RAVEN MANAGEMENT PLAN

*for the
California Desert
Conservation Area*

DRAFT

APRIL, 1990

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
CALIFORNIA DESERT DISTRICT OFFICE
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IN REPLY REFER TO
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MAY 21 1990

Dear Reviewer:

Enclosed for your review and comment is the Draft Environmental Impact Statement (DEIS) and associated draft plan for the proposed management of the common raven within the California Desert Conservation Area. Raven management has been proposed to reduce predation on juvenile desert tortoises by ravens. The purpose of the DEIS is to outline in advance the probable impacts that would result from these raven management actions.

The DEIS has been prepared to meet Federal requirements of the National Environmental Policy Act. The Bureau of Land Management's California Desert District prepared the document in coordination with the U.S. Fish and Wildlife Service, California Department of Fish and Game, U.S. Department of Agriculture, and U.S. Department of Defense.

We invite you to submit written comments on the adequacy, completeness, or accuracy of the DEIS

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DRAFT
RAVEN MANAGEMENT PLAN
FOR THE
CALIFORNIA DESERT CONSERVATION AREA

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SUMMARY

Common raven (Corvus corax) populations in the California deserts have rapidly increased over the preceding 20 years. Raven population increases appear to be a result of human-induced alterations of desert regions that provide numerous perching and nesting sites and stable food sources.

Raven predation on juvenile desert tortoises has increased substantially within those areas exhibiting highest raven population increases. Excessive predation by ravens has significantly affected the desert tortoise in these areas, lowering numbers of juvenile tortoises and altering tortoise age-class composition.

This management plan was developed to increase the understanding of the biology of the common raven in the California deserts, test several methods of controlling ravens, and implement raven control measures in a manner with the goal of restoring a "healthy" predator-prey relationship between these two coexisting species.

Specific management actions to accomplish this goal include conducting research on raven movement patterns and feeding behavior near landfills and at nest sites in desert tortoise habitats, inventorying desert regions for raven nesting and perching sites where tortoise remains are present, discouraging raven nesting and perching where high predation rates on juvenile tortoises occur, experimentally livetrapping and releasing ravens at distant points to reduce tortoise predation, implementing a program of selected raven control using lethal methods, and monitoring results of management actions.

INTRODUCTION

PURPOSE

BACKGROUND

The Bureau of Land Management (BLM or Bureau), in cooperation with other Federal, state, and local agencies, plans to implement a regional management program for the common raven (Corvus corax; hereafter referred to as "raven"). The area covered by this management plan encompasses the 25-million acre California Desert Conservation Area, including portions of Inyo, Kern, San Bernardino, Los Angeles, Riverside, San Diego, and Imperial Counties (Figure 1).

This management plan was developed in response to excessive predation rates by ravens on juvenile desert tortoises (Xerobates agassizii), a state listed threatened and federally listed endangered species. Desert tortoise populations in California have declined precipitously in recent years. Contributing factors include habitat loss and fragmentation, vandalism, outbreaks of disease, and predation. The BLM, as the major Federal agency administering public lands in desert tortoise habitat, has a responsibility to protect this species. Specific actions detailed in this plan are designed to limit excessive raven predation on juvenile desert tortoises to a level that allows for healthy recruitment into the adult population.

Raven control will take place only within those portions of the CDCA that contain desert tortoise populations. The distribution of the desert tortoise in the California deserts is not continuous, and has been influenced by such factors as elevation, topography, substrate, and level of prior disturbance.

This management plan addresses two aspects of raven control: (1) reducing ravens from areas where excessive predation on desert tortoises has been identified; and (2) experimentally attempting other forms of control and applying these on a regional long-term basis where proven successful. Actions to accomplish this focus on: (1) selectively poisoning and shooting ravens to reduce predation levels on a short-term basis; (2) concurrently undertaking research on the ecology of the raven in the CDCA; (3) concurrently testing nonlethal techniques of raven control; and (4) implementing effective raven control techniques desert-wide on a long-term basis.

Authorities under which this management plan has been developed include the Federal Land Policy and Management Act of 1976, the Sikes Act of 1974, as amended, the Migratory Bird Conservation Act of 1929, as amended (and treaties pertaining thereto), the

California Endangered Species Act of 1984, and the Federal Endangered Species Act of 1973, as amended.

PROGRAM GOALS

The objective of this management plan is to provide the framework for initiating a multi-agency program with the goal of restoring a balanced predator/prey relationship between the desert tortoise and raven in the California California Desert Conservation Area. Specific measures to accomplish this include actions to:

- (1) reduce levels of juvenile desert tortoise mortality caused by raven predation;
- (2) permit increased recruitment of juvenile desert tortoises into sub-adult and adult age-classes;
- (3) improve understanding of the biology of the raven through research and monitoring;
- (4) acquire additional data on means of limiting raven predation on juvenile tortoises;
- (5) implement those measures that are found to be effective for raven management and control; and
- (6) implement a monitoring program to determine effectiveness of program actions at reducing raven predation rates on desert tortoises.

Circumstantial evidence also suggests that predation by increasing numbers of ravens in the California deserts may be adversely affecting other wildlife species in addition to the desert tortoise. Information on the effects of raven predation on wildlife species in general is lacking. A second goal of this management plan will emphasize the collection of such data.

Additionally, actions undertaken as part of the plan will provide supplemental data that may be utilized to speed recovery and delisting of the desert tortoise. Information from the raven management program in California also will have application in other portions of the geographic range where excessive predation by ravens occurs.

An important assumption of the management plan is that the raven is a resident of the desert and an integral component of the desert ecosystem. As such, the raven will be managed in a manner that allows for the perpetuation of desert populations. Management relies on the selective control of ravens, and not on the extirpation of the species throughout the California deserts. An important goal of this management plan is therefore to maintain ravens in desert areas at levels that are self-

Figure 1. Boundary of California Desert Conservation Area, constituting raven management area under review. Locations of comparatively high density desert tortoise habitats are also shown (Adapted from Berry, 1984).

perpetuating but compatible with enhancement of desert tortoise populations.

BACKGROUND

THE COMMON RAVEN

Legal Status

The raven is a protected species under the Migratory Bird Treaty Act. Trapping or killing birds without a permit is prohibited. The authority to issue permits to trap, manipulate, or kill the species has been delegated to the U.S. Fish and Wildlife Service.

General Life History

Distribution

The raven is a large, all-black, member of the bird family Corvidae. It has an extensive geographic distribution over the northern hemisphere, ranging from Alaska, northern Canada, southern Greenland, and most of Eurasia, south into Central America and northern Africa (Goodwin 1976). The geographic range includes most of Alaska and the western continental United States. The raven also occurs in Maine, Minnesota, Wisconsin, Michigan, and Appalachia (Knight and Call 1980). Historically, the raven was extirpated from portions of the eastern and northern United States, possibly as a result of trapping and poisoning programs and the precipitous decline of bison herds (Hooper 1977; Knight and Call 1980). More recently, ravens have been recolonizing their historic range in portions of Alaska, Michigan, and southern Canada, and expanding into previously unoccupied areas in New England (Knight and Call 1980).

Information on the occurrence of the raven in the California deserts has been available, in part, by contract studies undertaken by the BLM during preparation of the California Desert Conservation Area Plan (Thelander 1977; Boyce 1977; Siperek 1977; Alten 1977), information compiled by Bureau wildlife staff on raptor nest sites, and results of breeding and wintering bird surveys conducted throughout the California deserts.

Social Behavior

Social behavior among ravens is complex. The species is highly vocal and given to involved posturing and display (Goodwin 1976). Ravens are also highly gregarious and congregate in groups of 100 or more individual birds. Intelligence of these birds is evident by their ability to "play" both individually (Dorn 1972; Elliott 1977) and in flying groups (Knight and Call 1980). Ravens have also been observed utilizing "tools" (Janes 1976; Montevecchi 1978; Heinrich 1988a).

Longevity

Ravens mature after 2-3 years of age. They reportedly mate for life, although this aspect of behavior has been subject to debate (Jollie 1976). Raven longevity may exceed 50 or more years.

Nesting Habits

Nests are constructed out of sticks (Dorn 1972; Stiehl 1978). Nesting sites are highly variable, and have included abandoned houses (Congdon 1948), cliffs (Jones 1935; Hooper 1977); oil derricks (Bowles and Decker 1930); railroad trestles (Johnson 1899); windmills (Bowles and Decker 1930); transmission towers and poles (Knight, University of Colorado, pers. comm.; BLM data); artificial platforms constructed specifically for raptors (Howard and Hilliard 1980); highway billboards and overpasses (White and Tanner-White 1988); and caves (Wolfe 1928). In the California Desert Conservation Area, raven nests have been observed in tamarisk trees, Joshua trees, transmission towers, and rock outcrops (Berry 1985; BLM data; Jim Raley, pers. comm.; Peter Woodman, pers. comm.).

Nest construction usually begins in late winter-early spring (Knight and Call 1980). Stiehl (1978) has reported that ravens will utilize the same nest site for several consecutive years. Nest completion occurs about one to four weeks before eggs are laid (Goodwin 1976). Intraspecific defense of nesting territories appears to be weak (Smith and Murphy 1973).

From three to six eggs are typically laid. These are incubated by the female and hatch in approximately 18-20 days. Both sexes care for young (Goodwin 1976). Young fledge at about 39 to 45 days of age (Dorn 1972). Parents continue to care for young birds for another one to four weeks after fledging (Knight and Call 1980).

About two to four young birds successfully fledge per nest (Stiehl 1978). Sixty percent of raven nests were successful in fledging one or more young in Oregon (Stiehl 1978). Where nesting failures occur, a replacement clutch may be laid (Stiehl 1978). Home ranges of nesting adult ravens during a study in the Great Basin Desert in Utah ranged from 1.86 to 2.98 square miles (Smith and Murphy 1973).

Feeding Habits

As food availability changes after the nesting season, birds may congregate into increasingly larger and more mobile groups (Stiehl 1978). These groups may migrate to take advantage of seasonal food sources during the winter months (Dorn 1972). During the breeding season, non-breeding birds may also flock

together at sites of food, such as garbage dumps (Dorn 1972). Communal roosting occurs with these groups of birds. Recorded roosts have included transmission lines and towers (Young and Engel 1988, Engel and Young 1989a), abandoned buildings (Temple 1974), pine trees (Cadman 1947), hemlock trees (Lucid and Conner 1974), hay fields (Cushing, Jr. 1941), bulrush stands (Stiehl 1978), railroad bridges (Jim Raley, Quail Unlimited, pers. comm.), and landfills (Knowles et al. 1989).

Ravens have been recorded scavenging on carcasses of a variety of species, including deer (Odocoileus virginianus), moose (Alces alces), domestic cows, domestic sheep, domestic goats, and caribou (Rangifer articus) (Nelson 1934; Heinrich 1988b). Austin (1971) recorded instances of ravens feeding on a variety of roadkills in the Mojave Desert. Species scavenged by ravens included antelope ground squirrels (Citellus leucurus), unidentified snakes, and black-tailed jackrabbits (Lepus californicus).

Ravens also opportunistically scavenge on human-produced food sources, such as slaughterhouse offal (Goodwin 1976, Heinrich 1988b) and refuse (McManus 1935; Harlow et al. 1975). Apparently, they will also scavenge human remains, since Goodwin (1976) lists "battlefields" as raven foraging areas. Sources of garbage accumulation that ravens can use as food supplies in the California deserts include dumps and landfills, sewage ponds, roadside pull-offs and rest areas, and campgrounds (Farrell, BLM, pers. observ. 1988; Knowles et al. 1989). Ravens have also been observed feeding on carcasses at roadside dump areas used by livestock shippers in the eastern Mojave Desert (Farrell, BLM, pers. obs. 1988).

Raven diets vary seasonally and between habitats. Ravens are opportunistic and highly adaptable in their feeding habits and are able to quickly learn to exploit any food source that becomes available. They are efficient predators and scavengers and, when necessary, have a vegetarian diet (Bent 1946; Dorn 1972) that includes cereal grains (Engel and Young 1989a). Temple (1974) concluded that ravens obtain half their energy income through scavenging and half through predation, although the majority of time was spent hunting for prey. Species occurring most frequently in the diet generally reflect those that are most abundant and easily obtained in a particular area (Harlow et al. 1975; Marquiss and Booth 1986; Dorn 1972). In addition, raven diets are influenced by seasonal food availability. Stiehl (1978) observed ravens abruptly change their feeding behavior in the month of July and concentrate on a dense population of grasshoppers. He also reported heavy predation on waterfowl eggs, a seasonally available food source.

Numerous animal species have been recorded from the diet (Nelson 1934; Bent 1946; Knowlton 1943; Murray 1943; Heinrich 1988a).

Dorn (1972) attempted to quantify diet by frequency of occurrence in raven pellets analyzed near Jackson Hole, Wyoming. Mammals comprised the largest portion of the diet (76%), followed by insects (33%), plant material (10%), birds (7%), and fish (5%). Harlow et al. (1975) estimated frequency of food composition by pellet analysis near Mountain Lake, Virginia. He found that mammal remains were most frequently encountered (74%), followed by plant materials (54%), and refuse (10%). Steihl (1978) found that mammals also constituted a primary food source in the diet of the raven (46%), followed by bird eggs (26%), bird parts (14%), fish (5.6%), insects (5.5%), vegetation (2.5%), and reptiles (1%).

Fluctuations in prey populations can influence food intake of ravens, as evidenced by regular monitoring undertaken in the Snake River Birds of Prey Natural Area, Idaho (Kochert et al. 1975, 1976, 1979, 1980, 1981).

Ravens may be extremely cautious when approaching potential food sources. Heinrich (1988c) has speculated that this behavior may be a result of prior persecution by humans or a behavioral mechanism to reduce vulnerability when approaching food.

Raven Status in the California Deserts

Historical Perspective

Ravens were uncommon in the deserts of California in the first half of the 20th century. When Eugene Cardiff, Curator of Natural History at the San Bernardino County Museum, first began searching for ravens in the western Mojave Desert in the early 1940's, he looked for about two years before he could locate a raven to collect for the museum (Eugene Cardiff, pers. comm.). Ravens were very scarce in the deserts of eastern California between the 1920's and 1940's also. Johnson et al. (1948), in a survey of the eastern Mojave Desert encompassing the Providence, New York, and Clark Mountains and adjacent areas, reported few observations of ravens. They saw so few ravens over a several year period that they noted that the raven was only a summer resident.

Raven populations grew substantially between the 1940's and 1970's and 1980's throughout the California deserts and parts of the Southwest. Data from both formal surveys and experienced observers indicate that increases in raven populations have been significant and that population growth continues. One of the more important sources of trend data is the U.S. Fish and Wildlife Service (Service), which developed a comprehensive breeding bird survey for the United States and Canada (Robbins et al. 1986). Using experts in bird songs and calls, the Service established a network of routes for breeding bird surveys and began to gather data in the 1960's. In the deserts, surveys were

usually conducted in May along established routes 25 miles long. The observer-listener made 50 stops at 0.5-mile intervals to record observations. Routes were established in 1968 and have been run consistently for 22 years.

In the Mojave Desert of California, southern Nevada, and extreme southwestern Utah, raven numbers have increased approximately 14.9% annually in the 20-year period between 1968 and 1988 (Unpubl. data, Service). Since 1968, the raven population has increased 15-fold or 1528%. In the same time period, raven numbers increased 9.1% annually for a total population increase of 474% in the Colorado and Sonoran desert regions of California and Arizona, respectively. Data for the Great Basin Desert in California and west-central Nevada indicate raven populations increased 5.05% annually and populations almost doubled (168% total increase) in the last 20 years. In the southern California basin extending from the Los Angeles-San Bernardino area south to San Diego, raven populations also have experienced significant increases of 7.5% annually with a 3-fold population increase (328% total increase) during the last 20 years. Increases are statistically significant at $P < 0.01$ for the Mojave and Colorado/Sonoran deserts and the southern California basin. Fish and Wildlife Service data are summarized in Table 1.

Table 1. Increase in Raven population in the western United States deserts (FWS data - 1968 to 1988).*

Region	No. of routes	Annual Trend (% annual change)	Change (%) in 20 years	P
Mojave Desert	14	+14.973	+1528	< 0.01
Colorado-Sonoran Desert	10	+ 9.134	+ 474	< 0.01
Great Basin Desert	16	+ 5.047	+ 168	< 0.1
So. California Basin	15	+ 7.539	+ 328	< 0.01

*Unpublished data courtesy of U.S. Fish and Wildlife Service, North American Breeding Bird Survey Program, Laurel, Maryland.

Other data from experienced observers, published papers, and reports support the findings of the Service. In the western Mojave Desert, there are many examples of high raven numbers. Eugene Cardiff reports substantial increases in the species in

the general region and has observed flocks of 100 to 400 birds in the Harper Dry Lake and marsh areas near Barstow (Cardiff, San Bernardino County Museum and San Bernardino Audubon Society files). Mike Phillips and Mark Hagen, biologists at Edwards Air Force Base, report flocks of 100 to 200 ravens at the base landfill in 1988. Groups of over 100 ravens have been regularly observed at the U.S. Marine Corps Air Ground Combat Center at Twentynine Palms (Roger Twitchell, USMC, pers. comm. 1989). Large numbers of ravens, ranging to over 100 birds, have also been observed at landfills for the desert communities of Boron, Apple Valley, Victorville, and Baker (Table 2).

Table 2. Raven observations at active landfills in the California desert during 1989*

Site	Total Number Ravens Observed	Maximum Count Birds	Frequency of Refuse Burial
Ridgecrest	444	82	Daily
Randsburg	31	15	Transfer Stat.
Boron	427	150	Daily
Hinkley	15	7	Daily
Yermo	115	74	Weekly
Newberry Springs	203	67	Weekly
Barstow	113	27	Daily
Apple Valley	950	200	Daily
Victorville	816	250	Daily
Camp Rock	278	66	Weekly
Landers	208	45	Daily
29 Palms	220	76	Daily
USMC 29 Palms Base	752-827	150	Daily
Baker	444	130	Weekly
Nipton	71	24	Periodic
Kelso	17	9	Periodic
Searchlight	71	28	Periodic
Needles	99	26	Daily
Goffs	54	30	Periodic
Essex	71	28	Never
Amboy	1	1	Periodic
Vidal Junction	11	4	Periodic
Desert Center	225	35	Weekly
Blythe	3	2	Daily
Palo Verde	0	0	Never
Indio	123	41	Daily

*Source: Knowles et al. 1989; BLM data 1989

**Raven numbers for the USMC 29 Palms Base landfill were derived over 14 days of monitoring between April 18, 1989 and August 16, 1989.

Lesser numbers of birds are regularly observed at sewage treatment sites at Ridgecrest, Baker, and Boron (Table 3). At

sewage ponds on the China Lake Naval Weapons Center, flocks of more than 100 ravens are common (Knowles et al. 1989). Knowles et al. (1989) have observed ravens feeding on filtered rags at sewage ponds and on the sewage in the ponds. Significantly, only five of 17 ponds under study showed consistent use by ravens.

Table 3. Raven counts at sewage treatment sites in the California deserts*

Site	Total Number Ravens Observed	Maximum Count Birds
California City	5	2
Inyokern	76	20
Ridgecrest	249	43
Federal Prison	4	2
East Boron	153	36
West Boron	4	2
Barstow	8	2
Yermo Marine Corps Base	2	2
Yermo Union Pacific RR	3	3
Silver Lakes	0	0
Victorville	6	3
Baker	181	47
Needles	3	3
Park Moabi	0	0
Blythe	0	0
Cactus City	3	2
Indio	0	0

* Source: Knowles et al. 1989.

In the eastern Mojave Desert, James Van Remsen conducted bird surveys in 1975-1976 and suggested that ravens were much more common during his field work than in earlier decades (Berry 1985; BLM files for the East Mojave Unit Resource Analysis: Wildlife, Needles and Riverside, California). By 1975-1976, the raven was a permanent resident (most seen/day = 15), whereas it was considered a summer resident only in the 1920's and 1940's (Johnson et al. 1948).

Road Survey Results

Austin (1971) conducted a study of the roadside distribution of the common raven in the eastern Mojave Desert of California and southern Nevada during 5,500 miles of travel between 1967 and 1969. More recently, regional inventories for ravens have been conducted under Bureau contract during 1989 (Knowles et al. 1989), and by BLM wildlife staff biologists Jim Farrell, Bill Montgomery, and Phillip Hughes during 1988-1989. Data

summarizing results of Austin's (1971) and Farrell's (1989) findings are provided in Table 4.

Table 4. Roadside distribution of ravens in the eastern Mojave Desert in the late 1960's compared to the late 1980's*

Type of Road Season	Years	Number of Ravens	Number of Miles	No. Ravens/ 100 Miles
Main Roads				
Nov-Feb	1967-69	38	1125	3.38
Mar-Apr	1967-69	13	862	1.51
May-Aug	1967-69	11	1463	0.75
Sep-Oct	1967-69	17	870	1.95
Totals		79	4320	1.83
Nov-Feb	1988-89	674	5603	12.0
Secondary Roads				
Totals	1967-69	9	1132	0.79
Nov-Feb	1988-89	85	1517	5.6
May-Aug	1988	154	2215	6.95

*Sources: Austin (1971); Farrell (1989)

This road survey information has been supplemented with a contract survey of four major regions of the California deserts (Knowles et al. 1989) and BLM staff in the Needles area. Knowles et al. (1989) conducted vehicle transects in the west Mojave, Ivanpah Valley, Fenner-Chemehuevi Valleys, and southern Colorado Desert of California during the winter of 1988-89. They recorded sightings of 4,328 ravens during 26,239 miles of driving on paved and unpaved roads. Ravens were most abundant in the western Mojave Desert and Ivanpah Valley. Significantly fewer ravens were observed in the Fenner-Chemehuevi Valleys and southern Colorado Desert. Observations along paved roads accounted for 92% of all raven sightings during this survey (Table 5). These results also are consistent with a concurrent survey conducted during 1989 for the Southern California Edison Company in the California deserts, showing a higher incidence of raven observations close to paved roads (Dr. Richard Knight, Colorado State University, pers. comm.).

Table 5. Results of road surveys conducted for ravens in the California deserts during the winter of 1988-1989*

Region	% Raven Observations		% Route		Ravens/100 miles	
	Paved	Dirt	Paved	Dirt	Paved	Dirt
West Mojave	79	21	78	22	33	31
Ivanpah Valley	89	11	56	44	22	3
Fenner-Chemehuevi	77	23	59	41	4	2
Southern Colorado	93	7	59	41	4	1
TOTAL	92	8	66	44	20	9

*Source: Knowles et al. 1989

Between November 1988 and May 1989, Bill Montgomery and Phillip Hughes of the BLM Needles Resource Area Office staff conducted surveys of paved and unpaved roads in the eastern Mojave Desert and northern Colorado Desert. Numbers of ravens observed and mileages driven were recorded during routes on freeways, County paved and unpaved, and dirt roads. A total of 840 observations of ravens were made during 12,036 miles of driving. Observations of ravens during this survey were significantly higher on dirt roads than for all classes of paved roads (Table 6).

Table 6. Summary of East Mojave and northern Colorado Desert surveys conducted by BLM staff*

Route Type	Ravens Observed	Miles Driven	Ravens/100 Miles
Freeway	194	3758	5.2
County Paved	180	1868	9.6
County Unpaved	44	1244	3.5
State Highway	197	3659	5.3
Dirt	188	912	20.6
Powerlines	37	597	6.1

* Source: Montgomery and Hughes data

Observations on Tortoise Study Plots

Data are being gathered on numbers of ravens observed flying over, perching, or otherwise present on desert tortoise permanent study plots. So far, data have been gathered on 10 of the 15 permanent study plots (Table 7). With the exception of the Goffs study plot where survey efforts were more intensive between 1983 and 1986, data were gathered during 60-day spring surveys of tortoise study plots varying in size from 1.0 to 1.6 square miles. The primary purpose of the 60-day spring survey is to gather data on desert tortoises. Sightings of ravens and other predatory birds are recorded as they occur and are opportunistic observations. The raven data from the tortoise plots provides a means of comparing the numbers of ravens seen per unit time during the spring months of March through June when tortoises are active. The data (presented in numbers of ravens observed per 100 hours of tortoise survey) can be compared from different desert regions and can offer an index of abundance of ravens in the open desert.

Numbers of ravens observed per 100 survey hours on tortoise study plots ranged from 0.41 to 45.32. A total of 14 ravens were observed per 100 hours of monitoring effort during the "pilot" raven control effort conducted at the Desert Tortoise Natural Area during 1989. Sites with significant losses of juveniles include areas where frequencies of raven observations range from about 3 to 45 ravens per 100 survey hours.

Management on Public Lands in California

Management of the common raven on Public Lands administered by the Bureau of Land Management has been largely passive. The raven has been afforded protection as a result of implementation of management actions for the protection of wildlife species in general. Such actions have included: restrictions on vehicle use; designation of wilderness study areas; protection of specific localities as Areas of Critical Environmental Concern; implementation of general mitigation measures to protect wildlife during a variety of activities; and increased ranger presence to enforce applicable laws.

Table 7. Numbers of ravens observed per 100 survey hours on permanent desert tortoise study plots between 1983 and 1988, and during pilot raven control program monitoring during 1989*

Region		Total No. Raven Seen/Mo.				Number ravens/ 100 hours
	Year	March	April	May	June	
Western Mojave Desert						
Fremont Valley	1987	16	33	6	n.d.	14.76
Desert Tortoise Natural Area	1988	n.d.	99	90	n.d.	45.32
	1989	n.d.	3	22	0	20
Kramer Hills	1988	35	96	66	n.d.	41.04
Stoddard Valley	1988	n.d.	26	91	n.d.	28.92
Eastern Mojave Desert						
Shadow Valley	1988	n.d.	45	15	3	20.81
Goffs	1983	n.d.	3	19	4	3.32
	1984	n.d.	7	0	2	1.5
	1985	n.d.	0	3	0	0.76
	1986	n.d.	11	9	2	3.9
Colorado Desert						
Ward Valley	1987	n.d.	14	22	0	8.73
Chemehuevi Valley	1988	9	12	n.d.	n.d.	3.32
Chuckwalla Valley	1987	n.d.	0	2	0	0.41
Chuckwalla Bench	1988	9	21	5	0	6.01

n.d. = no data collected for that month

*Sources: Berry, BLM data

THE DESERT TORTOISE

Legal Status

The desert tortoise was State listed as "threatened" in California on June 22, 1989 [California Code of Regulations, Section 670.5(b)(4) of title 14], and federally listed as "endangered" under the emergency listing provisions of the Endangered species Act on August 4, 1989 (54 Federal Register 32326-32331). Reasons for both Federal and State listing include loss or deterioration of habitat, disease, predation, and collection for pets. Contributing factors include urbanization, vandalism and poaching, release of sick pet animals into wild populations, excessive predation on juvenile tortoises by ravens, motorized vehicle use, and route proliferation. The desert tortoise receives legal protection afforded under both the California Endangered Species Act and the Federal Endangered Species Act of 1973, as amended. The U.S. Fish and Wildlife Service is currently seeking comment on a Proposed Rule to extend the Federal endangered status of the desert tortoise past the 240-day timeframe allowed under the emergency provisions of the Endangered Species Act (54 Federal Register 42270-42278).

General Life History

Distribution

The desert tortoise (Xerobates agassizii) is distributed over portions of the Mojave, Colorado, and Sonoran deserts of the southwestern United States and adjacent Mexico. It occupies a variety of habitats, ranging from Mojave Desert plains and valleys, Sonoran Desert bajadas and lower mountain slopes, and thorn scrub forest in northern Mexico. Associated plant species include creosote bush (Larrea tridentata), burrobush (Ambrosia dumosa), saltbush (Atriplex spp.), Joshua trees (Yucca brevifolia), ocotillo (Fouquieria splendens), saguaro cactus (Carnegiea gigantea), and palo verde (Cercidium floridum) (Woodbury and Hardy 1948; Schwartzmann and Ohmart 1977; Bury et al. 1978; Berry 1975, 1984)

Burrows

The tortoise is highly adapted for digging, with shovel-shaped front legs used to scoop out earth during burrow construction (Woodbury and Hardy 1948). Burrows are constructed to escape predators and to avoid harsh temperature extremes and dessication. Burrows constructed include a shallow and short "pallet" that is used on a regular basis during seasonal activity periods by foraging animals and a deeper and more extensive burrow that is used for overwintering or estivation (Woodbury and Hardy 1948; Berry 1975). Burrows may be constructed under the

canopy of a bush or shrub (Berry 1972), in the open (Burge 1976), along wash embankments (Woodbury and Hardy 1948); or under boulders (Coombs 1977).

Activity Periods

Periods of seasonal activity coincide when food supplies and water are available. Principal food plants include a variety of annuals (Berry 1975, Burge and Bradley 1976; Coombs 1977), and perennials (Hansen et al. 1976). Tortoises eat perennial grasses, a few half shrubs (such as Sphaeralcea ambigua), and occasionally the flowers of perennial shrubs. Tortoises will emerge during or immediately after spring or summer rainfall to drink (Medica et al. 1982).

Reproduction

Age to maturity is approximately 15-20 years (Woodbury and Hardy 1948). Animals may reach 100 years of age (Woodbury and Hardy 1948). Courtship is complex, and consists of initial trailing of a female by a male. Males will often precede copulation by circling, butting, ramming, and biting the female. Males may mate with several different females over the course of a season. Most mating occurs close to the female's burrow (Berry 1986).

Typically 1-2 clutches of from 2 to 14 eggs (Miller 1955; Berry 1974; Turner et al. 1987) are deposited during the spring or early summer in or near the burrow. During a study of the species at the Ivanpah Valley, California, tortoises laid their first clutch of eggs during mid-May. A second clutch was subsequently laid by 30% of the adult females during mid-June (Turner et al. 1984). Mean clutch size, determined during a population study near Goffs in the eastern Mojave Desert, was 4.5 (Turner et al. 1987). The eggs hatch in approximately 105 to 135 days (Coombs 1974). Hatchlings and juvenile tortoises have very thin shells that gradually harden as animals mature (Patterson 1978). Nest defense by female desert tortoises from predators such as gila monsters (Heloderma suspectum) has been observed (Vaughan and Humphrey 1984).

Social Behavior

Desert tortoises exhibit dominance hierarchies. Individual fighting or posturing between animals may occur between both males and females. Females are typically subordinate to males. Interactions between animals may include head bobbing and ramming. The "aggressor" in such instances is usually the larger and dominant animal. Outcomes of such encounters may result in the subordinate individual rapidly leaving the area or withdrawing into its shell (Berry 1986).

Desert tortoise rely on a combination of sight, smell, sound, and tactile signals. They will frequently sniff the soil and each other, and use their sense of smell to follow trails of other tortoises. Visual signals are used to communicate and include head bobbing, gaping, withdrawing limbs and head into the shell, and elevating the neck. Vocalization can occur, but use of sound for communication has received little attention to date (Berry 1986).

Home Range and Movements

Home range size for desert tortoises studied in the Ivanpah Valley, California, ranged from approximately 5 acres to 220 acres, with an average of about 50 acres for both sexes (Turner et al. 1981; Medica et al. 1982). Based on a comparison of results of different studies, males typically have a significantly larger home range than females (Berry 1986). Although home range appears to be relatively small, individual animals are capable of rapid linear movement. Males may move over 1000 yards per day within their home range. Tortoises have also been recorded moving distances of over four miles over an extended time period (Berry 1986).

Tortoise Status in the California Deserts

Abundance

Desert tortoise populations and habitats are subjected to a number of man-induced actions, including mineral exploration and development, urbanization, road construction, motorized vehicle recreation, grazing by domestic livestock, and energy development. The cumulative effects of such activities are direct loss of individual tortoises, habitat fragmentation and degradation, and habitat loss (Berry and Nicholson 1984).

In California, data on distribution and densities of tortoises have been derived from a database of over 2000 strip-transects and 30 study plots. Desert tortoises are distributed within approximately 40,156 square miles, 84% of which has low densities estimated at 0 to 20 tortoises per square mile (Berry and Nicholson 1984). Approximately 73% of habitat in California is on public lands administered by the BLM (Table 8).

Data gathered over periods ranging from 9 to 17 years on permanent study plots indicate that tortoise populations have declined precipitously in several areas since 1979-80. Areas experiencing severe declines include the "core" populations in the western Mojave Desert and southern Colorado Desert in California (Berry et al. 1987, 1988). Outbreaks of two different diseases, excessive raven predation, vandalism, and vehicle kills have contributed to population declines exceeding 50% in the last four to seven years.

Table 8. Land ownership of desert tortoise habitats containing 20 or more tortoises per square mile in California in the 1970's.*

Est. Tortoise Densities (no./sq. mile)	Land Ownership (sq. miles)**		Totals (sq. mi.)
	BLM	Private	
20 to 50	2,687	729	3,416
50 to 100	1,334	478	1,812
100 to 250	559	314	873
250	47	225	272
Totals	4,627	1,746	6,373

*Source: Berry and Nicholson (1984)

**Gross estimates that do not deduct habitat lost as a result of developments such as roads, small towns, off-road vehicle staging areas, etc. Actual habitat is less than shown.

In 1989 the BLM and California Department of Fish and Game contracted with two internationally recognized experts in reptilian diseases for assistance in identifying the pathogens involved in the disease outbreak in the western Mojave Desert. In addition, surveys were conducted on the epidemiology of the disease at the Desert Tortoise Natural Area, particularly to gather data on distribution and frequency of disease symptoms in tortoises (Faunawest 1989). In May and October of 1989, meetings were held with research veterinarians and other scientists to determine protocols for handling tortoises, for design of future research projects, and to share information about disease issues.

Management on Public Lands in California

In 1979 the BLM designated the desert tortoise as a "sensitive" species. According to the California Desert Conservation Area (CDCA) Plan of 1980 (BLM 1980), sensitive species are provided special consideration and attention during project planning and implementation. The CDCA Plan also contained designated Wildlife Habitat Management Areas (WHMAs) and Areas of Critical Environmental Concern (ACECs) for the desert tortoise in California. These are the western Mojave Desert (WHMA), western Rand Mountains (ACEC), Desert Tortoise Research Natural Area (ACEC), Shadow Valley (WHMA), Ivanpah Valley (WHMA), Fenner/Chemehuevi Valleys (WHMA), and the Chuckwalla Bench (ACEC) (BLM 1980). Management plans for the Desert Tortoise Research

Natural Area and the Chuckwalla Bench were completed in 1988 and 1986, respectively (BLM 1986; BLM 1988). An additional management plan for the desert tortoise population in the Fremont Valley-Rand Mountain area of eastern Kern County is nearing completion (BLM 1989a). Development of four regional habitat management plans encompassing tortoise populations in California was subsequently recommended (Sievers et al. 1988), and adopted by the BLM.

The BLM, as a "lead" Federal agency responsible for management of Public Lands containing a significant portion of desert tortoise habitats, has implemented several actions specifically for the desert tortoise. Aside from designation of special management areas, the Bureau has undertaken systematic transects over large portions of the geographic range of the desert tortoise to determine distribution and relative abundance; established permanent trend study to monitor population trends over time; instituted a program to acquire inholdings of private lands in two Areas of Critical Environmental Concern; undertaken specific studies to determine effects of land management actions on the desert tortoise; required some project-specific mitigation measures for the species; and assumed a lead agency role towards development of comprehensive management strategies for the desert tortoise.

In 1986, a Bureau-wide Task Force was established to develop a framework for management of the desert tortoise and its habitat throughout the geographic range of this species in the United States and to enhance cooperation and coordination between government agencies (Kennedy et al. 1987). The Task Force produced a report, Management of Desert Tortoise Habitat, and set the goal of ensuring that viable tortoise populations exist on Public Lands. In 1988, another team was assembled to begin implementation of the Task Force's recommendations (Spang et al. 1988). The team completed a report, Desert Tortoise Habitat Management on the Public Lands: A Rangewide Plan, in November of 1988. The plan contains 14 management objectives covering a range of subjects, including management of off-highway vehicle use, livestock grazing, and energy/mineral development.

At the same time that the BLM Washington Office was working on national rangewide recommendations for the desert tortoise, the Bureau's California Desert District Office established a California Desert Tortoise Workgroup composed of Bureau tortoise experts as well as representatives from the California Department of Fish and Game, Desert Tortoise Council, and Desert Tortoise Preserve Committee. The California Workgroup was charged with developing recommendations for definitive actions that might be taken to improve, protect, and enhance tortoise populations and habitat (Sievers et al. 1988). The Workgroup's report contains 47 recommendations for changes in management, including a specific statement about reducing the level of raven predation on

tortoises desert-wide in California. The BLM California Desert District Office is currently working on implementing some of the 47 recommendations, as well as addressing the 14 management objectives in the rangewide report.

In 1989, the Bureau has also established a Management Oversight Group (MOG), to oversee consistency of management direction and information collection within the four western states with desert tortoise habitat (Utah, Nevada, Arizona, and California). The MOG is comprised of Bureau officials and representatives of State wildlife agencies and the U.S. Fish and Wildlife Service to oversee consistency of management direction and information collection on the species. Each state also established a Technical Advisory Committee to provide recommendations for research and management of the desert tortoise. In California, the California Desert Advisory Council, consisting of representatives from conservation groups, use interests, recreation interests, local governments, and the public, has established a Coordination Committee specifically to review actions relating to the desert tortoise.

RAVEN PREDATION ON TORTOISES

Evidence of Predation

Ravens use tortoises for food. They have been observed killing tortoises several times. Ted Rado (BLM), Tom Campbell (Naval Weapons Center, China Lake), and Jim Farrell (BLM) have observed ravens in the process of killing tortoises. Laura Stockton (pers. comm.) and Bev Steveson (pers. comm.), tour guides for the Desert Tortoise Preserve Committee, rescued a juvenile tortoise that had been attacked by a raven at the Desert Tortoise Natural Area.

Woodman and Juarez (1988) described a raven nest and perch site with exceptionally high levels of predation on juvenile tortoises at the BLM's Kramer permanent study plot for tortoises. They collected remains of 190 juveniles killed between 1984 and 1987 and concluded that ravens accounted for probably 185 (97%) of the deaths. In the spring of 1988, they collected additional fresh remains of juvenile desert tortoises from the nest and perch area, bringing the total number of juveniles killed between spring 1984 and spring 1988 to 250 (Woodman, pers. comm.). Woodman and Juarez (1988) noted that ravens began killing larger juvenile tortoises, and after these were removed from the population, focused on progressively smaller juveniles.

John Wear, a biological consultant, collected shells of 24 freshly killed juvenile desert tortoises under a raven nest in the Chemehuevi Valley in 1985 (Berry 1985). In the fall of 1988, Jim Farrell (BLM, pers. comm.) found 46 shells here. Additional tortoise shells were also located at this location in 1989 (Jim

Raley, pers. comm.). In the spring of 1988, Bureau biologist Jim Farrell surveyed a few hundred miles of transmission line towers and wooden poles for raven nest sites in the eastern deserts of California. He found nine nests and one perch site used by nesting ravens and their families. Two of the nine nests were occupied by families of ravens that use tortoises extensively for food. One nest, on a transmission line tower in Ward Valley, had a total of 87 tortoise shells under the tower with the nest and under the adjacent five towers. The second nest, on a transmission line that crosses the Fenner and Piute Valleys in an east-west direction, had 61 tortoise shells. North of Kelso, a third raven family used a perch site consisting of eight wooden power poles for feeding. Nineteen shells were associated with this perch. Farrell was unable to locate the nest used by this raven family. Farrell concluded that three out of the ten nesting pairs of ravens under observation were consuming large amounts of desert tortoises in the eastern California desert. Farrell also found several other sites under towers with a few juvenile shells (Farrell 1989).

Followup inventories of transmission towers in portions of the eastern California deserts were undertaken during the spring of 1989 by BLM biologists Phillip Hughes and Bill Montgomery. Remains of juvenile desert tortoises were discovered beneath or near 11 different transmission towers (Bill Montgomery, BLM, field notes; Phillip Hughes, BLM, field notes). Monitoring conducted during a 1989 "pilot" raven control program documented additional juvenile tortoise remains underneath raven nesting and roosting sites (Jim Raley, Quail Unlimited, pers. comm.).

Campbell (1983) described the collection of 136 carcasses of juvenile desert tortoises ranging in size from 36 mm to 103 mm carapace length (estimated ages 0 to 7 years) at fence posts on the Desert Tortoise Research Natural Area in 1980 and 1981. Berry (1985) reported additional heavy predation rates in the Natural Area at a raven nest site along the fence and on a study plot in the late 1970's and early 1980's. Remains of seventy-three juvenile tortoises killed by ravens were found on one Natural Area study plot between 1978 and 1982. Additional remains of juvenile tortoises have been subsequently recovered along the Natural Area boundary fence (Rado 1990).

Remains of juvenile desert tortoises can be found at the base of transmission towers, at isolated fence posts, at mining claim stakes, next to road barricades, under Joshua trees, at the bottom of wash embankments, on hilltops, and elsewhere in the deserts of California (Berry 1985; Jim St. Amant, CDFG, pers. comm.; John Wear, consultant, pers. comm.; Jim Raley, Quail Unlimited, pers. comm.; Ted Rado, BLM, pers. observ.). Examples of sites with tortoise remains include the Desert Tortoise Research Natural Area perimeter fence, isolated Joshua trees in the Desert Tortoise Research Natural Area and immediately west of

the Kramer study plot, road barricades west of California City, the perimeter fence at the Barstow Woolly Sunflower Area of Critical Environmental Concern, several locations at the southern end of the U.S. Marine Corps Air Ground Combat Center at Twentynine Palms, the base of a rocky hill west of Needles, and below several different transmission towers in the northern Colorado Desert (Jim Raley, pers. comm., Roger Twitchell, USMC, pers. comm., Ted Rado, pers. observ.).

Ravens may also be consuming adult tortoises, although information is circumstantial. Farrell (pers. comm.) documented an instance in the northern Colorado Desert where tracks and a freshly killed adult tortoise indicated that an apparently healthy animal was attacked and killed by a group of ravens. Similar attacks on adult tortoises by groups of ravens in the central Mojave Desert near Kramer Junction have also been reported (Dr. Dave Morafka, California State University Dominguez Hills, pers. comm.). Additionally, remains of adult tortoises under an unidentified raptor nest west of the Desert Tortoise Research Natural Area have been photographed (Richard Buckberg, California Energy Commission, pers. comm.).

There is no evidence suggesting that ravens are scavenging large numbers of dead juvenile desert tortoises killed by disease or other causes. Until 1988, very few sick or disabled tortoises were observed on the 27 BLM study plots in the California deserts. In over 16,000 observations of live tortoises on California plots, fewer than 0.002% have shown signs of active diseases or damage. In 1988, two tortoise populations were discovered with diseases, one at the Desert Tortoise Natural Area and the other at the Chuckwalla Bench. Large numbers of dead juvenile desert tortoises have been found under raven perching and nesting sites in areas where incidence of diseased tortoises has not been documented. Ravens apparently have preyed on juvenile tortoises for many years (Miller 1932), but the examples of excessive predation are relatively recent and appear to coincide with the growth of predator populations.

Effects of Raven Predation on Desert Tortoise Populations

Data from permanent desert tortoise study plots provide a sample of the levels of raven predation occurring on juvenile desert tortoises in the California deserts (Berry 1985; Berry et al. 1986a, 1986b, 1987; BLM 1988 data). Data collected between 1976 and 1987 are displayed in Table 9. Frequencies are only shown for sample sizes of 25 or more.

Since the mid- to late 1970's and early 1980's, raven predation has had significant adverse effects on desert tortoise populations. Specifically, ravens have: (1) reduced numbers of

Table 9. Numbers of small tortoises (<110 mm carapace length) deaths attributed to common ravens on 15 desert tortoise study plots in California*

Desert Region Site Name	Years	Numbers of Deaths Raven Kills	Other	% due to Raven Kills
Western Mojave Desert				
Fremont Valley	1976-81	11	26	29.7
	1987	2	11	15.4
Desert Tortoise Natural Area	1978-82	73	19	79.4
Desert Tortoise Nat. Area Interp. Ctr.	1985	16	24	40.0
Fremont Peak	1977-79	2	5	
	1980-85	1	0	
Kramer	1980-82	9	11	45.0
	1987	44	50	46.8
Calico	1978	1	0	
Stoddard Valley	1978-81	14	15	48.3
Lucerne Valley	1980	4	2	
	1986	9	16	36.0
Johnson Valley	1980	8	9	47.1
TOTAL		198	202	49.5
Eastern Mojave Desert				
Ivanpah Valley	1977-79	3	10	14.3
	1986	1	14	
Goffs	1977-80	2	5	
TOTAL		6	29	17.1
Colorado Desert				
Ward Valley	1980	1	2	
	1987	5	27	17.1
Chemehuevi Valley	1977-82	1	35	2.8
Chuckwalla Bench	1977-82	13	34	27.6
Chuckwalla Valley	1980	0	4	
	1987	0	13	
TOTAL		20	115	14.8

*Sources: Berry 1985; Berry et al.
1986a, 1986b, 1987, 1988; 1989
BLM data.

juvenile tortoises in the hatchling to eight-year classes, (2) reduced recruitment of tortoises into the larger and older size-age classes (e.g., tortoises from 9 to 20 years of age), (3) altered the size-age class composition of the population to favor adults, and (4) contributed to overall populational declines from multiple sources. Examples of the degree and nature of the impacts are evident at five permanent study plots in the western Mojave Desert (Figure 2) and at two study plots in the northeastern Colorado Desert, as well as in other regions.

Briefly, for the purposes of analyzing tortoise population data, tortoises are divided into six size-age classes based on carapace length: juvenile 1 (<60 mm); juvenile 2 (60-99 mm); immature 1 (100-139 mm); immature 2 (140-179 mm); subadults (180-207 mm); and adults (>208 mm) (Turner and Berry 1984). The classes reflect age, degree of shell ossification, vulnerability to predators, and sexual maturity. In general, tortoises in the juvenile 1 class are less than three to four years old, those in the juvenile 2 class are four to seven years old, those in the immature 1 class are seven to 13 years old, and those in the immature 2 class range from 13 to 20 years of age. Ages for tortoises in the smaller size classes vary considerably and depend on food supply, precipitation, and other factors. However, most tortoises require 15 to 20 years to reach sexual maturity, which occurs when individuals reach 180 to 200 mm in length.

Because ravens prey heavily and selectively on small size-age classes and are very efficient predators, they have contributed to significant changes in size-age classes of tortoise populations throughout the California deserts. In the western Mojave Desert, where data are available from several study plots, the pattern is consistent and significant (Berry et al. 1986a, 1986b, 1987, 1988). Table 10 shows pairs of size-age class data for different years for five study plots. In every case, frequencies of tortoises in the juvenile and immature 1 size classes (e.g., tortoises less than 15 years of age) have declined, while subadult and adult frequencies have increased. In populations with little or no raven predation, size-age class frequencies for the juvenile and immature 1 tortoise groups are generally higher than the 6% to 22% shown in Table 10 for data collected between 1985 and 1988.

The data on population densities from the study plots underscore the severity of raven predation on young desert tortoises. Tortoise population densities have dropped substantially on the western Mojave Desert plots, with declines ranging from approximately 30% to 60% between 1979-1982 and 1985-1988 (Berry et al. 1986a, 1986b, 1987, 1988). Substantial losses to population densities are occurring in juvenile and immature 1

Table 10. Changes in size-age class composition of desert tortoises at five permanent study sites in the western Mojave Desert between the 1970's and the present*

Study Site	Year	Frequency of Size-Age Class (%)	
		Juvenile/Immature 1	Subadult/Adult
Fremont Valley	1981	30.0	52.2
	1987	22.3	64.5
Desert Tortoise Natural Area	1979	15.3	73.1
	1988	6.2	87.7
Desert Tortoise Nat. Area Interp. Ctr.	1979	18.6	67.6
	1985	13.5	80.6
Fremont Peak	1977	21.9	53.1
	1985	8.1	89.2
Kramer Hills	1982	38.9	51.4
	1987	17.5	65.1

*Berry et al. 1986a, 1986b, 1987

size classes. Another indicator of the magnitude of predation is the dead tortoises found on the plots (Table 9). High proportions of young tortoises <100 mm in length are being killed by ravens. Taken as a unit, this information reveals that raven predation is having a substantial adverse effect on the desert tortoise population in the western Mojave Desert.

Of considerable concern is the lack of recruitment of young tortoises into the adult breeding population. When tortoises are preyed upon heavily in the hatchling to eight-year cohorts (each year-class of tortoises is a "cohort"), then few tortoises are incorporated into the cohorts for nine to 20 years and older. Figure 2 shows a histogram of live tortoises registered at the Desert Tortoise Research Natural Area Interior Plot in 1979 and 1988. The 1979 histogram depicts a tortoise population experiencing intensive raven predation pressure; tortoise numbers were very low in the size-age classes representing 60 to 100 mm in length (i.e., 3 to 7 years of age). By 1988, the effects of raven predation pressure were evident in all tortoise juvenile and immature size-age classes, as well as in young subadults (i.e., 3 to 20 years of age). The presence of very small

Desert Tortoise Natural Area - 1979

Desert Tortoise Natural Area - 1988

Figure 2. Histograms of live tortoises captured at the Desert Tortoise Natural Area interior study site during 60-day spring surveys in 1979 and 1988. In the 1979 histogram, note the low numbers of juvenile tortoises 60-100 mm in length. In the 1988 histogram, note the lack of recruitment of juvenile tortoises 60-100 mm in length into the larger size classes.

tortoises at the bottom of the histogram indicates that females still lay eggs that are hatching. However, hatchling tortoises are not surviving to reach the larger size and older age categories. These histograms illustrate what is happening to desert tortoise populations in the western Mojave Desert.

Effects of raven predation on desert tortoise populations are similar in the northeastern Colorado Desert of California to that in the western Mojave Desert, although not as severe. Two study sites in the Ward Valley show low numbers of juvenile 1 and 2 tortoises (Berry et al. 1988, Karl 1988). One study plot established in 1980 showed a decline in juvenile tortoise size-age class frequencies from about 23% to 8% between 1980 and 1987. Excessive raven predation has been documented for this general area.

Without immediate action to counter the losses of young individuals in the tortoise populations, declines will continue. Tortoise populations must recruit juveniles and immatures on a regular basis to maintain themselves. While many other human uses have severe impacts on tortoises (e.g., Berry and Nicholson 1984, Berry 1986), any management effort to reduce these impacts will be fruitless unless tortoise populations have the opportunity to recruit young. Therefore, excessive raven predation should be reduced.

RAVEN EFFECTS ON OTHER RESOURCES

General Overview

Ravens have damaged crops, livestock, wild game, and structures. Crop damage has included extensive consumption of pistachios in the Central Valley of California (Salmon et al. 1986) and pecans in Oklahoma (Leppla II, 1980). Ravens have been responsible for killing lambs (Larsen and Dietrich 1970), calves (Knittle and Orr 1988), domestic turkeys (Lounsbury 1972), and chickens (McManus 1935). Damage by a relatively few birds can be extensive. At the Fish Springs Hatchery, California, a group of approximately 10-30 ravens have consumed an estimated 100,000 trout, comprising between 5-10% of total fingerling production (Jimmie Eichman, California Dept. of Fish and Game, pers. comm.). Damage has included power outages as a result of raven fecal contamination of transmission tower insulators in Idaho and Oregon (Young and Engel 1988).

Although extensive information is available on raven diet, there is a paucity of data regarding effects of raven predation on wildlife resources. Bowles and Decker (1930) commented that raven predation was exceedingly injurious to waterfowl due to the "great number of eggs and young birds devoured." Dorn (1972) observed a raven taking a young robin (Turdus migratorius) from a

nest. Maser (1975) observed a pair of ravens attack a flock of rock doves (Columbia livia), and kill one of the group, apparently for food. Mallory (1977) described a raven hunting voles (Microtus pennsylvanicus). Raven predation on sandhill crane (Grus canadensis) eggs has also been reported (Littlefield 1986).

Ravens have been implicated in predation on two federally listed endangered bird species: the California least tern (Sterna antillarum browni) (Clark Winchell, Camp Pendleton, pers. comm.) and California condor (Gymnogyps californianus) (Larry Salata and Bill Lehman, FWS, pers. comm.). Circumstantial evidence indicated that ravens destroyed eggs and nests and killed nestlings in the California least tern colonies at Camp Pendleton. Ravens have been observed stealing condor eggs on several occasions during the early 1980s. Additionally, a condor egg may have been destroyed by parent birds trying to chase ravens away from the nest (Bill Lehman, FWS, pers. comm.). Ravens have the capacity to prey on large numbers of individual animals. Steenhof and Kochert (1982), in a study of the Snake River Birds of Prey Area in Idaho, noted that ravens visited their nests to feed young an average of 51 times per day.

Raven Impacts in the California Deserts

Little information has been obtained on raven effects to other resources in the California deserts. Concentrations of ravens have been noted around waste grain near Boron in the central Mojave Desert (John Wear, pers. comm., Ron Rempel, CDFG, pers. comm.), suggesting that these birds can readily identify and consume grain crops. Declines in song bird nesting production at the Harper Dry Lake marsh in San Bernardino County have also coincided with a large increase in the raven population (Eugene Cardiff, San Bernardino County Museum, pers. comm.). Raven predation on nestling birds and bird eggs is believed to be a contributing factor to the observed declines (Eugene Cardiff, pers. comm.).

EFFORTS TO CONTROL RAVEN POPULATIONS

Synopsis of Bird Control Techniques

Control techniques for birds in general focus on modifying behavioral patterns or lowering population numbers. Briefly, these techniques include: use of chemicals to reduce feeding on crops (aversion), trapping, shooting, netting, modifying structures used for nesting and perching, sterilization, hazing (noise devices) or poisoning. These techniques have been applied in various circumstances for control of ravens. The following text provides an overview of these measures as they specifically relate to raven control.

Raven Control Measures

Raven control programs have been instituted to reduce predation of endangered California least tern chicks at Camp Pendleton in California (Knittle 1988), and egg predation of greater sandhill cranes (Grus canadensis tabida) in Malheur National Wildlife Refuge, Oregon (Littlefield 1984). Raven control programs have also been implemented to reduce raven attacks on livestock in Oregon (Larsen and Dietrich 1970) and Arizona (Knittle and Orr 1988), and predation on domestic turkey eggs in Apple Valley, California (Lounsbury 1972).

Lethal Control Methods

Control efforts have included poisoning ravens by treating hard-boiled chicken eggs with the avicide DRC-1339 (Starlicide) (Knittle and Orr 1988, Knittle 1988, Littlefield 1984) or injecting Starlicide into meat baits (Knittle and Orr 1988). Starlicide was developed for control of pest bird species by the U.S. Fish and Wildlife Service (USFWS 1985), and is acutely toxic to a narrow range of species, principally starlings, doves, and crows and their relatives. Game birds and owls are also highly susceptible (Table 11). A nonviolent death occurs in one to two days after ingestion of treated baits, from kidney failure or central nervous system depression (DeCino et al. 1966). Exposure potential to other wildlife species from secondary poisoning is very low (Schafer 1984); monitoring during the 1989 pilot raven control program in the California Desert Conservation Area did not document any contact with or observed interest in poisoned eggs (Rado 1990). Program monitoring results for control projects employing DRC-1339 ranged from substantial decline in the target raven population (Larsen and Dietrich 1970) to limited reductions of a few "targeted" birds (Knittle 1988). Starlicide poisoning has also been used in concert with shooting (Littlefield 1984).

A pilot program to selectively reduce raven numbers in portions of the California deserts was undertaken during 1989. The program was developed in response to documented declines in desert tortoise recruitment as a result of raven predation. The objective of the program was to boost desert tortoise recruitment by selective reductions of ravens. Program activities included identifying areas for control, monitoring control areas, and killing ravens at these sites using a combination of poisoning with DRC-1339 and shooting. Longer-term actions will involve monitoring desert tortoise populations near control sites. Raven control was focused in three areas: the Desert Tortoise Research Natural Area (western Mojave Desert, Figure 3), several raven nesting and perching sites in the general vicinity of Needles (Colorado Desert), and a landfill at the U.S. Marine Corps Air Ground Combat Center at Twentynine Palms (central Mojave Desert).

Table 11. Toxicity of Starlicide to various species of wildlife*

Species	Approximate lethal oral dose (50% of treated animals, mg/kg)
Amphibians	
Frog	225**
Reptiles	
Turtle	1,040**
Birds	
Blue-winged Teal	31.6
Starling	3.8
Redwinged Blackbird	1.8-3.2
Mourning Dove	5.6-10.0
Rock Dove	17.7
Ground Dove	4.2
White-winged Dove	4.2
Golden Eagle	100
American Kestrel	320
Cooper's Hawk	320 - 1,000
Northern Harrier	100
Red-tailed Hawk	320
California Quail	10
<u>Common Raven</u>	13.5
<u>American Crow</u>	1.33
White-crowned Sparrow	320
House Sparrow	320 - 448
Curve-billed Thrasher	3.2
Barn Owl	4.2
Mammals	
Cow	10 (no kill)
Coyote	100
Dog	100 (no kill)
Dog	71
Laboratory Mice	2,000
Deer Mouse	1,800
Laboratory Rats	1,170 - 1,770
Grey Squirrel	280
Sheep	1 animal harmed at 200; 1 animal killed at 400

*Sources: Schafer, 1984; Environmental Protection Agency data; Denver Wildlife Research Center data

**Dose not administered orally

Approximately 100-110 ravens were killed at the Twentynine Palms landfill. A total of 96 raven carcasses were subsequently recovered from this site (Table 12). Approximately 6-10 ravens were killed at the Desert Tortoise Research Natural Area. Program monitoring indicated that ravens readily accept and consume poisoned baits and risk potential to other species of wildlife during control is very low (Rado 1990).

Table 12. Results of raven control at the USMC Twentynine Palms landfill during 1989*

Date	Poisoned eggs	Raven carcasses recovered	
	Consumed	Poisoned	Shot
May 19	29	0	0
May 20	22	0	0
May 21	8	31	0
May 22	6	26	9
May 23	6	13	6
May 24	4	4	2
May 25	-	4	1
	Totals 75	78	18

*Source: U.S. Dept. of Agriculture Data

Nonlethal Control Methods

Limited research has been undertaken on more "passive" forms of raven control. Attempts to dissuade ravens from utilizing transmission towers as nesting sites in the Mojave Desert have been unsuccessful. When raven nests have been destroyed, the birds simply rebuild the nest or move to an adjacent tower (Dan Pearson, Southern California Edison Company, pers. comm.). Stiehl (1978) has noted that nest destruction early in the raven nesting season results in re-nesting by the birds. However, nests destroyed late in the season are not reoccupied.

Attempts to reduce the number of ravens at Malheur National Wildlife Refuge utilizing a program of nest destruction and destruction of raven eggs and broods were unsuccessful at reducing raven depredation on waterfowl eggs. Study results on raven behavior during this time indicated that almost 62% of all bird items collected were obtained from six of 34 raven nests under study. The researcher also noted that non-nesting area

Figure 3. Locations and results of raven monitoring efforts during the 1989 "pilot" raven control program at the Desert Tortoise Research Natural Area (BLM data).

ravens probably preyed heavily on waterfowl eggs; non-nesting flocks of ravens were observed carrying eggs, and waterfowl nest destruction was subsequently recorded where a raven flock had been observed on the previous day (Stiehl 1978).

Conditioned taste aversion has been undertaken to reduce raven predation on eider eggs in Iceland (Kristinn Skarphedinsson, University of Wisconsin, pers. comm.). Eggs were injected with the emetic carbachol to condition ravens to avoid eating eggs. This particular project was not successful. Birds routinely wandered through the area, making conditioning difficult. Additionally, aversion training for study ravens appeared to be poor; ravens eating carbachol-treated eggs would repeat this process within one week (Kristinn Skarphedinsson, pers. comm.).

However, in a separate experimental study on raven egg predation at Malheur National Wildlife Refuge, egg aversion conditioning significantly reduced egg predation relative to untreated eggs at "control" sites (Nicholaus 1987). The advantage of this process over lethal forms of control is that conditioned birds may defend territories against emigrants that may prey on "target" prey (Lowell Nicholaus, Northern Illinois State University, pers. comm.). Little information is available on the length of time that conditioned animals will avoid consuming "target" prey species (Lowell Nicholaus, pers. comm.).

Taste aversion has also been undertaken using two other compounds, Landrin and Mesurol. Control may be limited in duration, due to the ability of predator species to develop a tolerance to the chemical and resume feeding without any ill effects. Additionally, some of the animals that consume treated baits may die as a consequence (Woody Hill, FWS, pers. comm.).

Methods to reduce perching and roosting on structures have also been applied to control ravens. Young and Engel (1988) were able to prevent fecal contamination of transmission tower insulators by roosting ravens using a combination of plastic shields and wooden pegging. However, although insulator contamination was effectively minimized, ravens continued to use the original transmission towers as roosts. Different anti-perch wire designs experimentally tested lowered but did not prohibit continued perching by ravens (Young and Engel 1988).

Several anti-perching wire products are commercially available. These devices are affixed to fence posts or other sites where problem birds regularly perch. Independent research is lacking on the effectiveness of these devices (Ed Nittle, Denver Research Center, pers. comm.).

Anti-perch wire was experimentally placed on wooden fence posts along the entire 40-linear mile perimeter of the Desert tortoise Natural Area during the fall of 1989. Two different anti-perch

wire designs were used, Nixalite and Barrier Wire. The wire was placed by agency personnel, volunteers, staff assistance from Nixalite of America and Patented Products, Incorporated, and The Humane Society of the United States. These posts will be monitored in an effort to determine effectiveness at reducing raven perching opportunities. Incidence of raven predation on juvenile desert tortoises at the Natural Area will be obtained through continued monitoring of two study plots.

Unspecified declines in raven numbers have been noted during live-trapping (Lounsbury 1972). The disposition of live-trapped birds (whether killed or released elsewhere) was not discussed. Steihl (1978) believed that any live-trapped birds should be moved minimally 124 miles from initial point of capture before release. Live-trapping methods include cannon netting, which has been used successfully for ravens at concentration areas (Dave Ledig, FWS, pers. comm.).

MANAGEMENT ACTIONS

Overview of Planned Tasks

The raven management program consists of two basic components: (1) short-term application of lethal forms of raven control at sites where excessive predation threatens tortoise populations; and (2) longer-term regional management based on results of initial testing of nonlethal forms of control, research on the ecology of the raven in the California Deserts, and results of regional inventories to locate sites where raven predation on tortoises is occurring. Ravens will be selectively killed at sites where recruitment rates of juvenile tortoises into adult age-classes has been severely depressed as a result of predation. These sites include portions of the western Mojave Desert and northern Colorado Desert. Killing of birds is necessary on a short-term basis due to the severe losses of juvenile tortoises and immediate need to boost recruitment rates to increase chances of longer-term population survival.

Concurrently with initial site-specific poisoning and/or shooting of ravens, research shall be conducted on the ecology of the raven in the California deserts. The focus of this research effort shall be on obtaining information that may be used to more effectively manage and maintain raven populations in the desert while reducing predation rates on the desert tortoise. Baseline information on total numbers of ravens in the California deserts shall also be obtained. Current estimates of raven increases are based on comparisons of relative abundance (e.g., numbers of birds observed per unit time), and not on actual population numbers. Emphasis of research programs shall be outside of those site-specific areas where lethal control measures are applied.

Several nonlethal forms of raven control shall be experimentally applied to test effectiveness. Nonlethal techniques that will be experimentally applied include: conditioned taste aversion; timed destruction of raven nests; egg addling; placement of anti-perch devices; live-trapping and offsite release of birds; modification of human waste containment practices; and sterilization. Initial "focus" of this program shall be in specific areas that will be limited to that form of experimental control only in order to determine effectiveness. Where nonlethal forms of raven control are proven effective, these techniques can be used to substitute initial control using lethal methods. Over time, raven control using lethal techniques may be "phased out" or substantially reduced in favor of one or more nonlethal control measures.

Implementation of program actions are contingent upon inter-agency cooperation. A "lead" agency is assigned for each specific task in Table 13. The "lead" agency is responsible for coordinating project actions with other agencies, completing necessary paperwork to undertake the project, developing appropriate experimental design, implementing and monitoring results of the action, and preparing a written report of results. Establishment of an interagency Workgroup provides the basic framework necessary to undertake management plan tasks. Implementation of planned actions is contingent upon available staff time and funding by each participating agency.

Actions for implementation of the raven management plan are summarized below (Table 13). Management actions are designed to achieve a specific stated objective. Techniques have been subdivided into measures addressing research, nonlethal control, lethal control, and administrative actions.

Planned Actions

The following text details measures that will be undertaken for the management of the raven in the CDCA. Tasks have been subdivided into research, nonlethal control, lethal control, and administrative actions. Management actions are overviewed in Table 13.

Research Actions

- Action 1:** Conduct regional inventories of the California Desert Conservation Area to locate and map raven nesting, roosting, and perching sites (Call 1978). Inventories should include both private and public lands.
- Objective:** Increase information on the distribution and nesting habits of the common raven in the California deserts.

Table 13. Management actions, cooperating agencies, and proposed time frames for initiation.

Action	Agencies*	Date(s)
<u>Research</u>		
Inventory California deserts for raven nesting and roosting sites	BLM, FWS, CDFG**	1991-92
Determine methodologies for censusing and monitoring raven populations	FWS, CDFG, BLM	1990-91
Determine foraging and feeding behaviors of ravens	CDFG, FWS, BLM	1991-92
Determine seasonal movements and site fidelity of ravens	CDFG, FWS, BLM	1991-92
Conduct regional inventories to locate sites of raven predation on tortoises	BLM, FWS, CDFG	1990-91
Collect information on tortoise recruitment rates in raven habitats	BLM, CDFG, FWS, DOD	Continuous
<u>Nonlethal Control</u>		
Limit raven food sources from roadkills	Caltrans, FWHA, CDFG, BLM, FWS	Begin 1990
Modify landfill practices	Counties, Cities, SWMB, BLM	Begin 1990
Modify sewage containment practices	Counties, Cities, RWCB, BLM	Begin 1990
Modify raven use of landfills and sewage ponds by behavioral disruption techniques	Counties, Cities, SWMB, RWCB, CDFG, BLM	Begin 1991
Modify raven perches and roosts	BLM, CDFG, DOD, FWS, ADC	Begin 1990

Table 13. Continued

Action	Agencies*	Date(s)
Selectively destroy raven nests	ADC, BLM, FWS, CDFG, DOD	Begin 1991
Reduce raven nesting success by egg addling	ADC, BLM, FWS, CDFG, DOD	Begin 1991
Sterilize nesting ravens in areas of high tortoise predation	ADC, FWS, CDFG, DOD, BLM	Begin 1991
Reduce raven predation rates on tortoises by conditioned taste aversion	ADC, FWS, BLM, CDFG, DOD	Begin 1991
Live-trap and remove ravens for release outside of tortoise areas	CDFG, ADC, FWS, BLM, DOD,	Begin 1991
<u>Lethal Control</u>		
Selectively shoot ravens in areas of high tortoise predation	ADC, BLM, CDFG, FWS, DOD	Begin 1990
Kill ravens by poisoning	ADC, BLM, CDFG,	Begin 1990
Live-trap and kill ravens in areas of excessive tortoise predation	ADC, FWS, CDFG, BLM, DOD	Begin in 1993***
<u>Administrative Actions</u>		
Establish Interagency Workgroup to oversee management direction	BLM, FWS, CDFG, DOD, ADC, Counties	1991
Develop implementing agreement to ensure agency commitments	BLM, FWS, CDFG	1991
Modify management measures as determined by additional data/monitoring	All of above (BLM lead)	Begin 1990

*BLM = U.S. Bureau of Land Management
 FWS = U.S. Fish and Wildlife Service
 DOD = U.S. Department of Defense (includes the Marine Corps
 Air Ground Combat Training Center and the Air Force
 Flight Test Center)
 ADC = U.S. Dept. of Agriculture, Animal Damage Control
 FHWA = Federal Highways Administration
 CDFG = California Department of Fish and Game
 RWCB = Regional Water Quality Control Board
 Counties = Counties discussed under individual tasks below
 Cities = Cities discussed under individual tasks below
 **First agency listed is "lead", and has responsibility of
 establishing specific tasks, timeframes, and costs, and
 coordinating with other participating agencies.
 ***Action contingent upon success of livetrapping and release;
 would be dropped if release program successful.

Rationale: Information on raven nesting, perching, and roosting sites has been available largely as a result of incidental observation and site-specific surveys. Systematic inventories are required to more effectively manage and monitor this species.

Responsible Agencies: BLM, FWS, CDFG

Action 2: Determine methodologies for censusing and monitoring raven populations.

Objective: Standardize data collection on the raven between agencies.

Rationale: Management of the common raven will require several agencies. Duplication of effort will be minimized and funding best utilized by obtaining initial interagency agreement on the methodologies for censusing and monitoring raven populations.

Responsible Agencies: FWS, CDFG, BLM

Action 3: Determine foraging and feeding behaviors of common ravens, employing both studies of radio-transmitted birds captured at landfills and birds captured from roosting and nesting sites.

Objective: Supplement current life history information on the ecology of the raven to facilitate long-term management of populations in the CDCA.

Rationale: Little information is available on the home range size, foraging behavior patterns, and daily and seasonal feeding behaviors of ravens in the CDCA. Such information is needed to facilitate management of the species.

Responsible Agencies: CDFG, FWS, BLM

Action 4: Determine seasonal movements and site fidelity of ravens.

Objective: Increase understanding of the biology of the raven in the California deserts. Apply information to other management actions to manage ravens on a long-term basis.

Rationale: Little information is available on the daily and seasonal movement patterns of the raven in the California deserts. Basic information relating to seasonal use patterns of juvenile birds (that may collectively comprise the majority of the desert raven population), and nesting site fidelity of adult birds (that may function as the major source of predation on juvenile desert tortoises) is required.

Responsible Agencies: CDFG, FWS, BLM

Action 5: Conduct regional inventories to locate sites of raven predation on juvenile desert tortoises. Map locations, and record such data as: location, type of site, numbers and sizes of tortoise shells observed, numbers of ravens observed and behavior, and recommendations for reducing predation rates. Monitor sites on a regular basis to determine frequency of predation.

Objective: Determine specific areas of raven predation on juvenile desert tortoises.

Rationale: Information on raven predation, to date, has been based on site-specific studies and largely incidental observations of juvenile tortoise shells collected desert-wide. Additional information needs to be systematically collected and collated to more effectively manage both tortoise and raven populations.

Responsible Agencies: BLM, FWS, CDFG, DOD

Action 6: Collect baseline data on recruitment rates of juvenile desert tortoises. Establish a high priority for continued monitoring of tortoise populations at sites proximate to 1989 raven control efforts (Desert Tortoise Research Natural Area and U.S. Marine Corps Air Ground Combat Center at Twentynine Palms landfill). Establish trend plots to monitor effects of refuse containment practices and other raven control measures proximate to land fill sites and sewage treatment facilities.

Objective: Determine effectiveness of raven control for enhancing recruitment rates of juvenile desert tortoises into adult age-classes.

Rationale: Long-term results of the 1989 pilot raven control program and followup control efforts will require evaluation. Although pilot program efforts were limited during 1989, results clearly demonstrated that common ravens may be readily poisoned using DRC-1339 injected into hard-boiled eggs (Rado 1989). However, the results of this raven reduction effort towards enhancing desert tortoise recruitment rates will require study over a several-year timeframe. Results of other nonlethal and lethal forms of raven control outlined in this management plan will require similar evaluation.

Responsible Agencies: BLM, CDFG, FWS, DOD

Nonlethal Control Actions

Action 1: Reduce wildlife mortality along major roads bisecting desert tortoise populations. Provide maps of specific areas adjacent to State or Federal highways where raven predation on juvenile desert tortoises is excessive. Recommend placement of barrier fencing along such specific sections of highways to reduce vehicle-related mortality to wildlife. Also recommend that Caltrans implement a program of regular collection of wildlife carcasses from these roads for disposal and burial.

Objective: Limit raven food availability from road kills; reduce concentrations of birds in areas of high desert tortoise predation.

Rationale: Ravens are known to utilize roadkills as a food source (Alten 1971; Conner and Adkisson 1976). A program to reduce wildlife road mortality, emphasizing selective placement of protective fencing to impede animal movement onto the pavement and, secondarily, efficient collection and disposal of road-killed animals, may significantly reduce food for ravens in especially sensitive tortoise areas.

RESPONSIBLE AGENCIES: Caltrans, FHWA, BLM, CDFG

Action 2: Modify landfill containment practices in areas where raven predation on juvenile desert tortoises is excessive. Contact respective County and municipal governments and recommend landfill containment practice changes to reduce availability of food for ravens at these sites. Provide pertinent information to facilitate more effective refuse control.

Objective: Limit availability of food and water to ravens at raven concentration sites in tortoise habitats.

Rationale: Desert landfills provide a food supply for ravens and a "concentration" point for loafing and roosting birds. Food may serve to attract large numbers of birds into desert tortoise habitats. Ravens may fly up to 28 miles from a roosting site to forage for food (Stiehl 1978). Larger numbers of birds that utilize expansive desert areas surrounding each landfill for extended periods of time may contribute to significantly increased predation rates on juvenile desert tortoises.

Responsible Agencies: County of Kern, County of San Bernardino, County of Riverside, State of California Solid Waste Management Board, Cities of: Ridgecrest, Boron, Apple Valley, Victorville, Landers, Twentynine Palms, Baker, and Desert Center, BLM.

Action 3: Modify sewage treatment facility practices in areas where desert tortoise predation rates are excessive. Contact appropriate civil and State government agencies with recommendations for management modifications. Also request experimental research on measures to determine most effective means to reduce raven use.

- Objective:** Limit raven food and water availability at raven concentration areas in tortoise habitats.
- Rationale:** Sewage treatment sites provide a concentration point for large numbers of ravens and available sources of food and water. Concentrating birds and bird foraging areas may contribute to excessive tortoise predation on surrounding lands.
- Although Knowles et al. (1989) inventoried these sites, no specific measures to reduce raven use were provided. Actions that could be employed in this regard may include placement of a mesh netting over pond areas where birds habitually feed or installation of anti-perching wire on pipes or other structures used to provide access by feeding birds. Experimental application of measures to reduce raven feeding opportunities, focusing at the three sites where consistently high raven use was documented, is required to develop appropriate management techniques.
- Responsible Agencies:** County of Kern; County of San Bernardino; State of California Water Resources Quality Control Board; Cities of: Ridgecrest, Boron, and Baker; BLM
- Action 4:** Modify raven use of landfill and sewage pond sites by behavioral disruption techniques. Experimentally apply at selected sites to determine effectiveness. Utilize on a widespread basis if proven effective.
- Objective:** Prevent continued use of landfills and sewage ponds by large numbers of birds. Limit opportunities for access to food supplies.
- Rationale:** Implementation of measures such as "hazing" (i.e., disrupting raven perching and feeding by intermittent loud noise) and taste aversion conditioning may be useful tools to discourage raven use from concentration points such as landfills. Hazing, in association with modified trash containment practices to reduce food availability to ravens, may significantly reduce raven use of such areas.
- Responsible Agencies:** County of Kern; County of San Bernardino; RWCB; City governments administering landfill and sewage treatment sites; BLM

Action 5: Modify selected raven roosting and perching sites on artificial structures and natural features. Experimentally attempt to retard raven perching at selected sites by application of anti-perching wire or other devices. Monitor effectiveness of such measures and apply on a more widespread basis if monitoring results show techniques are effective.

Objective: Reduce raven concentration areas/limit raven predation opportunities on juvenile tortoises.

Rationale: Researchers (Campbell 1983; Berry 1985) have observed numbers of individual desert tortoise shells under specific raven nesting and perching sites. Predation and collection of many tortoises from nesting sites has also been observed at the same sites over several-year periods (Campbell 1983; Berry 1985; Woodman and Juarez 1988). This data indicates that, in certain areas, individual birds or nesting pairs of birds may be significantly reducing constituent tortoise recruitment rates. Restricting perching and roosting opportunities in these areas may force birds to modify foraging behavior patterns.

Responsible Agencies: ADC, BLM, CDFG, DOD, FWS

Action 6: Destroy raven nesting sites in areas experiencing high tortoise predation rates. Initially, experimentally destroy nests at pre-selected locations. Attempt to "time" nest destruction relatively late in the nesting season to increase likelihood of effectiveness. Monitor "parent" bird behavior following nest destruction. Apply on a more widespread basis if initial results prohibit successful nesting attempts by birds.

Objective: Modify nesting behavior to limit successful nesting by birds that prey most heavily on tortoises.

Rationale: Selective nest destruction, appropriately timed, may prohibit successful nesting by individual pairs of birds known to prey excessively on tortoises. Although successful nest destruction has been noted (Stiehl 1978), other information suggests that these measures do not prohibit ravens from nesting and perching in the same area (Dan Pearson, pers. comm.; Young and Engel 1988).

Responsible Agencies: ADC, BLM, FWS, CDFG, DOD

Action 7: Experimentally attempt to restrict successful raven nesting by "parent" birds determined to be preying on desert tortoises by addling of eggs. If successful on an experimental basis, apply this technique to other nesting sites.

Objective: Reduce successful nesting by ravens that prey heavily on tortoises. Limit opportunities for such birds to "teach" offspring to prey on tortoises.

Rationale: Egg addling (scrambling eggs on a nest by vigorous shaking, then returning eggs to confuse nesting "parent" birds) may provide a long-term means of selectively reducing numbers of individual birds in the desert raven population that have learned to efficiently hunt and kill tortoises. Application of this technique assumes that "parent" birds "teach" offspring to hunt for certain kinds of foods such as tortoises. A prior attempt to use this technique for raven control in Oregon did not significantly reduce raven nesting success (USFWS 1986). Experimental application in the California deserts is therefore necessary. Replacement of eggs with artificial ceramic eggs may also be undertaken at that time.

Responsible Agencies: ADC, BLM, FWS, CDFG, DOD

Action 8: Experimentally attempt to reduce raven population increases in desert areas by sterilization of birds. Attempt to sterilize birds in areas of high tortoise predation rates. Monitor raven population trends and tortoise predation rates by ravens in areas where sterilization has been undertaken. Expand sterilization program if successful.

Objective: Reduce raven population increases in an effort to limit predation rates by ravens on desert tortoises.

Rationale: Raven populations are increasing at a rapid rate in areas experiencing highest tortoise predation levels. Effective means to reduce reproductive rates of birds need to be explored. Trimethyl ether can be applied to grain baits administered to birds at regular intervals during the breeding season to prevent successful reproduction. Ravens need to consume this treated grain at 2-3 day intervals to be effective (Lowell Nicholas, pers.

comm.). However, the technique is untested on ravens and requires further study.

Responsible Agencies: ADC, FWS, CDFG, DOD, BLM

Action 9: Experimentally attempt to reduce raven predation rates by conditioned taste aversion using "dummy" tortoises treated with carbachol or similar emetic. Monitor feeding behavior of test birds after experimental treatment. If successful, apply technique on a widespread basis.

Objective: Modify selective predation pressure from ravens through conditioned taste aversion.

Rationale: Conditioned aversion training may provide a cost-effective method of reducing predation rates on juvenile desert tortoises. If successful, this technique has the added advantage of maintaining conditioned birds in areas that may otherwise be quickly re-occupied by emigrating ravens that prey on tortoises. Additionally, conditioned birds may "teach" offspring or mates to avoid tortoises.

Responsible Agencies: ADC, FWS, BLM, CDFG, DOD

Action 10: Experimentally attempt to reduce raven predation rates on desert tortoises by live-trapping and removal of birds. Live-trapping techniques include: cannon-netting, leg-hold traps, and drop-in traps (U.S. Fish and Wildlife Service 1983; Engel and Young 1989b; Bloom 1987). If successful, employ methods on a widespread basis.

Objective: Reduce raven numbers in areas where excessive tortoise predation has been documented to increase recruitment rates of juvenile tortoises into adult age-classes.

Rationale: Live-trapping has been used for ravens on a limited basis in the California deserts. Lounsbury (1972) mentioned reducing raven numbers in response to predation on domestic turkey eggs in Apple Valley by live-trapping. However, disposition of captured birds was not specified. Ravens have the capability to travel large distances (Steihl 1978; Kate Engel, University of Wisconsin, pers. comm.; Dick Steel, Southwestern Missouri State University, pers. comm.). Behavior patterns of captured and released birds also requires monitoring, since release may result in

increased predation on desert tortoises or other sensitive wildlife species within a previously unimpacted site.

Responsible Agencies: CDFG, ADC, FWS, BLM, DOD

Lethal Management Techniques

Action 1: Selectively reduce raven populations in areas of excessive tortoise predation by shooting birds.

Objective: Reduce raven predation rates on juvenile tortoises by killing birds where excessive rates of predation on tortoises have been documented.

Rationale: Nonlethal forms of raven control are largely experimental. Shooting can be an effective means of selective raven control at locations where limited numbers of birds may be significant contributors to tortoise declines.

Responsible Agencies: ADC, BLM, CDFG, FWS, DOD

Action 2: Reduce raven numbers in areas of excessive predation by poisoning birds. Poisoning will be applied on a site-specific basis within the California Desert Conservation Area. DRC-1339 (Starlicide) will be used. This avicide will be injected into hard-boiled eggs.

Objective: Increase tortoise recruitment rates by reducing levels of predation by ravens.

Rationale: Raven numbers can be reduced using DRC-1339; risk to other wildlife species using this technique is very low (Rado 1989). Conversely, alternative nonlethal measures of raven control are largely untested. Ravens that have their behavior patterns disrupted by restricting nesting or perching opportunities or by limiting roosting areas may simply move to other areas and prey on juvenile tortoises.

Responsible Agencies: ADC, BLM, CDFG, FWS

Action 3: Selectively reduce raven populations in areas of excessive juvenile desert tortoise predation by initially live-trapping, then killing birds. Implement this action if initial attempts to relocate ravens successfully fail.

Objective: Reduce raven numbers in areas where excessive tortoise predation has been documented to increase recruitment of juvenile tortoises into adult age-classes.

Rationale: Live-trapping of ravens may prove an effective means of capturing birds. However, subsequent release of captured birds may not reduce overall raven predation rates. Released birds may simply begin killing and eating tortoises at points of release, or may impact other sensitive wildlife species.

Responsible Agencies: ADC, FWS, CDFG, BLM, DOD

Administrative Actions

Action 1: Establish interagency Workgroup to oversee raven management program direction, review information, coordinate with other agencies/groups, solicit funding for implementation of specified management measures, and distribute information/data. The Workgroup shall meet regularly to discuss raven management actions.

Objective: Increase efficiency of raven management program in the CDCA.

Rationale: Implementation of management plan actions will require a coordinated effort by several agencies. The plan area covers roughly one third of the State of California. Management actions are large in scope and may be difficult to fund and implement. Several agencies maintain jurisdictional authorities over lands or permitting authorities over actions that require management. Increased coordination between these agencies will facilitate plan implementation.

Responsible Agencies: BLM; FWS; CDFG; DOD; ADC; County of San Bernardino, County of Kern, County of Riverside, County of Los Angeles, County of Inyo.

Action 2: Prepare an Implementing Agreement that shall provide specific direction and agency commitments for carrying out planned management tasks between Workgroup agencies. Representatives of each agency shall sign this agreement.

Rationale: Implementation of management measures specified in this plan will require a long-term commitment in terms of funding, personnel, and administrative time. A binding document that specifies roles of each agency towards raven management is needed to ensure that this commitment is maintained.

Responsible Agencies: BLM, FWS, CDFG, County of San Bernardino, County of Kern, County of Riverside, County of Los Angeles, County of Inyo.

Action 3: Monitor both raven status and effectiveness of management actions at reducing excessive predation rates on juvenile desert tortoises while maintaining viable raven populations in the California deserts. Adjust management measures as necessary to ensure that primary and secondary objectives of the management plan are met.

Rationale: Implementation of some of the preceding plan measures may be ineffective at accomplishing plan management goals. Additional actions may also be required. Plan changes may be desired based on additional information derived from monitoring or life history information obtained on the common raven through implementation of plan actions.

Responsible Agencies: BLM, FWS, CDFG, DOD, ADC, RWCB, SWMB, County and City governments.

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