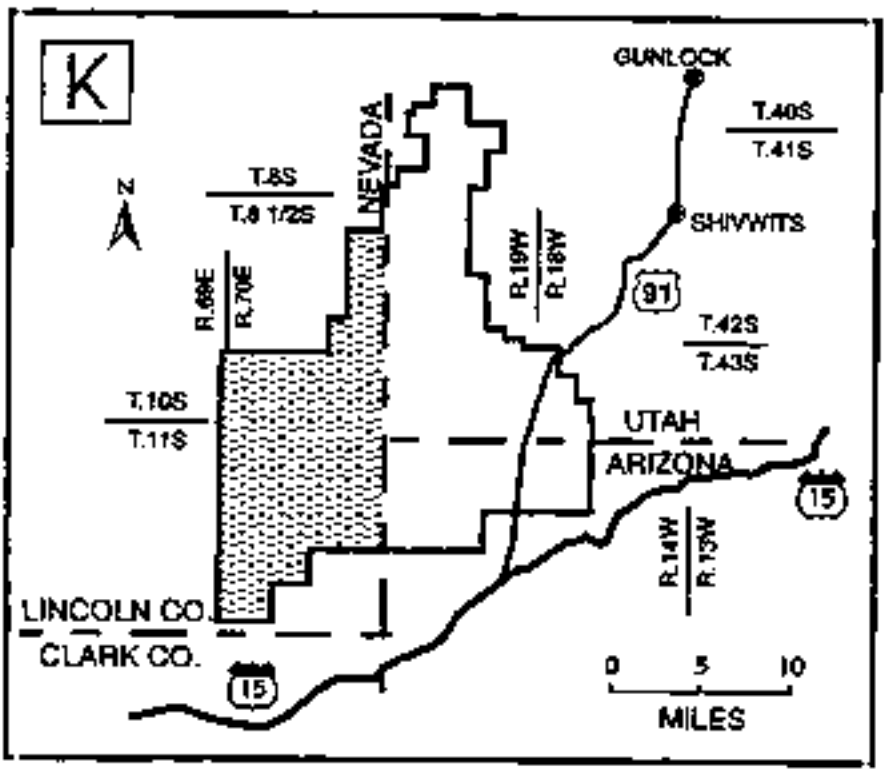
GOLD BUTTE-PAKOON
NEVADA



12. <u>Beaver Dam Slope Unit</u>. Lincoln County. From Bureau of Land Management Maps: Clover Mountains 1978 and Overton 1978. (Index map location K).

Mt. Diablo Meridian: T. 8 1/2 S., R. 71 E., that portion of sec. 34 lying south of a westerly extension of the north line of sec. 26, T. 41 S., R. 20 W. (Salt Lake Meridian), Washington County, Utah; T. 9 S., R. 71 E., secs. 3, 10, 15-17, 20-22, 27-29, and 32-34; T. 10 S., R. 70 E., secs. 19-36; T. 10 S., R. 71 E., secs. 3-5, 7-10, 15-22, and 27-34; T. 11 S., R. 70 E., secs. 1-36; T. 11 S., R. 71 E., secs. 3-10, 15-22, and 27-34; T. 12 S., R. 70 E., secs. 1-12, 14-23, and 28-33; T. 12 S., R. 71 E., secs. 3-10.

BEAVER DAM SLOPE
NEVADA

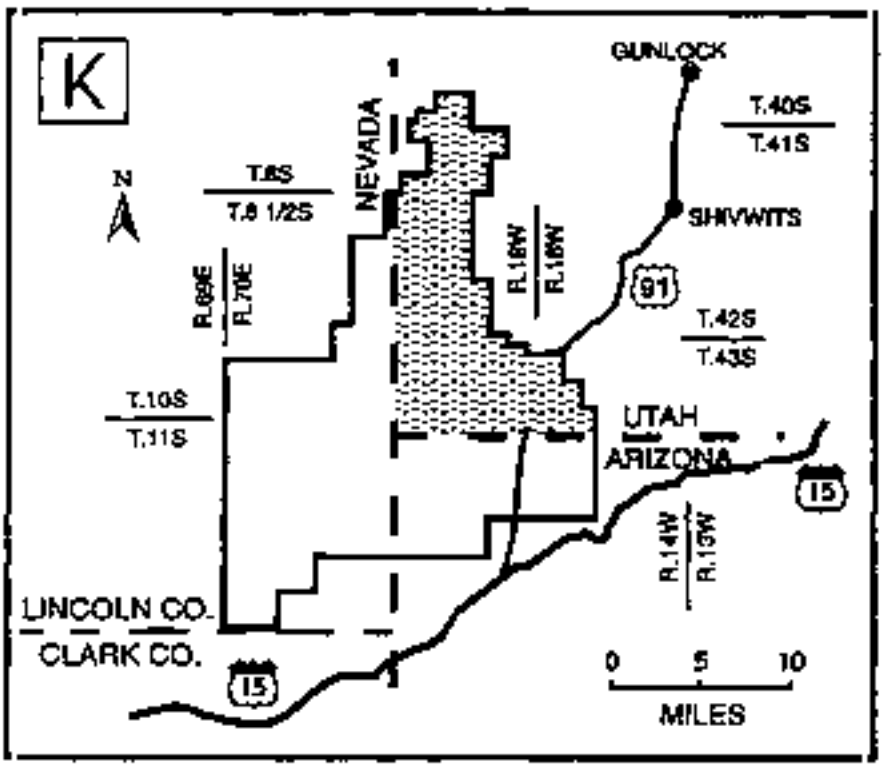


Utah. Areas of land as follows:

13. Beaver Dam Slope Unit. Washington County. From Bureau of Land Management Maps: St. George 1980 and Clover Mts. 1978. (Index map location K).

Salt Lake Meridian: T. 40 S., R. 19 W., S 1/2 sec. 28, S 1/2 sec. 29, S 1/2 sec. 31, secs. 32 and 33; T. 41 S., R. 19 W., S 1/2 sec. 2, S 1/2 sec. 3, secs. 4, 5, 6, E 1/2 sec. 7, secs. 8-11, 15-17, E 1/2 sec. 18, and secs. 19-22, and 28-33; T. 41 S., R. 20 W., E 1/2 sec. 1, secs. 24-26, 35, and 36; T. 42 S., R. 19 W., secs. 4-9, 16-22, and 27-34; T. 42 S., R. 20 W., secs. 1, 2, 11-14, 23-26, 35, and 36; T. 43 S., R. 18 W., secs. 7, 8, S 1/2 sec. 16, secs. 17-21, and 27-34; T. 43 S., R. 19 W., secs. 1-36 except N 1/2 sec. 1; T. 43 S., R. 20 W., secs. 1, 2, 11-14, 23-26, 35, and 36.

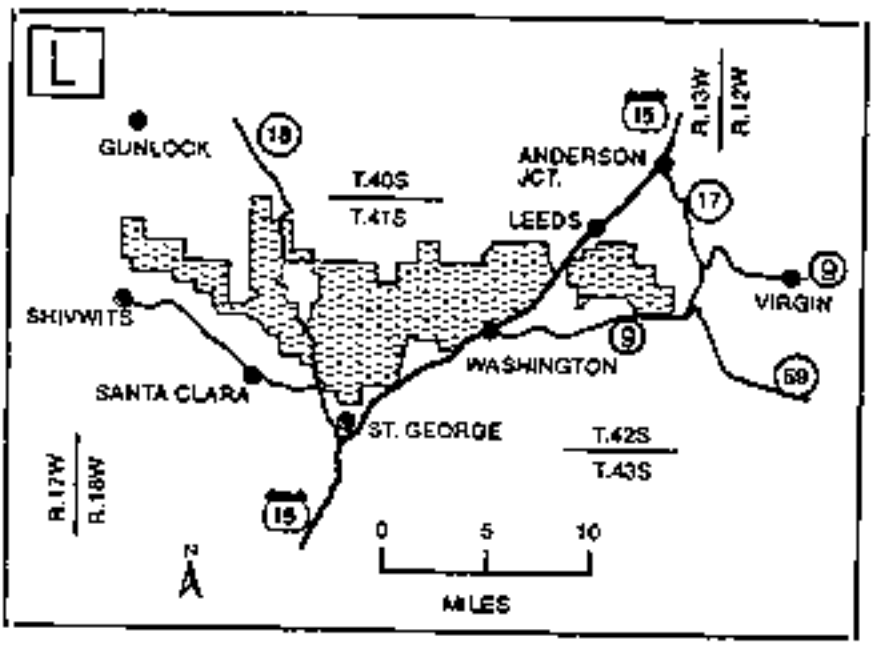
BEAVER DAM SLOPE
UTAH



14. **Upper Virgin River Unit.** Washington County. From Bureau of Land Management Map: St. George 1980. (Index map location L).

Salt Lake Meridian: T. 41 S., R. 13 W., secs. 17-21, except NW 1/4 NW 1/4 sec. 18, W 1/2 and W 1/2 E 1/2 sec. 27, 28, N 1/2 sec. 29, N 1/2 sec. 30, N 1/2 N 1/2 sec. 33, except that portion of secs. 28 and 33 lying westerly of Gould Wash, and N 1/2 NW 1/4 and NW 1/4 NE 1/4 sec. 34; T. 41 S., R. 14 W., S 1/2 S 1/2 and NE 1/4 SE 1/4 and SE 1/4 NE 1/4 sec. 13, that portion of sec. 14 lying westerly of Red Cliff Road, secs. 15-17 except N 1/2 NW 1/4 and SW 1/4 NW 1/4 sec. 17, secs. 19-22, that portion of sec. 23 lying westerly of Red Cliff Road and westerly of Interstate Highway 15, sec. 24, NE 1/4 and N 1/2 SE 1/4 and SW 1/4 SE 1/4 sec. 25, that portion of secs. 26, 27, and 32-34 lying northwesterly of Interstate Highway 15, and secs. 28-31; T. 41 S., R. 15 W., secs. 14, 19, 20, and 22-36; T. 41 S., R. 16 W., secs. 4, 9, 10, S 1/2 sec. 14, 15-16, 19, 21, W 1/2 sec. 22, secs. 24-25 except W 1/2 SW 1/4 sec. 24 and W 1/2 NW 1/4 and W 1/2 SW 1/4 sec. 25, and W 1/2 W 1/2 sec. 25, SW 1/4 NE 1/4 and NW 1/4 NW 1/4 and S 1/2 NW 1/4 and SW 1/4 and W 1/2 SE 1/4 sec. 27, E 1/2 and E 1/2 W 1/2 and NW 1/4 NW 1/4 and SW 1/4 SW 1/4 sec. 28, N 1/2 and SE 1/4 and E 1/2 SW 1/4 sec. 30, NE 1/4 sec. 31, N 1/2 sec. 32, N 1/2 and SE 1/4 and N 1/2 SW 1/4 sec. 33, sec. 34, SE 1/4 SE 1/4 and that portion of sec. 35 lying westerly of Utah Highway 18, and sec. 36; T. 41 S., R. 17 W., secs. 9, 14-16, NE 1/4 sec. 21, N 1/2 sec. 22, NW 1/4 and E 1/2 sec. 23, sec. 24, and NE 1/4 sec. 25; T. 42 S., R. 14 W., that portion of secs. 5 and 6 lying northwesterly of Interstate Highway 15; T. 42 S., R. 15 W., secs. 1, N 1/2 and N 1/2 S 1/2 sec. 2, NE 1/4 and W 1/2 sec. 3, secs. 4-9, W 1/2 W 1/2 sec. 10, N 1/2 N 1/2 sec. 12, secs. 16-18, N 1/2 and N 1/2 SE 1/4 and NE 1/4 SW 1/4 sec. 19, W 1/2 NW 1/4 and NW 1/4 SW 1/4 sec. 20, except that portion of secs. 1 and 12 lying southeasterly of Interstate Highway 15; T. 42 S., R. 16 W., secs. 1, 2, NW 1/4 and E 1/2 sec. 3, NE 1/4 NE 1/4 sec. 4, NE 1/4 sec. 10, NW 1/4 and E 1/2 sec. 11, sec. 12, E 1/2 and NW 1/4 and N 1/2 SW 1/4 sec. 13, N 1/2 NE 1/4 sec. 24, except that portion of sec. 13 lying westerly of Utah Highway 18.

UPPER VIRGIN RIVER

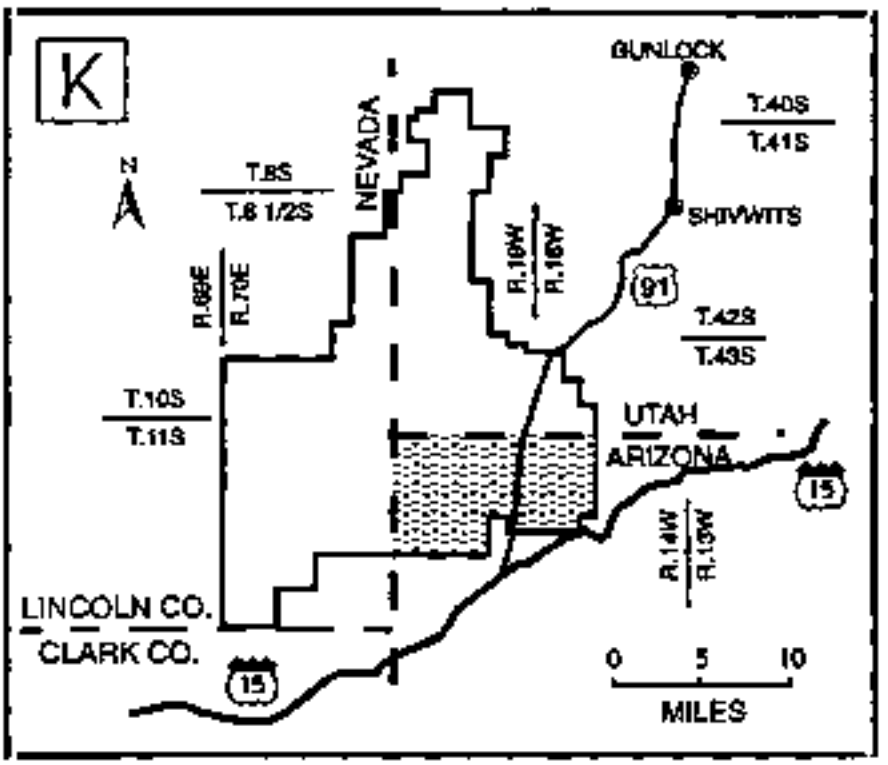


Arizona. Areas of land as follows:

15. **Beaver Dam Slope Unit.** Mohave County. From Bureau of Land Management Maps: Overton 1978 and Littlefield 1987. (Index map location K).

Gila and Salt River Meridian: T. 41 N., R. 14 W., secs. 6, 7, 18, and 19; T. 41 N., R. 15 W., secs. 1-24, 26-28, 30, and 31; T. 41 N., R. 16 W., secs. 1-5, 8-17, 20-29, and 32-36; T. 42 N., R. 14 W., sec. 31; T. 42 N., R. 15 W., secs. 31-36; T. 42 N., R. 16 W., secs. 32-36.

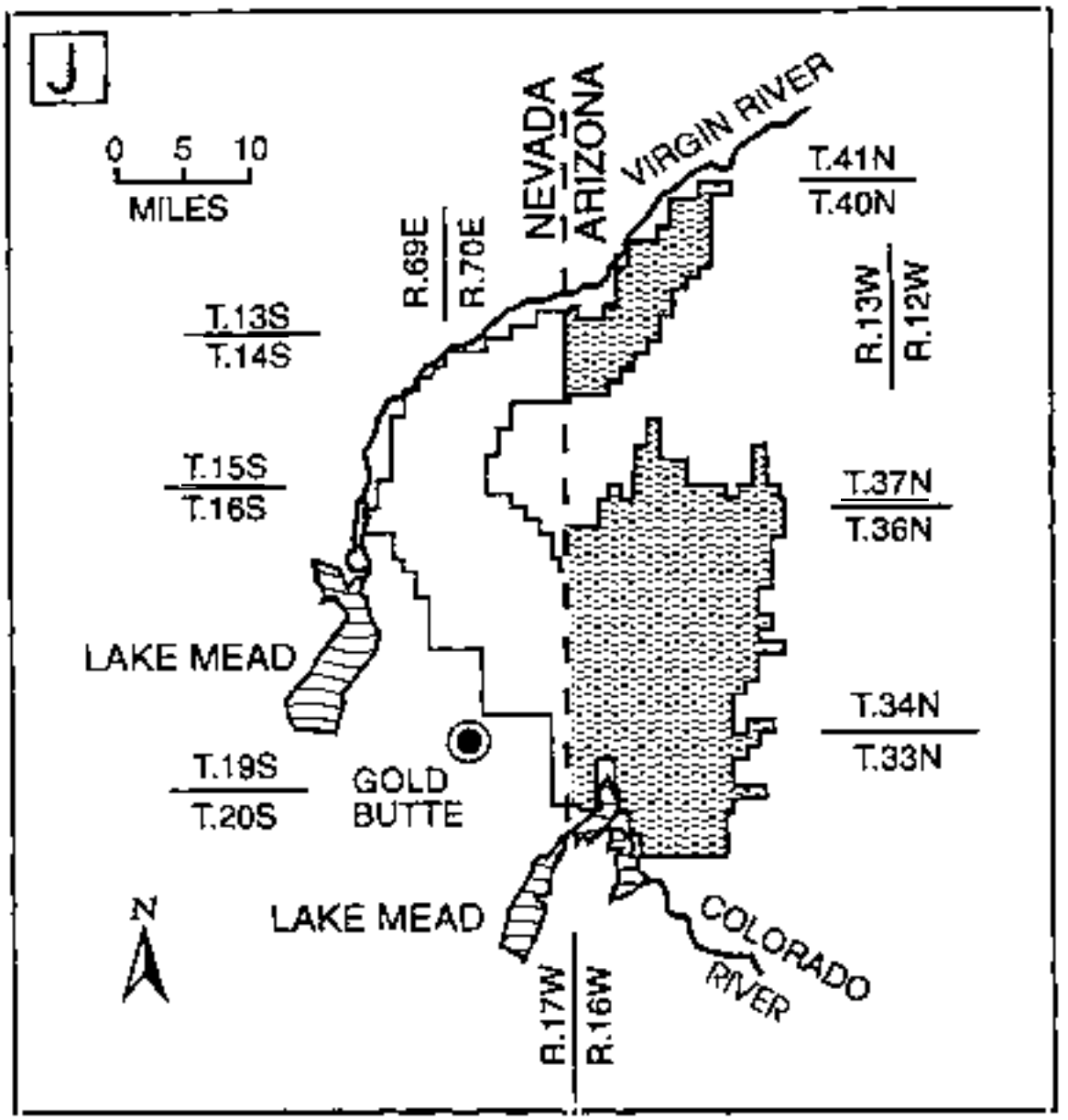
BEAVER DAM SLOPE
ARIZONA



16. **Gold Butte-Pakoon Unit.** Mohave County. From Bureau of Land Management Maps: Overton 1978, Littlefield 1987, Mount Trumbull 1986, and Lake Mead 1979. (Index map location J).

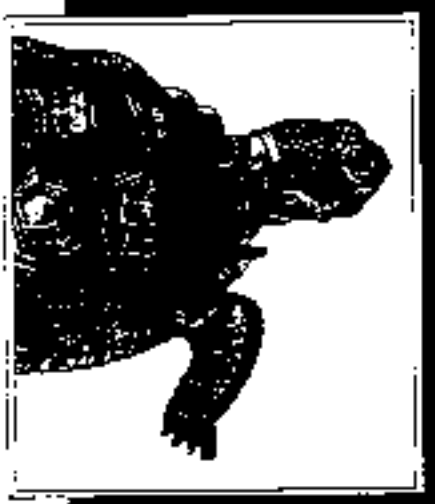
Gila and Salt River Meridian: T. 32 N., R. 15 W., secs. 1-18, except those portions of secs. 13-18 lying south of the Lake Mead National Recreation area boundary line; T. 32 N., R. 16 W., secs. 1, 2, 12, and 13; T. 32 1/2 N., R. 15 W., secs. 31-36; T. 32 1/2 N., R. 16 W., secs. 35 and 36; T. 33 N., R. 14 W., secs. 4-8, 18, 19, and 28-31; T. 33 N., R. 15 W., secs. 1-36; T. 33 N., R. 16 W., secs. 1-14, 17-20, 23-26, 29-32, 35, and 36; T. 34 N., R. 14 W., secs. 4-9, 17-19, 30, 31, 33, and 34; T. 34 N., R. 15 W., secs. 1-36; T. 34 N., R. 16 W., secs. 1-36; T. 35 N., R. 14 W., secs. 3-9, 16-22, and 28-35 ; T. 35 N., R. 15 W., secs. 1-36; T. 35 N., R. 16 W., secs. 1-36; T. 36 N., R. 14 W., secs. 2-11, 14-22, and 27-34; T. 36 N., R. 15 W., secs. 1-36; T. 36 N., R. 16 W., secs. 1-36 except secs. 4-9; T. 37 N., R. 14 W., secs. 15, 22, 27, 31, and 33-35; T. 37 N., R. 15 W., secs. 5, 8, 17-22, and 27-36; T. 37 N., R. 16 W., sec. 35; T. 38 N., R. 15 W., sec. 6; T. 38 N., R. 16 W., secs. 1-12 and
14-22 and 30; T. 39 N., R. 15 W., secs. 2-10, 16 -21, and 29-32; T. 39 N., R. 16 W., secs. 1, 12, 13, 20, 23-29, and 32-36; T. 40 N., R. 14 W., sec. 6; T. 40 N., R. 15 W., secs. 1, 10-15, and 21-36.

GOLD BUTTE-PAKOON
ARIZONA



Appendix I

Desert Tortoise
(Mojave Population)



Recovery Plan

Appendix I: Summary of the Agency and Public Comment on the Draft Desert Tortoise Recovery Plan

I. Summary of the Agency and Public Comment on the Draft Desert Tortoise Recovery Plan

In April, 1993, the U.S. Fish and Wildlife Service (Service) released the Draft Recovery Plan for the Desert Tortoise (Mojave Population) (Draft Plan) for a 60-day comment period ending on June 1, 1993 for Federal agencies, state and local governments, and members of the public (58 FR 16691). Due to the complexity of the plan, the Service extended this comment period an additional 30 days, ending on June 30, 1993 (58 FR 28894).

This section summarizes the content of significant comments on the Draft Plan. A total of 143 letters was received, each containing varying numbers of comments. Many specific comments re-occurred in letters.

This section provides a summary of general demographic information including the total number of letters received from various affiliations and states. It also provides a summary of the 21 major comments. A complete index of the commenters, by affiliation, is available from the U.S. Fish and Wildlife Service, Las Vegas Field Office, 1500 N. Decatur 01, Las Vegas, Nevada 89108. All letters of comment on the Draft Plan are kept on file in the Las Vegas Field Office.

Demographic Information

The following is a breakdown of the number of letters received from various affiliations:

Federal agencies	15 letters
state agencies	9 letters
local governments	6 letters
business/industry	12 letters
environmental/conservation organizations	15 letters
academia/professional	7 letters
multiple use/recreation organizations	9 letters
individual responses	70 letters

II. Summary of Comments and Service Responses

Executive Summary

Comment: The difference between the utility of Desert Wildlife Management Areas (DWMAs) and recovery units in the recovery and delisting of desert tortoises is unclear.

Response: As now defined in the Final Plan, the six recovery units are geographic areas which harbor evolutionarily distinct populations of the desert tortoise, and the 14 proposed DWMAs are the smaller administrative areas within each of the six geographic areas. DWMAs are the managed reserves which protect the desert tortoise populations until such time as recovery and delisting can occur while also maintaining and protecting other sensitive species and ecosystem functions. Each recovery unit should have at least one DWMA containing 1,000 square miles of desert tortoise habitat. Multiple 1,000 square mile DWMAs would provide additional protection in ensuring the persistence of the six evolutionarily distinct populations segments. Figure 6 further describes this concept in reserve design.

Comment: The budget numbers shown under "Need 1" are in three year increments after 1995. Does this mean that all the money will only be spent every third year? Additionally, these numbers do not appear to be consistent with the 10 year budget tables in the supplementary document "Proposed Desert Wildlife Management Areas for Recovery...."

Response: The expenditure of funds every 3 years reflects the 3-year cycle recommended in the Recovery Plan for monitoring desert tortoise populations. The 10-year tables shown in the supplementary document reflect what funding is projected to be necessary for implementation of all recovery actions. These figures will be revised following development of management plans for each DWMA, which will be much more site-specific and detailed.

Comment: The education budget listed under "Need 2" should be revised to allow some expenditures for public education throughout the term of the recovery plan, rather than spending all the money during the first year.

Response: As shown in the Implementation Schedule (Section III), continuing costs for implementing education programs are to be determined based on what is recommended in the environmental programs that are developed the first year.

Comment: What is Public Law 1010-618?

Response: Public Law 1010-618 is not relevant to this Recovery Plan, and the reference has been deleted.

Section I - Introduction

Comment: Based on an overview of the plant literature provided to Fish and Wildlife Service's Region 1 by the National Ecology Research Center (NERC), there is no scientific analysis of changes in perennial grass composition in the Mojave Desert.

Response: This information is reflected in D'Antonio and Vitousek's 1992 paper (see Literature Cited, Section IV) which was published after NERC's 1990 document.

Comment: It would be useful to provide the number of acres of desert tortoise habitat which is currently impacted by livestock grazing.

Response: Until DWMA boundaries are determined, it is not possible to estimate the number of acres within recovery areas impacted by livestock grazing.

Comment: Section 9 of the Endangered Species Act applies to endangered species only. The regulations at 50 CFR 1731 include threatened species such as the desert tortoise.

Response: Through section 4(d) of the Endangered Species Act, the Fish and Wildlife Service may issue regulations deemed necessary and advisable to provide for the conservation of threatened species. Through such regulation, the Fish and Wildlife Service may prohibit take of threatened species.

Section II - Recovery

Comment: Target densities for desert tortoise populations are specified without reference to or knowledge of predisturbance population levels. Many of the target densities appear unrealistically high and unobtainable. Under such circumstances delisting will not be possible in some recovery units.

Response: The Recovery Team agrees with this comment and has eliminated the reaching of target densities of desert tortoises within recovery units as a goal of recovery and delisting. Rather, the population within a recovery unit must show an upward or stationary (not declining) trend and maintain a population growth rate (Lambda) within each recovery unit equal to or greater than 1.0 for delisting to be considered by the Fish and Wildlife Service.

Comment: The definition of and prohibition within the Limited Use Zones (LUZs) should apply to the entire DWMA, provided that these parcels are being designated principally for the protection and preservation of Mojave Desert wildlife, including the desert tortoise; in this respect, the need for the special LUZ designation is questioned.

Response: The Recovery Team agrees with this comment, has eliminated the LUZ designation and extended LUZ-level protection to the entire DWMA, except where Experimental Management Zones (EMZs) are proposed. EMZs may only occupy 10% of a DWMA's total area and should be located on the periphery of the DWMA boundary where any negative effects from experimental activities will be less profoundly felt within the more protected area.

Comment: It is not clear when there is more than one DWMA established within a recovery unit if all DWMAs must meet the delisting criteria or can a recovery unit population be delisted if only one DWMA population meets the four criteria?

Response: Delisting is considered on a recovery unit basis. If more than one DWMA is established to meet the delisting criteria then the combined population trend and population growth rates (lambdas) are evaluated for recovery and delisting purposes.

Comment: Twelve years is too short a time period for evidence of upward trends in adult populations, upon which monitoring plans are based. Therefore, it is unrealistic to assume delisting can occur within this time frame.

Response: The Recovery Team agrees with this comment. The population within a recovery unit must exhibit a statistically significant upward tend or remain stationary for at least 25 years (one desert tortoise generation), thus allowing time for recruitment of baby and juvenile tortoises into the adult age class.

Comment: This method of population density estimation of desert tortoises is unrealistic in application due to the monetary expense and amount of time that would be required.

Response: The Recovery Team is aware of the potential problems associated with the recommended method, however, the proposal has initiated a useful dialogue on appropriate methodology for the estimation of desert tortoise population densities. Forthcoming (1994) will be a workshop at which statistically and economically acceptable methods will be discussed and recommended on an experimental basis.

Comment: The Desert Tortoise Management Oversight Group (MOG) is recommended as the group to facilitate interagency cooperation. As it is currently structured, this group's ability to perform this task is questioned. The Fish and Wildlife Service (FWS) should take the lead in facilitating interagency cooperation and coordination. The MOG has no formal status and it is a BLM-orchestrated group. If this is the group to be used, it should be restructured with the FWS assuming the leadership role.

Response: Because the majority of desert tortoise habitat is managed by the BLM, the MOG has proved to be a useful tool in implementing desert tortoise recovery efforts over the range of the desert tortoise in four states. The FWS will also be working closely with communities through the habitat conservation planning process to implement recovery on a local basis.

Comment Public education is not adequately addressed in the Recovery Plan.

Response: Both the Recovery Team and the FWS agree that public education is a vital component of desert tortoise recovery and has revised portions of the Recovery Plan to reflect more emphasis on public education. Cost estimates for development of a public information program are provided in the Implementation Schedule (Section III). The yearly costs for implementation of the program will be determined based on the requirements of the program.

Comment: The Recovery Plan makes no explicit recommendations for management of vehicle-caused mortalities on existing highways and roads in proposed DWMAs. Eleven of the 14 proposed DWMAs are bounded or transected by high traffic volume highways or roads.

Response: The Recovery Team agrees with this comment and has added an additional statement to Section II.E.2. of the Recovery Plan which recommends the establishment of fencing or other effective barriers along heavily-traveled roads to decrease desert tortoise mortality, and the installation of culverts that allow underpass of tortoises to alleviate habitat fragmentation.

Comment: The negative effects of human activities (including cattle grazing) on desert tortoises have not been demonstrated. Disallowing certain of these activities within DWMAs without providing quality supporting material which shows that these activities are contributing to declines in desert tortoise populations detracts from the credibility of the Recovery Plan.

Response: Desert tortoise recovery is the goal of management within DWMAs. Until data are forthcoming which show that these human activities can be compatible with recovery, it is important that they not be permitted.

Comment: The Service has failed to comply with the National Environmental Policy Act of 1969 (NEPA) by not preparing an Environmental Impact Statement (EIS) for this Plan.

Response: The Service is not required to comply with NEPA in development of recovery plans. Recovery plans are planning documents that list all tasks recommended for recovery of a species. These tasks involve potential actions by the Service, other Federal agencies, State and local governments, the private sector, or a combination of the above. Recovery plans impose no obligations on any agency, entity, or persons to implement the various tasks. Implementation of recovery actions will be subject to NEPA compliance, as appropriate, at the time they are actually "proposed" and an environmental assessment (EA) or EIS would be completed at that time.

Comment: The Service has failed to comply with Executive Order 12291.

Response: Executive Order 12291 requires Federal agencies to prepare regulatory impact analyses for any "major rule." A major rule is defined as any regulation that is likely to result in: (1) An annual effect on the economy of $100 million or more; (2) a major increase in costs or prices for consumers, individual industries, Federal, State, or local government agencies, or geographic regions; or (3) significant or adverse effects on competition, employment, investment, productivity, innovation, or on the ability of United States-based enterprises to compete with foreign-based enterprises in domestic or export markets (46 FR 13193). A recovery plan does not meet the definition of a regulation or rule as set forth in the Order. Recovery plans do not implement, interpret, or prescribe law or policy or describe the procedure or practice requirements of the Service. Therefore, the Service is not obligated to prepare a regulatory impact analysis.

Comment: The recommended desert tortoise habitat to be managed as DWMAs is unnecessary for recovery of the desert tortoise because existing reserved lands, such as national parks and wildlife refuges, provide sufficient land for the tortoise.

Response: The Service determined that the tortoise should be listed as a threatened species in 1990 (55 FR 12178) partly because insufficient habitat is protected within congressionally protected areas to adequately conserve desert tortoises. In addition, the Recovery Plan recognizes that

areas of sufficient size to support self-sustaining tortoise populations do not exist in already protected habitats.

Section III - Implementation Schedule

Comment: The budget in unconvincing. Where did the numbers come from?

Response: The numbers in the Implementation Schedule are estimates of what recovery will cost. The number will be revised as new information becomes available. Cost for full implementation of recovery actions will be based on the management plans that will be developed for each DWMA.

Comment: The Utah Division of Wildlife Resources (UDWR) is not included in the tasks for the Northeastern Mojave Recovery Unit, although a significant portion of the Beaver Dam Slope DWMA occurs in Utah. In addition, UDWR is included in the development activities for the Upper Virgin River DWMA, but is not included in the implementation and research sections. The UDWR is the lead agency on tortoise density research and monitoring, and reproductive research in Utah, as well as a cooperator on health and nutrition studies.

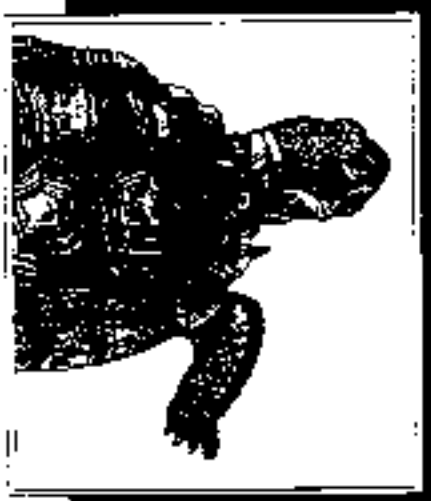
Response: The Implementation Schedule has been revised to reflect UDWR's role in the Northeastern Mojave Recovery Unit and in research and monitoring activities.

Acronyms Used in this Document

BLM	= Bureau of Land Management
BRTF	= Blue Ribbon Task Force of the BLM
CDSP	= California Department of State Parks
CFR	= Code of Federal Regulations
DTNA	= Desert Tortoise Natural Area
DWMA	= Desert Wildlife Management Area
ECRU	= Eastern Colorado recovery unit
EMRU	= Eastern Mojave recovery unit
EMZ	= Experimental Management Zone
ESU	= Ecologically significant unit
HCP	= Habitat conservation plan
kHz	= kilohertz
LUZ	= Limited Use Zone
mm	= millimeter
mtDNA	= mitochondrial deoxyribose nucleic acid
MVP	= Minimum viable population
NCRU	= Northern Colorado recovery unit
NEMRU	= Northeastern Mojave recovery unit
OHV	= off-highway vehicle
ORV	= off-road vehicle
PVA	= Population Viability Analysis
RECON	= Regional Environmental Consultants
TBD	= To be determined
UCLA	= University of California at Los Angeles
UDWR	= Utah Department of Wildlife Resources
USP	= Utah State Parks
URTD	= Upper Respiratory Tract Disease
U.S.C.	= United States Code
UVRRU	= Upper Virgin River recovery unit

Literature Cited

Desert Tortoise
(Mojave Population)



Recovery
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