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PEREGRINE FALCON RECOVERY ALONG THE WEST CENTRAL COAST OF THE BAJA CALIFORNIA PENINSULA, MEXICO

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ABSTRACT.—The central west coast of the Baja California peninsula was an important Peregrine Falcon (*Falco peregrinus*) breeding area supporting a population of about 13 breeding pairs. This population declined drastically during the 1960s and early 1970s. We conducted field surveys and compiled data on nesting Peregrine pairs from 1980–94 to address the current status of the Baja population. We found 10 pairs nesting in the area indicating the Peregrine population has recovered in the area since the late 1970s. Due to increased human activity in the area, proper management is needed to provide suitable nesting sites and to minimize human disturbances during the nesting season.

KEY WORDS: *Peregrine Falcon; recovery; status; Baja California; Falco peregrinus.*

Recuperación del halcón peregrino en la costa centro occidental de la península de Baja California, México.

RESUMEN.—La costa centro occidental de la península de Baja California, ha sido un área importante de reproducción del halcón peregrino (*Falco peregrinus*), manteniendo alrededor de 13 territorios de anidación. Esta población declinó drásticamente entre los años 1960s e inicios de los 1970s. Nosotros realizamos estudios en el campo y recabamos datos sobre las parejas anidantes de peregrinos entre 1980 y 1994 para determinar su situación actual. Encontramos diez parejas de peregrinos anidando en el área. Nuestros hallazgos sugieren que los peregrinos se han estado recuperando desde finales de los años 1970s. Las actividades humanas están creciendo en el área, lo que representa tanto amenazas como oportunidades para los peregrinos. Se requiere de un manejo apropiado que provea de sitios adecuados de anidamiento para minimizar las pérdidas reproductivas asociadas al hombre durante la estación reproductiva.

[Traducción Autores]

Peregrine Falcon (*Falco peregrinus*) recovery has been documented in several regions of the world (Fyfe 1988, Kiff 1988, Ratcliffe 1993, Anderson et al. 1995). Nesting territories, deserted during the decline of the species are now being reoccupied by breeding pairs. Reproduction has

now returned to pre-DDT levels (Kiff 1988, Newton 1979, Ratcliffe 1993). The ban on DDT use in many countries (Ratcliffe 1993) and the success of Peregrine recovery programs (Fyfe 1988, Ratcliffe 1993) has contributed to the Peregrine's removal from endangered status and to a redesign

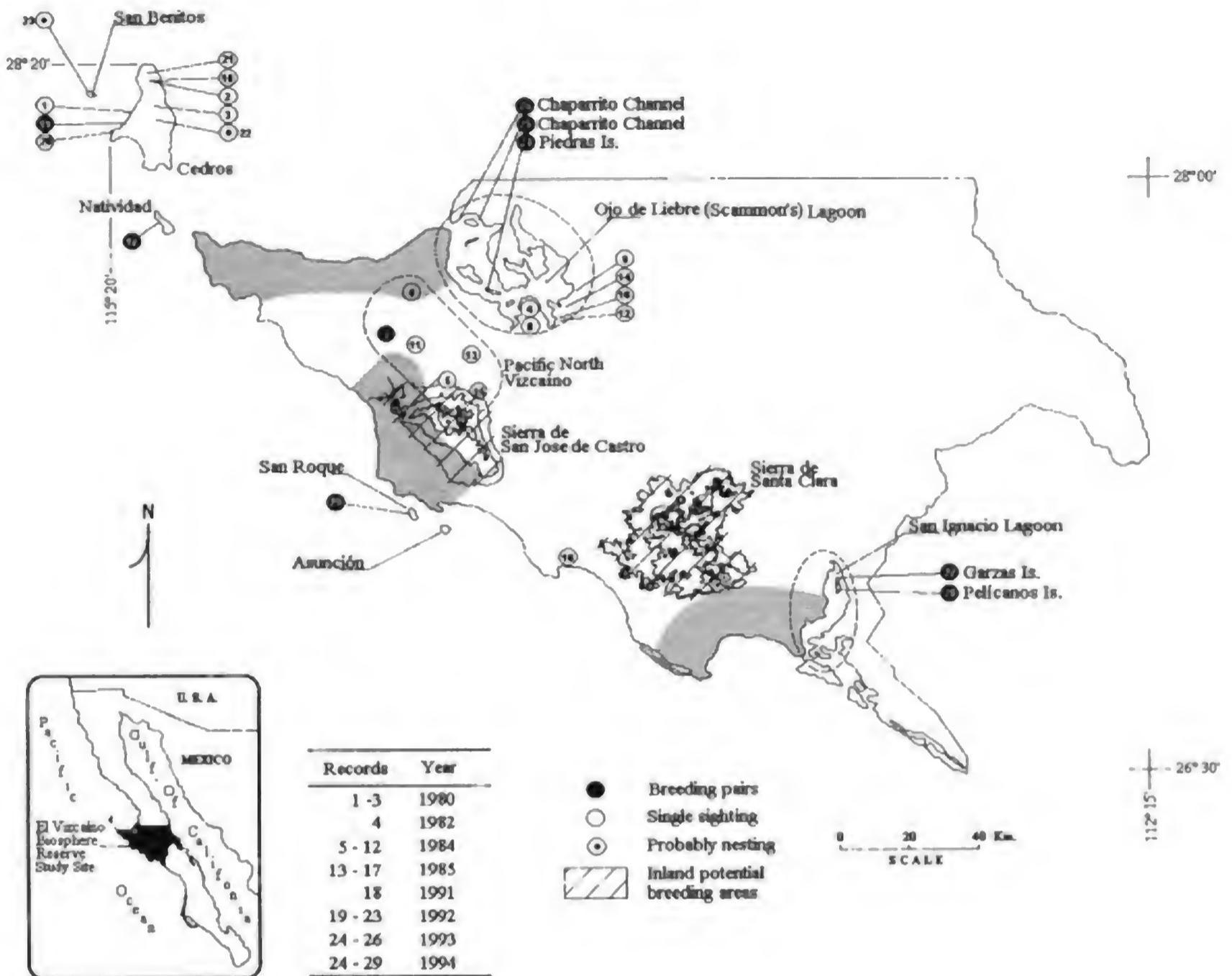


Figure 1. Recent records of nesting Peregrine Falcons on the central west coast of Baja California, Mexico. (Shaded areas are Banks, 1969 records.)

of its management strategies (Walton and Thelander 1988).

The historical and current status of the Mexican Peregrine Falcon population is not well known (Banks 1969, Fyfe et al. 1976). Populations in the Baja California peninsula and the Gulf of California are known to have declined between 1967–84 (Porter et al. 1988). By 1976, the Baja west coast population, once containing 38 breeding pairs, was considered on the brink of extirpation (Fyfe et al. 1976). However, recent reports of newly occupied nesting territories in this area (Daneman and Guzmán Poo 1992, Castellanos et al. 1994) suggest a recovery is in process. In this report, we provide information on current numbers, distribution, and productivity of Peregrines, and discuss their con-

servation needs on the west central coast of the Baja California peninsula.

STUDY AREA AND METHODS

The study area, a part of El Vizcaino biosphere reserve, covers about 350 km along the west coast of Baja California, Mexico (Fig. 1). The study area includes: desert islands, a coastal fringe of mostly sandy beaches and two big coastal lagoons with extensive wetlands (Massey and Palacios 1994). Most of the area is covered with halophytic vegetation, 30 cm high. Mountains are restricted to Benitos and Cedros Islands and some parts of the El Vizcaino reserve.

We used three data sources on the breeding population of Peregrine Falcons in the area. Data from 1980–85 were obtained by F. Jaramillo during wildlife inventories to promote the creation of the El Vizcaino Reserve and in 1994 on Cedros and Benitos Islands. Data from Ojo de Liebre and San Ignacio lagoons were obtained by

A. Castellanos, F. Salinas, C. Arguelles and A. Ortega in 1993–94. Nesting surveys of breeding Peregrine Falcons were conducted by searching the plateaus, canyons, hills and islands on foot and inspecting all potential nesting sites using binoculars. Boats were used to explore the lagoons and to reach the islands. We also used recent records in the oological collection of the Western Foundation of Vertebrate Zoology (WVZ) and personal reports from other individual observers. We compared our data with those of Banks (1969). Productivity of breeding pairs was estimated by checking three nests in 1993 and five nests in 1994.

RESULTS AND DISCUSSION

We located at least 10 nesting pairs of Peregrine Falcons in six locations in the survey area, including small islands in the open sea, islets inside coastal lagoons and an inland mountainous zone (Fig. 1). The maximum number of pairs seen in a single year was six pairs in 1994 when we observed pairs on San Roque islands, Laguna Ojo de Liebre (Piedras Island and El Chaparrito navigation channel) and San Ignacio Lagoon (Pelicano and Ballena Islands) (Fig. 1, Table 1). Because not all the historical and potential nesting sites were surveyed, we considered this to be a minimum estimate of the total number of breeding pairs in the area. The historical population estimate for the study area was about 13 pairs (Banks 1969).

Breeding pairs were found on small cliffs, directly on the ground, in Osprey nests and on artificial structures such as channel markers and shipwrecks. Ojo de Liebre (Scammon's) lagoon nest sites were new (Castellanos et al. 1994). Lack of inland nesting records from the study area led us to believe that the cliff-nesting pairs on Pacific North Vizcaino (near Sierra San José de Castro) were also new to the breeding population. A nesting record in the WVZ reported by B. Reitherman in 1981 documented a pair nesting at San Ignacio Lagoon for the first time. Daneman and Guzmán Poo (1992) also found two pairs nesting there in 1989.

In addition to the 10 nesting pairs, there were several recent single sightings and two probable nest site reports from Benitos and Cedros islands (Fig. 1, Table 1). Nearest nesting site distances varied between 4.4 and 60 km. Nests were 4.4 km apart in San Ignacio lagoon and 8 and 22 km apart in Ojo de Liebre lagoon (Fig. 1)

We followed the reproductive success of three pairs during 1993 and five pairs during 1994, located at Ojo de Liebre and San Ignacio Lagoons. An average of 3 eggs, 1.8 nestlings, and 1.6 fledg-

lings were produced per nest (Table 2). This productivity appeared to be within the range of productivity for healthy populations (Cade et al. 1988, Ratcliffe 1993).

The Peregrine Falcon is defined by Mexican law as a vulnerable species (Diario Oficial 16 de Mayo de 1994). In spite of its status, lack of national recovery programs on threatened species has failed to produce management plans in their Mexican range. The use of organochlorine pesticides in the region is not well documented but it has apparently been reduced since the late 1970s. Studies conducted then and in the late 1980s in Baja California, the Gulf of California and in northwestern Mexican waterfowl wintering areas show pesticide levels in eggs and bird tissues are among the lowest in North America (Spitzer et al. 1977, Mora et al. 1987). This evidence leads us to believe that current organochlorine pesticide use does not represent a major threat for Peregrines in the region.

We did, however, identify other threats to breeding Peregrines in the area. Nests on the ground are accessible to dogs and cats abandoned by fishermen in the islands. Coyotes (*Canis latrans*) temporarily invade Piedras island in Ojo de Liebre Lagoon destroying the nests of Peregrines, Ospreys and other birds. We found coyote tracks at one failed Peregrine nest in 1994 and presumed the coyote caused the nest failure. Avian depredation by Western Gulls (*Larus occidentalis*) and Common Ravens (*Corvus corax*) is also a problem. Gulls and ravens apparently caused the disappearance of three eggs from a nest on a tower over the water in Ojo de Liebre lagoon.

A third and more serious threat to nesting Peregrines in the area is from humans when fishing, tourism and other human activities cause incidental disturbances at nests (Daneman and Guzman Poo 1992). The study area is still relatively inaccessible and partially uninhabited, thus, habitat destruction apparently is not yet a factor of concern.

The coastal lagoons, islands and wetlands within the study area support a magnificent avifauna which provides adequate numbers and variety of Peregrine prey (Massey and Palacios 1993). Nevertheless, the density of breeding Peregrine Falcons in the area seems to be rather low for such an ideal location. Most of the resident pairs reported are coastal or "small island Peregrines" (Ratcliffe 1993) nesting on small cliffs or even on the ground. This is apparently because of a shortage of suitable natural nesting sites on the main-

Table 1. Historical and recent records of nesting Peregrine Falcons in the central west coast of Baja California. Recent records are from 1980–94.

LOCALITY	INDIVIDUAL/NEST	REFERENCE
SOURCES AND DATE		
San Benitos Islands		
Walker, 1927 and 1950	4 nests	Banks (1969)
Tyler, 8 April 1930	Nest with 2 eggs	WFVZ, this study
Harrison, 1 April 1938	Nest with 2 eggs	WFVZ, this study
22 March 1992	1 seen	This study
Cedros Island		
Kaeding, 1905	Common, breeding	Banks (1969)
Carpenter, 2 April 1932	Nest with 4 eggs	WFVZ, this study
8, 31 July and 18 August 1980	1 seen	This study
April 1991	1 seen	This study
2, 3 and 15 March 1992	1 pair, 2 sightings	This study
22 March 1992	1 female, 1 male	This study
Natividad Island		
Sechrist, 12 March 1917	Nest with 4 eggs	WFVZ, this study
Lamb, December 1924	6 pairs resident	Banks (1969)
D.S.D., 6 April 1930	Nest with 3 eggs	WFVZ, this study
Bancroft, 3 April 1932	2 nest with eggs	WFVZ, this study
31 July 1985	1 breeding pair	This study
Ojo de Liebre Lagoon		
26 January 1982	1 seen	This study
June, October, November 1984	1 seen	This study
29 July 1985	2 females and 2 males	This study
21 September 1985	1 seen	This study
1993 (Castellanos et al. 1994)	3 breeding pair	This study
San Roque Island		
Huey, 20 April 1927	Nest with 2 eggs	Banks (1969)
D.S.D., 5 April 1930	Nest with 3 eggs	WFVZ
Harrison, 6 April 1932	Nest with 4 eggs	WFVZ, this study
L. Flores, 1994	1 breeding pair	L. Flores pers. comm.
Asuncion Island		
Walker, 1938	1 pair	Banks (1969)
San Ignacio Lagoon		
Reitherman, 11 April 1981	Nest, 2 young, 2 eggs	WFVZ, this study
September 1985	1 pair, one seen	This study
Daneman & Guzmán Poo, 1992	2 breeding pairs	Daneman & Guzmán Poo, 1992
March–June, 1994	2 breeding pair	This study
Pacific North Vizcaino		
13 June, 1984	1 breeding pair	This study
June 1984	1 breeding pair	This study
4 November 1984	2 seen	This study
March and September 1985	2 seen	This study

Table 2. Peregrine Falcon reproductive success during 1993–1994 on the Scammon's and San Ignacio lagoons.

	1993	1994	
	SCAM- MON'S LAGOON	SCAM- MON'S LAGOON	SAN IGNACIO LAGOON
Occupied nests checked	3	3	2
Productive nests	3	1	1
Total eggs laid	10	10	4
Eggs failed to hatch	1	—	—
Eggs disappeared	—	6 ^a	—
Eggs broken	—	1 ^b	1 ^b
Average clutch size	3.3	3.3	2.0
Nestlings	9	3	3
Nestling disappeared	1	1	—
Total young fledged	8	2	3
Nestlings/occupied nest	3	1.0	1.5
Fledglings/occupied nest	2.6	0.6	1.5
Fledglings/productive nest	2.6	2.0	3.0

^a Probably avian and coyote depredation.

^b Unknown causes.

land coast, inland and on small islands, a factor that limits cliff-nesting raptors in other areas (Ratcliffe 1993). Peregrines do take advantage of suitable artificial nesting sites when they were available in the study area (Castellanos et al. 1994)

Given these circumstances, we suggest the implementation of a Peregrine Conservation Program in the El Vizcaino Reserve, focusing on the following: a) regular surveys of historical and new nesting territories to assess the current population status and trends; b) studies of biology and nesting ecology to enhance knowledge of this poorly known resident population; c) installation of artificial nesting substrates to increase the population on the mainland coast and at coastal lagoons; and d) an education program to promote public awareness of this and other species of wild birds.

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WINTER BALD EAGLE DISTRIBUTION IS INVERSELY CORRELATED WITH HUMAN ACTIVITY ALONG THE COLORADO RIVER, ARIZONA

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ABSTRACT.—Helicopter surveys for Bald Eagles (*Haliaeetus leucocephalus*) were conducted along the Colorado River through Glen Canyon National Recreation Area and Grand Canyon National Park, Arizona, U.S.A., during winter 1990–91. Eagle abundance and distribution were examined for a possible correlation with human activity levels as documented in National Park Service recreational use reports. Twenty-two times more eagles were detected in river reaches with low human use compared to river reaches with high to moderate human use. Eagle distribution did not correspond to prey abundance, biomass patterns, or habitat conditions frequently associated with eagle foraging habitat. Moderate to high levels of human activity may have been responsible for lower eagle abundance in some reaches of the river, reinforcing the need for continued management of some areas as refugia where species sensitive to human disturbance can be protected from higher levels of human activity.

KEY WORDS: *Bald Eagle, Colorado River, Arizona, Haliaeetus leucocephalus, human disturbance.*

La distribución invernal de el *Haliaeetus leucocephalus* esta correlacionada inverso con actividad humana enseguida del Río Colorado, Arizona.

RESUMEN.—Inspecciones de helicóptero para *Haliaeetus leucocephalus* fueron conducidas a lo largo del Río Colorado por el área Nacional de Recreación del Glen Canyon y el Parque Nacional del Grand Canyon, Arizona, U.S.A., durante el invierno de 1990–91. La abundancia y distribución del *H. leucocephalus* fueron examinados por una posible correlación con niveles de actividad humana como fueron documentado en reportes de el Servicio Nacional de Parques. Veinte-dos veces mas fueron los *H. leucocephalus* descubiertos en tramos del río con uso bajo de humanidad comparado con tramos del río con uso alto y moderado. La distribución de *H. leucocephalus* no correspondió con la presa abundante, patrón de distribución de materia biológica, y condiciones de hábitat frecuentemente asociada con hábitat de forraje de *H. leucocephalus*. Niveles altos a moderado de actividad humana puede ser responsable por la baja cantidad de *H. leucocephalus* en tramos de el río, reforzando la necesidad para la continuación de administración de unos área de refugio donde especie delicadas a molestos humanos pueden ser protegidos de niveles alto de actividad humana.

[Traducción de Raúl De La Garza, Jr.]

Human activities can influence Bald Eagle (*Haliaeetus leucocephalus*) behavior and distribution (Stalmaster 1987). Numerous studies have shown that eagle distribution and foraging behavior can be detrimentally affected by unmanaged human recreational activities such as hiking (Stalmaster and Newman 1978), fishing (Knight et al. 1991, Skagen et al. 1991), and boating (Knight and Knight 1984, McGarigal et al. 1991), and by physical developments within eagle habitat (Buehler et

al. 1991). These aspects of eagle-human interaction have been addressed primarily through two types of studies: those directly quantifying eagle "flush response distance" to different categories of human activity (e.g. Stalmaster and Newman 1978, McGarigal et al. 1991), and those indirectly linking eagle distribution to secondary measures of human activity such as housing density and development set-back distance (e.g., Buehler et al. 1991).

The purpose of our study was to test the null

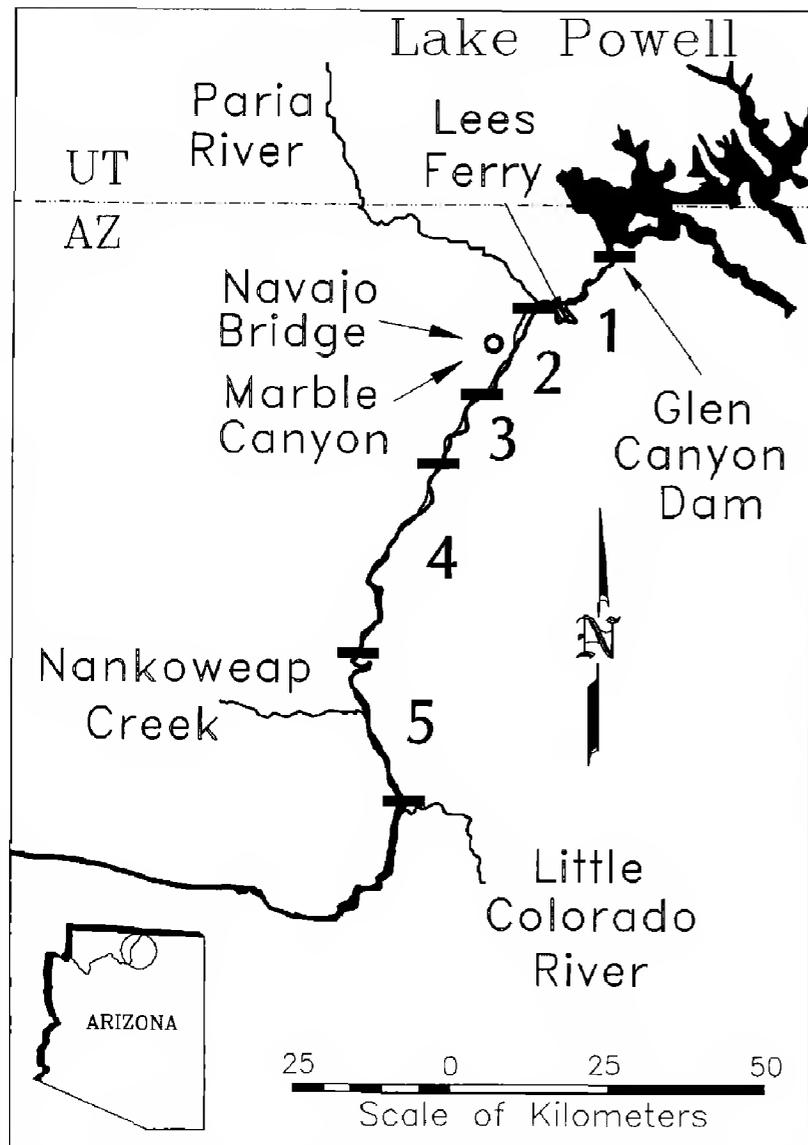


Figure 1. Map of the Colorado River study area in Glen Canyon National Recreation Area and Grand Canyon National Park, Arizona, showing River Reaches One through Five.

hypothesis that winter distribution of Bald Eagles along the Colorado River in Arizona was not correlated with indirect measures of human activity obtained from National Park Service (NPS) recreational use reports. We also considered physical variables and prey differences that may influence eagle distribution.

STUDY AREA AND METHODS

Our study was conducted along the Colorado River through Glen Canyon National Recreation Area (GCNRA) and Grand Canyon National Park (GCNP) in northern Arizona, from 2 km downstream of Glen Canyon Dam to the confluence of the Little Colorado River (120.2 km; Fig. 1). The completion of Glen Canyon Dam in 1963 altered the river's physical and biological characteristics, and a subsequent introduction of rainbow trout (*Oncorhynchus mykiss*) benefited wintering Bald Eagles (Brown et al. 1989, Brown and Stevens 1992, Brown 1993). A concentration of wintering eagles began to occur during the 1980s at Nankoweap Creek, 105 km downstream from the dam, when large numbers of spawning trout were present (Brown et al. 1989).

The study area was divided into five river reaches based on bedrock geology (modified after Schmidt and Graf 1990: Table 1). Reaches varied in geomorphic width, but all were in deep canyons bounded by cliffs typically >300 m high. Reach One, from Glen Canyon Dam to the Paria River, supported a productive rainbow trout fishery and was heavily used in winter by bank and boat fishermen from Lees Ferry. Boating activity upstream of Lees Ferry consisted of motorboats used by fishermen; downstream of Lees Ferry, motorized and nonmotorized rafts were on multi-day trips through GCNP. Reach Two, from the Paria River to Soap Creek Rapid, was moderately used by bank fishermen and hikers that accessed it from Lees Ferry or by several trails. The number of raft trips departing downstream to pass through GCNP was limited

Table 1. Habitat features, relative human activity levels, and prey parameters potentially influencing winter Bald Eagle distribution along the Colorado River in Glen and Grand canyons, Arizona.

PARAMETER	RIVER REACH				
	1	2	3	4	5
Length (km)	22.6	16.7	18.5	28.2	34.2
Surface ^a (ha/km)	12.6	9.3	5.3	5.7	9.2
% riffle/rapid ^a	5.7	4.3	13.9	15.8	11.4
Boats/mo ^b	671	30	19	19	19
Fishermen/mo ^c	570	350	10	10	10
Activity level	High	Moderate	Low	Low	Low
Fish ^d (kg/ha)	190	53	69	79	82
Waterfowl ^e	6344	157	101	35	21

^a Unpubl. data, U.S. Bureau of Reclamation.

^b Data provided by NPS; Reach 2 estimated.

^c Data provided by NPS; Reaches 2–5 estimated.

^d Unpubl. biomass data, 1990–1994, from R.A. Valdez and R.J. Ryel, BIO/WEST, Inc., Salt Lake City, UT, U.S.A.

^e Number winter waterfowl detected/km²/hr of observation (Unpubl. data).

Table 2. Numbers of Bald Eagles detected and expected by river reach in winter 1990–1991 along the Colorado River in Glen and Grand canyons, Arizona. Numbers/reach are presented two ways: the entire study period and that time when no spawning trout were in Nankoweap Creek in Reach Five.

PARAMETER	RIVER REACH				
	1	2	3	4	5
Entire study period					
No. detected	3	3	36	58	43
No. expected	28.5	19.0	22.6	30.3	42.6
Detections/km	0.13	0.18	1.95	2.06	1.26
No spawning trout					
No. detected	3	2	20	41	31
No. expected	19.3	12.9	15.3	20.6	28.9
Detections/km	0.13	0.12	1.08	1.45	0.91

by NPS regulations. The community of Marble Canyon was immediately adjacent to the river where Navajo Bridge on U.S. Highway 89 crossed Reach Two. Reaches Three, Four, and Five extended from Soap Creek Rapid to the Little Colorado River and were remote, far from roads, and accessed only by a few foot-trails, with the number of bank fishermen and hikers limited by NPS regulations. Nankoweap Creek was located in Reach Five.

Fifteen helicopter surveys of the study area were conducted, 1/wk from November 1990–March 1991, to determine eagle abundance and distribution. A special research permit was obtained from NPS for helicopter use because of the potential for helicopters to disturb park resources and visitors. Most surveys occurred before 1200 H. Air speed was approximately 90 km/hr at a height of 100 m above river level on a flight path directly over the river. Surveys were initiated from both ends of the study area. The pilot and front-seat observer detected eagles; a rear-seat assistant recorded observations and localities. Numbers of eagles detected were summarized by reach and compared to expected numbers of eagles/reach using a Chi-square goodness-of-fit test, with statistical significance accepted at $P < 0.05$. Expected numbers of eagles/reach were derived by multiplying the total number of eagles detected by the proportion of total river-km/reach.

Winter boat launches/mo and bank fishermen/mo for Reach One from November 1990–March 1991 were obtained from recreational records maintained by NPS at GCNRA; monthly totals were averaged to obtain mean use. Winter raft launches/mo for Reach Two were obtained from records maintained by NPS at GCNP. Reaches Two through Five had almost identical levels of boating activity since all raft trips launching at Lees Ferry must pass through them; Reach Two received slightly more overall boating use because of motorboat activity by NPS maintenance and patrol trips. Mean numbers of bank fishermen/mo for Reaches Two through Five were estimated based on interviews with NPS personnel and our personal observations.

RESULTS AND DISCUSSION

Twenty-two times more eagles were detected in Reaches Three through Five than in Reaches One and Two when total numbers of eagles detected were compared (Table 2; $\chi^2 = 44.0$, $df = 4$, $P < 0.001$); we found no difference in the number of eagles detected among Reaches Three through Five ($\chi^2 = 5.4$, $df = 2$, $P = 0.07$). Total numbers of eagles detected/km in Reaches Three through Five were more than 10 times greater than numbers of eagles detected in Reaches One and Two (Table 2).

Eagle distribution did not correspond to estimates of prey distribution. Fewer eagles were observed in Reaches One and Two despite biomass indices that indicated fish and winter waterfowl abundance to be greater in Reaches One and Two (Table 1). Reaches One and Two were wider with many pools with shallow margins all along the river. They also had a smaller percentage of riffle and rapid habitats making them more suitable for eagles as foraging areas (Hunt et al. 1992).

It appeared that negative effects due to moderate to high levels of human activity in these two reaches of the river may have reduced their suitability as eagle foraging areas or perhaps disturbed eagles from perching and roosting habitat. We did not find any eagles within 1 km of intensively used areas near Lees Ferry and Navajo Bridge at Marble Canyon. This negative correlation between human activity and Bald Eagle distribution was consistent with that reported in other studies (Buehler et al. 1991, McGarigal et al. 1991), although reasons why eagles avoid areas of higher human activity remain

unknown (Buehler et al. 1991). Repeated flushing by bank fishermen, hikers, or boats could have caused wintering eagles to avoid those reaches heavily used by anglers. McGarigal et al. (1991) reported a similar finding on the Columbia River where eagles avoided areas with heavy boat traffic. Although apparent habituation of Bald Eagles to human activity has been reported (Knight and Knight 1984), scarcity of eagles in Reaches One and Two of the Colorado River suggested that habituation did not occur in this area.

An alternative hypothesis was that more eagles occurred in Reaches Three through Five because they were attracted to easily accessible spawning trout in Nankoweap Creek (Reach Five). Abundant trout were spawning at Nankoweap from 15 February until the end of the study period (Brown and Stevens 1992). To test this hypothesis, we contrasted numbers of eagles detected/reach when spawning trout were and were not present at Nankoweap. Prior to 15 February, total numbers of eagles detected in Reaches Three through Five were 18 times greater than in Reaches One and Two (Table 2; $\chi^2 = 27.3$, $df = 4$, $P < 0.001$). Therefore, we rejected the alternative hypothesis.

Managed boating, hiking, and fishing activities are an established use of national parklands. However, we found an inverse correlation between wintering Bald Eagle distribution and human activity along the Colorado River within GCNRA and GCNP. Although correlation does not prove causation, we suggest human activity as the most likely cause. This would represent an apparent contradiction of NPS goals to preserve natural resources for future generations. A tradeoff of resources for recreation may be acceptable if the status quo can be maintained in Reaches Three through Five of our study area. However, the growing popularity of national parks such as GCNP increases economic and political pressures to provide more wilderness recreation opportunities (Frome 1992), and may result in long-term increases in human activity levels in Reaches Three through Five. Our findings reinforce the need to continue to manage some areas as refugia where species potentially sensitive to human disturbance, such as Bald Eagles, are not excluded or influenced by higher levels of human activity.

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POPULATION STATUS OF THE ENDANGERED HAWAIIAN HAWK

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ABSTRACT.—We assessed the current abundance and distribution of Hawaiian Hawks ('io; *Buteo solitarius*) on the island of Hawaii to determine if this federally endangered bird should be downlisted to threatened status. We found a density of 0.004 hawks/ha on the island. Using an estimate of 400 000 ha of suitable 'io habitat on Hawaii, we estimated a total of 1600 hawks (1120 adults; 560 pairs) on Hawaii. Based on the wide distribution of 'io among vegetation types on the island and little apparent change in numbers during the past decade, we agreed with the recommendation for downlisting the hawk but suggested that researchers collect long-term demographic data to better understand the status of this species.

KEY WORDS: *Buteo solitarius*, *Hawaiian hawk*, 'io, *population status*.

El estado de población del *Buteo solitarius* en peligro de extinción.

RESUMEN.—Nosotros fijamos la cantidad corriente y distribución de *Buteo solitarius* en la isla de Hawaii para determinar si el pájaro en peligro de extinción por leyes federales debe ser reducido a estado amenazado. Nosotros los encontramos una densidad de 0.004 halcón/ha en la isla. Usando la estimación de 400 000 ha de hábitat conveniente en Hawaii, nosotros estimamos un total de 1600 halcones (1120 adultos; 560 parejas) en Hawaii. En base de la distribución amplia de *B. solitarius* entre clases de vegetación en la isla y poco cambio aparente en la cantidad durante la década pasada, nosotros estamos de acuerdo con la recomendación para reducir el halcón pero sugerimos que los investigadores junten datos demográficos de larga duración para poder entender el estado de este especie mejor.

[Traducción de Raúl De La Garza, Jr.]

The Hawaiian Hawk (*Buteo solitarius*), or 'io, was federally listed as an Endangered Species in 1967 (37 FR 4001, 11 March 1967) based on its restricted range on the island of Hawaii (hereafter Hawaii), its low numbers at the time of listing (Berger 1981), and the perceived threats to its preferred habitat from agricultural and commercial developments (U.S. Fish and Wildlife Service [USFWS] 1984). At the time of listing, no intensive study of the ecology of the 'io had ever been conducted, and anecdotal accounts gave differing reports on its abundance across the island (Munro 1944, USFWS 1984).

Uncertainty over 'io abundance continued through the next decade. An intensive survey initiated by the USFWS in 1976 on Hawaiian forest birds was unable to estimate the 'io population size (Scott et al. 1986). After a detailed study of 'io breeding biology in <1% of the island's area, Grif-

fin (1985) found that the species might be relatively unaffected by habitat modifications compared to many other native bird species after finding that foraging and nesting occurred in agricultural areas and in stands of exotic vegetation (Baskett and Griffin 1985). Griffin (1985, 1989) estimated the population at 900 breeding pairs and a total of 2700 individuals in 1983. Because of this, the USFWS proposed downlisting the 'io from endangered to threatened status (58 FR 41684, 4 August 1993). Because of questions over the validity of basing such a reclassification on 10-year-old data, the USFWS requested that an island-wide survey be conducted of the 'io population to obtain a more current estimate of the population size.

Herein, we present our survey results and sampling design to provide a baseline for future surveys designed to monitor the size of the 'io population on Hawaii.

STUDY AREA AND METHODS

The most efficient way to sample dominant vegetation types across Hawaii for the occurrence of 'io was to conduct unlimited distance point counts (Blondel et al. 1981) along paved and dirt roads across the island. Point counts were selected to make our methods generally comparable to those of Scott et al. (1986), who conducted the most complete previous census of 'io on Hawaii as part of the USFWS's Hawaiian Forest Bird Survey (1976–79). We also needed a method that could sample the 'io's use of vegetation ranging from lowland agricultural areas to subalpine woodlands (Scott et al. 1986, Griffin 1989), and would be applicable to birds with home range sizes varying from 48 ha in agricultural areas to 490 ha in forests and mid-elevation pasturelands (Baskett and Griffin 1985). Use of roadways was the only feasible means of satisfying these objectives. Some studies have indicated that roadside counts can give biased estimates of bird densities and vegetation associations, but other studies have indicated that road counts can be useful and appropriate when large areas need to be sampled and monitored long term (Fuller and Mosher 1981).

When possible, we used roads that crisscrossed an area to more thoroughly sample for 'io. We conducted point counts 0.1–16 km off main roads to ensure that traffic noise did not interfere with the counts and that we more adequately sampled vegetation that could contain 'io. Count stations were located disproportionately among vegetation types (Table 1), based on information that 'io were unlikely (or very uncommon) in shrublands (vegetation type 10), upper-elevation mamane-naio (*Sophora chrysophylla*-*Myoporum sandwicense*) woodlands (vegetation type 12), and exotic pioneering lava vegetation (vegetation type 5) (J. Jeffrey and J. Giffin pers. comm.).

All count stations were 0.8–3.2 km apart, and counts were conducted by 1–2 observers between 0900–1700 H. Each point count lasted for exactly 10 min, which was the same count length used by Scott et al. (1986), and included 8 min of listening and watching for hawks, plus 2 min of playback of taped adult territorial and fledgling calls of 'io. After the first minute of the tape elapsed, we turned it off and observed the area for any hawks for 7 min. Anytime an 'io responded to the tape, either by calling or flying to the point, we immediately stopped the tape, but continued the count to determine if any additional hawks were observed. We then played the tape again for 1 min, and watched for the last minute of the count.

Although surveys have not previously used broadcast calls, Banko (1980) and Baskett and Griffin (1985) reported that 'io call and defend their territories in the winter. On 12–13 December 1993, we tested if broadcasted territorial calls elicited responses from 'io by going to areas known to have 'io present (J. Jeffrey pers. comm.). We watched 'io that were ≥ 200 m away while we played the taped calls. Eighty percent of the hawks responded by taking flight, calling or coming to the tape.

No counts were conducted when precipitation exceeded a light rain, or when wind exceeded 24 km/h. We recorded the distance from the point of initial detection of all observed hawks, the detection mode (visual, aural or both), the morph (light, dark, unknown), and the vegetation where the bird was observed (Table 1). Although

Table 1. Vegetation descriptions and codes for survey transects used in analyses of Hawaiian Hawk numbers across Hawaii in December 1993.^a

CODE	FRE- QUENCY ^b	DESCRIPTION
1	63	Sugar cane fields with exotic and/or native trees or shrubs at edges, as windrows.
2	41	Short or tall exotic trees with exotic shrubs, and sometimes exotic grasses.
3	22	Macadamia nut or papaya orchard with native and/or exotic trees or shrubs at edges.
4	38	Grassland with scattered exotic and/or native trees (especially o'hia); scattered homes.
5	5	Pioneer exotic vegetation growing on lava.
6	68	Native trees and native shrubs occasionally with scattered orchard trees, or exotic understory and homes.
7	99	Mixed exotic and native trees, sometimes with mixed exotic and native shrubs or grass.
8	24	Residential area with scattered exotic and native vegetation.
9	40	Native tree and mixed exotic and native shrub vegetation on lava, sometimes with scattered homes; a pioneer community.
10	2	Mixed exotic and native shrubs with scattered native and exotic trees.
11	16	Native trees and grassland; non-pioneer community.
12	4	Mamane-naio vegetation, with grass and/or exotic shrub understory, or sometimes with scattered exotic trees.

^a Scientific names of plants listed: sugar cane (*Saccharum officinarum*), macadamia nut (*Macadamia ternifolia*), papaya (*Carica papaya*), o'hia (*Metrosideros polymorpha*), mamane (*Sophora chrysophylla*), and naio (*Myoporum sandwicense*).

^b Frequency = total number of times the described vegetation was recorded along survey routes.

we tried to determine age and sex of hawks in the field, it was often difficult to make a positive identification, so in our analyses we combined all sightings.

We used program DISTANCE (Buckland et al. 1993, Laake et al. 1993) to estimate the densities of 'io in the 12 major vegetation types recorded during our surveys

Table 2. Summary of 'io density estimates (all ages together) by vegetation type, calculated by program DISTANCE (Laake et al. 1993) from survey data across Hawaii, December 1993.^a

VEGETATION CODE ^b	TO- TAL EF- FORT ^c	NO. POI- NTS	NO. 'IO OBS- VD.	ESTI- MA- TOR MOD- EL No. ^d	DENSITY ESTIMATIONS ^e										
					ESTI- MATE	SE	%CV	95%CI	df	DE- TECT. PROB.	ENC. RATE	DENSITY BOOTSTRAP ^f			
						ESTI- MATE	SE	%CV	95%CI	df	DE- TECT. PROB.	ENC. RATE	EST.	%CV	RUNS
All veg types	399	399	98	5	0.004	0.0007	15.9	0.003-0.006	345	0.02	0.24	0.004	23.7	400	
Veg 1	63	63	26	1	0.002	0.0006	29.1	0.001-0.003	86	0.08	0.41	0.002	56.2	100	
Veg 2	41	41	5	1	0.0004	0.0003	77.1	0.0001-0.002	12	0.11	0.12	— ^g			
Veg 3	22	22	5	1	0.003	0.0016	58.8	0.0009-0.008	22	0.03	0.23	—			
Veg 4	38	38	16	1	0.004	0.0011	29.1	0.002-0.006	52	0.04	0.42	—			
Veg 5	5	5	0	— ^h											
Veg 6	68	68	10	1	0.003	0.0014	41.3	0.002-0.007	76	0.02	0.15	—			
Veg 7	99	99	22	1	0.005	0.0013	26.6	0.003-0.008	118	0.02	0.22	0.005	67.6	100	
Veg 8	24	24	7	1	0.009	0.0046	54.0	0.003-0.024	26	0.01	0.29	—			
Veg 9	40	40	1	—											
Veg 10	2	2	0	—											
Veg 11	16	16	7	1	0.005	0.0024	50.5	0.002-0.013	17	0.03	0.44	—			
Veg 12	4	4	0	—											

^a For explanation of DISTANCE program estimations, see text.

^b For vegetation code explanation, see Table 1.

^c Total effort = the sum of the number of times each point and its corresponding vegetation was sampled.

^d Estimator Model No. = the mathematical estimator model selected by program DISTANCE to analyze the point data, where the chosen model was the one that had the smallest Akaike's Information Criterion value (AIC).

^e Density estimations: Estimate = density in number of 'io/hectare; SE = standard error of the estimation; %CV = percent coefficient of variation of the estimate; 95% CI = 95% confidence interval for the estimate; df = degrees of freedom used in the analysis; Detect Prob. = the estimate of average probability of detecting an 'io; Enc. rate = the number of animals expected to be observed per point.

^f Density Bootstrap values: Est. = bootstrapped density estimate; %CV = percent coefficient of variation of this estimate; Runs = total number of bootstrap runs conducted.

^g "—" = too few degrees of freedom to conduct bootstrap analyses.

^h "—" = no or too few 'io observed along this survey route, so no density analysis could be performed.

(Table 1). Observations of 'io were entered as the radial distance to the hawk from the point. We truncated the distances at 3000 m (the maximum distance at which most 'io were observed) to allow all hawk observations to be entered into the analyses. We instructed the program to select the most appropriate density estimation model for each analysis, based on maximum likelihood ratio tests of the models vs. each other. We also instructed the program to conduct 400 bootstrap samples for the island-wide data, to obtain reliable estimates of the variances around the density estimates, and 100 bootstrap samples for each of the analyses of density by vegetation type.

We estimated the current population size of the 'io on Hawaii based on the density of hawks per vegetation type, and the estimated percent cover by each vegetation type on the island of Hawaii (Jacobi and Scott 1985, Cuddihy and Stone 1990).

RESULTS AND DISCUSSION

We sampled 40 transects across Hawaii, with 399 points covering approximately 500 km of roads. Among these points, 98 different 'io were ob-

served. Thirty-three hawks were identified as adults, 7 as immatures, and 58 as unknown-aged. Forty-five hawks were light morph birds and 14 were dark morphs.

Densities ranged from a low of 0 in vegetation types 5, 9, 10, and 12 to a high of 0.009 hawks/ha in vegetation type 8 (Table 2). Most densities were between 0.003 and 0.005 hawks/ha, with an overall mean of 0.004 hawks/ha. Vegetation types 5 and 9 had lava as a major ground component, and thus had poorly-developed tree cover. Type 10 vegetation was dominated by shrubs, and type 12 was in mamane-naio woodland. Type 2 vegetation was typified by exotic trees of various sizes and had very few hawks. Type 8 vegetation consisted of residential areas with both native and exotic tree components and showed the highest hawk densities. Grasslands with scattered exotic and native trees (vegetation type 4) also had moderately-high den-

sities of birds. Bootstrapped density estimates matched the model estimates in all cases where adequate degrees of freedom existed.

Surveys found 'io most commonly in areas with native and/or exotic tree cover, usually with understories of exotic grass, and sometimes with native and/or exotic shrub understories. Although 'io were not found frequently in small patches of mixed native and exotic forest surrounded by open fields or orchards, they were commonly observed over the open areas, or in open places, with scattered native and/or exotic trees. For example, in sugar cane fields with ribbons of native or exotic trees between fields, or with trees extending down from higher elevation forests; in open pasture land with scattered native trees; in orchards (especially macadamia nut) with taller native and/or exotic trees at the perimeters. This indicated that 'io are now using areas that are not pure native forest. Based on these data and anecdotal breeding records from these more open areas, it appears that they are also able to successfully breed there (J. Jeffrey and J. Giffin unpubl. data).

Griffin (1985, 1989) estimated that the population of 'io on Hawaii was about 2700 hawks in 1983. Of this, 1800 were adults. This estimate served as the basis for the Hawaiian Hawk Recovery Plan developed by the USFWS (1984). It used an abundance of 2,000 hawks (the midpoint between the 1500 and 2500 adult birds thought to be needed for a self-sustaining population) as the target to downlist the species to threatened status. The island-wide estimate of 'io density was based on a total forested area of 343 000 ha (J.M. Scott pers. comm., Griffin 1989). This value corresponded roughly to the potential 'io habitat contained within the Hawaiian Forest Bird Survey area (Jacobi and Scott 1985). Using this area, and the overall estimate of 'io density from our surveys (0.004 birds/ha, 95% Confidence Interval [C.I.] = 0.003–0.006), we obtained a total density of 1372 'io (range = 1029–2058) on Hawaii. Much of the lowland forested areas of Hawaii, including the sugar cane, macadamia nut and other disturbed areas occupied by 'io, were excluded from Griffin's area estimate. We therefore modified the Griffin estimate by adding 60 000 ha of mixed sugar cane-lowland forested area and various other minor vegetation types (Cuddihy and Stone 1990), bringing the total potential 'io habitat to 400 000 ha. This raised our estimate of 'io on the island to about

1600 birds (range = 1200–2400), with 1120 adults or 560 pairs.

Our estimated density of adults (1120) is about 25% below the lower end of the target range necessary for a stable 'io population, according to the Recovery Plan (target = 1500–2500 adult birds). Assuming that all birds alive during our surveys survived to breed, the total number of birds we estimated (1600) is just above the lower end of the target range, but is still below the mean target value of 2000. The target value of adults is not enclosed in the confidence interval around the 0.004/ha value (95% C.I. = 0.003–0.006), but is enclosed if we assume that all hawks alive breed (400 000 ha x 0.006 = 2400 hawks).

We found a relatively high number of birds that were widely distributed among vegetation types on Hawaii, including heavily-disturbed areas. In addition, our results were similar to those found 10 years earlier by Griffin (1985, 1989), indicating the likelihood of a relatively stable population during the past decade. Thus, we concluded that downlisting to threatened status was supported.

As other biologists have suggested for the 'io, long-term demographic studies are necessary to accurately assess the overall status of the population (USFWS 1984, Griffin 1989). Our fieldwork did not assess population trends, reproductive fecundity and success, dispersal or mortality, all of which have been shown to be problematic for other forest birds on Hawaii (Scott et al. 1986). Thus, we think that the USFWS should initiate a long-term demographic study so future density estimations can be evaluated in light of other population data. Such a study is necessary before delisting from threatened status is considered.

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NEST-SITE SELECTION BY FOUR SYMPATRIC FOREST RAPTORS IN SOUTHERN NORWAY

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ABSTRACT.—Differences between 0.1 ha nest-site plots of Honey Buzzards (*Pernis apivorus*), European Sparrowhawks (*Accipiter nisus*), Northern Goshawks (*A. gentilis*) and Common Buzzards (*Buteo buteo*) were compared to randomly sampled 0.1 ha control plots within a 400 km² area with 80% forest and <2% agricultural land in southern Norway. At Honey Buzzard nest sites, forests were more productive than in control plots and there was a higher proportion of spruce, older trees and a higher tree density at Northern Goshawk nest sites than in control plots. Nests of European Sparrowhawks were also in sites with higher tree density than expected. Common Buzzard nest sites were situated in steeper terrain than control plots and more often had a southern aspect. For sparrowhawks, nesting in forests with high tree density may be an adaptation to avoid goshawks and pine martens (*Martes martes*) which are their main nest predators. For the larger species, nest-site selection may be a response both to nest predation risk, microclimate, foraging habitat and food supply.

KEY WORDS: *Honey Buzzard; European Sparrowhawk; Common Buzzard; Northern Goshawk; Accipiter nisus; Accipiter gentilis; Buteo buteo; Pernis apivorus; forest; nest-site selection; Norway.*

Selección del nido de cuatro rapaces de bosque sin que no aparean en el sur de Norway.

RESUMEN.—Diferencias entre 0.1 ha parcela de sitio de nido de *Pernis apivorus*, *Accipiter nisus*, *A. gentilis* y *Buteo buteo* fueron comparados con muestras alazar 0.1 ha parcelas manejadas dentro de una área de 400 km² con 80% bosque y <2% tierra agrícola en el sur de Norway. En nidos de *Pernis apivorus*, los bosques fueron mas productivo en las parcelas manejadas y había una proporción alta de *Picea*, árboles maduros y densidad alto de árboles en nidos de *A. nisus* también estaban en sitios con densidad alta de árboles mas de lo que esperábamos. Nidos de *B. buteo* estaban situados mas en terreno abrupto que en parcelas manejadas y con frecuencia tenía aspecto del sur. Para *A. nisus*, nidos en el bosque con densidad alta de árboles puede ser un adaptación para evitar *A. gentilis* y *Martes martes* que son su principal depredador de nido. Para la especie mas grande, la selección del nido puede ser reacción a riesgo de depredador al nido, microclima, hábitat de forraje y suministro de comida.

[Traducción de Raúl De La Garza, Jr.]

Breeding pairs of raptors use relatively large areas, and thus have a good opportunity to select nesting places that maximize the probability of successful breeding and lifetime reproduction (Newton 1979). Interspecific differences in nest-site selection may be due to differences in body size and flight performance of different species, but it can also be due to interspecific differences in nest predation risk, climatic conditions during breeding and feeding habits (Newton 1979, Janes 1985), or to interspecific competition for nest sites and territories (Newton 1979).

For several bird species, dense foliage close to the nest both reduces the rate of detection, and impedes the ability of predators to hunt in the vicinity of the nest (Martin 1993). On the other

hand, dense foliage may decrease the possibility for breeding birds to detect and escape from predators (Götmark et al. 1995). Thus, selection of nest site may be a trade-off between concealment and opportunities to escape or attack predators, which also depend on flight ability, body size or other characteristics of the species. Selection may also be affected by a trade-off between current and future reproduction, since short-lived species with large brood sizes have more to lose when nesting attempts fail than long-lived species with smaller brood sizes.

Cover may also be an important factor since it can shield nests from wind or rain and limit excessive nocturnal radiation loss or excessive diurnal heat-gain from solar radiation (Walsberg 1985).

Protection from thermal extremes may be the most important factor in nest-site selection by medium- and large-sized raptors where nest predation is low (Newton 1979, Janes 1985). At higher latitudes, the timing of breeding in these birds should be important, since early breeders are faced with more severe climatic conditions than those species which begin nesting later in spring.

If prey are not evenly dispersed throughout the landscape, raptors should select nest sites closest to the best hunting areas in order to reduce time and energy connected with foraging. Thus, local variation in the availability of food may influence the nest-site selection (Janes 1985), and explain interspecific differences in nesting habitat.

In Fennoscandia, four raptor species hunt and nest in forest-dominated landscapes. The European Sparrowhawk (*Accipiter nisus*; mean body mass male 150 g, female 260 g) is the main predator on small birds (Sulkava 1964a, Selås 1993), while the Northern Goshawk (*A. gentilis*; mean body mass male 870 g, female 1330 g) primarily feeds upon larger bird species and mammals (Höglund 1964, Sulkava 1964b, Widén 1987, Selås 1989). The Common Buzzard (*Buteo buteo*; mean body mass male 740 g, female 1100 g) is a generalist predator that responds functionally to changes in populations of its vole (*Microtus* spp.) prey (Suomus 1952, Spidsø and Selås 1988), while the Honey Buzzard (*Pernis apivorus*; mean body mass male 750 g, female 910 g) mainly feeds on the larvae and pupae of social hymenoptera species (Holstein 1944, Hagen and Bakke 1958, Itämies and Mikkola 1972).

Several authors have described nest sites used by sparrowhawks (Tinbergen 1946, Holstein 1950, Hald-Mortensen 1974), goshawks (Holstein 1942, Dietzen 1978, Link 1986), Common Buzzards (Holstein 1956, Knüwer and Loske 1980, Solonen 1982, Jedrzejewski et al. 1988, Hubert 1993) and Honey Buzzards (Holstein 1944, Amcoff et al. 1994) in Europe. However, no one has compared nest-site selection of sympatric populations of these species in a continuous forest habitat. My aim was to study the importance of different habitat variables on nest-site selection of these species by comparing habitat variables from plots at nest sites with those from plots placed randomly in the study area.

STUDY AREA AND METHODS

The study was conducted from 1985–93 in southern Norway (58° 43'N, 8°44'E). The study area covers about

400 km² and is situated 50–300 m a.s.l. and 10–30 km inland from the coast, in the boreo-nemoral zone (Abrahamsen et al. 1977). The climate is suboceanic, and snow usually covers the ground from December–April. The study area is hilly and sharply undulating. It is dominated by forests (80%), with scattered lakes (10%), bogs (5%) and less than 2% agricultural land. Forests are characterized by a fine-grained mosaic of young-, medium- and old-aged coniferous, mixed and deciduous stands, with Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), oak (*Quercus* spp.), aspen (*Populus tremula*) and birch (*Betula* spp.) the dominant tree species.

Forestry based on clear cutting, replanting and thinning of the regrowth was introduced to the area in the 1950s. At the time of my study, approximately 30% of the area had been clear-cut, with most regeneration <20 yr. The area is divided into numerous small ownerships with management of forests controlled by each of the land owners. Most of the properties are managed to provide a mosaic of forest types. Thus, there is a heterogeneous environment on a small scale, but a homogeneous, fragmented environment on a large scale.

The study area was searched for nest sites each year (cf. Forsman and Solonen 1984), and habitat variables were described at one nest site in each nesting territory located. If possible, the nest site used in 1988 was selected. In territories where the 1988 nest was not found, I usually described the nest site used in 1989. Alternatively, the nest site used closest in time to 1988 or 1989 was described. The breeding density of goshawks increased during the time of the study. To get a larger number of nest sites of this species, I first selected one nest site from each of the nesting territories used since 1985. Then, I selected one nest site in each of the 11 new nesting territories established during 1986–88, even though these territories substituted five of the existing ones. Since the goshawks in the five old territories had all been illegally shot by game keepers, I regarded the data to be independent. Thus, I described a total of 48 nest site plots of the sparrowhawk, 30 of the goshawk, 50 of the Common Buzzard, and 21 of the Honey Buzzard.

Control plots were described during 1989. Aerial photographs of the study area taken in spring 1989 (scale 1:15000) were covered by a grid with 100 numbered intersections of which two were randomly selected as control plots. Out of 122 selected points, 80 (65.6%) were located in forests >20 yr old and 25 (20.5%) were in forests <20 yr old (clear-cuts and regrowth), while 9 (7.4%) were on lakes, 4 (3.3%) on bogs, and 4 (3.3%) on agricultural land or developed areas. Measurements were made only in control plots in habitats apparently suitable for raptors (i.e., forests >20 yr old, $N = 80$).

Each of the nest site plots and the control plots covered 0.1 ha within a circle with a radius of 17.8 m. In nest site plots, the nest was in the center of the circle. The following habitat variables were used:

- 1) Site type, determined from the plant community (Kielland-Lund 1981, 1994). Plots dominated by *Barbilophozio-Pinetum* or *Vaccinio-Pinetum* were classified as sites with poor productivity, plots dominated by *Leucobryo-Pinetum*, *Eu-Piceetum myrtilletosum*, or *Populo-Quercetum* were classified as sites with intermediate productivity, and plots dominated by *Melico-Piceetum typi-*

Table 1. Test results (upper, right) and *P*-values (lower, left) of correlation analyses of habitat variables from randomly-sampled control plots (*N* = 80). Categorical variables were tested against each other by use of contingency table analysis (χ^2 value given) and against continuous variables by use of Mann-Whitney U-test (two categories, U-value given) or Kruskal-Wallis test (more than two categories, H-value given), while continuous variables were tested against each other by use of Spearman rank correlation (correlation coefficient given).

	SITE TYPE	FOREST TYPE	FOREST AGE	TREE DENSITY	SLOPE	ASPECT	ALTITUDE CATEGORY
Site type (3 categories)		40.60	5.78	28.51	9.70	4.97	5.52
Forest type (5 categories)	<0.01*		1.79	18.12	22.17	11.25	17.30
Forest age (continuous)	0.06	0.77		-0.26	0.01	770.5	2.79
Tree density (continuous)	<0.01*	<0.01*	0.02*		0.13	775.5	7.67
Slope (continuous)	<0.01*	<0.01*	0.91	0.25		778.0	4.00
Aspect (2 categories)	0.08	0.02*	0.81	0.85	0.87		1.30
Altitude category (3 categories)	0.24	0.03*	0.25	0.02*	0.14	0.52	

* Statistically significant.

cum, *Melico-Quercetum*, *Alno incanae-Prunetum padi* or *Ulmo glabrae-Tilietum cordatae* were classified as sites with the highest productivity.

- 2) Forest type, defined according to % pine and spruce trees with diameters >7 cm at breast height (DBH, 1.3 m above ground). Pine forest was >50% pine and spruce with pine >67%. Mixed coniferous forest was >50% pine and spruce with pine and spruce ≤67%. Spruce forest was >50% pine and spruce with spruce >67%. Mixed forest was 25–50% pine and spruce. Deciduous forest was <25% pine and spruce.
- 3) Forest age, defined as the mean age of four trees judged to represent the age of all trees with DBH >7 cm. Ages were measured using an increment borer at breast height.
- 4) Number of trees, regardless of species with DBH >7 cm.

- 5) Slope, measured from 0–100°.

- 6) Aspect, defined as one of two categories: north (1–100°, 301–400°) or south (101–300°). Nest-site plots and control plots with slopes <5° were omitted.

- 7) Altitude, defined as three altitude possible categories in relation to the altitude variation within a radius of 1 km from the plot. Plots were assigned to the lower altitude zone if situated in the lower third of the altitude difference between the lowest and highest point within this area. Middle and upper altitude zones were assigned correspondingly.

When considering the randomly-sampled control plots, several of the habitat variables were highly correlated (Table 1). To control for the effect of these correlations when comparing nest site plots and control plots, I used likelihood-ratio tests (SAS 1994) in a logistic regression model, with nest-site plots and control plots as responses and all habitat variables as explanatory variables (cf. Manly et al. 1993).

RESULTS

Site Type and Forest Type. Of sparrowhawk nest-site plots, none were on sites with poor productivity, 66.7% were on intermediate sites and 33.3% in the highest productivity sites. Corresponding values for goshawk nest-site plots were 16.7%, 73.3% and 10.0%; for Common Buzzard 16.0%, 60.0% and 24.0%, and for Honey Buzzard 0.0%, 57.1% and 42.9% compared to 42.5%, 47.5% and 10% for control plots. When controlling for effects of correlations between all habitat variables, there was a significant difference between Honey Buzzard nest-site plots and control plots, while the other species did not differ from the control plots (Likelihood-ratio tests, Table 2).

The distribution of goshawk nest-site plots in different forest types differed significantly from that

Table 2. Results (*P*-values) from Likelihood-Ratio tests in a logistic regression model with nest-site plots and randomly-sampled control plots (*N* = 80) as responses, and all habitat variables as explanatory variables. *R*² is the proportion of variation that is explained by the logistic regression model.

HABITAT VARIABLES	SPARROW- HAWK (<i>N</i> = 48)	GOSHAWK (<i>N</i> = 30)	COMMON BUZZARD (<i>N</i> = 50)	HONEY BUZZARD (<i>N</i> = 21)
Site type	0.58	0.80	0.54	0.004*
Forest type	0.38	0.023*	0.23	0.35
Forest age	0.94	0.027*	0.39	0.50
Tree density	<0.001*	0.013*	0.15	0.10
Slope	0.82	0.98	<0.001*	0.31
Aspect	0.92	0.06	0.037*	0.05
Altitude category	0.53	0.47	0.20	0.59
<i>R</i> ²	0.90	0.27	0.34	0.47

* Statistically significant.

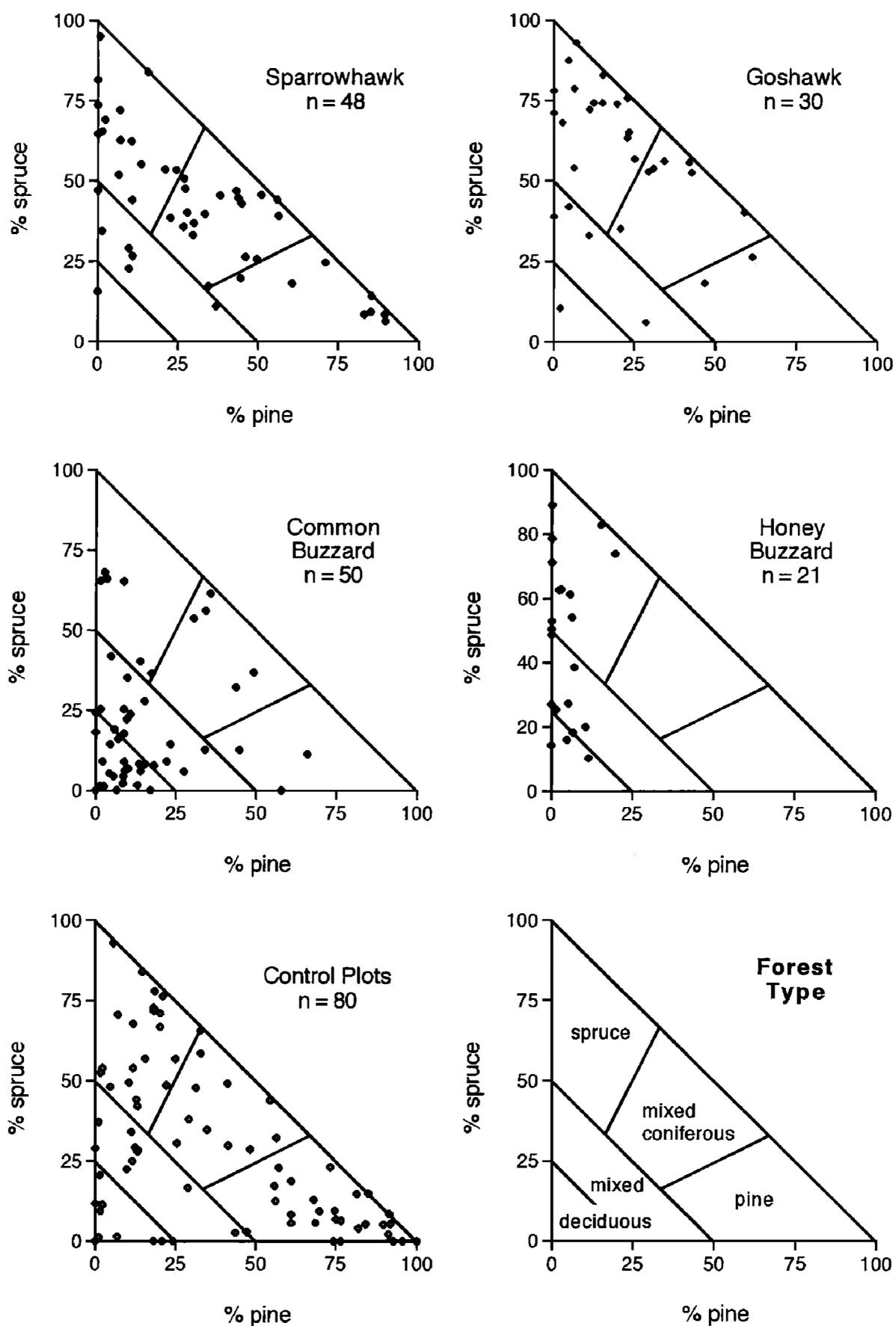


Figure 1. Distribution of nest-site plots of European Sparrowhawks, Northern Goshawks, Common Buzzards and Honey Buzzards, and randomly-selected control plots on different forest types. Forest types were defined according to the frequency of pine and spruce among all trees >7 cm in breast height (1.3 m above ground). The size of each plot is 0.1 ha.

of control plots, with a higher proportion of nest sites in spruce forests (Table 2, Fig. 1). Sparrowhawk, Common Buzzard and Honey Buzzard nest-site plots did not differ from control plots with respect to forest type when effects of correlations be-

tween habitat variables were adjusted for (Likelihood-ratio tests, Table 2, Fig. 1).

Forest Age and Tree Density. The mean forest age was 36.8 ± 18.5 (SD) yr in nest-site plots of sparrowhawks, 99.3 ± 19.1 yr in those of goshawks,

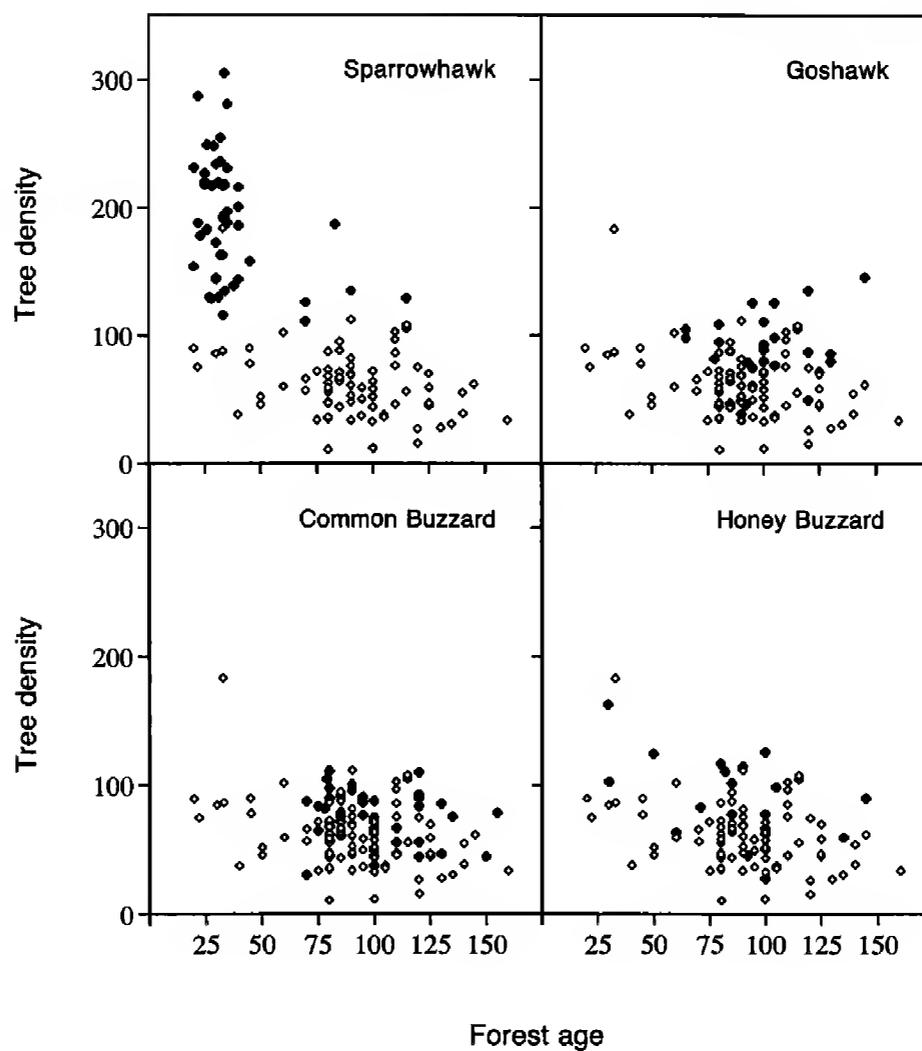


Figure 2. Forest age and number of trees (>7 cm in breast height) in nest-site plots of European Sparrowhawks, Northern Goshawks, Common Buzzards and Honey Buzzards (solid squares), and in randomly-selected control plots (open squares). The size of each plot is 0.1 ha.

98.5 ± 20.4 yr in those of Common Buzzards and 86.7 ± 28.3 yr in those of Honey Buzzards. When using likelihood-ratio tests, only nest sites of goshawks differed significantly from control plots, where the mean forest age was 90.7 ± 29.0 yr (Table 2, Fig. 2).

The mean number of trees was 190.4 ± 47.7 in nest-site plots of sparrowhawks, 84.9 ± 27.7 in those of goshawks, 73.3 ± 19.9 in those of Common Buzzards and 86.4 ± 33.4 in those of Honey Buzzards. The number of trees in nest-site plots of sparrowhawks and goshawks was significantly higher than in control plots, where the mean number of trees was 62.3 ± 26.3 (Likelihood-ratio tests, Table 2, Fig. 2).

Topographical Variables. The mean slope was $8.6 \pm 5.6^\circ$ in nest-site plots of sparrowhawks, $15.1 \pm 9.1^\circ$ in those of goshawks, $28.6 \pm 13.3^\circ$ in those of Common Buzzards, $16.3 \pm 7.2^\circ$ in those of Honey Buzzard and $15.0 \pm 10.5^\circ$ in control plots. Only nest sites of Common Buzzards differed significantly from control plots (Likelihood-ratio tests, Table 2, Fig. 3).

Sparrowhawk nest sites were on south-facing slopes 34.1% of the time while 63.3%, 76.0%, 33.3% and 53.8% of goshawk, Common Buzzard, Honey Buzzard, and control plots were on south-facing slopes, respectively. Only nest sites of Common Buzzards were on south-facing significantly more than control plots (Likelihood-ratio tests, Table 2, Fig. 3).

None of the nest sites of the four raptor species differed significantly from control plots in terms of their altitude (Likelihood-ratio tests, Table 2, Fig. 4).

DISCUSSION

Site Type and Forest Type. Only the Honey Buzzard showed a significant preference for nesting in sites with the highest productivity. This finding agreed with that of Amcoff et al. (1994). Unlike other raptor species, Honey Buzzard males do not provision females with food during the egg-laying and incubation period (Holstein 1944), possibly because their prey are too small to be profitably transported to the nest. Because of small size of its prey, short

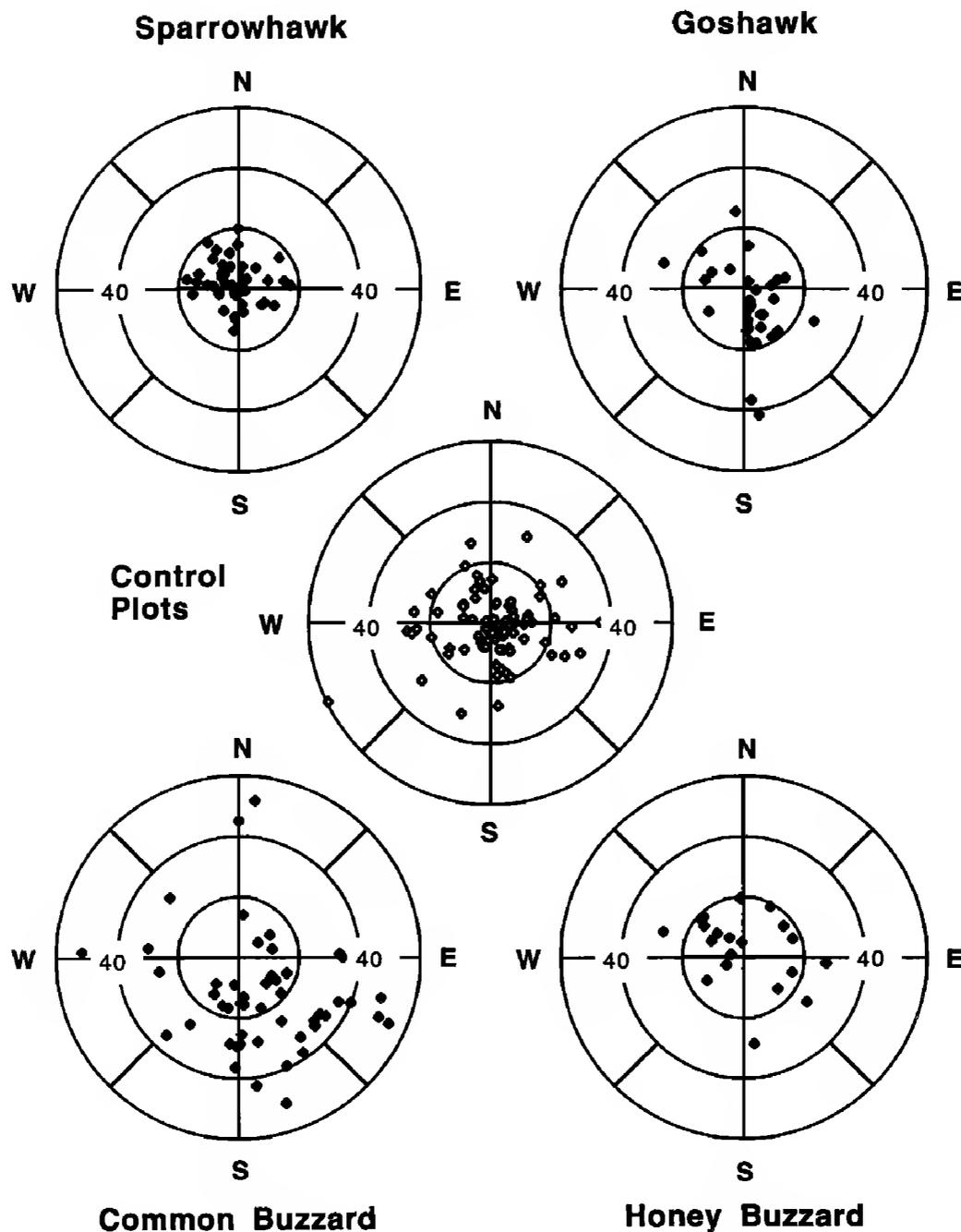


Figure 3. Slope ($0-100^\circ$) and aspect (NE, SE, SW, NW) of nest-site plots of European Sparrowhawks, Northern Goshawks, Common Buzzards and Honey Buzzards. The distance from the origin reflects the slope while the direction reflects the aspect of the plot. The size of each plot is 0.1 ha.

distances between nesting and foraging areas during incubation may be especially valuable for this species. Highly productive forests may be important for Honey Buzzards because they support high densities of juvenile passerines (Tiainen 1981, Helle 1985, Stokland 1994) which appear to be important prey in early stages of the breeding season (Amcoff et al. 1994). These forests also support high biomass of invertebrates (Birkemoe 1993, Stokland 1994) on which Honey Buzzards may also rely.

Preference for forest type was significant only for the goshawk, which selected spruce forest for nesting. This preference may be related to the larger number of important winter and spring prey species such as squirrels (*Sciurus vulgaris*, Andrén and Delin 1994), Hazel Grouse (*Bonasa bonasia*, Swenson and Angelstam 1993), and Capercaillie (*Tetrao*

urogallus, Swenson and Angelstam 1993) in spruce forest. However, preference for spruce may simply be related to the fact that it gives the best cover and thus the best protection against the main predator of the goshawk, the Eagle Owl (*Bubo bubo*, Utendörfer 1952, Mikkola 1983).

Forest Age and Tree Density. Goshawk nest sites were situated in older forests than control plots. Old forest is an important hunting habitat for the goshawk (Widén 1989) and it provides large trees for nest building (Dietzen 1978, Anonymous 1989, Siders and Kennedy 1996, Squires and Ruggiero 1996). Goshawk nests were also found in forests with a higher tree density than control plots. Goshawks may reduce the risk of predation by nesting in dense forests, since Eagle Owls prefer to hunt in open or semi-open landscapes (Mikkola 1983).

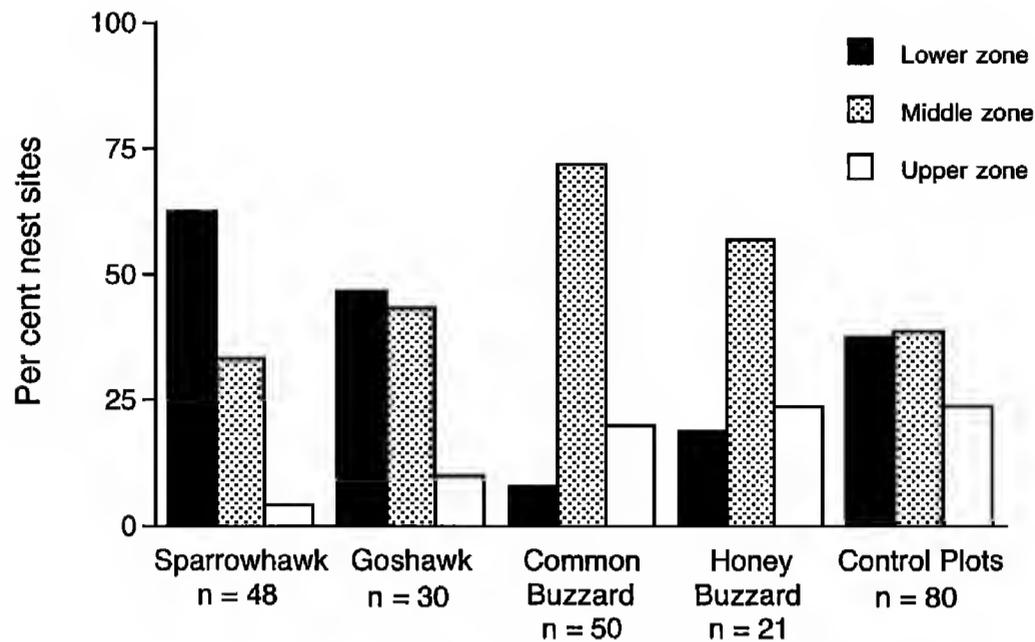


Figure 4. The distribution of nest-site plots of European Sparrowhawks, Northern Goshawks, Common Buzzards and Honey Buzzards, and of randomly-selected control plots by altitude categories. A plot was assigned to the lower altitude zone if situated in the lower third of the altitude difference between the lowest and highest point within 1 km from the plot, to the middle zone if situated in the middle third of this altitude difference, and to the upper zone if situated in the higher third.

For the smallest species investigated, the sparrowhawk, the only variable that discriminated between nest-site plots and control plots was tree density. I obtained similar results after a thinning experiment, where the reuse of nest stands in thinned young forests was lower than of nest stands in young forests not thinned (Selås 1996). Placement of nests in dense forest could hardly be profitable with respect to food of sparrowhawks, because the density of passerines is usually low here (Haapanen 1965, ødegaard 1982, Glowacinski and Weiner 1983, Helle 1985). Probably, predation is the most important aspect in the nest-site selection of sparrowhawks (Selås 1996), since its main predators, goshawks and pine martens (*Martes martes*), both prefer mature forest rather than young, dense forest when hunting (Pulliainen 1984, Widén 1989, Storch et al. 1990). Actually, dense forest seems to be less important as nesting habitat for the sparrowhawk when the goshawk is absent (Bomholt 1983, Newton 1986, Tømmeraas 1994). Pine martens will probably find raptor nests easy, because of the smell from pellets and prey remains. Since the pine marten is also known to remember different sites of food resources (Sonerud 1985), it is likely to be familiar with most of the old raptor nests within its home range. This may be one reason for why sparrowhawks rarely use nests for two successive years, unlike goshawks and Common Buzzards which are probably less vulnerable to pine marten predation due to their large size.

Goshawks and pine martens are also important predators of Honey Buzzard nestlings (Kostrzewa 1991). The Honey Buzzard seems to prefer spruce, which gives best cover, as nest trees (Amcoff et al. 1994). In contrast to the other species studied, Honey Buzzards are usually silent when disturbed by humans at the nest site (Holstein 1944, Hagen 1952, Kostrzewa 1985). Rather than selecting nesting habitats to avoid nest predation, Honey Buzzards appear to behave as cryptically as possible at the nest site, possibly because they are less efficient than other raptors in defending their nests against predators. In addition, low annual mortality and low clutch size of the Honey Buzzard (Holstein 1944, Kostrzewa 1985, Tjernberg and Rytman 1994) may make nest defense less profitable than for Common Buzzards and goshawks.

Topographical Variables. The only species which showed any preference for slope was the Common Buzzard, which usually nested in steep terrain. Similar results have been found for the Red-tailed Hawk (*Buteo jamaicensis*, Titus and Mosher 1981, Speiser and Bosakowski 1988). Flight energetics may be more favorable on steeper slopes for larger soaring raptors like eagles and large Buteos (Speiser and Bosakowski 1988). It may however also be important that these broad-winged species can best escape, or attack, predators in this habitat. Even though the Common Buzzard is able to rob prey from the goshawk (Fischer 1980, Jørgensen 1983), its breeding success has been found to be nega-

tively correlated with the distance to goshawk nests (Kostrzewa 1991). One reason for the difference in nest-site selection between the Common Buzzard and goshawk may be that the goshawk, which is better adapted for flight and foraging in dense forest, is more dangerous to Common Buzzard in dense forest.

Common Buzzards also preferred nest sites with southern aspects. There was also a tendency for a higher percentage of nest-site plots of goshawks to have southern aspects than expected, while those of Honey Buzzards tended to have northern aspects. Common Buzzards and goshawks start their breeding nearly one month earlier than sparrowhawks and more than one month earlier than Honey Buzzards (Forsman and Solonen 1984), at a time of the year when the temperatures may still be far below freezing in southern Norway. Nests of both species were most often found at sites with a southeastern aspect, which are the first heated by the morning sun when nest building occurs (Holstein 1942, 1956). Also in Alaska, goshawks have been found to favor southern slopes (McGowan 1975), while in more temperate areas, southern exposures are avoided (Dietzen 1978, Reynolds et al. 1982, Moore and Henny 1983, Link 1986, Speiser and Bosakowski 1987). A similar pattern has been observed for nest sites of Golden Eagles (*Aquila chrysaetos*, Mosher and White 1976, Pfaff 1993).

In Central Europe, Common Buzzards place their nest near forest edges (Knüwer and Loske 1980, Spitzer 1980, Hubert 1993), probably because they hunt from perches in open areas or from forest edges (Widén 1994). In my study area, open areas were usually covered by snow when Common Buzzards arrived to breed, making the field vole (*Microtus agrestis*), which is the most important prey species in this habitat (Hansson 1978, Spidsø and Selås 1988), nearly unavailable (Hansson 1982, Sonerud 1986). Early snow-free areas available for vole hunting in the spring are found on southfacing slopes and in steep terrain, where Common Buzzard nests are usually found.

Goshawks, Common Buzzards and Honey Buzzards rarely used nest sites with southwestern aspect, possibly because too much sun may be harmful to newly-hatched nestlings (c.f. Holstein 1942, Hald-Mortensen 1974, Reynolds et al. 1982, Link 1986). Unless there is good shelter, as in the dense young forests used by sparrowhawks, nest sites with a southwestern aspect are probably unprofitable regardless of when egg-laying begins.

The observed interspecific differences in nest-site selection between the raptor species investigated may be explained by interspecific differences in body size and flight performance, nest-predation risk, time of breeding and feeding habits. The risk of predation probably affects nest-site selection or breeding habits of all these species, but mostly sparrowhawks and Honey Buzzards which were most vulnerable to nest predation. Common Buzzards, goshawks, and Honey Buzzards also showed nest-site preferences which could be explained as an adaptation to microclimate. For these three species, nest-site selection could also be connected to the availability of food in the early stage of the breeding season. These species may have a broader habitat choice and it is possible that factors other than the habitat variables I selected for study may have been of importance. This may have been especially true for the goshawk, which builds larger nests than the other species and may be influenced by characters directly connected to the nest tree.

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DISTRIBUTION AND SPECIES RICHNESS OF A FOREST RAPTOR COMMUNITY IN RELATION TO URBANIZATION

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ABSTRACT.—We studied the species richness and distribution of the forest raptor community in a New Jersey watershed in relation to urbanization. Raptors were systematically surveyed using high volume broadcasts of conspecific and heterospecific calls during the breeding season at a total of 81 survey stations. Ten habitat variables relevant to urbanization were measured at each survey station using topographic maps and aerial photographs. Results showed a community composed of 10 species of breeding raptors. *Buteo lineatus*, *Accipiter gentilis* and *Strix varia* showed a significant avoidance of suburban habitat, whereas *B. jamaicensis* and *Bubo virginianus* had a greater tendency to occupy such areas. Lowland habitat was significantly selected by *S. varia*, *B. lineatus* and *A. cooperii*, a habitat usually most susceptible to development in the study region. Raptor species richness showed a strong positive correlation ($r = 0.79$, $P < 0.01$) with wilderness area size. No wilderness area less than 1000 ha had more than four raptor species while four to eight species were found in areas from 1000–8000 ha. Utilization of three increasing size classes of wilderness areas showed increasing trends for *B. lineatus*, *A. gentilis* and *S. varia*, and decreasing trends for *B. jamaicensis* and *Bubo virginianus*.

KEY WORDS: *forest raptors; community; urbanization; forest fragmentation; wilderness; survey.*

Distribución y fertilidad especie de una comunidad bosque de rapaces en relación a urbanización.

RESUMEN.—Nosotros estudiamos la fertilidad de la especie y distribución de una comunidad de rapaces de bosque en una línea divisoria de dos cuencas en New Jersey en relación a urbanización. Los rapaces fueron inspeccionados sistemáticamente usando llamadas de conoespecificos y heteroespecificos transmitidas en alto volumen durante la temporada de cría en un total de 81 estaciones de inspección. Diez variables de hábitat pertinente al urbanización fueron medidas en cada estación de inspección usando mapas topográficos y fotografía aérea. Los resultados enseñaron una comunidad compuesta de 10 especie de rapaces en cría. *Buteo lineatus*, *Accipiter gentilis*, y *Stix varia* mostraron un aversión significativa al hábitat suburbio, mientras *B. jamaicensis* y *Bubo virginianus* tuvieron una tendencia mayor para ocupar tales áreas. Hábitat de tierra baja fue sensiblemente escogido por *S. varia*, *B. lineatus* y *A. cooperii* el hábitat por lo general mas susceptible para el desarrollo en el estudio de la región. La de la especie riqueza de rapaces mostró una correlación fuerte y positiva ($r = 0.79$, $p < 0.01$) con la área del tamaño del bosque. Ningún área de bosque menos de 1000 ha tuvo mas de cuatro especie de rapaces mientras cuatro a ocho especie fueron encontrados en áreas de 1000–8000 ha. La utilización de tres clases aumentando y de diferente tamaño de áreas de bosque mostraron una tendencia de aumento para *B. lineatus*, *A. gentilis* y *S. varia* y una tendencia decreciente para *B. jamaicensis* y *Bubo virginianus*.

[Traducción de Raúl De La Garza, Jr.]

Raptors are secondary and tertiary consumers so trophic theory suggests that they will be fewer in abundance and lesser in diversity than other breeding bird communities. Factors that tend to promote high species diversity in raptor communities

are high prey diversity and high habitat heterogeneity (White 1974). Conversely, forest fragmentation and reduced forest interior tend to reduce raptor community diversity (Thiollay and Meyburg 1988). In Maryland, Robbins et al. (1989) examined the effect of forest area on breeding bird communities and found at least one raptor (the Red-shouldered Hawk, *Buteo lineatus*) was impacted

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by habitat fragmentation and urbanization and qualified to be categorized as an "area-sensitive species." Titus and Mosher (1981) examined natural habitat variables of four sympatric hawk species in Maryland, but urbanization and variables associated with habitat development were not included in their analysis. Nevertheless, Red-shouldered Hawks have been shown to avoid nesting near human dwellings (Bosakowski et al. 1992a) and Northern Goshawks (*Accipiter gentilis*) nest significantly farther from paved roads and human dwellings than randomly-selected sites (Bosakowski and Speiser 1994).

In this study, we examined a wider variety of urbanization variables than previously published for forest raptors and examined their association within a diverse community of breeding raptors. Such data could provide further insight into the preservation and management of viable forest ecosystems for diverse raptor communities rather than using a single species approach.

STUDY AREA

The study was conducted in the Highlands Physiographic Region (Braun 1950) which extends southwest to northeast across the New York-New Jersey border. The study area was part of the Pequannock Watershed, which is owned and operated by the city of Newark, New Jersey. The study area includes approximately 16 100 ha and includes parts of Passaic, Morris and Sussex Counties. This hilly, mostly forested terrain is part of the Eastern Deciduous Forest Biome (Shelford 1963).

Nearly all of the Highlands forests have been previously cut or burned within the last 200 years (Ohmann and Buell 1968, Russell 1981), resulting in largely second growth forest dominated by oaks (*Quercus* spp.) and other subclimax hardwood trees (Buell et al. 1966, Russell 1981). Older forest (>100 years of age) is rare and is typically limited to small remnant stands surrounded by younger forest.

The study area includes some of the last remaining wilderness in the northern half of New Jersey. Residential and commercial development is limited to about 10% of the study area. The remaining land area is composed of a mosaic of submature second growth and mature forest, typically ranging from about 40–80 years of age. About 75% of the forest is deciduous habitat, about 20% consists of hemlock-white pine (*Tsuga canadensis*-*Pinus strobus*) stands, and 5% is mature conifer plantations. Aquatic habitats include five major reservoirs, several smaller impoundments, beaver (*Castor canadensis*) ponds, marshes, shrub swamps and wooded swamps, the latter occurring in many areas. The study area is periodically thinned, but clear-cutting/burning is not permitted. Since access to these forests is regulated by recreational permits and motorized boats are not permitted on the reservoirs, human disturbance is greatest directly adjacent to some suburban areas.

METHODS

Sampling design. The spatial design of the survey systematically covered the Pequannock Watershed study area with a grid pattern of 81 broadcasting stations, spaced at approximately 1.2 km intervals. The spacing of stations was not used to estimate population size, since this investigation was aimed solely at determining occupancy in different habitat types. The survey stations were plotted on 15 min USGS quadrangle topographic maps of the study area. Four surveys were conducted at each of the 81 broadcasting stations. Surveys were conducted on fair weather days with low wind velocity (<15 km/hr) and no precipitation. The order of sampling of calling stations was different for each of the four surveys due to weather and wind conditions, but stations in the four cardinal quadrants of the study area were worked as equally as possible to avoid regional bias.

Target species. Previous pilot studies (Benzinger et al. 1988, Bosakowski et al. 1989a) revealed 11 potentially breeding raptor species in the study area (excluding Cathartid vultures). To reduce the number of surveys required to survey these 11 species, vocalizations of 2–3 hawk or owl species were broadcast on each survey, resulting in a total of two night surveys for owls and two daytime surveys for hawks. The selection of species for each survey was based on regional nesting phenology (Bull 1964, Bosakowski et al. 1989b, Speiser and Bosakowski 1991, and Bosakowski 1990). Broadcasts were ordered from the smallest to the largest raptor, to avoid potential inhibitory effects of large raptors on the response behavior of smaller species (Call 1978). About half of the raptors responded to heterospecific broadcasts, so every species was actually sampled twice during the day (or night) at all calling stations. Furthermore, some raptors were detected by visual observations or calling prior to broadcasts on either survey, regardless of the species that were broadcast.

Broadcast vocalizations and equipment. Eastern Screech-owl (*Otus asio*), Great Horned Owl (*Bubo virginianus*), Northern Saw-whet Owl (*Aegolius acadicus*), Barred Owl (*Strix varia*), Red-shouldered Hawk, Red-tailed Hawk (*Buteo jamaicensis*) and Broad-winged Hawk (*Buteo platypterus*) vocalizations were obtained from the National Geographic Society guide to Bird Songs (Evatone Soundsheets, Inc., Clearwater, FL, 1983). Northern Goshawk, Sharp-shinned Hawk (*Accipiter striatus*) and Long-eared Owl (*Asio otus*) vocalizations were from the Peterson Field Guide records, Cornell University, Laboratory of Ornithology. A Cooper's Hawk (*Accipiter cooperii*) tape of the female alarm call was obtained from R.N. Rosenfield (Rosenfield et al. 1985).

Tapes were broadcast from a Contec portable stereo cassette tapedeck (Model V83, Japan) rated at 10 watt output with two removable speakers. The units were powered by 8 "D" cell batteries. Cassette tapes (normal bias) were broadcast at a standard volume setting, approximately 95% of full capacity, but without detectable distortion. The speakers were high fidelity, each containing a woofer and tweeter component for more accurate sound replication of calls. The two speakers were mounted back-to-back to provide bidirectional broadcasting of vocalizations at all times.

Field protocol. Two surveys were conducted at night

for the five target owl species. These surveys began at least ½ hr after sunset and were terminated by 0100 H the following morning. The first owl survey was conducted from 21 March 1989–16 April 1989 for Eastern Screech-owls, Long-eared Owls, and Great Horned Owls. Species on the second owl survey, conducted from 16 April–19 May 1989, included the Northern Saw-whet Owl and Barred Owl. Hawk surveys were conducted from at least 2 hr after sunrise to no later than 2 hr before sunset. Species included on the first hawk survey conducted from 7 April–4 May 1989 included the Red-shouldered Hawk, Northern Goshawk, and Red-tailed Hawk. The second hawk survey from 18 May–20 June 1989 included the Sharp-shinned Hawk, Cooper's Hawk, and Broad-winged Hawk.

On each survey, tape-recorded vocalizations of three raptor species were played during an 18-min period. Vocalizations of each species were recorded on cassette tape for a 3-min period followed by a 3-min period of silence. The silent period served a dual function as a listening/watching period for vocal or visual responses of raptors and also as a refractory period prior to broadcasts of the next raptor species. The double speakers were hung on low tree branches about 1.5 m above ground during broadcasts.

Macrohabitat measurements. To measure habitat at the 81 calling stations, their location was plotted on topographic maps and their position noted on aerial photographs (1:8000) taken during the winter of 1982. Habitat at each calling station was quantified in a 300 m radius circle centered on the calling station. This distance was chosen as representative habitat of the calling station as all raptors were detected within this distance and most were detected within 100 m. On aerial photographs, a dot-grid overlay was used to quantify the suburban area within the 300 m radius circle. To measure the length of paved roads and forest edge within the habitat circles, we overlaid them with a fine thread, then the thread was straightened and measured. Forest edge can be considered as any abrupt change (Small and Hunter 1989) to open habitat (e.g., field, marsh, river or lake) that are easily discernable on the aerial photographs. We measured distances to forest openings (>0.5 ha), paved roads, human habitation and wetlands (>0.5 ha) from aerial photographs using a metric ruler with a mm scale. Topographic maps were used to calculate slope (rise in elevation over 300 m baseline). For the purposes of this paper, "wilderness" was defined according to a standard operational definition supplied by Webster's Dictionary as "any uninhabited, uncultivated region." Wilderness area was calculated as the total area of contiguous, uncultivated, uninhabited habitats bounded by paved roads and/or housing developments.

Statistical analysis. A total of 10 habitat variables relevant to urbanization were used to describe the 81 calling stations. Each raptor species had a unique set of stations where they were recorded and these data sets were used to calculate habitat means and standard deviations. In order to increase the sample size for Eastern Screech-owl ($N = 3$) and Northern Goshawk ($N = 2$), two screech-owl sightings and three goshawk nests from previous years were added to the data set. These additional raptor locations occurred in the mid- to late eighties and fell

Table 1. Species richness values for breeding raptor communities studied in North America.

STUDY	AREA (HA)	NO. OF SPECIES
New Jersey (this study)	16,100	10
Utah (Smith and Murphy 1973)	20,700	11
Wyoming (Craighead and Craighead 1956)	3,100	10
Michigan (Craighead and Craighead 1956)	9,600	7
Idaho (BLM 1979)	53,200	15

well within five of the 81 habitat circles described. No additional sites were known for the Long-eared Owl which was found at only two sites, or the Sharp-shinned Hawk which was found at one site, so they were dropped from any habitat analyses.

Each species was compared to the set of stations which did not have any raptor detections during the study (unoccupied habitat, $N = 20$) to provide a measure of habitat selection. For statistical comparison, we used a non-parametric test (Mann-Whitney U-test) since some of the data were percentages or nonnormal in distribution (Zar 1974). Species richness was determined for all wilderness areas with four or more survey stations and a logistic regression curve was calculated (Excel Software, Microsoft Corp., Redmond, WA, Version 5.0) to test the strength of the relationship. To detect area relationships for individual species, wilderness areas were grouped into three size class categories (0–1000, 1000–2000 and 2000–8000 ha) for all broadcast stations. The percentage of occupied stations by a species in each size class (% usage) was subtracted from the percentage of all stations sampled (% availability) to determine habitat utilization (Johnson 1980) for each wilderness area size class. Usage is said to be selective if resources are used disproportionately to their availability (Johnson 1980). Proportions in each category were tested for increasing or decreasing trends in relation to wilderness area size using an Armitage (1955) proportion trend test.

RESULTS AND DISCUSSION

Species Richness of the Raptor Community. We compared raptor species richness of the New Jersey raptor community with studies of other raptor communities (Table 1). Of these studies, the lowest species richness was found in Michigan (Craighead and Craighead 1956) which was mostly farmland (11% wooded). New Jersey forestland and the spruce-fir-pine slopes and sagebrush benches in the Snake River of Wyoming (Craighead and Craighead 1956) had slightly higher richness but both were surpassed by Utah scrub juniper desert (Smith and Murphy 1973). Highest species richness was reported for Snake River Canyon in Idaho

Table 2. Urbanization habitat variables for sites occupied by forest raptors in a northern New Jersey watershed. Top number represents the mean and bottom number represents the SD (* = $P < 0.05$, + = $P < 0.10$). Sample size for each species given in parenthesis. GHOW = Great Horned Owl, BAOW = Barred Owl, ESOW = Eastern Screech-owl, RTHA = Red-tailed Hawk, RSHA = Red-shouldered Hawk, BWHA = Broad-winged Hawk, COHA = Cooper's Hawk, NOGO = Northern Goshawk.

VARIABLE	GHOW (16)	BAOW (27)	ESOW (5)	RTHA (22)	RSHA (9)	BWHA (16)	COHA (10)	NOGO (5)	UNOCCU- PIED HABITAT (20)
Distance to Human Habitation (m)	426.6 325.9	671.9* 488.0	778.0 659.4	477.3 411.6	888.9* 569.7	769.4 704.4	651.5 672.0	676.0+ 533.5	505.0 496.2
Number of Houses/Bldgs. (#)	4.19 7.30	1.26* 3.14	0.60 0.89	3.32 5.55	0* 0	3.06 4.35	1.20 2.25	0* 0	2.35 4.35
Suburban Area (%)	2.7 4.1	1.0+ 2.5	0.2 0.3	2.4 3.7	0* 0	2.5 3.6	0.9 1.9	0* 0	1.5 2.4
Distance to Paved Road (m)	292.8 258.0	468.0 465.6	458.0 393.9	406.6 345.9	546.1 549.9	343.8 293.5	259.0 141.0	482.0 243.0	343.8 294.4
Road Mileage (m)	404.7 620.2	299.4 321.4	64.0 143.1	367.5 528.7	206.7 226.3	269.4 330.5	352.5 380.5	78.0 174.4	268.4 294.1
Edge Length (m)	623.7 632.7	370.0 524.2	652.0 536.6	595.9 617.6	492.2 618.8	374.1 374.9	656.5 420.5	369.0 550.1	467.0 526.6
Distance to Wetland (m)	563.1 518.2	197.0+ 247.9	662.0 581.8	442.0 585.0	62.2* 49.7	360.3 377.8	252.0 203.1	164.0 207.5	369.8 333.4
Distance to Forest Opening (m)	195.0 237.3	199.7 206.2	197.0 261.5	163.9 192.2	80.6* 91.4	141.6 148.1	112.0+ 109.6	147.0 141.3	240.2 195.4
Slope (%)	6.5 4.4	6.1 4.8	10.0 4.9	6.8 4.7	5.1+ 5.3	6.9 6.3	4.4* 4.1	6.8 6.7	8.0 5.5
Wilderness Area (ha)	2291.2 2731.4	3766.9 3164.4	5094.0 3543.4	2498.2 2971.8	4388.9 3179.1	3144.0 3204.8	2271.6 2181.3	5278.0 3320.5	2729.5 2636.0

(BLM 1979) with its vertical cliffs and sagebrush desert, probably reflecting the high structural habitat diversity as a result of vertical and horizontal habitat partitioning. Overall, cultivated land of Michigan (circa 1950s farming techniques) appeared to slightly reduce raptor diversity and abundance compared to contiguous forestland in New Jersey.

Urbanization and Forest Fragmentation. Urbanization and its ultimate effect in fragmenting forests into smaller wilderness areas is an unnatural factor which reduces raptor abundance and diversity. Robbins (1979) noted the disappearance of several nesting bird species including the Broad-

winged Hawk after 30 yr of severe fragmentation. In our study area, the proximity of human habitation showed marked differences in the habitat suitability for several forest raptors. The Red-shouldered Hawk was most sensitive to human disturbance and it occupied sites significantly further from human habitation than unoccupied habitat and it showed a complete lack of suburban habitat within the 300 m radius habitat circles examined (Table 2). The Northern Goshawk had the second largest distance to human habitation ($P < 0.10$) and similarly showed a significant lack of suburban habitat within the 300 m radius habitat circles examined. Additional data from 16 Northern Gos-

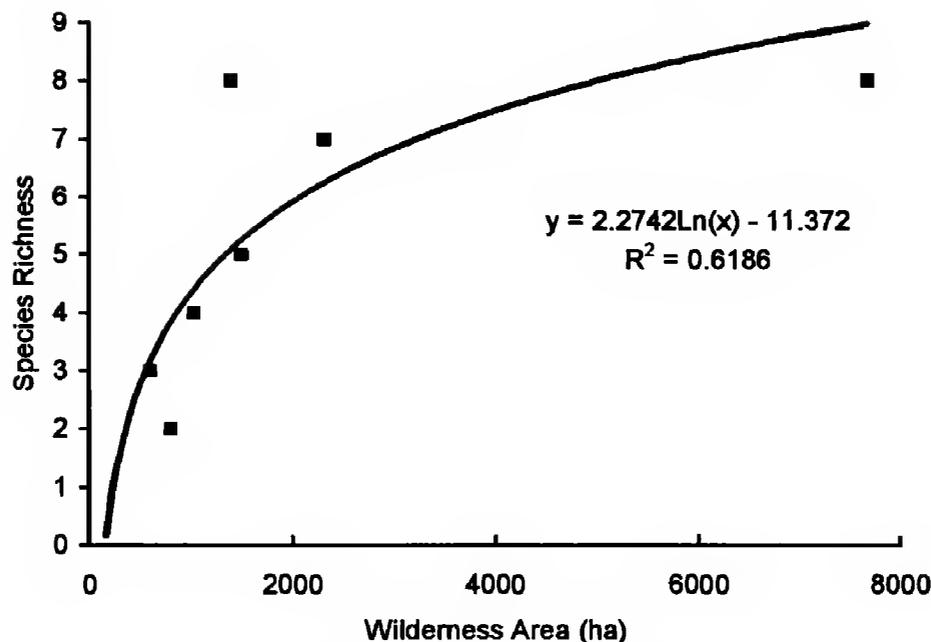


Figure 1. Species richness of forest raptors with respect to seven wilderness areas of varying size. Curve represents best-fit logistic regression function.

hawk nest sites in the study region also showed that the species nests further from human habitation and paved roads than expected (Bosakowski and Speiser 1994). In the study region, Northern Goshawk nests were significantly farther from human habitation than were Cooper's Hawk nests (Bosakowski et al. 1992c) or Red-tailed Hawk nests (Speiser and Bosakowski 1988). The Barred Owl was similar to the Red-shouldered Hawk and Northern Goshawk, occupying sites that were significantly farther from human habitation, with significantly fewer houses, and a tendency for less suburban habitat area ($P < 0.10$).

With regard to wetlands, the Red-shouldered Hawk occupied areas significantly closer to wetlands which resulted in a significantly lower slope percentage as well as a significantly closer distance to forest openings. The Barred Owl also had a tendency to be closer to wetlands ($P < 0.10$). The Cooper's Hawk occupied sites with significantly lower slope percentages and was often closer to forest openings ($P < 0.10$), but not necessarily due to a preference for wetlands since it often used suburban forest edge as well. Overall, these three lowland species had a greater vulnerability to development pressures as valley bottoms and flat terrain are generally the first areas targeted for roads, houses and commercial buildings (Tiner 1985).

Distance to paved roads, road mileage, edge length and wilderness area did not show any significant differences among any species compared to unoccupied habitat. Four species, Great horned Owl, Red-tailed Hawk, Eastern Screech-owl and

Broad-winged Hawk did not have any variables that were significantly different from unoccupied habitat, suggesting that they were less sensitive to urbanization.

Forest Area Relationships. Area-sensitive species respond negatively to decreasing forest size and show predictable declines or absence as the area of the forest shrinks (Robbins 1979, Ambuel and Temple 1983, Robbins et al. 1989). Within our study area we found a strong correlation ($r = 0.79$, $P < 0.01$) for species richness of forest raptors and increasing size of wilderness areas (Fig. 1). This is likely the result of the inclusion of area-sensitive species in large wilderness areas and their exclusion in smaller forest fragments. No area less than 1000 ha had more than four raptor species while 4–8 species were found in areas from 1000–8000 ha in size. Thiollay and Meyburg (1988) also noted a positive correlation between the size of reserves and the abundance index of diurnal raptors (Falconiformes) on the Island of Java.

When wilderness areas were grouped into size classes, several distinct trends emerged among the species. We calculated percent utilization of three wilderness area size classes and determined the probability of increasing or decreasing trends for raptors. Several species revealed increasing trends with increasing wilderness area size (Red-shouldered Hawk, $P = 0.97$; Northern Goshawk, $P = 0.84$; and Barred Owl, $P = 0.82$), whereas several species revealed decreasing trends (Red-tailed Hawk, $P = 0.95$ and Great Horned Owl, $P = 0.85$, Fig. 2). Craighead and Craighead (1956) noted

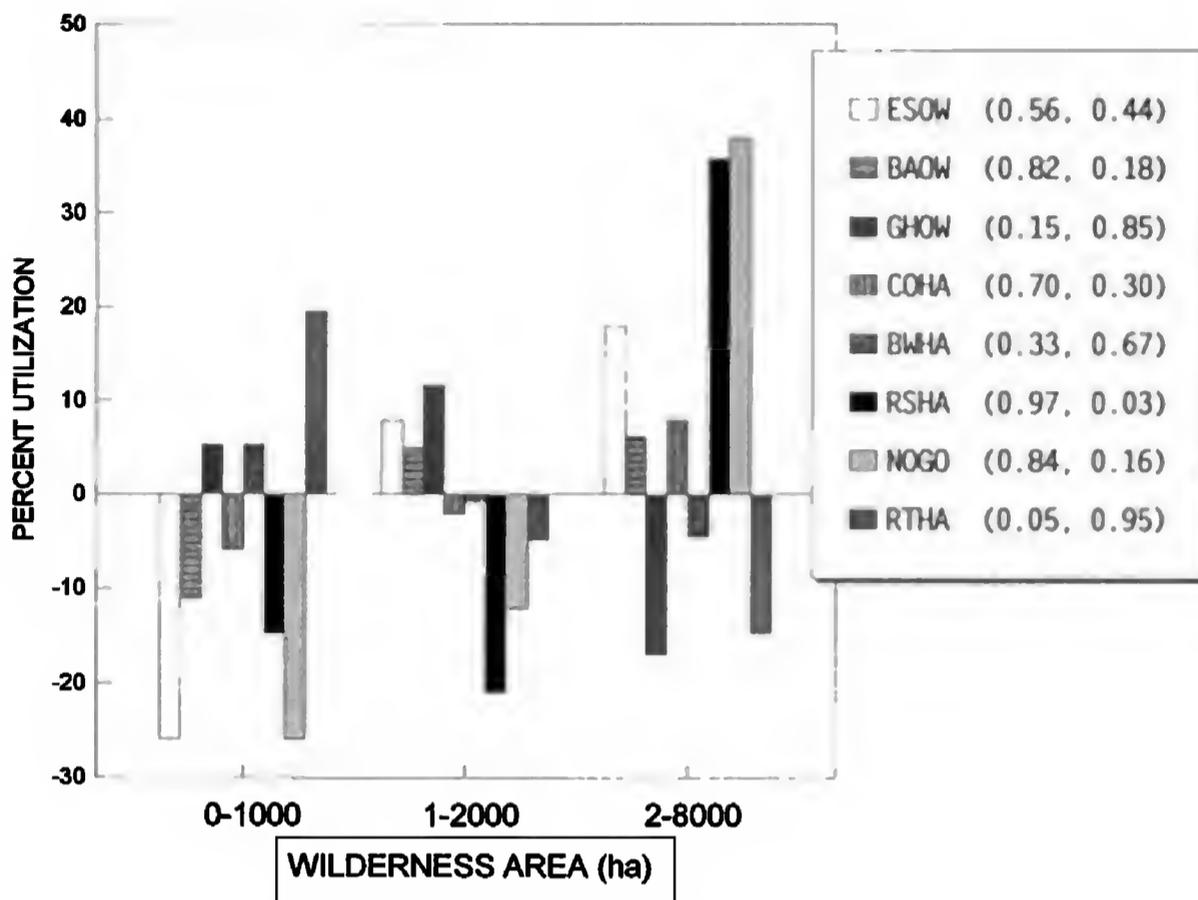


Figure 2. Relative utilization (use-availability) of different wilderness area size classes for eight sympatric forest raptor species (see Table 2 for species acronyms). Numbers in parentheses represent probability of species increasing and decreasing (I, D) in relation to wilderness area size (Proportion Trend Test—Armitage 1955).

that Red-tailed Hawks and Great Horned Owls were generalist predators and the results of this study indicate that they clearly benefit from forest fragmentation and urbanization (at least to the extent found in the study area). On the other hand, Red-shouldered Hawks, Northern Goshawks and Barred Owls usually prefer extensive remote areas of deep woods (Bosakowski 1989, Bosakowski et al. 1992a, Bosakowski and Speiser 1994).

The northern half of our study area was virtually all wilderness and contained all 10 species. However, the southern half had nearly all of the suburban areas and a four-lane highway, and was missing three species (Northern Goshawk, Sharpshinned Hawk and Red-shouldered Hawk). Results of this study predict the expansion of dominant, disturbance-tolerant Great Horned Owls and Red-tailed Hawks after forest fragmentation, and a reduction in raptor diversity.

A decrease in forest area can result in decreased bird species diversity (Lovejoy et al. 1986), disturbance to species in adjoining wetlands, reduced buffering against human disturbance and increased predation (Chasko and Gates 1982, Yahner 1988). It is also becoming increasingly clear that "edge effect" is beneficial to only a limited number of wildlife species and, by and large, it has a

strong negative impact on other members of forest communities (Robbins 1979, Wilcove et al. 1986, Yahner 1988, Robbins et al. 1989). For tropical rainforests, Thiollay (1984) found that raptors are among the first species to disappear in the process of human population growth and exploitation and are thus suitable indicators of habitat disturbance. The situation appears to be similar for temperate forests disrupted by urbanization and agriculture (Craighead and Craighead 1956).

Large raptor communities are needed as population reserves to maintain genetic diversity and to provide constant recruitment to marginal habitats (White 1974, Wilcove 1987). Results of this study suggest that only large wilderness areas (2000–8000 ha) can provide the full diversity of forest raptors necessary to stock marginal habitats. Until other data on reserve size become available, the present data could have useful management implications for conservation of Northeast forest raptors, either by regulating development and recreation, or deciding how large an area should be set aside for future reserves. In addition, further research will be needed to determine the number and distance of other reserves (Shaffer 1985, Hunter 1990) necessary to support a viable population network for each species (Wilcove 1987).

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DOES VEGETATION STRUCTURE LIMIT THE DISTRIBUTION OF NORTHERN GOSHAWKS IN THE OREGON COAST RANGES?

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ABSTRACT.—Northern Goshawks (*Accipiter gentilis*) breed in a variety of forested areas throughout the Pacific Northwest. Nevertheless, they were only first found breeding in the Coast Ranges of Oregon in 1995, despite apparently suitable habitat and abundant prey. We document the rarity of goshawks in the Coast Ranges by reviewing previous and current survey results for nests of goshawks and other forest birds since the 1960s, examining sightings of goshawks since 1980 and reporting on a survey we conducted in 1994. We suggest that nesting goshawks are rare in the Coast Ranges because of the vegetative structure of the area and its influence on prey availability.

KEY WORDS: *Northern Goshawk; Accipiter gentilis; distribution; habitat; foraging; reproduction; Oregon.*

Puede ser que la estructura de vegetación limite la distribución de *Accipiter gentilis* en la sierra costa de Oregon.

RESUMEN.—*Accipiter gentilis* se crían en una variedad de áreas de bosque en todas partes del noroeste pacífico. Sin embargo, la primera vez que los encontraron en la sierra costa de Oregon fue en 1955, a pesar de suficiente hábitat conveniente y presa abundante. Nosotros documentamos la rareza de *A. gentilis* en la sierra costa examinando anterior y corriente resultados de estudios para nidos de *A. gentilis* y otros pájaros de bosque desde los 1960s, examinando observaciones de *A. gentilis* desde 1980 y reportando un estudio que nosotros conducimos en 1994. Nosotros pensamos que los *A. gentilis* que hacen nido en la sierra costa es raro por la estructura de vegetación en el área y su influencia en la disponibilidad de presa.

[Traducción de Raúl De La Garza, Jr.]

Northern Goshawks (*Accipiter gentilis*) are distributed across northern North America and throughout forested areas of the western U.S. (Palmer 1988). They nest in a variety of forest types, including boreal, deciduous and western coniferous forests. In Oregon, goshawk nests are found throughout forested areas east of the Cascade Mountain Range, on east and west slopes of the Cascade Range, in the Siskiyou Mountains of southwestern Oregon and even in isolated stands of aspen (*Populus* spp.) in mountain draws and valleys in the

Great Basin region of southeastern Oregon (Marshall 1992). Goshawks were not known to breed in the Coast Ranges of western Oregon, even though their nests are found in all other areas of the state (Reynolds et al. 1982, Marshall 1992). Incidental sightings of goshawks have been reported in the Coast Ranges, but it was not until 1995 that two pairs of goshawks were found breeding there (Thraillkill and Andrews 1996).

Reynolds (1975, 1978) found breeding pairs of Cooper's Hawks (*Accipiter cooperii*) and Sharpshinned Hawks (*A. striatus*), but not goshawks after an extensive search of the Coast Ranges from 1968–78. He speculated that forest conditions, specifically dense understories which may interfere with a goshawk's ability to hunt, precluded goshawks from breeding in this area (Reynolds and

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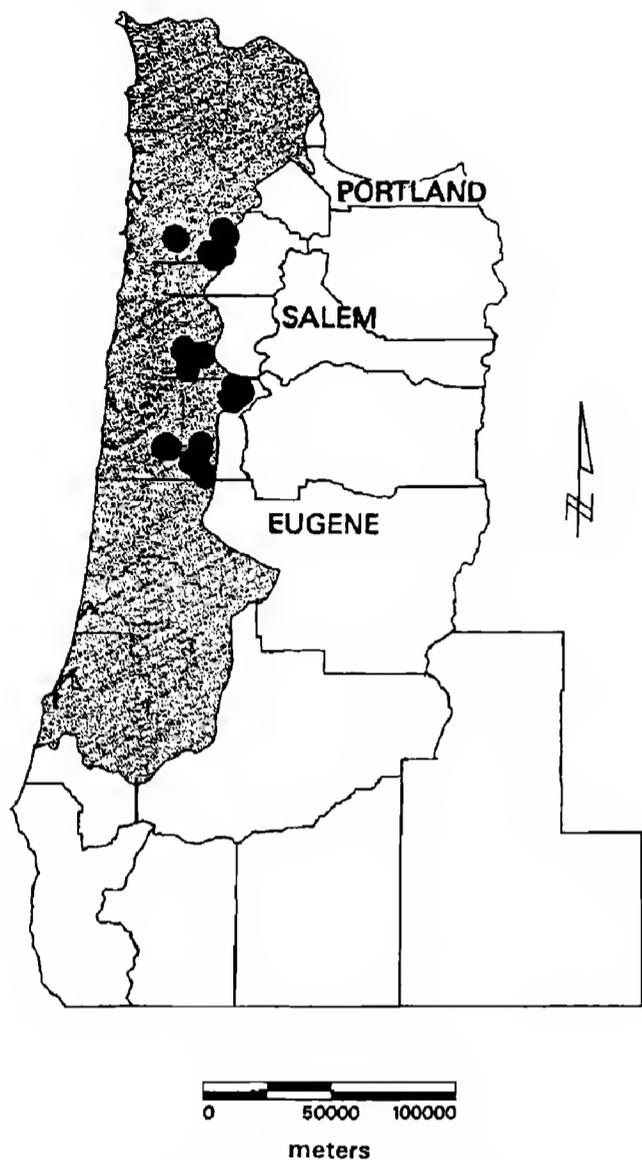


Figure 1. The Coast Ranges (shaded area) of western Oregon and areas (circles, which may represent ≥ 1 survey blocks) surveyed for Northern Goshawks during June-August 1994.

Wight 1978, Reynolds et al. 1982). No one has conducted systematic searches for goshawk nests in the Coast Ranges since, and no one has used broadcasts of goshawk vocalizations to survey for the presence of breeding pairs over large areas of the Coast Ranges (Woodbridge, USDA Forest Serv. unpubl. rep. 1990; Kennedy and Stahlecker 1993). Herein, we report results of a study conducted to document the presence of breeding Northern Goshawks and to assess vegetative conditions that might influence their distribution in the Oregon Coast Ranges.

STUDY AREA

The Coast Ranges of western Oregon lie north of the Coquille River and west of the Willamette Valley, and are separate from the Siskiyou Mountains in the southwestern corner of Oregon (Fig. 1). Topography is steep and dissected by many streams. Elevations range from sea level to 450–750 m at main ridge summits, with scattered peaks as high as 1250 m. Climate is characterized by mild,

wet winters and relatively dry summers (Franklin and Dyrness 1973).

Historically, the Coast Ranges were densely forested with sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*) (Franklin and Dyrness 1973). Most of the mature forest (>80 yr old) has been logged or burned during the past 150 yr (Franklin and Dyrness 1973). Much of what remains are stands of second-growth trees with older stands occurring as islands, fragmented by clearcut logging. As a result of these disturbances, and because of tree planting, Douglas-fir (*Pseudotsuga menziesii*) is now the major component of the forests in this area. Western hemlock and western redcedar are common coniferous species and red alder (*Alnus rubra*), vine maple (*Acer circinatum*) and bigleaf maple (*A. macrophyllum*) are common hardwood species (Franklin and Dyrness 1973, Forsman et al. 1996b).

METHODS

Goshawk Surveys. We surveyed for Northern Goshawks in 24 survey blocks, totaling 3285 ha (range 60–335 ha) during June–August 1994. Surveys covered the east and west slopes of the Coast Ranges and included federally administered public lands, the MacDonald-Dunn State Forest managed by Oregon State University and areas originally searched by Reynolds (1975, 1978). To maximize the potential for locating nesting goshawks, survey blocks were chosen based on our knowledge of goshawk nesting habitats (DeStefano et al. 1994), past sightings of goshawks, recommendations from agency biologists familiar with local conditions and habitat and examination of aerial photographs and topographic maps to determine accessibility of potential goshawk habitat. Whenever possible, older (>80 yr), larger contiguous forested blocks were surveyed. Because we were more interested in documenting the presence of breeding goshawks rather than calculating an unbiased estimate of nesting density, we focused on areas with the greatest potential for nesting habitat, based on the published literature and our experience in Oregon. We did, however, survey a variety of forest types and seral stages.

We used taped vocalizations of Northern Goshawks to elicit responses from adults and juveniles (Woodbridge, USDA Forest Serv., unpubl. rep. 1990; Kennedy and Stahlecker 1993); the adult alarm call was used during the nesting period in June–July, and both adult alarm and juvenile begging calls were used during the post-fledging period in July–August. Road and foot transects were first delineated on maps and aerial photographs. Foot transects were 200 m apart with broadcast stations every 300 m; stations along adjacent transects were staggered (Joy et al. 1994). Broadcast stations on roads were 250 m apart. At each station, vocalizations were broadcast in three directions (60°, 180°, and 300°) for 10 sec, with 30 sec between each call. This procedure was conducted at each station by one or two observers. Presence, location and behavior of raptors were recorded.

Historical Sightings. To document past sightings of goshawks in the Coast Ranges, we searched records and data bases compiled from 1980–1995 by state and federal land management and conservation agencies and local bird-watchers. We assessed the reliability of these sightings

and categorized them as 1 (questionable = observer had no or little experience identifying birds, or experience could not be assessed), 2 (reliable = experienced birder) and 3 (confirmed = experience observing raptors, professional biologist). Records were searched for date observed, behavior of adults, presence of immatures and other clues that might indicate reproductive activity. We also questioned biologists who have been conducting extensive surveys for Northern Spotted Owls (*Strix occidentalis*) and Marbled Murrelets (*Brachyramphus marmoratus*) in the Coast Ranges for the past 10–15 yr (see Nelson and Sealy 1995 and Forsman et al. 1996a for background and methods).

Vegetation Surveys. We examined vegetation in the 24 survey blocks for forest stand structure and composition, understory conditions and landscape patterns. Stand canopy structure, % canopy cover and tree species were recorded from ground surveys and aerial photos. After conducting ground assessments at each survey block, we then used a Geographic Information System (GIS) to calculate % cover of forest type and amounts of mature (>80 yr) and second-growth forest in survey blocks. We recorded the presence and % cover of dominant understory plant species at each survey site. Understory vegetation was classified into six associations, according to Franklin and Dyrness (1973), and represented a gradient from dry to wet conditions. These associations were (1) ocean-spray-salal (*Holodiscus discolor-Gaultheria shallon*) association found in dry, relatively open sites, (2) Pacific rhododendron-Oregon grape (*Rhododendron macrophyllum-Berberis nervosa*) found on dry, exposed ridgetops, (3) big huckleberry-beargrass (*Vaccinium membranaceum-Xerophyllum tenax*) on shallow, stony soils at high elevations, (4) vine maple-salal in cool, moist sites with moderately dense tree cover, (5) swordfern (*Polystichum munitum*) in moist sites associated with mature overstory conditions, and (6) swordfern-Oregon oxalis (*Oxalis oregana*) along streamside slopes.

RESULTS

Goshawk Surveys. We found no Northern Goshawks in the entire 3285 ha survey area. However, we did find two Sharp-shinned Hawks, seven Red-tailed Hawks (*Buteo jamaicensis*) and two unidentified raptors (too small to be goshawks). We also found two small, unoccupied accipiter nests (probably Sharp-shinned Hawks built in previous years).

Vegetation Surveys. Of the 24 survey blocks covered, 23 were dominated by a Douglas-fir overstory. The one remaining block was a fire-regenerated stand dominated by noble fir (*Abies procera*); this site was undisturbed by logging, except for access roads. For all 24 survey blocks combined, 63% of the area was in older (>80 yr) Douglas-fir with 85% canopy cover, 24% was conifer-hardwood mix (Douglas-fir, western hemlock, western redcedar, red alder, vine and bigleaf maple) with $\leq 65\%$ canopy cover, 7% was open mixed conifer (Douglas-fir, western hemlock, western red cedar) with

$\geq 65\%$ canopy cover, 3% was young (<80 yr) Douglas-fir with $\geq 85\%$ canopy cover, 2% was older Douglas-fir with $\leq 30\%$ canopy cover, and 1% was clearcut areas, meadows or water.

Ground cover within the survey blocks was dominated by understory types 4 and 5; these two types were present in 20 and 14 of the 24 stands, respectively. Vine maple, salal and swordfern were the most common species overall, and each survey block, with the exception of the stand of noble fir, had a dense shrub layer with 45–100% ground cover ($\bar{x} = 81\%$, SE = 3%, N = 23). Twenty-three of the 24 blocks were previously disturbed by logging and fire.

Historical Sightings. Records of previous sightings indicated that goshawks have been seen throughout the Coast Ranges every year, and during each month in any given year, for the past 15 years (Table 1), with apparent peaks in sightings in the spring and fall (Fig. 2). This would coincide with dispersing or migrating hawks. Numbers of observations were low, however, and prior to 1995, no confirmed evidence of reproductive activity had been documented. Few reports have described aggressive, territorial behavior or repeated sightings of adults in a particular area during the breeding season. Goshawk sightings in the Coast Ranges have been much lower than for other parts of the state (Fig. 3).

DISCUSSION

Determining the “absence” or rarity of a species in a geographic region, and whether or not this is meaningful ecologically, can be a difficult task, especially when the species is normally secretive and present in low densities. At least two elements are involved in making this determination. The first is that large-scale searches (both spatially and temporally) must be conducted because occupation of habitat by a species can vary over space and time (Morris 1987, Block and Brennan 1993, DeStefano et al. 1994, Keane and Morrison 1994). Our survey for goshawks over a single breeding season is obviously inadequate to address this concern, but coupled with surveys in the 1960s and 1970s, the consistent and widespread searches for Northern Spotted Owl and Marbled Murrelet nests during the 1970s-90s, and the reports of birdwatchers and agency biologists for the past 15 years, the temporal and spatial scope of the search for goshawk nests in the Coast Ranges has been broad.

The second element involves a determination,

Table 1. Sightings of Northern Goshawks, grouped by year, in the Coast Ranges of western Oregon, 1980–95. Only records by experienced agency biologists or birders (levels 2 and 3; see text) were used. Unknown age or behavior indicates observer was unsure or information was not reported.

YEAR	AGE			OBSERVED BEHAVIORS	SOURCE ^a
	ADULT	IMM.	UNK.		
1995	4	5	0	2 nests located on BLM lands	BLM, OCWRU
1994	3	1	5	Hunting, calling, respond to owl tape, fly-by	Private, OCWRU, BLM
1993	1	0	5	Unknown	OB 19:57, BLM, ONHP, Private
1992	3	1	2	Fly-by, perched, soaring, unknown	OCWRU, BLM, Private
1991	0	0	2	Unknown	BLM, Private
1990	3	0	5	Near spotted owl nest, chasing spotted owl, unknown	OB 16:94,185, BLM, Private
1989	1	0	1	Fly-by, unknown	BLM, Private
1988	1	1	2	Unknown, soaring	Private
1987	1	2	2	Unknown, aggressive interaction with red-tailed hawk	OB 13:232,314, Private, Crannel and DeStefano 1992
1986	0	0	2	Unknown	OB 12:212
1985	0	0	6	Unknown	USFS, Private
1984	1	2	1	Unknown, soaring	Private
1983	0	0	2	Unknown	OB 10:130, Private
1982	0	0	4	Unknown	Private
1981	0	0	4	Unknown	Private
1980	0	0	2	Unknown	Private

^a Source codes: BLM = Bureau of Land Management; OB = various issues (vol.:page) of the journal *Oregon Birds* (individual issues not listed in Lit. Cited); OCWRU = Oregon Cooperative Wildlife Research Unit; ONHP = Oregon Natural Heritage Program; Private = records of private individuals; USFS = U.S. Forest Service.

probably on both objective and subjective bases, that a species is absent from a region because important components of the habitat are lacking. Otherwise, the absence of a species from a region is meaningless. Our contention is that the absence, or at least rarity, of nesting goshawks in the Coast Ranges of western Oregon is an interesting phe-

nomenon, and one that suggests something about vegetation structure on the distribution of this species.

The Northern Goshawk has been called a forest habitat generalist (Reynolds et al. 1992). The location of the Coast Ranges of western Oregon in relation to the geographic range of the goshawk in North America, and the general forest conditions (mixture of mature and second-growth coniferous forest and openings) that exist there, appear to indicate that the Coast Ranges should be part of the breeding range of this species. Rarity is common along the geographic boundaries of a species' range, yet goshawks nest in areas north, south, and east of the Coast Ranges.

Why is there a gap in the breeding range of this species and what is it about the Coast Ranges of Oregon that prevents goshawks from nesting there? It could be related to climate. The Coast Ranges receive 150–300 cm of annual rainfall (Franklin and Dryness 1973), much of it falling during the spring breeding season. However, Northern Goshawks breed commonly on the

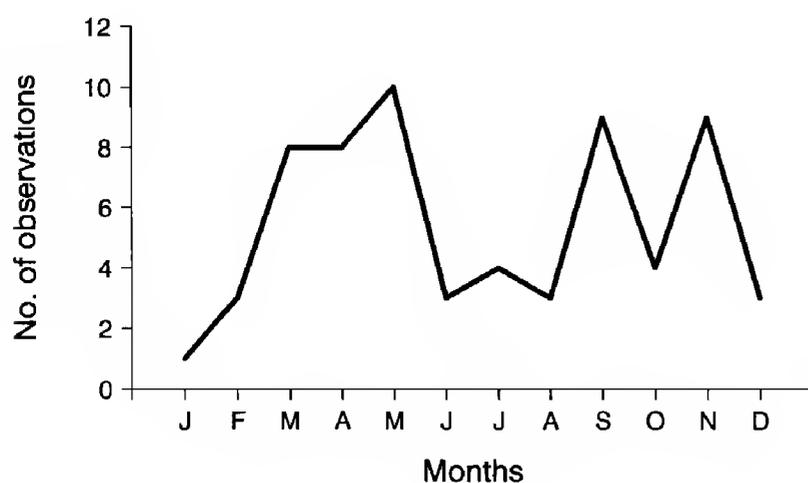


Figure 2. Distribution of Northern Goshawk sightings by month, consolidated for the years 1980–95, in the Coast Ranges of western Oregon. Adults and young from two nest sites located in June 1995 are not included.



Figure 3. Relative abundance of Northern Goshawks by county in Oregon, based on records of the Oregon Audubon Society and Oregon Department of Fish and Wildlife. Abundance ratings are common (black), occasional (dark gray), rare (light gray), and unknown (white). Note that coastal regions of Lane and Douglas Counties would likely be rated as having rare (light gray) sightings of goshawks, but both counties are rated as occasional (dark gray) because large portions of each reach into the Cascade Mountain foothills and range, where goshawks are seen more often.

Olympic Peninsula of Washington (E. Forsman pers. comm.) and in southeastern Alaska (K. Titus pers. comm.), where annual precipitation equals or exceeds levels received in Oregon's Coast Ranges.

A second possibility might involve predation or competition from other raptors. Great Horned Owls (*Bubo virginianus*) and Red-tailed Hawks frequently interact with Northern Goshawks and often use their nests (Moore and Henny 1983, Crannell and DeStefano 1992, Rohner and Doyle 1992). It is unlikely, though, that this form of predation and/or competition is more intense in the Coast Ranges than other parts of the goshawks' geographic range.

The third explanation involves vegetation structure as it relates to prey availability. Goshawks tend to hunt in the ground-shrub and shrub-canopy zones of the forest (Reynolds and Meslow 1984). A dense shrub layer is characteristic of most forest areas of the Coast Ranges and disturbances such as logging and fire have decreased mature overstory canopy closure, allowing more sunlight to reach the ground. These conditions, coupled with high levels of rainfall, have resulted in increased under-

story stem densities and dense, lush undergrowth on many sites (Franklin and Dyrness 1973). Prey, which are varied and abundant in the Coast Ranges, include such species as snowshoe hares (*Lepus americanus*), brush rabbits (*Sylvilagus bachmani*), Douglas squirrels (*Tamiasciurus douglasii*), Ruffed Grouse (*Bonasa umbellus*), Mountain Quail (*Oreortyx pictus*), Northern Flickers (*Colaptes auratus*) and other woodpeckers, and Stellar's and Gray Jays (*Cyanocitta stellari* and *Perisoreus canadensis*, respectively). Many of these prey species may be difficult for goshawks to capture because of the dense understory conditions that exist throughout most of the Coast Ranges (Reynolds and Meslow 1984). In addition, the larger biomass prey species (lagomorphs, grouse) may be more important to breeding goshawks than smaller prey (jays, woodpeckers) (Reynolds et al. 1992), and low availability of larger prey may depress reproductive potential (Alaska Dept. Fish and Game 1993). Dense understory conditions would make the larger, ground-dwelling species more difficult to capture (Reynolds et al. 1992).

Others have found the distribution of raptor foraging to be inversely related to the density of plant cover (Southern and Lowe 1968, Wakely 1978, Baker and Brooks 1981, Bechard 1982, Collopy and Bildstein 1987). Preston (1990) summarized these findings by describing raptor hunting distribution as a function of both prey abundance and availability, which in turn is a function of a suite of environmental factors, including habitat characteristics (e.g., vegetation structure). In fact, suitable foraging habitat may be more important than nesting habitat in determining the distribution of goshawks in boreal forest (Widén 1989). The importance of prey in the distribution and management of northern goshawks has been emphasized in the management guidelines of Reynolds et al. (1992).

If a relationship between vegetation structure and availability of prey does indeed exist, then the forest conditions present in the Coast Ranges of Oregon may limit prey availability to goshawks and thus prevent or depress reproductive activity, despite potentially suitable nesting substrate and adequate populations of prey.

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FOOD HABITS OF THE LANNER FALCON (*FALCO BIARMICUS FELDEGGII*) IN CENTRAL ITALY

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ABSTRACT.—The diet of the Lanner Falcon (*Falco biarmicus feldeggii*) was studied in an area of central Italy for one yr. Diet composition differed according to the methodology used for data collection with mammals, small passerines and insects found more frequently or exclusively in pellets. Conversely, analysis based on pluckings and observations of prey taken to the nest indicated the diet consisted of only nonpasserine and large passerine birds. Overall, the birds including European Starling (*Sturnus vulgaris*), Green Woodpecker (*Picus viridis*), and Jay (*Garrulus glandarius*) were the most common prey taken by Lanner Falcon. Mammals taken included wood mouse (*Apodemus* sp.), common dormouse (*Muscardinus avellanarius*) and Savi's pine vole (*Microtus savii*).

KEY WORDS: Lanner Falcon; *Falco biarmicus*; diet; feeding ecology; Italy.

Habitos alimenticios del *Falco biarmicus feldeggii* en la región central de Italia.

RESUMEN.—La dieta del *Falco biarmicus feldeggii* fue estudiada durante un año en un área de la región central de Italia. Se observó que la composición de la dieta variaba de acuerdo con la metodología utilizada para la recolección de datos, de tal manera que se encontraron pequeñas aves passerinas, mamíferos e insectos más frecuentemente o exclusivamente en las egagrópilas. Por el contrario, al analizar la presa en el nido y al realizar desplumamiento, se halló que la dieta consistía únicamente de aves no passerinas y grandes passerinas. Sobre todo aves como *Sturnus vulgaris*, *Picus viridis*, *Garrulus glandarius*, fueron la presa más común de *F. biarmicus feldeggii*. Los mamíferos incluidos en la dieta eran *Apodemus* sp., *Muscardinus avellanarius* y *Microtus savii*.

[Traducción de Agustina Lanusse]

The European subspecies of the Lanner Falcon (*Falco biarmicus feldeggii*) is limited in its distribution to southern Italy and the Balkans with a population estimated to be just a few hundred pairs (Gensbøl 1992). There are <60 pairs in the Italian peninsula but, in Sicily, the population consists of >80 pairs (Massa et al. 1991). In Tuscany, central Italy, five breeding pairs are known in a 8300 km² area, with a density of 1 pair/1660 km².

The biology of the Lanner Falcon in Europe is poorly studied (Cramp and Simmons 1980). Most work has been done on the African subspecies (Cade 1965, Maclean 1984, Goodman and Haynes 1989, 1992) and very few studies have been conducted in the Mediterranean area (Mebis 1959, Bonora and Chiavetta 1975, Massa et al. 1991). Lanner falcons nest on cliffs, making it difficult to

find perches and roosts where food remains may be collected for dietary studies (Massa et al. 1991, Chiavetta 1992). Apart from studies conducted in Sicily (Mebis 1959, Massa et al. 1991), no detailed research has been done so far on the food habits of Lanner Falcons. Herein, we present results of an analysis of the diet of a pair of Lanner Falcons in central Italy based on remains collected at plucking areas and the nest site and observations of prey delivered to the nest.

STUDY AREA

The study was conducted in a rural area named "Crete Senesi" in Tuscany, central Italy, at 200–300 m elevation. The climate of the area is temperate, locally subarid, with an average annual temperature of 18°C. It is very hilly, open and eroded at the bases of hills which has created an abundance of small clay/sand cliffs ranging from 10–

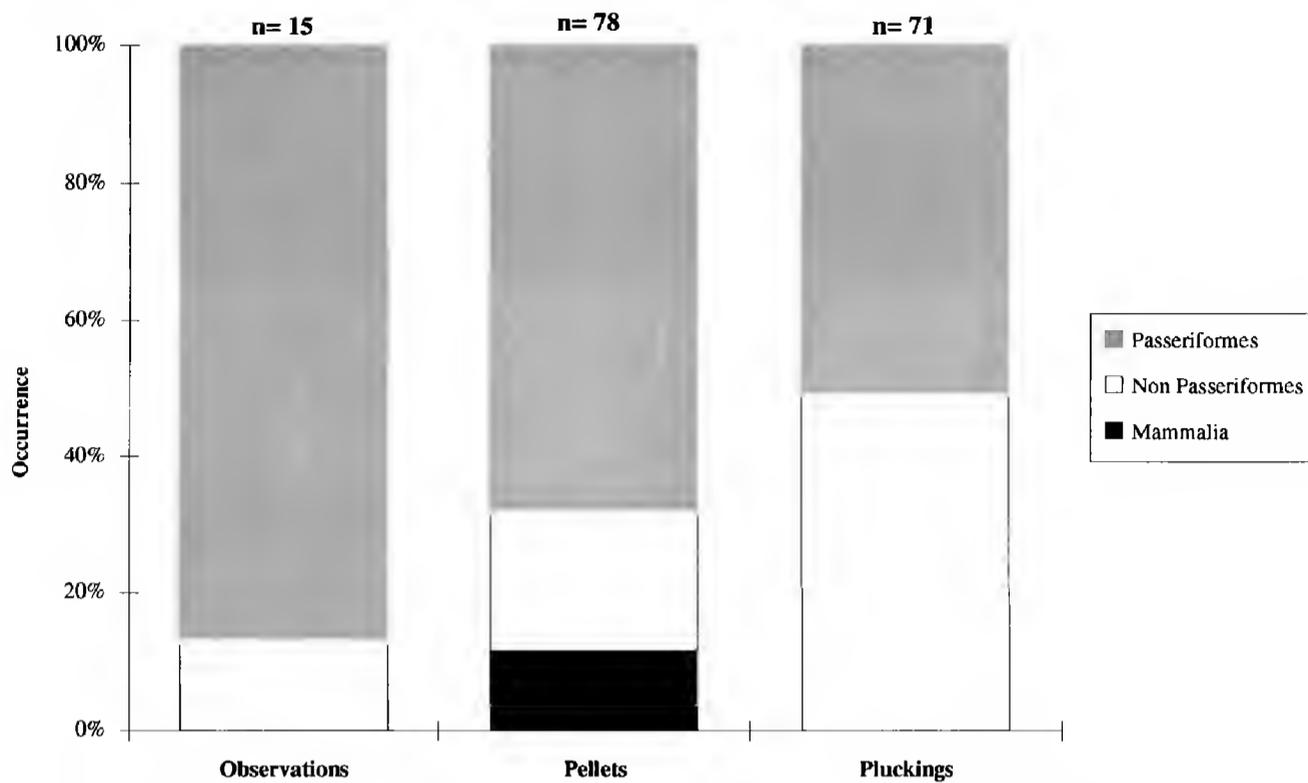


Figure 1. Composition of the diet of Lanner Falcons during the breeding season (December–June) using three different methods: direct observations of prey taken to the nest, pellets, and plucked remains. Numbers above the bars refer to sample size for each method.

40 m in height. These small cliffs are used for nesting by Lanner Falcons (Morimando et al. 1994). The vegetation of the area is dominated by pastureland with small oakwoods (*Quercus pubescens*) interspersed with cereal crops and small patches of olive trees (*Olea europea*).

METHODS

We observed a pair of Lanner Falcons through two reproductive seasons from spring 1994–summer 1995. We made direct observations on prey brought to the nest and we collected prey remains at the bases of nest cliffs. By watching activity patterns, we also found two main perches where the falcons plucked and ate their prey. From June 1994, we collected prey remains at these perches twice a month by searching the ground carefully under each perch. Prey were often identified in the field based on feathers and fresh remains. Remains that were not readily recognized as well as pellets were examined using a dissecting microscope and remains were identified using museum specimens and identification guides (Brown et al. 1987, Svensson 1992). We also used taxonomic keys (Chaline et al. 1974) and a sample of specimens collected locally to compare bones and skeletal remains.

We calculated the % occurrence and % biomass of each prey category in the diet based on each of the three methods. Prey biomass was determined based on the average weight of prey taxa reported in the literature (Cramp 1977–94, for birds; Macdonald and Barret 1993, for mammals). We calculated the mean prey weight (MPW) using the formula: Total Biomass/Total Numbers of each prey species.

RESULTS

We observed the nest 16 times for a total of 96 hr. We also collected plucked remains 26 times and

collected 59 pellets under perches. Altogether, we identified 15 prey items delivered to the nest, 78 prey items from pellets, and 71 prey items from plucked remains (Table 1). The mean number of prey per collecting event was 0.94 prey for observations, 1.32 for pellets and 2.73 for pluckings.

Direct observations at the nest showed that passerine birds were delivered to the nest more frequently than nonpasserines (Table 1). Although most of these birds were not identified, the main prey species taken to the nest appeared to be the European Starling (*Sturnus vulgaris*) and Blackbird (*Turdus merula*). The MPW of prey brought to the nest was 121 g (SE = 38.27). During nest observations, we twice saw the male storing small prey in a cliff hole that was used as a cache.

Nearly identical percentages of passerines and nonpasserines were identified from plucked remains (Table 1). The MPW of prey based on this type of analysis was 182.01 g (SE = 216.94), considerably larger than that of prey taken to the nest ($t = 2.47$, $df = 20$; $P < 0.02$). Based on this type of analysis, the main prey were Green Woodpecker (*Picus viridis*), Jay (*Garrulus glandarius*) and European Starling. Most of the biomass in the Lanner diet was from nonpasserines of which the Green Woodpecker was the largest and most frequently taken species.

Bone fragments in pellets were small and diffi-

Table 1. Numbers (N), percentage of biomass (%B) and percentage of occurrence (%O) of prey items in Lanner Falcon diet in Tuscany, Italy, according to collecting methods.

PREY ITEM	PELLETS			PLUCKINGS			OBSERVATIONS		
	N	%B	%O	N	%B	%O	N	%B	%O
MAMMALS									
<i>Muscardinus avellanarius</i>	1	0.38	1.28	0	0	0	0	0	0
<i>Apodemus</i> spp.	3	0.96	3.85	0	0	0	0	0	0
<i>Microtus savii</i>	1	0.38	1.28	0	0	0	0	0	0
<i>Rodentia</i> ind.	4	0.9	5.13	0	0	0	0	0	0
Total mammals	9	2.62	11.54	0	0	0	0	0	0
BIRDS									
<i>Falco tinnunculus</i>	0	0	0	4	6.19	5.63	0	0	0
<i>Phasianus colchicus</i>	0	0	0	2	10.83	2.82	1	38.57	6.67
<i>Columba livia</i>	3	11.49	3.85	7	16.25	9.86	1	16.53	6.67
<i>Columba palumbus</i>	1	5.74	1.28	1	3.48	1.31	0	0	0
<i>Streptopelia turtur</i>	1	19.1	1.28	3	3.48	4.23	0	0	0
<i>Athene noctua</i>	0	0	0	1	1.08	1.41	0	0	0
<i>Apus apus</i>	0	0	0	1	0.31	1.41	0	0	0
<i>Picus viridus</i>	11	35.10	14.10	16	30.95	22.54	0	0	0
Total nonpasserines	16	54.24	20.51	35	72.58	49.30	2	55.10	13.33
<i>Alauda arvensis</i>	0	0	0	2	0.57	2.82	0	0	0
<i>Turdus merula</i>	6	6.13	7.69	1	0.62	1.41	3	13.22	20
<i>Turdus philomelos</i>	0	0	0	3	1.58	4.23	0	0	0
<i>Garrulus glandarius</i>	0	0	0	11	14.47	15.49	0	0	0
<i>Pica pica</i>	3	6.89	3.85	3	4.18	4.23	0	0	0
<i>Corvus monedula</i>	0	0	0	0	0	0	1	10.74	6.67
<i>Sturnus vulgaris</i>	37	28.33	47.44	11	5.11	15.49	5	16.53	33.33
<i>Emberiza calandra</i>	0	0	0	1	0.29	1.41	0	0	0
<i>Anthus pratensis</i>	0	0	0	1	0.14	1.41	0	0	0
<i>Passeriformes</i> ind.	7	1.79	8.97	3	0.46	4.23	4	4.41	26.67
Total passerines	53	43.14	67.95	36	27.42	50.70	13	44.90	86.67
Total birds	69	97.38	88.46	71	100	100	15	100	100

cult to recognize. Nevertheless, this form of analysis showed that mammals also occur in the diet of the Lanner Falcon (Table 1). Mammals identified were wood mouse (*Apodemus* spp.), common dormouse (*Muscardinus avellanarius*) and Savi's pine vole (*Microtus savii*). Also, some pellets were made solely of insects remains, mainly Formicidae and small Coleopterans. A careful inspection of pellets showed that most insects were inside the gizzard remains of Green Woodpeckers and Starlings. Passerines were the most frequent prey found in pellets, but nonpasserine species accounted for slightly more biomass using this method of analysis. Main prey species represented in the pellets were the European Starling, Green Woodpecker and Blackbird. The MPW in pellets was 100.44 g (SE =

163.01) which was smaller than the MPW found in pluckings ($t = 2.80$, $df = 20$; $P < 0.01$).

Medium-sized passerines ($\bar{x} = 98.41$ g) and large nonpasserines ($\bar{x} = 268.70$ g) were the primary species found in plucked remains. In pellets, mammals ($\bar{x} = 22.71$ g) and mainly passerines of small size ($\bar{x} = 63.70$ g) were present. Small passerines ($\bar{x} = 62.69$ g) and few nonpasserines of large size ($\bar{x} = 265.62$ g) were taken to the nest. The differences among plucked remains, pellets and direct observations as to the three main categories of prey found (passerines, nonpasserines and mammals), were highly significant ($\chi^2 = 13.46$, $df = 4$, $P < 0.009$).

DISCUSSION

We concluded that use of a single method to determine the diet of Lanner Falcon biases the re-

sults. Data from plucking sites provided more information about diet composition per searching effort than other collecting methods. Pellets are also important because they provided more complete information on the composition of prey, especially that of mammals and insects. Direct observations of prey taken to the nest appear to be unnecessary since they add little to quantitative information on the Lanner Falcon's diet. The use of plucking data alone may result in overestimates of large- and medium-size birds, as generally longer and heavier feathers fall directly beneath the perches, while the light feathers of small birds tend to disperse (e.g., in the wind). Analysis of pellets alone tends to overestimate the amount of small passerines and mammals. Lanner Falcons generally swallow small birds almost entirely, whereas they tear flesh and feathers from larger birds. This probably accounts for the high frequency of small passerine remains found in pellets. We feel that it would be best to evaluate information obtained from all the collecting methods to most accurately assess the diet of Lanner Falcons.

We found the diet of Lanner Falcon in central Italy to be qualitatively different from that of Lanner Falcon in other areas. Birds comprised 88–100% of the diet in our study area depending on the method of diet analysis used. These results were consistent with those of Cramp and Simmons (1980), except we found for the first time that Green Woodpecker is taken by Lanners. We also confirmed that they eat small mammals but that they do not appear to eat reptiles and insects as reported by Massa et al. (1991). In Sicily, birds (90.4%), reptiles (4.1%) and mammals (2.7%) are in the diet of Lanners (Mebs 1959), with Jackdaw (*Corvus monedula*), Lesser Kestrel (*Falco naumanni*) and feral Pigeon (*Columba livia*) preyed upon the most. Magpie (*Pica pica*) and Spanish Sparrow (*Passer hispaniolensis*) are also preyed upon in Sicily (Massa et al. 1991) and small mammals and reptiles account for only a small percentage of the diet (4% and 2.3%, respectively).

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NESTING DISTRIBUTION AND POPULATION STATUS OF U.S. OSPREYS 1994

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ABSTRACT.—Ospreys (*Pandion haliaetus*) once nested throughout most of the U.S. The decline in this population due to biocide use has been well documented, as has its recovery following the U.S. ban on DDT in 1972. A general increase in the nesting distribution and abundance of Ospreys was reported in the U.S. in 1981 but there was limited dispersal into states with low or extirpated populations. We conducted a nationwide nesting survey of nesting Ospreys in 1994, updating the 1981 data. Our data indicate a dramatic increase in the U.S. Osprey population from ~8000 nesting pairs in 1981 to ~14 200 in 1994. The most dramatic increases were seen in traditional nesting areas, with some new nesting in the interior U.S. Hacking projects, construction of reservoirs, nest platform management and increased public relations have contributed to the growth of this nesting population.

KEY WORDS: *Pandion haliaetus*; *Ospreys*; *population status*; *limiting factors*; *dispersal*; *management*.

RESUMEN.—Aguila pescadoras (*Pandion haliaetus*), anidaba comunmente en la mayor parte de los EE.UU. hasta que sus poblaciones fueron afectadas severamente debido al uso de insecticidas. Sin embargo, después de la prohibición del uso de DDT en 1972, la especie parece estar recuperandose. En 1981, se reportó un incremento general en la distribución de sitios de nidación y abundancia de la especie. Sin embargo, la recuperación parece ser menor en los estados en los que las poblaciones fueron mas afectadas o extirpadas. En este estudio, reportamos el resultado de un muestreo nacional de nidos de Aguila Pescadora, que realizamos en 1994 y que reemplaza los datos de 1981. Nuestros datos indican un incremento dramático en las poblaciones del Aquila de ~8000 pares anidando en 1981 a ~14 200 in 1994. Los incrementos mas dramáticos fueron observados en áreas tradicionales de nidación, y en algunos sitios nuevos en el interior de los EE.UU. Proyectos de reintroducción, construcción de presas, implementación de plataformas de nidación, y un mejor entendimiento del problema por parte del público, han sido factores importantes que han contribuído a la recuperación de la especie.

[Traducción de Jorge Vega Rivera]

Ospreys generally occur along rivers, lakes, sea coast bays and estuaries, reservoirs, small streams and ponds, or any body of water where fish, their principal food, are available (Poole 1989a). Historical data, though limited, indicate that Ospreys once nested in suitable habitats throughout most of the contiguous U.S., but their numbers were never equally distributed throughout the country. Records suggest that the Central States Region (Fig. 1) had the smallest population, which was nearly extirpated by the early 1900s. The entire U.S. Osprey population declined precipitously throughout the 1950s, 60s and early 70s, a result of widespread use of chlorinated hydrocarbon insecticides and habitat destruction (Ames and Mer-

sereau 1964, Ames 1966, Peterson 1969, Postupalsky 1969, Henny and Ogden 1970). The population was "Redbook listed" under "rare and endangered fish and wildlife of the U.S." and classified as "status undetermined" by the U.S. Fish and Wildlife Service in 1966 and 1968 (Henny 1977).

Henny (1983) conducted a comprehensive survey of the distribution and abundance of the entire U.S. Osprey population in 1981. His research indicated a general increase in the overall population, with limited dispersal into states with low or extirpated populations. This population enhancement was primarily the result of greater reproductive output after the U.S. ban on DDT in 1972. The slow dispersal rate was principally a consequence of high natal site fidelity, especially for males (Spitzer et al. 1983). Such slow, limited dispersal forced hacking methods as a means of restoration in areas with low or extirpated populations. In the

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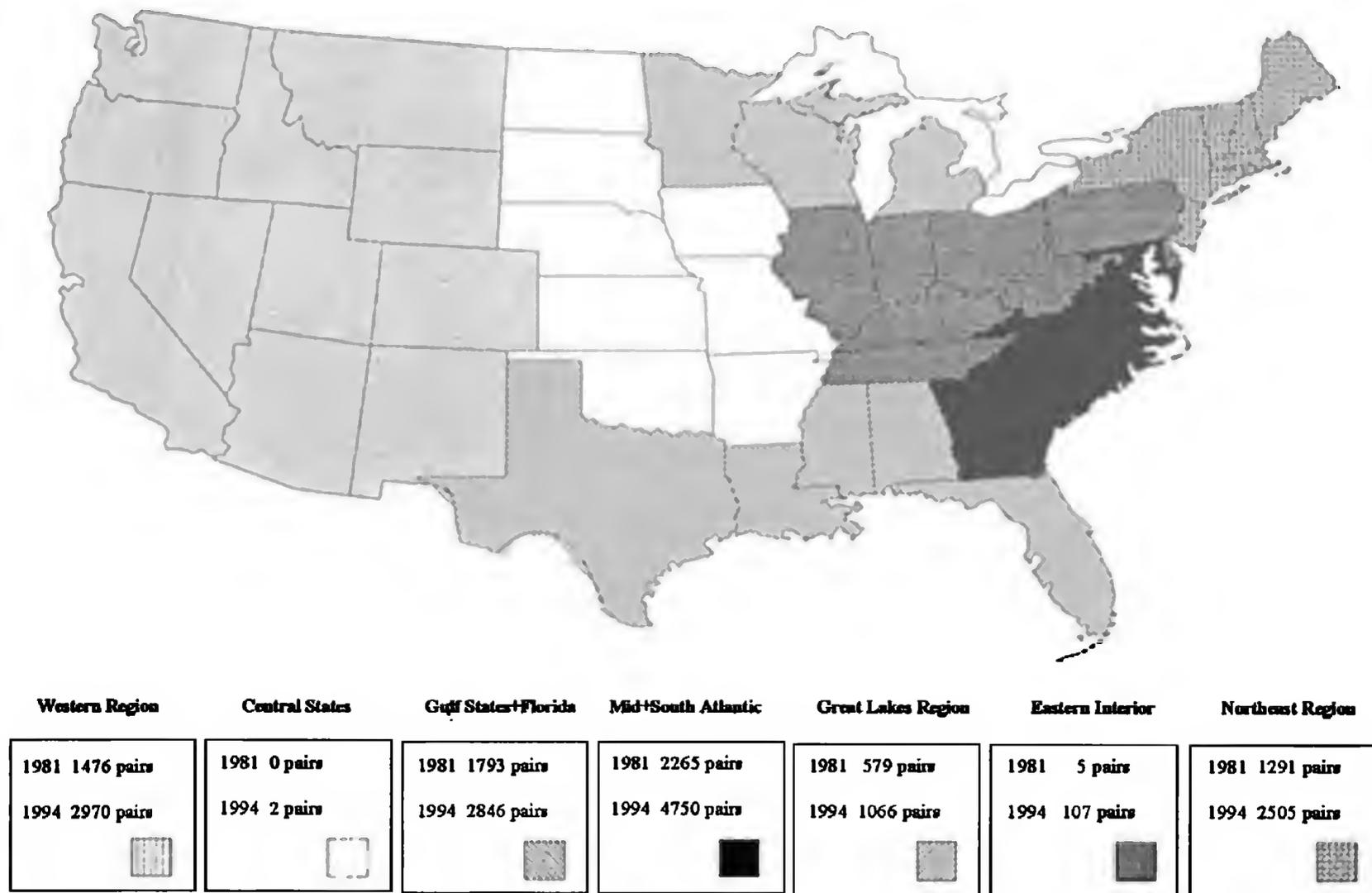


Figure 1. U.S. Osprey regions (1994).

late 1970s and early 1980s, Pennsylvania, New York and Tennessee began programs to restore low or extirpated populations (Hatcher and Hammer 1983, Schaadt and Rymon 1983).

Our objectives in this study were: 1) to survey 48 states for information concerning the general trend of U.S. Osprey nesting populations, 2) to compare the 1994 and 1981 distribution and abundance of U.S. nesting Ospreys, 3) to examine any changes in population numbers and range expansion that may have occurred since 1981, and 4) to suggest continued management options.

METHODS AND MATERIALS

Data on the U.S. Osprey population were obtained from professional sources in each of the lower 48 states. Biologists from state and federal agencies and individual Osprey researchers were contacted by telephone or in person. A follow up questionnaire, state distribution map and completed sample questionnaire was sent to each of the contacted individuals. Survey questions addressed the distribution, abundance, historical data, nesting preferences, reproductive success and hacking status of the U.S. Osprey population. State breeding bird atlases and other published and unpublished sources were also reviewed, as were state bird books, for information on the historical population and broad population and dispersal

patterns and trends. To provide an estimate of the completeness of nesting data, we completed a list of nesting survey methods used by each state (some states had no recent surveys) (Table 1).

For purposes of evaluation, Henny (1983) divided the entire U.S. Osprey population into five regional populations: Pacific Northwest, Western Interior, Great Lakes Region, Atlantic Coast, and Gulf States and Florida. An alternate approach was taken in our study. Comparable regional populations (Western Region, Great Lakes, Northeast, Mid and South Atlantic Coast, and Gulf States and Florida) were established, but additional regions (Eastern Interior and Central States) were added to examine dispersal patterns, recent population fluctuations and migratory movements between wintering and breeding areas (Fig. 1)

RESULTS AND DISCUSSION

Mid and South Atlantic Coastal Region. This region begins in Delaware Bay and encompasses all of Delaware, Maryland, the coastal plain of Virginia, North and South Carolina and Georgia (Fig. 2). It supports one of the largest concentrations of nesting Ospreys in the world (Chesapeake Bay) (Henny 1983, Poole 1989a). It is within this major estuarine system that most Ospreys in Virginia and Maryland breed. The number of nests in the Ches-

Table 1. Approximate number of Osprey nesting pairs in the U.S. (1981 vs. 1994).

STATE	NESTING PAIRS		SOURCE
	1981	1994	
Alabama	2	23 ²	R. Clay, Alabama Game and Fish
Arizona	4	25–35 ³	G. Beatty, Bald Eagle Management Coordinator
Arkansas	0	0 ⁴	K. Yaich, Arkansas
California	359 (1975)	500–700 ⁵	Ron Jurek, California Dept. of Fish and Game
Colorado	9	17 ²	J. Craig, Colorado Division of Wildlife
Connecticut	25	95 ²	J. Victoria, CT Supervisor of Wildlife Research
Delaware	56	75–85 ²	L. Galvin-Innvaer, DE Div. of Fish and Wildlife
Florida	1750	2500–3000 ⁴	Mark Westall, President TIOF
Georgia	95	225–275 ³	J. Ozier, GA Dept. of Natural Resources
Idaho	323 (1974–80)	400–425 ⁴	W. Melquist, Idaho Fish and Game Department
Illinois	0	0 ⁴	V. Kleen, Department of Conservation
Indiana	0	1 ³	J. Castrale, Indiana Nongame Biologist
Iowa	0	0 ⁴	B. Harrisman, IA Dept. of Natural Resources
Kansas	0	0 ⁴	J. Zimmerman, Div. of Biology, KSU
Kentucky	0	16 ¹	D. Yancy, KY Dept. of Fish and Wildlife Resource
Louisiana	1	10 ³	S. Shively, LA Dept. of Wildlife and Fisheries
Maine	1000	1300–1800 ⁵	D. Hudson, ME Fish and Game
Maryland	847 (1973–75)	1000–1400 ⁴	S. Cardano, MD Dept of Natural Resources
Massachusetts	32 (1980)	260 ²	B. Davis, MA Division of Fisheries and Wildlife
Michigan	123	223 ¹	S. Postupalsky pers. comm.
Minnesota	160	350–450 ²	M. Martell, UMN Raptor Center
Mississippi	40	55–65 ²	M. Woodrie, MS State Ornithologist
Missouri	0	0 ⁴	W. Crawford, Raptor Res. Tyson Research Center
Montana	149	500–600 ⁴	D. Flath, Montana Fish, Wildlife and Parks, MSU
Nebraska	0	0 ⁴	J. Dinan, NE Game and Parks Commission
Nevada	1	4 ³	G. Herron, NV Department of Wildlife
New Hampshire	8	29 ²	C. Martin, Audubon Society of New Hampshire
New Jersey	87	200 ² (1993)	C. Clark, Endangered + Nongame Species Program
New Mexico	0	2 ³	S. O. Williams III, NM Dept. of Game and Fish
New York	120	315 ²	B. Loucks, NY Endangered Species Unit
North Carolina	450 (1974)	800–1200 ⁴	R. Wilson, NC Wild Resource Commission
North Dakota	0	0 ⁴	C. Grondahl, ND Game and Fish Department
Ohio	0	1 ³	D. Case, Ohio Division of Wildlife
Oklahoma	0	0 ⁴	S. Sherrod, Dir. G.M. Sutton Avian Res. Center
Oregon	308 (1976)	675–700 ²	C.J. Henny, NBS Leader NW Research Station
Pennsylvania	0	20 ²	L.M. Rymon, Environmental Studies Dir., ESU
Rhode Island	19	44 ²	L. Suprock, Div. Fish, Wildl. and Estuarine Res.
South Carolina	151 (1979)	800–1000 ⁴	T. Murphy, South Carolina
South Dakota	0	2 ³	D. Backlandi, SD Game and Fish Department
Tennessee	5	66 ²	B. Hatcher, TN Nongame and Endangered Species
Texas	0	3 ³	B. Ortego, Biologist, TX
Utah	12	30 ³ (1995)	S. Cranney, UT Division of Wildlife Resources
Vermont	0	12 ²	S. Parren, VT Fish and Wildlife
Virginia	722 (1973–75)	1300–1500 ⁴ (1987)	Westall 1990
Washington	229	350–400 ²	K. McCallister, WA Department of Wildlife
West Virginia	0	3 ³	S. Butterworth, WVA Div. of Wildlife Resources
Wisconsin	176	391 ¹	D. Flaspohler, WN Bureau of Endangered Res.
Wyoming	82 (1974–81)	150–200 ⁴	B. Oakleaf, WY Game and Fish Department
Estimated Total	8000	12,769–15,603	

Completeness of data

¹ Both aerial and ground surveys, this percent was established by Henny et al. (1974) for the efficiency of combined aerial and ground

Table 1. Continued.

surveys and based on visibility rates.

² Less intense aerial, ground, or boat surveys (Osprey nests recorded during Bald Eagle aerial surveys, or incomplete aerial and ground surveys).

³ Intense local surveys, or only surveying/monitoring of suspected and/or traditional nesting areas.

⁴ No statewide surveys, information acquired from local biologist and/or other individuals aware of current nesting and population trends.

⁵ No statewide data available, therefore, a percent increase for regional data was determined and this percent increase was applied to the most recent statewide nesting data in order to provide a current estimate.

⁶ Very low number of nesting pairs (<15), no statewide survey (* states with <15 nests are listed under other categories where appropriate).

apeake Bay area has increased slowly over the past 20 years. Apparently, there has been a large increase in occupied nests along the Patuxent River from 22 in 1973 to 72 in 1994 (S. Cardano pers. comm.). Overall, the number of Ospreys nesting in the Bay area appears to be leveling off and Spitzer (1989) suggests that the population is nearing carrying capacity. Spitzer (1989) estimated the mean age at first breeding in part of the Chesapeake Bay region to be about two years higher than that of the region between New York City and Boston (5.7 vs. 3.7 yr), apparently the result of limited

nest-site availability. This delay should slow population growth rate by bringing mortality into balance with natality (Spitzer 1989, Poole 1989b). The number of Ospreys nesting in Virginia, the coastal Carolinas and Georgia has more than doubled since 1981. Several new interior sites have contributed to this growth (T. Murphy and J. Ozier pers. comm., Westall 1990).

Despite fluctuations, the overall number of nesting pairs in Delaware increased from 56 pairs in 1981 to 75–85 in 1994 (L. Gelvin-Innaer pers. comm.). In Delaware Bay, however, where breed-

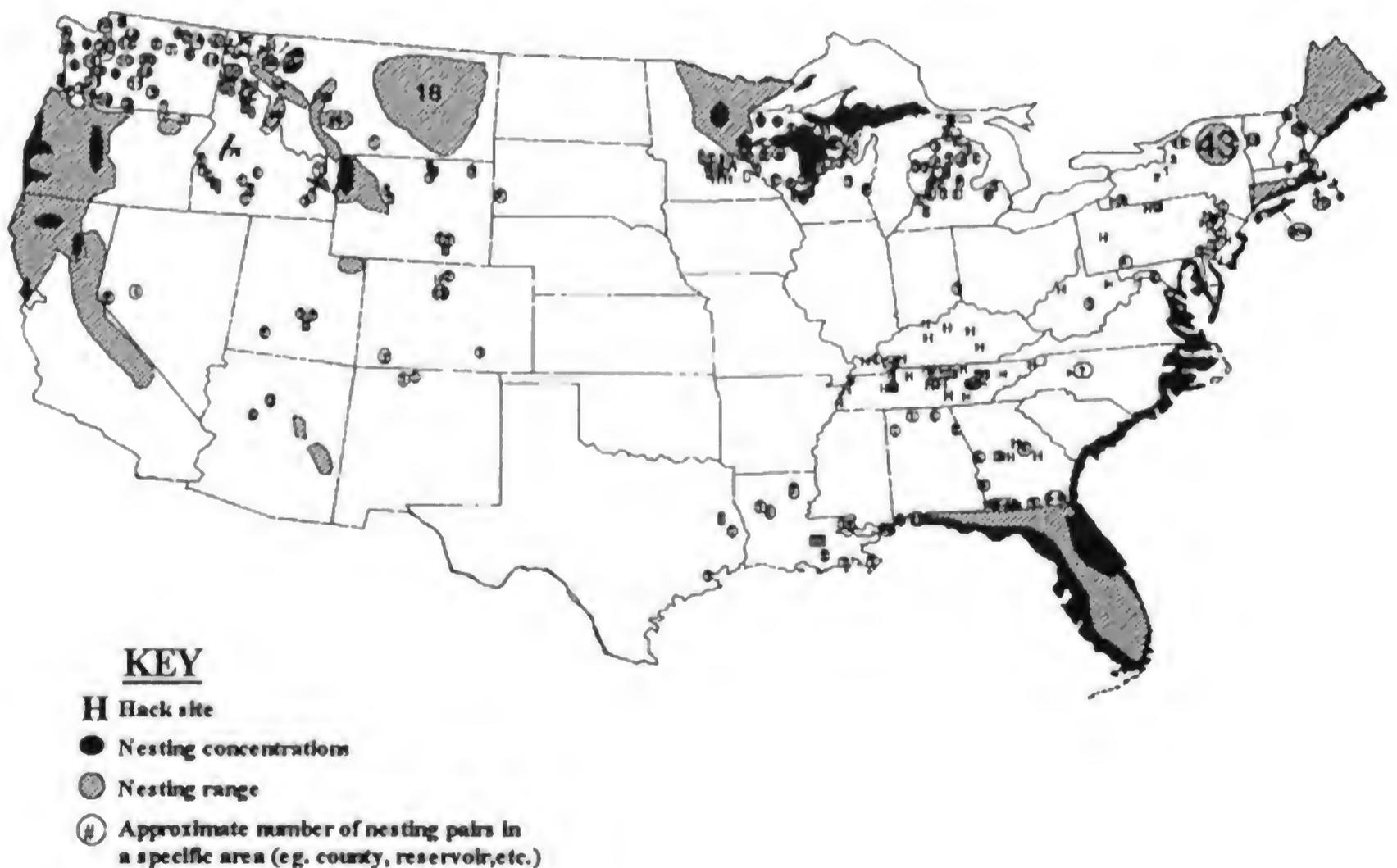


Figure 2. U.S. Osprey nesting distribution and abundance (1994).

ing pairs declined drastically in the 1960s and early 1970s apparently due to use of biocides, recovery has not occurred. On the Delaware side of the Bay, a region which historically supported numerous nests, only three nests were occupied in 1987 (Spitzer 1989) and approximately the same number were reported in 1994 (L. Gelvin-Innaer pers. comm.). Spitzer (1989) suggests increased water turbidity may be one limiting factor.

The general trend in traditional areas of these states has been rapid population growth but very limited range expansion.

Northeast Region. This region has both coastal and interior populations. Maine is the only state in this region which shows a contiguous population linking the coast with the interior. New Hampshire has an interior nesting population contiguous with that of Maine. Other northeast interior populations are located in northeastern Massachusetts, western Vermont, western New York and the Adirondack Mountain region of New York (Spitzer 1989).

Expansion of the breeding range of Ospreys in this region has been slow. From 1975–87, there was only a gradual spread of breeders along the coast of Connecticut, New York (Long Island), Rhode Island and Massachusetts, and relatively few Ospreys dispersed 25 km or more into substantially different and unoccupied habitats (Poole 1989a, Spitzer 1989). Spitzer (1989) recorded eight pairs that made moderate dispersals to the interior zone and this number has increased slightly (2–5 additional pairs) within the past 5 yr.

Most new nests in the Northeast region are located in the vicinity of previously established Osprey breeding habitats. In the coastal region, this trend has been due in large part to intensive management, including nest-site protection and nest platform construction during the last two decades (1967–87) (Poole 1989a, Spitzer 1989).

The area from Cape May, New Jersey to Cape Cod, Massachusetts was most heavily affected by biocide use. The number of nesting pairs in this vicinity declined from over 1000 nesting pairs in the early to mid 1900s to less than 200 nesting pairs in the mid 1970s (Henny 1977, Spitzer et al. 1983). Following the 1972 ban on DDT, nesting pairs in this region have gradually increased (Poole 1989a, Spitzer 1989).

In Massachusetts, nesting has increased dramatically as a result of nesting platform construction. Over 90% of the Ospreys nesting in Massachusetts

now use such platforms (B. Davis pers. comm.). In 1994, seven out of the 12 Vermont nests were on platforms and active management should continue to play a major role in the expansion of this population (S. Parren pers. comm.). Nest management, particularly predator guarding of natural nests, is credited for recent increases in the Osprey breeding population in New Hampshire (C. Martin pers. comm.).

The number of Ospreys nesting between New York City and Boston has grown approximately 10% annually since 1975. If this trend continues, the number of Ospreys nesting there in the year 2000 should equal or exceed historical records (Spitzer 1989). New Jersey has experienced an increase of approximately 6% annually (Clark and Jenkins 1993). New limiting factors (loss of suitable habitat and decreased suitability of nest sites), however, may prevent the number of nesting pairs from reaching historical or pre DDT numbers (Clark and Jenkins 1993).

Western Region. Statewide aerial and ground surveys have been limited in this region so available data are less conclusive. Despite this, the Osprey population is considered to be expanding and increasing in the region.

In Montana, Ospreys nest primarily in western portions of the state, mostly at Flathead Lake. In 1974, approximately 23 nesting pairs were located along the Northern Valley of Flathead Lake. In 1986, there were 66 (Henny and Anthony 1989) and, in 1994, there were close to 100 nesting pairs (D. Flath pers. comm.). Overall, statewide nesting increased from 149 nesting pairs in 1981 to 500–600 in 1994 (D. Flath pers. comm.).

Wyoming Ospreys are concentrated near the Montana border, in the northwestern part of the state (Yellowstone and Grand Teton National Parks). Henny and Anthony (1989) indicated that new nesting occurred in Johnson, Sheridan, Crook and Carbon Counties and it is estimated that the number of nesting pairs in Wyoming at least doubled between 1981–94 from 80 to ~160 pairs (B. Oakleaf pers. comm.).

In Idaho, nesting concentrations occur at Lake Coeur d'Alene, Lake Pend Oreille, Palisades Reservoir and Cascade Lake (W. Melquist pers. comm.). Henny and Anthony (1989) reported nesting productivity at Lake Coeur d'Alene in the mid to late 1980s to be among the highest reported in the literature. W. Melquist (pers. comm.) estimated the 1994 population to be over 400 nesting

pairs, a number which greatly exceeds historical records (Larrison et al. 1967).

Washington state conducted aerial and ground surveys in 1984 and 1989. Nesting data from these surveys indicated major nesting concentrations in both eastern and western portions of the state. These surveys showed an increasing population, with 275 nesting pairs in 1984 and 346 in 1989 (Watson and K. McCallister unpubl. data). The average annual percent increase from 1981–89 was approximately 5%. If the rate of growth remained constant between 1989–94, the number of nesting pairs in 1994 should have been approximately 450–500. However, because of potential limiting factors such as a lack of suitable nest sites and habitat availability, a more conservative estimate for this population in 1994 is 350–400 pairs.

In Oregon, the largest concentration of nesting Ospreys is located in the Central Cascade Mountains. The overall Osprey population in Oregon appears to be expanding. Henny and Kaiser (1996) reported that the nesting population along the Willamette River (between Portland and Eugene) increased from 13 pairs in 1976 to 78 pairs in 1993. Sixty-six of the pairs were nesting on utility structures in 1993, while none were nesting on them in 1976. The number of Osprey nesting within the state has increased from 308 in 1976 (Henny et al. 1978) to >700 in 1994 (C. Henny pers. comm.)

California nesting populations are concentrated in northern coastal and mountain regions (P. Bloom pers. comm.). Henny and Anthony (1989) identified four major populations at Klamath-Trinity system, Shasta Lake, Eagle Lake and Lake Alman, but an estimate for the state's nesting population in 1994 was not available. R. Jurek (pers. comm.) indicated that there were 21–23 nests on Tamales Bay, 15–20 nests along the Russian River, 35 pairs along the upper Sacramento River and 52 occupied and 30 successful nests in Marin County. He also noted that the overall number of Ospreys nesting in California has risen dramatically over the past 20 yr. Numbers of nesting pairs at Eagle Lake do not appear to be increasing (Bloom pers. comm.). Henny and Anthony (1989) indicated a substantial range expansion and population increase on small reservoirs in extreme northeastern California (Modoc County) where the population increased from three pairs in 1980 to 10 pairs in 1987. They also noted an increase in nesting pairs at Kent Lake (Marin County) from seven pairs in 1975 to 22 in 1986, and an increase in the number

of nesting pairs located within the Sierra Nevada region. Since 1975, newly reported Osprey nesting areas have included: Lake Tahoe (El Dorado County), Lake Oroville (Butte County), Basse Lake (Madera County), New Melones Reservoir (Tuolumne County) and New Bullards Bar Reservoir (Yuba County) (Henny and Anthony 1989).

The number of Ospreys nesting in Nevada remains low. Two of the four existing pairs are located at Lake Tahoe and the other two pairs are nesting along the Huntington Valley (Gary Herron pers. comm.).

In Arizona, a sizable increase in nesting pairs has taken place within the past 10 yr. Most of the Ospreys nest at the White River east/west fork and the main stem of the Black River in southeastern Arizona. However, three nests are located near Flagstaff, there was a new breeding attempt on Lynx Lake near Prescott in 1994 and, in 1996, a pair nested for the first time in over 30 yr at the confluence of the Salt and Verde Rivers, east of Mesa (G. Beatty and R. Vahle pers. comm.).

New Mexico had its only two pairs of Osprey (1994) nesting on reservoirs in the northern portion of the state. Both pairs began nesting in the 1990s (S. Williams pers. comm.).

The Colorado Osprey population (1994) is small and concentrated in the northcentral portion of the state. Hacking has been undertaken to enhance the already existing population and to extend breeding to the front range of the Rockies. Currently, three nesting pairs are located far from the hacking areas; two are located in La Plata County and one in Pueblo County (J. Craig and K. Luft pers. comm.).

Most Ospreys in Utah nest along the Green River and Flaming Gorge Reservoir area in the northeast corner of the state (S. Cranney unpubl. data). C. Monson (unpubl. data) reports that nesting also occurs at Fish Lake (six pairs), Panguitch Lake Navajo (two pairs), and, in 1995, one pair nested on Deer Creek Reservoir and another pair nested in Highland. Construction of reservoirs appears to have increased growth of Utah's Osprey population.

Many western states continue to show an expansion of nesting pairs eastward, partially due to changes in inland habitat, particularly the construction of reservoirs (Swenson 1981, Henny 1983). Reservoirs often provide foraging advantages over rivers and lakes because their still, shallow, open, water areas and reduced turbidity result in

increased water clarity and higher visibility of fish (Swenson 1981, Henny 1983).

A comparison of foraging times and nesting densities between free-flowing river habitat and three river impoundments on the upper Missouri River in Montana showed food sources and Osprey nesting densities to be higher at impoundments (Grover 1984). This indicates that additional impoundments could benefit Osprey populations and encourage future range expansion.

Florida and the Gulf Coast. Florida has the highest number of nesting Ospreys in this region, with distinct concentrations from the St. Johns River south to Lake Okeechobee (Westall 1990). Ospreys also nest along the east and west coasts and across Florida Bay, including the Ten Thousand Islands area (southwest Florida). Ospreys nesting in peninsular Florida south of the 29th parallel are non-migratory or resident birds and, therefore, may be subject to different biological limiting factors than Ospreys nesting further north (Poole 1989a).

Food stress may be affecting the once healthy Florida Bay population (Poole 1989). Declines there have prompted Florida to designate Osprey as a species of concern in Monroe, County. Although Florida Ospreys are currently adapting to an exploding human population, further land development could limit food supply and nesting habitat and thus should be carefully monitored (Ogden 1978, Westall 1990).

Nesting in the Gulf Coast has been extremely limited and sporadic (Lowery 1974, Imhof 1976, Henny 1983, Reinman 1984). The number of Ospreys nesting in this region has fluctuated throughout this century and only limited nesting has been documented (Henny 1983). J. and B. Jackson (unpubl. data) note that Ospreys were historically more abundant along the lower Mississippi than now. A decrease in the number of nesting pairs there has most likely resulted from human disturbance and manipulation (change in water flow, industry and pollution, and loss of nesting habitat).

In 1994, Gulf Coast Ospreys were most abundant on the gulf islands at the southern tip of Mississippi (50–55 pairs) (M. Woodrie pers. comm.). Only three nesting pairs were recorded in Texas in 1994, and though no statewide survey was conducted, it is unlikely that many more Ospreys nested there. However, many Ospreys migrate through Texas and several have been recorded during winter months (B. Ortego pers. comm.). Alabama and Louisiana have increasing populations (Table 1),

but inland nests remain sparse and irregular. The low number of documented nests in these states may be partially related to a lack of survey coverage. Why nesting remains low is unclear, but it merits further attention (Westall 1990). This region is an important study area for future productivity, range expansion, nesting and predation research.

The Great Lakes Region. The total number of breeding pairs in the Great Lakes region has almost doubled from an estimated 579 pairs in 1981 to approximately 1014 in 1994. Today's distribution of nests is similar to that reported for the period of 1963–71 (Postupalsky 1969, 1977); however, the aggregations are larger, additional adjunct nests exist between traditional clusters and some range expansion has occurred. Nests still remain concentrated in northcentral and northeastern Minnesota and in northern portions of Michigan and Wisconsin (M. Martell pers. comm.).

The growth of the statewide population in Michigan observed during 1977–92 has apparently stopped and some local declines have been noted, despite high availability of nest sites. The statewide total remained near 225 pairs from 1992–94 (S. Postupalsky pers. comm.). Wisconsin Osprey nesting data indicate that the number of nesting pairs there increased steadily during 1983–93, however, S. Postupalsky (pers. comm.) suggests that present numbers may be leveling off. Minnesota's nesting data was inconclusive but >200 nests were unoccupied in 1994 (M. Martell pers. comm.).

Wisconsin, Minnesota and Michigan all show signs of range expansion to the south. The expansion in Minnesota has been enhanced by hacking efforts initiated in Hennepin County in 1984 (M. Martell pers. comm.). Further expansion and dispersal is expected as nesting continues and more hacked birds return. A recent surge of nesting on artificial structures (~68% of nests in Wisconsin), could affect future Osprey numbers and status in this region. This region should continue to be evaluated for factors limiting population growth (e.g., measurements of aquatic productivity, fish population dynamics, prey accessibility to Ospreys, predators and competitors, and land use) (S. Postupalsky pers. comm.).

Eastern Interior. Major nesting concentrations such as those in Florida and Chesapeake Bay may never be realized in this region, but with the advent of large water-management projects such as the TVA reservoir and waterway system, and the hacking projects that have been implemented

throughout this region, a sizable increase in the number of nesting pairs and distribution may be expected (Westall 1990).

Freshwater reservoirs have been most beneficial to the nesting success here, particularly in Kentucky, Tennessee, West Virginia and Pennsylvania where impoundments have benefited recent Osprey reintroductions. Overall, the Osprey population in these states surged from five nesting pairs in 1981 to 105 in 1994. Many of these breeding pairs are known to be the result of several intensive hacking programs. For example, in Pennsylvania 17 of the 20 statewide nesting pairs include hacked birds, four of which were hacked in West Virginia (L. Rymon unpubl. data). All three of West Virginia's pairs are the result of hacking in West Virginia. Most of the Ospreys now nesting in Tennessee are either the direct result of hacking or were attracted by recruits from local hacking projects (B. Hatcher pers. comm.). Kentucky has had similar results but the birds in both Tennessee and Kentucky have not been well monitored.

Central States. Both the Mississippi and Missouri Rivers seem ideal as conduits for interior nesting, yet they remain virtually unoccupied by Ospreys. Historical data suggest that Ospreys once nested in small numbers along parts of the Mississippi (J. and B. Jackson unpubl. data). Other historical records indicate that very few Ospreys nested within the Central States Region (Hicks 1935, Black 1992, Robbins and Easterla 1992). Reasons why Ospreys are not presently nesting in most of this region remain unclear but the Osprey's slow pioneering rate may be responsible. Many of these states appear to have some suitable habitat and most are adjacent to states where Ospreys currently nest. Habitat Suitability Indices could be used to determine if habitat is a major limiting factor (Vana-Miller 1987). However, recent dispersals into South Dakota, New Mexico, Texas, Ohio and Indiana, all states with no known nesting pairs in 1981, indicate that it may only be a matter of time before Ospreys expand their range into this region also. If time is inhibitory, hacking may be one option for accelerating the process (Rymon 1989a).

CONCLUSION

1994 U.S. Osprey Distribution and Abundance. There has been a significant increase in the number of nesting pairs in the U.S. from 1981-94. The overall estimate for the population in 1981 (Henny 1983) was approximately 8000 nesting pairs. Our

1994 population estimate was $\sim 14\,186 \pm 1417$ (SD) indicating that the U.S. Osprey population has increased $\sim 75\%$ in just over the past decade.

There were many similarities in the distribution and abundance of Osprey nesting pairs between 1981 and 1994. Largest increases in numbers of nesting pairs took place in areas of traditional nesting: the Atlantic Coast, Pacific Northwest and the Great Lakes Region. A large increase in nesting pairs also occurred in the Eastern Interior Region where hacking has taken place. Although the recent interior population expansion can be attributed to hacking efforts, hacking has only expanded the range and played a very modest role in the growth of the entire U.S. Osprey population.

Overall, population growth has resulted from: 1) increased production rates following the 1972 ban on DDT, most prominent in the Northeast and Great Lakes Regions, 2) construction of numerous new impoundments, especially in the Western and Eastern Interior Regions, 3) artificial nest construction in nearly all regions, particularly the relatively recent use of utility structures and other man-made structures in the west (Henny and Kaiser 1996), 4) hacking projects in the interior, and 5) increased public awareness and support. These dramatic changes stress the importance for regional Osprey management while monitoring the entire U.S. population.

Growth and Expansion of the U.S. Osprey Population. The future growth of regional Osprey populations depends, in part, on the rate at which new breeders are recruited. Regional differences in the dispersal distances of young may be a reflection of the differences in the density and availability of nest sites (Poole 1989b). In New England, where nesting pairs were severely reduced by pesticides during the 1950s and 60s, artificial nest sites are now clustered, abundant and widely available so most new recruits find nests quickly and breed soon after arrival (Poole 1989b). In New England, dispersal distances >50 km are rare (Poole unpubl. data).

Ospreys in western and midwestern North America seem to be dispersing much greater distances. There the breeding range may be restricted by lack of suitable nest sites and large expanses of unsuitable habitat (Poole 1989a). Ospreys in the western U.S. have traditionally nested in trees or snags near lakes and rivers (Henny 1983); however, nesting areas are becoming saturated (C. Henny pers. comm.) For this reason, they are slowly dispersing

into new breeding areas around reservoirs where breeding densities may largely exceed those along nearby free-flowing rivers (Henny 1983, Swenson 1981, Grover 1984). Lack of natural nest sites at traditional nesting areas in the western states may have caused longer dispersal and colonization at newly constructed impoundments and along utility structures (Henny and Kaiser 1996).

In the Chesapeake Bay area where nest sites are saturated, Ospreys have begun to delay breeding rather than disperse to new areas (Spitzer 1989). Perhaps this is due to their high natal-site fidelity. Changes in breeding rates, proportions of non-breeders in different populations, choices of nest sites, competition for nest sites, natal dispersal distances, age at first breeding and nesting dispersion should be monitored in future seasons (Spitzer 1989).

An increase in the use of artificial nest structures has played an important role in the overall increase in the number of nesting pairs in the U.S. (Poole 1989a). Regional data on nesting structures indicate that approximately 64% of Ospreys in the U.S. nest on artificial structures, particularly artificial platforms erected specifically for them (approximately 50%). Excessive construction of nesting platforms may have drawbacks in the long run, including habituation to humans, necessary maintenance of platforms and higher predation rates (Poole 1989a).

The construction and addition of artificial nest structures on public lands has played a critical role in increasing public awareness and support for Osprey. Several states have had volunteer Osprey nest platform projects, and some have set aside viewing areas for aesthetic and educational purposes. Nest platform management is just one example of expanding public awareness. Support from public utilities and media coverage appear to be enhancing efforts in public relations which will continue to be important for the preservation of this species (Rymon 1989b).

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THE DELAWARE BAYSHORE OF NEW JERSEY: A RAPTOR MIGRATION AND WINTERING SITE OF HEMISPHERIC SIGNIFICANCE

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ABSTRACT.—The Delaware Bayshore of New Jersey, including the lower Maurice and Cohansey Rivers and the coastal zone of Cumberland County, is a major migration and wintering area for raptors. Over 89 days of autumn migration for three years, almost 12 000 raptors of 17 species were counted at East Point at the mouth of the Maurice River ($\bar{x} = 30.7$ raptors/hr). In addition, the lower drainage areas of the Maurice and Cohansey Rivers and the Cumberland County coastal zone were found to support high densities of Black (*Coragyps atratus*) and Turkey Vultures (*Cathartes aura*), Bald Eagles (*Haliaeetus leucocephalus*), Red-tailed Hawks (*Buteo jamaicensis*), Northern Harriers (*Circus cyaneus*), Cooper's Hawks (*Accipiter cooperii*), Sharp-shinned Hawks (*A. striatus*), Rough-legged Hawks (*Buteo lagopus*) and American Kestrels (*Falco sparverius*) in winter. Such high numbers and diversity of migrating and wintering raptors make the area exceptional and, perhaps, unique in eastern North America. The importance of this area for raptors emphasizes the need for its conservation, especially in light of rapid development of nearby farmlands and forests for homes and industry.

KEY WORDS: *migration; winter population; Delaware Bayshore; conservation.*

El Delaware Bayshore de New Jersey: Una migración de rapaces y invernada con importancia hemisférica.

RESUMEN.—El Delaware Bayshore de New Jersey, incluyendo los ríos abajo de Maurice y Cohansey y la zona costera de el condado Cumberland, es el mayor lugar de migración invernada para rapaces. Arriba de 89 días de migración en el otoño por tres años, casi 12000 rapaces de 17 especie fueron contados en el Punto Este en la boca del Río Maurice ($x = 30.7$ rapaces/hr). En suma, en la boca baja del desagüe del Maurice y Cohansey Ríos y la zona costera del condado Cumberland se encontró apoyo de densidad alto de *Coragyps atratus* y *Cathartes aura*, *Haliaeetus leucocephalus*, *Buteo jamaicensis*, *Circus cyaneus*, *Accipiter cooperii*, *A. striatus*, *Buteo lagopus*, y *Falco sparverius* en invierno. Tanta cantidad y diversidad de rapaces de migración y sitios de invierno hace la área excepcional y, quizás, único en el este de Norte América. La importancia de este área para rapaces énfasisa la necesidad para su conservación, especialmente con el rápido desarrollo de tierras agrícolas y bosques para casas e industria.

[Traducción de Raúl De La Garza, Jr.]

The Delaware Bayshore of New Jersey, especially Cape May, has long been known as a critical area for a diversity of migrating birds (Allen and Peterson 1936, Stone 1937, Dunne and Sutton 1986, Wiedner et al. 1992). Although much of the region has been threatened or altered by human development, areas north of Cape May along the Delaware Bayshore including Cumberland County, have been largely spared. Recent proposals for

barge port development, industrial sand mines and other projects along the Maurice and Cohansey rivers in Cumberland County threaten to alter aquatic habitats, wetlands and uplands, rendering them less suitable for wildlife.

Because of these threats, we conducted an 8-yr study of raptor use during autumn migration and winter along the Delaware Bayshore of Cumberland County, New Jersey including the Maurice and Cohansey river drainages. In this report we document a large and previously unknown aggregation of migrating and wintering raptors in this area that is of hemispheric significance and worthy of major conservation effort.

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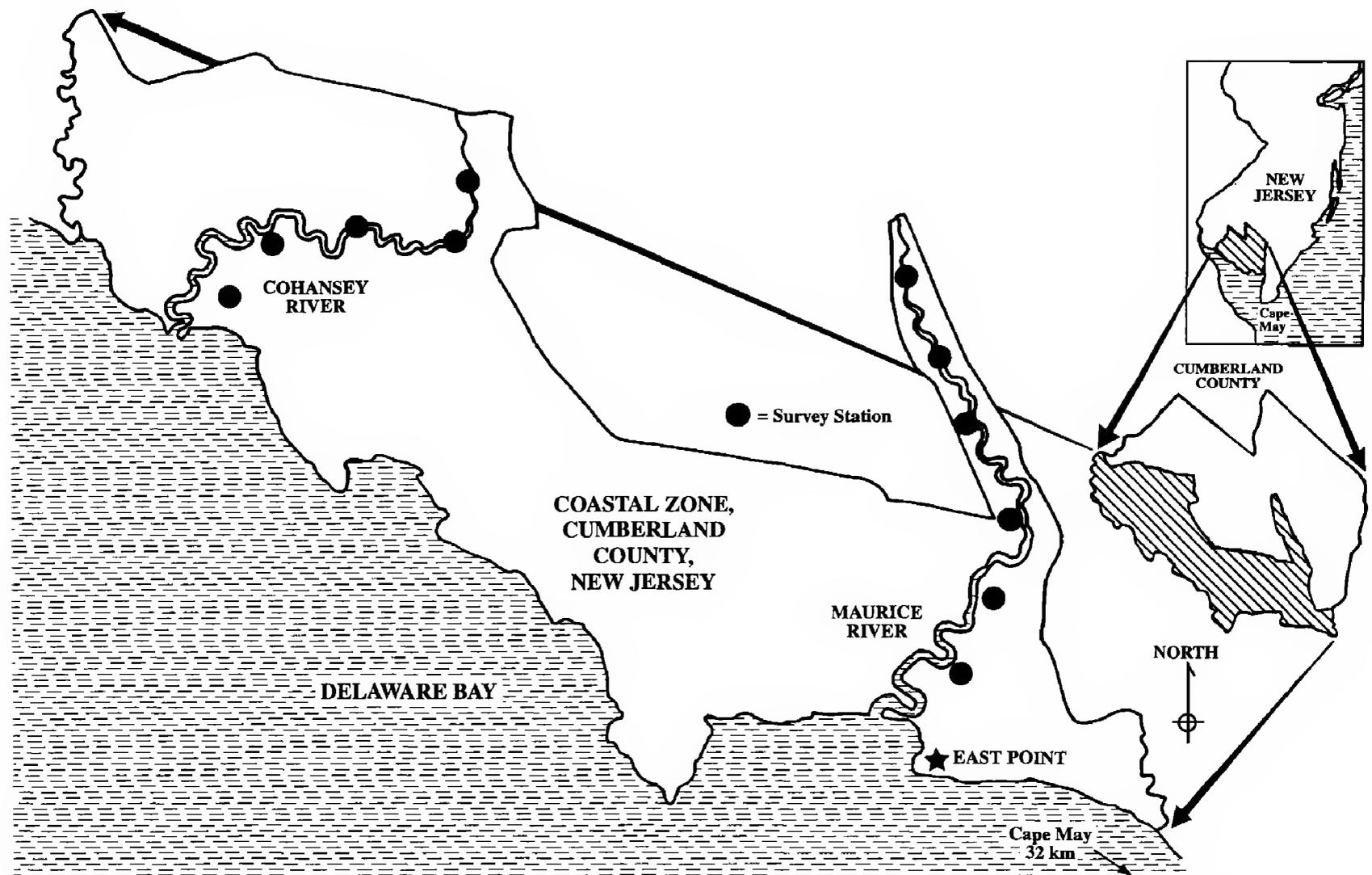


Figure 1. Maps of New Jersey and Cumberland County Coastal Zone study area including the lower Maurice and Cohanse Rivers, and the Delaware Bayshore. Closed circles indicate observation sites along the rivers. East Point hawk watch is denoted by a star at the mouth of the Maurice River.

METHODS

Migrating raptors were counted at East Point, Cumberland County, New Jersey (Fig. 1) from 9 September–30 November 1989–91, by a single observer during predetermined peak flight hours (mid-morning through mid-afternoon) for an average of 4.4 hr per day (range = 1–9 hr) from the wooded edge of a salt marsh near the mouth of the Maurice River at Delaware Bay. On about one-third of all days, the observation site was moved 3 km inland from the Bay at about midday, as the flight became higher and moved farther inland. East Point is a peninsula that juts out into Delaware Bay. To assess the relative importance of this site, counts from East Point were compared with same day hawk migration counts from Cape May Point, New Jersey, 32 km to the south. Counters at both sites used standard Hawk Migration Association of North America methods and recording forms (Bednarz and Kerlinger 1990, Kerlinger 1989).

We sampled wintering raptors along tidal portions of the Maurice River during eight winters, 1987–88 through 1994–95; the Cohanse River during five winters, 1990–91 and 1994–95; and in the Cumberland County Coastal Zone (CCCZ) in five winters 1989–94. Transport among sites was by automobile. Surveys were done between 22 November–21 March, mostly between 0800–1600 EST. A total of 69 surveys were done on the Maurice River and 16 on the Cohanse River. On the Maurice River, a survey

consisted of seven observation stations from a point 22.4 km upstream from the river mouth (Fig. 1) to East Point and at five stations on the Cohanse River from Bridgeton downstream to within 2 km of the mouth of the river, a distance of 17.6 km. At each observation site, all flying and perched raptors within view were counted for 50 min. Care was taken to avoid recounting individuals by noting plumage characteristics and flight direction. If a raptor was observed flying into the adjacent sampling area it was not counted if resighted in that area. Raptors seen perched between sampling sites were included in the nearest sampling site if an individual of that species was not sighted from the adjacent stations. Ten power binoculars and a 20 power spotting scope were used. On about 96% of the surveys, two observers were present and on the remaining surveys only one observer. The same observer was present for 65 of the 69 Maurice River surveys and all of the others.

Counts were conducted mostly in sunny weather with northwest winds. Ninety percent of the counts were done with these conditions, since they promoted soaring and hunting of raptors. Habitat along the Maurice and Cohanse rivers and the Cumberland County coastal zone includes tidal marsh and swamp forest, as well as adjoining upland forests and farms. Wetlands in these areas range from marshes typical of tidally inundated areas to tidally influenced freshwater marshes farther upstream.

Saltmarsh cordgrass (*Spartina alterniflora*) dominates the marshes at the mouth of the rivers, with saltmarsh hay (*S. patens*) present. Farther upstream, although tidally influenced, the marshes are comprised of freshwater and brackish wetland plants such as wild rice (*Zizania aquatica*), common reed (*Phragmites communis*), pickerel weed (*Pontederia cordata*), arrow arum (*Peltandra virginica*), spatterdock (*Nuphar advena*), waterlily (*Nymphaea odorata*) and cattail (*Typha latifolia*). Common reed is more prevalent on the Cohansey River. The banks along portions of the Maurice River are quite steep and often heavily wooded, although cropland is near both rivers. Developed areas are limited to single family homes and a few recreational boat yards. Both rivers average less than one-half mile wide and both are about one mile wide near the mouth.

In addition to surveys on the Maurice and Cohansey rivers, one road survey per year was made in the first two weeks of January 1990–94, during which raptors were counted in the entire Cumberland County coastal zone (Fig. 1). This latter survey consisted of 12 primary observation sites along a 48 km course. Standard raptor road survey methods were used between observation sites. The coastal zone count included regular counts (nearest calendar date) from the Maurice and Cohansey rivers, all conducted in a 3-d-period. This method was an attempt to determine roughly the total number of raptors that winter in the Cumberland coastal region.

RESULTS AND DISCUSSION

Over 89 d (389.25 hr), we observed 11 944 hawks (30.7/hr) of 17 species at East Point (Table 1). Sharp-shinned Hawks (*Accipiter striatus*) were most numerous, accounting for 39.7% of all hawks counted. This species, plus Turkey Vultures (*Cathartes aura*), Northern Harriers (*Circus cyaneus*), Red-tailed Hawks (*Buteo jamaicensis*) and American Kestrels (*Falco sparverius*) accounted for 84.5% of all raptors observed. In 1990, the year most observations were made, a total of 9042 raptors was recorded during 308.5 hr of observation on 60 d (9 September–7 December). This was 34.6% of the 26 164 raptors seen at Cape May Point during the same 60-d-period.

Species composition differed between East Point and Cape May Point which may be attributable, in part, to differences among species in their tendency to cross water. Greater numbers of vultures, Bald Eagles (*Haliaeetus leucocephalus*), Northern Harriers, Rough-legged Hawks (*Buteo lagopus*), Red-tailed Hawks and relatively fewer Ospreys, Sharp-shinned Hawks and falcons were counted at East Point (Table 1). Kerlinger (1985) documented differences in water crossing tendency among most of the species reported here in a study at Cape May Point. Upon reaching the end of the peninsula, only some species crossed without hesitation. At

Table 1. Summary of autumn migrants recorded at East Point and Cape May, New Jersey, on the same 89 days during 1989, 1990 and 1991. Total numbers of migrants counted and percentage of total hawks counted at each site are given. One Swainson's Hawk (*Buteo swainsoni*) was also seen at East Point.

SPECIES	EAST POINT		CAPE MAY	
	COUNT	PER-CENT	COUNT	PER-CENT
Black Vulture	39	<1%	24	<1%
Turkey Vulture	1219	10%	62	2%
Osprey	233	2%	2012	6%
Bald Eagle	97	1%	65	<1%
Northern Harrier	888	7%	1110	3%
Sharp-shinned Hawk	4744	40%	16 853	47%
Cooper's Hawk	754	6%	2312	6%
Northern Goshawk	7	<1%	36	<1%
Red-shouldered Hawk	91	1%	234	<1%
Broad-winged Hawk	188	2%	1168	3%
Red-tailed Hawk	1398	12%	1453	4%
Rough-legged Hawk	42	<1%	4	<1%
Golden Eagle	14	<1%	28	<1%
American Kestrel	1854	16%	7400	21%
Merlin	297	3%	1551	4%
Peregrine Falcon	72	1%	855	2%
Total Hawks	11 944		35 968	
Total Hours	389.25		798.5	
Hawks Per Hour	30.7		45.0	

East Point, the vast majority of most species moved west, whereas Osprey (*Pandion haliaetus*), Merlins (*Falco columbarius*) and Peregrine Falcons (*Falco peregrinus*) usually flew to the southeast toward Cape May. The latter species are not reluctant to cross Delaware Bay (Kerlinger 1985, 1989). It is likely that upon seeing the end of the Cape May peninsula, many soaring birds turn westward to follow the Delaware Bayshore, rather than proceeding to the tip of the Cape May peninsula where they would be counted. Others fly through Cape May and are counted near the Point before flying north and west along the Bayshore toward East Point.

During January road surveys of the coastal zone, 14 species were observed totaling between 472 and 932 birds/survey (Table 2). This year to year variation was attributable largely to variation in the number of roosting vultures and, perhaps, to weather. Species composition and numbers of most species observed along the Maurice and Cohansey rivers were similar (Table 2). The numbers of American Kestrels and Sharp-shinned Hawks along

Table 2. Summary of wintering diurnal raptors along Maurice and Cohansey Rivers and the Cumberland County Coastal zone area. Letters following species names indicate status of the species (T = federally threatened, t = New Jersey threatened, e = New Jersey endangered, u = unknown status in New Jersey; first of state letters indicates breeding season, second indicates nonbreeding season—migration and winter). Totals are the mean of yearly mean totals and min–max of yearly average totals.

SPECIES	MAURICE RIVER (1987–1995)		COHANSEY RIVER (1990–1995)		CUMBERLAND COASTAL ZONE (1989–1994)	
	MEAN	RANGE	MEAN	RANGE	MEAN	RANGE
Black Vulture	9.9	1–45	7.0	3–10	35.8	9–77
Turkey Vulture	73.4	49–111	54.8	41–68	272.8	165–501
Bald Eagle (T,e,e)	5.5	3–10	2.4	2–4	21.2	17–27
Northern Harrier (e,u)	20.0	15–24	19.0	16–22	122	79–171
Sharp-shinned Hawk	2.6	2–4	4.1	3–6	19.8	6–37
Cooper's Hawk (e,e)	1.3	1–2	1.9	1–3	8.2	3–14
Northern Goshawk	0.1	0–1	0.2	0–1	1.4	0–2
Red-shouldered Hawk (e,t)	0.2	0–1	0.4	0–1	3.6	2–5
Red-tailed Hawk	37.9	33–42	37.3	34–42	134.6	86–159
Rough-legged Hawk	1.0	0–2	0.4	0–1	10.2	4–17
Golden Eagle	0.2	0–1	0.1	0–1	0.8	0–3
American Kestrel	2.2	1–3	7.2	6–11	30.6	18–43
Merlin	0.1	0–1	0.2	0–1	1.4	0–4
Peregrine Falcon (T,e,e)	0.1	0–1	0.2	0–1	1.2	0–2
Totals	154.7	117–204	134.7	115–151	663.8	72–932
Years of sureys	8		5		5	
Mean number of surveys per year (range)	8.6	7–14	3.2	2–4	1	

the Cohansey River were slightly greater than along the Maurice River because there is more farmland and forest edge along the Cohansey. Conversely, more Bald Eagles and Turkey Vultures were reported from the Maurice River, a function of greater waterfowl numbers, waterfowl hunting and carrion present at a livestock farm. Determining absolute abundance for statistical comparison is extremely difficult in such a heterogeneous landscape.

Turkey Vultures were the most numerous of all species, followed by Red-tailed Hawks and Northern Harriers. Bald Eagles were an important component of the winter raptor community of the Delaware Bayshore of New Jersey; as many as 16 were seen on a survey of the Maurice River. Among the wintering raptors observed, five were on the federal or New Jersey threatened or endangered lists (Table 2). Single Merlins, typically a Neotropical migrant, wintered on the study site in most years.

Probably a combination of factors is attributable to the great diversity and abundance of raptors migrating and wintering along the Delaware Bayshore. Delaware Bay is a topographic barrier to mi-

gration. Raptors reluctant to cross water seem to either fly around the Bay or terminate their migration along the Bayshore. The importance of migration stopovers among songbirds, shorebirds and waterfowl has long been known, but few biologists have recognized its importance among raptors (Newton 1979, Kerlinger 1989). Many of these birds are compelled to make migratory stopovers in the area. The abundance of open space, high-quality habitat and abundant prey make the Bayshore very attractive to both migrating and wintering hawks.

The Bayshore has frequently been recognized as an ecosystem of hemispheric or global significance. For example, the wetlands of the Delaware Bay are a RAMSAR site, in part because they support globally important populations of shorebirds and waterfowl. In addition, the EPA National Estuary Program has recognized the area as biotically important and has funded major studies of the area (Zapalorti et al. 1993). Much of the Maurice River and three tributaries, the Manumuskin River, Menanico Creek and Muskee Creek, are now included in the U.S. National Park Service Wild and Scenic Riv-

er program. The data presented herein support these designations.

Another factor that influences the winter abundance of Bald Eagles, vultures and to a lesser extent Red-tailed Hawks, Golden Eagles and Peregrine Falcons are the vast concentrations of waterfowl and other birds that migrate and winter along the Delaware Bayshore. Winter waterfowl counts conducted simultaneous to these raptor counts show that more than 25 species of waterfowl in numbers totaling greater than 10 000 to 15 000 occur regularly on the Maurice River portion of the study site alone (Sutton 1988). Likewise, huge numbers of migrating songbirds, prey for some hawks, are known to frequent the Delaware Bayshore (Wiedner et al. 1992). These birds search for stopover habitat as they move along the Bayshore.

Our data indicate that the Delaware Bayshore, and Maurice and Cohansey river drainages, support one of the largest and most diverse concentrations of migrating and wintering raptors reported in eastern North America. We make this claim understanding that there is little comparative information on abundance and winter concentration areas for raptors in eastern North America (other than for eagles and vultures). The Delaware Bayshore is all the more important because it serves hawks during both winter and migration. We know of no other migration sites that also serve as important wintering areas for raptors. It seems that many migrants end their southbound migration on the Delaware Bayshore. The conservation value of this area is obvious.

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FOOD HABITS OF COMMON BARN-OWLS ALONG AN ELEVATIONAL GRADIENT IN ANDEAN ARGENTINE PATAGONIA

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ABSTRACT.—We evaluated the diet of Common Barn-owls (*Tyto alba*) along an elevational gradient in Argentine Patagonia. Small mammals (mainly rodents) were the main prey accounting for 93.2% of total prey items. Consumption of rodents appeared to be dependent on their availability. Sizes of mammalian prey were variable but most ranged from 10–100 g in body mass. We concluded that the diet of these barn owls could be used as an index of cricetid rodent populations along the gradient.

KEY WORDS: *Common Barn-owl; Tyto alba; prey; Patagonia; selectivity; gradient.*

Dieta de la lechuza (*Tyto alba*) a lo largo de un gradiente altitudinal en la Patagonia Andina Argentina.

RESUMEN.—Se estudió la dieta de la lechuza (*Tyto alba*) y se la contrastó con la composición específica de la comunidad de micromamíferos a lo largo de un gradiente altitudinal en la Patagonia Argentina. La principal presa la constituyeron pequeños mamíferos (fundamentalmente roedores) alcanzando un 93.2% del total de presas consumidas. La masa corporal media de los mamíferos presa se concentró fuertemente en un rango comprendido entre 10 y 100 g. La dieta de la lechuza resultó ser un buen indicador de la composición de Cricetidos a lo largo del gradiente estudiado. El consumo de cada uno de los roedores presa dependió de su disponibilidad en el terreno.

[Traducción Autores]

Few of the many studies of Common Barn-owl (*Tyto alba*) food habits have examined dietary responses to elevational distribution of prey species (Herrera 1974, Brunet-Lecomte and Delibes 1984). In northwestern Patagonia, a steep elevational gradient (600–3000 m) occurs over just a few km. The abrupt change in elevation and the associated change in precipitation (300–3600 mm) causes a distinct shift in the vegetation from shrubsteppe to montaneous forest habitat within a few km. Pearson and Pearson (1982) qualitatively described the small mammal species composition along this gradient. They found six species of rodents (*Aconnaemys fuscus*, *Dromiciops australis*, *Notiomys macronyx*, *Notiomys valdivianus*, *Irenomys tarsalis* and *Akodon olivaceous*) occurred in the humid

forest, while another seven rodent species (*Ctenomys haigi*, *Akodon xanthorinus*, *Reithrodon auritus*, *Eligmodontia typus*, *Phyllotis darwini*, *Euneomys* sp, and a marsupial, *Lestodelphis hally*) were in the dry shrubsteppe. They also analyzed the diets of Common Barn-owls at three different localities at the forest-steppe transition and found that the proportions of species captured by traps and by owls were different.

Besides providing new information on the trophic niche of Common Barn-owls in Argentina, here we test the feasibility of using barn owl food habits to describe changes in composition and abundance of small mammals along an elevational-precipitation gradient. We considered the data provided by Pearson and Pearson (1982) as the ac-

tual representation of the small mammal community along this gradient and the barn owl prey as its descriptor. Additionally, Pearson (1986) provided data on relative abundance of cricetid species in eight different habitats ranging from steppe to forest over an 8-yr-period.

We made two comparisons between estimates of rodent availability and their occurrence in the diet of common barn owls: (1) on a broad scale, along the elevational-precipitation gradient, using data from Pearson and Pearson (1982), and (2) on a fine scale, along a segment of the complete gradient, using abundance estimates for rodent species given by Pearson (1986). We predicted that the barn owl diet would reflect gradient changes in rodent community composition (Herrera 1974, Pearson and Pearson 1982, Taylor 1994), but it would be less accurate in reflecting availability of prey at a fine scale (Jaksic and Yañez 1979).

STUDY AREA AND METHODS

Located in northwestern Patagonia (70°30'–71°30'W; 39°30'–40°20'S), the study area constitutes a portion of the Precordillera gradient and partially overlaps with the area studied by Pearson and Pearson (1982) and Pearson (1986). The greatest distance between our site and that of Pearson was under 150 km. The climate of the area is dry and cold with frost throughout most of the year and frequent snowfall in winter. Topographically, the area consists of plains from 800–900 m above sea level that are dissected by steep rugged valleys and large rivers. In general, the study area consists of lowland which coincides with river valleys and highland Piedmont with an intermediate area between them. Pearson (1986, 1987, 1988) has described five different habitats in intermediate and highland Piedmont: steppe or scattered bushes, usually <1 m tall, usually mixed with bunch grass, much of the ground is devoid of vegetation; bunchgrass or habitats with relatively pure stands of one or more species of bunchgrass; weeds or areas with dense weeds and grasses, usually growing in moist places; rocks or cliffs with tumbled rocks large enough to provide refuge for rodents; and bare ground or large areas not vegetated with a substrate of fine scree or rock and very few rocky shelters.

Barn owl pellets were collected from September–February 1991, 1992 and 1994–95. Pellets were collected at 32 isolated localities more than 2 km apart. On this basis, we assumed that barn owls at each locality were different individuals. Only fresh pellets were included in our samples in order to restrict our study to the spring season and avoid seasonal variation. All pellets were dissected using standard techniques (Yalden 1977). Small mammal remains were identified using taxonomic keys (Pearson 1986), reference specimens collected in the study area and museum collections. Small mammal biomass was derived from Pearson (1983, 1984) and Redford and Eisenberg (1992).

Following Herrera and Jaksic (1980), we characterized barn owl food habits by the following parameters: mean

mass of all small mammals (MWSM) in the diet; H'_{NGG} , trophic diversity in relation to the number of individuals contributed by each higher taxonomic unit (mammals, birds, amphibians, invertebrates); H'_{NM} , trophic diversity in relation to the small mammal component of the diet (rodents, lagomorphs, marsupials); and H'_{NR} , trophic diversity in relation to the number of individuals contributed by each rodent species. The latter three parameters were computed by means of Shannon's information function (Ludwig and Reynolds 1988). Corresponding values of evenness ($J = H'/H'_{\text{max}}$) were also calculated.

The use of the barn owl food habits to detect and describe changes in the composition and abundance of small mammals along a gradient was explored using correspondence analysis (SAS 1987). This is a multivariate ordination method (Digby and Kempton 1987, Pielou 1984), applied on a data matrix that included frequencies of appearance (%) of several prey categories for each barn owl locality. This type of analysis permits one to plot points for both rows and columns (here localities and small mammal prey categories) on the same plane. Correspondence analysis is especially appropriate for matrices with numerical frequencies (Cuadras 1980) and does not normally require previous transformation of data (Digby and Kempton 1987). We used this analysis to verify if the pattern in rodent species distribution derived from barn owl diets was similar to that described by Pearson and Pearson (1982) along both the elevational and precipitation gradients. For this analysis, we restricted ourselves to those localities ($N = 23$) with >30 identified prey items.

Selection among potential prey species was studied only in intermediate and highland Piedmont. Barn owl selectivity was evaluated by comparing the species' rank for each cricetid rodent in the barn owl diet with the species' abundance in the field as estimated by Pearson (1986). We used a Spearman Rank Correlation Coefficient (Siegel and Castellan 1988) for this analysis. It was calculated from the sum of the ranks obtained for each species in each of the five habitats considered. Comparison was restricted to cricetids because these were the rodent species for which Pearson (1983) estimated relative abundance.

RESULTS

A total of 2447 prey items were identified from barn owl pellets. Small mammals were the main prey in northwestern Patagonia, accounting for 93.2% of the total. Birds, amphibians and invertebrates made up the remaining 6.8% (Table 1). Calculated from a random sample of 71 pellets, the mean number of prey/pellet was 1.85 (SD = 1.09, range 1–6).

Among mammals, rodents most frequently occurred in the diet, representing the 98.9% of the total (Table 1). The MWSM was 54.2 g (SD = 36.7, range 17.5 g for *Calomys musculus*, 286.1 g for *Microcavia australis*) but most small mammals were between 10–100 g (Fig. 1).

Table 1. Composition of the Common Barn-owl in the lowland, midland, and highland piedmont, northwestern Argentine Patagonia.

PREY TYPE	LOWLAND	MIDLAND	HIGHLAND	TOTAL	
	PIEDMONT (%)	PIEDMONT (%)	PIEDMONT (%)	N	%
MAMMALS					
Rodents					
Hystricognath					
<i>Ctenomys haigi</i>	13.1	3.1	3.0	134	5.5
<i>Galea musteloides</i>	1.7	0.3	0.0	13	0.5
<i>Microcavia australis</i>	0.3	0.0	0.0	2	0.1
Cricetids					
<i>Akodon</i> spp	9.6	21.4	25.0	484	19.8
<i>Auliscomys micropus</i>	0.2	6.3	18.7	226	9.2
<i>Chelemys macronix</i>	0.0	1.0	3.1	37	1.5
<i>Eligmodontia typus</i>	31.6	13.1	6.7	374	15.3
<i>Euneomys</i> sp	0.0	0.1	2.8	25	1.0
<i>Geoxus valdivianus</i>	0.2	0.3	1.0	13	0.5
<i>Irenomys tarsalis</i>	0.0	0.1	0.5	5	0.2
<i>Oryzomys longicaudatus</i>	6.6	8.2	6.0	171	7.0
<i>Phyllotis darwini</i>	4.0	12.8	5.6	198	8.1
<i>Reithrodon auritus</i>	23.0	16.9	24.4	522	21.3
<i>Calomys musculus</i>	5.4	1.9	0.0	51	2.1
Marsupials					
<i>Marmosa pusilla</i>	1.8	1.1	0.0	22	1.0
Lagomorphs					
<i>Oryctolagus cuniculus</i>	0.0	0.2	0.1	3	0.1
Birds	1.3	0.8	0.3	19	0.8
AMPHIBIANS	0.0	0.5	0.0	5	0.2
INSECTS	0.3	11.9	2.8	143	5.8
TOTAL PREY	(595)	(980)	(872)	(2447)	
H'NGG				0.28	
JNGG				0.20	
H'NM				0.06	
JNM				0.05	
H'NR				2.06	
JNR				0.78	

These barn owls had a relatively narrow diet as shown by the H'NGG value (Table 1). The low evenness index was largely due to their concentration on mammal prey (Table 1). The diversity and evenness of the small mammal component (H'NM) showed that the diet was based upon a small number of small mammal species, most of which were rodents. Among rodents, H'NR (2.06) and evenness (0.78) reached the highest values, denoting both the high number of rodent prey species consumed ($N = 14$, 82% of total present in the area) and their overall even representation in the diet.

Two axes generated by the correspondence anal-

ysis accounted for 49.5% of the variance in the diet (Fig. 2). Representation of localities and prey categories on the plane defined by the two axes clearly segregated the dry, lowland Piedmont localities (which tended to the positive zone of Axis I and negative zone of Axis II) from the rest of localities (which occupied all the space defined by Axis I and the positive zone of Axis II). Prey in the lowland Piedmont localities included *Ctenomys haigi*, *Microcavia australis*, *Galea musteloides*, *Eligmodontia typus* and *Calomys musculus*. Prey in most of the other localities, included in mid- and high Piedmonts were *Akodon* sp, *Auliscomys micropus*, *Chelemys*

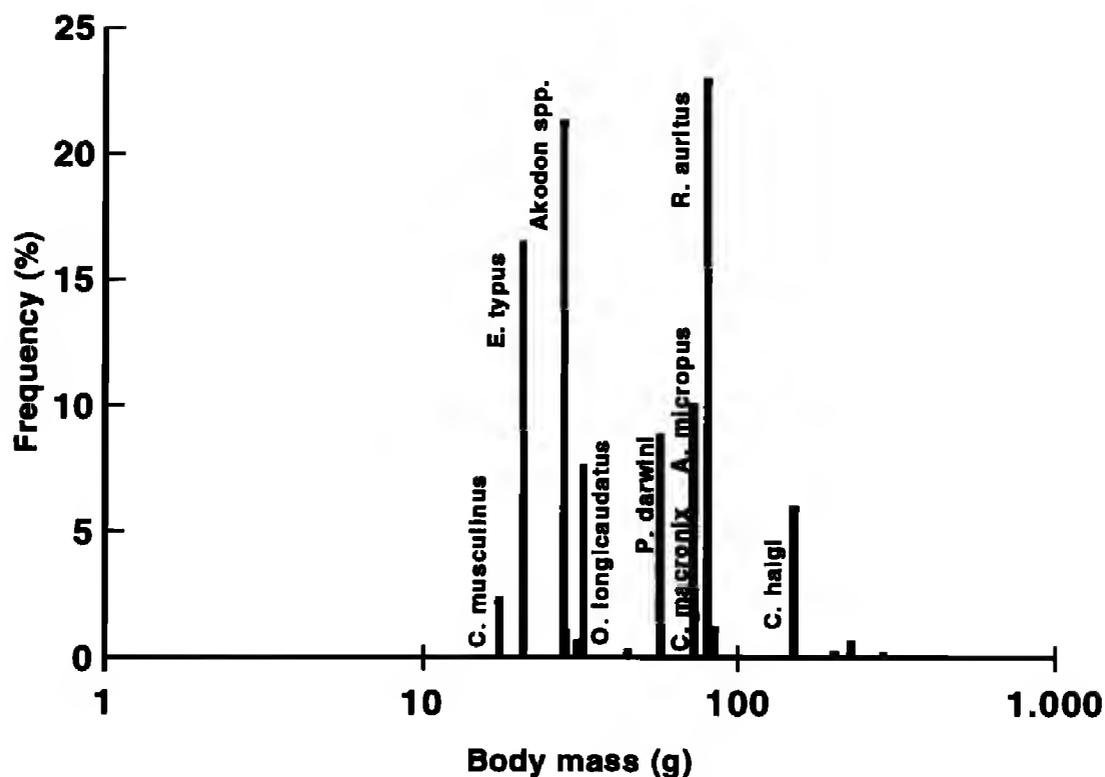


Figure 1. Relative frequencies (%) of small mammal prey in the diet of Common Barn-owls in northwestern Argentine Patagonia, ordered along a logarithmic axis of body weights.

macronix and *Geoxus valdivianus*. In a few localities, *Phyllotis darwini* and *Euneomys* sp. also occurred.

The similarity between the expected and observed rank order in cricetid species in the diet

(Table 2) indicated that barn owls fed on prey according to their availability in intermediate and highland Piedmont areas ($r_s = 0.91$, $P < 0.01$). The most important difference was the greater importance of *Reithrodon auritus* and the overall absence of *Akodon* sp. in the diet.

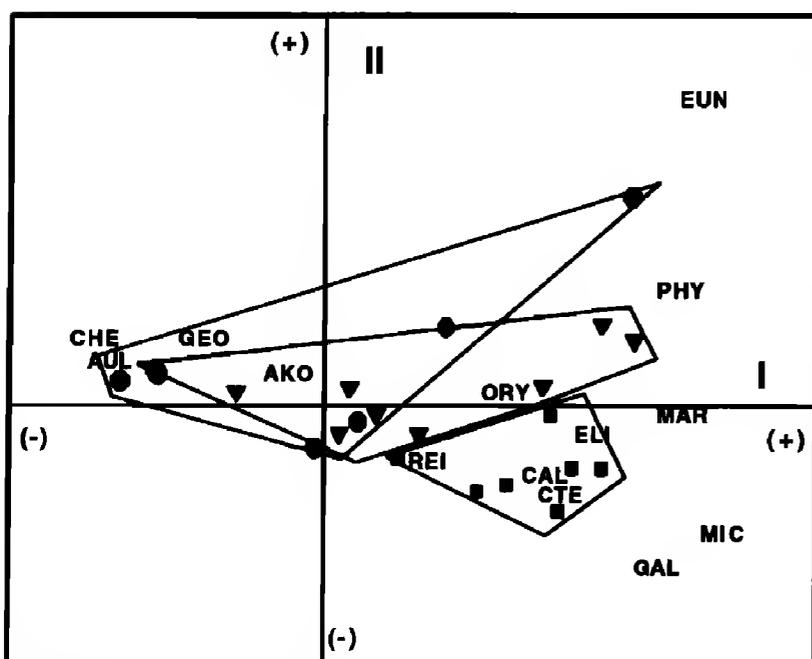


Figure 2. Variation in the taxonomic composition of the diet of the Common Barn-owl in northwestern Argentine Patagonia. Plot of the Correspondence Analysis, areas of each delimited by minimum polygon. See Table 2 for most species abbreviations. MAR, *Marmosa pusilla*; CAL, *Calomys musculus*; GAL, *Galea musteloides*; CTE, *Ctenomys haigi*. Circles correspond to highland Piedmont, quadrats to lowland Piedmont and triangles to intermediate Piedmont.

DISCUSSION

Barn owls in our study preyed almost exclusively on rodents, as found in most other studies (Smith and Cole 1989, Bellocq 1990, Iriarte et al. 1990, De Santis et al. 1994, Taylor 1994). This suggests that these barn owls do not behave as opportunistic, nonselective predators as suggested by Mikkola (1983). Taking this into account, care should be taken when interpreting the unusually high predation on birds reported by Noriega et al. (1993) in the Patagonian zoogeographic domain (Ringuelet 1961). Their data may reflect individual differences of individual barn owls.

Our mean body mass estimate of small mammals in the diet (56.2 g) was intermediate between that reported in Spain (21.2 g) and Chile (70.7 g) (Herrera and Jaksic 1980). Because the largest prey taken in the three areas was the European rabbit, (*Oryctolagus cuniculus*), the smaller MWSM in Argentina when compared with Chile was a consequence of both the high concentration of smaller prey than in Chile (30–500), and the greater consumption of smaller rodents than in Chile. In Argentine Patagonia, only one of the three available rodent species weighing more than 150 g (*Ctenomys haigi*) was readily consumed by owls, while in Chile three of four such species were consumed in amounts similar to that of our *C. haigi* (Herrera and Jaksic 1980).

H'NGG diversity and evenness indexes were similar to

Table 2. Expected composition of Common Barn-owl diet expressed as a percentage for five habitats, based on Pearson (1983, 1986).

SPECIES ¹	BUNCH					OWL DIET	OWL DIET	FIELD RANK
	STEPPE	GRASS	WEEDS	ROCKS	BARE			
AKO	42.0	76.0	49.0	41.0	36.0	27.0	AKO	AKO
AUL	2.0	12.0	16.0	2.0	23.0	12.0	REI	ELI
CHE	0.0	0.0	1.0	0.0	10.0	1.9	ELI	AUL
ELI	43.0	12.0	2.0	3.0	3.0	13.0	AUL	ORY
EUN	0.0	0.0	0.0	1.0	15.0	2.8	PHY	REI
GEO	0.0	0.0	2.0	0.0	2.0	1.0	ORY	PHY
IRE	0.0	0.0	0.0	1.0	0.0	0.3	EUN	EUN
ORY	4.0	0.0	19.0	2.0	8.0	10.0	CHE	CHE
PHY	4.0	0.0	0.0	48.0	1.0	11.0	GEO	GEO
REI	5.0	0.0	11.0	2.0	2.0	21.0	IRE	IRE

¹ AKO, *Akodon* sp.; AUL, *Auliscomys micropus*; CHE, *Chelemys macronix*; ELI, *Eligmodontia typus*; EUN, *Euneomys* sp.; GEO, *Geoxus valdivianus*; IRE, *Irenomys tarsalis*; ORY, *Oryzomys longicaudatus*; PHY, *Phyllotis darwini*; REI, *Reithrodon auritus*.

those found by Herrera and Jaksic (1980) for Chilean barn owls. The inclusion of amphibians and the absence of reptiles by the Argentine owls were the main reasons for these differences.

Among mammals, the preponderance of rodents among the diets of Argentine owls made the H'NM diversity and evenness indices very low compared to those obtained for Chilean owls (Herrera and Jaksic 1980), which were more equally represented. In Chile, Spain and Argentina, the low consumption of the European rabbit is likely related to its large body size.

The correspondence analysis results concurred with results obtained by Pearson and Pearson (1982) and our prediction with respect to the gradient with which cricetid rodents are associated. Both species and localities were segregated by an aridity gradient.

Irenomys tarsalis occurred in the barn owl diet only near the *Nothophagus* forest. *Auliscomys micropus* was eaten only in forest or dense cover habitats but *Oryzomys longicaudatus* was eaten in all the habitats considered for this analysis. *Eligmodontia typus* occurred in the diet of owls only in open habitats with bare soil and scattered desert shrubs, *Ctenomys haigi* occurred in the diet in open areas with sandy soils, and *Calomys musculus* and *Reithrodon auritus* occurred in the diet of birds associated with the arid portion of our gradient.

Observed consumption of *Reithrodon auritus* was, both in percent frequency and rank order, higher than expected. A similar situation was observed by Jaksic and Rau (1986) for the Great Horned Owl (*Bubo virginianus*) in a Chilean Patagonian steppe with about the same mammalian composition that we report. As in Europe and North America, comparison of the abundance of small mammal species is often susceptible to problems of differential trapability. On the other hand, *Akodon* sp. was consumed less than expected by chance in all five habitats. Perhaps their more diurnal activity period and small body weight contributed to these results (Taylor 1994). Based on our knowledge, the ecology of *Reithrodon auritus* and *Akodon* sp. resembles that of voles and mice described in North America and Europe (Marti 1974, Col-

vin 1984). There, barn owls frequently select voles in the presence of other prey, probably because the former are heavier and easier to catch (Taylor 1994). Three factors provide a plausible explanation. First, *R. auritus* (80.4 g) is 3 times heavier than *Akodon* sp. (28.0 g), even a bigger difference to that found between voles and mice (Marti 1974, Colvin 1984). Second, *Akodon* sp. shows greater activity during the daytime (Rau et al. 1981). The opposite is true for *R. auritus* which is a typical nocturnal species (Pearson 1988), thus overlapping its activity period with that of the barn owl. Finally, *R. auritus* feeds in open grassy habitat where it may be more exposed to owl predation, while *Akodon* sp. prefers dense bushes in the steppe (Pearson and Pearson 1982), perhaps gaining protection against owl predation.

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INDICATORS OF MALE QUALITY IN THE HOOTS OF TAWNY OWLS (*STRIX ALUCO*)

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ABSTRACT.—The number of songs in a male's repertoire, and the amount of time he spends singing, have been shown to correlate with territory size and quality, reproductive success, parental care and parasite load in some passerine species. In addition, females of some species use song rate and complexity as a cue to mate choice and are more responsive to more frequent and complex songs. Few studies, however, have examined the influence of body size and parasitic infections on the sound frequency (pitch) and structure of vocalizations of birds. The Tawny Owl (*Strix aluco*) hoot is important in communication between birds at night when visual information is limited, and is simple enough to allow a quantitative analysis of its structure. Six temporal and four frequency measures of the hoots of 50 Tawny Owls were taken, and compared to body mass, wing length, breeding success and number and intensity of parasitic infections of the singers. There was a decrease in call frequency with increasing body mass and the vibrato tail of the last note was longer in larger birds, but there was no part of the call that correlated with breeding success. There was an increase in call frequency as the number of parasitic infections increased, and there was a decrease in the length of calls as the intensity of parasitic infections increased.

KEY WORDS: *Strix aluco*; hoot structure; body weight; body size; breeding success; blood parasites; female choice; assessment.

Indicadores de calidad del macho en ululatos de *Strix aluco*.

RESUMEN.—La cantidad de canciones en el repertorio del macho, y la cantidad de tiempo que dedica cantando, han mostrado una correlación entre el tamaño del territorio y la calidad del éxito de reproducción, preocupación paterna, y carga parasítica en especies *passerinus*. En suma, hembras usan la velocidad y complicación de la canción como señal para escoger su pareja están más interesadas en canciones complicadas y de más frecuencia. Pocos estudios, sin embargo, han examinado la influencia del tamaño corporal y infección parasítica en la frecuencia modulada del sonido (tono) y estructura de vocalización en pájaros. El ululato de *Strix aluco* es importante en comunicación entre los pájaros por la noche cuando información visual es limitada, y es lo suficientemente simple para dejar un análisis cualitativo de su estructura. Seis temporal y cuatro frecuencias moduladas de los ululatos de 50 *S. aluco* fueron tomados, y comparados al tamaño corporal, largo de ala, éxito de cría, y número e intensidad de infección parasítica de los cantadores. Hubo reducción en frecuencia de llamadas y aumento de el tamaño corporal y la cola *vibratus* de la última nota fue más larga en los pájaros grandes, pero no hubo ninguna parte de la llamada que hizo correlación con el éxito de cría. Hubo un aumento en la frecuencia de llamadas cuando la cantidad de infección parasítica aumentaron, y hubo una reducción en la duración de llamadas cuando la intensidad de infección parasítica aumento.

[Traducción de Raúl De La Garza, Jr.]

Some bird species can recognize their offspring (Tschanz 1968, Beer 1969, Beecher et al. 1981), mates (White 1971, Brooke 1978, Jouventin et al. 1979) and territorial neighbors (Falls 1992, Galeotti and Pavan 1993) through their vocalizations.

Song can also give information on the position and orientation of the signaler (Richards 1981, McGregor and Falls 1984, McGregor and Krebs 1984).

Song appears to also be important in sexual selection in many species and females have been

shown to be more responsive to males with higher song output (Houtman 1992, Payne and Payne 1977) whether song output was increased by lengthening songs or reducing intersong intervals (Wasserman & Cigliano 1991). In Willow Warbler (*Phylloscopus trochilus*) males, there was a link between high song output and good territories (Radesater et al. 1987, Radesater & Jakobsson 1989), and Houtman (1992) showed that Zebra Finch (*Poephila guttata*) males with higher song output produced heavier offspring. Females of some species have also been shown to prefer males with more complex repertoires (Searcy & Marler 1984, Baker et al. 1986, Catchpole et al. 1984, Eens et al. 1991a). The complexity of song has been found to correlate with territory size, survival and reproductive success (Hiebert et al. 1989, McGregor et al. 1981, Catchpole 1986).

As song is used by males to attract females, it has been hypothesized that song may give information on the parasite infections of male singers. Hamilton & Zuk (1982) found bird species with more complex songs were more likely to have blood parasite infections, but this correlation disappeared when phylogeny was taken into account (Read & Weary 1990). Møller (1991) studied the effect of parasites within a population of Barn Swallows (*Hirundo rustica*) and found that males infected with mites produced less song.

Despite the implications for mate choice, little is known about how the size and weight of a bird affects its vocalizations, and whether parasite infections affect the structure or frequency of a bird's call. This is particularly relevant for nocturnal birds, which may not have detailed visual information about a potential mate or rival. In this paper, we present an analysis of the information contained in the "hoot" vocalization of the Tawny Owl (*Strix aluco*). Tawny Owls are nocturnal woodland birds, so visual information transferred between territorial rivals or potential mates at night is probably very limited. The hoot is individually distinct and constant with time and is thought to function in communication between the sexes as well as territorial defense (Galeotti & Pavan 1991).

METHODS

Recordings of Tawny Owls were made at Wytham Woods, Oxfordshire (51.46° N 1.2° W), Monks Wood, Cambridgeshire (52.24° N 0.14° W), a farmland area, (The 'Fens') Cambridgeshire (52.29° N 0.1° W) and Kielder Forest, Northumberland (55° 15' N 2° 35' W). Recordings were made using a Uher or Sony Walkman Pro-

fessional tape recorder (TC-D5 PRO) with a Sennheiser MZW 816 microphone. Recordings were made of male birds on calm, dry nights from October–December 1992–93 in Wytham Woods, and in March 1993 in Monks Wood and the Fens. Recordings of birds at Kielder Forest were made in November 1994. Birds were stimulated to hoot using playback of an unfamiliar male owl. The hoots of male owls can be distinguished from hoots of female owls by the squeaky grating quality of the female hoot. In the case of the Wytham owls, the sex of the birds was confirmed using radiotags. Recordings were made as near to birds as possible, at distances between 5–50 m.

Sonograms were produced on a Macintosh LCII computer. Tawny Owl hoots have a basic structure of three notes (Fig. 1) that can be clearly determined in owls from all areas. Sonograms of the whole hoot were made using Soundedit Pro software (Macromind Paracomp, Inc., 600 Townsend, San Francisco, CA 94103 U.S.A. 1992) and temporal measures were recorded. Soundedit Pro did not give accurate frequency measures, so sonograms of the first note of each hoot were made with Canary software (Cornell Laboratory of Ornithology, 159 Sapsucker Woods Road, Ithaca, NY 14850 U.S.A.), and the frequency measures were recorded.

Temporal measures used were similar to those described by Galeotti and Pavan (1991). Six temporal measures were recorded for each call. These were: note 1 (D1), internote interval one (I4), note two (D2), internote interval two (I5) and note 3 was split up into frequency modulated length (FML) and tail (Fig. 1). Frequency measures used were the highest and two lowest frequencies of the first note (HIGH, LOW1 and LOW2) and the middle of the highest part of the first note (MED). All time measures were recorded in milliseconds (ms) and all frequency measures were recorded in KHz. Only clear recordings with little background noise were used for making sonograms. Any sonograms where all call parameters could not be determined were discarded. An "average" sonogram was calculated for each owl by taking the mean of a minimum of 3 calls from each owl.

Breeding success of owls was measured at Wytham Woods, Monks Wood and the Fens in 1993. Breeding success was defined as the total number of owlets fledged/-breeding area and was found by monitoring nests or by locating calling chicks in June and July before mortality of fledged chicks has occurred. Fledged young can be located in June and July when they call loudly and continuously for food (Muir 1954, Southern 1970).

Males were caught in spring 1993 and 1994 using nest-box traps (Petty et al. 1994). Males were weighed, measured for wing length and blood slides were prepared by placing a drop of blood from the branchial vein directly onto a glass slide and smearing it with a second slide to produce a blood layer one cell thick. The smear was then air dried and fixed in absolute ethanol and stained with Giemsa's stain. Parasite species were identified by M. Anwar at Oxford University and the number of each species was quantified by counting the number of parasites in 10 000 blood cells. The two measures of parasite infection used were the number of parasite species present and the total number of blood cells containing parasites (all parasite species pooled). For some owls, the blood parasite counts and body measurements were taken at differ-

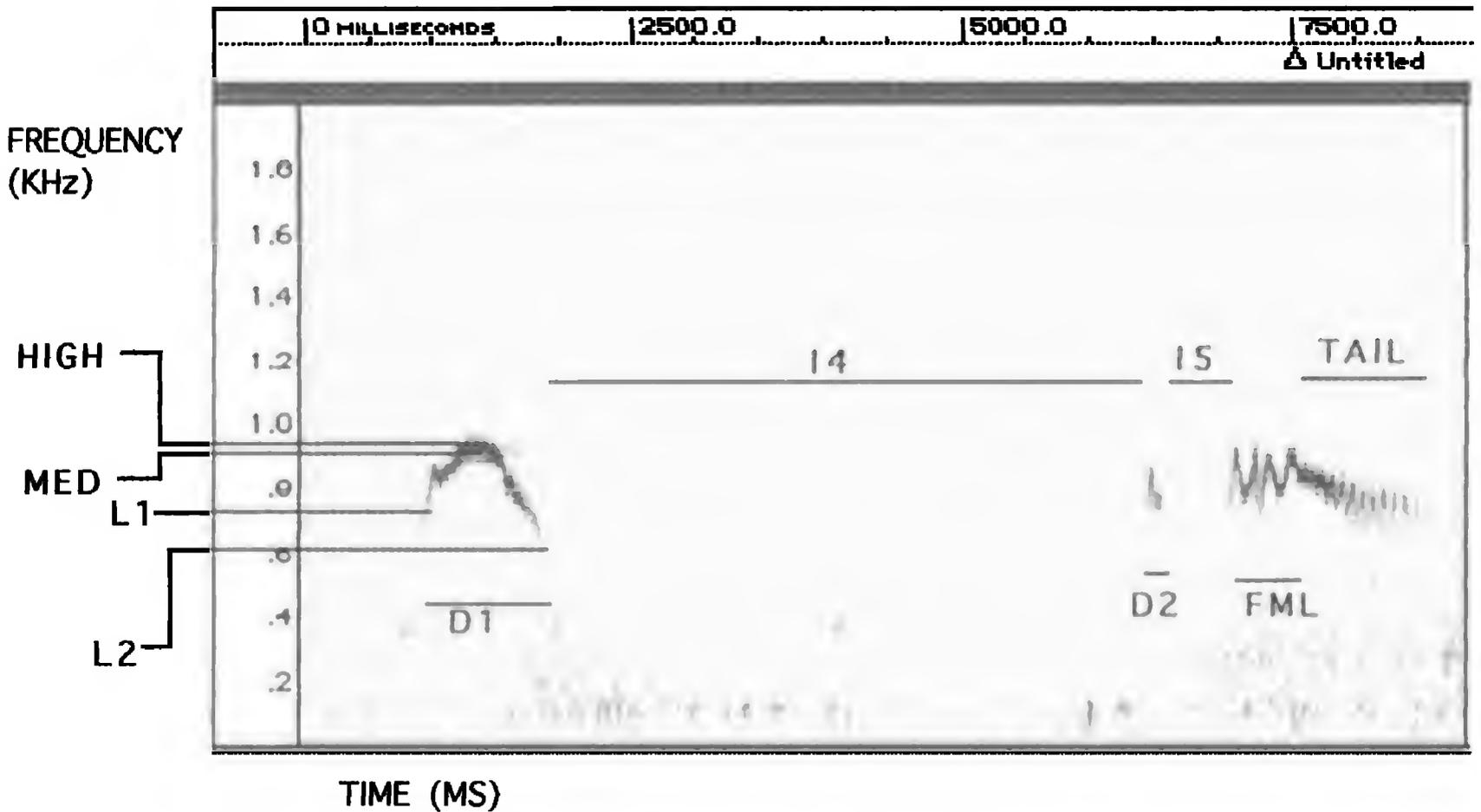


Figure 1. Sonogram of Tawny Owl hoot showing time and frequency measures.

ent times of year than recordings of their hoots. In this case, the identity of the owl was confirmed using radiotags or by confirming that the same male was present the following breeding season.

The data were examined visually using histograms and no evidence was found for a significant deviation from the normal distribution. Parametric tests were therefore used.

RESULTS

The hoots of 50 male Tawny Owls were recorded at the four study sites (Table 1). Although none of the temporal measures of call varied significantly among the four sites (ANOVA, $P > 0.05$), there was a significant difference between the sites in all of

Table 1. The number of Tawny Owls from the four study sites for which data on both call parameters and body measurements, breeding success and parasite loads were available.

STUDY SITE	# OWLS	BODY MASS	WING LENGTH	FLEDGING SUCCESS	# INFECTIONS	PARASITE LOAD
Wytham	20	5	5	20	4	4
Monks Wood	9	4	4	9	0	0
Fens	16	6	6	16	0	0
Kielder	5	4	0	0	4	4

the frequency measures (LOW1 $F_{3,46} = 17.03$, $P < 0.0001$; LOW2 $F_{3,46} = 12.58$, $P < 0.0001$; MED $F_{3,46} = 4.63$, $P = 0.007$; HIGH $F_{3,46} = 6.08$, $P = 0.001$). The Kielder owls were lighter than those of the other populations ($F_{3,15} = 3.25$, $P = 0.051$), but this was based on only 4 birds from Kielder and there was no significant difference among the sites for wing length and the breeding success of pairs ($P > 0.05$).

Pearson Rank Correlations were not significant for body mass, wing length, breeding success and parasite number and load for any of the owls used in the analysis; however, there was a significant correlation between number of parasites and breeding success ($r = 1$, $P < 0.001$) which was based on only four Wytham owls.

There was no significant correlation between the body mass of a bird and the length of any of the notes or the internote intervals of its call, but there was a negative correlation between the highest frequency of the song and body mass (Fig. 2, $r = -0.48$, $P < 0.05$). There was no significant correlation between wing length and any of the frequency measures of the call. The only time measure of the call that correlated significantly with wing length was the tail of the third note ($r = 0.71$, $P < 0.003$). Likewise, there was no significant cor-

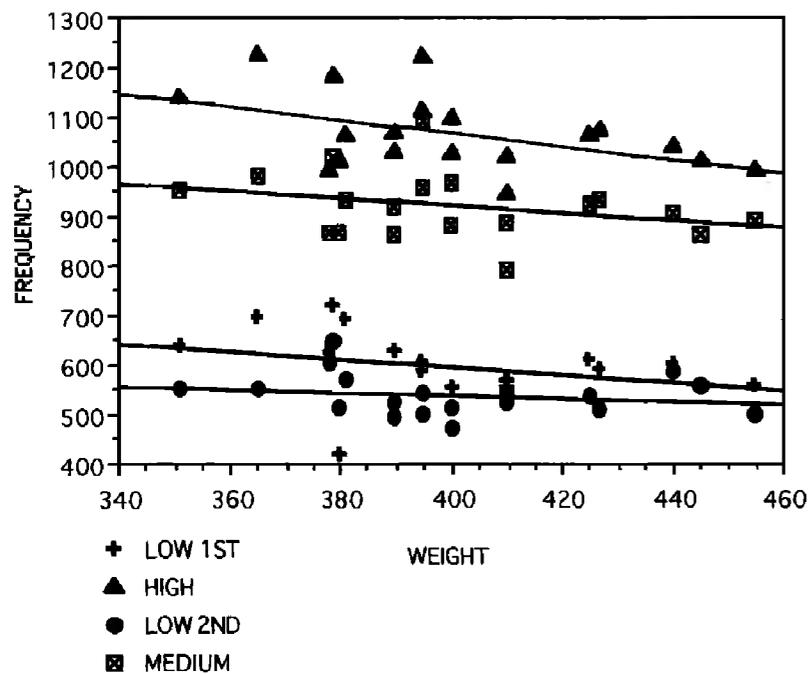


Figure 2. Effect of body mass of Tawny Owls on the four frequency measures of their hoots.

relation between average breeding success in 1993 and any of the call parameters. All four frequencies were entered into a regression model as independent variables to try to predict breeding success as the dependent variable, however the model did not significantly predict breeding success ($F_{4,40} = 0.29, P = 0.88$).

The number of parasite species present in an individual ranged between one and four. The parasites found were *Leucozytozoon ziemanni*, *Haemoproctus syrnni*, *H. noctuae* and *Trypanosoma*. All frequency measures increased with increasing num-

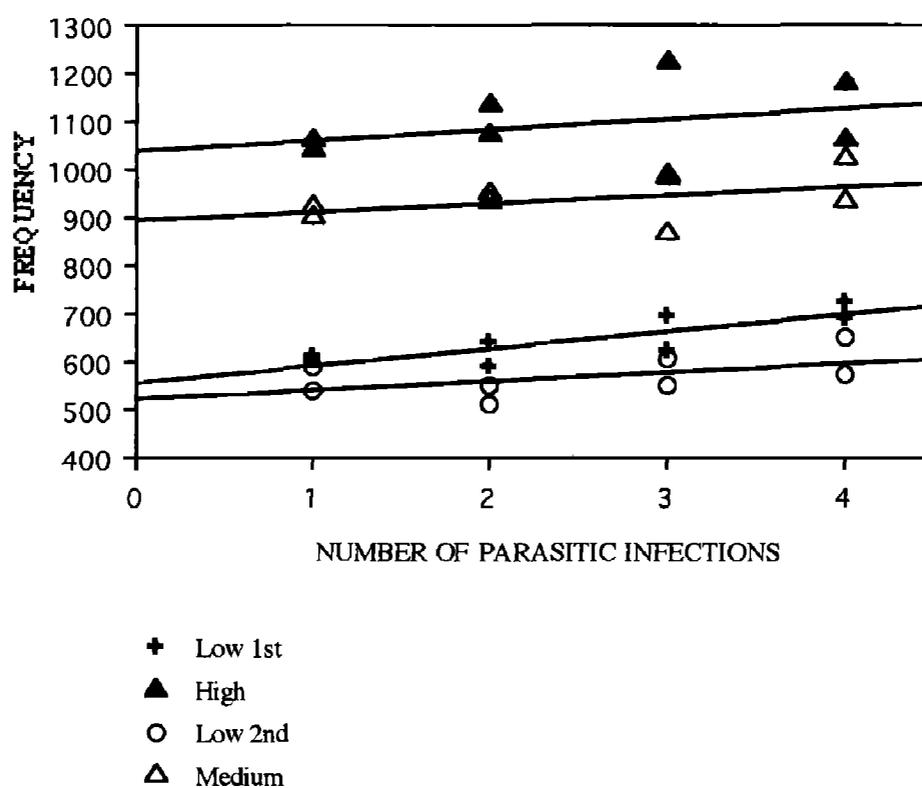


Figure 3. Effect of parasitic infections of Tawny Owls on the four frequency measures of their hoots.

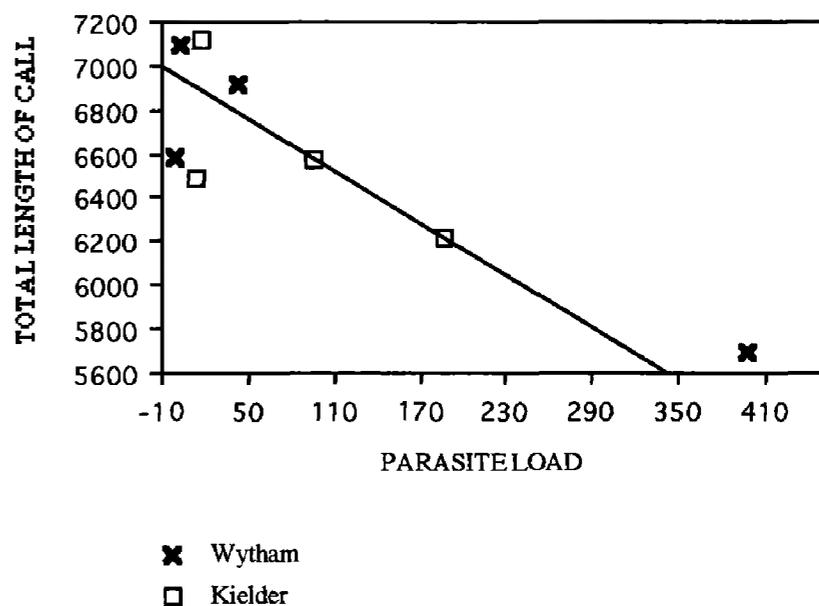


Figure 4. Effect of parasite load on the total length of Tawny Owl hoots.

bers of parasites (Fig. 3), but this was only significant for the lowest frequency at the start of the first note. The Kielder birds had higher numbers of parasites and higher frequency calls, but due to the small sample size it was not possible to analyze the data by site to see if the relationship held in each case.

There was a significant negative correlation between the length of the internote interval ($r = -0.75, P < 0.05$), gaps in the song ($r = -0.76, P < 0.05$), and the total length of the song (Fig. 4, $r = -0.87, P < 0.05$) and the parasite load, but there was no significant correlation with any of the frequencies measured ($P > 0.05$).

DISCUSSION

For a bird embarking on a territorial dispute, assessing the size of the opponent is important in predicting the probable outcome of a fight. This is especially true for an aggressive bird like a Tawny Owl, where vocal disputes are often fierce and prolonged. For a female assessing a potential mate, the body mass of a male might give information on resources available in his territory. The size of the syrinx is likely to affect the frequency of the call and could vary with the size of a bird. We found that the highest frequency of Tawny Owl calls to be more closely correlated with body mass than the lowest frequency. This decrease in highest note frequency with size implies that birds might be emitting their highest note to advertise their small size. Newton (1988) found that smaller sparrowhawk males had a higher lifetime reproductive success than large males. Although the selective pressures favoring reduced size in Tawny Owl males are probably different to those in sparrowhawks, reversed sexual dimorphism implies there might be selection for smaller males in Tawny Owls. Females might, therefore, favor small males and be using male hoots to assess this.

The only call parameter that correlated significantly with wing length was the length of the vibrato tail of the third note, which increased with wing length. Wing length is an indication of body size of birds. It is possible that a larger bird might be able to sustain the last note for a longer time, perhaps due to increased lung volume. Data on more birds would be needed to ascertain whether the length of the last note was a reliable signal of body size.

None of the measures of the call were significantly correlated with breeding success, so there is no detectable signal that females could reliably use to assess the breeding capability of a potential partner. As there was only one year's breeding data available, and this varies with food supply and site (Petty 1992), it is possible that a correlation does exist between reproductive ability and call parameters, but it was obscured by other factors.

All measures of frequency increased with increasing number of parasitic infections and this was significant for the lowest frequency at the start of the first note. Males that are able to give low frequency calls might therefore be indicating a resistance to parasites. Birds with higher parasite loads gave significantly shorter calls. Physiological reasons that might cause this are obscure, but it might imply that long calls are costly to give and are therefore an indication of good health. In frogs, heavily infested males have also been shown to have below average call durations (Read 1988), and long calls in frogs are more effective in attracting females (Rand and Ryan 1981, Wells and Schwartz 1984, Ryan 1985). Lengths of owl hoots are fairly constant with time (Hirons 1976) so it is possible that call length could be utilized to signal parasite burdens and potential breeding capabilities.

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ROLE OF REFUSE AS FOOD FOR MIGRANT, FLOATER AND BREEDING BLACK KITES (*MILVUS MIGRANS*)

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ABSTRACT.—The use of refuse by breeding, floating, and migrating Black Kites (*Milvus migrans*) was studied near a large garbage dump in Madrid, Spain. Refuse was an important food resource for nonbreeding Black Kites, especially migrants that fed almost exclusively at the garbage dump. The dump was only of secondary and variable importance for kites during the breeding season. Pairs of breeding kites nesting in nearby wooded areas foraged mainly on a wide variety of wild prey and only sporadically ate refuse at the dump. Floaters roosted in nearby wooded areas but, unlike breeding pairs, they foraged mainly by scavenging at the dump. Exploitation of food resources other than refuse by breeding kites may be due to their need for large amounts of prey biomass for brood provisioning. Perhaps dumps augment populations of Black Kites by providing rich foraging areas where large numbers of nonbreeding and migratory kites can scavenge for food.

KEY WORDS: *Black Kite, Milvus migrans; garbage dump; foraging; refuse.*

Importancia de la basura en la dieta de Milanos Negros (*Milvus migrans*) migrantes, flotantes y reproductores.

RESUMEN.—La importancia de la basura en la dieta de Milanos Negros (*Milvus migrans*) reproductores, migradores e integrantes de la población flotante fue estudiada en las cercanías del basurero de Madrid, España. La basura fue un recurso importante para los milanos no reproductores, especialmente para los migrantes, pero su papel fue secundario aunque variable para los milanos que se reprodujeron cerca del basurero. Los individuos flotantes forrajearon en el basurero pero también consumieron una amplia variedad de presas salvajes. La abundancia de alimento en el basurero no provocó que los milanos nidificaran en sus cercanías, ya que la parejas que así lo hicieron consumieron basura sólo esporádicamente. Por el contrario, los individuos flotantes pernoctaron a diario en la zona arbolada más cercana al basurero. El uso preferencial de presas salvajes frente a la basura por los milanos reproductores puede ser explicado como consecuencia de la necesidad de presas de gran biomasa para su consumo por los pollos en crecimiento. Durante la estación reproductora, el vertedero de Madrid podría tener una importancia indirecta para el mantenimiento y conservación de la población reproductora a través del reemplazo de las pérdidas en los reproductores por los individuos flotantes.

[Traducción del Autor]

Breeding and nonbreeding segments of raptor populations often share the same foraging habitats (Newton 1979). Floaters, nonbreeding, nonterritorial adults and subadults, have larger home ranges and greater mobility than breeders, and usually concentrate in areas rich in food (Newton 1979, Ceballos and Donazar 1990). Interactions between floaters and breeding conspecifics has been little studied despite its potential to influence raptor population dynamics (Newton 1979). Both breeders and floaters of social species such as the *Milvus* kites coexist in breeding areas when food is abundant (Espina 1986, Koga et al. 1989, Heredia et al.

1991), especially where large waste accumulations occur at garbage dumps (Ceballos and Donazar 1988, Blanco 1994). Rubbish dumps and dungheaps are frequently used by scavenging birds that normally exploit temporary and unpredictable food sources (Pomeroy 1975, Donazar 1992). The importance of refuse dumps for breeding populations of scavenging birds has been repeatedly emphasized (Pomeroy 1975, Coulson et al. 1987, Donazar 1992) but, to date, it is not known whether these unnatural foraging places are influencing the population dynamics of scavenging species.

The Black Kite (*Milvus migrans*) is a widespread

species that opportunistically exploits a wide array of food sources (Delibes 1975, Shiraishi et al. 1990). Floaters form an unknown proportion of populations, and usually share habitat with the breeding segment (Espina 1986, Koga et al. 1989, Blanco 1994). At present, little is known about the relationship between these two sectors of Black Kite populations. This study deals with the role of refuse in the diet of breeding, floating and migrating Black Kites living in the vicinity of a large garbage dump near Madrid, Spain.

STUDY AREA AND METHODS

The study area was located at an elevation of 500–700 m in the flood plain of the Jarama River at its confluence with River Manzanares (40° 19'N, 3° 31'W) in southeastern Madrid Province, central Spain. It included a complex of riverine gypsum cliffs, riparian forests dominated by poplars (*Populus alba*, *P. nigra*, *P. × cultivar*), willows (*Salix* spp.) and elms (*Ulmus minor*), but most of the area was converted to agriculture (mainly cereal crops, sunflower, alfalfa and vegetables), cattle grazing and gravel extraction. The Madrid garbage dump was located in the northeastern portion of the study area. From 100 to >1000 Black Kites routinely gathered there to feed on the refuse (Blanco 1994).

During the breeding season of 1994, the Black Kite population consisted of about 50 pairs nesting on trees, cliffs and electric pylons, and about 80–300 nonbreeding individuals forming a floating population of both adults and subadults (Blanco 1994). Each day, resident floaters roosted communally about 4 km southeast of the dump, in a portion of riverine elm forest where 6–10 pairs nested. Numbers of Black Kites in the area increased considerably after breeding and especially during migration (Blanco 1994).

I determined the diet of nonbreeding kites by analyzing food remains collected beneath roosting and diurnal communal perching trees during the period when Black Kites are resident in the area (Blanco 1994). All prey remains (bones, fur and feathers) were collected on each visit to the roost, from the final stage of the nestling period (June) to the end of August. Prey collections were grouped into three time periods (22 July, 31 July and August) to assess possible temporal variations in the consumption of refuse. The first period (Period A: until 22 July) included the spring migration, breeding season, fledgling period and the start of migrant arrivals; Period B (23–31 July) coincided with an increase in the influx of migrants; and Period C (from 1 August to the end of that month) included the peak abundance of migrants and the remainder of the residency period of Black Kites in the area (Blanco 1994). Because all food remains found below the roosting trees were collected in each visit to the roost, I am confident that they were accurately grouped on a temporal basis. Because breeding Black Kites usually roosted close to their nesting sites during the breeding period, prey remains found at the communal roost site were mostly from food eaten by local nonbreeders. Prey remains found at the roost after the breeding season corresponded to food of both local

(breeding and floating) and migrant kites. After the breeding season, field observations suggested that breeding Black Kites and their fledglings joined communal roosts together with floaters and northern migrants (J. Viñuela pers. comm. and pers. obs.). The first juveniles appeared in the roost soon after the breeding season (Blanco 1994) when breeders left their territories. Therefore, some remains collected at this time might have originated from prey of local breeders which represented a high proportion of the birds roosting communally from 23–31 July. Afterwards, the collecting period coincided with the major influx of migrants (>1000 kites in early August); at this time local breeders constituted a small proportion of the birds.

The diet of breeding kites and their nestlings was determined by analysis of food remains found in and below the nests of 18 pairs. The material was collected after the breeding season to avoid disturbance at the nests. Pairs studied nested in trees and cliffs about 4–12.5 km from the dump.

Food remains were identified by macroscopic comparison with reference collections and quantified assuming the smallest possible number of individuals (Marti 1987). Two main categories of food were considered in the analysis: wild prey obtained by hunting and scavenging (e.g., wild birds, mammals, fish), and refuse (e.g., food items intentionally discarded by humans such as domestic refuse, offal from slaughterhouses and butcher shops, and marine fish). To detect general differences in food habits of breeding and nonbreeding Black Kites, prey items were classified into nine major groups (Table 1). The data were likely biased in favor of the most durable prey remains and did not reflect the importance of arthropods and other prey (Marti 1987). However, the study was not designed to provide detailed descriptions of the Black Kite diet (Delibes 1975, Veiga and Hiraldo 1989, Shiraishi et al. 1990) but to detect broad differences in the consumption of refuse.

Biomass of each prey species was estimated using mean weights of each prey taxon obtained from the literature. Weights of prey taxon identified at nests could not exceed 300 g even when the mean weight of the taxon exceeded that weight because Black Kites usually do not transport heavier prey to the nest (Espina 1986, pers. obs.). In this case, I assumed that prey heavier than 300 g were not delivered to the nest whole. Weights of large prey from the roost were estimated based on the daily food requirements of adult Black Kites (100 g, Espina 1986; see also Heredia et al. 1991 for Red Kites [*Milvus milvus*]). Therefore, I assumed that the maximum ingestion capacity per feeding bout to be equivalent to the daily food requirements (Blanco et al. 1990). Although Black Kites may tear off small pieces of the prey and bring them to the nest one by one (J. Viñuela pers. comm.), and nonbreeding kites may eat prey over several days, I felt my criteria avoided an overestimation of the biomass of large prey up to the size of a White Stork (*Ciconia ciconia*, weight = 3.5 kg).

Refuse consumed both by breeding and nonbreeding kites typically consisted of small pieces of food, including parts of fish and fowl (mostly heads, wings and legs) and livestock bones, but no large fragments of food, which was estimated to yield 50 g of biomass on average. Be-

Table 1. Diets of breeding and nonbreeding Black Kites in the southeast of Madrid during and after the breeding season of 1994. Results are expressed as percentages of number of prey (NP) and biomass (B) for each prey class.

PREY ITEMS	BREEDING BLACK KITES		NON-BREEDING BLACK KITES			
	% NP	% B	BREEDING SEASON		NONBREEDING SEASON	
			% NP	% B	% NP	% B
Wild prey	76.4	93.1	40.6	57.4	21.4	29.4
Rabbits and Hares ^a	22.5	39.7	18.8	26.9	8.7	16.3
Other mammals ^b	6.0	4.9	3.1	4.5	1.0	1.8
Pigeons ^c	8.8	15.5	3.1	4.5	2.9	5.4
Other birds ^d	18.7	21.1	12.5	17.0	2.9	5.4
Fish ^e	13.2	11.0	3.1	4.5	0.0	0.0
Other prey ^f	7.1	0.9	0.0	0.0	5.8	0.4
Refuse	23.6	6.9	59.4	42.6	78.6	70.6
Livestock carrion	17.0	5.0	37.5	26.9	48.5	42.6
Chicken	5.5	1.6	18.8	13.5	22.3	20.8
Marine fish	1.1	0.3	3.1	2.2	7.8	7.2
Number of prey	182		32		103	
H'	0.87		0.73		0.66	

^a *Oryctolagus cuniculus*, *Lepus granatensis*.

^b *Erinaceus europaeus*, *Rattus norvegicus*, *Apodemus sylvaticus*, unidentified rodents.

^c *Columba livia*, *Columba livia* var. *domestica*, *Columba palumbus*, unidentified pigeons.

^d *Ciconia ciconia*, *Anas platyrhynchos*, unidentified Anatidae, *Milvus migrans*, *Alectoris rufa*, *Gallinula chloropus*, *Larus ridibundus*, *Clamator glandarius*, *Otus scops*, *Athene noctua*, *Picus viridis*, *Sturnus unicolor*, *Pica pica*, *Corvus monedula*, unidentified corvid, *Turdus merula*, *Passer* sp., unidentified bird.

^e *Cyprinus carpio*, *Ictalurus melas*, unidentified fish.

^f *Lacerta lepida*, unidentified Colubridae, unidentified Coleopterans, bird eggs.

cause of the difficulty in accurately estimating biomass values from prey remains of scavengers and facultative predators (Marti 1987), the analysis conducted in this respect should be considered as a simple approximation of the diet. The aim of the biomass analysis was provide a comparative assessment of the energetic role of refuse with the natural prey for breeding and nonbreeding kites.

Dietary diversity was calculated with the Shannon-Weaver index (H') considering the major prey classes (Table 1). Dietary overlap between breeding and nonbreeding kites was calculated using Pianka's index (Pianka 1973). Chi-square tests with Yates' correction when $df = 1$, were used to test for differences in the number of prey items (NP) consumed by breeding and nonbreeding kites.

RESULTS

General Food Habits. The diet of Black Kites included a wide range of wild prey and refuse (Table 1). Up to 300 nonbreeding kites returned to the roost every day from the garbage dump throughout the breeding season. Most of the food they obtained from the dump was small pieces of domestic refuse and slaughter offal (*Ovis*, *Sus*, *Bovis*, *Gallus*) which was spread fairly evenly over large amounts of inorganic materials because of the daily treat-

ment measures at the dump. Unidentified marine fishes, available only at the dump, were also consumed. Wild prey consumed by nonbreeders included mostly European rabbits (*Oryctolagus cuniculus*, NP = 34.3%, B = 41.4%), but hares (*Lepus granatensis*) and pigeons (*Columba* spp.) also were of some importance.

Breeding kites ate mainly wild prey (Table 1), the main prey species being European rabbits (NP = 18.7%, B = 32.9%). Altogether, birds accounted for 27.5% by NP and 36.6% by B, and they were mostly medium-sized corvids and pigeons.

Spatial Variation in the Consumption of Refuse by Breeding Kites. The roost site used by nonbreeding kites was 4 km from the dump. Pairs nesting near the roost site had a higher proportion of refuse in their diets than did pairs that nested 5.1–12.5 km from the dump ($\bar{x} \pm SE = 6.6 \pm 0.6$ km; $\chi^2 = 12.53$, $df = 1$, $P < 0.001$ for NP; Fig. 1). However, there was variation in the consumption of refuse among pairs that nested close to the dump (18.2–72.7% of NP, Fig. 2), with somewhat lower values for biomass (5.4–30.8%, Fig. 1).

Although some kites probably obtained refuse at

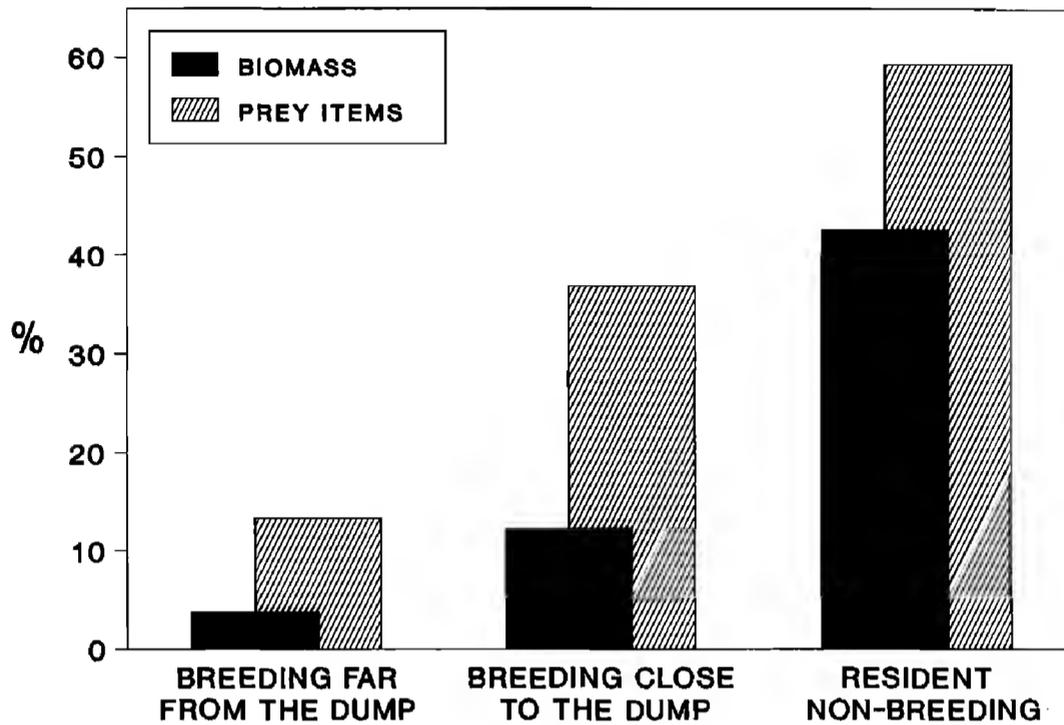


Figure 1. Percentage of refuse in the diet of Black Kites. Data are presented for resident floaters and for kites nesting either far or close to the garbage dump of Madrid, respectively.

sites other than the dump, the proportion of refuse in the diet of breeding pairs was negatively related to distance to the dump (Spearman rank correlation coefficient $r_s = -0.64$, $P = 0.0087$ and $r_s = -0.70$, $P = 0.0038$ for %NP and %B, respectively, $N = 18$, Fig. 2). Thus, the proportion of refuse in the diet of breeding Black Kites was variable for those pairs breeding in the vicinity of the dump but almost insignificant in terms of biomass for the remainder of the breeding population.

Diet Differences and Overlap within the Local Population. The proportion of prey remains included in the refuse class was significantly higher

for nonbreeding than for breeding kites (100 of 135 vs. 44 of 182, $\chi^2 = 75.84$, $df = 1$, $P < 0.001$). A similar conclusion was reached by comparing food remains from the breeding season only, both for all nests ($\chi^2 = 14.58$, $df = 1$, $P < 0.001$ for NP) and when nests located close to and far from the roosting area were considered separately ($P < 0.05$ in all cases, Fig. 1). I found a higher overlap in the diets of breeding Black Kites for prey biomass than for prey type (Table 2). Nonbreeding floaters showed a higher overlap with kites breeding close to the dump than with those breeding farther away, both in type and biomass of the prey they con-

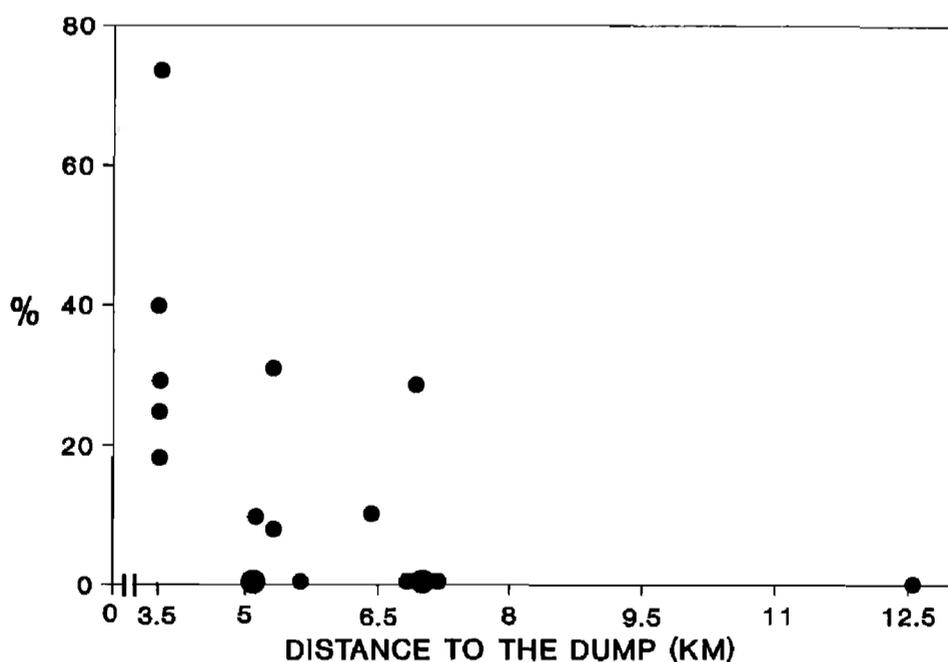


Figure 2. Proportion of prey from refuse in the diet of breeding Black Kites ($N = 18$ pairs) in relation to the distance of their nest from the garbage dump of Madrid. Large dots represent two nests.

Table 2. Percentage of diet overlap (Pianka's index) between breeding and nonbreeding Black Kites.

COMPARISONS	% OF DIET OVERLAP	
	NUMBER OF PREY	BIOMASS
Breeding close vs. far from the dump	69.8	86.0
Breeding close vs. nonbreeding	91.0	80.9
Breeding far vs. nonbreeding	55.6	70.8

sumed. Nevertheless, dietary overlap was high in all the comparisons as expected for individuals of the same species.

Seasonal Variation in the Consumption of Refuse by Non-breeding Kites. Refuse was the main food for nonbreeding kites (Table 3). However, the proportion of refuse increased as the season progressed from the breeding season, when most kites gathering at the roost belonged to the local nonbreeding population, toward the end of the collecting period when most kites were migrants ($\chi^2 = 7.75$, $df = 2$, $P = 0.02$ for NP; Table 3). As a result, dietary diversity declined as the season progressed.

DISCUSSION

In this study, refuse was a more important food resource for Black Kites, especially nonbreeding and migrant individuals. Floaters roosted in wooded areas near the dump and consumed refuse almost extensively and very seldom taking wild prey. Apparently they were able to exploit this abundant and predictable food source because their movements were not restrained by breeding. Contrastingly, breeding Black Kites fed mostly on wild prey items but there was a significant correlation between the distance of nests from the dump and the consumption of refuse with pairs nearest the dump increasing their consumption of refuse. Preferential use of natural food sources by breeding Black Kites is probably related to constraints placed on breeding kites by the need to provision broods of developing young with adequate prey biomass (Donazar 1988, Viñuela and Veiga 1992). In addition, high percentages of rubbish/carrion in the diet could negatively affect the growth of young (Hiraldo et al. 1990, Viñuela 1991).

After the breeding season, refuse is also used by local breeders and their fledglings. Inexperienced juveniles benefit greatly by using the dump and by

Table 3. Seasonal variation in the consumption of refuse by nonbreeding Black Kites, expressed as percentage of number of prey items (NP) and biomass (B).

Period	% B	% NP	H'	n
A (to July 22)	42.6	59.4	0.73	32
B (23–31 July)	64.7	69.8	0.66	43
C (August)	75.0	85.0	0.60	60

group foraging at a place where several hundreds of kites feed together.

The presence of floaters may enhance the breeding population of a species by providing a mechanism for quick replacement of lost mates at nest sites. Through their support of juvenile and subadult, nonbreeders, garbage dumps may provide a mechanism of increasing the survival and recruitment of breeding individuals into the populations of scavenging birds. Indeed, garbage dumps have been highlighted for their potential importance in the conservation of Black Kite populations, especially during migration (Donazar 1992, Blanco 1994).

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SHORT COMMUNICATIONS

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INTERSPECIFIC AND INTRASPECIFIC AGGRESSION AMONG GRIFFON AND CINEREOUS VULTURES AT NESTING AND FORAGING SITES

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KEY WORDS: *Aegypius monachus*; *Cinereous Vulture*; *Gyps fulvus*; *Griffon vulture*; *foraging*; *nesting*; *aggression*.

Food partitioning within vulture guilds reduces the intensity of competition even when several species share the same carcass (König 1983, Hiraldo 1977, Mundy 1982). Apparently, aggressive encounters are minimized by the relative sizes and ages of individuals in these feeding groups (Alvárez et al. 1976, Grubh 1978, Anderson and Horwitz 1979, Mundy 1982, Blanco and Martínez 1996). Interspecific and intraspecific aggression is frequent when large numbers gather at large carcasses (Mundy 1982). Most interactions involve dominance displays that either do not result in direct contact or, at most, result in slight disputes reduced to minor pecking and kicking. Overall, severe aggression seems to be avoided.

In addition to carcasses, vultures can at times also show intra- and interspecific competitive behaviors at their nest sites. Here too, competition may be passive and regulated by the abundance, spacing and timing of breeding of the different species, or it may result in active aggression and displacement among individuals of the same species (Donázar et al. 1989, Fernández and Donázar 1991).

Griffon Vultures (*Gyps fulvus*) and Cinereous Vultures (*Aegypius monachus*) share feeding and nesting situations across wide areas of the Iberian peninsula, but little is known of the frequency, intensity and context of agonistic interactions that result from competition between them (König 1974, Alvárez et al. 1976, Fernández and Donázar 1991, Hiraldo et al. 1991). In this note we report

two cases of intense aggression between Griffon and Cinereous Vultures.

The first case occurred while we observed Cinereous and Griffon Vultures feeding on a cattle carcass near the Natural Park of Monfragüe, Cáceres Province (western Spain) in November 1992. A maximum of 94 Griffon Vultures and 48 Cinereous Vultures were observed gathered to feed on the carcass. Most of them were feeding on the back of the cow, but two subadult Cinereous Vultures were feeding on the head by putting their heads inside the mouth of the cow. A first-year Griffon Vulture approached and began to feed together with the two Cinereous Vultures. When the Griffon Vulture had its head inside the mouth of the cow, an adult Cinereous Vulture approached and attacked the Griffon Vulture by grasping its neck with its bill for >30 sec. When the Cinereous Vulture released the Griffon Vulture, it left a deep wound that bled profusely. Immediately the injured vulture abandoned the carcass, leaving a clear blood trail and disappeared into the adjacent vegetation. The wound appeared serious enough that it might have been lethal.

The second case involved of a conflict between two adult (probably female) Griffon Vultures at a nesting site traditionally used in the gorges of the Riaza River, Segovia Province (central Spain) in November 1995. We had observed an adult pair at this nest two months previously showing pair-bonding behavior and even copulating. The mates were sexed when copulation occurred and subsequently were easily recognized by individual plumage features. The third bird was probably a female, based on the size and shape of the bill and head. The aggressive en-

counter began when the two presumed female Griffon Vultures began to make rasping calls and to fight at the nest site. During the fight, one of the vultures laid on its back with its wings extended and defended itself with its legs and bill from pecking attacks by the other vulture. The two vultures continued to fight, alternating positions and pecking at each other's head and neck for >20 min. At the end of the fight, both females remained motionless on their backs and face to face with their wings extended for about 5 min. Finally, after another 6 min of violent aggression, one of the vultures displaced the other from the nest site. As a result of the fight, both vultures sustained numerous bleeding wounds on their heads and necks, especially around their eyes, mandibles, and throats.

Initially, the male watched the conflict from the edge of the nest site and only pecked a few times at the tips of the primaries of the fighting females. The male later flew to a nearby rock from which he observed the fight for the remainder of its duration.

During many years of research, we have observed several hundred vulture gatherings at carcasses where numerous agonistic interactions have occurred. Most aggressive behaviors have been between individuals of the same species and especially between the more social and abundant Griffon Vulture (Hiraldo et al. 1979). These encounters never generated wounds and usually resulted in the loss of a few neck or rarely primary feathers. The more violent encounters have involved first-year birds assaulted by older individuals indicating that immature vultures may not have yet established dominance relationships or developed appropriate social behavior. Our first observation indicates that Cinereous Vultures are capable of occasionally injuring Griffon Vultures seriously enough to result in death. Undoubtedly, their larger body size and stronger bill enables them to dominate in aggressive encounters (König 1983). Nevertheless, this behavior is exceptional and probably occurs only when large numbers of vultures, especially Cinereous Vultures, gather at a carcass.

Competition for nest sites may be a cause of aggression between conspecifics under conditions of high population density (Martínez and Cobo 1993). The availability of nest sites for Griffon Vultures has not been documented to be a factor limiting the population size in northern Spain where high densities are reached (Arroyo et al. 1990, Donazar and Fernández 1990). Nevertheless, we observed an increasing number of aggressive interactions over the past 10 years (Martínez and Cobo 1993). These encounters have mainly been brief and have amounted to nothing more than attempts to steal nest material and food delivered to nestling. Our observation of actual fighting between two female Griffon Vultures was unusual but it may indicate that as the density of the nesting population of Griffon Vultures continues to in-

crease in the Riaza River gorge, aggression within this species will become more violent.

RESUMEN.—Se describe un caso de agresión violenta de un buitre negro (*Aegypius monachus*) adulto a un juvenil de buitre leonado (*Gyps fulvus*) en una carroña de vaca que congregó un número inusual de individuos de la primera especie. El buitre leonado pudo haber muerto como consecuencia de la gravedad de la herida producida en el cuello por el buitre negro. Se documenta también la observación de una pelea muy violenta entre dos hembras de buitre leonado en un lugar de nidificación ocupado por una de ellas y su pareja, lo cual se interpreta como resultado de una fuerte competencia por el lugar de nidificación en una colonia de muy alta densidad poblacional en España.

[Traducción de los Autores]

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HUNTING SYNCHRONY IN WHITE-TAILED KITES

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KEY WORDS: *White-tailed Kite, hunting, Elanus leucurus, California.*

examined whether kites hunted independent of other individuals hunting.

Hunting behavior of White-tailed Kites (*Elanus leucurus*) has been extensively studied (Bammann 1975, Warner and Rudd 1975, Mendelsohn and Jaksic 1989). Kites primarily use open to semi-open habitats for hunting (Waian 1973, Bammann 1975, Dunk and Cooper 1994). In California, kites almost exclusively hover while they hunt (Mendelsohn and Jaksic 1989, Dunk 1995) and prey on small mammals, primarily voles (*Microtus* spp.) (Hawbecker 1940, 1942, Stendell 1972).

In previous studies of kites, we observed that groups of kites (2–20 individuals) appeared to hunt relatively synchronously and the probability of an individual kite hunting appeared to be related to whether other kites were hunting. Hunting synchrony could result from kites advertising their presence to conspecific territory holders to potentially decrease subsequent interactions, or to more easily patrol and defend a territory, or from kites responding to variability in prey availability as a function of prey activity rhythms. Shields (1976, cited in Madison 1985) found California voles (*M. californicus*) exhibited ultradian rhythms in activity varying from 2–6 hr. Daan et al. (1982) reported positive correlations between vole activity and timing of hunting by raptors in Europe. We

STUDY AREA AND METHODS

This study was conducted at the Mad River Slough Wildlife Area, Arcata, California. The area consists of approximately 185 ha of ungrazed grassland with little topographic relief. It contains very few trees and shrubs, and fence posts and T-bars (ca. 3-m tall) provide most of the perches for raptors. The climate is maritime with mild winters and cool summers.

The study took place from 20 November 1994–30 January 1995. We made observations during seven 1–2 hr periods. Random points within the study area were established from which observations were made. Scan sampling (Altmann 1974) was used to record number of kites hunting. Using a landmark on the horizon as a starting point, we slowly scanned (\bar{x} time per scan = 90 sec, range = 45–135 sec) 360° and recorded the number of kites hunting (hovering). Scans were made using binoculars. All kites were within approximately 400 m of the observer. We waited 5 min between scans based on Bammann's (1975) findings that mean hunting time for kites was 5.04 min ($N = 674$ hunts) in this area.

To determine whether kites hunted independent of other hunting kites, we compared observed numbers of kites hunting during each scan to expected numbers under the Poisson distribution using Chi-square analysis. We used this analysis because comparison of observed events

Table 1. Number of White-tailed Kites observed vs. expected (using the Poisson distribution) to be hunting simultaneously at Arcata, CA 1994–95.

NUMBER HUNTING PER SCAN	NUMBER OF TIMES OBSERVED	NUMBER OF TIMES EXPECTED
0	43	29
1	31	41
2	21	29
3	13	14
4+	11	5

to the Poisson distribution allows a test of the independence of the individual events (Zar 1984). Groups of 4, 5, 6 and 7 kites hunting simultaneously had expected frequencies less than 5, so they were combined into one group (>4 individuals).

RESULTS

We observed 168 kites hunting during 119 scans. Mean number of kites hunting per scan was 1.41 (range = 0–7). Individual kites hunted in a nonrandom fashion with respect to the presence of other hunting kites ($\chi^2 = 19.36$, $df = 3$, $P = 0.0002$). Few kites (1 or 2) hunted less often than expected whereas many kites (≥ 4) hunted simultaneously more often than expected (Table 1).

DISCUSSION

We found that kites hunted in a nonrandom way with respect to the presence of other hunting kites. Our statistical test was probably conservative because data were analyzed as if there were always ≥ 4 kites on the study area that could have hunted simultaneously. On some occasions there were only a couple of kites in the sampling area. Thus, our analysis was probably biased against observing ≥ 4 kites hunting simultaneously more than expected. It appears that kites responded to either other individuals hunting or, very rapidly, to some other factor. It was beyond the scope of this study to examine whether kites were ultimately responding to vole activity rhythms, to other individual kites for territorial reasons, or both. Proximately, however, kites appeared to respond to other hunting kites.

Species such as Common Ravens (*Corvus corax*), Bald Eagles (*Haliaeetus leucocephalus*), and many vultures are known to forage together and “obtain information” about food resources from one another (Knight and Knight 1983, Heinrich 1988), often at communal roosts, but also through local enhancement (Knight and Knight 1983) where searchers are attracted to actively foraging individuals, or by actually recruiting other individuals (Heinrich 1988). Although kites are also communal roosters during the nonbreeding season (Bolander and Arnold 1965, Waian 1973, Clark and Wheeler 1989), their diurnal behavior during the nonbreeding season contrasts with other species in that kites hold hunting territories (Dunk and Cooper 1994). Moreover, amongst Common Ravens, Bald Eagles, vultures and kites, kite prey items are relatively more predictable spatially because they are not nearly as

patchily distributed and are of much smaller size. We propose that the information that nonhunting kites obtain from hunting individuals is not where to forage, as has been found for other species, but when to forage.

If kites were ultimately responding to variations in vole activity, nonhunting kites probably benefit by observing whether a hunting kite makes an attempt at prey (whether successful or not because any attempt is presumably in response to a prey detection). If no prey attempts are made, then nonhunting individuals should remain perched and thus conserve energy. If attempts at prey are made, then nonhunting kites should use this information to decide whether to hunt. If this “vole rhythm” hypothesis is correct, then voles should exhibit synchronous activity rhythms over relatively large areas, at least the size of our study area. Subsequent studies should examine the relationship between vole activity and the number of kites (and other raptors) hunting.

RESUMEN.—Nosotros examinamos si *Elanus leucurus* en el norte de California cazaba en sincronización mas que esperaban bajo el pronóstico Poisson. Nosotros encontramos que pocos *E. leucurus* cazaban con menos frecuencia de lo que esperaban y muchos (≥ 4) *E. leucurus* cazaban con mas frecuencia de lo que esperaban según parecen responder con la presencia de otros *E. leucurus* cazando. Finalmente, *E. leucurus* podía estar respondiendo a actividad rítmica de presa, a otros *E. leucurus* por razones territorial, o los dos.

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BLOOD PARASITES OF NESTLING GOSHAWKS

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KEY WORDS: *Northern Goshawk*; *Accipiter gentilis*; *nestling survival*; *blood parasites*.

There are a few studies which have investigated pathogenic effects of haematozoa on wild raptors. Ashford et al. (1990, 1991) were unable to demonstrate any effect of *Leucocytozoon toddi* on the mortality of nestling or adult European Sparrowhawks (*Accipiter nisus*) in England and Korpi-maki et al. (1993) showed no effect of *L. ziemanni* on body mass or molting progress in almost 200 Tengmalm's Owls (*Aegolius funereus*) in Finland. They did, however, find that four of six females which laid unusually small clutches had relatively heavy infections. In a second large study, Korpi-maki et al. (1995) found that mates of male European Kestrels (*Falco tinnunculus*) infected with *Haemoproteus* produced smaller clutches earlier than mates of uninfected males. It

is unfortunate that the precise ages of these birds were unknown as this was likely to be the confounding variable.

The occurrence of blood parasites in nestling Northern Goshawks (*Accipiter gentilis*) is unknown and, if they do occur, their role as a factor of regulation of goshawk reproduction is unclear. The aim of this preliminary study was to investigate occurrences of blood parasites and to assess whether they are a significant mortality factor in nestling goshawks.

METHODS

Nests of Northern Goshawks were studied from March through late July 1994. Clutch sizes were determined by viewing nest contents in late April and early May 1994 with a mirror attached to a telescopic pole. We climbed into nests between 11–14 June to sex, band, weigh and measure wing lengths (standard B.T.O. maximum chord: Spencer 1984) of nestlings. Body mass was adjusted for crop contents by subtracting 60 g if nestlings had full crops and 15 g if they had crops that were half-full or less. Wing-length measurements were used to age nestlings (± 4 d) from growth equations of Swedish goshawks (Kenward et al. 1993). The first

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Table 1. Distribution of infections of *Leucocytozoon toddi* in nestling Northern Goshawks by brood size and sex.

	BROOD SIZE			TOTAL NESTS
	1	2	3	
# Infected broods	1	5	2	8
# Uninfected broods	4	6	5	15
# Infected males	1	3	0	4
# Infected females	0	2	3	5

egg-laying date, if not known from direct observations, was calculated by backdating from the age of the oldest nestling in a brood. The incubation period used was 38 d (36 d + 2 d), as incubation does not start until at least the second egg is laid, two days after the first egg is laid (Cramp & Simmons 1980). We are not aware of any instances of goshawks removing unhatched eggs from their nests, so any eggs that were unaccounted for, after thorough searches of nest material, were assumed to have hatched and the resulting young to have died. In late July, nesting territories were revisited to check for occupancy and fledgling mortalities. Juveniles were classified as having dispersed when they were >400 m from the nesting territory and its immediate vicinity.

Blood samples were taken at the same time as nestlings were banded. This was done by clipping the tip of the talon on the inner toe. All nestlings were handled in the same manner by the same observers. Blood smears were prepared in the field, immediately air-dried, fixed with absolute methanol and later stained with Giemsa stain in a laboratory. Slides were examined under a microscope and the parasite load was estimated on a logarithmic scale of 0 to 4, where 0 = no parasites seen in the entire film examined; 1 = fewer than 1 parasite per 100 high-power fields ($\times 400$); 2 = 1–10 parasites per 100 high-power fields; 3 = 11–100 parasites per 100 high-powered fields; 4 = more than 100 parasites per 100 high-power fields.

RESULTS AND DISCUSSION

We examined the blood of 48 nestlings from 23 nests. Five female (26% of females) and four male (14% of males) nestlings from eight nests were infected with *Leucocytozoon toddi* (Table 1). One male was infected with a trypanosome, presumably *Trypanosoma avium*, but not with *L. toddi*. The single trypanosome infection suggested that trypanosomes had a negligible impact on nestling mortality. In Britain, avian trypanosomes are also found in blackflies (*Simulium* sp.) and European Sparrowhawks (Pierce and Marquiss 1983, Dirie et al. 1990).

The median date for first egg laying of infected broods (median = 13 April, range = 7–9 April, $N = 8$) was similar to that of uninfected broods (median = 9 April, range = 31 March–18 April, $N = 14$; Mann-Whitney U-test, $U_{8,14} = 35.0$, $P > 0.05$) suggesting parasite infection and date of egg laying were not related. *L. toddi* infections also did not appear to be associated with body mass or sex of nestlings, as male and female nestlings of differing body masses and ages were infected and, in gen-

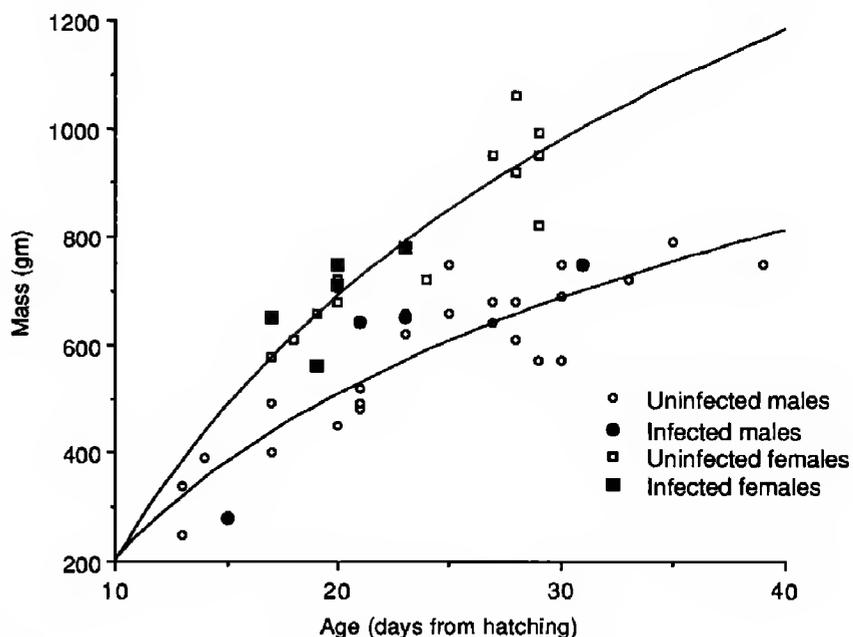


Figure 1. Effect of *Leucocytozoon toddi* infection on growth of male and female nestling Northern Goshawks in Wales in 1994. Males: $Y = -805.9 + 1010.0 \log(x)$, females: $Y = -1434.5 + 1632.8 \log(x)$.

eral, the mass of infected individuals of both sexes were within ranges of uninfected nestlings (Fig. 1).

There was no apparent association between infections and brood size (Likelihood ratio test, $\chi^2_2 = 1.182$, $P > 0.05$, Table 1), nor was there any apparent clustering of infections by sex with brood size ($\chi^2_2 = 6.352$, $P > 0.05$). Four male nestlings had infection loads of 1 and 2 and none had loads of 3. Conversely, only two female nestlings had infection loads of 1 and 2 and three had loads of 3. Although higher infection loads were higher in females this was not significant ($\chi^2_2 = 5.094$, $P > 0.05$).

The mean clutch size, brood size at banding and fledglings at dispersal in infected and uninfected broods were similar (Table 2). The mortality of young goshawks up to time of banding (>13 d) in infected broods (5 from 19 broods) was not significantly higher than in uninfected broods (4 from 28 broods; Fisher's exact 1-tail test, $P = 0.255$, Table 2). Parasites take around 14 d to appear in the blood (Pierce and Marquiss 1983), but infected nestlings

Table 2. Productivity and survival of Northern Goshawk eggs and nestlings in nests infected ($N = 6$) and uninfected ($N = 10$) with the blood parasite *Leucocytozoon toddi* in Wales in 1994.

	UNINFECTED NESTS (NUMBER)	INFECTED NESTS (NUMBER)
Eggs laid	33	22
Unhatched eggs	5	3
Nestlings hatching	28	19
Nestlings dying	4	5
Nestlings fledging	24	14
Fledglings dying	1	0
Fledglings dispersing	23	14

may be ill and possibly die during this prepatent period. Further studies involving a larger sample size are needed to examine if there is a higher mortality of young goshawks in infected broods. If so, this might explain why only light infections were found since heavy infections, if they occurred, would have resulted in death before 13 d of age.

There was no association between infection and mortality in a brood between banding (13–39 d) and fledging as nestlings from both infected and uninfected broods died ($\chi^2_1 = 0.166$, $P > 0.05$). This suggested that infections did not reduce the survival of nestlings past the young nestling stage (>14 d).

The geographic distribution and physical characteristics of nesting territories of infected goshawks were compared to those of uninfected goshawks (Mann-Whitney U-test). There were no statistically significant differences ($P > 0.05$) between distances to nest trees in other nesting territories and running water, or between nesting territory elevations of infected and uninfected goshawks. The distribution of infected nestlings within the study area did not suggest any clustering. Physical characteristics of nesting territories of infected and uninfected territories were also similar. This was not surprising because most nests were built in larch (*Larix* sp.) trees ≥ 25 yr old and larch was the most common tree providing a suitable nesting substrate for goshawks.

Our results suggest that parasitic infections are likely to cause no short-term mortalities in goshawks in the post-dispersal period. Infection loads were light compared with those of sparrowhawks (Ashford et al. 1990, 1991).

RESUMEN.—Nosotros encontramos nueve pajaritos de *Accipiter gentilis* (cinco hembras y cuatro machos) en ocho nidos de 48 pajaritos en 23 nidos en Wales que estaban infectados con *Leucocytozoon toddi* y un macho que estaba infectado con *Trypanosoma*. La mortalidad de los pajaritos hasta el tiempo de ser marcados (>13 d) en crías infectadas no fue considerablemente mas alto que en crías que no estaban infectados, ni hubo ninguna asociación entre infecciones y mortalidad en una cría entre los marcados (13–39 d) y los pájaros jóvenes porque los pajaritos de los infectados y sin infección murieron.

[Traducción de Raúl De La Garza, Jr.]

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MIGRATION OF FLOCKS OF HONEY BUZZARDS IN SOUTHERN ITALY AND MALTA

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KEY WORDS: *Honey Buzzards*; *Pernis apivorus*; *migration*; *flocking behavior*; *orientation*; *navigation*.

Honey Buzzards (*Pernis apivorus*) frequently migrate in flocks that become concentrated in narrow coastal areas (Cramp and Simmons 1980, Kerlinger 1989). During migration over the central Mediterranean, they use mainly two routes. One route is from Sicily to Tunisia and the second route goes across a larger stretch of sea via the islands of Malta (Moreau 1953, Beaman and Galea 1974, Brown et al. 1982, Agostini et al. 1994b). In autumn, a major concentration of buzzards occurs in the Calabrian Apennines (southern Italy), where the distance between the Tyrrhenian and Jonian coasts is narrowest (Agostini and Logozzo 1995a, 1995b). As at the Strait of Gibraltar and the Bosphorus Porter and Willis 1968, Bernis 1973),

peak numbers of buzzards are observed between the end of August and the beginning of September.

Adult Honey Buzzards migrate using this route and probably use the same route in spring, crossing the central Mediterranean between Sicily and Tunisia (Agostini et al. 1994a, Agostini and Logozzo 1995b). This assumption is supported by observations on the island of Marittimo (western Sicily), where large flocks of buzzards are seen between the end of August and the beginning of September (Zangirolami pers. comm.). Unlike adults, young buzzards appear to concentrate on the island of Malta (Agostini and Logozzo 1995b) after the second week of September (Beaman and Galea 1974). This study was undertaken to determine if flocks of immature buzzards on Malta result because young birds stopover on the island during periods of bad weather or if they con-

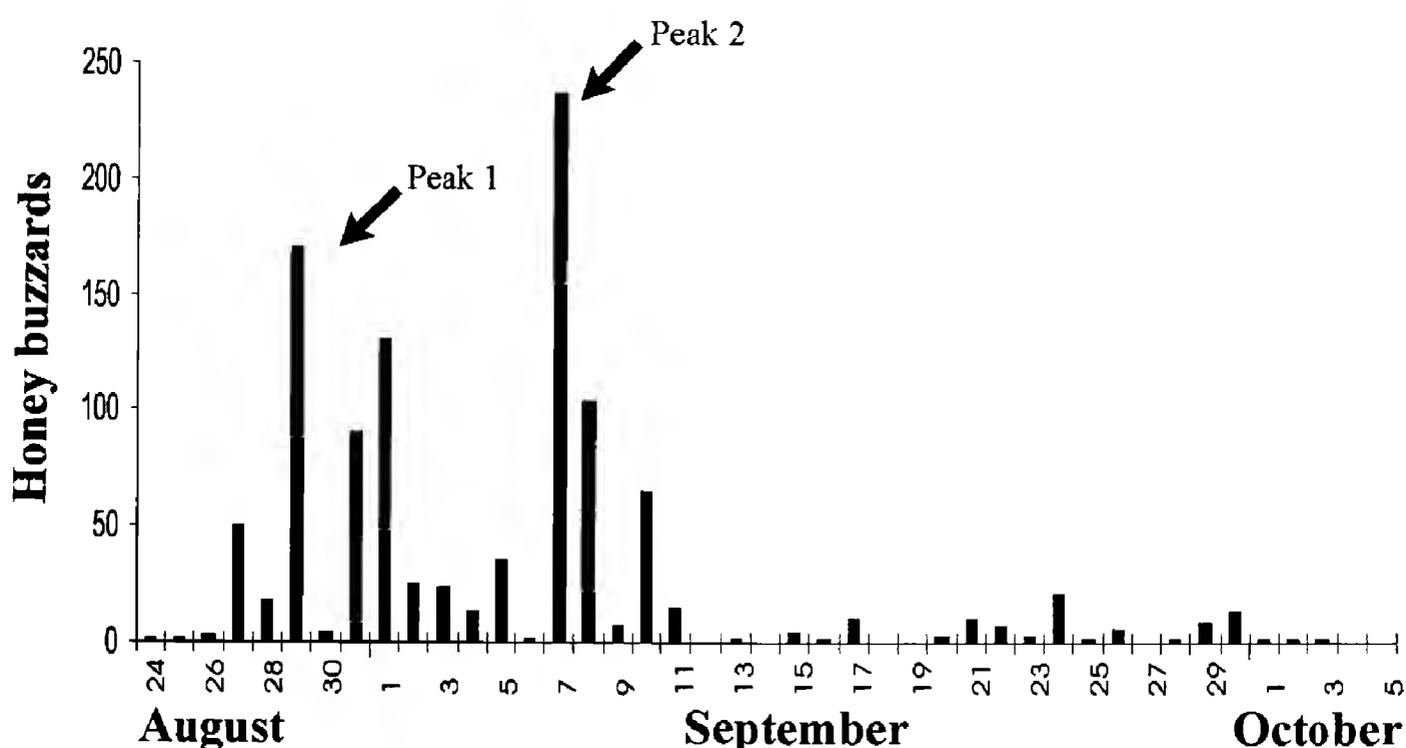


Figure 1. Seasonal occurrence of migrating Honey Buzzards in the Calabrian Apennines in summer and autumn of 1995.

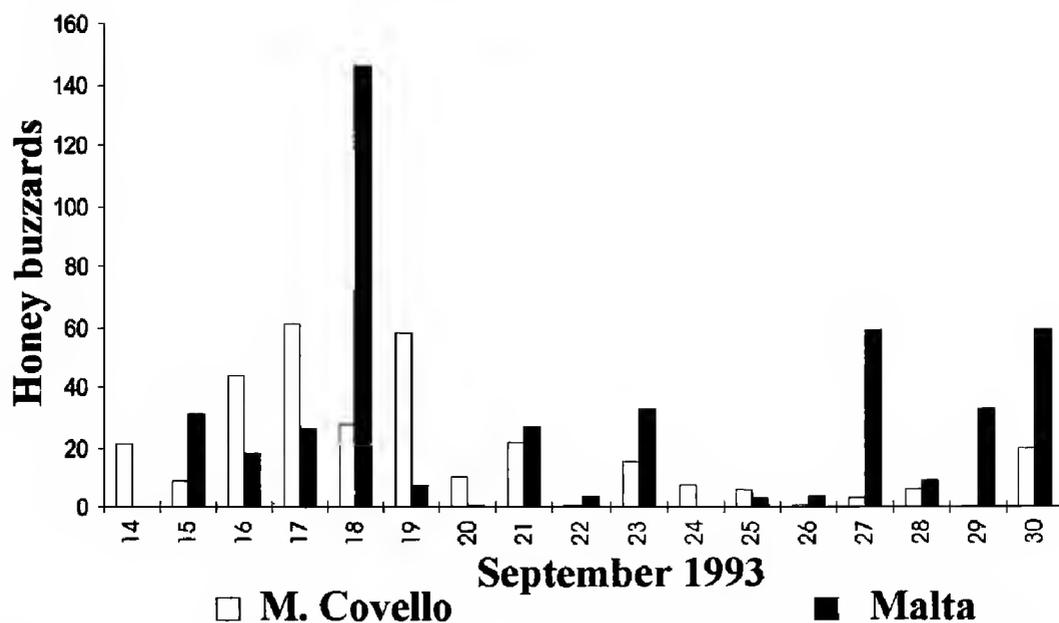


Figure 2. Variations in migration of Honey Buzzards from 14–30 September 1993 on Mount Covello and Malta.

gregate until adult buzzards can show them the shortest route across the Mediterranean.

STUDY AREA AND METHODS

Migrating Honey Buzzards were counted in the Calabrian Apennines and from a post on the slopes of Mount Covello (elevation 700 m) from 24 August–5 October 1993 and 1995. Buzzards were also counted on the Island of Malta. There, the observation post was situated on the highest point on the island (approximately 250 m elevation) from 6 September–5 October 1993 and 1995. A total of 334 hr of observations were tallied at Mount Covello using 10 × 50 binoculars and a total of 188 and 177 hr of observation were tallied using 10 × 40 binoculars on the Island of Malta in 1993 and 1995, respectively.

RESULTS

A total of 1095 Honey Buzzards were counted in the Calabrian Apennines and more than 90% were observed between 24 August–12 September. The number of migrating buzzards showed a bimodal distribution with peaks occurring in late August and after the first week of September (Fig. 1). In both years, there was overlap in the migration periods of adult and juvenile buzzards but over twice as many adults were observed in both years (adults = 346, juveniles = 136). In 1995, the number of adults observed was also significantly greater than in 1993 ($\chi^2 = 6.38$, $P < 0.05$).

A total of 483 Honey Buzzards were counted on the Island of Malta in 1993 but only 88 were counted in 1995. More than 97% of them were observed in September and this corresponded with counts in the Calabrian Apennines (Fig. 2).

DISCUSSION

Some authors have shown that migrating birds orient better when they fly in groups (Keeton 1970, Rabol and Noer 1973, Wallraff 1978, Von Helbig and Laske 1986), especially when groups contain adults that can show to correct migration route (Kerlinger 1989). Our observations suggest that juvenile Honey Buzzards learn the shortest route to cross the central Mediterranean by mi-

grating in flocks of adults. This would explain why the Honey Buzzard is commonly seen in Malta, where the African coasts are more than 400 km away.

Flocking behavior might have another function. Studies carried out on the Cap Bon promontory (Tunisia) during the spring migration of Honey Buzzards and Black Kites (*Milvus migrans*) have shown that these raptors cross the Channel of Sicily more frequently when migrating in large flocks (Agostini and Duchi 1994, Agostini et al. 1994a). This behavior suggests that flocking is important for water crossing because an increase in flock size increases the probability the journey over water will be successfully completed (Agostini and Duchi 1994, Agostini et al. 1994b).

RESUMEN.—Observaciones de *Pernis apivorus* emigrando a través de el centro Mediterranean fueron hechos en los Calabrian Apennines (el sur de Italy) del 24 de agosto–5 de octubre 1995, y en Malta del 6 de septiembre–5 de octubre 1993 y 1995. En los Calabrian Apennines, 1095 *P. apivorus* fueron observados, con un máximo de 237 pájaros emigrando e el 7 de septiembre. Casi todos los *P. apivorus* fueron observados entre el 24 de agosto–12 de septiembre. En Malta, 483 y 83 *P. apivorus* fueron contados en 1993 y 1995, respectivamente, con casi todos contados después del 15 de septiembre. Estos resultados proponen que *P. apivorus* jóvenes aprenden la ruta mas corta para cruzar el centro Mediterranean durante el primer año de migración cuando van en bandadas con adultos que han hecho la migración antes.

[Traducción de Raúl De La Garza, Jr.]

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NESTING-TREE PREFERENCE AND NESTING SUCCESS OF JAPANESE LESSER SPARROWHAWKS IN JAPAN

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KEY WORDS: *Accipiter gularis*; *Pinus densiflora*; *Japanese Lesser Sparrowhawk*; *Japanese red pine*; *nesting success*; *nest tree preference*.

Japanese Lesser Sparrowhawks (*Accipiter gularis*) breed throughout northeastern Asia (Brown and Amadon 1968). It has been shown that tree plantings in lowland areas are important breeding sites for this hawk in Japan (Endo et al. 1991) and these hawks mainly nest in Japanese red pines (*Pinus densiflora*) (Endo and Hirano 1990, Hirano and Kimizima 1992). Because prey abundance does not seem to be limiting (Hirano and Kimizima 1992, Ueta 1992), the availability of nest sites may be an important factor limiting the population of Japanese Lesser Sparrowhawks (Ueta 1996). Because nest sites of Japa-

nese Lesser Sparrowhawks are important in predicting future populations of this hawk in Japan, I examined the nest-tree preferences of Japanese Lesser Sparrowhawks and determined whether such preferences influence nesting success.

METHODS

The study was conducted from 1987–94 at 16 groves of trees in suburban areas of Tokyo. The groves were isolated and ranged from 1–4 ha in area. They were mainly coppices composed primarily of Japanese chestnut oak (*Quercus acutissima*), Storax (*Styrax japonica*) and Sawara cypress (*Chamaecyparis pisifera*).

To determine nest-site preference, use by sparrowhawks and the availability of different tree species were compared. I excluded nests in which the hawks did not

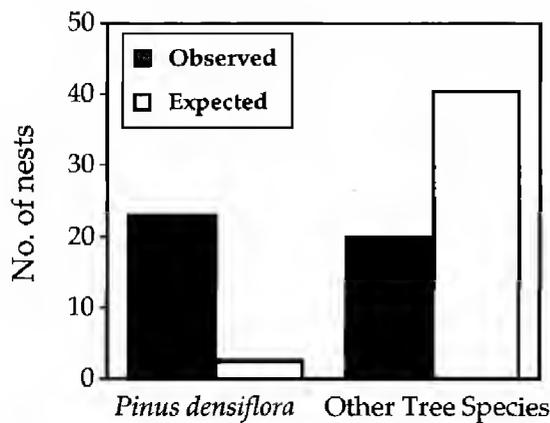


Figure 1. Nest-site preference of Japanese Lesser Sparrowhawks. Values for expected use were calculated based on the total number of sparrowhawk nests found and the percentage of Japanese red pines and other tree species in study groves.

lay eggs. Because the sparrowhawks nested mostly near the periphery of groves (3.89 ± 5.4 m inward from the edge, \pm SD, $N = 16$; Ueta unpubl. data), I counted the number of each tree species on the edges of all nesting groves. To determine the abundance of different tree species in the groves, I used three 10×20 m rectangles that were randomly placed along the edges of groves and counted the number of each tree species larger than 25 cm in DBH (diameter at breast height, the ideal tree size for nesting Japanese Lesser Sparrowhawks, Hirano and Kimizima 1992) within each rectangle.

Nesting success of sparrowhawks in Japanese red pines and in other tree species was compared to determine the effect, if any, of nest-tree use on nesting success. Nesting success was calculated as the number of successful nests per total occupied nests and a successful nest is defined as one in which at least one fledgling was raised.

To determine the availability of preferred nest sites and to predict their future availability, I measured DBH of all Japanese red pines in all nesting groves.

RESULTS

I found a total of 43 Japanese Lesser Sparrowhawk nest structures from 1987–94. More than half of the nests were in Japanese red pines (53.5%) despite the fact that pines were the least available of all nest tree species (Fig. 1). Because I could not identify individual hawks, I analyzed nest-site preference, using only the first nesting record in each grove to avoid the affects of any individual variation in preference. Again, 10 of 16 occupied nests were in Japanese red pines (62.5%) despite that fact that pines were not the most abundant tree species in the nesting groves (5.8%, $N = 774$) indicating that sparrowhawks significantly preferred pine trees as nest sites over other nesting substrates (Binomial test, $P < 0.001$).

Eight nests in Japanese red pines successfully fledged young for a nesting success of 80% ($N = 10$ nests). Nesting success was significantly lower (Fisher Exact Probability Test, $P = 0.025$) for other tree species at only 16.7% ($N = 6$). Causes of nesting failures were confirmed for 15 of 18 failed nests. Most failures resulted when nests fell from branches (93.3%, $N = 15$) and 6.7% were due to predation by Japanese rat snakes (*Elaphe climacophora*).

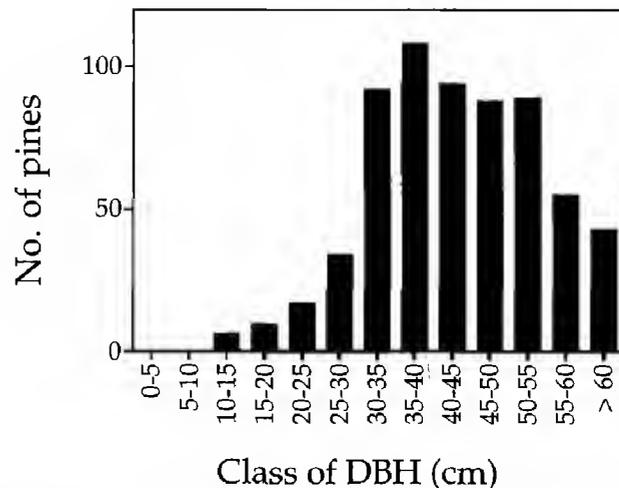


Figure 2. Frequency distribution of DBH of Japanese red pines in 16 groves in suburban areas of Tokyo.

Most pine trees in the study area had DBHs larger than 25 cm (95.0%, $N = 635$, Fig. 2). There were on average 37.7 pine trees within each grove ($N = 16$). No new pine trees had recently been planted in the area.

DISCUSSION

Many studies show the importance of nest-site preference in reducing nest predation (Martin and Roper 1988, Martin 1993a, Kelly 1993, Picman et al. 1993) indicating that nest predation is a common source of nesting failure for many bird species (Nilsson 1986, Martin 1988, 1993b). In this study, nest predation was minimal and 93.3% of nest failures of Japanese Lesser Sparrowhawks were caused when nests fell from nest trees. Therefore, it may be more important for sparrowhawks to select nesting substrates which best hold their nests rather than to avoid nest predation.

The stature of Japanese red pines seems to prevent nests from falling from branches. Sparrowhawk nests are built on thick, stable branches. Japanese red pines require abundant sunshine for growth. There were few young Japanese red pines in the study area probably because the crowns of groves had become closed by Japanese chestnut oaks. Numbers of Japanese red pines have decreased in some areas of Japan (Da and Osawa 1992, Fujiwara et al. 1992) and the lack of young pine trees indicates that there will be further decreases in the numbers of pine trees in the future. Because the nesting success of Japanese Lesser Sparrowhawks appears to rely on the availability of Japanese red pines, the breeding population of the sparrowhawks in Japan could correspondingly decline if the abundance of pine trees continues to decline.

RESUMEN.—Yo estudie la preferencia del árbol para el nido de *Accipiter gularis* y sus efectos en el éxito del nido. *A. gularis* prefirió hacer nido en *Pinus densiflora*, y el éxito del nido fue significativamente mas alto en *P. densiflora* que en otras especies de árboles. éxitos de razón altos resultaron porque nidos casi nunca se cayeron de los *P. densiflora* pero frecuentemente se cayeron o estaban caídos cuando construidos en otras especies de árboles. Los resultados indicaron que la preferencia de nido en *P. densiflora* por *A. gularis* evitaba el desalojamiento del nido.

La estructura por años del *P. densiflora* en estudios de arboleda fueron medidos para pronosticar el futuro disponibilidad de nidos. Pinos jóvenes mas bajos que 25 cm DBH hicieron no mas de 5% de todos los árboles y ningún pino nuevo fue recientemente plantado en la área. Desde entonces una falta posible de árboles de nido conveniente puede ocurrir en el futuro, yo a concluido que la población de *A. gularis* también se va ir disminuyendo mientras la disponibilidad de pinos también disminuye si no tomamos pasos para otra vez continuar plantación de pinos en Japan.

[Traducción de Raúl De La Garza, Jr.]

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LETTER

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NOTES ON NORTHERN GOSHAWKS NESTING IN AN ABANDONED HERONRY IN WALES

In Britain, Northern Goshawks (*Accipiter gentilis*) nest in a variety of wooded habitats including plantations (S.J. Petty 1989, Forestry Commission Bulletin 81, Her Majesty's Stationery Office, London, UK; E.P. Toyne 1994, Ph.D. dissertation, Imperial College, London, UK). In Wales, they usually build their own nests or build on old Common Buzzard (*Buteo buteo*) and European Sparrowhawk (*Accipiter nisus*) nests. This paper presents the first account of goshawks using the nests of Grey Herons (*Ardea cinerea*). We are aware of only one other instance of an accipiter using a heron nest. This was of a European Sparrowhawk that successfully nested on a Little Egret's (*Egretta garzetta*) nest while the egrets occupied the heronry (H. Hafner 1978, *La Terre at La Vie* 32:279–289).

The heronry was situated in Wales in an area comprised of conifer plantations, hill sheep farms, moorland and watercourses. The area was semi-upland (80–500 m elevation) and the majority of goshawk nesting territories were around 250 m (E.P. Toyne 1994, Ph.D. dissertation, Imperial College, London, UK). The heronry was in a 3-ha stand of Sitka Spruce (*Picea sitchensis*) planted in 1950 in a managed forest (>1000 ha). The stand was approximately 800 m from a reservoir and 5 km from the nearest town.

In 1989, the heronry was used by approximately 25 pairs of breeding herons. The herons began to use the heronry again in April 1990 but, shortly after their eggs were laid, strong winds blew them from the nests and heron eggs were found littering the ground. After the herons had left the heronry, a goshawk was found nesting in one of the abandoned heron nests. Over the next seven breeding seasons, goshawks bred in a total of six abandoned heron nests laying an average of 3.3 eggs (range = 2–4) and fledging an average of 2.5 young (range = 1–4).

All nest trees were Sitka Spruce and all heron nests were made of larch (*Larix sp.*) branches. Goshawks refurbished these nests with larch branches and lined the nest cups with foliage from larch, spruce and Douglas-fir (*Pseudotsuga menziesii*). Nest measurements were similar to other goshawk nests built on whorls of larch and conifer trees (length: 0.94–1.20 m, breadth: 0.83–1.00 m, depth: 0.25–0.50 m, $N = 3$). Five of the six nests that were used were well concealed in trees with dense canopies. The other nest was in an open, thin-crowned tree.

It was unclear why the herons moved from the heronry and where they moved. Herons often relay after egg loss (C. Voisin 1991, *The herons of Europe*, T. & A.D. Poyser, London, UK) so it was unlikely they deserted their colony after losing their clutches during the wind storm. Although there is no record of goshawks in Britain killing herons (M. Marquiss and I. Newton 1982, *British Birds* 75:243–260; E.P. Toyne 1994, Ph.D. dissertation, Imperial College, London, UK), it is plausible that the pair of goshawks disturbed the herons enough to make them move elsewhere. At another site within the study area, herons moved after goshawks first nested within 500 m of a heronry indicating that the presence of goshawks may cause herons to desert their nesting areas.

Goshawks are known to use existing nests, including artificial ones (P. Saurola 1978, Pages 72–80 in T.A. Geer [Ed.], *Bird of prey management techniques*, British Falconer's Club, Oxford, UK; S.J. Petty 1989, Forestry Commission Bulletin, Her Majesty's Stationery Office, London, UK). In our study, larch appeared to be the preferred nest tree of goshawks with 61.2% of 116 nesting attempts in larch as opposed to 15.5% in Sitka spruce (E.P. Toyne 1994, Ph.D. dissertation, Imperial College, London, UK). While larch trees were nearby the heronry, the presence of heron nests appears to have attracted goshawks to the spruce site.

Data for this paper were collected during a larger study of goshawk ecology supported by the Science and Engineering Research Council, Imperial College, Forest Enterprise, The British Ecological Society and The Hawk and Owl Trust. We are grateful to the Countryside Council for Wales for providing the necessary licences. We thank Steve Petty, Thomas Bosakowski and an anonymous referee for useful comments to an earlier draft. We thank Herman Ostroznik Jr., Mike Coleman, Steve Binney, Steve Galleozzie and staff of the Forest Enterprise for aid with this fieldwork.—E.P. Toyne,¹ Department of Biology, Imperial College, London SW7 2BB, UK and H. Ostroznik, % The Hawk and Owl Trust, Zoological Society of London, Regent's Park, London NW1 4RY, UK.

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BOOK REVIEW

EDITED BY JEFFREY S. MARKS

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Handbook of the Birds of the World, Volume 2. New World Vultures to Guineafowl. Edited by Josep del Hoyo, Andrew Elliott and Jordi Sargatal. 1994. Lynx Edicions, Barcelona. 638 pp., 60 color plates, 302 color photographs, 590 distribution maps. ISBN 84-87334-15-6. Cloth, \$175.00.—The volumes in this series are magnificent in both appearance and content. This volume covers the Falconiformes and Galliformes, and volume 3 (Hoatzin to alcedids) will appear before this review is published. Twelve volumes are planned in all. The price tag might seem excessive until one puts things in proper perspective. Volume 2 weighs in at 8 pounds, for a cost of about \$1.37 per ounce. By comparison, Cody's *Habitat Selection in Birds* (1985) now costs \$136.00 in cloth, or about \$4.00 per ounce (and even in 1985, it cost more than \$2.00 per ounce). Given the sheer quantity of information and quality of presentation, I believe that *The Handbook* is an exceptional deal in today's market of inflated book prices.

The book is organized by family, each of which contains a general review of the topics "Systematics," "Morphological Aspects," "Habitat," "General Habits," "Voice," "Food and Feeding," "Breeding," "Movements," "Relationships with Man" and "Status and Conservation." Following the family introductions are the species accounts, typically two to four per page. Virtually every extant species is covered, with each account containing notes on taxonomy, subspecies and distribution (including a range map), habitat, food, breeding biology, movements and conservation status. Each account concludes with a list of recent references. In addition, each species is depicted in a color

plate (averaging more than 20 individuals per plate), often with multiple paintings to show differences in sex, color morph and subspecies. The color plates appear to be excellent, although I am not qualified to evaluate all of them. The color photographs scattered throughout the text are absolutely outstanding. A tremendous range of species is presented, and each photograph is sharply focused and pleasingly composed. Moreover, many of the photographs depict individuals that are actually *doing* something besides posing for portraits. For example, a Verreaux's Eagle (*Aquila verreauxii*) is seen capturing a hyrax (p. 78), an African Harrier-Hawk (*Polyboroides typus*) hanging from a weaver nest (with a nestling in its bill; p. 81), and a female Montagu's Harrier (*Circus pygargus*) delivering a prey item to its nestlings (p. 101).

I should mention that the family overviews and species accounts were written by well-qualified raptor biologists, including Richard Bierregaard, William Clark, David Houston, Alan Kemp, Lloyd Kiff, Bernd-Ulrich Meyburg, Penny Olsen, Alan Poole, Jean Marc Thiollay and Clayton White. The depth of treatment in the species accounts does not surpass Brown and Amadon's *Eagles, Hawks and Falcons of the World* (1968), but the updated information and excellent plates and photographs provided in *The Handbook* make it an excellent companion piece to Brown and Amadon. As a sound, general reference, *The Handbook* will be indispensable. I cannot imagine that anyone with a keen interest in raptors could be disappointed with this book. As a bonus, the material on the Galliformes is just as impressive as that on the raptors. I urge you to obtain your own copy, or at the very least, to prod your library into acquiring the entire series.—**Jeff Marks, Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, MT 59812 U.S.A.**

MANUSCRIPT REFEREES

The following people reviewed manuscripts for the *Journal of raptor Research* in 1996. Peer review plays a vital role in the publishing process and in improving the quality of the *Journal*. The names of individuals who reviewed two or more manuscripts are followed with an asterisk.

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Names for birds should follow the A.O.U. Checklist of North American Birds (6th ed., 1983) or another authoritative source for other regions. Subspecific identification should be cited only when pertinent to the material presented. Metric units should be used for all measurements. Use the 24-hour clock (e.g., 0830 H and 2030 H) and "continental" dating (e.g., 1 January 1990).

Refer to a recent issue of the journal for details in format. Explicit instructions and publication policy are outlined in "Information for contributors," *J. Raptor Res.*, Vol. 27(4), and are available from the editor.

1997 ANNUAL MEETING

The Raptor Research Foundation, Inc. 1997 annual meeting will be hosted by Georgia Southern University and will be held October 30 through November 2 at the Marriott Riverfront in Savannah, Georgia. Details about the meeting and a call for papers will be mailed to Foundation members in the spring of 1997. For more information, contact Michelle Pittman (912/681-5555, e-mail: meeden@gsvms2.cc.gasou.edu) or Steve Hein (912/681-0831) at Georgia Southern University.

RAPTOR RESEARCH FOUNDATION, INC., AWARDS Recognition for Significant Contributions¹

- The **Dean Amadon Award** recognizes an individual who has made significant contributions in the field of systematics or distribution of raptors. Contact: **Dr. Clayton White, 161 WIDB, Department of Zoology, Brigham Young University, Provo, UT 84602 U.S.A.** Deadline August 15.
- The **Tom Cade Award** recognizes an individual who has made significant advances in the area of captive propagation and reintroduction of raptors. Contact: **Dr. Brian Walton, Predatory Bird Research Group, Lower Quarry, University of California, Santa Cruz, CA 95064 U.S.A.** Deadline: August 15.
- The **Fran and Frederick Hamerstrom Award** recognizes an individual who has contributed significantly to the understanding of raptor ecology and natural history. Contact: **Dr. David E. Andersen, Department of Fisheries and Wildlife, 200 Hodson Hall, 1980 Folwell Avenue, University of Minnesota, St. Paul, MN 55108 U.S.A.** Deadline: August 15.

Recognition and Travel Assistance

- The **James R. Koplín Travel Award** is given to a student who is the senior author of the paper to be presented at the meeting for which travel funds are requested. Contact: **Dr. Petra Wood, West Virginia Cooperative Fish and Wildlife Research Unit, P.O. Box 6125, Percival Hall, Room 333, Morgantown, WV 26506-6125 U.S.A.** Deadline: established for conference paper abstracts.
- The **William C. Andersen Memorial Award** is given to the student who presents the best paper at the annual Raptor Research Foundation Meeting. Contact: **Ms. Laurie Goodrich, Hawk Mountain Sanctuary, Rural Route 2, Box 191, Kempton, PA 19529-9449 U.S.A.** Deadline: Deadline established for meeting paper abstracts.

Grants²

- The **Stephen R. Tully Memorial Grant** for \$500 is given to support research, management and conservation of raptors, especially to students and amateurs with limited access to alternative funding. Contact: **Dr. Kimberly Titus, Alaska Division of Wildlife Conservation, P.O. Box 20, Douglas, AK 99824 U.S.A.** Deadline: September 10.
- The **Leslie Brown Memorial Grant** for \$500-\$1,000 is given to support research and/or the dissemination of information on raptors, especially to individuals carrying out work in Africa. Contact: **Dr. Jeffrey L. Lincer, Sweetwater Environmental Biologists, Inc., 3838 Camino del Rio North, Suite 270, San Diego, CA 92108 U.S.A.** Deadline: September 15.

¹ Nominations should include: (1) the name, title and address of both nominee and nominator, (2) the names of three persons qualified to evaluate the nominee's scientific contribution, (3) a brief (one page) summary of the scientific contribution of the nominee.

² Send 5 copies of a proposal (≤ 5 pages) describing the applicant's background, study goals and methods, anticipated budget, and other funding.