

# THE JOURNAL OF RAPTOR RESEARCH

A QUARTERLY PUBLICATION OF THE RAPTOR RESEARCH FOUNDATION, INC.

VOL. 38

JUNE 2004

No. 2

*J. Raptor Res.* 38(2):107–117

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## APLOMADO FALCON ABUNDANCE AND DISTRIBUTION IN THE NORTHERN CHIHUAHUAN DESERT OF MEXICO

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**ABSTRACT.**—The northern Aplomado Falcon (*Falco femoralis septentrionalis*) historically occupied coastal prairies, savannas, and desert grasslands from southern Mexico north to southern and southwestern Texas, southern New Mexico, and southeastern Arizona. Current resident Aplomado Falcon populations are primarily in Mexico, with isolated populations in southern Texas and from northern Chihuahua to southern New Mexico. We conducted surveys in semidesert grasslands/savannas and associated habitats in northern Chihuahua to locate Aplomado Falcons and to better delineate their distribution and abundance in the northern Chihuahuan Desert during 1998–99. Data were collected by surveying large tracts, transects in nonrandomly selected grasslands, and from a falcon monitoring study. Based on all survey effort, the minimum known population of adult Aplomado Falcons in the study area in northern Chihuahua was 79 individuals. Aplomado Falcons were primarily associated with grassland communities. Most falcon nests (88%) were found in grassland communities with soaptree yucca (*Yucca elata*) or Torrey yucca (*Y. torreyi*). Aplomado Falcons were found fairly clustered in the north-central to north-eastern part of the study area. We found falcons nesting ca. 50 km west of the Texas border (ca. 120 km south of El Paso) in northern Chihuahua. Because Aplomado Falcons are associated with grassland communities, continued degradation of Chihuahuan Desert semidesert grasslands will continue to influence their distribution.

**KEY WORDS:** *Aplomado Falcon; Falco femoralis; Chihuahuan Desert; Chihuahua, Mexico; distribution.*

## ABUNDANCIA Y DISTRIBUCION DEL HALCÓN PERDICERO EN EL DESIERTO NORTEÑO DE CHIHUAHUA EN MEXICO

**RESUMEN.**—El Halcón perdicero del norte (*Falco femoralis septentrionalis*) históricamente ha ocupado praderas costeras, sabanas, y pastizales desérticos desde México meridional al norte, hasta el sur y sur occidente de Texas, el sur de Nuevo México y el sur oriente de Arizona. Las poblaciones residentes actuales del halcón perdicero se encuentran principalmente en México, con poblaciones aisladas en el

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sur de Texas y desde el Chihuahua del norte hasta el sur de Nuevo México. Conducimos estudios en pastizales/sabanas semidesérticas y hábitats asociados en el Chihuahua del norte para localizar Halcones perdiceros y para hacer un mejor bosquejo de su distribución y abundancia en el Desierto Norteño de Chihuahua durante 1998–99. Los datos fueron colectados estudiando distancias largas por medio de transeptos en pastizales seleccionados (no al azar) y a partir de un estudio de monitoreo de halcones. Con base en todo el esfuerzo de estudio, la población mínima conocida de halcones perdiceros adultos en el área de estudio en el norte de Chihuahua fue de 79 individuos. Los halcones perdiceros estuvieron asociados principalmente con comunidades de pastizales. La mayoría de los nidos de halcón (88%) fueron encontrados en comunidades de pastizales con árboles de yucca (*Yucca elata*) o yucca Torrey (*Y. torreyi*). Los halcones perdiceros se encontraron ligeramente concentrados en la parte norcentral a nororiental de la zona de estudio. Encontramos halcones anidando aproximadamente 50 km al occidente de la frontera de Texas (ca. 120 km al sur de El Paso) en el Chihuahua del norte. Debido a que los halcones perdiceros están asociados con comunidades de pastizales, la continua degradación de los pastizales semidesérticos del Desierto de Chihuahua continuará influenciando su distribución.

[Traducción de César Márquez]

The northern Aplomado Falcon (*Falco femoralis septentrionalis*) occupied coastal prairies, savannas, and desert grasslands historically from southern Mexico north to southern and southwestern Texas, southern New Mexico, and southeastern Arizona (Oberholser 1974, American Ornithologists' Union 1998, Keddy-Hector 2000). In Mexico, Aplomado Falcons historically occurred along the east coast from Tamaulipas to Yucatán, and along the west coast in lowlands from Sinaloa and Nayarit to Oaxaca (Lawrence 1874, Cade et al. 1991, Keddy-Hector 2000; Fig. 1). The U.S. Fish and Wildlife Service (1990) and Howell and Webb (1995) suggested that Aplomado Falcons occurred throughout the northern Mexican Plateau. However, the lack of documented occurrences leaves the falcon's historical distribution in the Chihuahuan Desert and elsewhere in interior northern Mexico unclear. Aplomado Falcon reports in Durango are limited to one falcon sighted in 1950 at high elevation in a pine forest west of Durango City (Webster and Orr 1952). There were no documented reports of Aplomado Falcons in Sonora pre-1966 (Van Rossem 1945, Russell and Monson 1998). Alden (1969) and Gallucci (1981) reported falcon sightings in Sonora in 1966 and 1979; however, Russell and Monson (1998) claimed these sightings were unsubstantiated. In Chihuahua, historical Aplomado Falcon reports were sparse. Bailey (1928) mentions a falcon was taken in 1892 at the playas of Palomas, Chihuahua, near the New Mexico border. Further, a nest was located in Chihuahua, Mexico, southwest of Antelope Wells, New Mexico by Arnold Bayne in 1952 (Truett 2002).

There was better documentation of early falcon reports in the United States' (U.S.) portion of the Chihuahuan Desert (Williams 1997, Truett 2002,

R. Meyer, C. Perez, and S. Williams III unpubl. data). Early reports in the northern Chihuahuan Desert indicated Aplomado Falcons were found in open plains with sparse woody vegetation (e.g., Bendire 1892, Visher 1910, Bailey 1928, Ligon 1961). Specimen records and documented sightings indicated that falcons were common throughout their range in the U.S. until ca. 1930 (Bent 1938, Hector 1987). Arnold Bayne located the last known historical falcon nest in southern New Mexico in 1952 (Ligon 1961). The last known historical falcon nest in southeastern Arizona was pre-1940s (Phillips et al. 1964, Monson and Phillips 1981).

There were occasional Aplomado Falcon sightings in the Chihuahuan Desert in the 1960s, 1970s, and 1980s; however, these sightings were usually discounted because the species was believed to be extirpated from the Chihuahuan Desert. Williams and Hubbard (1991) considered the origin of an Aplomado Falcon photographed in southern New Mexico in 1991 a mystery, citing falcons in the savannas of Veracruz as the closest known population. The resident population in northern Chihuahua was not discovered until 1992.

Current resident northern Aplomado Falcon populations are primarily in Mexico (Fig. 1). Extant populations exist along the Gulf of Mexico to the Yucatán Peninsula (Howell and Webb 1995, Keddy-Hector 2000). Also, an Aplomado Falcon population exists in the northern Chihuahuan Desert from north-central Chihuahua to southern New Mexico (Montoya et al. 1997, Truett 2002, Williams 2002, Young et al. 2002, R. Meyer, C. Perez, and S. Williams III unpubl. data). Since the 1990s, there have been occasional sightings of Aplomado Falcons in northern Chihuahua, Mexico near the New Mexico border, and near Lagunas

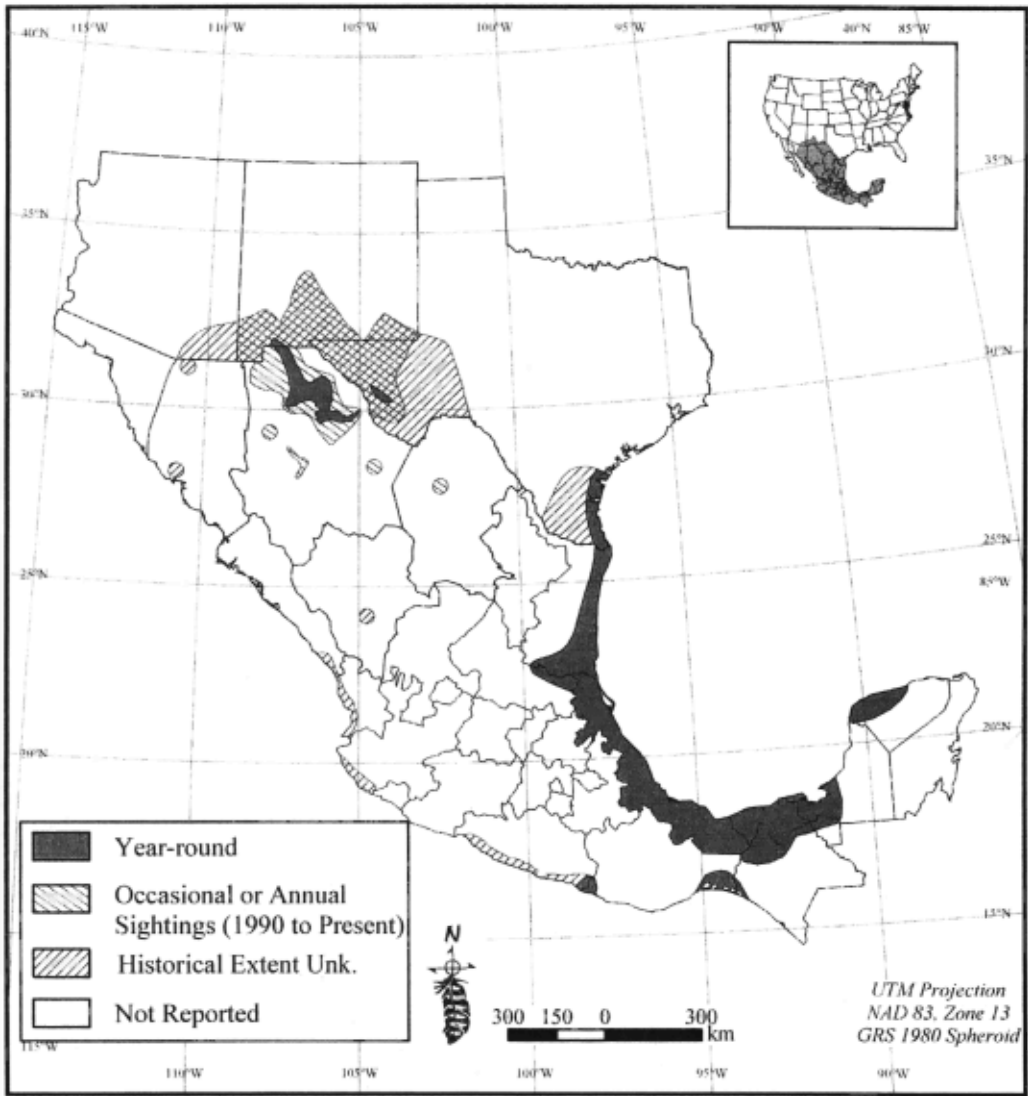


Figure 1. Distribution of northern Aplomado Falcons in the United States and Mexico. Map redrawn from information provided by Lawrence (1874), Webster and Orr (1952), Phillips et al. (1964), Alden (1969), Oberholster (1974), Gallucci (1981), Monson and Phillips (1981), Cade et al. (1991), Howell and Webb (1995), Montoya et al. (1997), Williams (1997), Russell and Monson (1998), Peterson and Zimmer (1998), U.S. Fish and Wildlife Service (1990), Keddy-Hector (2000), Williams (2002), Truett (2002), Meyer (unpubl. data), E. Iñigo-Elias (pers. comm.), and data collected during this study.

Babicora, Mexicanos, and Bustillos, and La Perla (Benítez et al. 1999, Lafon Terrazas unpubl. data). Further, an Aplomado Falcon was sighted in Coahuila in the late 1990s (E. Iñigo-Elias pers. comm.).

In the U.S., there are annual falcon sightings in southern New Mexico and occasional sightings in western Texas (Fig. 1) (Williams 1993, 1994, 1996,

1997, 2000, Peterson and Zimmer 1998, Truett 2002, R. Meyer, C. Perez, and S. Williams III unpubl. data). The first successful nest recorded in New Mexico since 1952 fledged three young in 2002 (Williams 2002, R. Meyer, C. Perez, and S. Williams III unpubl. data). Along the southern Texas coast, a population of Aplomado Falcons was

initiated from reintroduction efforts (Cade et al. 1991). In addition, Aplomado Falcons were released in western Texas in 2002.

The Aplomado Falcon was first considered a candidate for endangered status in 1973 (U.S. Department of the Interior 1973) and was listed as endangered in March 1986 (U.S. Fish and Wildlife Service 1986). At the time of listing, critical habitat was not designated because there were no known nests in the U.S. for at least 25 yr (U.S. Fish and Wildlife Service 1986). The Aplomado Falcon was added to the endangered list due to its loss as a breeding bird in the U.S. and continued threats within its range. Factors that attributed to the falcon's decline were primarily habitat degradation due to woody plant encroachment, and secondarily, egg and specimen collecting, and continued pesticide contamination (DDT) within the range of the falcon (Kiff et al. 1980, U.S. Fish and Wildlife Service 1986, Cade et al. 1991).

The Mexican government listed the northern Aplomado Falcon as endangered in Mexico in May 1994 (DOF-Semarnat 1994, Ceballos and Márquez Valdelamar 2000). However, because information about population-level status of each species was lacking, governmental agencies, scientific institutions, and societies collaborated to review information and produce a new threatened and endangered species list for Mexico. This list was published in March 2002, and the status of the northern Aplomado Falcon was changed from "endangered" to "subject to special protection" (DOF-Semarnat 2002). Subject to special protection status is given to a species or population which could become threatened from factors that negatively affect their viability; thus, there exists a need to promote their recovery and conservation (DOF-Semarnat 2002).

Increases in reliable falcon sightings in the Chihuahuan Desert in the early 1990s prompted additional interest in recovery of the species in New Mexico (Williams 1997, R. Meyer, C. Perez, and S. Williams III unpubl. data). We conducted raptor surveys in semidesert grasslands/savannas and associated habitats in northern Chihuahua, Mexico to locate Aplomado Falcons and to better delineate their distribution and abundance in the northern Chihuahuan Desert. We surveyed a variety of dominant vegetation communities to identify habitat associations. We recorded presence of raptors and ravens (*Corvus* spp.) to investigate the association of Aplomado Falcons with presence of primary nest builders (U.S. Fish and Wildlife Service 1990).

#### STUDY AREA AND METHODS

Our study area (100 735 km<sup>2</sup>) consisted of a 160-km belt south of the U.S./Mexico border in Chihuahua, Mexico (Fig. 2). Municipalities in the study area included Ahumada, Aldama, Ascensión, Buenaventura, Camargo, Casas Grandes, Chihuahua, Coyame, Delicias, Galeana, Guadalupe, Janos, Juárez, Julimes, Manuel Benavides, Nuevo Casas Grandes, Ojinaga, Praxedis G. Guerrero, and Zaragoza. Land ownership included private and communal (ejido) land. Annual precipitation is 200–300 mm, the majority (≥80%) of which occurs during July–September (COTECOCA 1978). Topography is characterized by disjunct north-southeast-oriented mountain ranges with maximum elevations of ca. 2200 m. Plains, lowlands, and basins are prevalent throughout the study region and are ca. 1200 m above sea level.

Semidesert-basin-grassland communities consist primarily of alkali sacaton (*Sporobolus airoides*) and tobosa (*Pleuraphis mutica*) (COTECOCA 1978, Brown 1994, Young et al. 2002). Lowlands predominantly contain tobosa with honey mesquite (*Prosopis glandulosa*) and soap-tree yucca (*Yucca elata*). Plains are comprised of blue grama (*Bouteloua gracilis*), black grama (*B. eriopoda*), fluff grass (*Dasycholea pulchella*), burrograss (*Scleropogon brevifolius*), alkali sacaton, and sand dropseed (*Sporobolus cryptandrus*) (COTECOCA 1978, Young et al. 2002). Common woody plants in plains consist of honey mesquite, creosote bush (*Larrea tridentata*), acacia (*Acacia* spp.), soap-tree yucca, mariola (*Parthenium incanum*), and tarbush (*Flourensia cernua*). Sloped areas support sideoats grama (*B. curtipendula*), fluff grass, burrograss, creosote bush, lechuguilla (*Agave lechuguilla*), and sotol (*Dasyliirion wheeleri*) (COTECOCA 1978, Brown 1994, Young et al. 2002).

**Falcon Surveys.** Aplomado Falcon distribution and abundance were described from surveys conducted in large sample tracts and in linear transects in northern Chihuahua during 1998–99. We also included distribution and abundance information from a separate study designed to monitor falcon habitat and productivity in northern Chihuahua (Macias Duarte 2002).

Frequency of occurrence (percent of tracts in which a species occurred) analyses were restricted to raptors and ravens observed during tract surveys. We define a falcon *nest site* as a location where Aplomado Falcons nested, either successfully or unsuccessfully. We refer to a falcon *detection site* as a location where a nest was not found, but either a single or pair of falcons were found one or more times. Reproductive activity was not always determined for detection sites. We use the term *site* to refer to a spatially and temporally independent falcon location (includes both nest and detection sites). As such, falcons located during both years of the study in the same or proximate area were only counted once.

**Tract surveys.** Survey tracts in northern Chihuahua were selected in two ways: (1) a stratified random sample indicated on the amount of dominant vegetation derived from a 1:250 000 printed vegetation map (INEGI 1982), and (2) a simple random sample of prospective areas identified during an aerial flight of the study area. For samples derived from the vegetation map, ca. amounts of dominant vegetation were estimated by tracing polygon boundaries with a planimeter. A 9 × 9 km grid was placed on the vegetation map, and 60 grids (representing

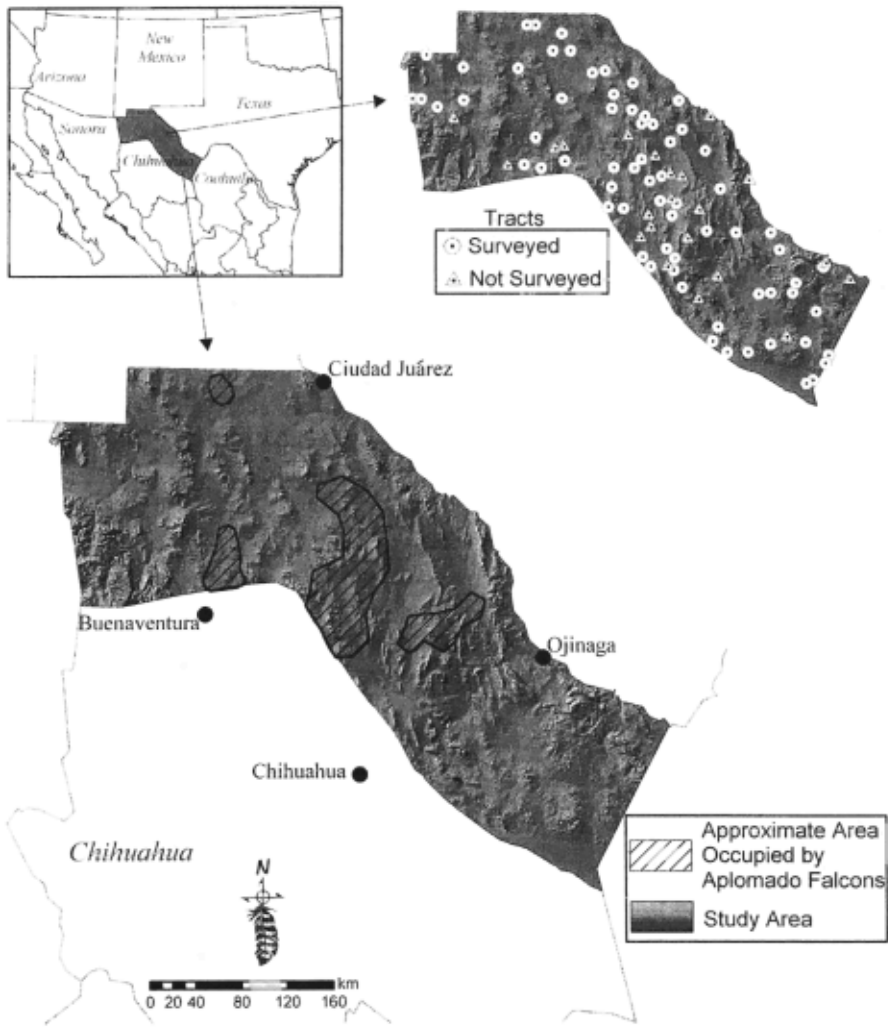


Figure 2. Distribution of tracts surveyed for Aplomado Falcons (upper right corner) and approximate areas occupied by Aplomado Falcons in northern Chihuahua during 1998–99.

survey tracts) were randomly selected in proportion to the percent of vegetation calculated (Table 1). We also flew the entire study area in December 1998 to locate prospective survey areas that represented vegetation communities known to be used by Aplomado Falcons. Prospective areas for sampling were recorded with a Global Positioning System (GPS) receiver for subsequent falcon surveys. We randomly selected 30 of the 58 prospective grassland areas observed for tract placement. After a survey area was located in the field, observers established the largest tract size possible to conduct Aplomado Falcon surveys.

Each tract received a complete, systematic survey by placing point stations at 0.3–1.0 km intervals along roads, depending on vegetation and topography. Observers spent 3–5 min at each point station where they recorded

all raptors and ravens detected using 8× binoculars and a 20× spotting scope. In areas with limited road access, observers walked and established point stations to ensure complete coverage of the tract. Between point stations on roads, observers drove <6 km/hr and recorded all individual raptors observed. Likelihood of double counting individual raptors was minimized by observers recording raptor and raven flight direction and movements during the survey.

Actual surveyed area in tracts was estimated by buffering survey point stations 600-m (ca. maximum observable distance from most point stations) in ArcView 3.2 (Environmental Systems Research Institute, Inc. 2000). As such, tract size and configuration depended on juxtaposition and number of survey stations established.

*Transect surveys.* Transect surveys were road surveys

Table 1 Dominant vegetation zones derived from a 1:250 000 vegetation map and number of survey tracts randomly placed in each vegetation zone in the northern Chihuahua study area in Mexico.

SPANISH NAME <sup>a</sup>	ENGLISH NAME	AREA ESTIMATED (km <sup>2</sup> ) <sup>b</sup>	PERCENT OF LAND AREA	NO. OF TRACTS
Pastizal natural	Natural grassland	20 141	20	12
Pastizal holófilo	Grasslands in saline or alkaline conditions	5836	6	4
Matorral rosetófilo	Shrubs—mesquite, cactus, agave, and yucca	10 151	10	6
Matorral desértico micrófilo	Small leaf shrubs primarily in alluvial zones	53 943	52	31
Desierto arenoso	Sand dunes	6042	6	4
Vegetación halófilo	Vegetation in closed basins with high salt content	5772	6	3
Chaparral	Forested area—dense fire resistant trees and shrubs such as oaks and manzanita	805	<1	0
Total		102 690		60 <sup>c</sup>

<sup>a</sup> Derived from a printed vegetation map of Chihuahua, Mexico (INEGI 1982).

<sup>b</sup> Area estimated with a planimeter.

<sup>c</sup> Eleven of these tracts were not examined during field data collection.

(not area based) conducted in nonrandomly selected grasslands and around unconfirmed Aplomado Falcon sightings in northern Chihuahua. Survey methods were similar to tract surveys in that point stations were established at 0.3–1.0 km intervals along roads. However, transect surveys were not designed to survey a given area completely, but provide additional information about selected areas thought to be used by Aplomado Falcons.

**Monitoring study.** The Aplomado Falcon monitoring study was initiated in 1996 in two areas in northern Chihuahua: one approximately 160 km north of Chihuahua City and the other approximately 160 km northeast of Chihuahua City (Montoya et al. 1997). Falcon territories within the monitoring study area were surveyed for occupancy in 1998 and 1999. A territory was considered occupied when a pair of falcons were observed at or near a nesting structure, and there was no reason to believe the pair was from another territory (Macias Duarte 2002). Each occupied and previously-occupied territory was visited at least twice/mo. In some cases, territories noted as unoccupied may have contained undetected pairs or single birds. Nonnesting pairs were recorded, but not monitored.

Falcon surveys for the monitoring study were conducted from vehicles on roads in areas considered to be potential habitat. Observers stopped ca. every 1.0 km and scanned the terrain for falcons using 10× binoculars and a 15× spotting scope. Surveys were initiated prior to incubation and continued until fledging or failure was confirmed.

**Dominant Vegetation Community.** Dominant vegetation community was estimated at two different scales. For falcon sites located by the monitoring study and transect surveys, dominant vegetation type was estimated ocularly for an area ca. 500-m around the site center. Conversely, for falcons located during tract surveys, dominant vegetation type was estimated ocularly during falcon surveys and summarized over the entire tract. Surveyors classified dominant vegetation community among three shrub-dominated and four grass-dominated vegetation communities: creosote bush-tarbrush, mesquite-acacia, creosote bush-tarbrush/mesquite-acacia, grass/creosote bush-tarbrush, grass/mesquite-acacia, grass/yucca, or grassland (Buffington and Herbel 1965, Johnson 1977, Rzedowski 1990, Dinerstein et al. 2001). These communities graded from structurally simple types to structurally diverse types varying in density, canopy, and interspersion. This classification was used as a post-stratification description of the tracts and falcon sites.

## RESULTS

**Survey Effort Among Vegetation Communities.** We surveyed 68 tracts (2005 km<sup>2</sup>) in 1998 and 1999 (Table 2, Fig. 2). Ten tracts were surveyed in both 1998 and 1999, yielding a total of 78 different surveys. Tracts surveyed in both years had either an Aplomado Falcon detection in 1998, or potential Aplomado Falcon habitat. We were unable to survey 22 tracts (11 tracts from the vegetation map sample and 11 prospective areas identified during

Table 2. Total number of tracts and associated area (km<sup>2</sup>) of dominant vegetation communities surveyed for raptors in northern Chihuahua, Mexico during 1998–99.

DOMINANT VEGETATION COMMUNITY	1998			1999			OVERALL <sup>a</sup>		
	NO. OF TRACTS	AREA (km <sup>2</sup> )	% AREA	NO. OF TRACTS	AREA (km <sup>2</sup> )	% AREA	NO. OF TRACTS	AREA (km <sup>2</sup> )	% AREA
Grassland	2	47	4	6	230	19	7	200	10
Grassland with soaptree/Torrey yucca	2	43	4	4	170	14	5	144	7
Grassland with creosote bush/tarbush	2	38	3	3	112	9	4	130	6
Grassland with acacia/honey mesquite	5	90	7	11	421	36	13	396	20
Desert shrubland with acacia/honey mesquite and creosote bush/tarbush	16	492	40	2	60	5	17	536	27
Desert shrubland with acacia/honey mesquite	9	220	18	1	29	2	9	220	11
Desert shrubland with creosote bush/tarbush	11	312	25	4	160	14	13	379	19
Total	47	1242		31 <sup>b</sup>	1182		68	2005	

<sup>a</sup> Total independent tracts surveyed in 1998–99; 10 tracts were surveyed in both yr.

<sup>b</sup> Includes 10 tracts surveyed in 1998.

the flight of the study area) due to restricted land access or time constraints (Fig. 2).

During May–October 1998, four field crews spent 308 hr surveying 47 tracts. Tract area averaged  $26.4 \pm 1.1$  km<sup>2</sup>, but ranged from 7.0–41.8 km<sup>2</sup>. In 1998, we surveyed 1242 km<sup>2</sup> in the tracts and a total of ca. 1300 km<sup>2</sup> including transect surveys.

During February–October 1999, five field crews surveyed 31 tracts representing 438 hr of survey time. Tract area averaged  $38.1 \pm 2.9$  km<sup>2</sup>, but ranged from 16.4–77.7 km<sup>2</sup>. In 1999, we surveyed 1182 km<sup>2</sup> in the tracts and a total of ca. 1467 km<sup>2</sup> including transect surveys. Larger tracts were not feasible to establish and survey because of vegetation heterogeneity, restricted land access, and time constraints.

Tracts surveyed in 1998 were primarily shrub-dominated communities (84%), comprised of creosote bush-tarbush, mesquite-acacia, or creosote-tarbush/mesquite-acacia. Conversely, in 1999, tracts surveyed were primarily in grassland communities (75%), represented by grasslands with or without complexes of mesquite-acacia, creosote bush-tarbush, or yucca (Table 2).

**Aplomado Falcon Abundance and Distribution.**

Aplomado Falcons were detected in 17 (25%) of the 68 tracts surveyed. Tract surveys yielded four nests and 14 detection sites, representing 11 falcon pairs and seven singles, for a total of 29 birds. No additional falcons were found in tracts surveyed in both years. An additional three pairs (one nest and two detection sites) were located during transect surveys. The monitoring study located 13 falcon nests and nine detection sites representing 22 pairs. Based on combined survey effort, the minimum known population of adult Aplomado Falcons identified in the study area during the survey period was 79 individuals (43 independent sites; 18 nest and 25 detection sites). However, given that detection rates for Aplomado Falcons was low (e.g., >40 survey hr per site was needed for each detection), additional falcons probably would be located with additional surveys.

Aplomado Falcons were associated with most vegetation types, but they were detected most often in grass-dominated communities (Table 3). Specifically, 16 (88%) Aplomado Falcon nests and 10 (40%) detection sites were found in grassland communities with soaptree yucca or Torrey yucca (*Y. torreyi*). Of the 79 individuals found in northern Chihuahua, only three single birds were located in

Table 3. Minimum numbers of Aplomado Falcon sites and individuals identified in each dominant vegetation community in northern Chihuahua, Mexico in 1998-99.

DOMINANT VEGETATION COMMUNITY	No. OF SITES			No. OF			MINIMUM No. OF	
	NESTS	DETECTION	PAIRS	SINGLES	INDEPENDENT		INDIVIDUALS	
					SITES	SITES		
Grassland	1	3	3	1	4	4	7	
Grassland with soaptree/Torrey yucca	16	10	26	—	26	26	52	
Grassland with creosote bush/tarbush	—	5	3	2	5	5	8	
Grassland with acacia/honey mesquite	1	4	4	1	5	5	9	
Desert shrubland with acacia/honey mesquite and creosote bush/tarbush	—	2	—	2	2	2	2	
Desert shrubland with acacia/honey mesquite	—	1	—	1	1	1	1	
Desert shrubland with creosote bush/tarbush	—	—	—	—	—	—	—	
Total	18	25	36	7	43	43	79	

shrub-dominated communities. No falcon detections occurred in creosote bush/tarbush communities (Table 3).

Aplomado Falcons were fairly concentrated in the north-central to northeastern part of the study area (Fig. 2). This distribution coincides closely with the distribution of extensive grasslands in northern Chihuahua identified from our aerial flight. We found falcons nesting ca. 50 km west of the Texas border (ca. 120 km south of El Paso, TX) in northern Chihuahua. Also, single Aplomado Falcons were detected in the same area ca. 12-18 km south of the New Mexico border near Palomas, Chihuahua, in each survey yr. Reproductive status for these detections was not determined.

Aplomado Falcons rely on nests constructed by other raptors or corvids. Potential nest builders present in northern Chihuahua included ravens (primarily *Corvus cryptoleucus*), Swainson's Hawk (*Buteo swainsoni*), Red-tailed Hawk (*Buteo jamaicensis*), Harris's Hawk (*Parabuteo unicinctus*), and White-tailed Kite (*Elanus leucurus*). Except Harris's Hawk and White-tailed Kite, these nest builders were common in tracts where Aplomado Falcons were detected (>70% frequency; Table 4). Swainson's Hawks, Red-tailed Hawks, and ravens were more commonly detected in tracts with Aplomado Falcons than in tracts without Aplomado Falcons ( $\chi^2 = 34.56$ ,  $df = 3$ ,  $P < 0.001$ ).

#### DISCUSSION AND CONSERVATION IMPLICATIONS

Aplomado Falcons are fairly conspicuous when foraging or perching on tall substrates. However, locating new falcons required >40 survey hr per site (estimated from tract surveys), and determining nesting status required additional time. As such, methods that require complete surveys of large areas are more likely to detect falcons. We detected falcons in 25% of tracts surveyed, locating 18 falcon sites which were not previously known. Given the short duration of surveys, we feel the tract survey method provided reasonable results.

Before the 1980s, information on Aplomado Falcons in the Chihuahuan Desert was limited to a few incidental and historical accounts. The state of knowledge has developed from the perception that Aplomado Falcons were extirpated from the Chihuahuan Desert, to documenting a population that exists from north-central Chihuahua to southern New Mexico. However, it seems that the falcon population on the Mexican Plateau is geographically isolated from coastal populations (Fig. 1). Additional research is necessary to better define pop-



Table 4. Association of raptor species observed in 17 survey tracts with Aplomado Falcon detections and 51 tracts without Aplomado Falcon detections in northern Chihuahua, Mexico in 1998–99.

	NUMBER OF TRACTS			
	WITH APLOMADO FALCONS <sup>a</sup>		WITHOUT APLOMADO FALCONS	
	NUMBER	PERCENT	NUMBER	PERCENT
Swainson's Hawk	17	100	33	65
Ravens	16	94	49	96
Red-tailed Hawk	12	71	25	49
White-tailed Kite	2	12	1	2
Harris's Hawk	1	6	1	2

<sup>a</sup> Detection of Aplomado Falcons was highly associated with tracts where hawks and ravens were detected ( $\chi^2 = 34.56$ ,  $df = 3$ ,  $P = <0.001$ ); White-tailed Kite and Harris's Hawk detections were combined for analyses.

ulation dynamics and connectivity between falcon populations in Mexico.

The U.S. Fish and Wildlife Service (1990) stated that critical information regarding falcon distribution, abundance, and habitat requirements in Mexico was needed to aid in recovery of the species. Our study, as well as studies by Montoya et al. (1997), Truett (2002), and R. Meyer, C. Perez, and S. Williams III (unpubl. data), will aid resource managers in developing recovery strategies for the falcon in the Chihuahuan Desert by providing baseline information on the current distribution of the falcon.

The Chihuahuan Desert is the largest desert (ca. 629 000 km<sup>2</sup>) in North America (Beck and Gibbens 1999, Dinerstein et al. 2001) and is among the most biologically diverse desert ecoregions worldwide (Ricklefs and Schluter 1993). Most of the Chihuahuan Desert is located in the states of Chihuahua and Coahuila in Mexico, but portions extend into eastern Arizona, southern New Mexico, and western Texas. This vast and unique arid region supports a wide variety of habitats including grasslands, scrublands, shrub communities, and yucca woodlands as well as mixed conifer forests and oak woodlands at higher elevations (Gehlbach 1993). About 14% of Mexico's land area is covered by grasslands of which 90% occur in arid and semi-arid regions (Burquez et al. 1998). Although limited in area, grasslands are vital to certain species and to the biodiversity of the Chihuahuan Desert (Beck and Gibbens 1999).

The Mexican government created the National Commission for the Knowledge and Use of Biodiversity (CONABIO) in 1992 that established a network of regional areas that were important for bio-

diversity conservation. In the Chihuahuan Desert portion of the Aplomado Falcon's range, four priority areas for biodiversity conservation in grassland habitats were identified (Arizmendi and Márquez 1999). CONABIO also established areas that were considered important for the conservation of birds (AICAS) in Mexico. However, within the range of the Aplomado Falcon in the Chihuahuan Desert, there was only one area designated near Janos, Chihuahua. Although there are occasional falcon sightings in this AICAS, there were no AICAS designated in areas of known year-round Aplomado Falcon habitation. Given the falcon's status of "subject to special protection" in Mexico, updated information on Aplomado Falcon distribution may assist in evaluating areas for future AICAS in Chihuahua, Mexico and promote falcon recovery and conservation.

The U.S. Fish and Wildlife Service (1986) implicates habitat degradation due to brush encroachment as the main factor responsible for disappearance of Aplomado Falcons from the U.S. The Chihuahuan Desert has undergone considerable transition in vegetation communities since the mid-1800s, primarily from perennial grassland to shrubland (Buffington and Herbel 1965, Allred 1996, Beck and Gibbens 1999). Over the past century, factors such as climatic changes, diversion of surface water for agricultural purposes, livestock grazing, erosion, introduction of exotic plant and animal species, and increased urban development have profoundly and negatively impacted the natural processes of the Chihuahuan Desert (Lloyd et al. 1998, Beck and Gibbens 1999). Changes in bird assemblages, including raptors, associated with altered vegetation structure and climatic conditions

have been detected and discussed by Raitt and Pimm (1976, 1977) and Lloyd et al. (1998) for Chihuahuan Desert environments. Change in grasslands will naturally affect species that are grassland adapted. The current state of knowledge on Aplomado Falcons indicates that this falcon is likely to be detrimentally affected by alteration and loss of grassland habitat. Further, key raptor or raven species relied upon by Aplomado Falcons to provide nest structures have substantial association with grassland dominated communities (Desmond et al. in press). Grassland conservation is paramount in conserving Aplomado Falcons and other grassland birds in the Chihuahuan Desert.

#### ACKNOWLEDGMENTS

Research was funded by the Bureau of Land Management, White Sands Missile Range, Fort Bliss Military Reservation, U.S. Fish and Wildlife Service, Sevilleta National Wildlife Refuge, The Peregrine Fund, Border Wildlife Consultants, T & E, Inc., La Tierra Consulting, World Wildlife Fund, and Geo-Marine Inc. Additional financial support was provided by the New Mexico Agricultural Experiment Station. We greatly appreciate the Secretaria de Medio Ambiente Recursos Naturales y Pesca for providing the necessary permits to conduct research in Mexico. We thank A. Alvarez, E. Carreon, E. Carrillo, C. Mendez, R. Meyer, J. Montoya, C. Morales, F. Pinion, R. Rodriguez, C. Sanchez, and E. Zamarron for their assistance in collecting data. S. Lanham, Environmental Flying Services, Tucson Arizona, provided a productive flight over northern Chihuahua. We thank M. Howard, B. Locke, R. Meyer, C. Perez, and S. Williams for helpful critiques of this manuscript. We thank the numerous private landowners in Chihuahua, Mexico with a special thanks to A. Borunda and E. Baeza for providing land access.

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