Bull. Southern California Acad. Sci.
101(2), 2002, pp. 86–102

An evaluation of the distribution and abundance of Common Ravens at Joshua Tree National Park

William I. Boarman[1] and Sharon J. Coe[2]

[1]*U.S. Geological Survey, Western Ecological Research Center, 5745 Kearny Villa Drive, Suite M, San Diego, CA 92123*
[2]*Department of Biology, University of California, Riverside, California 92521*

Abstract.—We located and evaluated data from the past 100 years to assess the historical and contemporary abundance and distribution of Common Ravens (*Corvus corax*) at and near Joshua Tree National Park in southern California. We found evidence to support the hypothesis that numbers and distribution of this species have increased in the park in the last 50 years. Increases in raven numbers pose a potential threat to populations of Desert Tortoise (*Gopherus agassizii*), as juvenile tortoises are known prey of the Common Raven. We obtained additional data that support the hypotheses that raven densities may be higher in the Mojave Desert than the Colorado Desert, and that densities appear to be lower in regions with few roads. Some of the largest concentration areas for ravens are found at landfills in the Mojave Desert.

The Common Raven (*Corvus corax*) is native to the deserts of southern California but its abundance in the Mojave Desert has grown substantially in recent years. An analysis of Breeding Bird Survey (BBS) data for the Sonoran and Mojave Deserts (Boarman and Berry 1995) showed that raven populations increased 450–1000% over a recent 24-year period. Such increases have raised concerns among wildlife biologists and resource managers because ravens are known to prey on juvenile Desert Tortoises (*Gopherus agassizii*), a species federally-listed as Threatened in the Southwest (U.S. Fish and Wildlife Service 1994). Increases in Common Raven densities in desert areas have been implicated as contributing to the decline of some Desert Tortoise populations (Bureau of Land Management 1990, Boarman 1993, U.S. Fish and Wildlife Service 1994). Ravens prey on avian species that are declining, as well. This includes predation of eggs of the California condor (*Gymnogyps californianus;* Snyder et al. 1986), of the state- Endangered California least tern (*Sterna antillarum browni;* Avery et al. 1995), and of the greater sandhill crane (*Grus canadensis tabida;* Littlefield and Thompson 1987), a California state-listed Threatened species. Ravens prey on eggs and chicks of the western snowy plover (*Charadrius alexandrinus nivosus*) on the California coast (pers. comm. Gary Page, Point Reyes Bird Observatory), a species whose coastal nesting populations are federally-listed as Threatened.

Increases in Common Raven numbers have been attributed to an increase in human occupation in the region (Boarman and Berry 1995). One anthropogenic resource used by ravens in the deserts of California is landfills. Ravens use landfills as foraging sites, including the consumption of organic materials exposed along the active face of landfills (FaunaWest Wildlife Consultants 1991). Imple-

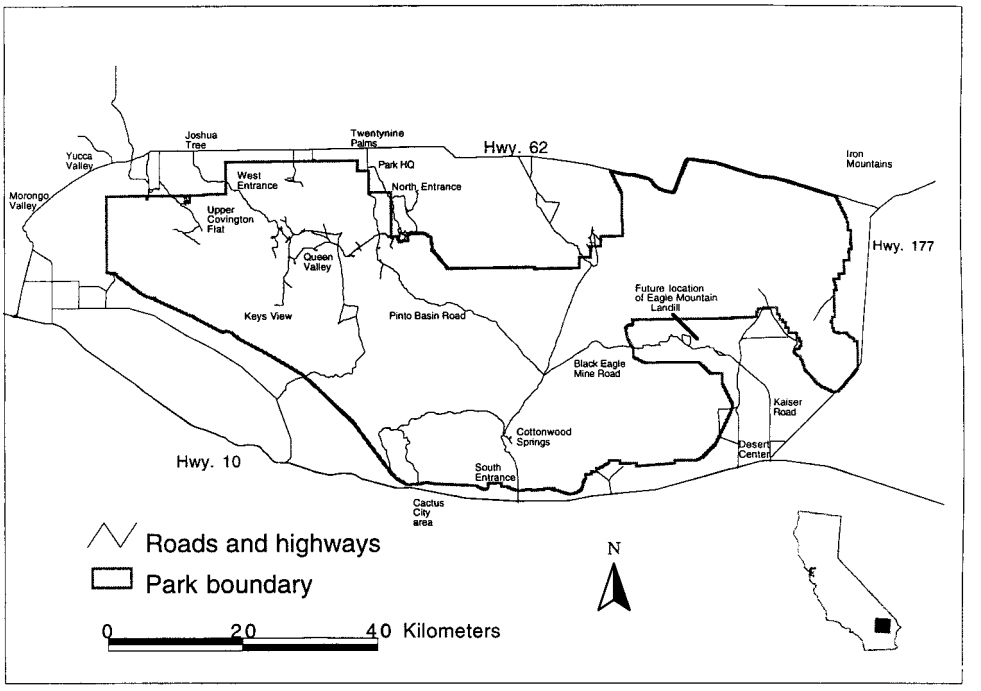

Fig. 1. Joshua Tree National Park and immediate surroundings.

mentation of a proposed large solid waste landfill in southeastern California adjacent to Joshua Tree National Park (JTNP) is considered to be a factor that could promote the establishment of additional populations of Common Ravens in the region, and/or increases in existing populations, which could further threaten the Desert Tortoise (Fig. 1). The proposed landfill, Eagle Mountain Landfill (EML), is currently in litigation. Should it be implemented as it was configured prior to legal proceedings, it is expected to receive up to 1,814 metric tons (1 metric ton=1000 kg) of garbage per day.

Resource managers at JTNP asked us to obtain and review information on the abundance and distribution of Common Ravens in and near the park as baseline information to be used in evaluating whether raven populations increase should EML be implemented (Boarman and Coe 2000a, 2000b). We located and evaluated both contemporary and historic data to assess what was known about Common Raven abundance and distribution.

Joshua Tree National Park consists of 794,000 hectares of Mojave Desert and Sonoran (Colorado) Desert plant communities. Areas that currently comprise JTNP were established as a National Monument in 1936. Through the California Desert Protection Act of 1994, the monument increased by 94,670 hectares and acquired National Park status. We refer to observations that were made within either the monument or park as having occurred in JTNP.

Methods

We searched for published and unpublished sources of information describing Common Raven abundance and distribution in and near JTNP. We obtained un-

published data such as field notes, species lists, and reports with the assistance of JTNP staff within the Resources Management and Interpretation Divisions. We also contacted JTNP volunteers and local experts, who held first-hand knowledge of ravens at the park, and obtained additional field notes from them. We acquired unpublished Breeding Bird Atlas (BBA) data for the two counties where JTNP is located (San Bernardino and Riverside Counties). We also contacted museums (California Academy of Sciences [CAS], Los Angeles County Museum of Natural History [LACMNH], San Bernardino County Museum [SBCM], San Diego Natural History Museum [SDNHM], Museum of Vertebrate Zoology [MVZ], and Western Foundation of Vertebrate Zoology [WFVZ]) for locations and dates of skins and eggs that had been collected in the region.

Results and Discussion

We located more than 13 sources of information pertaining to the occurrence of Common Ravens in JTNP and its vicinity, most of which pertained to the past 50 years (Table 1). The majority of data were unpublished records and pertained to observations within JTNP, although some included observations outside the park's boundaries.

Prehistoric information

Evidence from the fossil record indicates that Common Ravens were present in California deserts in prehistoric times. The species is known from Late Quaternary period deposits in San Bernardino County (Jefferson 1991). These include deposits that date back 100,000 to 4,000,000 years before present (BP) from the Mitchell Caverns located in the Providence Mountains (approximately 98 km northeast of JTNP). Raven fossils, whose age was estimated using radiometric dating to be approximately 12,500 years BP, are also known from Schuiling Cave in the Newberry Mountains (approximately 85 km northwest of JTNP; Jefferson 1991).

Historical (pre-1940) observations

Historical observations of Common Ravens in and near JTNP, and in southern California in general, helped us to estimate their densities prior to contemporary levels of human occupancy. Scant information is available about the abundance of the species in and adjacent to JTNP at the turn of the twentieth century. One of the earliest sources was the Death Valley Expedition of 1891 (Fisher 1893). Common Ravens were seen in Death Valley by every party that visited there between early January and late June. They were also seen in the Mojave Desert (location not provided) in early January, and in the Antelope Valley in June. Little information on the abundance of the species can be gleaned from this account. However, an observation of a minimum of 40 individuals foraging on grasshoppers in the Antelope Valley in June indicates that relatively large groups occurred at least occasionally. The report also stated that Common Ravens were believed to breed in the desert ranges of southern California and Nevada.

Van Rossem (1911) observed Common Ravens ''about every day usually in pairs'' in the winter of 1910/1911 in the Salton Sea region (Colorado Desert); the northern portion of the Salton Sea lies approximately 19 km from the southern border of JTNP. The species may have been more common to the north of the

Table 1. Sources of data obtained containing Common Raven occurrence in and near Joshua Tree National Park.

Source	Observers/Authors	Date	Description
1. Charles Adams' Bird Check list for Joshua Tree National Monument	C. Adams	1955–1956	Recorded species and numbers of birds observed at multiple locations
2. Joshua Tree National Park Natural History Field Observation Cards	Park visitors and staff	1959–1994	Observers recorded incidental sightings
3. National Audubon Society Christmas Bird Counts	Volunteers	Joshua Tree National Monument Count: 1969–present	Once each winter groups of observers count birds in a 24.2 km/15-mile diameter circle in an approximately 12-hour period
	Volunteers	Morongo Valley Count: 1982–present	
4. U.S.G.S. North American Breeding Bird Survey	Various observers	Joshua Tree route: 1970–1978, 1980, 1981, 1986–1988, 1991, 1994–2000	Count species and numbers of birds at stops every 0.8 km along three 39.4 km-long routes (50 stops per each route)
	Chet McGaugh	Cottonwood route: 1973, 1975, 1976, 1980, 1981, 1986–2000	
	Bill Truesdell	Cholla Garden route: 1995–2000	
5. Relative Abundance and distribution of Common Ravens	Knowles et al. 1989; Fauna-West Wildlife Consultants 1991	October 1988–March 1989	Recorded numbers of ravens along road transects that were driven twice per month
6. Personal field notes	Michael A. Patten	Spring 1987–Fall 1999	In both spring and fall of each year, counted all species of birds observed at five general locations: Morongo Valley, Twentynine Palms, Cactus City vicinity, Desert Center, Iron Mountain
7. JTNP Resource Management Division Common Raven Observations 1990–1992	Resource Management Division staff and volunteers	1990–1992	Observers recorded incidental sightings
8. Eagle Mountain Raven Transects	Camp et al. 1993	May–June 1992	Walked 32 transects
	A. Garry, C. Miller, J. Freilich, C. Collins, J. Grant, L. Johnson	January 1994	Walked four transects

Table 1. Continued..

Source	Observers/Authors	Date	Description
9. Eagle Mountain Landfill Biological Mitigation and Monitoring Program	RECON 1994	March 1993–February 1994	Recorded ravens at five point count locations and along three road transects
10. San Bernardino County and Riverside County Breeding Bird Atlases	Volunteers	Spring–Summer of 1987, 1988, 1989, 1991, 1992, 1994, 1996, 1997, 1998	Walked portions of a designated 5-km square and record species of birds and evaluate breeding status
11. Adopt-a-Raven Transects	Twentynine Palms Elementary School, Yucca Valley High School, Capistrano Valley High School	Spring 1997 through present	Road transect surveys; both the survey route length and the numbers of stops made along each route vary
12. Linear-right-of-way surveys	Knight and Kawashima 1993	May–June 1989	Numbers of Common Ravens and red-tailed hawks recorded on helicopter transects flown along linear right-of-ways
13. Museum records	Six museums in California	N/A	Museums provided records of specimens or eggs collected from Riverside and San Bernardino counties
14. Spring 1999 Observations	W. Boarman, S. Coe, W. Truesdell	April, May 1999	Incidental observations of ravens and raven nests

park, as Lamb (1912) reported it in the Mojave River Valley (102 km north of JTNP) in 1910 and 1911 as ''common at all times everywhere, nesting on cliffs in the mountains.'' Gilman (1935) observed as many as 40 Common Ravens at one time at a wildlife feeding station at Death Valley National Park during observations made between October 1933 and May 1934 where he also reported a nest in a cliff. The earliest record from Joshua Tree National Park was an observation of a pair of Common Ravens in 1935 at Twentynine Palms Oasis, an area that lies within current park boundaries (Carter 1937). No indication of the abundance of the species was provided.

Few specimens from this time period and this region exist in museum collections. Therefore, little information about Common Raven distribution was gained beyond what we obtained from other sources; no information on abundance was acquired. The specimen taken closest to the park boundaries was 29 km southwest of the park border, collected in Mecca (Riverside County) in March 1908 (MVZ # 770). A specimen collected in ''Walters, Imperial County'' in January 1890 is considered to be from what is currently known as Mecca (SDNHM # 748; pers. comm. Philip Unitt). Two ravens were collected approximately 80 km northwest of JTNP in Victorville (San Bernardino County) in March 1907 (MVZ # 206) and in March 1914 (MVZ # 24573). All other specimens are from greater than 80 km from JTNP.

Distribution since 1940

There is an increasing amount of information about bird populations, including ravens, beginning in the mid-1900s. Grinnell and Miller (1944) cited portions of the Mojave Desert as being a major center of abundance of the species in California. However, Common Ravens do not appear on a species list for JTNP compiled in 1945 by Alden H. Miller that is on file at JTNP's Interpretation Division. Twenty years later, however, ravens were reported as a ''sparse permanent resident'' within JTNP (Miller and Stebbins 1964). What were populations like in the twenty-year period between 1945 and 1964?

Fortunately, detailed observations of Common Ravens within JTNP were collected in the mid-1950s by JTNP naturalist Charles Adams. He recorded species of birds at 76 locations within JTNP between January 1955 and September 1956, observing ravens in low numbers at 23 of the 76 locations. Most sightings were of 2–3 individuals per location per visit; the largest number at one location on a single visit was fourteen. It is possible that the absence of this species from Miller's 1945 bird list, in contrast to observations made by Adams roughly 10 years later, reflects an increase in size of the raven population in JTNP concomitant with an increase in human occupation and associated food resources in the area.

To gain insight into changes in distribution, we evaluated recent data for observations at locations where Adams never reported ravens. While Adams recorded the birds that were present at Cottonwood Springs 38 times, he did not record ravens as being present there (Fig. 1). Ravens have since been reported at Cottonwood Springs in two different data sets: (1) observations by visitors to the park reported on pre-printed index cards since the late 1950s (called Natural History Field Observation Cards); and (2) observations made by staff and volunteers of JTNP's Resource Management Division on an *ad hoc* basis between

1990 and 1992 both in and near JTNP. In the first data set, ravens were reported at Cottonwood Spring proper three times in 1978; in addition, one observation was made at a nearby picnic area in 1973, and two observations were made at a nearby residence in 1972 and 1973. In the second data set, the species was recorded once at the picnic area, and once on the road leading to the Spring. Similarly, Adams recorded no ravens at a location known as Queen Valley despite 32 visits. More recently, ravens have been reported in this area, on Natural History Field Observation Cards in 1978, and by the authors in 1999.

Both the Natural History Field Observation Cards and the JTNP's Resource Management Division observations support the hypothesis of current widespread distribution of ravens within JTNP. The former data set contains sightings of ravens at 29 locations, the latter contains 57 sightings at locations within and adjacent to the JTNP. Miller and Stebbins (1964) also reported Common Ravens as frequent scavengers along highways in the Coachella Valley in the Colorado Desert, which abuts JTNP's southern edge.

Breeding Bird Atlases are organized by volunteers and birding organizations in many regions throughout the United States to determine the breeding range of nesting species. In San Bernardino and Riverside Counties, BBA volunteers surveyed atlas ''blocks'' measuring 5 km square. This project confirms that Common Ravens bred in JTNP in 1987, 1992, and 1994. Ravens were designated as ''probable'' breeders in three blocks total (in 1987, 1988, and 1991), and as ''possible'' breeders in four blocks total (in 1987 and 1991). That the species is a current breeder at JTNP is not surprising given prior observations and the abundant suitable nesting habitat contained therein.

Densities in the Region

Virtually no information regarding densities of ravens is available for prior to the mid-1900s. The earliest data of this kind are from Charles Adams' work (maximum numbers observed) and from Miller and Stebbins (1964) who reported the species as ''surprisingly scarce'' at JTNP compared to their widespread occurrence in the desert and near cliffs in the southwest.

We did obtain three sources of data on raven densities from the past 12 years. The first source consisted of vehicle transect surveys conducted along paved highways and improved dirt roads in four regions of the California deserts in 1988 and 1989 (Knowles et al. 1989, FaunaWest Wildlife Consultants 1991). Only one portion of one of the routes occurred within JTNP, but three were located in its vicinity. Landfills and sewage ponds were also surveyed, with three of the landfills occurring near JTNP. Surveys were conducted over four 6-month periods. An index of the number of ravens observed per 161 km was calculated because the number of kilometers surveyed for each route varied. The portion of the route located in JTNP, running from the South Entrance to the North Entrance, recorded $<$1.0 to 6.0 ravens per 161 km over the four survey periods. For each of the three routes in the vicinity of JTNP, the number of ravens per 161 km ranged from 0 to 5.0 for all four survey periods (Table 2). These values are small compared to observations from routes in other parts of the study area (including areas with greater human density), which ranged from one to 49 ravens per 161 km.

Numbers of ravens at landfills ranged from 0 to 210 (Table 3) and tended to correspond positively with the numbers observed on road transects in their prox-

Table 2. Summary of Common Ravens observed on three road transects in the vicinity of JTNP (Knowles et al. 1989, FaunaWest Wildlife Consultants 1991).

Route	No. ravens observed	No. km traveled	No. observed per 161 km
SC-1			
Fall 1988	10	2309	.70
Winter 1989	18	2516	1.2
Spring 1989	3	2541	<1
Summer 1989	0	2533	0
SC-2			
Fall 1988	71	2297	5.0
Winter 1989	56	1911	4.7
Spring 1989	44	2309	3
Summer 1989	14	2127	1
FC-2			
Fall 1988	48	2202	3.5
Winter 1989	52	2178	3.8
Spring 1989	32	2217	2
Summer 1989	25	2212	2

imity. Landfills supported the largest concentrations of ravens in all four regions surveyed. Knowles et al. (1989) concluded that raven numbers observed at landfills were associated with the type, effectiveness, and frequency of waste burial and not with the size of the landfill or the amount of garbage present. They also concluded that ravens were more common in the Mojave Desert than the Colorado Desert, that their distribution tended to be clumped on certain road segments rather than being more or less evenly distributed, and that densities were highest near areas populated by humans (Knowles et al. 1989).

Surveys conducted in the immediate vicinity of the proposed Eagle Mountain Landfill provided even more recent information about raven densities (RECON 1994). Surveys were conducted in 1993 and 1994 on a monthly basis and included both hour-long counts made at single locations and vehicle transects along three routes (Table 4). The largest numbers of ravens observed at a point count location was at an existing small-scale landfill approximately 8 km from the proposed EML (range 5–40 individuals). The number observed on the three vehicle tran-

Table 3. Common Ravens observed at landfills in vicinity of Joshua Tree National Park (Knowles et al. 1989, FaunaWest Wildlife Consultants 1989).

	Total ravens observed on 12 twice-monthly visits					
Landfill	Fall 1988	Winter 1989	TOTAL	Spring 1989	Summer 1989	TOTAL
Landers	131	63	194	210	107	317
Amboy	1	0	1	2	0	2
Essex	40	31	71	2	0	2
Twenty-nine Palms	130	90	220	152	116	268
Desert Center	136	89	225	62	17	79
Indio	64	59	123	31	54	85

Table 4. Common Ravens observed on surveys for the Eagle Mountain Landfill Biological Mitigation and Monitoring Program (RECON 1994).

Location	Average no. ravens observed	Range of no. ravens observed	No. ravens observed per 1.61 km[1]
Point Stations			
Desert Center Dump	20	5–40	—
Kaiser Townsite	1	0–4	—
Eagle Mountain Mine	1	0–7	—
Tower[2]	0	0–4	—
Joshua Tree[3]	1	0–3	—
Vehicle Transects			
Eagle Mtn. Road (from I-10 to Metropolitan Water District pumping station; 11.3 km)	1	0–10	0.17
Kaiser Road (from Desert Center to Eagle Mountain Mine; 16.1 km)	2	0–10	0.15
Interstate 10 (from Chiriaco Summit to Desert Center Road; 31.4 km)	2	0–7	0.01

[1] (Route length) × (12 surveys).
[2] A tower located between Eagle Mountain Mine and Joshua Tree National Park.
[3] Overlooking Joshua Tree National Park from unspecified location.

sects was one, 15, and 17 ravens per 161 km, making the density on the last two routes notably higher than those observed by Knowles et al. (1989) and FaunaWest Wildlife Consultants (1991).

Knight and Kawashima (1993) surveyed linear right-of-ways by helicopter in May and June of 1989. Their coverage of 45,000 square km of Mojave Desert in San Bernardino County showed that ravens were more numerous on transects near powerlines and highways than in control areas. Also, raven nests were significantly more abundant along powerlines than along either highways or control areas. On the eight transects located in or near JTNP, only one raven was observed.

Raven Abundance In and Near JTNP

For monitoring changes in raven abundance over time, we considered standardized vehicle transects to be one of the best methods. Two such data sets exist: the U.S.G.S. North American Breeding Bird Survey (BBS), and a program coordinated by JTNP called Adopt-a-Raven Transects. The BBS has a vehicle route length of 39.4 km. At 0.8 km intervals counts are made of all birds heard and seen for a 3-minute period within a 0.4 km radius. Three BBS routes occur entirely or partially within the park. The ''Joshua Tree'' route (#14131) has been surveyed for 22 years since 1970, the ''Cottonwood'' route (#14088) for 20 years since 1973, and the ''Cholla Garden'' route (#14907) for six consecutive years beginning in 1995. The number of ravens recorded on the ''Joshua Tree'' route has increased over time (Fig. 2). For example, before 1989, numbers of ravens observed ranged between zero and nine. Since 1991, numbers observed have increased to between 10 and 32 per survey. This route starts in the northwest portion of JTNP and runs north through the town of Joshua Tree. We consider it likely that these data reflect actual increases in numbers of ravens given the stan-

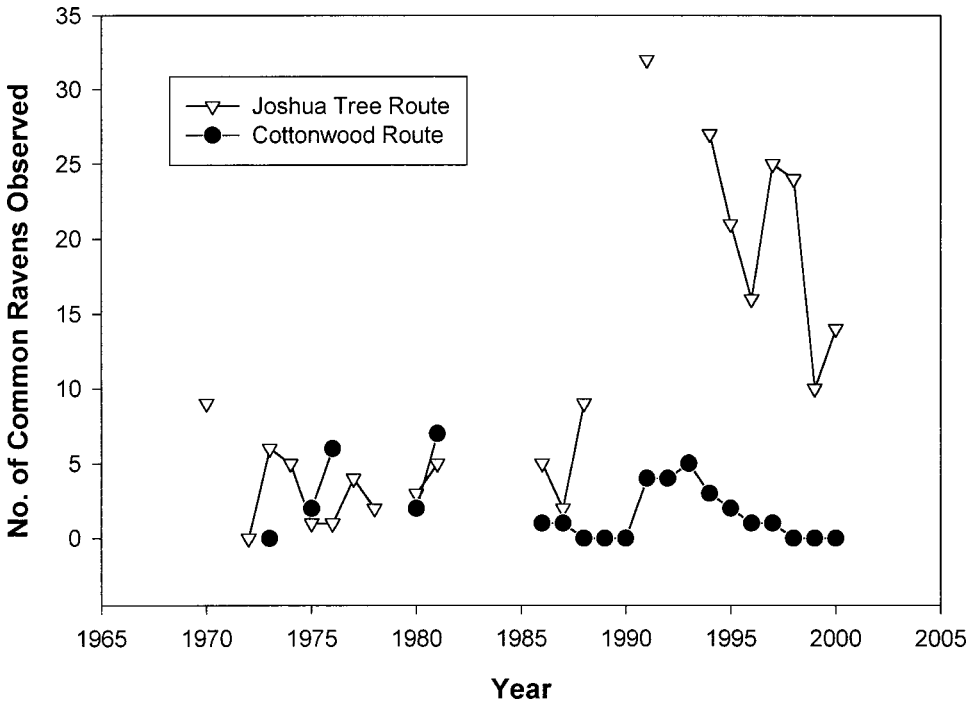

Fig. 2. Common Ravens observed on the ''Joshua Tree'' BBS Route between 1970 and 2000, and on the ''Cottonwood'' BBS Route between 1973 and 1997.

dardized survey methods. The increases in numbers observed may be correlated with the fact that the route is adjacent to, and travels through, the town of Joshua Tree, which has increased in human population size in the last 30 years; between 1970 and 1990, Joshua Tree's population more than tripled from 1,211 to 3,898 persons (California State Department of Finance 2000).

A second BBS route (''Cottonwood'') runs from the park's south entrance to approximately its center. Relatively few ravens have been observed on this route (range 0–7) despite its having been surveyed in 20 different years, and in contrast to the ''Joshua Tree'' route, the small numbers have decreased since the early 1990's (Fig. 2). On the ''Cholla Garden'' route, which runs roughly east-west in the central portion of the park, the number of ravens observed has ranged from seven in 1996 to 21 in 1995; no increase has been detected.

BBS surveys occur strictly along paved roads, and because ravens tend to be attracted to roads (Knight and Kawashima 1993, Boarman and Heinrich 1999), BBS routes potentially overestimate the abundance of ravens in an area. Furthermore, the results of surveys like the BBS that are performed only once each year should be interpreted conservatively. Despite these caveats, increases in the numbers of ravens in the 1990's on the ''Joshua Tree'' route well above numbers from the 1970's and 1980's likely reflect actual increases in raven density in this area.

Like the BBS, the Adopt-a-Raven Transects were vehicular surveys. Counts were made at roughly 0.8 km intervals on five different routes in JTNP and one adjacent to it, ranging from twice to 35 times each. The route lengths are shorter than for the BBS surveys (ranging between 6.4 and 20.1 km), but cover both

paved and unpaved roads. Most were repeated several times each year (Table 5). Because observers occasionally deviated from the established protocol and varied the distance between count locations, we calculated the average number of ravens per stop rather than the average number per kilometer. Of the three routes surveyed more than three times each, the two routes in the northeastern portion of JTNP resulted in more raven observations per point surveyed than did the route adjacent to the EML site. These differences could reflect a positive correlation between raven densities and human density. They may instead, or additionally, reflect a lower number of ravens in the Colorado Desert portion of JTNP due to habitat preferences.

The results of a relatively recent survey of undeveloped areas of the park supports the idea that raven densities in roadless regions in JTNP are much lower than in areas containing roads. Camp et al. (1993) surveyed for ravens in unpopulated areas adjacent to the proposed EML. Thirty-two transects totaling 283 km were walked in a 4-week period in 1992 in a largely roadless area. For each transect, the number of ravens observed per kilometer was calculated, and then averaged to obtain the number of ravens per 100 km. Only eight ravens were observed on the 32 transects surveyed. All observations were of single birds. The density was estimated to be 4.6 per 100 km (SD = 9.78), much lower than the mean of 36.5 ravens per 100 km estimated by Knight and Kawashima (1993) along paved highways in the Mojave Desert.

National Audubon Society Christmas Bird Count (CBC) data have been collected at Joshua Tree National Park once each winter since 1969 and at a second site immediately west of JTNP (Morongo Valley) since 1981. We interpreted these data cautiously because CBC methods are not well standardized compared to other sources of information (Bock and Root 1981). A CBC involves a group of observers counting the number of individuals of all species within a 24-km diameter circle in a 24-hour period, although little time is spent surveying in non-daylight hours. The participants typically divide themselves into small groups and each group covers different, non-overlapping locations in the 24-km area. A master list is compiled on which each group reports the total number of each species observed. We calculated the number of ravens observed per party-hour (the number ravens divided by the number of ''party-hours'') in an effort to partially reduce variation in CBC data resulting from the fact that the numbers of observers participating in the counts tends to vary among years. There was no way that we could control for differences in amount of time spent surveying different areas within the count circle, or for variation in weather. The number of ravens per party hour for both the Joshua Tree National Monument CBC and the Morongo Valley CBC showed statistically significant increases over their respective 30-year and 18-year histories (Fig. 3, Fig. 4; Joshua Tree: $r_s = 0.705$, $p < 0.0005$; Morongo Valley: $r_s = 0.834$, $p < 0.0005$).

We also analyzed unpublished observations of ravens by Michael A. Patten, a locally-based professional biologist with expertise in ornithology. Patten recorded birds between 1987 and 1999 at five areas near JTNP: Morongo Valley, Twentynine Palms, Iron Mountain (approximately 12.9 km northeast of the northeast border of the park), Cactus City (12.9 km west of the park's south entrance), and Desert Center (Fig. 1). Each year, surveys were made in spring and fall of some or all of the five areas. We calculated the average number of ravens observed at

Table 5. Common Ravens observed on Adopt-a-Raven Transect surveys.

Transect Name	Period surveyed	No. of times surveyed	Route length	Average no. observed each visit	Average no. observed per point (stop) surveyed
Inside of JTNP					
Queen Mountain Road	3/19/97–4/16/97	3	10–11.6 km	5 (range 0–3)	0.71
Covington Flats	4/30/97–5/30/98	17	6.4–7.2 km	2.1 (range 0–5)	0.22
Keys View Road	10/15/97–6/3/98	16	8.1–12.9 km	4.9 (range 0–39)	0.45
Black Eagle Mine Road	4/19/97–5/99, 7/99–10/99 (on-going)	35	9.7–17.0 km	0.3 (range 0–2)	0.5
''Geology Tour''	3/15/97, 3/16/97	2	12.1–20.1 km	5.5 (range 3–8)	0.82
Outside of JTNP					
Kaiser Road (Desert Center)	5/14/97–10/19/97	2	12.1–19.3 km	6 (range 4–10)	0.75

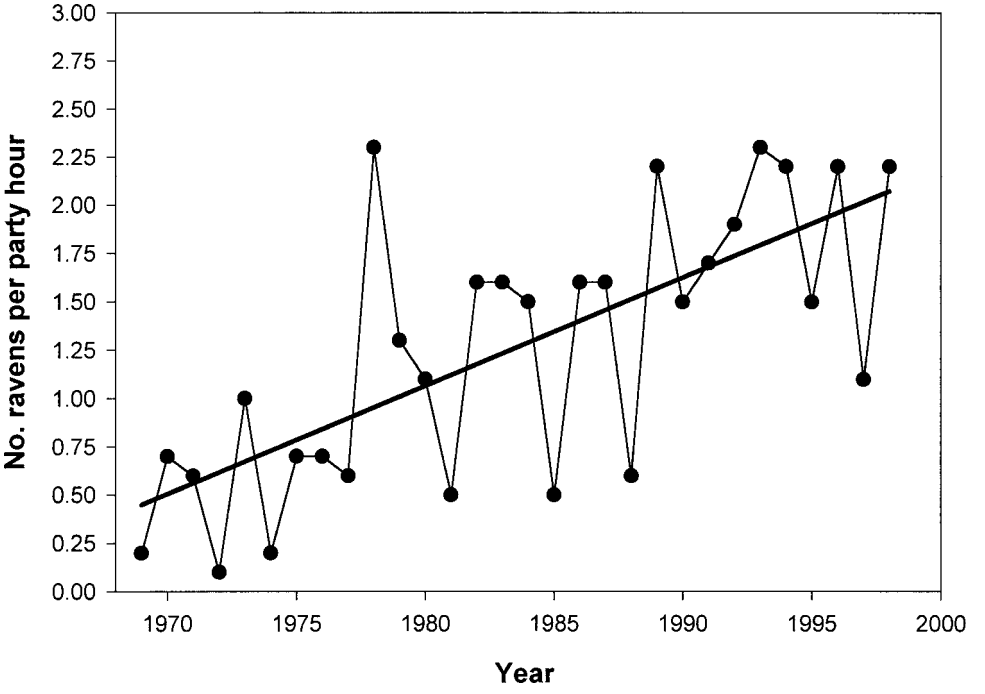

Fig. 3. Common Ravens observed on the Joshua Tree Christmas Bird Counts ($r_s = 0.705$, $p < 0.0005$).

each of the five survey regions for spring and fall observations separately. A statistically significant increase in raven numbers was observed for fall surveys (Spearman rank correlation, $r_s = 0.624$, $p < 0.05$) but not for spring surveys (Spearman rank correlation, $r_s = -0.036$, $p > 0.90$).

A Breeding Bird Census (BBC) conducted in Morongo Valley at the Big Morongo Canyon Reserve annually between 1977 and 1995 produced ravens in only a few years. The area was censused 8–9 times each spring to determine the numbers of species breeding and/or otherwise utilizing the area. Ravens were listed as a ''visitor'' in 1983, 1984, 1985, 1986, 1988, and 1994, indicating that individuals were observed in the census area but were not observed breeding when observed. The numbers of ravens that were observed were not provided. The census area was 15.38 hectares in size and consisted of marsh, riparian woodland and mesquite thickets (95% of total area), and small areas of brush. The habitat characteristics may have influenced the infrequency of observations since ravens tend not to utilize woodland and thicket habitat in deserts of southern California.

Conclusions

None of the data sets we obtained was a comprehensive assessment of Common Raven distribution or density in JTNP for any time period. Furthermore, the majority of the sources consisted of data that were collected without the use of a standardized methodology, and/or were collected over a short time period. Despite

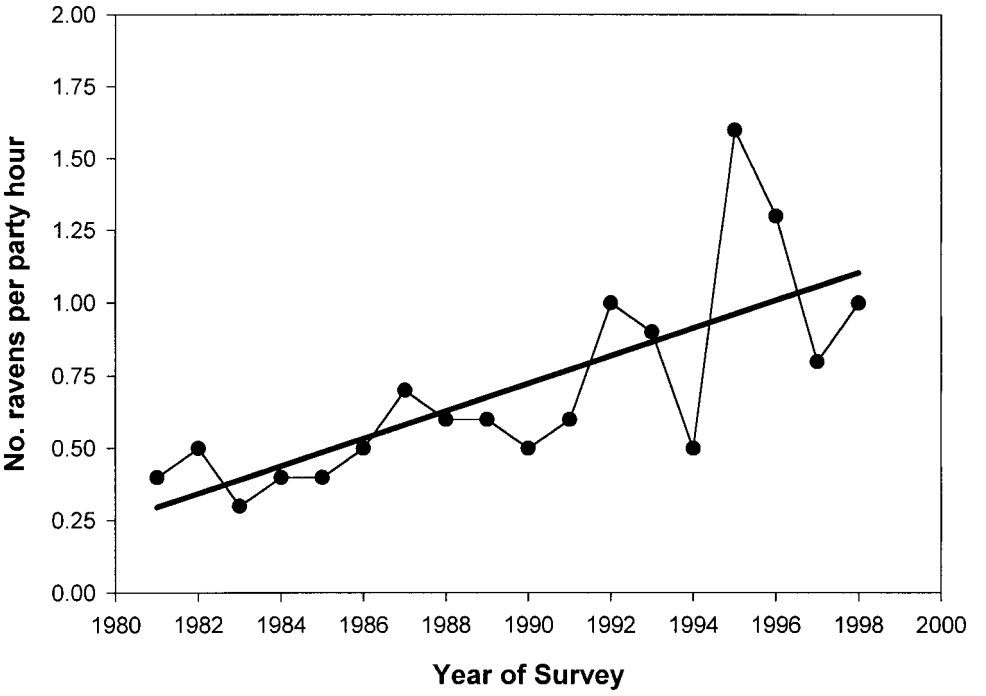

Fig. 4. Common Ravens observed on the Morongo Valley Christmas Bird Counts ($r_s = 0.834$, $p < 0.0005$).

these limitations, we gained enough historical and temporal information about ravens to reach the following qualitative conclusions:

1. Ravens were present in the southern California desert (east Mojave) thousands of years ago.

Fossil evidence shows that ravens occupied the east Mojave Desert tens of thousands of years ago. Observations of live individuals in the Mojave and Colorado Deserts date back as far as the late 1800s and early 1900s. These data support the contention that Common Ravens are a native component of the avifauna in southern California deserts.

2. Ravens have been documented in JTNP for more than 50 years.

The first documented observation of ravens in JTNP was in 1935 (Carter 1937), later supplemented extensively by observations from Charles Adams in the mid-1950s. Breeding in the region was suggested by observations during the Death Valley Expedition of 1891 (Fisher 1893). Breeding Bird Atlas (BBA) data confirmed that ravens continue to breed in JTNP. In limited surveys in 1999, we located eight nests in the park (Boarman and Coe 2000a).

3. Raven densities may be higher in the Mojave Desert than the Colorado Desert.

JTNP consists of two types of desert: Mojave and Colorado. During the Adopt-a-Raven Transects surveys, more ravens were observed along routes in the north-

ern portions of the park (Mojave) than in the central and southeast portions (Colorado). These observations are in agreement with those of Knowles et al. (1989) and FaunaWest Wildlife Consultants (1991) that indicated ravens were more common in the Mojave than in the Colorado Desert based on vehicle transect surveys. Patten et al. (in press) also reports Common Ravens as being uncommon in the Salton Sink portion of the Colorado Desert and fewer in number than in the Mojave Desert.

4. The numbers of ravens observed in JTNP has increased over the last 50 years.

The absence of Common Raven from Miller's 1945 bird list for JTNP, compared to the regular observations by Charles Adams in the mid-1950s may suggest a period when populations began visibly expanding. BBS data suggest that raven numbers have increased on the ''Joshua Tree'' route. Although the ''Cottonwood'' BBS route has not shown a corresponding increase, this route covers Colorado Desert habitat where ravens may be less abundant (see Conclusion 3, above).

CBC data also indicate an increase in raven numbers. The number of ravens per party hour for both the Joshua Tree National Monument CBC and the Morongo Valley CBC increased over their respective histories. Increases in ravens in JTNP are consistent with the results of an analysis of BBS data for the Sonoran and Mojave Deserts by Boarman and Berry (1995) showing that raven populations increased 450–1000% over a recent 24-year period.

5. The distribution of ravens in JTNP has expanded in the last 50 years.

Common Ravens are now known to occur in locations where Charles Adams never reported them in the mid-1950s (e.g., Cottonwood Springs and Queen Valley).

6. Raven densities are lower in regions without roads.

Surveys by Camp et al. (1993) in unpopulated areas adjacent to the proposed Eagle Mountain Landfill resulted in a density estimate of 4.63 per 100 km which was lower than the mean of 36.5 ravens per 100 km estimated by Knight and Kawashima (1993) along paved highways in the Mojave Desert.

7. Landfills in the Mojave Desert are some of the largest concentration areas for ravens.

This observation was made by Knowles et al. (1989) and FaunaWest Wildlife Consultants (1991) who surveyed landfills, sewage ponds and roads. In addition, multi-year surveys in the western Mojave Desert at Fort Irwin (approximately 130 km north of the park), and in and around Edwards Air Force Base (approximately 130 km north-east of the Park), yielded significantly more ravens at landfills than at sewage ponds, golf courses, city streets, and undeveloped desert locations (Boarman et al. 1995).

Observations of ravens in Joshua Tree National Park have increased and their populations are presumably expanding. Because of their use of landfills for food, raven numbers in JTNP will likely increase following implementation of Eagle Mountain Landfill. A program to monitor raven populations in and around JTNP should be implemented to evaluate expected changes and should cover areas

where ravens have occurred regularly over the past 50 years, as well as where they have rarely occurred. Road-based surveys coupled with point counts at specific attraction sites, following standardized protocols and occurring throughout the year, would provide the most reliable results. Following radio- and wing-tagged ravens from the landfill would yield important data on the direct influence the landfill has on the JTNP raven population.

Acknowledgements

We would like to thank the numerous persons who provided data and information for this manuscript, including William Truesdell, Ray Panici, Michael A. Patten, Chet McGaugh, Richard Camp, and JTNP staff Gillian Bowser and Joseph Zarki. Several museums provided information from their collections including California Academy of Sciences (Douglas Long), Los Angeles County Museum of Natural History (Kimball Garrett), San Bernardino County Museum (Robert McKernan), San Diego Natural History Museum (Philip Unitt), Museum of Vertebrate Zoology, and Western Foundation of Vertebrate Zoology (Rene Corado). Comments and suggestions were provided by Michael A. Patten, Richard Camp, and Chet McGaugh. We also thank Gillian Bowser, Hank McCutchen, and Ernie Quintana for their support of the project from its inception.

Literature Cited

Avery, M.L., M.A. Pavelka, D.L. Bergman, D.G. Decker, C.E. Knittle, G.M. Linz. 1995. Aversive conditioning to reduce raven predation on California Least Tern eggs. Colonial waterbirds, 18(2):131–145.

Boarman, W.I. 1993. When a native predator becomes a pest: a case study. Pp. 191–206 *in* Conservation and resource management. (S. K. Majumdar, E. W. Miller, D. E. Baker, E. K. Brown, J. R. Pratt, and R. F. Schmalz, eds.), Penn. Acad. of Sc., Philadelphia. 444 pp.

Boarman, W.I., and S.J. Coe. 2000a. Evaluation of the distribution and abundance of Common Ravens in and around Joshua Tree National Park. Joshua Tree National Park Resources Management Division, Twentynine Palms, California.

Boarman, W.I., and S.J. Coe 2000b. Finding value in pre-existing data sets. Conservation biology in practice, 1(1):32–34.

Boarman, W.I., and K.H. Berry. 1995. Common Ravens in the southwestern U.S. 1968–1972. Pp 73–75 *in* Our living resources: a report to the nation on the distribution, abundance, and health of U.S. plants, animals, and ecosystems. (E.T. LaRoe, G.S. Farris, C.E. Puckett, P.D. Doran, and M.J. Mac, eds.), U.S. Department of Interior, National Biological Service, Washington, DC. 530 pp.

Boarman, W.I., R.J. Camp, M. Hagan, and W. Deal. 1995. Raven abundance at anthropogenic resources in the Western Mojave Desert, California. Prepared for Edwards Airforce Base, California. Prepared by National Biological Survey. Contact author at U.S. Geologic Survey, Western Ecological Research Center, 5745 Kearny Villa Road, Suite M, San Diego, California, 92123.

Boarman, W.I., and B. Heinrich. 1999. The Common Raven (*Corvus corax*). No. 476. *in* The birds of North America (A. Poole and F. Gill, eds), Philadelphia Academy of Sciences and American Ornithologists' Union.

Bock, C.E., and T.L. Root. 1981. The Christmas Bird Count and avian ecology. Studies in avian biology No. 6:17–23.

Bureau of Land Management. 1990. Draft raven management plan for the California Desert Conservation Area. U.S. Dept. Int., Bureau of Land Management, California Desert District, Riverside, California.

California State Department of Finance. 2000. Historical census population of places, towns, and cities in California, 1850–1990. Demographic Research Unit. Sacramento, California. ⟨www.dof.ca.gov/html/demograp/repndat.htm⟩ August 2001.

Camp, R.J., R.L. Knight, and J. Freilich. 1993. Common Raven populations in Joshua Tree National Monument, California. Western Birds, 24:198–199.

Carter, F. 1937. Bird life at Twentynine Palms. Condor, 39:210–219.

FaunaWest Wildlife Consultants. 1991. Relative abundance and distribution of the Common Raven in the deserts of southern California and Nevada during spring and summer of 1989. Prepared for Bureau of Land Management, California Desert District, Contract No. YA651-CT9-340035. Prepared by FaunaWest Wildlife Consultants, P.O. Box 113, Boulder, Montana, 59632.

Fisher, A.K. 1893. The Death Valley Expedition: a biological survey of parts of California, Nevada, Arizona, and Utah. North America Fauna no. 7.

Gilman, M.F. 1935. Notes on birds in Death Valley. Condor, 37:238–242.

Grinnell, J., and A.H. Miller. 1944. The distribution of the birds of California. Pacific Coast Avifauna no. 27.

Jefferson, G.T. 1991. A catalogue of Late Quaternary vertebrates from California: Part One, Nonmarine lower vertebrates and avian taxa. Natural History Museum of Los Angeles County Technical Report no 5.

Knight, R.L., and J.Y. Kawashima. 1993. Responses of raven and red-tailed hawk populations to linear right-of-ways. J. Wildl. Manage., 57:266–271.

Knowles, C., R. Gumtow, P. Knowles, and P. Houghton. 1989. Relative abundance and distribution of the Common Raven in the deserts of southern California and Nevada during fall and winter of 1988–1989. Prepared for Bureau of Land Management, California Desert District. Contract No. CA950-CT8-56. Available from FaunaWest Wildlife Consultants, P.O. Box 113, Boulder, Montana, 59632.

Lamb, C. 1912. Birds of a Mohave Desert oasis. Condor, 14:32–40.

Miller, A.H., and R.C. Stebbins. 1964. The lives of desert animals in Joshua Tree National Monument. Univ. of California Press. 452 pp.

Patten, M.A., P. Unitt, and G. McCaskie. In press. Birds of the Salton Sea: status, ecology, and biogeography. Univ. of California Press.

RECON (Regional Environmental Consultants). 1994. Annual summary report for the Eagle Mountain Landfill Biological Mitigation and Monitoring Program, Riverside County, California. Prepared for Mine Reclamation Corporation.

U.S. Fish and Wildlife Service. 1994. Desert tortoise (Mojave population) Recovery Plan. U.S. Fish and Wildlife Service, Portland, OR.

van Rossem, A. 1911. Winter birds of the Salton Sea region. Condor, 13:129–137.

Accepted for publication 16 March 2001.