

ABSTRACTS OF PRESENTATIONS MADE AT THE ANNUAL MEETING OF THE
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NORTHERN GOSHAWK SYMPOSIUM

INFLUENCE OF VEGETATION STRUCTURE ON SELECTION OF
FORAGING HABITAT BY NORTHERN GOSHAWKS IN A
PONDEROSA PINE FOREST

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Data are needed to assess the relative importance of vegetation structure versus prey abundance in selection of foraging sites by northern goshawks (*Accipiter gentilis*) in the ponderosa pine vegetation type. Therefore, we radio-tagged adult breeding goshawks on the Coconino National Forest in 1993-94, and used precise (± 25 m) radio-locations as centers of 1.8-ha plots, and contrasted vegetation structure at these plots to nearby paired plots within the same animal's home range. Thus we studied selection of sites within individual home ranges; Drennan (this symposium) indexed prey abundance at these same paired plots. We measured tree heights, tree diameters, canopy closure, ground cover, and numbers of shrubs, saplings, snags, and logs. Preliminary results from 43 pairs of plots suggest that some goshawks selected sites with more and larger trees. Results from about 60 plots and 10 goshawks will be presented.

INTERSEXUAL PREY PARTITIONING IN NORTHERN
GOSHAWKS

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A common explanation proffered for reversed sexual size dimorphism among raptors is that size dimorphism allows prey size partitioning between the sexes and reduces intersexual competition for food. We compared intersexual differences in prey captured by male and female northern goshawks (*Accipiter gentilis*) at 16 nests in northern Arizona during the breeding season of 1990-92. On basis of 192 prey items captured by male and 46 prey items captured by female goshawks, we found no difference between the sexes in mean weight of prey captured (paired *t*-test, $P = 0.14$), or in the distribution of prey sizes (Kolmogorov-Smirnov 2-sample test, $P = 0.27$). There was no difference between the sexes in capture rates of mammals and birds ($P = 0.35$); mammals accounted for 85% and 79% of the prey captured by female and male goshawks, respectively. The sexes had a high degree of dietary overlap

(92%; Pianka's Index) but male goshawks used the available prey species less equitably than female goshawks (male = 0.37, female = 0.51; min = 0.0; max = 1.0). Prey captured in different foraging zones did not differ between the sexes ($P = 0.72$). Our findings suggest that prey partitioning during the breeding season may not be an adequate explanation for reversed sexual size dimorphism.

DEVELOPING A PRACTICAL METHOD FOR SURVEYING
NORTHERN GOSHAWKS IN MANAGED FORESTS OF THE
WESTERN CASCADES

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We developed and tested several modifications that might potentially improve the current Forest Service protocol for surveying northern goshawks (*Accipiter gentilis*) in the Pacific Northwest (an adaptation of the Kennedy and Stahlecker method). Because of the steep, rugged terrain of the Western Cascade Mountains, our survey design was intended to: (1) make greater use of numerous logging roads in managed forests, (2) improve broadcasting equipment used on road surveys, (3) increase distance between broadcast stations, (4) avoid traversing ridgetop habitat which is not normally used by goshawks for nesting, and (5) replace transects with a variable distance grid pattern to achieve complete systematic coverage. Road stations were surveyed using two outdoor powerhorn speakers (40-watt rating) powered by the vehicle cassette player. The speakers were mounted on the truck in opposite directions and were audible at 0.32-0.40 km depending on direction. To account for variation in topography, wind, and foliage density, we tested a conservative spacing maximum of 0.48 km for all broadcast stations. Foot stations were done by the U.S. Forest Service method using an amplified megaphone and mini-cassette player which had a similar broadcast range. A GIS was used to select potential nesting habitat (mean dbh > 30 cm, height > 24 m, density 250-750 trees/ha) for surveying. Then, buffer circles (240 m calling radius) were drawn centered on road stations. Along ridgelines, foot stations were set 240 m downslope. Finally, any habitat not covered by buffer circles was covered by additional foot stations. A field test of both methods in two study areas yielded comparable results in detection of goshawks, but with a savings of 36-50% in labor with the improved method.

THE HISTORY OF GOSHAWK HABITAT MANAGEMENT IN THE SOUTHWESTERN UNITED STATES

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Northern goshawk (*Accipiter gentilis*) habitat management is very controversial in the southwestern United States. In 1993, at the request of the Arizona Chapter of the Wildlife Society, the Wildlife Society and the American Ornithologists' Union established a blue-ribbon panel of scientists to review USDA, Forest Service goshawk habitat management. We trace the history of goshawk management in the southwest from the 1970s through 1993. We discuss the issues that were raised by the state game and fish agencies, the environmental community and industry. We describe how the USDA, Forest Service developed its management policy. We discuss fire and timber management practices and their impact on goshawk habitat quality. Finally, we briefly outline the major components of the "state-of-the-art" goshawk habitat management in North America.

MANAGING PONDEROSA PINE FORESTS FOR PREDATOR AND PREY—A PROTOTYPE FOR ECOSYSTEM MANAGEMENT

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Single species management plans are being replaced by multiple-species habitat management plans in the southwestern United States. Here we describe the basis for managing ponderosa pine forests using the habitat needs of a wide-ranging predator and the habitat needs of its prey. We present pre-settlement forest conditions, existing forest conditions, and the desired forest conditions needed to sustain the ecosystem for the northern goshawk (*Accipiter gentilis*) and its prey centuries into the future. We discuss the sustainability of the ponderosa pine forest in terms of vegetative structural stages and illustrate the importance of a single vegetative structural stage for one prey species.

NORTHERN GOSHAWK AND SOUTHWESTERN FOREST MANAGEMENT: A REVIEW

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The American Ornithologists' Union and The Wildlife Society organized a review, November 1993, of USDA Forest Service management guidelines and implementation designed to maintain habitats for the northern goshawk (*Accipiter gentilis*) in southwestern forests. Specific charges were to review the scientific literature concerning northern goshawk biology and management pertinent to the Southwest, evaluate the scientific basis and policy guidance for the interim guidelines, perform an on-the-ground inspection of forest management conditions in the Southwest relative to implementation of the interim guidelines, and prepare a report outlining the findings and recommendations. A summary of this report that focuses on status of the northern goshawk, forest management, and implementation guidelines is presented.

NORTHERN GOSHAWK REPRODUCTION RELATIVE TO SELECTION HARVEST IN ARIZONA

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In Crocker-Bedford (1990, *Wildl. Soc. Bull.* 18:262-269), I limited my 1985-87 analyses of the effects of timber harvesting on northern goshawk (*Accipiter gentilis*) to 31 nest clusters which were consistent with the 1982 study plan. At the 1993 RRF annual meeting Boyce et al. suggested that I should have used all my 1987 data. The following analysis does so, except for nest clusters first discovered in 1987 (to avoid bias due to active territories being easier to discover). Rates of goshawk occupancy and nestling production in 1987, on the North Kaibab Ranger District, Arizona, were compared against the amount of selection harvesting 1973-86 within an assumed home range of 2.7-km radius around the center of each nest cluster. Species use of clusters was confirmed by goshawks in nests (83% of clusters—was 97% for territories in Crocker-Bedford 1990), or was presumed from nest and stand characteristics along with nearby goshawks (15% of clusters—was 3% in Crocker-Bedford 1990). Occupancy in 1987 was confirmed by eggs or goshawks in nests (86%—was 100% in Crocker-Bedford 1990), recently fledged goshawks near used nests (9%), or by reconstruction of historical nest with adult goshawk nearby (5%). Young were counted near time of fledging. I separated 53 nest clusters into four categories: 12 in assumed home ranges which had received little or no harvesting 1973-86; 14 which had selection harvesting on 10-39% of each home range area; 16 which had harvesting on 40-69% of each home range area; and 11 which had selection harvesting 1973- on 70-90% of each home range area. For the four categories, respectively, occupancy rates were 83%, 43%, 31%, and 9% ($P < 0.001$). Mean young per nest attempt were, respectively, two, two, one, and zero. Considering both

occupied and unoccupied nest clusters, young produced per nest cluster were, respectively, 1.67, 0.86, 0.31, and 0.00 ($P < 0.001$). These and other data could indicate some real decline in the local breeding population and productivity, and/or represent movement of successful breeders from more logged to less logged areas.

INFLUENCE OF PREY ABUNDANCE ON SELECTION OF FORAGING HABITAT BY NORTHERN GOSHAWKS IN A PONDEROSA PINE FOREST

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Data are needed to assess the relative importance of prey abundance versus vegetation structure in selection of foraging sites by northern goshawks (*Accipiter gentilis*) in the ponderosa pine vegetation type. Therefore, we radiotagged adult breeding goshawks on the Coconino National Forest in 1993–94, and used precise (± 25 m) radio-locations as centers of 2.25-ha plots, and contrasted prey abundance at these plots to nearby paired plots within the same animal's home range. Thus we studied selection of sites within individual home ranges; Beier (this symposium) measured vegetation structure on these same plots. We indexed abundance of mammalian prey by track stations, and abundance of avian prey by point counts. The track station counts were highly correlated with numbers of chipmunks ($r^2 = 0.79$) and golden-mantled ground squirrels ($r^2 = 0.71$) on 15 plots where live-trapping immediately followed track station sampling. Preliminary results do not suggest that bird or sciurid abundance is an important factor in site selection. Results from about 60 pairs of plots will be presented.

NEST-SITE SELECTION BY NORTHERN GOSHAWKS IN A PONDEROSA PINE FOREST IN EASTCENTRAL ARIZONA

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Physical and vegetative characteristics at 20 nest sites of northern goshawks (*Accipiter gentilis*) and 54 random sites on the Sitgreaves National Forest were measured to determine if selection occurs. Nest sites and random plots were limited to the ponderosa pine (*Pinus ponderosa*) habitat type. Survey plots consisted of a 25-m-radius area (main plot) centered around the nest tree or the nearest tree ≥ 30.5 cm dbh to the random point. Canopy cover, basal area, number and dbh of all stems ≥ 30.5 cm, plot aspect, percent slope and ground cover were measured. Within each main plot four randomly selected 4-m-radius satellite plots were established to measure all woody stems < 30.5 cm. Northern goshawks selected larger and taller nest trees ($P < 0.01$ and $P < 0.001$, respectively) with a smaller green crown length ($P < 0.001$) than expected. Northern goshawks selected a nest tree that was part of a

clump ($P < 0.001$) and placed on the lower third of a slope ($P < 0.001$) more often than expected. Canopy cover in the immediate vicinity of the nest tree ($P < 0.05$) and within the main plot ($P < 0.001$) was higher more often than expected. Northern goshawks exhibited an apparent selection for nest placement in stands with mature forest characteristics.

POSTFLEDGING MOVEMENTS OF THE NORTHERN GOSHAWK IN NORTHCENTRAL NEW MEXICO

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The postfledging movements of 42 radio-tagged northern goshawks (*Accipiter gentilis*) from 28 broods were studied in northcentral New Mexico during 1992–93. These 28 broods were part of a food supplementation experiment to determine the influence of extra food on the timing and pattern of dispersal. Half of the broods were given supplemental food from hatching (late April) until mid-October. The remaining broods were controls. Telemetry locations were made approximately every 2 d from fledging until mid-October in 1992 and late November in 1993. During the early fledgling-dependency period (wk 1–4 after fledging) the majority of the juveniles, treatment and controls, were located within 200 m of the nest. From 4–8 wk postfledging the treatment and control juveniles were usually within 1 km of the nest. However, by 11 wk postfledging, most control birds were located > 20 km from their nests. Treatment birds were never located ≥ 30 km from the nest for the duration of the experiment. We conclude that the control birds migrated out of the study area and the treatment birds remained. To our knowledge, this is the first documentation of a change in migration patterns after providing excess food.

GOSHAWKS IN EUROPE AND RANGES IV: SOME RETROSPECTIVE ANALYSES

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The Ranges IV software for analyzing animal location data was written after completion of a study in Sweden of more than 350 radio-tagged goshawks (*Accipiter gentilis*). Early analyses of goshawk foraging ranges are reviewed. More recent techniques, including sociality indices and compositional analysis, are applied to confirm and enhance the previous findings on winter foraging and habitat use. Contouring, peeled polygons, concave polygons and incremental cluster analyses are used to examine how range size and structure relate to food supply and breeding success in European goshawks. The conclusion provides answers to the question "What can the behavior of radio-

tagged goshawks reveal about habitat suitability for this species?"

LOCATION OF GOSHAWK NEST SITES IN RELATION TO RIPARIAN AREAS IN THE CENTENNIAL MOUNTAINS, NORTHEASTERN IDAHO

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Many studies have reported that northern goshawks (*Accipiter gentilis*) often build nests near permanent water sources. Fifteen active nest sites found between 1989 and 1992 on the south side of the Centennial Mountains (Targhee National Forest, Idaho) were located an average distance of 238 ± 180 (SD) m from streams ($N = 11$), springs ($N = 3$), or ponds ($N = 1$). In order to determine if goshawks disproportionately select nest sites in or adjacent to riparian habitats we used taped broadcast calls to systematically survey a 75 km² contiguous area of relatively undisturbed habitat. Within the survey area, two active and five alternate nests were found. Average distance to water of these nests, 152 ± 82 (SD) m, did not differ significantly from historic sites. An analysis of available versus used habitats within the study area will be presented. Nest-site characteristics and the density of nests found using systematic survey methods will be compared to nests found on the forest over the past 5 yr using non-random search methods.

THE BREEDING PERFORMANCE OF AN INTRODUCED POPULATION OF NORTHERN GOSHAWKS IN BRITAIN: IMPLICATIONS FOR FOREST MANAGEMENT

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Northern goshawks (*Accipiter gentilis*) were introduced into coniferous forests in the English/Scottish borders in the late 1960s to early 1970s. The first breeding attempts were confirmed in 1972, but it was not until 1977 that successful breeding was recorded. Since then the population has increased annually to at least 61 occupied home ranges in 1993. We report on breeding performance and range expansion, and explore which factors are limiting the growth of this isolated population. Goshawks are still rare in the UK where they have established numerous widely scattered populations resulting from introductions by falconers. Goshawks also have a high level of legal protection which required the development of a management strategy to minimize the impact of forestry operations during the breeding season. The rationale behind this strategy is described together with problems associated with an increasing population in managed woodlands.

NEST-SITE AND MATE FIDELITY OF NORTHERN GOSHAWKS IN THE INDEPENDENCE AND BULL RUN MOUNTAINS OF NORTHEASTERN NEVADA

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In 1991, a study was begun to examine possible impacts of gold mining activity on a population of northern goshawks (*Accipiter gentilis*) breeding in the Independence and Bull Run Mountains of northeastern Nevada, Elko County. Aerial surveys by helicopter conducted in early April of 1991, 1992 and 1994 located 10, six and 26 occupied goshawk nests in the study area, respectively. Occupancy was ground-truthed in early to mid-May. An additional 14, 22 and five nests were found on foot in 1991, 1992 and 1994, respectively. In 1992, breeding pairs and offspring were banded with USFWS bands and color-anodized alpha-numeric bands, beginning long-term monitoring of nest stand fidelity, turnover rates and lifetime reproduction of goshawks in the study area. Adults were trapped using a live great horned owl (*Bubo virginianus*) and dho-ghaza net. In one case a female was trapped using a plastic decoy owl. By the end of the 1994 season 194 adult and immature goshawks had been colormarked for future identification. In 1993, 11 of 15 mated pairs banded in 1992 returned to the same nest stand, three nest stands were unoccupied and one female returned to the same nest with a new mate. Of seven nests where the female only was banded in 1992, six returned to the same nest stand. In 1994, only four previously banded pairs returned to the same nest stand and four males returned to the same nest stand with new mates. There were five cases of nest switching. Two females moved <1.6 km to alternate nests within the nesting territory, two females moved 4.8 and 9.6 km, and one male moved 9.6 km. Despite the apparent stability of the population in the study area, trends may indicate a state of flux. Further data on the movements of color-marked birds in this population will be necessary before any conclusions concerning the long-term stability of this population can be made.

NESTING HABITAT PREFERENCE AND AVAILABILITY OF SUITABLE NESTING HABITAT OF COEXISTING ACCIPITER IN THE JEMEZ MOUNTAINS OF NORTHCENTRAL NEW MEXICO

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Three species of accipiter (northern goshawk, *Accipiter gentilis*, $N = 42$; Cooper's hawk, *A. cooperii*, $N = 52$; sharp-shinned hawk, *A. striatus*, $N = 16$) nest sympatrically in

the Jemez Mountains of New Mexico. It has been proposed that these three species partition their nesting habitat based on vegetation characteristics that are correlated with their body sizes. From this proposed relationship, we would predict that the accipiter hawks would show preference for nesting habitat in which their body size is (1) positively correlated with stand size class and basal area; and (2) inversely correlated with stand tree density and stand percent canopy closure. To evaluate these predictions, we conducted a 2-yr preference study of accipiter habitat using a landscape approach. A Landsat classification was conducted to provide habitat availability data for the study area and these data were compared to the nest site data to analyze species preference for forest cover type, percent canopy closure, slope, aspect and thermal reflectance. Size class and basal area preference were determined through comparison of random-point locations and nest sites. Nesting habitat characteristics for the three accipiters overlapped greatly. Areas of suitable nesting habitat were determined from areas of use and preference for all habitat layers for each species. Quantity of suitable habitat in the Jemez Mountains was examined for all three species and nesting habitat limitation is discussed.

NEST-SITE SELECTION OF GOSHAWKS IN SOUTHCENTRAL WYOMING

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Little is known regarding nest-site selection of northern goshawks (*Accipiter gentilis*) in lodgepole pine (*Pinus contorta*) forests. In 1992, we studied nest-site selection of goshawks (39 active pairs) in lodgepole pine forests of southcentral Wyoming, Medicine Bow National Forest. We described the nesting habitat of goshawks at three spatial scales—nest tree, nest-tree area (0.04-ha circle centered at nest tree), and nest area (homogeneous forest stand surrounding nest). Nest-site habitat characteristics were compared to those randomly available. Goshawks selected the largest nest trees available. Nest trees were larger ($P < 0.001$) in dbh than average trees in either the nest-tree area or nest area. Nest trees were taller ($P < 0.001$) and larger ($P < 0.001$) than random trees on the study area. Dbh of nest trees ranged from 17.0–50.5 cm ($\bar{x} = 31.6$ cm, SE = 1.3). Slopes at goshawk nests were more ($P = 0.04$) moderate (11%, SE = 1.1, range 1–34%) compared to those randomly available (16%, SE = 2.1). Aspects at goshawk nests were similar ($P = 0.61$) to those randomly available. Nest areas used by goshawks differed from those ($P < 0.001$) randomly available. Tree density in goshawk nest stands was lower (1299 trees/ha) than a sample of random stands (1562 trees/ha, $P = 0.045$). However, nest areas had a higher ($P < 0.001$) density of large trees (475.3

trees/ha, SE = 17.2, vs. 315.8 trees/ha, SE = 20.1). Trees in nest areas were also taller (mean = 20.2 m, SE = 0.4, $P < 0.001$) with greater ($P = 0.006$) heights to live canopy. The density of small trees at nest areas (212.9 trees/ha, SE = 25.3) was less ($P = 0.001$) than half those present in random stands (452.5, SE = 68.2). Nest areas were not “old-growth” in the classic sense of being multistoried stands with large diameter trees, high canopy closure, and large dead and down woody debris. Rather, nest areas were in even-aged, single-storied, mature forest stands with high canopy closure (mean 65%, SE = 1.4) and clear forest floors.

NORTHERN GOSHAWK HABITAT ASSOCIATIONS, USE AREAS AND JUVENILE DISPERSAL ON THE TONGASS NATIONAL FOREST, ALASKA

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We used aerial radiotelemetry to assess habitat associations and the size of areas used by adult and juvenile northern goshawks (*Accipiter gentilis*) during nesting and post-nesting seasons within the temperate rainforest of the Tongass National Forest, southeast Alaska. This information is being used to assist with the development of management guidelines for maintaining goshawk habitat across the Tongass National Forest. A total of 51 goshawks were radiotagged and followed from 1992–94, including 24 juveniles. Total areas used in 1992–93 by adult goshawks varied from 769–141 240 ha indicating that concepts such as mean home range size do not currently apply because of the extreme individual variability. The size of areas used by adult goshawks during the brood-rearing period varied from 728–19 408 ha for males ($N = 9$) and 273–111 410 ha for females ($N = 8$). The number of relocations varied from 8–50 per bird making interpretation of home range sizes difficult. The large brood-rearing areas used by two females were the result of nest abandonment during the fledgling-dependency period. Adults were nonmigratory. Adult males generally maintained year-round areas of use loosely associated with the nest area. Some adult females vacated the nesting area and had fall/winter use areas distinct from their nesting area. Of seven radiotagged adult females that re-nested in subsequent years, two nested near their previous year's nest, and five selected new mates and moved 4 km, 11 km, 26 km, 27 km, and 43 km to another nest area. Documented juvenile dispersal distances through mid-winter 1993/94 ranged from 16–151 km. Aerial estimates of habitat use based on 667 relocations from 30 goshawks indicated that 89% were judged to be in old-growth coniferous forests.

EFFECTS OF EXPERIMENTAL FOOD ADDITION ON THE REPRODUCTIVE ECOLOGY OF THE NORTHERN GOSHAWK DURING BROOD-REARING

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In 1992 and 1993, 28 northern goshawk (*Accipiter gentilis*) broods in northcentral New Mexico were used in a supplemental feeding experiment to determine if there was a causal relationship between food availability and survival of young goshawks. The 28 nests were randomly assigned as treatments or controls, and treatment nestlings were given extra food from hatching (late April) until juvenile dispersal (mid-October). Morphometric measurements were taken and tarsal-mounted transmitters with mortality switches were attached to 42 nestling goshawks when they were 21 d old. Telemetry locations were made every 2 d until mid-October in 1992 and late November in 1993. Treatment birds had a significantly higher survival rate during the nestling period in 1993, but not in 1992. Because most control nestlings died from predation, we attribute the higher survival not to the slightly better physiological condition of supplemented nestlings, but to increased time spent in the nest stands by adult females whose presence probably deterred predators. There were no significant differences in nestling size or fledging dates. Treatment birds dispersed first but remained in the study area, whereas the control birds migrated out of the study area by October. We propose that both northern goshawk parental care and juvenile dispersal strategies vary with food availability.

MEXICAN SPOTTED OWL SYMPOSIUM

MEXICAN SPOTTED OWLS IN SOUTHEASTERN ARIZONA: CURRENT KNOWLEDGE

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Mexican spotted owls (*Strix occidentalis lucida*) exist in a naturally dispersed habitat matrix on isolated "sky-island" mountain ranges in sub-Mogollon Arizona. These mountain islands are mainly separated by desert-grassland associations or locally desert scrub, and are biogeographically linked to the Sierra Madre Occidental to the south and the Rocky Mountains to the north. In this mountain archipelago, spotted owls are mainly found in Madrean

evergreen woodland and forest associations, and to a lesser degree relict conifer and Rocky Mountain montane conifer forest associations. These sites mainly contain multistoried, older-aged stands of trees. The majority of diurnal roost and nest sites coincide with a Mexican oak-pine woodland and mixed conifer or ponderosa pine forest mosaic at 2072–2286 m. These sites are often associated with canyon bottom habitat that includes riparian deciduous forest and woodland associations, and cliff sites are often present. Diet in southeastern Arizona consists of a wide variety of nocturnal and diurnal prey species, but woodrats (*Neotoma* spp.) and white-footed mice (*Peromyscus* spp.) are the most important prey items in terms of biomass and numbers taken. As part of an ongoing color-marking study we have banded over 150 adult, subadult, and juvenile spotted owls in southeastern Arizona. Of 56 hatching year juveniles banded from 1990–93, five have successfully dispersed and bonded with a mate. The sky-island mountain ranges of southeastern Arizona provides an ideal experimental setting to test questions of dispersal, genetic isolation, and demographics of small isolated populations of this species. We also discuss their distribution, density, reproduction, dispersal within and between isolated populations, and other aspects of their natural history in southeastern Arizona. In addition, a brief discussion of the possible effects of recent sweeping fires to spotted owls in the mountains of southeastern Arizona will be given.

SPOTTED OWLS AND ASSOCIATED RAPTORS IN ISOLATED CONIFEROUS FORESTS: IMPLICATIONS FOR THE RAPPROCHEMENT OF MAN AND NATURE

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For breeding birds of the coniferous forest, area of habitat is the major determinant of avifaunal size which peaks at 28 species in 30 km² on 12 isolated mountain ranges in southern Arizona, New Mexico, and trans-Pecos Texas. Species with northern biogeographic affinities are strongly constrained by habitat, whereas those with primary Sierra Madrean relations are also determined by isolation distance. Spotted owls (*Strix occidentalis*) have both Rocky Mountain and Sierra Madrean affinities and nest on forested mountain tops with at least 10 km² of habitat along with five other raptors (hawks are *Accipiter gentilis* and *A. striatus*). In the guild of four owls (*S. occidentalis*, *Aegolius acadicus*, *Glaucidium gnoma*, and *Otus flammeolus*), complementary feeding niches can contribute to habitat stability, so large patches of coniferous forest should be more stable. Implications for forest management in this and the avifaunal size-habitat area relationship are noted with special reference to the controversy about endangered species and habitat loss to a new astrophysical facility on Mt. Graham, Arizona.

DISPERSAL BEHAVIOR OF JUVENILE MEXICAN SPOTTED OWLS IN NEW MEXICO

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Populations of Mexican spotted owls (*Strix occidentalis lucida*) in the southwestern United States often are small and restricted to "islands" of habitat within isolated mountain ranges. Annual variation in the reproductive success of these owls is high, with few or no young produced in some years. Demographic models predict that most populations under these conditions should quickly go extinct unless there is immigration from other populations. We are currently conducting a study of juvenile dispersal in the Mexican spotted owl in the mountains of central New Mexico to understand the processes by which individuals move among isolated populations. Radiotransmitters were attached to five juveniles in the southern part of the San Mateo Mountains during 1993. All five survived to disperse from their natal territories in late August and September, and none spent the winter in the area where they had been born. Three birds moved to lower elevations in different parts of the San Mateo Mountains, while two others moved across at least 15 km of grasslands to another mountain range southeast of the study area. These birds apparently moved beyond this range as well, although their ultimate fate is unknown. One juvenile that dispersed within the San Mateos in 1993 established a new territory as a singleton at high elevations within the same range during the summer of 1984. The implications of these and related observations for the management of the Mexican spotted owl in the Southwest will be discussed.

GENETIC POPULATION STRUCTURE OF THE MEXICAN SPOTTED OWL (*STRIX OCCIDENTALIS LUCIDA*)

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Mexican spotted owl (*Strix occidentalis lucida*) populations in the mountains of the American Southwest are typically small and naturally fragmented. We have undertaken a study of the genetic population structure of this subspecies to (1) determine if local populations interact as metapopulations, (2) test several alternative models of metapopulation function, and (3) determine if local populations exhibit low levels of genetic diversity. As the initial step in this analysis, we are developing primers for microsatellite loci which can be used to assess genetic variation within and among populations at different geographic and taxonomic scales. Screening of a genomic library with ten different trinucleotide repeats has thus far revealed an abundance of microsatellite sequences. We present results from a preliminary survey of these loci that will allow us to detect and evaluate variation among owls in adjacent

mountain ranges (same potential metapopulation), distant mountain ranges (different metapopulations), geographically isolated populations (limited gene flow), and populations from different subspecies (no gene flow), as well as from sister species and more distantly related species within the same genus.

DEMOGRAPHY OF TWO MEXICAN SPOTTED OWL POPULATIONS IN ARIZONA AND NEW MEXICO: PRELIMINARY RESULTS

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We examined demographic characteristics in a population of Mexican spotted owls (*Strix occidentalis lucida*) in central Arizona and a population in westcentral New Mexico. We located owls at 48 sites in Arizona and 37 sites in New Mexico from 1991-93. Each year we captured and color-banded at least 73% of the territorial owls in Arizona and 90% in New Mexico. We measured density, territory occupancy, social status, nesting effort, fledging rate, fecundity, and survivorship. The highest densities for both areas were observed in 1993, 0.15 owls/km² in Arizona, and 0.18 owls/km² in New Mexico. Higher densities on the New Mexico study area may be due to a higher proportion of suitable owl habitat. Proportion of the Arizona population composed of subadults tripled from 1991 (0.11) to 1993 (0.33), and more than doubled in the New Mexico population from 1991 (0.07) to 1993 (0.16). The large proportion and rapid increase of subadults in the Arizona population may be due to population recovery following suboptimal years prior to our study. Reproductive activity and survivorship were similar between the two areas for all years. There was a large increase in the territorial population on the Arizona study from 1991-93. Such large fluctuations indicate the population may be unstable, and susceptible to extinction. Our data indicate the New Mexico population was close to saturation at the initiation of our study, and is probably more stable.

DENSITIES OF MEXICAN SPOTTED OWLS IN MIXED-CONIFER, PONDEROSA PINE AND PINYON-JUNIPER HABITATS OF SOUTHCENTRAL NEW MEXICO

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During the spring and summer of 1988 we inventoried Mexican spotted owls (*Strix occidentalis lucida*) in the Sacramento Mountains of southcentral New Mexico in order to estimate relative densities of owls in forest and woodland habitats. We stratified our study area into mixed conifer, ponderosa pine, and pinyon-juniper cover types and within each type we inventoried six randomly selected 23 km² plots. Each of the 18 inventory plots received three com-

plete-coverage nocturnal surveys to detect owl presence. Follow-up daytime visits were conducted to search for roosts and nests near nocturnal detection sites. We detected spotted owls in 13 plots and were able to resolve those detections to 33 territories within 12 plots. Density of owl territories in mixed conifer (one territory/5.8 km²) was significantly greater than densities in ponderosa pine (one territory/23.3 km²) and pinyon-juniper (one territory/46.6 km²). Roost sites of owls residing in pine and pinyon-juniper inventory plots were located in mixed conifer stands in canyon bottoms or on sheltered north-facing slopes.

REGIONAL PATTERNS IN THE FOOD HABITS OF THE MEXICAN SPOTTED OWL

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Food habits compiled from 13 studies of the Mexican spotted owl (*Strix occidentalis lucida*) were examined to help plan a conservation strategy for this threatened species. Data from these studies were comprised of 11 164 prey items in 25 samples representing 18 different geographic locations and a minimum of 204 owls. A cumulative distribution of items (%) ranked according to prevalence indicated that on average, 90% of the owl's diet consisted of woodrats (*Neotoma* spp.; 30%), white-footed mice (*Peromyscus* spp.; 28%), arthropods (13%), voles (*Microtus* spp.; 9%), birds (5%), and other medium-sized rodents (primarily diurnal sciurids; 4%). A cumulative distribution of consumed biomass (%) indicated that 90% of the owl's diet consisted of woodrats (53%), rabbits (*Sylvilagus* spp., *Lepus* spp.; 13%), white-footed mice (9%), birds (9%), and other medium-sized rodents (6%). However, we found regional differences in the frequency of woodrats ($F = 4.16$, $df = 6, 18$, $P = 0.008$), birds ($F = 5.12$, $df = 6, 15$, $P = 0.005$), and other medium-sized mammals ($F = 4.44$, $df = 6, 14$, $P = 0.010$) taken by the owls among seven geographic provinces. We also found that range-wide averages of the owl's diet may not adequately reflect prey associated with the owl's reproduction. We considered these differences to be reflections of local habitat conditions that varied geographically. These find-

ings supported a regional approach to conservation of the Mexican spotted owl.

HOME RANGE CHARACTERISTICS OF MEXICAN SPOTTED OWLS IN SOUTHERN UTAH

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Due to difficulties in observing nocturnal movements of Mexican spotted owls (*Strix occidentalis lucida*) in rocky canyonland terrain, our understanding of their habitat is poor. We radiotracked 14 adult Mexican spotted owls in rocky canyonlands across southern Utah for 6–22 mo. Owls were tracked on foot using a hand-held receiving system and from a Cessna 172 fixed-wing aircraft using wing-mounted antennae. Owls selected home ranges characterized by steep complex cliffs and deeply eroded canyons within the landscape. Minimum convex polygon home ranges of individual owls were 689–2055 ha and adaptive kernel home ranges were 509–2302 ha. Average summer minimum convex polygon home range size of individual owls was 361 ha in contrast to 886 ha for winter home ranges. Nocturnal spatial use patterns indicated that individuals utilized activity centers within home ranges. Overall, seasonal movements of owls showed considerable variability, and several owls used distinct summer and winter home ranges. Southwestern dwarf woodland was the most common vegetation community found within spotted owl home ranges, followed by mixed-conifer forest, mountain shrub, ponderosa pine forest and deciduous woodland, and finally, various desert grassland-shrub communities.

DENSITY, REPRODUCTIVE STATUS, AND HABITAT RELATIONSHIPS OF MEXICAN SPOTTED OWLS IN SOUTHWESTERN CHIHUAHUA, MEXICO

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In Mexico, little is known about current density, reproductive status and habitat use by Mexican spotted owls (*Strix occidentalis lucida*). The objective of the study was to estimate density, reproductive success and characterize habitat at Mexican spotted owl roosting and nesting sites. Five quadrats of 70–80 km² each were established in the study area and completely surveyed four times between April and August 1994. Eleven pairs, 10 single males, and one single female were found in the study area. Crude

density of spotted owls per km² in the five quadrats were 0.0708, 0.1007, 0.0794, 0.0563, and 0.0685, respectively. Eight owl territories were checked for reproduction. There was no reproduction for seven owl territories, and only one juvenile was fledged from the nesting pair. Habitat analysis was conducted on 13 roosting sites in 12 owl territories and one nest site. Mexican spotted owls roosting sites were characterized by pine-oak associations. Dominant tree species found at roosting sites were oaks (*Quercus* spp.), Mexican white pine (*Pinus ayacahuite*), Douglas fir (*Pseudotsuga menziesii*) and Arizona pine (*Pinus arizonica*). Dominant tree species at the nesting site was characterized by Mexican white pine and Arizona pine. Mexican spotted owl habitat in southwestern Chihuahua has become extensively fragmented due to forest exploitation.

SWAINSON'S HAWK SYMPOSIUM

PRODUCTIVITY, FOOD HABITS, AND BEHAVIOR OF SWAINSON'S HAWKS BREEDING IN SOUTHEAST COLORADO

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From 1984 through 1988, I studied Swainson's hawk (*Buteo swainsoni*) ecology during the breeding season on the Pinon Canyon Maneuver Site (PCMS) in southeast Colorado. The number of nesting attempts monitored annually ranged from a low of four in 1984, to a high of 22 in 1987. Nests used by Swainson's hawks were located in one-seed juniper (*Juniperus monosperma*) or cottonwood (*Populus* spp.) trees. Fractional nest success averaged 0.64 (SE = 0.341) and ranged from a low of 0.42 in 1985 to a high of 1.00 in 1984. Based on prey remains ($N = 60$) collected at nest sites, food deliveries to nestlings consisted primarily of small birds (50%) and mammals (45%), and diet breadth ($B = 2.65$) was low. Minimum convex polygon home range size of radio-marked adults during the post-fledging period averaged 21.2 km² ($N = 4$, SE = 10.0) in 1985 and 27.3 km² ($N = 4$, SE = 13.0) in 1986, with males exhibiting larger home ranges than females ($P = 0.15$) across years. Compared with other breeding Swainson's hawk populations, birds on the PCMS exhibited high site reoccupancy among years, had large home ranges, and preyed heavily on ground-nesting birds.

HOME RANGE AND HABITAT ANALYSIS OF BREEDING SWAINSON'S HAWKS IN THE SACRAMENTO VALLEY OF CALIFORNIA

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Until recently, very little was known about the breeding home range and foraging habitat requirements of the

Swainson's hawk (*Buteo swainsoni*) in the Sacramento Valley of California. And yet, this region is home to the highest concentration of Swainson's hawks in the state. In the Sacramento Valley, foraging ranges and total home range area are strongly influenced by current agricultural cropping patterns and cover-types. The mean home range size of five radio-marked breeding Swainson's hawks along the Sacramento River in 1992 was 40.9 km². Core areas of intensive use by nesting Swainson's hawks ranged from 0.25–0.82 km². Individual hawks foraged as far as 24 km from the nest area during foraging activities. During the radiotelemetry study, cover-types with less overall vegetative cover and greater prey availability (alfalfa, disced and fallow fields, dryland pasture, grain crops) ranked highest in foraging use. The use of crop and other cover-types were directly correlated with the amount of vegetative cover, prey availability, and farming activities such as harvesting, discing, mowing, and flood irrigating. The predominance of less suitable cover-types within the study area may explain the relatively large home ranges exhibited by the Swainson's hawks in this study.

CHANGES IN A NESTING POPULATION OF SWAINSON'S HAWKS IN THE LOS MEDANOS AREA, NEW MEXICO (1981–90)

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Reproductive success of 238 Swainson's hawk (*Buteo swainsoni*) nests and the availability of some prey populations were monitored between 1981 and 1990 in the Los Medanos area of southeastern New Mexico. Mean clutch size declined significantly from 2.71 ($N = 7$) in 1981 to 1.90 ($N = 42$) in 1988 and 1989. Nest success dropped significantly from 100% ($N = 11$) in 1982 to 39.1% ($N = 23$) in 1988. Mean number of young fledged per nest decreased dramatically from 1.91 ($N = 22$) in 1981–1982 to a low of 0.65 ($N = 34$) in 1989. Measures of reproductive success improved slightly in 1990 but were not statistically different from the lows recorded in 1988 and 1989. Mean counts of desert cottontails (*Sylvilagus audubonii*) dropped precipitously from 11.9 per census in 1985 to 0.9 in 1988. Rodent numbers were lowest in 1986–87 and began increasing slowly thereafter. All measures of hawk reproductive performance were correlated ($P < 0.05$) with mean numbers of lagomorphs counted on censuses; the strongest relationship was between clutch size and numbers of cottontails ($r = 0.86$, $P = 0.003$). Annual precipitation was not correlated with measures of available prey or hawk reproductive success. This analysis demonstrates that Swainson's hawk reproductive performance varies annually and is closely linked to numbers of available prey. Conservation of local Swainson's hawk populations may ultimately depend on metapopulation phe-

nomena in which sources and sinks are temporally dynamic (spreading of risk).

GIS ANALYSIS OF LAND-USE PATTERNS AND NESTING DENSITY OF SWAINSON'S AND RED-TAILED HAWKS IN NORTHERN UTAH

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A total of 30 red-tailed hawk (*Buteo jamaicensis*) nests and 28 Swainson's hawk (*B. swainsoni*) nests were discovered in Cache Valley, Utah, during the summers of 1992 and 1993. All nests were found in trees, but red-tailed hawks more often nested in dead trees. GIS analysis of land-use patterns was made for 1-km radius around nest sites. Results revealed that overall land-use at nest areas was dominated by cropland, alfalfa, and pasture, but no significant differences were found between species. Red-tailed hawk nests were surrounded by greater areas of riparian areas and fallow fields. Swainson's hawk nests were surrounded by significantly greater areas of industrial/commercial zones. Despite this difference, distance to the nearest paved road and building was very similar for both species implying that little difference exists in the tolerance levels for human activities. In the intensive study area, ecological nesting densities (minimum convex polygon method) were 2.56 km²/nest for Swainson's hawk and 6.35 km²/nest for red-tailed hawk. Nearest neighbor distances were 1.52 km for Swainson's hawk nests and 2.88 km for red-tailed hawk nests. The only clear management strategy favoring Swainson's hawks would be to keep tree densities down or manage open lands away from riparian zones.

NEST-SITE SELECTION AND REPRODUCTIVE PERFORMANCE OF URBAN NESTING SWAINSON'S HAWKS IN THE CENTRAL VALLEY OF CALIFORNIA

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In the last 5 yr, Swainson's hawks (*Buteo swainsoni*) have been regularly observed nesting in urban settings in Davis, Stockton, and Woodland, California. These Central Valley communities are small- and medium-sized cities surrounded by agricultural crops used as foraging habitat by Swainson's hawks; distance to foraging habitat is typically <5.0 km. Urban nesting hawks select nests in three settings: (1) large, non-native trees in neighborhoods greater

than 50 yr old; (2) smaller, non-native trees with dense canopies (primarily conifers) in neighborhoods 20-40 yr old; and (3) remnant riparian or oak woodland trees that existed prior to development. Preliminary analysis of the number of young fledged per occupied nesting territory does not indicate a statistically significant difference ($P > 0.05$, Kruskal-Wallis ANOVA by ranks) between nests in urban, rural, or edge settings. Similar, but unoccupied, urban nesting habitat is located in older neighborhoods in the Central Valley communities of Lodi and Sacramento, small and large communities respectively. These potential nesting areas are surrounded by large expanses of either vineyards (Lodi) or urban development (Sacramento); neither are suitable Swainson's hawk foraging habitat. In both instances, distance to foraging habitat is typically >8.0 km. The results of this analysis suggest that the success of urban Swainson's hawk nesting territories in Davis, Stockton, Woodland, or other Central Valley cities may decline as distance to foraging habitat increases.

OVERVIEW OF SWAINSON'S HAWK POPULATION STATUS AND NATURAL HISTORY

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Swainson's hawks (*Buteo swainsoni*) were originally birds of open savannah-steppe, where nesting habitat of large trees was surrounded by foraging habitat with prey of small mammals, some birds and large insects. The conversion of large areas of western North America to agriculture has changed much habitat, and Swainson's hawks have adapted in both breeding and foraging habits. Compatible agriculture for foraging now includes pasture, sugarbeets and alfalfa cropland, plus newly harvested fields of several crops, and foraging areas are often at considerable distance from nesting areas. Some agriculture-adapted Swainson's hawks have adopted urban breeding locations, nesting in trees in towns and cities in central California. Drought, and its effect on prey populations, has had a cyclical negative effect on Swainson's hawk populations throughout their breeding range in nonirrigated areas. Where conditions are favorable, there is evidence that individual birds do shift to foraging in agricultural areas when natural prey populations drop. However, despite some populations showing adaptation to human encroachment and a shift in foraging to agriculture, a significant loss of breeding populations has occurred. Much loss has been due to urbanization and loss of all suitable foraging habitat, but populations have also been extirpated from some apparently suitable habitat, possibly correlated with long-term rodent control programs.

ECOLOGICAL RELATIONSHIPS BETWEEN NESTING SWAINSON'S AND RED-TAILED HAWKS IN SOUTHEASTERN IDAHO

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We compared reproductive success, nest site characteristics, and food habits of nesting Swainson's (*Buteo swainsoni*) and red-tailed (*B. jamaicensis*) hawks along the Big Lost River and Birch Creek on the Idaho National Engineering Laboratory between 1991 and 1993. Productivity was similar between species. Twenty-six red-tailed hawk nests produced 37 fledglings (1.3/attempt) while 17 Swainson's hawk nests produced 21 fledglings (1.2/attempt). Nest trees used by Swainson's hawks were shorter, smaller, and in better condition than those used by red-tailed hawks ($P < 0.01$, Wilcoxon). Swainson's hawk nest trees were more foliated than most trees along Birch Creek and the Big Lost River ($P < 0.006$, Wilcoxon). Red-tailed hawk nest trees were similar to available trees. Food habits were similar between hawk species with *Microtus* spp. and leporids comprising the majority of prey consumed. Riparian vegetation condition, notably the lack of cottonwood and willow regeneration, appeared to be a major factor accounting for a decline in Swainson's hawk nesting along river channels on the INEL.

THE SWAINSON'S HAWK PRODUCTIVITY CRASH

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Swainson's hawks (*Buteo swainsoni*) were healthy and reproducing consistently well in western Saskatchewan from 1969 through 1987. Suddenly trouble became apparent, with six consecutive "bad" years occurring in a row, the six worst in 25 yr. Decreased productivity became evident in both grassland pastures and croplands near Kindersley in 1988, but at Alsask only in 1992. By 1993, the number of nesting pairs in Kindersley was less than half of that found 10 yr previously, most pairs failed, and even the successful pairs raised only one young per nest. The decline began in drought years and accelerated in two wet years, but finally began to reverse at Kindersley in 1994. Through 1993, the drastically decreased numbers of Richardson ground squirrels (*Citellus richardsonii*), the hawk's main prey species, may in part have been related to increased numbers of foxes (*Vulpes* spp.) and coyotes (*Canis latrans*).

SEXUAL AND GEOGRAPHICAL COLOR VARIATION AMONG SWAINSON'S HAWKS

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We examined ventral plumage coloration of breeding Swainson's hawks (*Buteo swainsoni*). These hawks are highly variable in their plumage coloration and this variation was due to differences in the color of melanin pigment and differences in pigment distribution. Females tended to be darker than males. Swainson's hawks were smaller and darker in California than in Alberta. We could find no differences in reproductive success based on plumage. A comparison of parents and offspring suggests that the differences in coloration are heritable.

SWAINSON'S HAWK ASSOCIATIONS IN THE SACRAMENTO VALLEY'S AGRICULTURAL LANDSCAPE

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Most studies of Swainson's hawk (*Buteo swainsoni*) foraging habits and habitat use involve monitoring of birds within a cluster of home ranges. The interpretative value of these studies can be increased by integrating their results with those from studies across a much larger spatial scale. I designed an extensive sampling program to express foraging habits and habitat use across many potential home ranges, thereby representing the population-level interaction with an agricultural landscape. After 5 yr and 110 surveys along a 200-km road transect from a car traveling at 50–55 mph, I made 151 observations of Swainson's hawk. These observations were mapped on a GIS and analyzed for associations with attributes of the landscape. Most Swainson's hawk observations were on a short stretch of transect in the east-west center of the valley near riparian habitat and groves of valley oak (*Quercus lobata*). Most (82%) were of birds in flight, and 62% were in groups, including 15 pairs and a foraging group of 23 individuals. Given the percentages of landscape elements along the transect, Swainson's hawks were observed less often than expected by chance at irrigated pasture, rice and rice stubble, and plowed fields with very little plant debris. They preferred alfalfa (especially stands >2 yr old), riparian habitat, asparagus, and especially, annual field crops during harvest and till. In addition to conditions on its wintering range, the future status of the Swainson's hawk population in the Sacramento Valley will depend on trends in crop acreage, cultural practices, and the extent of high-quality nesting habitat across the landscape. The Swainson's hawk population in the Sacramento Valley might increase substantially by establishing a well-connected network of nesting and prey-bearing habitat corridors, which is central to the proposed Habitat Management Program of Yolo County, California.

ANNUAL TURNOVER AND REPRODUCTIVE SUCCESS OF MARKED ADULT SWAINSON'S HAWKS IN THE BUTTE VALLEY, CALIFORNIA

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Results of a 10-yr study of a breeding population of Swainson's hawks (*Buteo swainsoni*) in the Butte Valley, northern California, are presented. Occupancy and reproductive performance were monitored at 23–83 territories between 1984 and 1994, and 454 breeding attempts were recorded. One-hundred and fifty breeding adults have been trapped and colorbanded since 1984; we present data in territory fidelity and annual turnover rates of marked adults. In 1994, 61 territories were known to be occupied by pairs. Of the 124 adults observed in the study area, 81% were colormarked or banded. Approximately 550 nestlings have been banded since 1979; 42 of these were later recaptured as breeding adults 3–12 yr of age. We discuss annual variability in adult turnover and reproductive performance.

GENERAL SCIENTIFIC PROGRAM

FERRUGINOUS HAWKS IN MONTANA WITH SPECIAL EMPHASIS PLACED ON DELINEATION OF SUITABLE HABITATS FOR SURVEYS GENERATED THROUGH A STATEWIDE GIS

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Statewide distribution of ferruginous hawks (*Buteo regalis*) in Montana was reviewed with an emphasis placed upon habitat use in four very different and very separated study areas. This habitat assessment was joined with a statewide geographic information system (Montana Agricultural Potentials System) to provide maps of potential ferruginous hawk habitat. These maps were generated with a resolution of 21.3 km² and were produced through the use of three land-attribute layers: land ownership, land use, and climax vegetation. These maps will provide the land-manager and field biologist with easily accessible baseline information regarding the placement of long-term ferruginous hawk nesting quadrats for population monitoring.

ORANGE-BREASTED FALCON (*FALCO DEIROLEUCUS*) BREEDING BIOLOGY, NESTING SITES, AND DISTRIBUTION IN GUATEMALA AND BELIZE

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We studied the breeding biology of the orange-breasted falcon (*Falco deiroleucus*) in Guatemala and Belize during 1992, 1993, and 1994. Historically considered a species dependent on vast tracts of primary forest, four of our 15 known sites exist in severely fragmented habitats of primary and secondary forest, agriculture, and pasture. To what degree these non-primary forest habitats are utilized is unknown. Of 26 nesting attempts, 13 succeeded in fledging 28 young. Three nests failed during incubation and three while brooding. In 1994 an adult male was trapped and outfitted with a tail-mounted transmitter. Although this pilot study was conducted through biangulation, it indicates that this male was commonly travelling from 5–10 km from the nest over successional forest, intensive agriculture, and pasture. In 1994 nine active sites in Belize fit inside a diameter of 30 km and 13 active sites in Guatemala and Belize within a 160 km diameter. Orange-breasted falcons occur and appear to be successful in a variety of habitats and nesting circumstances. Perhaps, like the peregrine falcon, they are more adaptable to a rapidly changing landscape than previously suspected.

COMPARISON OF ROADSIDE COUNTS AND RADIOTELEMETRY TO DETERMINE HABITAT USE OF FERRUGINOUS HAWKS WINTERING ON ROCKY MOUNTAIN ARSENAL, COLORADO

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The ferruginous hawk (*Buteo regalis*) is currently classified as a candidate species for inclusion on the federal threatened and endangered species list. As a migratory raptor, the over-wintering condition of ferruginous hawks is important to the overall reproductive rate of the species. However, little information is available on the habitat use of wintering ferruginous hawks. We used two standard methods, roadside counts and radio-tracking, to evaluate habitat use of ferruginous hawks wintering on Rocky Mountain Arsenal (RMA), northeast of Denver, Colorado. A comparison of the similarities and differences of the two survey methods will be presented. The results of this study will provide information on the advantages, disadvantages, and applicability of survey methods to evaluate raptor habitat use. The RMA has recently been designated a national wildlife area and is also a major superfund site currently in the initial stages of extensive clean-up operations. Providing habitat use information will allow the U.S. Fish and Wildlife Service to manage resources, wildlife viewing opportunities, and provide input into clean-up operations that may impact ferruginous hawks.

HABITAT REQUIREMENTS OF THE MADAGASCAR FISH-EAGLE

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Madagascar fish-eagle (*Haliaeetus vociferoides*) populations have declined dramatically in recent decades as a result of habitat loss and human persecution. Fish-eagle habitat requirements were investigated to help determine what management action should be taken to prevent the eagle's extinction. Characteristics of fish-eagle nesting habitat were examined from May to August 1994 in a 3000 km² area of lakes, rivers, and wetlands in the Antsalova region of Western Madagascar. Habitat variables were measured at sites used by eagles and compared with values measured at random sites within the same area. Comparisons were made at the following levels: nest and perch trees, nest sites, shoreline habitat, and aquatic habitat. Logistic regression was used to identify the variables that best distinguish habitat used by eagles and to develop a predictive model for suitable fish-eagle habitat. The model will be used to locate other areas of suitable fish-eagle habitat and to survey these areas for eagle use. The results of this study will help to determine the extent to which the fish-eagle is limited by habitat availability and whether there are areas of unoccupied habitat where the species could be reintroduced.

ANTICUCKOLDRY BEHAVIOR IN THE WESTERN BURROWING OWL (*SPEOTYTO CUNICULARIA HYPUGAEA*)

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Even though burrowing owls (*Speotyto cunicularia*) are monogamous within a breeding season, their large clutch sizes provide a lengthy fertile period over which extra-pair copulations could take place. Burrowing owls also frequently nest in loose colonies, a situation which makes encounters with conspecifics more likely. If male burrowing owls guarded their mates wherever they went, however, they could risk losing their burrows since burrow takeovers are common. We, thus, expected to observe mate guarding behaviors at burrows prior to clutch initiation. For 8 wk following the spring arrival of females into our study area in 1993 and 1994, we recorded the following behaviors that may be involved in paternity assurance: copulations, allopreening and male primary calls. The duration of time that the male and female spent at the burrow entrance alone and together was also recorded along with nearest neighbor distances. Copulations oc-

curred in all weeks but were most frequent during week five of the observation period. The duration of time that the pair spent together at the burrow entrance was high during weeks 1-5 and declined thereafter. The duration of time that the female was left alone at the burrow entrance was low initially and peaked during weeks 6-8. The frequency of copulations and male primary calls were not significantly correlated with nearest neighbor distance. The frequency of allopreening was low during weeks 1-5 but increased sharply during weeks 6-8, after the peak in copulations. A peak in copulations during week 5 and the amount of time in which the female was left alone suggest anticuckoldry behavior by male burrowing owls. Allopreening and the lack of a correlation between copulations and primary calls with nearest neighbor distance, however, do not. Further observations are necessary in order to further confirm anticuckoldry behavior by male burrowing owls.

FACTORS CONTROLLING BALD EAGLE REPRODUCTION IN THE GREAT LAKES REGION

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The bald eagle (*Haliaeetus leucocephalus*) population, within and adjacent to the Great Lakes Basin, constitutes the greatest single population within the contiguous United States. Bald eagles were largely extirpated from the Great Lakes by the mid-1960s, due to the effects of DDE. Eagles began to repopulate and raise young again along the shores of the Great Lakes, with the exception of Lake Ontario, by the 1980s. Factors limiting bald eagle populations in this region were studied. We compared and contrasted nesting eagles from 10 subpopulations including six interior and four Great Lakes, in a region from northern Minnesota though the north shore of Lake Erie in Ohio for the period 1977-93. Ecological factors investigated included food habits, nest tree use, winter habitat use, and the identification of potential nesting habitat. Bald eagles primarily foraged on fish (suckers, bullheads, northern pike, carp, and freshwater drum). Eagle nests were built primarily in white pines, but in cottonwoods near Lake Erie. Potential nesting habitat exists along the shorelines of all Great Lakes, primarily along Lakes Huron and Superior. Habitat availability, however, may limit the Lake Erie subpopulation, which has little unoccupied habitat and great density of nesting eagles. Toxicological aspects investigated included monitoring concentrations of PCBs and p,p'-DDE in plasma, mercury and selenium in feathers. Concentrations of p,p'-DDE or PCBs, but not mercury or selenium, were significantly, and inversely correlated with regional reproductive productivity and success rates. Reproductive productivity of bald eagles within this population is primarily regulated by concentrations of or-

ganochlorine compounds along the shorelines of the Great Lakes, and density dependent factors in the interior, relatively uncontaminated areas. The continuing recovery of this population will depend on maintaining greater productivity in interior areas to compensate for lesser fecundity and greater adult mortality along the shorelines of the Great Lakes.

BREEDING SUCCESS OF PEREGRINE FALCONS IN RELATION TO WEATHER IN AN ARCTIC ENVIRONMENT

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We studied variability in breeding success and correlated breeding success with weather in an Arctic population of peregrine falcons (*Falco peregrinus*). We found that breeding phenology had a low degree of variability, and was related to weather only one year out of 12. Breeding success was high for the species (on average 1.4 chicks per territorial pair, or 2.5 chicks per successful pair), but variability was also high (0.6–2.5 chicks per territorial pair). Clutch size was correlated with rainfall and wind during the prelaying stage ($r^2 = 0.75$, $P < 0.01$) and severe weather events coincided with high mortality of young during both the incubation and nestling stages of the breeding season. We also found that severe weather early in the breeding season could delay and cause subsequent high chick mortality. Mortality of young was significantly different among the three stages of the breeding season, but this difference was only seven percent (26% mortality during the nestling stage, 33% during the incubation stage). Long term climatic changes that result in an increase in snowfall or storms could be deleterious to Arctic peregrine falcons.

AUTUMN MIGRATION OF PEREGRINE FALCONS DETERMINED BY SATELLITE RADIOTELEMETRY

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We report on the results of a study of fall migration of adult female peregrine falcons (*Falco peregrinus*) tracked by satellite radiotelemetry. In July and August 1994, we captured 15 adult female peregrine falcons on their upper Yukon River breeding area in eastcentral Alaska and attached satellite radiotransmitters to them using backpack-style harnesses. We report on the migration route, direction and speed of the birds and analyze their movements in light of broad scale weather patterns during autumn.

CUTTING THE BOREAL FOREST: IMPLICATIONS FOR CANADIAN FOREST-DWELLING RAPTORS

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Recently, very large forestry leases have been granted to companies interested in cutting aspen (*Populus* spp.) in the mixed-wood boreal forest of western Canada for pulp production. In less than 2 yr, the government of Alberta leased over 220 000 km² of this forest without any environmental impact assessments or public hearings. Subsequently, several forestry/wildlife impact studies were initiated, however little consideration was given to the effect of these harvests on forest-dwelling raptorial birds. Eight species of owls, three species of accipitrine hawks, and two forest-dwelling buteos may breed within this region and the target harvest species (mature aspen) comprises the type of habitat used by several of these raptors for foraging and nesting. For some Vulnerable (C.O.S.E.W.I.C.) species, like the Cooper's hawk (*Accipiter cooperii*), the forests of Northern Alberta may represent a large portion of the unbroken nesting habitat remaining within the range of this bird in Canada. Until recently, there has been no attempt to survey for populations of raptors in the mixed-wood leases, much less attempt to determine the relative abundance of different species or how forest cutting practices might affect populations. During the summers of 1993 and 1994, we attempted to survey raptors in a portion of the largest forest management area in Alberta. Here, we provide preliminary results of these surveys and detail plans for future work on raptor populations in this area. We highlight potential impacts of aspen harvesting on migratory species so as to encourage international raptor migration/count programs to evaluate population trends in light of very large industrial forest operations in Canada.

LEAD LEVELS IN GOLDEN EAGLES IN SOUTHEASTERN IDAHO

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We studied the occurrence of lead in free-ranging golden eagles (*Aquila chrysaetos*) in two adjacent river valleys in southeastern Idaho from December 1989 to present. Blood samples ($N = 178$) from golden eagles were analyzed for lead and grouped into one of four categories: <0.20 ppm = background; 0.20 – 0.59 ppm = exposed; 0.60 – 0.99 ppm = clinically affected; ≥ 1.00 ppm = acute lead poisoning. Forty-two percent of all wintering golden eagles sampled had elevated blood lead levels (≥ 0.20 ppm) and there was a highly significant difference in lead levels between golden eagles wintering in the two river valleys. All the eagles in

the Pahsimeroi Valley with elevated blood lead levels (35.1%) were in the lowest exposure group (0.20–0.59 ppm). In the Lemhi Valley, 48.0% of the golden eagles had elevated blood lead levels and 27.5% of these had levels ≥ 0.60 ppm lead. Both resident and migrant golden eagles winter in the study areas; however, recapture data indicate there is little movement of eagles between the two valleys during the winter. Nestling eagles in these valleys did not have elevated blood lead levels. The source of lead contamination in Idaho eagles is not known, nor is it known if the lead contamination is confined to resident or migrant eagles. We plan to expand the study in the future in an attempt to answer these questions.

ELECTROCUTION AS A MORTALITY FACTOR IN AN URBAN POPULATION OF HARRIS' HAWKS

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We studied the ecology of Harris' hawks (*Parabuteo unicinctus*) nesting in an urban environment in and near Tucson, Arizona, 1990–93, and examined the role of electrocution as a mortality agent. We attempted to recover and examine the remains of all hawks that died in our study area. We used a hierarchical approach to classifying electrocutions based on field examinations, laboratory necropsies, and, in some instances, credible anecdotal and circumstantial evidence. We recorded 177 mortalities and classified them as either electrocutions (112), possible electrocutions (44) or instances in which we could not determine cause of death (21). Electrocution most commonly occurred on residential power lines and transformers and was the most common mortality factor encountered during our study. Fledglings at some nests were particularly susceptible to electrocution during the first 2 wk after fledging, possibly due to the proximity of power poles to nest trees. Among adults, females were most commonly electrocuted possibly due to larger body size and their behavioral roles in dominance interactions. Although nesting success by urban breeding groups was high, survival of fledglings was low due to electrocution. High mortality among adults in groups appeared to be offset by an abundance of floaters in urban areas that quickly replaced hawks that died. High mortality may have also kept breeding group sizes lower than was common among groups nesting in nonurban areas.

PRELIMINARY RAPTOR SURVEYS IN WESTERN MONGOLIA

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Raptors were observed on a 5200 km expedition from Ulaan Baatar through the Hangay Mountains to the Russian Altay Mountains with return through the Gobi Altay Mountains. The focus of the expedition was on nesting ecology of the Saker (*Falco cherrug*) and Altay falcons (*F. altaicus*) (25 eyries were located), but nests were also found for seven other species including more than 30 nests found of the upland buzzard (*Buteo hemilasius*). We conducted 21 day-long counts and 10 more formal raptor road counts. Raptors were concentrated in areas where perches were common and where food was most abundant. Western Mongolia remains a vast undeveloped land where camel trains and yak carts are normal. No developed highway network exists. Raptor work in the interior must be supported by four-wheel drive vehicles traveling cross country. Food and fuel for a research team are difficult to procure, but raptor populations are largely unexploited. Raptors frequently nest on the ground or on very low cliffs and tress, and often nest in close proximity of pairs of their own and other species. Several areas of special significance to raptors are discussed including the Taleen Ulaan (Red Steppe) areas of granite dells which we recommend for status as an international reserve.

POSTFLEDGING BEHAVIOR OF WESTERN SCREECH-OWLS; THE EFFECT OF DOMINANCE ON TIMING OF DISPERSAL

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Behavioral dominance may be a proximate factor related to dispersal in birds. One component of dispersal that dominance may affect is the timing of movements that juveniles make away from their natal areas. In one manner, subordinate juveniles may initiate dispersal before dominants if dominants aggressively force subordinate siblings to disperse. For example, dominant birds may chase subordinate siblings from natal areas. Conversely, if vacant territories are limited and early arriving birds are more successful in acquiring territories, selection would likely operate on young to disperse as early as possible. In this case, dominant individuals, because they have priority of access to resources and presumably mature more rapidly, would disperse before subordinate siblings. We are examining the effect of dominance, body size, and sex on dispersal in western screech-owls (*Otus kennicottii*) in southwestern Idaho using radiotelemetry to observe young during the postfledging period and as they initiate dispersal movements. To assign dominance status within broods, we videotape interactions among nestlings during the pre-fledging period which allows us to evaluate and assign social ranks based on wins and losses during agonistic interactions. Subsequently, the social ranks are examined

relative to the timing of dispersal. Our paper will focus on results of the first year of a 2-yr study.

DIURNAL ACTIVITIES OF MIGRATING JUVENILE RED-TAILED HAWKS

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From 1990-93, we studied fall movements of nine juvenile red-tailed hawks (*Buteo jamaicensis*) via radiotracking. Our tracking time for each bird ranged from 24 hr to 9 d (total days of tracking = 76). Birds were observed to begin soaring approximately 2.5 hr after sunrise with their directional flight commencing approximately 1 hr later. The day's directional flight ceased approximately 2 hr before sunset and soaring ceased 1.5 hr before sunset. The mean distance traveled from roost to roost was 65.3 km (range 12-198 km). Additionally, we were able to estimate the distance of the actual travel path (\bar{x} = 80.5 km, range 12-207 km). The estimated travel path averaged 20% greater than the roost to roost distance. The amount of time traveled each day ranged from 1.12-8.25 hrs (\bar{x} = 4.3 hrs). The average daily speed was 21 km/hr, and the maximum speed recorded was 78 km/hr.

HABITAT UTILIZATION BY BALD EAGLES WINTERING IN INDIANA

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Biweekly helicopter surveys of bald eagle (*Haliaeetus leucocephalus*) activity were conducted from November 1991 through April 1992, using 12 specific routes. The survey routes were characterized as to habitat usage by bald eagles through census and statistical determination of the most influential variables, of interface and creek mouths. Thirty-six habitat variables were noted and measured for 696 eagle sightings. Classification of priority management sites for Indiana was done based on the presence of high eagle use sites. As eagle nesting season was initiated, a substantial increase in sport fishing activity occurred at several sites, as did human activity—particularly on the reservoirs. Total eagle sightings peaked in late January. Immature and juvenile eagles were more easily flushed, while adults and subadult birds were more tolerant of helicopter disturbance. Habitat was segmented into 4-km segments, and analyzed for eagle usage. Waterfowl data and human and boat activity are also correlated with eagle occurrence. There is some evidence to suggest that eagles avoid areas of regular human disturbance, and aggregate in certain other areas. These include the Wabash River stretch near a power plant and protected areas on Monroe Reservoir. Trees selected as perch sites were most often deciduous trees, 6.5 m from the water's edge. Wintering eagles utilized large reservoirs more often than large rivers. There

is also some association between eagles utilizing segments with waterfowl present in peak winter months.

HOW TO MEASURE A HAWK MIGRATION— EVOLUTION OF THE QUADRANT SYSTEM AT THE GOLDEN GATE

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In the 1980s we were frustrated trying to apply historical hawk counting techniques to the autumn hawk flight over the Marin Headlands, just north of San Francisco, California. The conditions of the count site—steep topography, unpredictable fog, and lots of year-round raptor activity—necessitated that we develop a new system of counting as well as a new perspective on what we were measuring. In 1989, we began using a quadrant system to record daily rates of visible raptor activity for 19 species, with a primary goal of establishing a consistent and repeatable measure for use over the long-term. In use through 1993, the 4-mo count has yielded annual rates from 21.5-43.7 hawks per hour, corresponding with absolute counts ranging from 13 600-22 500 hawk-sightings. I will discuss the pros and cons of hawk counting systems, including the importance of defining specific counting techniques, assumptions, and units of measurement.

FAT CONTENT OF AMERICAN KESTRELS (*FALCO SPARVERIUS*) AND SHARP-SHINNED HAWKS (*ACCIPITER STRIATUS*) ESTIMATED BY TOTAL BODY ELECTRICAL CONDUCTIVITY

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Total body electrical conductivity (TOBEC) is a noninvasive method for the estimation of lean mass in live subjects. Lipid content can be calculated from the body mass measured and the lean mass estimated from TOBEC. We used live American kestrels (*Falco sparverius*) to study the accuracy of this method. TOBEC measurements were compared to actual body content determined by Soxhlet fat extraction using petroleum ether as the solvent. TOBEC estimated 73.7% of the variation in lean mass in a sample of 21 live kestrels and estimated 83.8% of the variation in lean mass for 21 kestrel carcasses warmed to 39.8°C. No significant difference was found between the slope or elevation of the calibration lines developed using live or dead kestrels. Body temperature altered the TOBEC measurements by an average of 1.54% (SE = 0.55) for each 1°C change over a temperature range of 7.0°C (37.3-44.4). The calibration developed for kestrels was used to estimate lean mass and compute fat mass of migrating kestrels, sharp-shinned hawks (*Accipiter striatus*) and merlins (*Falco columbarius*). The average percent fat mass of kestrels trapped during migration at Cape May, New Jersey, was 6.01% (SE = 1.92, N = 12) for males

and 8.51% (SE = 2.00, $N = 13$) for females. The fat mass of sharp-shinned hawks averaged 5.55% (SE = 0.94, $N = 53$) for males and 10.92% (SE = 0.80, $N = 87$) for females. Male merlins had an average fat mass of 18.05% (SE = 3.35, $N = 7$) and females averaged 14.19% (SE = 3.15, $N = 8$).

**NEST-SWITCHING BEHAVIOR IN JUVENILE OSPREYS:
A FORTUNATE ACCIDENT OR OPTION FOR SURVIVAL?**

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In 1993-94 I examined postfledging behaviors of young ospreys (*Pandion haliaetus*) at Cascade Reservoir, Idaho. I observed single and three-young broods to examine effects of brood size, food distribution, and competition among nest-mates on subsequent fledgling behaviors. I monitored movements, behavior, and interactions of nine fledglings in 1993 (three from single nests, six from sibling groups) and 16 fledglings (seven singles, nine siblings) in 1994. At least three and possibly six fledglings switched from their natal nest to another nest occupied by breeding ospreys in 1993. In 1994, three fledglings have moved to nests occupied by reproductive pairs; one switched into the nest of a nonreproductive pair. Analyses of food intake and behavior at nonnatal nests will indicate whether nest-switching is a behavioral strategy to improve individual fitness or a random event.

**REPRODUCTION AND DISTRIBUTION OF
BALD EAGLES IN VOYAGEURS NATIONAL PARK,
MINNESOTA, 1973-93**

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The bald eagle (*Haliaeetus leucocephalus*) is classified as a threatened species in Minnesota. In 1973 the National Park Service began monitoring bald eagle distribution and breeding success within and immediately adjacent to Voyageurs National Park, to obtain data that could be used by park management to protect eagles from the impacts of visitor use and facility development. Thirty-seven breeding areas were identified from 1973-93. Mean productivity ranged from 0.00-1.42 young per occupied nest and averaged 0.68 for 21 breeding seasons. The number of breeding pairs tripled and the mean number of young fledged increased five times during the study period. The percentage of success for breeding attempts doubled. However, in over three-fourths of the years, mean productivity and percent nest success in Voyageurs were below the 1.00 young per occupied nest and 70% percent nest success criteria considered necessary for healthy bald eagle populations. We suspect a complex of variables including

toxic substances, human disturbance, severe weather and food source availability in early spring may have kept bald eagles at Voyageurs from achieving productivity levels similar to the nearby Chippewa National Forest population in northcentral Minnesota. The cumulative effects of these variables on bald eagle productivity and habitat are unknown and should be determined. Breeding pairs preferred pine covered island nest sites on the park's four major lakes near areas free of ice in early spring. Ninety percent of the 129 nests observed were built in super canopy white pines. Only one nest was built on one of the 31 smaller park lakes.

**AUTUMN MOVEMENTS OF RADIO-TAGGED
JUVENILE RED-TAILED HAWKS IN CENTRAL
COASTAL CALIFORNIA**

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From 1990-93, nine juvenile red-tailed hawks (*Buteo jaicensis*) have been radiotagged in the Marin Headlands, Marin County, California. Each hawk was tracked after release by three teams of volunteers of the Golden Gate Raptor Observatory. The overall movements of these hawks is to the southeast. One bird flew 315 km northwest after release, although it was later rediscovered 200 km south-east of the Headlands. The pattern of these red-tailed hawks is similar to the locations of banded juvenile red-tails recovered within a few months of release. The tagged red-tailed hawks were seen to cross San Francisco Bay without hesitation. Total migration distance for these hawks ranged from 51 km to 445 km, and no bird was observed to travel south of Los Angeles or east of the Central Valley. These data suggest that many of the juvenile red-tailed hawks passing through the Marin Headlands in autumn are travelling to areas south of San Francisco within 100 km of the Pacific coast.

**ACTIVITY AND CORTICOSTERONE LEVELS IN
FOOD RESTRICTED POSTFLEDGING AMERICAN
KESTRELS (*FALCO SPARVERIUS*)**

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Departure from the natal area occurs in many bird species during the postfledging period, but the corresponding physiological and proximate factors responsible for this movement remain unclear. Physiological and proximate factors may involve environmental conditions (food availability), vulnerability to environmental conditions (physical condition), and hormonal responses. Corticosterone is the major hormone involved in stressful situations, such as anticipation of starvation, and may be related to increased foraging and locomotor activity. In the laboratory, we studied activity and corticosterone levels in 12 post-

fledging American kestrels (*Falco sparverius*) taken from nest boxes in southwest Idaho. We removed birds from the box at 23–25 d of age and divided them into three groups. We maintained kestrels at 100%, 90%, or 80% of *ad libitum* body weights for 21 d. We measured movement with pedometers fitted backpack-style and collected blood samples once/wk. We used radioimmunoassay to measure corticosterone levels. Preliminary analysis suggests there may be a threshold body condition below which birds respond to restricted food by increasing activity levels. Male kestrels may be more sensitive to this threshold than females.

EFFECTS OF ROTENONE USE TO KILL "TRASH" FISH ON OSPREY PRODUCTIVITY AT A RESERVOIR IN OREGON

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We studied ospreys (*Pandion haliaetus*) nesting at two reservoirs in the Cascade Mountains of southern Oregon from 1988–92. Both reservoirs had nesting ospreys present in 1988 (11 and 27 occupied nests). Productivity rates at both locations were similar and judged to be excellent in 1988 and 1989. However, in the autumn of 1989 (after the ospreys migrated south), the reservoir with fewer nesting pairs was treated with rotenone to eliminate the brown bullhead population and any other fish. The reservoir was to be later restocked with rainbow trout. The response of nesting ospreys in 1990, 1991, and 1992 to the elimination of fish in one reservoir in the autumn of 1989 is the subject of this preliminary report. Osprey nest site occupancy, foraging parameters (e.g., dive success and prey delivery rates) and reproductive success are compared between the two reservoirs (rotenone treated versus control with no treatment).

U.S. OSPREY NESTING DISTRIBUTION "TO HACK OR NOT TO HACK"

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Osprey (*Pandion haliaetus*) once nested throughout most of the United States. The decline in the osprey population due to biocide use is well documented, as is their recovery following the U.S. ban on DDT in 1972. Henny reported the nesting distribution and abundance of osprey in the U.S. and noted a general increase in the population. However, due to a strong natal site fidelity, inland dispersal had been slow or nonexistent in states with low or extirpated populations. Therefore, in the early 1980s hacking was initiated as a technique for population restoration. In 1988 Rymon conducted a survey of eleven U.S. states

known to have attempted osprey hacking projects. His data indicated that hacking was a viable method for accelerating the slow dispersal of this species. Several other states have inquired about the feasibility of initiating their own hacking programs. In an attempt to best address this issue, we have conducted a nationwide nesting survey updating Henny's 1981 data and constructed a model of current nesting dispersal patterns. We have determined that in states where osprey nesting populations had been low, nesting pairs have increased as much as tenfold, and in Pennsylvania where hacking was initiated in 1980, nesting pairs have increased from 0–19. Eight states that had recorded no known nesting pairs in 1981, now have osprey nesting as a result of hacking projects, and/or natural dispersal. The question remains, should areas where dispersal is slow choose hacking or waiting as a method of recovery?

HOME RANGE SIZE AND FORAGING HABITAT PATTERNS OF RED-SHOULDERED HAWKS IN MANAGED PINE FORESTS OF GEORGIA

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In the southeastern United States, emphasis on production of pine timber continues to reduce riparian woodland, an important habitat of the red-shouldered hawk (*Buteo lineatus*), to narrow corridors and streamside management zones. Loss or alteration of riparian habitat has contributed to regional declines in this hawk throughout its range. Without knowledge of its space and foraging habitat requirements in the Southeast, it is difficult to predict or mitigate impacts to the species and its habitats. Therefore, movements of five male and two female red-shouldered hawks fitted with posture-sensitive radiotransmitters were monitored on a 5000-ha study area in the Piedmont physiographic region of eastcentral Georgia March to July 1994. Hawk home ranges were estimated based on harmonic mean isopleths and minimum convex polygons. A digital database created with the geographic information system ARC/INFO was used to determine macrohabitat characteristics within home ranges. Selection of foraging habitats was determined by comparing the proportion of observed habitat use, based on the number of radio locations within each habitat, with the proportion of available habitat within hawk home ranges. Vegetative structure and physiography of habitats at both foraging and random locations are also examined.

BALD EAGLE SURVEYS IN ALASKA'S CHILKAT VALLEY, 1984–94

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Alaska's Chilkat River Valley attracts North America's largest gathering of bald eagles (*Haliaeetus leucocephalus*). Aerial surveys were conducted from 1984-94 to assess the fall abundance and distribution of eagles. Surveys were also flown during the nesting seasons of 1984-87 and 1992 to obtain productivity data. Other studies, using radiotelemetry, have documented movements into the Chilkat Valley by eagles from distant locations. Returns of spawning chum salmon (*Oncorhynchus keta*) have recently declined, but still attract large numbers of eagles to the Chilkat. Fall bald eagle numbers varied from 510-3988. Annual peak counts had a mean of 2500 eagles. The designated critical habitat area held 53% of eagles over all surveys. Most occupied nests were abandoned as the nesting season progressed. Only 11% of occupied nests were successful in 1986, 44% in 1987, and an estimated 21% success in 1992. Compared to the marine coastal environment, most Chilkat Valley nest territories do not supply a reliable source of food throughout the entire nesting period. The number of human visitors in the summer increased dramatically, and will expand further with the construction of a proposed docking facility to accommodate large cruise ships.

SEVEN YEARS OF RAPTOR GUILD DYNAMICS IN SEMIARID CHILE

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I report a 7-yr ongoing study in the semi-arid region of Chile. Concurrent with the 1987 El Niño episode of unusually heavy rains, a small-mammal irruption was able to support as many as 10 vertebrate predator species (four hawks, four owls, two foxes). As mammal populations declined over the following 5 yr, all of the hawks and half of the owls sequentially left the site. A hard core of two owl and two fox species remained despite a 10-fold decrease in mammalian abundance. A second and milder El Niño event (1992) triggered the recovery of mammal populations to apparently normal levels (100/ha), and owls first and hawks later began to return to the site. One hawk of the original set is still missing. Mammal irruptions are a built-in component of the site's dynamics, and predators display two different strategies to cope with it. Some (the hard core) wait out the lean years while others scatter broadly and thinly over the landscape. Given this type of ecosystem, affected by large-scale and temporally unpredictable factors such as El Niño events, it is very difficult to design preservation units. These results suggest that it is imperative to protect areas with high habitat diversity (e.g., numerous different slopes, exposures, basins, ravines, elevations) in which mammalian fluctuations in different subsets may be out of phase with one another, as I believe that the spatio-temporal variability in the mammalian prey base is at the root of many of the changes in this predatory guild.

SERUM CHOLINESTERASE ACTIVITY FROM MIGRATING RAPTORS IN UTAH

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Since the banning of several organochlorine pesticides in the early 1970s, organophosphate (OP) and carbamate (CB) pesticides have seen increased use. Detection of exposure to these compounds involves measuring levels of acetylcholinesterase (AChE) activity from brain tissue or blood serum. With the exception of a handful of domesticated species, there are few published values of brain AChE activity, and even fewer reported values for serum levels in avian species. We will be reporting reference cholinesterase values from all species of diurnal raptors trapped during 1990 fall migration at Squaw Peak banding station in Utah County, Utah and 1993-94 fall migration at Cutler Dam Banding Station in Cache County, Utah. In addition, preliminary data which partially characterizes serum acetylcholinesterase in sharp-shinned (*Accipiter striatus*) and Cooper's (*A. cooperii*) hawks will be reported.

POSTFLEDGING BEHAVIOR OF BURROWING OWLS: EFFECTS OF FOOD AVAILABILITY ON DISPERSAL MOVEMENTS

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One of the proximate factors that may prompt young birds to leave natal areas is the lack of sufficient food. Young birds may have difficulty locating food after parents terminate care and/or prey reserves become depleted. In either case, young may be forced to seek more abundant prey elsewhere by dispersing. In contrast, if young have easy access to abundant food they may delay dispersal movements or fail to disperse. To investigate the effects of food availability on dispersal, we provided supplemental food to individuals in several family groups of burrowing owls (*Speotyto cunicularia*) in southwestern Idaho in 1994. Supplemental feeding of dead lab mice and day-old chickens began in mid-May and continued until juveniles left their respective natal areas. Our research also examined the behavior of juvenile burrowing owls between the time of fledging and the initiation of fall migration. We radiotracked both adult and juvenile burrowing owls to examine daily movements in relation to natal burrows, association of individuals in family groups, and relationships between individuals in neighboring family groups. Our study is designed to determine when juvenile owls attain independence, when young disperse, if food availability influences dispersal, and when adult and juvenile owls

initiate fall migration. We will discuss findings from the first year of this 2-yr study.

REPRODUCTIVE AND PROVISIONING BEHAVIOR OF THE AMERICAN KESTREL IN EASTERN TEXAS

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In eastern Texas, American kestrels (*Falco sparverius*) are uncommon breeding residents presumably of the southeastern coastal plain subspecies *F. s. paulus*, which is currently listed as threatened in Florida. The apparent rarity of the breeding population and the population declines in the eastern portion of the subspecies' range warranted our investigation of American kestrel status and breeding behavior in eastern Texas from March 1992 to the present. Kestrels are opportunistic foragers; their diet consists of a wide range of prey items, including arthropods, small rodents, birds and reptiles, and is highly dependent upon location and season. Our data indicate that the percentage of herptiles in the diet of forest residents is much higher than that indicated in the literature for kestrels in other areas of the country. Although some kestrels may feed exclusively on arthropods in winter, breeding kestrels in eastern Texas appear to be nutritionally or energetically dependent on vertebrate prey. In most kestrel pairs, females become sedentary within a small area around the cavity tree two or more weeks before commencing incubation. The female remains largely dependent upon her mate for food from this time until approximately 2 wk after the eggs hatch, when she will begin foraging, assisting the male in provisioning the young. We have found that kestrels readily capture green anoles (*Anolis carolinensis*), which are quite abundant during the breeding season. Field observations to date indicate that eastern Texas resident kestrels rely almost exclusively upon a lizard prey base during the provisioning portion of the breeding cycle.

ADAPTIVE RADIATION IN DIURNAL BIRDS OF PREY ON THE BASIS OF THE JAW APPARATUS

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The results of morpho-functional analysis of the jaw apparatus in the Falconiformes are discussed. The particularities of structure and functions of the jaw in different groups of raptors are considered. Adaptive interpretations are presented. Factors perceived to influence the formation of specific groups of birds of prey are presented. Vultures are perhaps a very ancient group, but evolution of their jaw apparatus could not originate from accipitrid-like ancestors. It is not possible to connect the specific morphological adaptations in the Cathartidae jaw and hyoid ap-

paratus with their foraging techniques. More probable, Cathartidae peculiarities originate from a more closely tied ancestor who was a near-water bird with a low jaw and a relatively long bill. New World vultures are not connected with other Falconiformes in their origin. Perhaps vultures should be more closely connected to Procellariiformes and Pelicaniformes. Scavenging was not a major factor in the evolution of Accipitridae. This group evolved into relatively generalized, active woodland raptor life forms.

HOME-RANGE AND FORAGING BEHAVIOR OF THE FERRUGINOUS HAWK IN SOUTH-CENTRAL WASHINGTON

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We studied movements of six adult male ferruginous hawks (*Buteo regalis*) nesting on and adjacent to the U.S. Department of Energy's Hanford Site in south-central Washington, from May through August 1994, using radiotelemetry. Observations were recorded during all daylight hours to determine daily foraging activity. In addition to foraging, we noted the number of prey deliveries to nests, prey sizes delivered, and the distances prey items were carried to nest sites. Preliminary results indicate home ranges of males nesting on the Hanford Site were similar to those of males nesting off-site. Males nesting both on and off of the Hanford Site used agricultural fields for foraging. All males captured and delivered a variety of small- and medium-sized prey items (i.e., small = mice, shrews, voles; medium = ground squirrels and pocket gophers) to the nest, but none were observed capturing or delivering any large prey items such as jackrabbits.

ASSESSING ABUNDANCE AND NESTING SUCCESS OF BENCHLAND RAPTORS IN THE SNAKE RIVER BIRDS OF PREY NATIONAL CONSERVATION AREA—AN EVALUATION OF METHODS

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From 1991-94, we assessed relative abundance and nesting success of ferruginous hawks (*Buteo regalis*), northern harriers (*Circus cyaneus*), burrowing owls (*Speotyto cunicularia*), and short-eared owls (*Asio flammeus*) in the Snake River Birds of Prey National Conservation Area (NCA) in southwestern Idaho. This was the first attempt to monitor these species in the NCA's desert uplands. To assess relative abundance, we searched randomly selected plots to locate occupied nesting areas using four sampling methods: variable circular plots, line transects, and quadrats of two sizes. To assess reproductive success, we tried to de-

termine fate at nesting areas found during random sampling efforts, at historically occupied nesting areas, and at nesting areas found opportunistically by our study team. In this paper, we compare detection rates for the four sampling methods used for relative abundance assessments, discuss potential biases in assessing nesting success, and discuss factors affecting raptor monitoring efforts in a desert area where nesting densities tend to be low.

ABUNDANCE AND DIET OF CHILEAN SPOTTED OWLS IN NEW AND OLD-GROWTH FORESTS

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We report the first quantitative information on the abundance of Chilean spotted owls (*Strix rufipes*) in six new (DBH 10–50 cm, canopy cover 50–75%, 80–200-yr-old) and five old-growth (DBH > 50 cm, canopy cover >75%, >200-yr-old) rainforests of southern Chile. Over 37 nights within a year we surveyed 37 linear kilometers of new and 49 km of old-growth forests, detecting by calls the presence of four and 11 spotted owl pairs (0.11 and 0.22 pairs/km), respectively. This difference was marginally significant at $P = 0.08$. Pooling all data and applying a stepwise regression with five supposedly independent but highly correlated variables, canopy cover accounted for 68% of the variance in owl abundance using a maximum improvement procedure (reduction in residual variance). Mean DBH and snags/ha accounted for only 4% of the unexplained variance. Elevation and age accounted for very little of the residual variance. When removing canopy cover from the stepwise regression, mean DBH accounted for 34% of the variance in owl abundance; adding snag/ha improved it negligibly, and age explained <8% of the residual variance. We also collected 161 pellets over 4 yr in two patches of old-growth forest, and identified 376 prey items. Insects, amphibians, and birds accounted for 33, 0.5, and 1.5% of the prey by numbers, and mammals for the remainder. Among the latter, an arboreal mouse (*Irenomys tarsalis* = 42 g) and an arboreal opossum (*Dromiciops australis* = 34 g), together with a scansorial mouse (*Oryzomys longicaudatus* = 26 g), accounted for >72% of the total prey consumed.

CHANGES IN GOLDEN EAGLE REPRODUCTIVE SUCCESS IN DENALI NATIONAL PARK, ALASKA, 1988–94

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Since 1988 I have studied the reproductive success of golden eagles (*Aquila chrysaetos*) in a 2500 km² study area in Denali National Park, Alaska. Nesting territory occupancy, the percentage of territorial pairs nesting, nesting success and productivity were measured at ≥60 nesting ter-

ritories each year. Data were collected using two systematic aerial surveys each year. The first annual survey was conducted during incubation in late April and early May to document nesting territory occupancy and nesting attempts. A territory was defined as occupied if evidence of a territorial pair was observed during the first annual survey. A pair was considered to be nesting if incubating adults or eggs were observed in a nest during the first annual survey. The second annual survey was conducted in the late nestling stage in late July, when most nestlings had reached ≥80% of their fledging age, to document nesting success and productivity. Nesting success was defined as the percentage of territorial pairs that successfully raised ≥ one fledgling and productivity was defined as the number of fledglings raised per occupied nesting territory. Nesting territory occupancy remained relatively stable (range: 65–87%) among years; however, between 1989 and 1994, the percentage of territorial pairs nesting decreased from 88% to 33%. Over the same time period, nesting success decreased from 71–15% and productivity decreased from 1.22–0.17 fledged young per occupied nesting territory. Decreases in the percentage of pairs nesting, nesting success and productivity coincided with observed decreases in the number of snowshoe hare (*Lepus americanus*) and willow ptarmigan (*Lagopus lagopus*) in the study area among years from 1989–94. I suggest that food supply, particularly prior to laying, has a strong influence on whether golden eagles lay eggs. Furthermore, I suggest that food supply after laying influences nesting success and productivity.

OPPORTUNISTIC RESPONSE BY CAPTIVE NORTHERN HAWK-OWLS (*SURNIA ULULA*) TO OVERHEAD CORRIDOR ROUTES TO OTHER ENCLOSURES, FOR PURPOSES OF SOCIAL ENCOUNTERS

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The Owl Foundation is a behavioral observation center, affording permanently damaged, wild, native owls the opportunity to make choices of territories and potential mates within extended cage complexes. Many observations are through video monitoring devices. Of 54 compounds covering 1.6 ha, seven, on 0.2 ha of forested slope, are designated for the northern hawk owl (*Surnia ulula*), a species seldom studied in North America. Some 15 yr of continuous observation suggest that this nomadic species quickly exploits any new opportunity for investigation. Ten individuals, evenly divided by sex, inhabit these seven enclosures totalling 1160 m², with six connecting overhead corridors from 1.5–6 m in length. Gates in corridors are opened by March, allowing travel by all residents to any part of the seven-cage complex. Both sexes seize this opportunity to explore vocally advertised assets, although females more regularly return to familiar territories, often followed by males. Others may solicit males from 'home'

base. Breeding occurs each year with equal success in either male or female 'owned' enclosures. An alternate corridor route, opened each September, allows flighted young to vacate parental territories and travel to a more remote overwintering enclosure (with live prey predation and early spring release). Parents do not follow their young. Finally, most corridors are closed again by November when the adults have established winter routines. By this time there is no evidence for recognition of partners of the previous spring.

TRACKING THE MIGRATIONS OF 30 RAPTORS BY SATELLITE

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During the period July 1992 to July 1994 we fitted 30 eagles (10 *Aquila nipalensis*, 10 *A. pomarina*, three *A. clanga*, four *A. heliaca*, one *A. wahlbergi*, one *Haliaeetus albicilla* and one *H. pelagicus*) with satellite transmitters (PTTs) of different sizes (28–95 g). All steppe eagles were caught in Saudi Arabia in October except one immature which was caught in March. All young and most adult steppe eagles migrated into Africa via Bab el Mandeb. From there they dispersed in various directions. One adult and one immature bird turned north and wintered in Ethiopia, Sudan and Chad. One adult female was tracked for over 15 000 km all the way from Saudi Arabia to southern Africa and back to its breeding grounds in Kazakhstan via Suez and Eilat. It stayed in its wintering grounds from 22 November until 29 January, spending most of the time in Botswana. The spring migration lasted from 1 February until 24 March. An adult greater spotted eagle wintered in southwestern Saudi Arabia from 29 October until 24 November, afterwards in northern Yemen east of Saana. It departed on 2 February and arrived in its breeding grounds in western Siberia northwest of Omsk on 21 April. A young lesser spotted eagle from Latvia took one month to arrive in the largest African wetland area, the Sudd in Sudan (ca. 6000 km from the breeding area), where it remained for over 6 wk. It then went into the Serengeti NP and Masai Mara Reserve on the border of Tanzania and Kenya. A new generation of solar-powered transmitters has become available in 1993 which gives some hope that the movements of at least large species could be studied in greater detail and for longer periods in the future. Such a transmitter has been fitted to a juvenile sea eagle in Germany. During the first year of its life 877 satellite locations were obtained, each location corresponding to a customarily obtained "recovery" of a ringed bird. Many of the PTTs are still presently active.

NEST SITE MACROHABITAT SELECTION BY WOODLAND HAWKS ON A MANAGED FOREST IN THE GEORGIA PIEDMONT

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In the southeastern United States, major emphasis in forest management is directed toward increased timber production. If wildlife management and increased timber production are to coexist, relationships between wildlife habitat preferences and silvicultural practices must be better understood. Previous research on woodland hawks determined that nest site selection occurs at a microhabitat level. However, it is difficult for a land manager to select for habitat characteristics on a small scale. It is more practical to design management schemes that aim for critical macrohabitat types. In 1994, 12 red-shouldered hawk (*Buteo lineatus*) and 10 red-tailed hawk (*B. jamaicensis*) nests were located on a 5000-ha wildlife management area in the Georgia Piedmont. Nest site macrohabitat preferences were examined using a geographic information system (GIS). Hardwood habitat was separated into upland and bottomland macrohabitat types, and pine habitat was separated by age and structural characteristics into six macrohabitat types. Using the GIS, three concentric circles of increasing size were created around each nest. Macrohabitat percentages within each concentric circle were compared to total percentages available on the study area. Circle macrohabitats that occurred in higher proportions than expected based on total availability were considered critical.

BREEDING BIOLOGY AND NEST SUCCESS OF FLORIDA'S CRESTED CARACARAS

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Breeding chronology, nest success, and productivity of the crested caracara (*Caracara plancus*) in southcentral Florida were examined for 28 nests during the 1993–94 breeding season. Reproductive activity was documented from October through June; peaks of the incubation, nestling, and fledging periods occurred in January, February, and early April respectively. Nests were monitored weekly to determine clutch size, laying, hatching, and fledging dates. I estimated weekly Mayfield and traditional nest success and survival probabilities for the incubation, nestling, and fledgling dependency (8 wk postfledging) periods for each nest. Total Mayfield probability of success for each period was 0.74, 1.00, and 0.90 respectively and for all three periods combined for 28 nests was 0.66. Twenty-five nests successfully fledged young (89%), two failed during incubation, and one failed just after fledging. Most nests produced two fledglings (53%). At five nests (18%), three fledglings were successfully raised to the end of the fledgling dependency period. Productivity for all nests was 1.6. Survival probabilities were also estimated for each egg for all three periods. We documented three cases of double brooding; in all cases the fledglings from the first nest

effort remained in the territory well into the nestling period of the second brood and continued to be fed by the parents. Despite apparent high nest success, continued observation of marked birds suggests much lower recruitment. After the fledgling dependency period, juvenile mortality greatly increases, primarily due to collisions with vehicles.

METABOLIC BASIS FOR GLUCOSE INTOLERANCE IN RAPTORS

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Anecdotal reports have suggested that raptors are relatively intolerant to glucose and in some cases have died after receiving glucose i.v. or subcutaneously. It was of interest to find the mechanisms responsible for their intolerance and to access their adaptability to a diet containing glucose. Nonreleasable barn owls (*Tyto alba*) and white leghorn chicks (*Gallus domesticus*) (6 wk) were fed a LPHG (33.44 Protein: 23.67 CHO: 29.96 Fat: 12.93 Ash) diet and HPLG (55.35 Protein: 1.5 CHO: 29.98 Fat: 13.17 Ash) diet for 8 d. Birds were subjected to a glucose tolerance test (1 g glucose/kg of body weight, i.v.) and hepatic glucose metabolism was examined. LPHG diet significantly ($P = 0.005$) decreased baseline glucose levels in both species yet did not alter the shape of the glucose tolerance curve. Chickens, regardless of diet, reached a peak of 400 mg glucose/dL and took 1 hr to return to baseline while owls peaked at 700 mg glucose/dL and took 3.5 hr to return to baseline. These species differences were significant at $P = 0.0001$. Malic enzyme (ME) increased and alanine aminotransferase (ALT) decreased significantly with LPHG feeding in the chicken but only ALT significantly decreased in the owl. All enzymes measured significantly differed across species with large differences ($P = 0.0001$) in glucokinase (GK), ME (five and three times higher, respectively, in chickens), and phosphoenolpyruvate carboxykinase (PEPCK; three times higher in owls). In vitro experiments revealed that chicken hepatocytes partitioned five times more lactate to glucose as compared to owl hepatocytes, yet owls partitioned three times more threonine to glucose than chickens. It appears from these studies that the owl may be intolerant to glucose because of low enzyme adaptability, low GK activity, and a failure to suppress gluconeogenesis in presence of exogenous glucose. Due to these results it is recommended that injured raptors in need of glucose be given small doses of glucose over time.

SEX ALLOCATION IN THE AMERICAN KESTREL: IS IT RELATED TO THE PHENOTYPE OF THE PARENTS?

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In the case of the American kestrel (*Falco sparverius*), Wiebe and Bortolotti (1992, *Behav. Ecol. Sociobiol.* 30:379–386) reported that small females produced more sons. This could be an adaptive mechanism given that males are smaller and possibly less costly to rear. To determine whether kestrel sex-ratios can be manipulated we conducted an experiment on captive American kestrels maintained at McGill University in 1994. All 300 birds in the colony were weighed and measured (wing chord). The smallest 20 males were paired to the smallest 20 females. Conversely, the largest 20 males were paired to the largest 20 females. Small parents reared 16 broods, 10 (63%) of which were male-biased. Sex ratio was 55% males ($N = 56$). Large parents reared 14 broods, eight (57%) of them male-biased. Sex ratio was 52% males ($N = 44$). Differences between the two groups were not statistically significant.

ECOLOGY OF BALD EAGLES WINTERING AND BREEDING NEAR CABALLO RESERVOIR, NEW MEXICO

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The bald eagle (*Haliaeetus leucocephalus*) was listed as an endangered species in the United States in 1978. Intensive state and federal efforts to protect habitat and nest sites have contributed to downlisting in 1994 from endangered to threatened for all but the southwestern population. The number of bald eagles wintering in New Mexico has increased from 175 recorded in 1984 to 478 in 1994; however, there are only two known active nests in New Mexico. This project was initiated to determine if reservoir pool size affects bald eagles wintering and breeding near Caballo Reservoir, New Mexico. Bald eagles wintering on the reservoir were censused by boat or truck from December 1992 through March 1993, and December 1993 through March 1994. Concomitantly, aerial census surveys were performed throughout the middle Rio Grande valley. Behavioral observations were recorded during both winter periods; foraging behavior, perch use, and food habits documentation were the major areas of emphasis. Caballo Reservoir was sampled every three weeks during winter months to determine fish (prey) availability. Optimal foraging experiments were conducted on wintering eagles during 1993 and 1994. The pair of breeding bald eagles that nest near Caballo Reservoir were observed in 1993 and 1994. Two eaglets successfully fledged during the 1993 breeding season, while one eaglet fledged in 1994 (the other egg failed to hatch). Nest observations indicated fish, predominantly gizzard shad (*Dorosoma cepedianum*), were the most common prey item delivered to the nest

Data will be compiled, analyzed, and utilized in the construction of a diurnal time budget and an energetics simulation model.

SALT RIVER PROJECT'S AVIAN PROTECTION PROGRAM

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Salt River Project (SRP), an electric and water utility, has had an Avian Protection Program in continual development since the 1980s. The Avian Protection Program is aimed at protecting birds from harmful contact with electrical distribution facilities. Although the program strives to protect all migratory birds, an emphasis is placed on raptors because of their larger wingspan. The most common raptor species to interact with power facilities in the Phoenix, Arizona, area include the Harris' hawk (*Parabuteo unicinctus*), red-tailed hawk (*Buteo jamaicensis*), and great horned owl (*Bubo virginianus*). SRP protects birds from the electric system in a number of ways. For all new construction, bird protection measures include insulating "jumper" wires, capping transformer bushings and coating transformers with nonconductive paint. Other system revisions include installation of perches and visual deterrents, or changes in equipment configuration. The program also includes partnerships with Arizona Game and Fish Department and Liberty Wildlife Rehabilitation Foundation. Compliance with the Migratory Bird Treaty Act is ensured through permits obtained from U.S. Fish and Wildlife Service. SRP has been tracking bird mortalities and collecting data including species and location for several years. This information is now being interfaced with a GIS system of the distribution system. The graphic interface enables SRP to identify problem areas and prioritize where upgrades of older systems are needed. This proactive approach allows SRP to complete system corrections before additional electrocutions can occur.

DISPERSAL AND HABITAT SELECTION OF RELEASED APLOMADO FALCONS

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Aplomado falcons (*Falco femoralis*) were last recorded in the United States in the 1950s. A priority of the recovery plan is to reintroduce this endangered species in suitable habitats in the United States. As a result of a joint venture between The Peregrine Fund and the U.S. Fish and Wildlife Service, 26 young-of-the-year aplomado falcons were released into the wild in 1993 and 12 during 1994. These falcons were released at Laguna Atascosa National Wildlife Refuge, an 18 000-ha coastal refuge approximately 32 km north of Brownsville, Texas. The young fledgling

falcons were recaptured after about 3 wk and tail-mounted radiotransmitters were attached. Ten aplomado falcons with operational transmitters were monitored for 6 mo in 1993. Only four mortalities were confirmed. Thus far, in late 1994, six aplomados are currently being monitored. Monitoring of released falcons is conducted for at least 6 mo or until the transmitter fails. In 1993 dispersal distances ranged from 2–16 km. Average daily movements between roost and forage sites averaged about 5 km. Preferred habitats appear to be coastal grasslands adjacent to marshy areas or saltflats containing scattered mesquite (*Prosopis glandulosa*) and yucca (*Yucca treculeana*). Dominant vegetation at forage sites is typically less than 60 cm tall with patches of bare ground.

FACTORS LIMITING A POPULATION OF TAWNY OWLS IN A CONIFEROUS FOREST IN NORTHERN BRITAIN

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The number of occupied tawny owl (*Strix aluco*) territories increased during 1981–91, while reproduction and turnover in the owl population varied greatly in response to a 3-yr cycle of field vole (*Microtus agrestis*) abundance. The increasing number of occupied owl territories resulted ultimately from an improvement in the carrying capacity of the forest for tawny owls, although the increase in owls lagged behind the habitat improvements. To facilitate this increase, the resident territorial owl population received more recruits than was necessary to replace losses, and recruitment was the proximate factor most closely associated with year-to-year changes in the number of occupied territories. Recruitment was also influenced by the stage of the vole cycle. In years when vole numbers were increasing, virtually all birds in the nonterritorial sector were recruited. In years when vole numbers were declining or low, only some of the nonterritorial owls were recruited and most deferred recruitment until vole numbers increased.

WINTERING ECOLOGY OF PRAIRIE FALCONS IN THE SNAKE RIVER BIRDS OF PREY NATIONAL CONSERVATION AREA

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We determined differences in winter home ranges and observed hunting attempts of nine male and six female prairie falcons (*Falco mexicanus*) trapped in the Snake River Birds of Prey National Conservation Area (SRBOPNCA) in Idaho, between November and March, 1993. Winter home ranges of females were not larger than males. Successful capture attempts suggest prairie falcons prey mainly on horned larks (*Eremophila alpestris*) (seven

of nine successful attempts). There appears to be two groups of falcons wintering in the SRBOPNCA; those that bred there the previous summer and those that migrated into the SRBOPNCA. The sex ratio of the nine breeders that remained was significantly biased toward males (nine males: one female; $\chi^2 = 4.01$, $P < 0.05$). However, the sex ratio of the 17 birds trapped during the winter (that likely migrated into the SRBOPNCA) was not significantly different from a 1:1 ratio (10 males: seven females; $\chi^2 = 1.41$, $P < 0.25$). We will discuss different migration strategies, methodology, climatology, and status of resource base as alternative explanations for the difference in sex ratios between the two groups of wintering prairie falcons.

RESPONSES OF GREAT HORNED OWLS (*BUBO VIRGINIANUS*) TO THE SNOWSHOE HARE CYCLE IN THE BOREAL FOREST

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Great horned owls (*Bubo virginianus*) were studied in the subarctic boreal forest in the southwestern Yukon from 1988-93. During the increase phase of the population cycle of snowshoe hares (*Lepus americanus*), almost all resident owl pairs bred and raised large broods. Survival of young owls in their first two years of life was high, and two females were observed to breed as yearlings. Densities of territorial owls almost doubled, but most juveniles became nonterritorial 'floaters,' presumably because social behavior was limiting the number of territories. Floaters were silent, their ranges overlapped with territories, and their density reached 40-50% of the total population. As snowshoe hares declined, the number of recruits dropped sharply. Postfledging mortality was high, and the role of predation and disease in interaction with food shortage are evaluated. Overall mortality and emigration increased earlier for floaters than for territorial birds as hare densities further declined. A behavioral mechanism for the time lag in the numerical response to the hare cycle is proposed, and constraints to increase reproduction at high prey densities are interpreted in the context of life history evolution.

GRASSLAND PASSERINES AS INDICATORS OF HABITAT USE BY NORTHERN HARRIERS IN RECLAIMED SURFACE MINES OF PENNSYLVANIA

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We documented the presence of grassland passerines associated with areas used by northern harriers (*Circus cyaneus*) in reclaimed grassland surface mines of Pennsylvania. Reclamation of surface mines in Pennsylvania has created suitable grassland habitat for nesting and foraging

harriers and other grassland avifauna. This research was part of a long-term research project that examines the status and the management of northern harriers in Pennsylvania. Our objective was to determine if grassland passerines can be used as indicators of suitable harrier habitat. We surveyed and compared communities of grassland passerines associated with sites frequently used by harriers (harrier observation sites) to three types of randomly selected sites that were infrequently or unused by harriers. Harrier observation sites and random sites were selected based on approximately 124.9 hr of surveying for harriers along 108 km of survey routes that transected reclaimed surface-mine habitat. Three of 10 grassland passerine species that commonly were associated with harrier observation and random sites significantly differed among site types. Bobolinks (*Dolichonyx oryzivorus*) ($P < 0.001$) and Henslow's sparrows (*Ammodramus henslowii*) ($P < 0.01$) were observed more frequently than expected at harrier observation sites, whereas chipping sparrows (*Spizella passerina*) were observed less frequently than expected ($P < 0.025$) at these sites. Results of this research are being used to develop management recommendations for harriers and grassland passerines using reclaimed surface mines.

NEST-SITE FIDELITY OF COOPER'S HAWKS IN WISCONSIN

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Long-term data on nest-site fidelity on Cooper's hawks (*Accipiter cooperii*) is unavailable. Captures of 154 separate individual breeding male Cooper's hawks at 102 nesting areas during 1980-94, plus 86 recaptures of 60 marked males at 45 nesting areas were used to examine nest-site fidelity in Wisconsin. All recaptured males were found on sites where originally trapped; no movement was detected. Detections of inter-year movements in breeding females and natal dispersal of both sexes, and other lines of evidence indicated that our sample sizes offered adequate opportunity to detect potential breeding dispersal in males. We suggest that breeding male Cooper's hawks in Wisconsin exhibit lifetime nest-site fidelity.

BREEDING BIOLOGY, DIET, AND HUNTING BEHAVIOR OF PLUMBEOUS KITES (*ICTINIA PLUMBEA*) IN TIKAL NATIONAL PARK, PETÉN, GUATEMALA

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We studied the breeding biology of the plumbeous kite (*Ictinia plumbea*) in Tikal National Park, Petén, Guate-

mala during 1992, 1993 and 1994. Seven of 12 nests failed during incubation, and of the five young that hatched, four survived to fledging age. All clutches documented were of a single egg. Incubation periods of 32 and 33 d were recorded for two nests. Nestling periods for the four successful nests were 36, 39, 39 and 40 d. Males and females shared tasks of incubation, and of delivering prey to the nest and feeding chicks. Insects made up 73–95% of the prey items delivered to the nest. Lizards, bats, birds, frogs and snakes were also recorded as prey items. Plumbeous kites hunted on the wing, while soaring over the canopy, and by making short flights or stoops from perches. Though most insects were plucked from the air, a smaller percentage of insects and other prey items were captured when the kites snatched them from the forest canopy. Spatio-temporal patterns of insect abundance have probably exerted a strong influence on the evolution of plumbeous kite breeding biology and behavior.

A PHYLOGENETIC ANALYSIS OF THE AVIAN FAMILY ACCIPITRIDAE BASED ON MOLECULAR DATA

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The avian family Accipitridae is a large, diverse family composed of approximately 230 species divided into 56 genera. The evolutionary relationships among accipitrid taxa have been examined previously using phenetic and parsimony approaches against a variety of data sets ranging from behavior to karyotypic. These studies have resulted in conflicting phylogenies, presumably due to the high level of homoplasy, perhaps, the result of morphological convergence on diet. We analyzed DNA sequence data from the mitochondrial encoded cytochrome-b gene using maximum parsimony, distance and maximum likelihood methods to explore the phylogenetic relationships among the major morphological lineages within Accipitridae. Additionally, an analysis of branch lengths between nodes was made under the assumptions cytochrome-b evolving in a clock-like fashion and with differing rates of evolution over time. The major findings in this study include support for the polyphyly of the kite genera and the sister group relationship of the osprey (*Pandion haliaetus*) with accipitrid taxa, and evidence for a number of periods of rapid morphological diversification.

DICHROMATISM IN THE GENUS *FALCO*: SEXUAL SELECTION VERSUS AN ADAPTIVE PEAK

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Approximately one-fifth of all species in the genus *Falco* exhibit marked sexual dichromatism. In the absence of substantial differences in diet or foraging behavior between the sexes, it is likely that dichromatism evolved in response to sexual selection (e.g., mate attraction) rather than to natural selection. Falcons exhibit considerable interspecific variability in diet and in the manner in which prey are captured, ranging from invertebrates and small mammals captured on the ground to birds captured in flight. A number of morphological characteristics, including tarsal length, toe length, overall body size, and the degree of sexual size dimorphism, have been suggested to be adaptive to the specialized foraging niche of aerial avivory. In this study, we examined the associations among dichromatism, foraging niche (bird specialist or not), body size (based on an analysis of log-transformed body mass and wing length), and body size dimorphism. The results support the view that large falcons tend to be monochromatic bird-eaters exhibiting a large degree of size dimorphism. However, in contrast to widespread perception, foraging niche was not significantly related to size dimorphism; for many bird specialists, the female is not much larger than the male. Because foraging specialists likely occupy a steeper adaptive peak, and therefore lack the evolutionary plasticity to withstand much sexual selection, we expected dichromatism to be significantly more common among foraging generalists. Indeed, the merlin (*F. columbarius*) is the only falcon species that is both dichromatic and a bird specialist.

RELATIONSHIPS BETWEEN HABITAT SELECTION AND PRODUCTIVITY OF RED-SHOULDERED HAWKS IN NEW JERSEY AND NEW YORK

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Thirty red-shouldered hawk (*Buteo lineatus*) nests were monitored for productivity and habitat structure was measured. Stepwise multiple regression (SMR) analysis was run for mean annual productivity versus habitat variables. A separate analysis was run for macrohabitat (landscape level), microhabitat (stand level), tree species composition, and nest tree parameters. The macrohabitat SMR indicated higher productivity was correlated with greater distance to human habitation (i.e., less forest fragmentation and disturbance) and at lower elevations (i.e., more wetlands). The microhabitat SMR indicated higher productivity with greater tree densities in the 40–50 and 70+ cm diameter classes and higher percent decadence, parameters associated with older growth stands. The tree species SMR indicated that nest stands with higher relative dominance

of yellow birch (*Betula papyrifera*) and northern red oak (*Quercus rubra*) were correlated with higher productivity, although overall, eastern hemlock (*Tsuga canadensis*) had the highest mean relative dominance. The nest tree SMR indicated that nest tree selection did not effect productivity.

PRESENT SOUTHERN BREEDING LIMITS OF THE BOREAL OWL IN NORTH AMERICA

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Existence of breeding boreal owls (*Aegolius funereus*) in North America south of Canada was unknown in the 1950s, but by 1989 residency of the species had been documented to the southern terminus of the Rocky Mountains in northern New Mexico. We conducted surveys using tape playback of the staccato song to consolidate distributional data in northern New Mexico (63 hr) and to search for the species in isolated mountain ranges in central and southwestern New Mexico (27 hr) and on the Colorado Plateau of Arizona (280 hr). Eleven additional records between November 1989 and August 1993, including two of fledged juveniles, firmly establish the boreal owl as a breeding bird in the Sangre de Cristo, San Juan, and Jemez Mountains of northern New Mexico. Response rates of boreal and northern saw-whet owls (*Aegolius acadicus*) in northern New Mexico were 0.15 and 0.08 owls/survey hour, respectively. In mountain ranges apparently not occupied by boreal owls, northern saw-whet owls responded at a rate of 0.11 owls/survey hour; their response rate was higher in New Mexico (0.44/survey hour in 27 hr) than Arizona (0.08/survey hour in 280 hr). This difference was most likely due to sample size and timing of surveys: summer-autumn in New Mexico, spring in Arizona. Potential habitat for boreal owls away from the Rocky Mountains was generally isolated, small patches that likely would not sustain minimum viable populations. We continue to believe that the boreal owl in the Rocky Mountains is a pleistocene relict, and the inhospitable nature of their high elevation spruce-fir (*Picea engelmannii*-*Abies* spp.) habitat during their most vocal period (February to April) hindered scientific knowledge. Paleontological, archeological, and late 18th- to early 19th-century autumnal sightings in the southern Rockies support this view, despite current efforts to suggest a more recent range expansion.

NEST BOX FIDELITY AND DISPERSAL DISTANCES OF AMERICAN KESTRELS IN SOUTHWEST IDAHO, 1993-94

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Few individuals marked as breeding adults in 1993 returned to breed in the same box in 1994. Of 37 females marked as breeders in 1993, only three returned to nest in the same box in 1994; two of 22 males reused their 1993 boxes. Four males marked in 1993 moved to different boxes within the study area, 0.4 to 4.6 km from their 1993 boxes. Despite banding nearly 600 nestling kestrels in our study area, we have encountered only six breeding kestrels (five females and one male) that were originally marked as nestlings in the study area. Females moved an average 9.9 km from their natal boxes to their breeding boxes (range: 8.3-10.8 km; SD = 1.03), and the male moved 7.6 km. We suspect that our low return rate and the low reuse of boxes is associated with high mortality, availability of alternative nesting substrates, or a combination of the two

RED-SHOULDERED HAWK REPRODUCTIVE SUCCESS WITHIN POOLS 9-11 OF THE UPPER MISSISSIPPI RIVER, 1983-94

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Between 1983 and 1994, we monitored 84 red-shouldered hawk (*Buteo lineatus*) nesting attempts at 15 territories within the McGregor District of the Upper Mississippi River National Wildlife and Fish Refuge (pools 9-11). Of the 60 attempts with known outcomes, 43 were successful (71.7%) and 17 were unsuccessful (28.3%). The 43 successful nesting attempts produced 91 red-shouldered hawk fledglings, for an average of 2.12 per successful nest and 1.52 per nesting attempt. Production varied during the study period. Between 1983 and 1989, 20 of 24 (83.3%) nesting attempts were successful; a total of 49 fledglings were produced for an average of 2.45 per successful nest and 2.04 per nesting attempt. However, between 1990 and 1994 production was considerably lower; of 36 known outcomes, 23 (63.8%) were successful and average number of fledglings dropped to 1.83 per successful nest and 1.17 per nesting attempt. Red-shouldered hawk reproduction was especially poor during the record floods of 1993. Flood waters covered shallow wetlands and other feeding areas as well as many of the nest sites causing fledglings to drown when they left the nest. Only four (36.4%) of eleven attempts were successful and the number of fledglings dropped to 1.24 per successful nesting attempt and 0.45 per nesting attempt. Also, during the following season, at least four confirmed nesting territories were abandoned, and we observed only one juvenile red-shouldered hawk. Consequently, we suspect that replacement rates within the study area may not be satisfactory.

ECOLOGY OF THE CRANE HAWK IN TIKAL NATIONAL PARK, PETÉN, GUATEMALA

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The breeding ecology of the crane hawk (*Geranospiza caerulescens*) was studied from 19 February to 15 July 1994 in Tikal National Park, located in the northern department of the Petén, Guatemala. This research is part of a comprehensive study of raptors being conducted by The Peregrine Fund, Inc.'s Maya Project in Guatemala, Mexico, and Belize. Areas of crane hawk activity were located from observation points in canopy-emergent trees, via foot searches, and by vocalizations. Breeding and nonbreeding crane hawks were monitored to estimate density within the park. Measurements of nesting habitat were collected for both active and historic nest sites. In 1994, five active nests were located and studied in the park. Growth and development of six nestlings were measured. Rodents (Heteromyidae and Muridae) comprised 56.3% of 87 identified prey items in the diet while frogs, lizards, birds, bats, and snakes made up the remainder. Adult crane hawks were fitted with radiotransmitters to estimate home ranges, movements after breeding and habitat use. To study post-fledging dependency and dispersal, one male fledgling was fitted with a radiotransmitter. Preliminary conclusions of the first year of a 2-yr study indicate that certain nesting habitat components, as well as intra- and interspecific interactions are important factors influencing nesting success and productivity.

DNA FINGERPRINTING REVEALS SUCCESSFUL POLYGYNY IN THE LESSER KESTREL (*FALCO NAUMANNI*)

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Raptorial species are predominantly monogamous. Although a few species seem to practice alternative mating systems, no paternity analyses have been published so far to confirm polygamy in any bird of prey. Using DNA fingerprinting we examined parentage in 28 nests of lesser kestrels (*Falco naumanni*) from northern Spain and confirmed the first case of successful polygyny in the species. In one of the nests, two females and one male were observed several times. DNA fingerprinting revealed that the first of the four nestlings reared at the nest was from the earliest arriving female, while the remaining three were from the second female. The attending male was the father of all four nestlings. Our results indicate variability from strict

monogamy in this falcon and emphasize the importance of behavioral observations and genetic markers to study breeding success of raptors.

THE FERTILIZATION WINDOW OF THE AMERICAN KESTREL (*FALCO SPARVERIUS*): CHARACTERIZATION AND CONSEQUENCES

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Raptors are believed to increase their frequency of copulation during the fertilization window, a period between ovulation and eggshell formation when the ovum is fertilized. This time interval has not been characterized for any raptor species, although its definition in the reproductive process and for sperm competition theory is critical. We observed the daily laying patterns of 41 pairs of American kestrels in captivity recording time, date and consistency of laying as well as the effect of weather patterns and egg pulling. Of 156 ovipositions we observed, 48% were laid in the morning (0730–1130 H). Variation between pairs in starting dates and consistency of egg laying did not correlate significantly to bird age or weather. Egg pulling on 20 focal pairs had no significant effects. Our results indicate a wider fertilization window than previously suggested, which better explains the highly variable daily copulation frequency of this falcon.

GROWTH, DEVELOPMENT AND EXPERIMENTAL MANAGEMENT OF THE MADAGASCAR FISH-EAGLE (*HALIAEETUS VOCIFEROIDES*)

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Increasing population size and distribution in suitable unoccupied habitat is one of several management options that would help prevent extinction of the Madagascar fish-eagle, one of the rarest raptors in the world. Breeding studies in 1991 and 1992 showed that this species exhibits obligate siblicide. In 1993 we tested "Abel rescue" as a low-cost *in situ* method for increasing annual production in Madagascar fish-eagles. Of three nests tested, two fledged two young using an abbreviated captive rearing period in which removed siblings were reintroduced to the nest as soon as they could defend themselves from siblings and compete for food. Measurements of growth, and description of behavioral development of chicks in captivity and in the nest for a period close to fledging, provided a method to estimate age of chicks in the nest as well as a better understanding of siblicide in this species.

POSTER PRESENTATIONS

STATUS OF RAPTORS IN ARGENTINA

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A total of 78 species of raptors occur in Argentina (vultures: five species; eagles, hawks, and kites: 40 species; falcons and caracaras: 15 species; owls: 17 species; and the osprey). Habitat deterioration, however, is limiting the distribution of several species, some of which are already restricted to protected areas. Approximately 73% of Argentinean raptors have been classified as scarce, uncommon, or hypothetically present in the country. In the Red Data Books of 1990-92, the status of eight raptors were classified as rare, undetermined or insufficiently known in Argentina. Of the 40 raptor species known to inhabit the wet forest of northern Argentina, 25 of them were classified as scarce or uncommon, presumably due to deforestation and hunting of prey. An apparent recovery of raptors in northern Patagonia during the 1980s seems related to decreasing human persecution. During the 1990s, Argentina has quickly begun to develop an increasing awareness of wildlife conservation through education.

A NEW MODEL FOR DISPERSAL IN SCREECH-OWLS: CORTICOSTERONE, BODY CONDITION, AND BEHAVIOR

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In virtually all birds and mammals, juveniles of one or both sexes leave their natal area before breeding. In screech-owls (*Otus asio* and *O. kennicottii*), both sexes of young disperse, but there is variation in the timing of dispersal within and among broods. We developed a model that explains dispersal in screech-owls and similar nonmigratory species where young birds obtain and defend territories following dispersal. The model is based on interactions among body condition, hormones, and social stimuli. We hypothesize that corticosterone secretion increases just prior to dispersal, through a combination of endogenous and external events. Rising plasma corticosterone may stimulate increased movement, but the precise effect on dispersal timing depends on the body condition of the bird. Juveniles with sufficient body condition and fat reserves will disperse when corticosterone rises. Birds in poor body condition or with poor reserves will not, but they will increase foraging activity until they obtain the necessary body condition to disperse. We will review results of preliminary field and laboratory studies that examine predictions of the model, and we will discuss future directions of the work.

A SIMPLE AND EFFECTIVE BURROWING OWL (*SPEOTYTO CUNICULARIA*) TRAP

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A new trap designed to safely live-trap burrowing owls (*Speotyto cunicularia*) in the most inaccessible burrows was developed and tested on the campus of New Mexico State University in Las Cruces, New Mexico. The trap consists of a 61 cm piece of 10.16 cm diameter PVC pipe in which two (or one depending on the application) plexiglas one-way doors are installed. A hinged door is installed in the tube in order to remove captured owls safely and easily. The trap is inserted into the burrow and the space between the tunnel and the trap filled with mesh screen. This trap possesses the following advantages over other burrowing owl traps: it is easy to transport from burrow to burrow, it is easy to install even in difficult to reach burrows, and it is completely safe (no owl has ever been injured using this trap). This trap has been used to capture both adults and nestlings in southern New Mexico.

HABITAT SELECTION AND REPRODUCTIVE BIOLOGY OF LOGGERHEAD SHRIKES IN EASTERN CANADA

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The status and distribution of endangered loggerhead shrikes (*Lanius ludovicianus*) in southern Ontario and Quebec was studied during the 1991 and 1992 breeding seasons. Shrikes returned from wintering areas in April and egg-laying commenced from the end of April to early May. The population of loggerhead shrikes in eastern Ontario was roughly 50 pairs over three core areas, each associated with a limestone plain. Only one breeding pair was located in Quebec in 1991 and two in 1992. Shrikes nested in hawthorn (*Crataegus* spp.), red cedar (*Juniperus virginiana*) and other species, most often in actively grazed pastures. Suitable historic nesting sites were reoccupied and there was a high rate of reoccupancy of 1991 sites in 1992. Breeding territory selection was affected by the amount of habitat fragmentation around a site, but nest site selection appeared to be random within a suitable territory. Shrikes nesting in Ontario had a high rate of reproductive success (50-93%); however, only half of the eggs produced young that survived the 3-4 wk postfledging to become independent (2.30 of 4.91 in 1991 and 2.50 of 5.56 in 1992). Shrikes were found to renest several times and double brooding was observed.

BREEDING BIOLOGY OF THE ZONE-TAILED HAWK AT THE LIMIT OF ITS DISTRIBUTION.

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Twelve zone-tailed hawk (*Buteo albonotatus*) nest sites in eight territories were studied in northcentral New Mexico during 1990–92 to determine the nesting chronology, nesting habitat, diet and productivity of a population that is at the limit of the species' distribution. Zone-tailed hawks arrived on the study area from late March to early April and their breeding season ended in mid–late September when the family unit left the nesting territory. All nest stands were in ponderosa pine (*Pinus ponderosa*) forests located in steep canyon bottoms or slopes and frequently in close proximity to cliffs. Stand basal area averaged 23.8 m²/ha and % canopy closure averaged 69.2% ($N = 10$). Nest trees were large, averaging 23.8 m in height and 59.8 cm dbh ($N = 8$). The diet consisted of a mixture of mammalian, avian and reptilian prey species that are common in the study area. During 1990 and 1991 only one of six known territories successfully fledged two and one young, respectively. During 1992 two new territories were located and these were the only successful nests (fledged one and two young). We suggest that the low productivity we observed during the 3 yr of the study is representative of the population productivity and is not an anomaly due to small sample sizes. We suggest that this pattern is typical of populations at range margins and occurs because (1) the birds are nesting in marginal habitat, and/or (2) the population was founded by a few individuals with philopatric young and is exhibiting inbreeding depression.

COMMUNAL ROOSTS: SEASONAL DYNAMICS OF A WHITE-TAILED KITE POPULATION IN THE SACRAMENTO VALLEY, CALIFORNIA

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We studied 10 communal roosts of white-tailed kites (*Elanus leucurus*) in a 900 km² area of the Sacramento Valley, California. The objectives were to examine the annual temporal dynamics of roost use and roosting behaviors and to analyze habitat characteristics of roosts using AtlasTM, a geographic information system. In June 1993 first year birds began arriving at roosts with adult escorts. Roosts were observed 4–7 nights/wk. Three roosts were in suburban habitat, four were in deciduous orchards, and three were in natural vegetation. Kites aggregated into two to three large roosts in the fall and winter ($N = 30–95$) and gradually dispersed into more numerous, less populous roosts (10 with $N = 10$ at each) in the breeding season. In the winter kites came from <1–50 km away. Telemetry on five kites aided in tracking inter-roost shifts. Kites are

very loyal to roosts despite frequent human disturbances. Behaviors associated with roosting changed dramatically with season. Roosts were evenly spaced in winter (2.5 km apart) but in spring became centered near nests. Bird species which roosted with kites include northern harriers (*Circus cyaneus*), herons and egrets (Ardeidae spp.), and American crows (*Corvus brachyrhynchos*). Pre-roost staging, soaring, ground perching, and hunting were behaviors associated with fall and winter roosts. Eruptions in which groups of kites ($N = 5–50$) departed abruptly in the same direction, occurred only in December and January. Based on telemetry and banding data, there are sexual shifts in roost attendance. Communal roosting is postulated to have distinct social contexts for individuals, sexes, and families at different times of the year.

A SUMMARY OF THE FIRST FIVE YEARS OF RAPTOR MIGRATION COUNTS AT DINOSAUR RIDGE, COLORADO

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We have counted migrating raptors at Dinosaur Ridge located 19 km west of downtown Denver, Colorado, each spring since 1990. Dinosaur Ridge is staffed jointly by the Denver Museum of Natural History and The Colorado Bird Observatory and is one of only two spring migration count sites currently operated in the southwestern US. As many as 18 raptor species totaling 5443 individuals have been identified at the site in a single season. The most frequently observed species are the red-tailed hawk (*Buteo jamaicensis*), and American kestrel (*Falco sparverius*), but moderate numbers of bald eagles (*Haliaeetus leucocephalus*), golden eagles (*Aquila chrysaetos*) and ferruginous hawks (*Buteo regalis*) are also recorded. The consistent productivity of Dinosaur Ridge, together with its proximity to a large metropolitan area, provide great opportunities for research, monitoring and environmental education.

WHEN JUVENILES LOOK LIKE ADULTS—GRAY COOPER'S HAWKS IN THE SAN FRANCISCO BAY AREA

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In the 1993 breeding season, an unusually pale gray-breasted adult male Cooper's hawk (*Accipiter cooperii*) was discovered nesting in an urban park in Alameda County, California. The 1994 nesting was monitored closely as the pale gray male mated with a normally plumaged female. Three of four resulting young had gray backs and breast-

streaking in lieu of the normal brown. Across San Francisco Bay, during fall migration trapping in 1993 in the Marin Headlands, two of approximately 500 immature Cooper's hawks banded were of the gray aberrant plumage. Photographs of all of these hawks will be shown. We have found no previous reference to gray Cooper's hawks in the literature.

RED-TAILED HAWK AND GREAT HORNED OWL: ARE THEY DIURNAL/NOCTURNAL COUNTERPARTS?

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Red-tailed hawks (*Buteo jamaicensis*) and great horned owls (*Bubo virginianus*) have been portrayed as ecological equivalents, eating the same prey by day and night. Similar in size (red-tailed hawk mean mass = 1126 g, great horned owl mean mass = 1354 g), both raptors are relatively common in North America and occupy a wide range of habitats, often sympatrically. We compared trophic characteristics in 13 sets of published data from across the United States to test the ecological similarity of the two species. Mean prey weight of red-tailed hawks was significantly greater than that of great horned owls. Both species ate primarily birds and mammals and mean proportions of the two prey types were not significantly different between paired diets of the two raptors. Red-tailed hawks ate significantly more reptiles, and great horned owls ate significantly more invertebrates. At the prey class level, dietary diversity was not significantly different, and diet overlap between the two species averaged 91%. At the species level, dietary overlap averaged only 50%, and red-tailed hawk dietary diversity was significantly greater than that of great horned owls. Populations in the western U.S. differed trophically much more than did eastern populations. We conclude that, although the two species are generalist predators, they take largely different prey species in the same localities resulting in distinctive trophic characteristics.

THE U.S. FISH & WILDLIFE SERVICE'S PROPOSAL TO RECLASSIFY THE BALD EAGLE IN MOST OF THE LOWER 48 STATES

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The bald eagle (*Haliaeetus leucocephalus*) is listed as endangered under the Endangered Species Act of 1973 (Act) in the lower 48 states, except Washington, Oregon, Minnesota, Wisconsin, and Michigan, where it is listed as threatened. The bald eagle also occurs in Alaska and Canada, where it is not at risk and is not protected under the Act; and in small numbers in northern Mexico. The Fish and Wildlife Service proposes to reclassify the bald eagle from endangered to threatened in the lower 48 states except

the southwestern population in Arizona, New Mexico, the southeast corner of California within 10 miles of the Colorado River or the river's mainstem reservoirs, and those portions of Texas and Oklahoma that are west of the 100th meridian. The bald eagle would remain threatened in the five states where it is currently listed as threatened and be listed as endangered in Mexico under this proposal. In 1963, a National Audubon Society survey reported only 417 active nests in the lower 48 states with an average of 0.59 young per nest. In 1993, the number of occupied territories exceeded 4000 with an estimated young per nest approaching one. This significant rebound is attributable to the banning of DDT in 1972 and the protection provided by the Endangered Species Act. Significant threats remain but with strong public support, population numbers should continue to improve. National and regional bald eagle population trends are presented.

PRELIMINARY REPORT ON HISTORICAL FALCO PEREGRINUS NEST SITE DISTRIBUTION IN JAPAN

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The distribution and characteristics of historically active peregrine falcon (*Falco peregrinus*) nest sites in Japan were compiled from published and unpublished reports, personal contacts and questionnaires distributed to 120 raptor enthusiasts in 1993. Around the four main islands of Japan, 191 nest sites were identified, 80 of which were on the northern island, Hokkaido. Excluding Hokkaido, the highest numbers were found on the Japan Sea coast, in Fukui (nine), Niigata (10), and Aomori (13) Prefectures. A high concentration was also identified on the coasts of Iwate and Miyagi Prefectures (possibly 41). Only eight inland and three artificial structure sites were recorded, the remaining were on coastal cliffs or islands. The average height of inland nests sites ($N = 5$) was 83.5 m (range 18–150 m), and that of coastal and island sites ($N = 22$) was 43.5 m (range 10–110 m). Conservation of these sites demands their protection from disturbance of nearby construction, amateur photographers and fishermen, and juvenile predation by jungle crows (*Corvus macrorhynchos*).

SELECTIVE CAPTURE METHODS FOR CRESTED CARACARAS

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During an ongoing study of the reproductive ecology and habitat use of the crested caracara (*Caracara plancus*) in southcentral Florida, 10 adults and 16 subadults were captured using two methods. Walk-in cage traps proved successful though not reliable for subadult caracaras. Groups of this age class tend to congregate at a large food

source and with sufficient pre-baiting of the site and a period during which the trap is left open so they can enter and exit freely, up to five individuals were caught at one time. Vultures, however, pose a great interference problem when attempting to capture caracaras at large baits. Adult caracaras are extremely wary and will not approach any trap, despite camouflage or abundant bait. Typically used noose traps are completely avoided. Experimentation with a taxidermic mount of an adult caracara indicated that these birds are very territorial and do not tolerate intruders near the nest. Subsequently, successful capture of adults was accomplished only in the nesting territory, using a large bow-type net (Q-net) and a tethered live caracara. Success rate with this method was 44% and improved over time as we refined our technique. All juvenile caracaras were marked while still in the nest, between 7 and 8 wk of age, because after fledging, they quickly seem to learn from their parents to avoid traps.

MOLT IN TAWNY OWLS IN RELATION TO BREEDING PERFORMANCE AND FIELD VOLE ABUNDANCE

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The number of flight feathers molted annually in tawny owls (*Strix aluco*) was investigated by dyeing feathers of captured owls and reexamining the same birds in the following year. Owls were caught during the nestling period before molt started. There was considerable annual variation in the number of primary and secondary feathers molted related to breeding success, which in turn was related to a 3-yr cycle of abundance of field voles (*Microtus agrestis*), the owls' main food. Owls molted most wing feathers in years of low vole abundance when most pairs did not breed, and fewest in years with high vole numbers when most pairs bred. Tail feather molt was not related to breeding success or to any other factor investigated, with most birds replacing all tail feathers biennially. Reasons for the evolution of this complex molt are discussed. An almost identical molt sequence occurs in the larger Ural owl (*Strix uralensis*) in Finland, and it would be valuable to undertake similar studies on wild barred (*Strix varia*) and spotted owls (*Strix occidentalis*) in North America.

RELATIONSHIP OF WATER LEVEL TO BALD EAGLE REPRODUCTION AT SHASTA RESERVOIR, CALIFORNIA

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Stable bald eagle (*Haliaeetus leucocephalus*) populations produce 0.7–1.2 young per occupied site and the Pacific Bald Eagle Recovery Plan states that the goal for reproductive rates for recovery is one eagle chick for each occupied nest site or 50% of the maximum reproductive

potential for eagles. Data on the number of occupied bald eagle nests and the number of young produced from these nests has been collected at Shasta Reservoir since 1977. Relationships between water levels at Shasta Reservoir and the number of young eagles produced at each site were determined through regression analyses; these relationships are based on the measured water levels at the reservoirs (USGS, 1979 through 1991), and data on bald eagle reproduction. At Shasta Reservoir, analyses indicated a general increase in eagle reproduction as water level increased. A variety of factors probably contribute to reduced reproductive success in bald eagles. Many of these factors may depend either directly or indirectly on lake water level. Water level affects such factors as surface area of the lake, fish availability, and competition for eagle nesting and foraging areas. About 50% of the variability in bald eagle reproductive success was accounted for by a linear correlation with the average (April through September) Shasta Lake water elevation. This percentage of explainable variability suggests a strong relationship between lake water level and eagle reproductive success. The model created predicts that average lake elevations over 311 meters meet the USFWS recovery goal of one bald eagle chick per occupied nest and average levels below 308 m predicts eagle reproduction below the recovery goal.

ENVIRONMENTAL COMPONENTS OF DIFFERENCES IN OSPREY GROWTH

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There is significant geographic variation in growth rate and asymptotic size between osprey (*Pandion haliaetus*) nesting in arid Sonora, Mexico and temperate Nova Scotia, Canada. This poster presents gradients in environmental variables including, at least, (a) migratory versus sedentary habits, (b) synchronous versus asynchronous breeding, (c) time-limited breeding seasons, and (d) climatic factors as important possible causes to account for the growth and size differences observed between the two populations.

MIGRATION ROUTES AND WINTER RANGES OF GOLDEN EAGLES

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Effective conservation of avian breeding populations can involve a very large area (breeding grounds, wintering grounds, and migration routes). Golden eagles (*Aquila chrysaetos*) that nest in Alaska are difficult to follow on

wintering grounds in southwestern Idaho, because their ranges can be large and include mountainous terrain and roadless areas. We used radiotelemetry to locate and describe golden eagle wintering areas. We radio-tagged 11 golden eagles on their wintering grounds in southwestern Idaho with conventional and satellite received transmitters during 1993-94. Movements were monitored one to two times per week visually and daily by satellite. Adult golden eagles showed fidelity to wintering areas, but did not defend them from other eagles. Adults were more consistently tracked by conventional telemetry than were subadults. Wintering areas of subadult eagles were larger than those of adults. Wintering ranges derived from satellite locations were larger than those derived from visual locations. Non-resident adults spent the breeding season in Alaska and western Canada while subadults stayed in the northwestern United States. Travel times for migration of adults to presumed breeding grounds varied from 6-27 da.

BAND RECOVERIES OF DIURNAL RAPTORS BANNED IN THE MARIN HEADLANDS, MARIN COUNTY, CALIFORNIA

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Since 1983, 15 species of diurnal raptors have been banded in the Marin Headlands, Marin County, California. These birds are trapped at blinds in the Headlands from August through December by volunteers of the Golden Gate Raptor Observatory. To date, we have banded 6523 diurnal raptors, and have had 162 band recoveries of eight species. We have had 141 band recoveries from California, with the remainder from Oregon, Washington, Idaho, and Baja California and Sonora, Mexico. Of the 15 species, we have banded red-tailed hawks (*Buteo jamaicensis*), Cooper's hawks (*Accipiter cooperii*), and sharp-shinned hawks (*A. striatus*) in the greatest numbers. For 2631 red-tailed hawks banded, 83 band recoveries have been reported, with a 3.2% recovery rate. We have mapped the band recoveries by age of bird and by season of recovery to make seasonal comparisons of the data. For example, autumn band recoveries for juvenile red-tailed hawks extend 190 km inland from the Pacific Coast, and occur from central to northern California. Autumn band recoveries for adult red-tailed hawks are found in a larger area, extending 350 km inland, and extending from southern California to central Washington. Winter band recoveries for juvenile and adult red-tailed hawks occur predominately within 80 km of the Pacific Coast, representing a smaller area than autumn recoveries. These results suggest that there are some differences in geographic areas used in autumn and winter by the juvenile and adult red-tailed hawks. Smaller band recovery sample sizes for Cooper's and sharp-shinned hawks allow for a more limited set of comparisons. Of

interest are several autumn and winter band recoveries in Baja California for juvenile Cooper's and sharp-shinned hawks.

WINTERING HABITAT AND FEEDING BEHAVIOR OF WHITE-TAILED SEA-EAGLES AND STELLER'S SEA-EAGLES IN HOKKAIDO, JAPAN

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Hokkaido, Japan is a part of the wintering region of white-tailed sea-eagles (*Haliaeetus albicilla*) and Steller's sea-eagles (*Haliaeetus pelagicus*). However their wintering ecology in Hokkaido was little known. I studied the habitat and food resource use of eagles in winter seasons. First, I counted the number of eagles at the 71 fixed sites near water or garbage sites in the northern and eastern parts of Hokkaido as a preliminary study. These censuses were carried out six times at each site during November 1991 to April 1992. These sites were divided into five habitat types such as sea, lake, basin, estuary, and garbage dump. Habitats where eagles congregated shifted according to the census time. Eagles changed wintering areas flexibly corresponding to environmental conditions and fishery activities. Additionally, it seems that the selection of wintering habitat differed with species and age. Next, I observed the feeding behavior of eagles in three different habitats (river, lake, and garbage dump) from November 1993 to March 1994. The relationships among the food items, inter- and intra-specific interactions, and the feeding strategies will be discussed. This study was funded by WWF Japan.

INVESTIGATION OF ARIZONA PEREGRINE FALCON EGG SHELL THICKNESS

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In 1993, the Arizona Game and Fish Department initiated a study to collect and measure peregrine falcon (*Falco peregrinus*) eggshells from the Arizona breeding population. This sample mean will be compared with a sample mean for eggshells collected in Arizona more than 10 yr ago and a pre-DDT sample mean for eggshells collected in California. We present our 1993 and 1994 collection results.

VOCALIZATION BEHAVIOR OF LOGGERHEAD SHRIKES (*LANIUS LUDOVICIANUS*) IN CAPTIVITY

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Loggerhead shrikes are classified as predatory songbirds. Yet song patterns of this species are poorly understood. From April until August 1994 we studied the vocalization behavior of captive-bred shrikes at McGill University and found sex-related song characteristics. During the breeding season several types of auditory displays and/or visual displays related to breeding behavior were also analyzed, including nest-site selection, food offering, food begging, courtship (pre-, during-, and post-copulation), feeding, and aggressive calls.

**FIRST CAPTURE OF A LIVE MADAGASCAR SERPENT-EAGLE (*EUTRIORCHIS ASTUR*) AND PHOTOGRAPHS OF A LIVE MADAGASCAR RED OWL (*TYTO SOUMAGNEI*)
CONFIRM THE SURVIVAL OF THESE SPECIES**

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Until recently, the Madagascar serpent-eagle, considered among the rarest raptors in the world, was known only from 11 museum specimens, the last of which was collected in 1930. A reported sighting in 1989 and a dead bird found in 1990 were the only evidence that the species remained extant. Repeated sightings and the capture of *Eutriorchis*

astur by Peregrine Fund biologists in 1993 and 1994 have provided the first opportunity to study the biology and behavior of this species in the wild. A single sighting and photograph of a Madagascar red owl taken in February 1994 provides only the third account of this species since 1934, when the last museum specimen was collected. Previous sightings were made in 1974 and a bird was found in captivity in 1993 but died soon after discovery. Sightings described in this paper occurred on Masoala Peninsula, northeastern Madagascar.

SURVEY OF SAVANNA GRASSLAND HABITAT FOR APLOMADO FALCONS AND OTHER RAPTORS

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Wild aplomado falcons (*Falco femoralis*) have been observed in New Mexico and Texas in recent years. In 1994, the Arizona Game and Fish Department initiated surveys for this species and other raptors in southeastern Arizona grassland habitat. Ten survey routes were established. We will present the protocol and preliminary survey results including data on raptor occurrence, distribution and density.