CURRENT RAPTOR STUDIES IN MÉXICO

Edited by

Ricardo Rodríguez-Estrella

Centro de Investigaciones Biológicas del Noroeste, S.C.
Comisión Nacional para el Conocimiento y Uso de la Biodiversidad
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PREFACE

Biological diversity of México, raptors and scientific research

México is one of the most biologically diverse countries on the planet, as a result of its very complex geological history, geographic position, and environmental heterogeneity, among other factors. Its biological diversity is such, that together with 17 other countries such as India, China and Brazil, it is referred to as Megadiverse. Together, these countries sustain more than 70% of all living organisms, including plants, animals and microorganisms, México ranking first for its diversity of reptiles and amphibians, third for its mammalian diversity, fourth for its diversity of vascular plants, and eleventh for its diversity of birds. Moreover, a high percentage of the species, up to 65% in amphibians, are endemic to México; i.e. with geographic ranges restricted to the country.

The biological diversity of México has been part of the geographic and natural settings that have accompanied its inhabitants since they first settled in the country more than 12,000 years ago. The legendary diversity of the country has astonished scientists such as Baron Alexander Von Humbolt, who described México as a biological paradise. Unfortunately, this impressive natural diversity of the country is practically unknown by most Mexicans, who instead should be proud of their biological inheritance.

Nowadays, the biological diversity of México is seriously threatened. Hundreds of species and thousands of populations are endangered, mainly because of human population size and social inequity. México's population size is expected to become stable around 145 millions, but only in three decades. The loss of biological diversity has severe consequences at a biological and social level, because populations and species are the basis for the structure and functioning of biological systems, which provide us for free with environmental goods and services. These goods and services, which include the maintenance of a proper atmospheric gas composition, the ozone layer, soil fertility and quality and quantity of water, among others, generate the environmental conditions that allow life on Earth. They are the basis of our existence. Paradoxically, their continuance depends on our activities.

The only way to understand the complex relationships of living organisms with their environment, their role in providing environmental services, and better management of these living organisms to reconcile their use with their conservation, is through a solid investment in scientific research. However, many governments, including the Mexican government, surrender to the temptation of investing little in scientific and technological research, focusing on other approaches to fight social and economic problems. Those governments ignore that one of the few ways out of poverty is through the generation of scientific and technological knowledge, which is fundamental to the development of any country.

That is why I have received with great satisfaction this volume addressing the ecology and conservation of raptors – one group of species very sensitive to anthropogenic disturbances. As top predators, with low population sizes, raptors are susceptible to environmental changes that can affect them negatively, and thus increase the risk of their extinction. That is precisely why their status is an indication of environmental conditions, much like canary birds long ago used to indicate the presence of toxic gases to miners. The results presented by researchers working with raptors in México can have an immediate application in conservation.

The careful editing of the editor has produced an interesting book of high scientific quality. I am sure that time will be the best test of the benefits of this type of publications, which are essential to maintain the welfare of our society.

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Raptor and raven electrocutions in northwestern México: a preliminary regional assessment of the impact of concrete power poles

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ABSTRACT

Recent research has shown that concrete power poles with steel cross-arms are responsible for large numbers of raptor and raven electrocutions in northwestern Chihuahua. Monitoring of raptor and raven mortality in that area is important, but there is also a need for information regarding the numbers of concrete power poles and their impact in other parts of México. From February 2002 through March 2004, we conducted power-line surveys in Chihuahua, Sonora, and Baja California Sur. In Chihuahua, most areas we inspected had either wooden poles or concrete poles that had been retrofitted with wooden cross-arms, perch guards, or polyvinyl chloride (PVC) covering. Only the northwestern part of the state was found to have large numbers of non-retrofitted concrete poles, along with important bird mortality (chiefly of Chihuahuan ravens [*Corvus cryptoleucus*] and red-tailed hawks [*Buteo jamaicensis*]), including along power lines never before surveyed. In Sonora,

concrete poles were found to be widespread, but as in Chihuahua many of them had been retrofitted. We found a total of 10 dead birds (2 turkey vultures [*Cathartes aura*] and 8 ravens) under non-retrofitted poles in the northeastern part of the state. Five dead birds including 2 red-tailed hawks were also detected under non-retrofitted poles of a power line in coastal west-central Sonora. In Baja California Sur, few power lines with concrete poles were observed, and of these, only 1 yielded an electrocuted bird, a common raven (*Corvus corax*). The results of our surveys suggest that prior to the retrofitting effort now taking place, bird electrocutions on concrete poles were very widespread, affecting much of Sonora and Chihuahua, and some areas of Baja California Sur. With many concrete poles now retrofitted, raptor and raven mortality should be lower along power lines of northwestern México, but more surveys are needed to verify the effectiveness of all retrofitting techniques and materials.

Key words: *Aquila chrysaetos*, *Buteo jamaicensis*, *Buteo regalis*, concrete poles, electrocutions, ferruginous hawk, golden eagle, raptors, ravens, red-tailed hawk.

RESUMEN

Investigaciones recientes han demostrado que los postes de concreto con brazos de acero cruzados en líneas eléctricas, son responsables de un gran número de electrocuciones de rapaces y cuervos en el noroeste de Chihuahua. El monitoreo de la mortalidad de las rapaces y del cuervo en esta área es importante, pero también existe una necesidad de contar con información disponible del número de postes de

concreto y su impacto en otras partes de México. De febrero de 2002 a marzo de 2004 se realizaron muestreos en líneas de transmisión en Chihuahua, Sonora y Baja California Sur. En Chihuahua, muchas áreas fueron inspeccionadas buscando si tenían postes de madera o de concreto que hubiesen sido modificados con brazos cruzados de madera, perchas de guardia, o cubiertos de PVC. Sólo en la parte noroeste del estado se encontró un gran número de postes de concreto no modificados, junto con una importante mortandad de aves (principalmente del cuervo de Chihuahua [*Corvus cryptoleucus*] y del halcón cola roja [*Buteo jamaicensis*]), incluyendo líneas de transmisión nunca antes muestreadas. En Sonora, los postes de concreto fueron ampliamente utilizados, pero muchos de ellos fueron modificados, como en Chihuahua. Se encontró un total de 10 aves muertas (2 zopilotes auras [*Cathartes aura*] y 8 cuervos) en postes no modificados en el noreste del estado. Se detectaron 5 aves muertas, incluyendo 2 halcones cola roja, a lo largo de una línea de transmisión no modificada, muestreada en la parte costera del oeste-centro de Sonora. En Baja California Sur, se encontraron pocos postes de concreto y de éstos, sólo 1 tenía por debajo un ave muerta electrocutada, un cuervo (*Corvus corax*). Los resultados de nuestros muestreos muestran que, previo a los esfuerzos de modificación de postes que tienen lugar ahora, las electrocuciones de las aves en postes de concreto eran ampliamente distribuidas, afectando partes de Sonora y Chihuahua, y en menor extensión a Baja California Sur. Con la gran cantidad de postes de concreto ahora modificados, la mortandad de rapaces y cuervos en líneas de transmisión del noroeste

de México debe ser menor, pero se necesitan más muestreos para verificar la efectividad de todas las técnicas de modificación y de los materiales utilizados.

INTRODUCTION

Power poles are an important cause of raptor mortality throughout much of the world (e.g., Markus 1972, Haas 1980, Ledger and Annegarn 1981, Ferrer and Hiraldo 1991, LaRoe *et al.* 1995, Ferrer and Janss 1999, Harness and Wilson 2001). In the western U.S., most poles are built with wood, which under dry weather conditions is a non-conductive material. As a result, electrocutions on wooden poles occur typically when a bird spans the distance between 2 energized wires. In contrast, México has since the 1970s often been using poles that are conductive, as they are made of concrete and fitted with steel cross-arms (Cartron *et al.* 2005). A bird perched on the steel cross-arm of a concrete pole is grounded and need only touch 1 energized wire to be electrocuted. For that reason the risk of electrocution is higher on this type of pole. It may be further compounded by relatively high voltage (34.5 kV in the Janos – Casas Grandes area; see further on) used along distribution power lines of México (Cartron *et al.* 2005). Higher voltage results in arcing over larger distances, and thus the possibility exists that on a concrete pole, a bird can be electrocuted by simply perching very close to an energized wire without actually touching it. Finally, much of northern México is characterized by an arid climate. The lack of tall vegetation at low and middle elevations increases the likelihood that raptors and other birds will

use power poles as perches (APLIC 1996).

In March 2002, a workshop was organized in México City to present and discuss information on the impact of power lines on birds in México. Biologists from México and the U.S. as well as representatives of the *Comisión Federal de Electricidad* (CFE) attended the workshop. Other than the research conducted in northwestern Chihuahua (Cartron *et al.* 2000, 2005), there was virtually no information available on bird electrocutions on concrete poles from anywhere in México.

In northwestern Chihuahua, electrocuted raptors have been reported since 1999, chiefly from the Janos – Casas Grandes (JCG) prairie dog town complex and surrounding area (Cartron *et al.* 2005). More than 20 raptor species occur in that area (Manzano-Fischer *et al.* 1999, in press), which also has a large number of concrete poles. Most recently, monthly surveys were conducted in the JCG area from December 2000 through November 2001 (Cartron *et al.* 2005). The remains of 178 birds (52 raptors, 123 ravens, 2 great blue herons [*Ardea herodias*], 1 unidentified) were found during those surveys, all but one at the base of concrete poles. The remains of only 12 dead birds were discovered elsewhere in northwestern Chihuahua, but surveys outside the prairie dog town complex area were very limited. In all survey locations, many, if not most, of the remains bore signs of electrocution (e.g., singed feathers). Those that did not were typically old and/or incomplete remains. Another important finding was that double dead-end poles with double cross-arms (Fig. 1) were associated with higher mortality compared to all other types of concrete poles

(Cartron *et al.* 2005).

At the time of Cartron *et al.*'s (2005) monitoring effort, CFE began to retrofit some of the concrete power poles in the JCG area. What remained unclear, even despite the workshop, was whether CFE was engaged in similar retrofitting efforts elsewhere in Chihuahua or even in other parts of México. In the JCG area, retrofitting consisted of replacing steel cross-arms with longer cross-arms made out of wood.

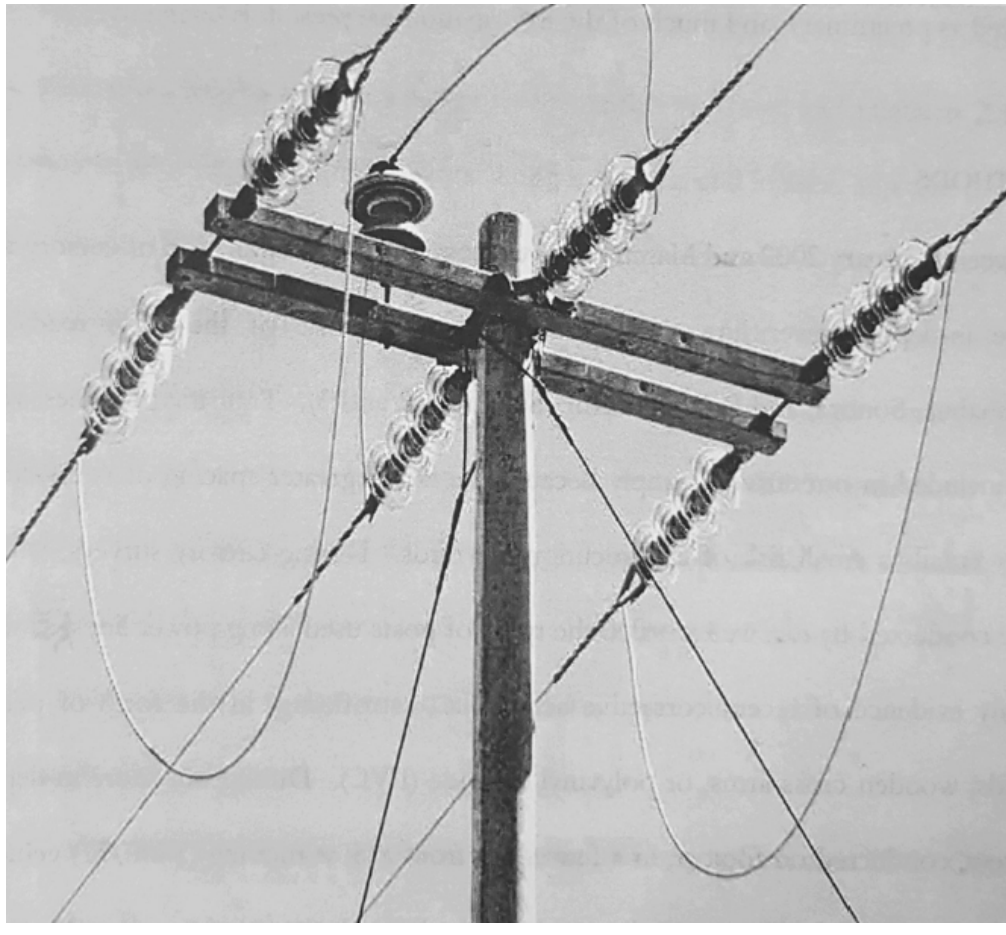

Figure 1. Double dead-end pole with double cross-arms.

In this chapter, we report the results of power-line surveys we conducted from February 2002 to March 2004 in Chihuahua, Sonora, and Baja California Sur. The 3 main objectives of the study were to 1) gather information on the number and location of concrete power poles in those 3 states; 2) assess the magnitude of the retrofitting effort at a regional scale; and 3) search for electrocuted birds under non-retrofitted concrete poles. Although not the principal focus of this study, we also continued to monitor power lines in the JCG general area. This study should be viewed as preliminary, and much of the information we present is qualitative.

METHODS

Between February 2002 and March 2004, we conducted a combination of cursory and more in-depth power line surveys along or near some of the main roads of Chihuahua, Sonora, and Baja California Sur (Figs. 2 and 3). Transmission lines were not included in our surveys simply because the much greater spacing of conductors likely entails a small risk of electrocution for birds. During cursory surveys, which were conducted by car, we recorded the types of posts used along power lines, as well as any evidence of recent corrective action (i.e., retrofitting) in the form of perch guards, wooden cross-arms, or polyvinyl chloride (PVC). During our more in-depth surveys, conducted on foot or, in a few cases, from a slow-moving (5 km/hr) vehicle driven directly under the power line, we searched for electrocuted raptors. Most of the in-depth surveys were along power lines with non-retrofitted concrete poles, but

we also inspected a few power lines with wooden poles or concrete poles retrofitted with wooden cross-arms. Every set of remains found under a pole was examined for signs of electrocution, primarily singed feathers. We recorded the location of every set of remains using a Garmin hand-held GPS unit.

Surveys in Chihuahua were conducted on 9-11 February, 26-28 April, 5-8 June, 25-26 July, 28 October, and 11-12 November 2002, and on 18 March 2004. They were conducted directly along Mexican Highway 23 (between Palomas and Highway 2), Highway 16 between Ojinaga and Cd. Chihuahua, Highway 45 north of Cd. Chihuahua, Highway 10 from near Buenaventura to Janos, and Highway 2 from its junction with Highway 23 to the border with Sonora, and in areas adjacent to these main roads (Fig. 2). In total, these surveys spread over a total distance of approximately 1,000 km of roads and covered much of the eastern, central, and northwestern parts of the state. In the JCG prairie dog town complex area (west of Highway 10 and south of Highway 2; see Cartron *et al.* 2005), vegetation types included open grassland, mesquite (*Prosopis* sp.) grassland, shrublands dominated by mesquite or *Ephedra*, and agricultural fields. Elsewhere in Chihuahua, some of the same vegetation types also occurred, with mesquite-yucca (*Yucca* sp.) or yucca grasslands also widespread.

Power-line surveys in northeastern Sonora were conducted on 28-29 October 2002 (Fig. 2). In northern and west-central Sonora they were conducted on 18-20 March 2004. The combined road distance over which these surveys were conducted

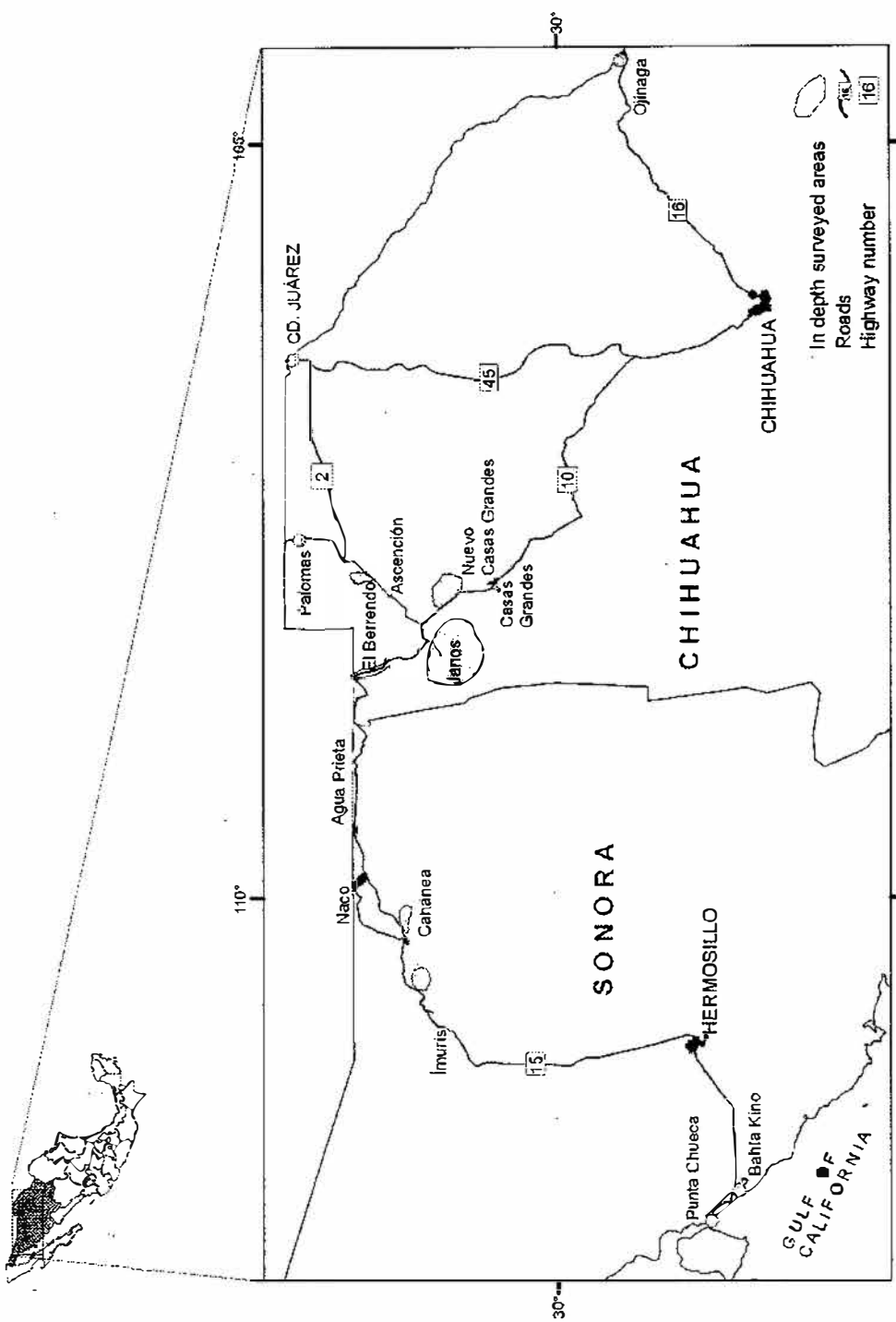

Figure 2. Chihuahua and Sonora, with main roads and areas selected for 'in-depth' surveys.

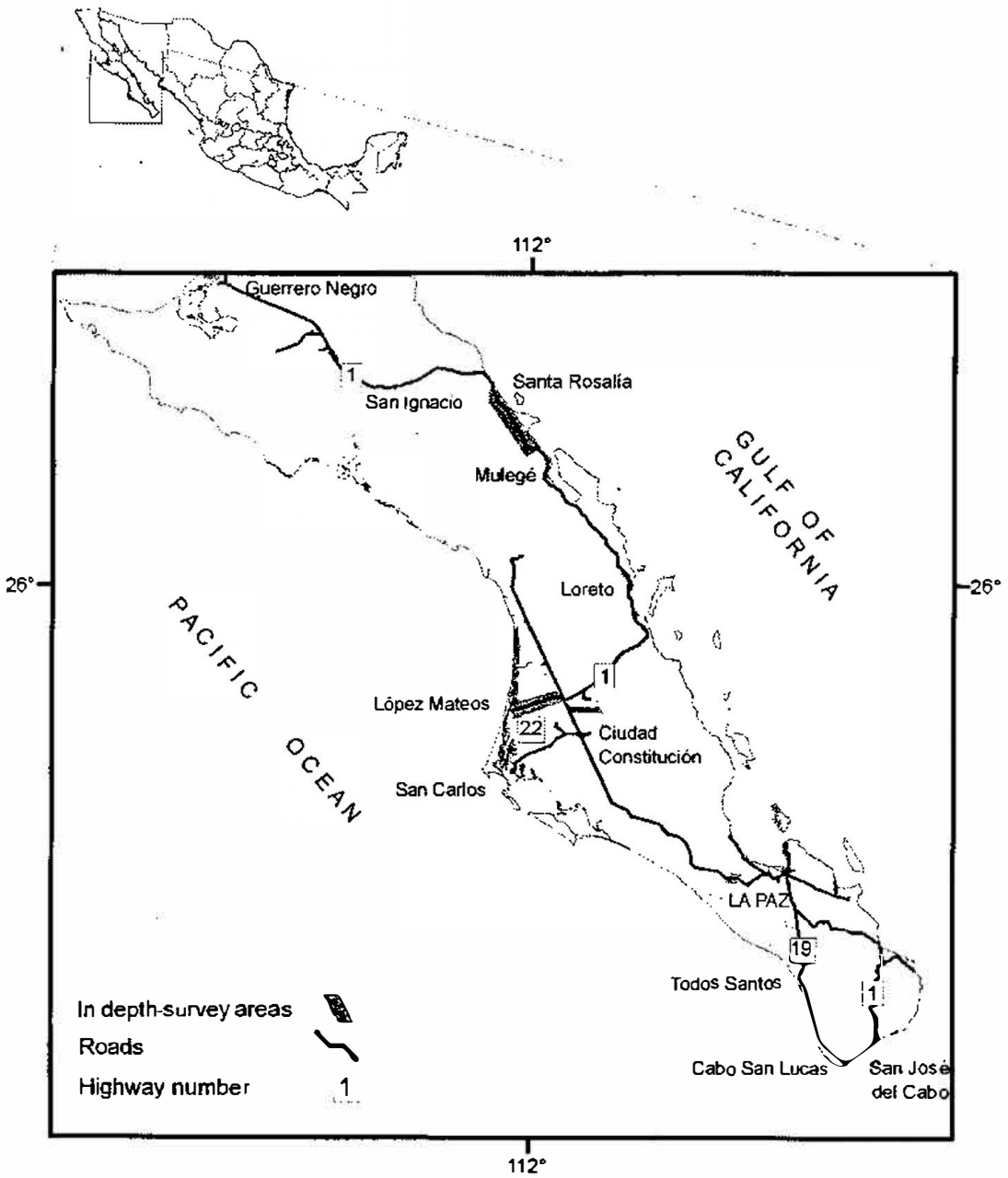

Figure 3. Baja California Sur with main roads and areas selected for 'in-depth' surveys.

totaled approximately 600 km. The vegetation varied widely based in part on elevation. In the northeastern part of the state, some of the areas we inspected had mesquite grasslands or shrublands. In west-central Sonora, a power-line survey was conducted in the vegetational subregion of the Sonoran Desert designated by Shreve (1951) as the Central Gulf Coast. The vegetation was dominated by cacti (e.g., *Pachycereus pringlei, Stenocereus gummosus, S. thurberi, Lophocereus schottii, Opuntia fulgida*) and arborescent shrubs (*Cercidium* sp., *Olneya tesota, Prosopis* sp.).

All work in Baja California Sur was conducted between 11 April and 26 May, 2003 (Fig. 3). In most places the landscape was dominated by 1.5 to 2 m tall microphyllous Sonoran desert vegetation that included *Atamisquea emarginata, Yucca valida,* and *Pachycereus pringlei.* In the Vizcaino Desert (another subdivision of the Sonoran Desert), the vegetation tended to be smaller and consisted chiefly of *Encelia palmieri, Lycium californicum, Atriplex policarpa,* and *Errazurizia megacarpa.* We first conducted a preliminary inspection of power lines from Cabo San Lucas north to the Vizcaino Desert to locate concrete poles, for a total travel distance of 1,419 km. We then initiated in-depth surveys for electrocuted birds along power lines with concrete poles. Collectively, power lines with concrete power poles spread over a total distance of 189 km. Raptors present in survey areas in Baja California Sur and their use of power poles are presented in Appendix 1.

RESULTS

Distribution of concrete poles

In Chihuahua, concrete poles with steel cross-arms were found to be widespread. The power line along Highway 23 (the road from the border town of Palomas to Highway 2; Fig. 2) consisted entirely of concrete poles, most of them tangent units (Fig. 4), with also some double poles (for a discussion of pole configurations see APLIC 1996 and Cartron *et al.* 2005). We counted approximately 370 poles, none of them retrofitted. Highway 2 from the junction with Highway 23 west to the border with Sonora had several stretches of power lines with a total of > 400 concrete poles (mostly tangent poles but also some double dead-end units). Initially, none of these poles was retrofitted. However, on 28 October 2002, white PVC covering was observed around the conductors on tangent poles west of Janos. Finally, non-retrofitted concrete poles were found in the JCG prairie dog complex area and east of Highway 10 between Nuevo Casas Grandes and Janos. All these concrete poles were located along power lines supplying electricity to small rural communities (e.g., ejidos; Tables 1 and 2).

Elsewhere, we did not detect any power lines with more than a few scattered non-retrofitted concrete poles. Power lines along Highway 16 consisted almost entirely of wooden poles. In the vicinity of Cd. Chihuahua and along Highway 10 near Nuevo Casas Grandes, concrete poles numbered in the hundreds (the exact number of poles was not counted). However, most of them had been retrofitted with

wooden cross-arms (Cd. Chihuahua and vicinity) or with perch guards (Nuevo Casas Grandes area).

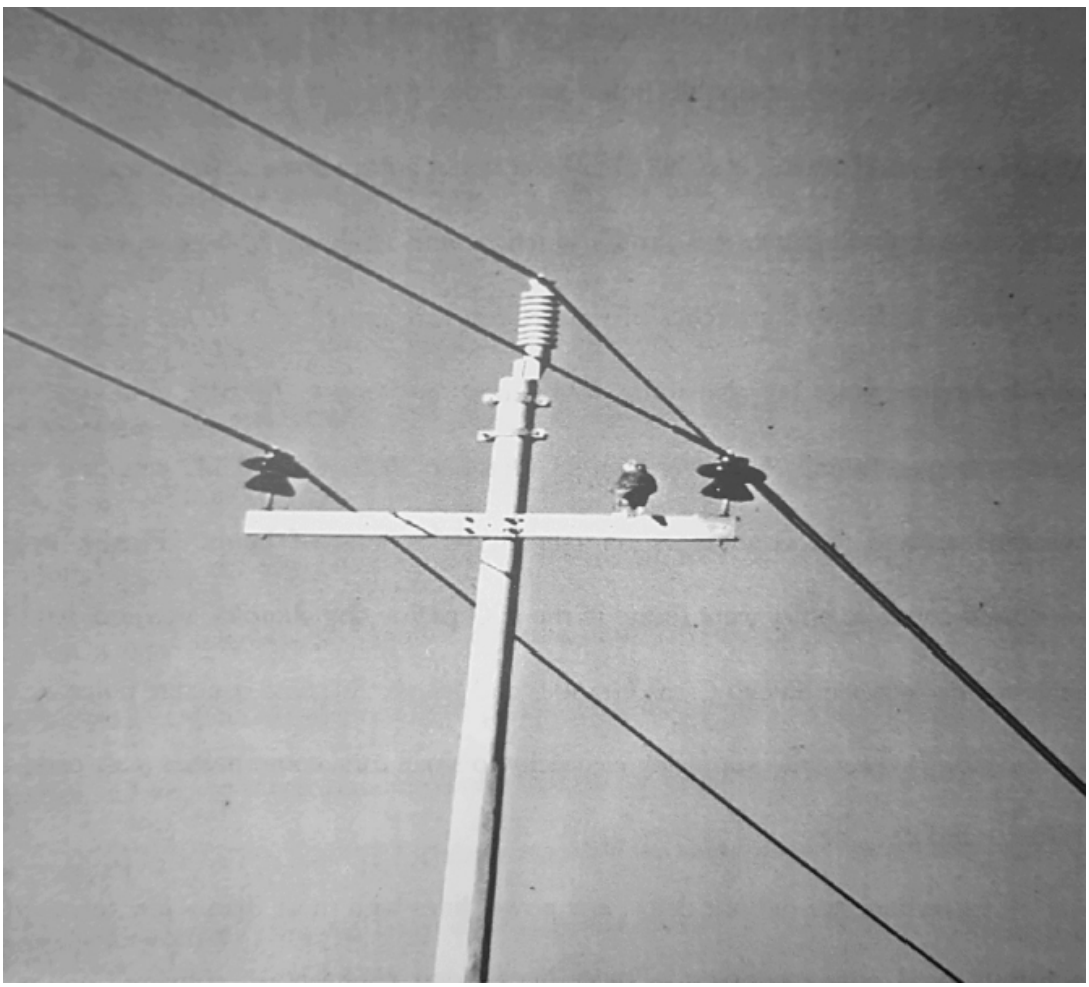

Figure 4. Tangent unit with perched raptor.

Table 1. Characteristics of areas where in-depth power-line surveys were conducted in the Janos-Casas Grandes prairie dog town complex area of northwestern Chihuahua, with associated mortality findings.

location	date of survey	surrounding vegetation	number and configuration of inspected power poles	findings[1]
Casa de Janos	February 10, 2002 April 27, 2002 November 12, 2002	Grassland and fields	53 (36 tangent, 5 double dead-end) concrete poles	1 (0) red-tailed hawk (November 02)
El Cuervo	February 9, 2002 April 26, 2002 June 5, 2002 November 11, 2002	Grassland, mesquite grassland, and crop fields, with numerous active prairie dog burrows	389 (271 tangent) concrete poles	1 (1) turkey vulture (April 02) 1 (0) red-tailed hawk (April 02) 8 (7) Chihuahuan ravens (April 02) 2 (1) Chihuahuan ravens (June 02) 2 (1) turkey vultures (November 02) 1 (0) golden eagle (November 02) 1 (0) ferruginous hawk (November 02) 1 (1) red-tailed hawk (November 02) 5 (5) Chihuahuan ravens (November 02)
Ignacio Zaragoza	February 10, 2002 April 27, 2002 November 12, 2002	Grassland, barren soil, shrubland, with some prairie dog burrows	98 (6 tangent, 78 retrofitted tangent) concrete poles	1 (1) Chihuahuan raven (April 02)
North access road to San Pedro	February 10, 2002 April 27, 2002 June 5, 2002 November 11, 2002 March 18, 2004	Grassland	64 (50 tangent) concrete poles	1 (0) red-tailed hawk (June 02) 1 (1) unidentified eagle (November 02) 1 (1) American kestrel (March 04)

Table 1. *Continued.*

location	date of survey	surrounding vegetation	number and configuration of inspected power poles	findings[1]
Pancho Villa	February 10, 2002	Grassland with creosote and mesquite shrubs and some prairie dog burrows	121 (22 tangent, 96 retrofitted tangent) concrete poles	No remains
Power line southwest of San Pedro	February 10, 2002 April 27, 2002 June 5, 2002 November 12, 2002 March 18, 2004	Low shrubland with *Ephedra* and nearby field at one end	40 (30 tangent, 3 double dead-end) concrete poles	2 (2) Chihuahuan ravens (April 02) 3 (3) Chihuahuan ravens (June 02) 1 (1) red-tailed hawk (June 02) 1 (0) raven (March 04) 2 (2) Chihuahuan ravens (March 04) 1 (1) red-tailed hawk (March 04)
Power line west of Buenos Aires	November 12, 2002	Grassland and fields	21 (18 tangent) concrete poles	1 (1) unidentified eagle
North-south road at western end of road to Ignacio Zaragoza	February 10, 2002 April 27, 2002 November 12, 2002	Mesquite shrubland	46 (18 tangent, 28 retrofitted tangent) concrete poles	1 (1) Chihuahuan raven (November 02)

[1] The number of dead birds showing signs of electrocutions is given in parentheses.

Table 2. Characteristics of areas where in-depth power-line surveys were conducted in (northwestern) Chihuahua outside of the Janos-Casas Grandes prairie dog complex, with associated mortality findings.

location	date of survey	surrounding vegetation	number and configuration of inspected power poles	findings[1]
Colonia Hidalgo, north of Nuevo Casas Grandes, east of Highway 10	June 7, 2002	Crop fields with human dwellings	62 (60 tangent, 2 double dead-end) concrete poles	2 (2) red-tailed hawks
Ejido Hidalgo, north of Nuevo Casas Grandes, east of Highway 10	June 7, 2002 July 26, 2002	Mesquite shrubland	102 (48 tangent, 7 double dead-end) concrete poles[2]	1 (1) Chihuahuan raven (June 02) 3 (0) red-tailed hawks (July 02) 1 (0) great blue heron (July 02)
El Berrendo, near state limit with Sonora, north of Highway 2	April 28, 2002	Mesquite grassland	19 (16 tangent, 3 double dead-end) concrete poles	No remains
Hacienda Corralitos, east of Highway 10	June 6, 2002	Mesquite-yucca grassland, mesquite shrubland, and crop fields	135 (12 double dead-end) concrete poles	1 (1) Chihuahuan raven 1 (1) unidentified hawk
Rancho de Toritos, northeast of Ascensión, north of Highway 2	October 28, 2002	Creosote shrubland	22 (20 tangent, 2 double dead-end) concrete poles	No remains
Rancho Mary Paz, west of Janos along Highway 2	April 28, 2002	Mesquite shrubland	10 (8 tangent, 2 double dead-end) concrete poles	No remains

[1] The number of dead birds showing signs of electrocutions is given in parentheses. [2] Tally for the June survey; in July 2002, surveys were extended farther to the east along an offshoot of the power line surveyed a month before.

In northeastern, northern, and west-central Sonora, concrete power poles were also widespread (although generally not as numerous as wooden poles). Along Highway 2 in northeastern Sonora, the cross-arms were typically covered with yellow PVC covering. Non-retrofitted poles were still present along Highway 2 to Naco, and along power lines originating from Highway 2 and supplying electricity to rural communities in the general area of Cananea (Fig. 2, Table 3). Most concrete poles were tangent structures, but 1 power line in the area of Ejido Zaragoza, just east of Cananea, had concrete poles with lower and upper cross-arms. Stretches of power lines with concrete poles, most of them tangent units, were also observed between Imuris and Hermosillo along Mexican Highway 15, in the Hermosillo area, and between Hermosillo and Bahía Kino. A power line from Bahía Kino to the Seri Indian village of Punta Chueca had concrete poles. They consisted chiefly of tangent poles retrofitted with wooden cross-arms. A total of 23 double dead-end units were counted along this power line, and none of them had been retrofitted. An offshoot of the Bahía Kino – Punta Chueca power line was observed on private property. It had concrete tangent poles with steel cross-arms.

In Baja California Sur, most of the power poles we observed were made of wood. Our preliminary surveys, most of them along Highway 1, led to the discovery of only 608 concrete poles fitted with steel cross-arms. Stretches of power lines with concrete poles were located mainly in the northern part of the State, between Mulegé and Santa Rosalía; concrete poles were also observed between Loreto and Mulegé and

between San Ignacio and Vizcaíno (Fig. 3, Table 4). Few concrete poles were observed along power lines between La Paz and Ciudad Constitución and between La Paz and Cabo San Lucas (Fig. 3, Table 4). Most concrete poles were tangent units. Only 30 double dead-end units were counted along all surveyed power lines, and none of them had been retrofitted. Interestingly, between Villa Insurgentes and López Mateos, 15 concrete poles were fitted with platforms for ospreys (*Pandion haliaetus*) to perch and build their nests. In-depth surveys were conducted everywhere concrete power poles were found but also included a total of 295 wood poles (Table 4).

Table 3. Characteristics of areas where in-depth power-line surveys were conducted in Sonora, with associated mortality findings.

location	date of survey	surrounding vegetation	number and configuration of inspected power poles	findings[1]
Ejido Cuitaca (about 25 km west of Cananea)	October 29, 2002	Mesquite shrubland	11 (11 tangent) concrete poles (interspersed with wooden poles)	2 (2) turkey vultures
Ejido Zaragoza (about 15 km east of Cananea)	October 29, 2002	Mesquite grassland	94 (88 tangent) concrete poles	5 (3) ravens 2 (1) Chihuahuan ravens
Pueblo Naco, along Highway 2 (about 5 km west of Agua Prieta)	October 29, 2002	Mesquite grassland	20 (19 tangent) concrete poles	1 (0) raven
Road from Bahía Kino to Punta Chueca	March 18, 2004	Sonoran Desert (Central Gulf Coast subdivision)	23 (23 double dead-end) concrete poles (interspersed with retrofitted tangent poles)	2 (0) red-tailed hawks 3 (0) unidentified birds

[1] The number of dead birds showing signs of electrocutions is given in parentheses

Table 4. Characteristics of areas where in-depth power line surveys were conducted in Baja California Sur, with associated mortality findings. Vegetation characterization follows Wiggins (1980) and (INEGI 1981).

survey area	date of survey	surrounding vegetation	number and type of poles	findings[1]
Road from La Paz to Cd. Constitución	April 11, 2003 May 9, 2003	Sonoran desertscrub, sarcocaulescent vegetation association	35 (2 double dead-end, 33 tangent) concrete poles	1 (1) common raven
	April 11, 2003 May 9, 2003	Sonoran desertscrub, sarcocaulescent vegetation association	35 (33 tangent, 1 double dead-end) wooden poles	No remains
Cd. Constitución	April 11, 2003 May 9, 2003	Urbanized area, with nearby fields	10 (2 tangent , 3 double dead-end) concrete poles	No remains
	April 11, 2003 May 9, 2003	Cultivated area	10 (7 tangent, 3 double dead-end) wooden poles	No remains
Road to Puerto San Carlos	April 11, 2003 May 9, 2003	Sonoran desertscrub, sarcocaulescent vegetation association	10 (10 tangent) concrete poles	No remains
	April 11, 2003 May 9, 2003	Sonoran desertscrub, sarcocaulescent vegetation association, containing a large area of creeping devil cactus (low-tall vegetation)	46 (46 tangent) wooden poles	No remains
Deviation road to Ejido 419	May 9, 2003	Sonoran desertscrub, sarcocaulescent vegetation association and cultivated area	155 (149 tangent, 6 double dead-end) wooden poles	No remains

Table 4. *Continued.*

survey area	date of survey	surrounding vegetation	number and type of poles	finding s[1]
Road to López Mateos	April 11, 2003 May 9, 2003	Cultivated area and Sonoran desertscrub, sarcocaulescent vegetation association	147, (132 tangent, 15 with platforms) concrete poles	No remains
	April 11, 2003 May 9, 2003	Sonoran desertscrub, sarcocaulescent vegetation association and cultivated area	49 (42 tangent, 6 double dead-end) wooden poles	No remains
Road from Vizcaíno to San Ignacio	May 24, 2003	Sonoran desertscrub, sarcocaulescent vegetation association, non-thorny scrub, with small cultivated areas	63 (63 tangent) concrete poles	No remains
Road from Mulegé to Loreto	May 26, 2003	Sonoran desertscrub, sarcocaulescent vegetation association	83 concrete poles	No remains
Road from Santa Rosalía to Mulegé	May 26, 2003	Sonoran desertscrub, sarcocaulescent vegetation association	260 (260 tangent) concrete poles	No remains

Search for electrocuted raptors

In the JCG area, we found a total of 39 dead birds (14 raptors) during 5 rounds of surveys from February 2002 through March 2004 (Table 1). No remains were found in February 2002. In April 2002, however, we found a total of 13 dead birds under concrete poles of the area. Eleven of the 13 dead birds were Chihuahuan ravens (*Corvus cryptoleucus*); the other 2 birds were a red-tailed hawk (*Buteo jamaicensis*) and a

turkey vulture (*Cathartes aura*). Ten of the 11 ravens and the turkey vulture had singed feathers. Seven of the ravens and the turkey vulture were found under 8 double dead-end units. No dead bird was found at any of the retrofitted concrete poles we surveyed.

In June 2002, our surveys yielded a total of 7 dead birds, 2 red-tailed hawks and 5 Chihuahuan ravens (Table 1). One of the 2 red-tailed hawks and 4 of the 5 Chihuahuan ravens had singed feathers. Two of the dead birds (1 red-tailed hawk and 1 Chihuahuan raven) were found under double dead-end units.

In November 2002, dead birds consisted of 1 immature golden eagle (*Aquila chrysaetos*), 2 unidentified eagles, 1 ferruginous hawk (*Buteo regalis*), 2 red-tailed hawks, 2 turkey vultures, and 6 Chihuahuan ravens (Table 1). The 2 unidentified eagles, 1 of the 2 turkey vultures, 1 red-tailed hawk, and all 6 ravens had singed feathers. In addition to the dead birds, an injured red-tailed hawk was observed along one of the power lines we surveyed.

In March 2004 an American kestrel (*Falco sparverius*) with singed feathers was found under 1 of 64 concrete poles along 1 power line with tangent units and double poles (Table 1). Along a second power line, a total of 4 dead birds were discovered, 1 red-tailed hawk, 2 Chihuahuan ravens, and 1 raven that could not be identified to species. Both Chihuahuan ravens and the red-tailed hawk had singed feathers. The 3 ravens were found under the same pole, a double dead-end unit.

Outside of the JCG prairie dog complex area, our in-depth surveys were

restricted to an area east of Highway 10 between Nuevo Casas Grandes and Janos, and to a few power lines branching off the main line along Highway 2 (Table 2). We found a total of 9 dead birds, all of them east of Highway 10: 5 red-tailed hawks, 1 unidentified hawk, 2 Chihuahuan ravens, and 1 great blue heron. No dead bird was discovered during in-depth surveys along Highway 2. However, cursory surveys along that same road led to the discovery in February 2002 of 1 great horned owl (*Bubo virginianus*, under a wooden pole fitted with a steel cross-arm) and 1 unidentified raven (under a double dead-end concrete pole).

The 9 dead birds east of Highway 10 were found during surveys conducted in June and July 2002. In June, we discovered 2 red-tailed hawks (both with singed feathers) under the same concrete tangent structure in the area of Colonia Hidalgo. In the vicinity of Ejido Hidalgo, 1 Chihuahuan raven with singed feathers was found at a tangent structure. Finally, at Hacienda Corralitos, an unidentified hawk and a Chihuahuan raven both had singed feathers. The raven was found under a double dead-end pole (this type of configuration was represented in all 3 of the areas surveyed east of Highway 10). In July the same areas were revisited, leading to the discovery of 3 red-tailed hawks and a great blue heron, none of them with visible signs of electrocution.

In northeastern Sonora in October 2002, we found a total of 10 dead birds along 3 power lines surveyed on foot. The remains of 2 turkey vultures, both of them with singed feathers, were discovered under 1 of 11 concrete poles (a tangent

structure) near Ejido Cuitaca, west of Cananea. About 15 km east of Cananea, an inspection of 94 concrete poles near Ejido Zaragoza yielded a total of 7 ravens, 4 of which had singed feathers. Of these 7 ravens, 2 were identified as Chihuahuan ravens. The others were too incomplete or old to identify to species. Along Highway 2 to Naco, 1 set of old raven remains was discovered under 1 of 20 concrete poles we inspected. None of the poles along the 3 power lines were double dead-end units, and the 10 dead birds were found under poles with a variety of configurations.

In west-central Sonora, a total of 5 sets of bird remains were found under 5 of the 23 double dead-end poles along the power line to Punta Chueca. Among the remains were those of 2 red-tailed hawks. The other 3 sets of remains could not be identified, although 1 appeared to belong to a raptor species. None of the remains showed any signs of electrocution, but all except 1 of the 2 red-tailed hawks were old.

In Baja California Sur, we found the remains of only 1 common raven (*Corvus corax*) beneath a tangent concrete pole. No other dead bird was discovered during our surveys. The raven seemed to have died several months prior to the survey. It presented singed feathers.

DISCUSSION

While we were conducting this study, other people observed additional dead birds under concrete poles in the JCG area. Reports of dead birds included those of 2 golden eagles in February and March 2002 (J. Harris, pers. comm.), as well as 2 more

golden eagles, 3 ferruginous hawks, and 1 turkey vulture in January 2003 (J. Watson, pers. comm.). Together with the results of this and earlier studies (Cartron *et al.* 2000, 2005), those additional findings by others bring the total of dead birds discovered since January 1999 under concrete poles to 292 (112 raptors, 178 ravens, and 2 great blue herons) in the JCG area. Elsewhere in Chihuahua (along Highway 23 and along Highway 2, as well as east of Highway 10), 22 (13 raptors, 8 ravens, and 1 great blue heron) dead birds have now been found under concrete poles. For all of northwestern Chihuahua, a total of 316 dead birds have been documented to date. To this total could be added a raven discovered in 2001 under a double wooden pole (Cartron *et al.* 2005) and the great horned owl discovered (in this study) under a wooden pole fitted with a steel cross-arm (along Highway 2).

In this study, no dead bird was found in central or eastern Chihuahua. In some of the areas we explored, either there were no distribution lines or all poles were wooden. However, the presence of perch guards on poles along Highway 10 and new wooden cross-arms in the vicinity of Cd. Chihuahua suggest that in those areas, bird electrocutions were sufficiently frequent as to warrant the cost of retrofitting poles. Together with findings of dead birds through much of northwestern Chihuahua, evidence of retrofitting in other parts of the state thus suggests a widespread problem of bird electrocutions until the recent past. Based on this and earlier studies, it is likely that most electrocutions statewide were associated with 2 species, the red-tailed hawk and the Chihuahuan raven. To date, golden eagle,

bald eagle (*Haliaeetus leucocephalus*), and ferruginous hawk mortality has been recorded only in the JCG prairie dog town area. As these 3 species are federally listed in México, the U.S., or both, this last pattern emphasizes the need to focus retrofitting efforts on the JCG area in particular. During this study, a long stretch of the power line crossing the largest prairie dog town in the complex was retrofitted using wooden cross-arms (retrofitting occurred after our last survey of that power line). However, many power lines with concrete poles have not yet been retrofitted. That is the case in particular with 1 small power line near San Pedro. Over a 6-month period, 1 dead bird was discovered per every 2 poles, on average (see Cartron *et al.* 2005).

Our study is the first to document raptor and/or raven electrocutions in Sonora and Baja California Sur. None of the birds discovered in west-central Sonora showed signs of electrocution. However, most of the remains were old, and because they were found under double dead-end poles with double cross-arms, electrocution is a likely cause of the observed mortality. In northeastern Sonora, 2 of us (JLEC and RR) interviewed several CFE engineers and technicians, who confirmed a past history of bird electrocutions along Highway 2. According to these CFE employees, the incidence of bird electrocutions has decreased drastically since PVC has been used around steel cross-arms. Near Agua Prieta, use of PVC along Highway 2 began in 1999 or 2000, while in the Cananea area it dated back to the year of our survey (2002). As in Chihuahua, the wide distribution of concrete poles, evidence of retrofitting in several of the areas that we visited, and findings of dead birds all

suggest an important problem of bird electrocutions on concrete poles through much of Sonora. Only in Baja California Sur did our surveys suggest that, although bird electrocutions occur on concrete poles, their incidence is likely fairly low. This may be simply because the number of concrete power poles in Baja California Sur is low. It may also be due to the high density of cardon cacti in the surrounding vegetation in many areas. Because these cacti stand approximately 8 m tall, power poles are not the only vantage points available to raptors and ravens, in contrast to survey areas in northeastern Sonora and in Chihuahua. In Baja California, conservation strategies should include maintaining a high number of cardons around concrete poles in order to avoid electrocutions.

Our methodology did not allow us to compare the incidence of bird electrocutions as a function of pole configuration. However, Cartron *et al.* (2005) established that the incidence of bird electrocutions was disproportionately high at double dead-end poles. As shown by our study, these poles are widely distributed, and thus they should be a priority of all remaining retrofitting efforts. Additional power-line surveys are needed to evaluate the impact of concrete poles in areas that have not yet been checked, and to monitor the success of retrofitting. International funding to help retrofit all power lines in the JNC area would also be beneficial. Retrofitting in the area is occurring, but at a slow pace. Meanwhile, conservation sensitive species such as the ferruginous hawk and the golden eagle continue to experience important mortality at least locally.

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Appendix 1. List of raptor species in Baja California Sur (Migratory status: Res=Resident; Mig=Migratory). All species were recorded perching on cardon cacti except ferruginous hawk.

species	english common name	mexican common name	status
Cathartes aura[1]	turkey vulture	zopilote aura	Res/ Mig
Pandion haliaetus[1]	osprey	águila pescadora	Res/Mig
Elanus leucurus	white-tailed kite	milano cola blanca	Res
Haliaeetus leucocephalus	bald eagle	águila cabeza blanca	Res
Circus cyaneus	northern Harrier	gavilán rastrero	Mig
Accipiter striatus	sharp-shinned hawk	gavilán pecho rufo	Mig
Accipiter cooperii	Cooper's hawk	gavilán de Cooper	Mig
Parabuteo unicinctus[1]	Harris's hawk	aguililla rojinegra	Res
Buteo lineatus[1]	red-shouldered hawk	aguililla pecho rojo	Mig
Buteo swainsoni	Swainson's hawk	aguililla de Swainson	Mig
Buteo albonotatus	zone-tailed hawk	aguililla aura	Res/Mig
Buteo jamaicensis[1]	red-tailed hawk	aguililla cola roja	Res/Mig
Buteo regalis	ferruginous hawk	aguililla real	Mig
Aquila chrysaetos[1]	golden eagle	águila real	Res
Caracara cheriway[1]	crested caracara	Caracara, quebrantahuesos	Res
Falco sparverius[1]	American kestrel	cernícalo Americano	Res/Mig
Falco columbarius	merlin	halcón esmerejón	Mig
Falco peregrinus[1]	peregrine falcon	halcón peregrino	Res/Mig
Falco mexicanus	prairie falcon	halcón mexicano	Res/Mig

[1] Recorded perching on poles.